सत्यमेव जयते

AESA BASED IPM PACKAGE

OIL PALM

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FOREWORD

One of the fallouts of green revolution based on intensive use of inputs including agrochemicals has been it adverse impact on the ecological balance in different agro-ecosystems of the country. The problem has been compounded by unscientific and indiscriminate use of the agrochemicals by the farmers. It is manifest by the problems of pesticide resistance, pest resurgence, pesticide residues and pest replacement, that one sees. This has necessitated promotion of environmentally sustainable agriculture practices. Integrated Pest Management (IPM) meets such a requirement. However, IPM strategies relying on economic thresholds & crop scouting, over the years has become synonymous with chemical pesticide based pest management. Growing awareness of the adverse consequences of agrochemicals is happily effecting a shift to ecological approaches that rely on the intrinsic strengths of the ecosystem services rendered by the agro-ecosystems. Bio-intensive pest management approaches that are ecologically sound, such as Agro-ecosystem Analysis (AESA) in conjunction with ecological engineering for pest management are gaining acceptance globally. Unlike ETL, AESA analyses the crop field situation critically with regards to both abiotic and biotic factors and their interaction for taking informed pest management decisions vis-a-vis a growing crop.

The Government is now emphasizing on soil test based nutrient management and safe & judicious use of pesticides. Under AESA based IPM, chemical pesticides are to be used only as a last resort, as per the policy of Government of India. Ecological engineering for pest management approach, a new paradigm, creates favourable conditions in the crop ecosystem & enhances natural enemies by providing food, shelter and alternate prey, thereby supporting biological control. Reliance on chemical pesticides for pest management can be reduced with such ecological approaches and the balance and stability can be restored in the agro-ecosystems.

The AESA based IPM package of practices for various crops developed by the experts, incorporating the latest knowledge/information on AESA based PHM in conjunction with ecological engineering for pest management will be useful for extension functionaries from State and Central Government agencies, researchers / scientists from ICAR/SAUs and farmers for managing important crop pests and disseminating novel and innovative technologies for sustainable agriculture.

A Dalwai 25/06/2015

Dated: 25.06.2015

[Ashok Dalwai]

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FOREWORD

IPM is a holistic approach of crop protection based on the integration of multiple strategies viz., cultural, physical, mechanical, biological, botanicals and chemical. Over the years IPM underwent several changes, shifting its focus from damage boundary, economic injury to economic threshold. Currently most stake holders rely upon economic threshold levels (ETL) and tend to apply chemical pesticides at the first instance in the event of a pest attack, though Government of India has advocated need based and judicious application of chemicals. This approach is likely to cause adverse effects on agro-ecosystems and increase the cost of agricultural production due to problems of pest resurgence, insecticide resistance and sustainability.

During the late 90s FAO started advocating Agro-Ecosystem Analysis (AESA) based IPM. Experience in different countries have since shown that AESA, which takes into account ecological principles and relies on the balance that is maintained by biotic factors in an ecosystem has also resulted in reduction in cost of production and increase in yields. AESA based IPM also takes into account the need for active participation of farmers and promotes experiential learning and discovery based decision making by farmers. AESA based IPM in conjunction with ecological engineering for pest management promotes bio-intensive strategies as against current chemical intensive approaches, while retaining the option to apply chemical pesticides judiciously as a measure of last resort.

The resource persons of NIPHM and DPPQ&S have made sincere efforts in revising IPM packages for different crops by incorporating agro-ecosystem analysis, ecological engineering, pesticide application techniques and other IPM options with the active cooperation of crop based plant protection scientists working in State Agricultural Universities and ICAR institutions. I hope this IPM package will serve as a ready reference for extension functionaries of Central/ State Governments, NGOs and progressive farmers in adopting sustainable plant protection strategies by minimizing the dependence on chemical pesticides.

(Utpal Kumar Singh)

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PREFACE

Need for environmentally sustainable agricultural practices is recognised worldwide in view of the wide spread ecological imbalances caused by highly intensive agricultural systems. In order to address the adverse impacts of chemical pesticides on agro-ecosystems, Integrated Pest Management has evolved further from ETL based approach to Agro-ecosystem Analysis based Integrated Pest Management (IPM).

In AESA based IPM the whole agro-ecosystem, plant health at different stages, built-in-compensation abilities of the plant, pest and defender population dynamics, soil conditions, climatic factors and farmers' past experience are considered. In AESA, informed decisions are taken by farmers after field observation, AESA chart preparation followed by group discussion and decision making. Insect zoo is created to enable the farmer understand predation of pests by Natural Enemies. AESA based PHM also results in reduction of chemical pesticide usage and conserves the agro-ecosystems.

Ecological Engineering for Pest Management, a new paradigm, is gaining acceptance as a strategy for promoting Biointensive Integrated Pest Management. Ecological Engineering for Pest Management relies on cultural practices to effect habitat manipulation and enhance biological control. The strategies focus on pest management both below ground and above ground. There is a growing need to integrate AESA based IPM and principles of ecological engineering for pest management.

There is a rising public concern about the potential adverse effects of chemical pesticides on the human health, environment and biodiversity. The intensity of these negative externalities, though cannot be eliminated altogether, can be minimized through development, dissemination and promotion of sustainable biointensive approaches.

Directorate of Plant Protection Quarantine and Storage (DPPQS), has developed IPM package of practices during 2001 and 2002. These packages are currently providing guidance to the Extension Officers in transferring IPM strategies to farmers. These IPM package of practices, have been revised incorporating the principles of AESA based IPM in detail and also the concept of Ecological Engineering for Pest Management. It is hoped that the suggested practices, which aim at enhancing biodiversity, biointensive strategies for pest management and promotion of plant health, will enable the farmers to take informed decisions based on experiential learning and it will also result in use of chemical pesticides only as a last resort & in a safe and judicious manner.

(K. SATYAGOPAL)

CONTENTS

AESA BASED IPM PACKAGE FOR OIL PALM

Oil palm-Plant description:

Oil palm (*Elaeis guineensis*; Family: Arecaceae) is grown for its oil which is used in cooking and in industry. Oil palm trees are unbranched with a long stout single stem, or trunk, terminating in a crown of 7–100 leaves. The leaves are pinnate and can reach 3–5 m (9.8–16.4 ft) in length. The tree produces large, spherical red fruits in bunches. Up to 200 fruits can be produced per bunch and the oil is extracted from the pulp and kernel. Oil palm can reach heights of 20–30 m (65.6–98.4 ft) and has an economic lifespan of 25–30 years, at which point they become too tall to be managed efficiently and are cut down. Left alone, oil palm has been known to live for periods up to 200 years.

Oil palm is the richest source for vegetable oil production with a capacity of 4-6 tons of oil per ha per year. It is the most sustainable crop to feed the hungry mouths of the world as it is recognized universally as the most efficient, effective and highest yielding form of edible oil production. The eco friendliness is manifested as it is a perennial plantation crop, maintains its green canopy throughout 30 years of its economic life and does not cause soil erosion, river siltation, etc.

I. PESTS

A. Pests of National Significance

1. Insect pests

- **1.1 Spindle bug: *Carvalhoia arecae* (Miller) (Hemiptera: Miridae)**
- **1.2 Root grub: *Leucopholis burmeisteri* (Brenske) (Coleoptera:Melolonthidae)**
- **1.3 Rhinocerous beetle: *Oryctes rhinoceros* (Linneaus) (Coleoptera: Scarabaeidae)**
- **1.4 Red palm weevil: *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae)**
- **1.5 Case worm: *Pteroma pendula* (de Joannis) (Lepidoptera: Psychidae)**

1.6. Acaria sp.

2. Diseases

2.1 Stem wet root/ stem bleeding: *Theilaviopsis paradoxa* (*de Seynes)*

2.2 Bud rot disease: *Phytophthora palmivora* (Butler)

2.3 Basal stem rot: *Ganoderma lucidum* (Karst)

2.4 Bunch rot*: Marasmius palmivorus* (Sharples)

2.5 Anthracnose: *Botryodiplodia palmarum* (Cooker)

2.6 Leaf spot: *Pestalotiopsis* spp

2.7 Bacterial bud rot/Spear rot: *Erwinia* spp

3. Weeds

Broad leaf weeds

3.1 Crofton weed: *Eupatorium odoratum* L. (Asteraceae)

3.2.Sensitive plant: *Mimosa pudica* L. (Fabaceae)

3.3 Siam weed: *Chromolaena odorata* (L) R.M. King & H. Rob (Asteraceae)

3.4 Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)

3.5 Coat buttons: *Tridax procumbens* L. (Asteraceae)

3.6 Horse purslane: *Trianthema portulacastrum* L. (Aizoaceae)

3.7 Pig weed: *Amaranthus viridis* Hook. F. (Amaranthaceae)

3.8 Common purselane: *Portulaca oleracea* L. (Portualacaceae)

3.9 Plantation bindweed: *Convolvulus arvensis* L. (Convolvulaceae)

3.10 Painted spurge: *Euphorbia geniculata* (Ortega) Klotzsch & Garcke (Euphorbiaceae)

3.11 False Mallow: *Malvastrum coromandelianum* (L.) Garcke (Malvaceae)

Grassy weeds

3.12 Cogon grass: *Imperata cylindrical* (L.) Raeusch. (Poaceae)

3.13 Goosegrass: *Eleusine indica* (L.) Gaertner. (Poaceae)

3.14 Burmuda Grass:*Cynodon dactylon* (Poaceae)

3.15 Rabbit/crow foot grass: *Dactyloctenium aegyptium* (L.) Willd (Poaceae)

Sedges

3.16. Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)

3.17. Flat sedge: *Cyperus iria* L. (Cyperaceae)

4.Rodents

4.1 Lesser bandicoot: *Bandicota bengalensis*

4.2 Soft furred plantation rat: *Millardia meltada*

4.3 Common house rat: *Rattus rattus*

5. Vertebrate pest

5.1 Common mynah: *Acidotheres tristis*

5.2. Forest crow

B. Pest of Regional Significance

1. Insect and Mite pests

1.1 Scale: *Aspidiotus destructor* (Signoret) (Hemiptera: Diaspididae)

1.2 Mealy bug: *Dysmicoccus brevipes* (Cockerell) (Homoptera: Pseudococcidae)

1.3 Termites: *Odontotermes obesus (Rambur)* (Isoptera: Termiitidae)

1.4 Nettle caterpillar: *Thosea andamanica* (Holloway) (Lepidoptera: Limacodidae)

1.5 Mite: *Tetranychus piercei* (McGergor) ((Acarida: Tetranychidae)

II. AGRO-ECOSYSTEM ANALYSIS (AESA) BASED INTEGRATED PESTS MANAGEMENT (IPM)

A. AESA

The IPM has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment and manage the crop pests by adopting various IPM practices on eco-friendly manner, viz., Cultural, Mechanical, Biological, Botanical & Chemical. The economic threshold level (ETL) was the basis for several decades but in modern IPM (FAO 2002) emphasis is given to AESA where farmers take decisions based on larger range of plantation observations. The health of a plant is determined by its environment which includes physical factors (i.e. soil, rain, sunshine hours, wind etc.) and biological factors (i.e. pests, diseases and weeds). All these factors can play a role in the balance which exists between herbivore insects and their natural enemies. Understanding the intricate interactions in an ecosystem can play a critical role in pest management.

Decision making in pest management requires a thorough analysis of the agro-ecosystem. Farmer has to learn how to observe the crop, how to analyze the plantation situation and how to make proper decisions for their crop management. This process is called the AESA. Participants of AESA will have to make a drawing on a large piece of paper (60 x 80 cm), to include all their observations. The advantage of using a drawing is that it requires the participants/farmers to observe closely and intensively. It is a focal point for the analysis and for the discussions that follow, and the drawing can be kept as a record.

AESA is an approach, which can be gainfully employed by extension functionaries and farmers to analyze the plantation situations with regards to pests, defenders, soil conditions, plant health and the influence of climatic factors and their relationship for growing a healthy crop. The basic components of AESA are

- Plant health at different stages
- Built-in compensation abilities of plants
- Pest and defender population dynamics
- Soil conditions
- Climatic factors
- Farmers past experience

Principles of AESA based IPM:

Grow a healthy crop

- Select a variety resistant/tolerant to major pests
- Treat the seed with recommended pesticides especially biopesticides
- Select healthy seeds and seedlings
- Follow proper spacing
- Soil health improvement (mulching and green manuring)
- Nutrient management especially through organic manures and biofertilizers based on the soil test results should be followed. If the dose of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dosages are too low, the crop growth is retarded. So, the farmers should maintain proper soil fertility level through integrated nutrient management approach for best results.
- Proper irrigation

Observe the plantation regularly (climatic factors, soil and biotic factors)
Farmers should

- Monitor the plantation situation at least once a week (soil, water, plants, pests, natural enemies, weather factors etc.)
- Make decisions based on the plantation situation and P: D ratio
- Take direct action when needed (e.g. collect egg masses, remove infested plants etc.)

Plant compensation ability

Compensation is defined as the replacement of plant biomass lost to herbivores has been associated with increased photosynthetic rates and mobilization of stored resources from source organs to sinks (e.g., from roots and remaining leaves to new leaves). Plant tolerance to herbivory can arise from the interaction of a variety of plant traits and external environmental factors. Several studies have documented compensatory regrowth via side braches, through increased growth and photosynthetic rates.

Understand and conserve defenders

- Know defenders/natural enemies to understand their role through regular observations of the agro-ecosystem
- Avoid the use of chemical pesticides especially with broad-spectrum activity

Insect zoo

In plantation various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in crop plantation. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial and harmful insects. In this method, unfamiliar/unknown predators are collected in plastic containers with brush from the plantation and brought to a place for study. Each predator is placed inside a plastic bottle together with

parts of the plant and some known insect pests. Insects in the bottle are observed for certain time and determined whether the test insect is a pest (feeds on plant) or a predator (feeds on other insects).

Pest: Defender ratio (P: D ratio):
Identifying the number of pests and beneficial insects helps the farmers to make appropriate pest management decisions. Sweep net, visual counts etc. can be adopted to arrive at the numbers of pests and defenders. The P: D ratio can vary depending on the feeding potential of natural enemy as well as the type of pest. The natural enemies of oil palm pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens.

Model Agro-Ecosystem Analysis Chart

Date:
Village:
Farmer:

Decision taken based on the analysis of plantation situations

Soil conditions :
Weather conditions :
Diseases types and severity:
Weeds types and intensity :
Rodent damage (if any) :
No. of insect pests :
No. of natural enemies :

P: D ratio :

The general rule to be adopted for management decisions relying on the P: D ratio is 2: 1. However, some of the parasitoids and predators will be able to control more than 2 pests. Wherever specific P: D ratios are not found, it is safer to adopt the 2: 1, as P: D ratio. Whenever the P: D ratio is found to be favourable, there is no need for adoption of other management strategies. In cases where the P: D ratio is found to be unfavourable, the farmers can be advised to resort to inundative release of parasitoids/predators depending upon the type of pest. In addition to inundative release of parasitoids and predators, the usage of microbial biopesticides (Botanicals, *Trichoderma viride, Trichoderma harzianum, pseudomonas fluorescens* .etc) and biochemical biopesticides (Insect regulators, Pheromone traps etc) can be relied upon before resorting to synthetic chemical pesticides.

Decision making

Farmers become experts in crop management

Farmers have to make timely decisions about the management of their crops. AESA farmers have learned to make these decisions based on observations and analysis viz. abiotic and biotic factors of the crop ecosystem. The past experience of the farmers should also be considered for decision making. However, as plantation conditions continue to change and new technologies become available, farmers need to continue improving their skills and knowledge.

- Farmers are capable of improving farming practices by experimentation
- Farmers can share their knowledge with other farmers

AESA methodology

- Go to the plantation in groups (about 5 farmers per group). Walk across the plantation and choose 20plants/acre randomly. Observe keenly each of these plants and record your observations:

    - Plant: Observe the plant height, crop stage, deficiency symptoms etc.
    - Pests: Observe and count pests at different places on the plant.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
    - Rats: Count number of plants affected by rats.
    - Weeds: Observe weeds in the plantation and their intensity.
    - Water: Observe the water situation of the plantation.
    - Weather: Observe the weather condition.

- While walking in the plantation, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the plantation situation in detail and present their observations and analysis in a drawing (the AESA drawing).

- Each drawing will show a plant representing the plantation situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on what plantation management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording

Farmers should record data in a notebook and drawing on a chart

- Keep records of what has happened
- Help us making an analysis and draw conclusions

Data to be recorded

- **Check the plant growth (weekly):** Number of leaves
- **Crop situation (e.g. for AESA):** Plant health; Pests, diseases, weeds; Natural enemies; Soil condition; Irrigation; Weather conditions
- **Input costs:** Seeds; Fertilizer; Pesticides; Labour
- **Harvest:** Yield (kg/acre); Price of produce (Rs./kg)

Some questions that can be used during the discussion

- Summarize the present situation of the plantation?
- What crop management aspect is most important at this moment?
- Is there a big change in crop situation compared to last visit? What kind of change?
- Is there any serious pest or disease outbreak?
- What is the situation of the beneficial insects?
- Is there a balance in the plantation between pests and defenders?
- Were you able to identify all pests and diseases?
- Do you think the crop is healthy?
- What management practices are needed at this moment?
- When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.
- Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest buildup?
- What problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.

Advantages of AESA over ETL

One of the problems of the ETL is that it is based on parameters that are changing all the time, and that are often not known. The damage or losses caused by a certain density of insects cannot be predicted at all. In ETL the due recognition of the role of natural enemies in decreasing pest population is ignored. Farmers cannot base their decisions on just a simple count of pests. They will have to consider many other aspects of the crop (crop ecology, growth stage, natural enemies, weather condition, etc.) and their own economic and social situation before they can make the right crop management decisions. In ETL based IPM, natural enemies, plant compensation ability and abiotic factors are not considered. In AESA based IPM emphasis is given to natural enemies, plant compensation ability, abiotic factors and P: D ratio.

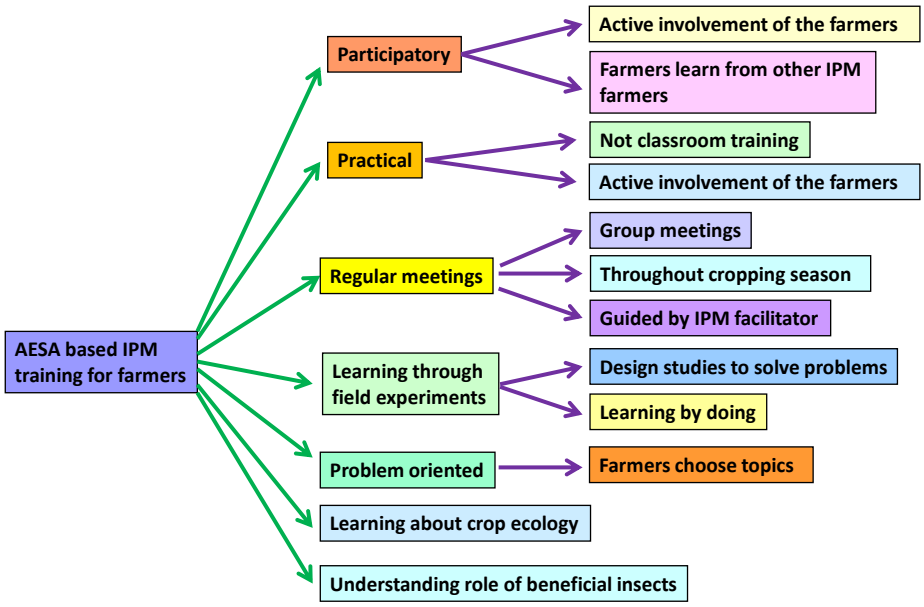
AESA and farmer plantation school (FFS)

AESA is a season-long training activity that takes place in the farmer plantation. It is season-long so that it covers all the different developmental stages of the crop and their related management practices. The process is always learner-centered, participatory and relying on an experiential learning approach and therefore it has become an integral part of FFS.

Farmers can learn from AESA

- Identification of pests and their nature of damage Identification of natural enemies
- Management of pests
- Water and nutrient management
- Influence of weather factors on pest buildup
- Role of natural enemies in pest management

FFS to teach AESA based IPM skills



B. Plantation scouting

AESA requires skill. So only the trained farmers can undertake their exercise. However, other farmers also can do plantation scouting in their own plantations at regular intervals to monitor the major pest situation.
Surveillance on pest occurrence at the main plantation should commence soon after crop establishment after transplanting and at weekly intervals thereafter. In each of the plantations, select five spots randomly. Select five random plants at each spot for recording counts of insects as per procedure finalized for individual insects.

For sucking pests:

Mites: Count and record the number of both nymphs and adults on five randomly selected leaves per plant.

For Diseases:
Damage symptoms on the plant may be caused by weather, fertilizers, deficiencies, herbicides and soil problems and diseases. In many cases, the cause of the symptom is not obvious. Whenever scouting, be aware that symptoms of plant disease problems may be caused by biotic or abiotic factors like weather, fertilizers, deficiencies, herbicides and soil problems. In many cases, the cause of the symptom is not obvious. Very close examination and a laboratory culture or analysis are required to confirm the causal agent. Basic examination techniques and details for specific diseases are given in the section on specific plant diseases. Generally fungal diseases cause the obvious symptoms with irregular growth, pattern & colour (except viruses), however abiotic problems cause regular, uniform symptoms. Pathogen presence (signs) on the symptoms can also be observed like fungal growth.

Root sampling
Always check plants that appear unhealthy. If there are no obvious symptoms on plants, examine plants randomly and look for lesions or rots on roots and stems. Observe the signs of the causal organism (fungal growth or ooze). Always check plants that appear unhealthy. It is often necessary to wash the roots with water to examine them properly. If the roots are well developed, cut into them to examine the roots for internal infections (discoloration & signs). Count the total number of stem damaged/infested/infected due to rot should be counted and incidence should be recorded.

Leaf sampling
Examine all leaves and or sheaths on each plant for lesions and determine the amount area of leaf infection. Leaf diseases cause most damage during the seedling and flowering stages of plant growth. Observe for the symptoms and signs on the infected plant parts. Count the number of leaves (leaf area diameter)/ plant infected due to disease and incidence should be recorded.

Stem and head sampling
Carefully examine the stems, heads and pods of plants for signs of fungal material diseases or lesions. The stems, pods and heads should be split or taken apart and examined for discoloration caused by fungi and bacteria. Count the number of plant, pod infected due to disease and incidence should be recorded.

C. Surveillance through pheromone trap catches for Red palm weevil and *Rhinoceros* beetle:
Pheromone traps for Red palm weevil and *Rhinoceros* beetle @ 4-5 / fixed plantation has to be installed. Install the traps for each species separated by a distance of > 75 feet in the vicinity of selected fixed plantation. Fixed the traps to supporting pole at a height of one foot above the plant canopy. Change the lure should be made at 2-3 week interval (regular interval). During each week of surveillance, the number of moths/trap should be counted and entered.
Procedure for observation: Total number of adults of *Rhinoceros* beetle and Red palm weevil /trap/week should be recorded year round. The trapped moths should be destroyed and removed after each recording.
D. Sticky traps
Blue sticky trap @ 4-5 traps/acre. Locally available empty tins can be painted blue coated with grease/Vaseline/castor oil on outer surface may also be used.

E. Light traps
Set up light traps 1 trap/acre 15 cm above the crop canopy for monitoring and mass trapping of root grub and rhinoceros beetle. Light traps with exit option for natural enemies of smaller size should be installed and operate around the dusk time (6 pm to 10 pm).

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

Ecological engineering for pest management has recently emerged as a paradigm for considering pest management approaches that rely on the use of cultural techniques to effect habitat manipulation and to enhance biological control. Ecological engineering for pest management is based on informed ecological knowledge rather than high technology approaches such as synthetic pesticides and genetically engineered crops (Gurr et al. 2004).

Ecological Engineering for Pest Management – Below Ground:

There is a growing realization that the soil borne, seed and seedling borne diseases can be managed with microbial interventions, besides choosing appropriate plant varieties. The following activities increase the beneficial microbial population and enhance soil fertility.

- Crop rotations with leguminous plants which enhance nitrogen content.
- Keep soils covered year-round with living vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance below ground biodiversity of beneficial microbes and insects.
- Application of balanced dose of nutrients using biofertilizers based on soil test report.
- Application of biofertilizers with special focus on mycorrhiza and plant growth promoting rhizobacteria (PGPR)

Ecological Engineering for Pest Management – Above Ground:

Natural enemies play a very significant role in control of foliar insect pests. Natural enemy diversity contributes significantly to management of insect pests both below and above ground.

Natural enemies may require:

1. Food in the form of pollen and nectar.
2. Shelter, overwintering sites and moderate microclimate, etc.
3. Alternate hosts when primary hosts are not present.

In order to attract natural enemies following activities should be practiced:

- Raise the flowering plants / compatible cash crops along the plantation border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population
- Grow flowering plants on the internal bunds inside the plantation
- Not to uproot weed plants those are growing naturally such as *Tridax procumbens, Ageratum* spp, *Alternanthera* spp. etc. which act as nectar source for natural enemies,
- Not to apply broad spectrum chemical pesticides, when the P: D ratio is favourable. The plant compensation ability should also be considered before applying chemical pesticides.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Select and plant appropriate companion plants which could be trap crops and pest repellent crops. The trap crops and pest repellent crops will also recruit natural enemies as their flowers provide nectar and the plants provide suitable microclimate.

Due to enhancement of biodiversity by the flowering plants, parasitoids and predators (natural enemies) number also will increase due to availability of nectar, pollen and insects etc. The major predators are a wide variety of spiders, ladybird beetles, long horned grasshoppers, *Chrysoperla,* earwigs, etc.

Plants suitable for Ecological Engineering for Pest Management

Attractant plants

Anise

Caraway

Marigold

Dill

Parsley

Mustard

Sunflower

Buck wheat

Cowpea

White clover

Carrot

Fennel

Tansy

Crocuses

Sweet clover

French bean

Repellent plants

***Ocimum* sp**

Peppermint

Marigold

The flowering plants suggested under Ecological Engineering for pest management strategy are known as attractant plants to the natural enemies of the selected pests. The information is based on published research literature. However, the actual selection of flowering plants could be based on availability, agro-climatic conditions and soil types.

Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators

Biodiversity of natural enemies: Spiders

IV. CROP STAGE-WISE IPM

<table>
<tr><th>Management</th><th>Activity</th></tr>
<tr><td colspan="2">Pre-planting *</td></tr>
<tr><td>Soils</td><td>• Best-suited soils are moist, well-drained, deep, loamy alluvial soils, rich in organic matter with good water permeability. At least one-meter depth of soil is required. Avoid highly alkaline, highly saline, waterlogged and coastal sandy soils</td></tr>
<tr><td>Variety</td><td>• Tenera is the ruling hybrid and it is a cross between thick-shelled Dura and shell less
• Pisifera. Tenera has a thin shell, medium to high mesocarp content and high oil content</td></tr>
<tr><td>Nutrients</td><td>• Oil palm seedlings are planted in the main plantation in triangular system in pits of 60 cubic cm size at a spacing of 9 x 9 m. The pits are dug during summer season and kept open for soil solarisation. Pits are filled with a mixture of top soil and FYM. Planting is preferably done at the onset of rains during June-July.
• Apply nutrients based on soil test report and recommendation for the zone.</td></tr>
<tr><td>Weeds</td><td>• Deep ploughing during summer
• Ploughing the plantation before planting to destroy existing weeds in the plantation</td></tr>
<tr><td colspan="2">Nursery*/ Seedling</td></tr>
<tr><td>Nutrients</td><td>• For the newly planted crop, the first dose of fertilizer needs to be applied three months after planting. Add 50-100 kg FYM or 100kg green manure per palm along with the second dose of fertilizer application. Five kg neem cake per palm can also be applied. Broadcast the fertilizers around the clean-weeded basin, about 50 cm away from the palm base and incorporate into the soil with the help of fork. Irrigate the palms immediately after fertilizer application.</td></tr>
<tr><td>Weeds</td><td>• Use healthy, certified and weed-free seeds for raising nursery.
• Keep the Primary Nursery and Secondary Nursery (Poly bags) weed-free during the whole year to obtain the healthy Palm seedlings.
• For conserving the moisture and weed suppression in the basins, apply coconut husk or paddy husk or saw dust, cut leaves or male inflorescence as mulching.</td></tr>
<tr><td>Anthracnose</td><td><u>Cultural control:</u>
• Collection and destruction of infected shoots</td></tr>
<tr><td colspan="2">Planting</td></tr>
<tr><td></td><td><u>Common cultural practices:</u>
• Best season for planting is June-December i.e., during monsoon.
• In case of planting during summer, adequate irrigation, mulching and growing cover crops like sun hemp in the basin would help in avoiding hot winds during summer.
• 12 -14 months old healthy seedlings with 1-1.3m height and 13 functional leaves are recommended for planting.
• While planting, 143 plants per hectare should be maintained with a spacing of 9m x 9m x 9m (triangular planting). Planting should be done in pit size of 60 cm x 60 cm x 60 cm (length, breadth and depth)</td></tr>
<tr><td>Nutrients</td><td>Manures and Fertilizers: In general, nutrients are applied as mentioned below;
<table>
<tr><td rowspan="2">Age</td><td>N</td><td>P_2O_5</td><td>K_2O</td><td>$MgSO_4$</td><td>Borax</td></tr>
<tr><td colspan="5">g/palm/year</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td></td><td>
<table>
<tr><td>First year</td><td>400</td><td>200</td><td>400</td><td>125</td><td>25</td></tr>
<tr><td>Second year</td><td>800</td><td>400</td><td>800</td><td>250</td><td>50</td></tr>
<tr><td>Third year onwards</td><td>1200</td><td>600</td><td>1200</td><td>500</td><td>100</td></tr>
</table>
Fertilizers should be applied in two equal split doses (in June and September) within 2 m diameter around the palm and forked in. Application of potassium fertilizer may be enhanced depending on the requirement of the palm on soil test basis.
</td></tr>
<tr><td>Weeds</td><td>The Palm basins are to be kept clean by regular weeding. For conserving the moisture and weed suppression in the basins, apply Coconut husk or saw dust or paddy husk or cut leaves & male inflorescence of Oil Palm as mulching.
In the juvenile phase, grow the region specific recommended intercrops/ cover cro gourds and other Vegetables, chillies, turmeric, ginger, pineapple, banana, flowers, t etc.</td></tr>
<tr><td>Termites**</td><td><u>Cultural control:</u>
Locate termite mounds in or near the oil palm nursery or garden and destroy
Adoption of plantation sanitation by disposal of organic matter in nursery soil and covering germinating seeds with a layer of river sand
Copious irrigation</td></tr>
<tr><td>Spindle bug</td><td><u>Cultural control:</u>
Digging and forking of the soil before and after the monsoon will help in eliminating the various developmental stages of the beetle
<u>Biological control:</u>
Conserve predators such as wasps, green lacewings, earwigs, ground beetles, rove beetles, spiders, coccinellids, syrphids etc</td></tr>
<tr><td>Mealy bug** and Scale**</td><td><u>Cultural control:</u>
Collection and destruction of infested plant parts
Collect planting material from unaffected plantation
Insecticidal soap is a safe and effective alternative to conventional insecticides. You can use bleach-free dishwashing liquid (1 and 1/2 teaspoons per one quart of water) in place of commercial insecticide soaps. Homemade control of plant scale can also be achieved with oil spray. Mix two tablespoons of cooking oil and two tablespoons of baby shampoo in one gallon of water. This can also be mixed with one cup of alcohol to help penetrate the insect’s shell
<u>Biological control:</u>
Conservation and augmentation of natural enemies such as ladybird beetle etc
For mealybug: Release coccinellid beetle, Cryptolaemus montrouzieri @ 10 / tree</td></tr>
<tr><td>Root grub</td><td><u>Cultural control:</u>
Fill the seedling bags with the soil free from root grub infestation
Exposure of grubs by ploughing or digging the soil during pre and post monsoon periods
<u>Mechanical control:</u>
Collection and destruction of beetles during their emergence from the soil in the evening hours
Install light traps @ 1 trap/acre and operate between 6 pm and 10 pm
<u>Biological control:</u>
Conserve entomopathogenic nematodes such as Heterorhabditis spp. and</td></tr>
</table>

	Steinernema spp.
Basal stem rot	**<u>Mechanical control:</u>** • **Plantation Sanitation:** Removal and destruction of the dead and diseased palms in order to prevent the spread of the disease • **Isolation of diseased Palms:** The palms in the early or middle stages of the disease should be isolated from the neighboring palms by taking trenches of 1 m deep and 30 cm wide • Irrigate the palms at least once in a fortnight during summer months **<u>Biological control:</u>** • Apply heavy doses of FYM or compost for green manure at 50 Kg/tree/year along with 5 kg of neem cake
Vegetative growth stage and mature palm	
Nutrients	• Four equal split doses of fertilizers are to be applied starting from June/July at three month interval. For the newly planted crop, the first dose of fertilizer needs to be applied three months after planting. Add 50-100 kg FYM or 100kg green manure per palm along with the second dose of fertilizer application. Five kg neem cake/palm can also be applied. Broadcast the fertilizers around the clean-weeded basin, about 50 cm away from the palm base and incorporate into the soil with the help of fork. Irrigate the palms immediately after fertilizer application
Weeds	• The Palm basins are to be kept clean by regular weeding. For conserving the moisture and weed suppression in the basins, apply Coconut husk or saw dust or paddy husk or cut leaves & male inflorescence of Oil Palm as mulching. • Up to the 8 years of planting, grow the region specific recommended intercrops/ cover crops like gourds and other Vegetables, chillies, turmeric, ginger, pineapple, banana, flowers, tobacco etc. • In the 8-12 years old oil palm plantations, partially shaded region specific recommended intercrops like Cocoa, Pepper, Heliconia and Ginger lily etc. may be grown between the rows. • Whenever intercrop are not grown between the rows slashing and mowing of weed or shallow ploughing of plantation leaving the basin area may be adopted.
Irrigation	• Oil palm requires sufficient irrigation, as it is a fast growing crop with high productivity and biomass production. Do not grow oil palm if assured and adequate irrigation facility is not available. For grown up yielding palms of 3 years age and above, a minimum of 150 to 200 liters of water per day is required. However, in older plantations during hot summer this quantity may be increased up to 300 lit • Basin method of irrigation is to be taken up when irrigation water is not a constraint. Required quantity of water is to be given at 4-5 days interval • Drip or Microjet irrigation method is practiced. If • land is of undulated terrain
Ablation	• Ablation is the removal of male and female flowers produced in the early stages of plantation. This enables the plant to gain adequate stem girth, vigour and develop adequate root system. Flowering starts from 14th to 18th month after planting. Start ablation immediately after the appearance of inflorescences on the palms. They can be removed easily by hand pulling or using the tool developed at DOPR. Ablation can be extended up to 2-1/2 to 3 years depending upon the plant growth and vigour

Pollination	• Oil palm is a highly cross-pollinated crop. Wind and insects assist pollination, but wind pollination is not adequate. Effective pollinating insects like *Elaeidobius kamerunicus* helps in good pollination and fruit set. Release of this weevil after 2-1/2 year of planting is advisable. If the plants are not having good girth and vigour, release the weevils after 3 years
Red palm weevil	**<u>Mechanical control:</u>** • Remove and burn all wilting or damaged palms in coconut gardens to prevent further perpetuation of the pest • Avoid injuries on stems of palms as the wounds may serve as oviposition sites for the weevil. Fill all holes in the stem with cement • Avoid the cutting of green leaves. If needed, they should be cut about 120 cm away from the stem. • Setting up of attractant traps (mud pots) containing sugarcane molasses 2½ kg or toddy 2½ litres + acetic acid 5 ml + yeast 5 g + longitudinally split tender oilpalm stem/logs of green petiole of leaves of 30 numbers in one acre to trap adult red palm weevils in large numbers. • Install pheromone trap @1/2 ha **<u>Biological control:</u>** • Fill the crown and the axils of top most three leaves with a mixture of fine sand and neem seed powder or neem seed kernel powder (2:1) once in three months to prevent the attack of rhinoceros beetle damage in which the red palm weevil lays eggs
***Rhinoceros* beetle**	**<u>Mechanical control:</u>** • Remove and burn all dead coconut trees in the garden (which are likely to serve as breeding ground) to maintain good sanitation • plant a cover crop to deter egg laying by females as they do not lay eggs in areas covered by vegetation • Collect and destroy the various bio-stages of the beetle from the manure pits (breeding ground of the pest) whenever manure is lifted from the pits. • Examine the crowns of tree at every harvest and hook out and kill the adults • Set up light traps following the first rains in summer and monsoon 200 period to attract and kill the adult beetles • Set up rhinolure pheromone trap @ 1/ac to trap and kill the beetles **<u>Biological control:</u>** • Soak castor cake at 1 kg in 5 l of water in small mud pots and keep them in the oilpalm gardens to attract and kill the adults • Treat the longitudinally split tender coconut stem and green petiole of fronds with fresh toddy and keep them in the garden to attract and trap the beetles • For seedlings, apply 3 naphthalene balls/palm weighing 3.5 g each at the base of inter space in leaf sheath in the 3 inner most leaves of the crown once in 45 days • Apply mixture of either neem seed powder + sand (1:2) @150 g per palm or neem seed kernel powder + sand (1:2) @150 g per palm in the base of the 3 inner most leaves in the crown
Mealy bug and Scales****	• Same as in planting stage
Nettle caterpillar**	**<u>Cultural control:</u>** • Cutting and burning the badly affected and dried leaves

Case worm	**Cultural control:** • Cutting and burning affected and dried leaves **Biological control:** • Conservation and augmentation of parasitoids such as *Pediobius anomalus*
Mites**	**Biological control:** • Conservation and augmentation of predatory mites
Termites **	• Same as planting stage
Stem wet rot	**Mechanical control:** • Improvement in agronomic practices, providing drainage, avoid flooding of the plantation etc • Adequate fertilization. • Scoop out the diseased tissue with a portion of healthy tissues, burn the exposed tissue and apply molten coal tar
Bud rot	**Cultural control:** • Remove and burn badly affected trees which are beyond recovery • If diseases is detected in early stage, remove the infected tissue thoroughly by cutting the infected spindle along with two leaves surrounding it
Bunch rot	**Cultural control:** • **Sanitation:** Before on-set of monsoon, crown cleaning by means of removing the dead inflorescences, bunch stalks, aborted bunches etc. will help in reducing the inoculums buildup and harbouring of pathogen
Leaf spot	**Cultural control:** • Severely diseased palm, should be removed from plantation and destroyed. • Palms should be planted with adequate spacing to allow air to circulate between trees. • Remove weeds from around palms
Bacterial bud rot/Spear rot	**Cultural control:** • Oil palm plant varieties with resistance to the bacteria. • Rotting tissue on spear leaves should be removed to prevent bacteria spreading to buds.
Common mynah	**Cultural control:** • Cover the fruit bunches with wire mesh or coconut or oil palm leaves after 150 days of fruit set. (Twenty two gauge galvanized iron wire mesh (60 x 90 cm) (the size depending upon the fruit bunches) used to cover the Fresh Fruit Bunches (FFB) atleast of 3-4 times. At least 10 cm gap between the net and the fruit bunch) • Use bird scare devices
Wild boar	**Cultural control:** • Wild boar scaring device may be kept
Bunch failure	**Cultural control:** • The situation can be improved by assisted pollination as well as by adopting hygienic measures like removal of infected bunches and dry male inflorescence

Note:** pest of regional significance

V. RODENT PEST MANAGEMENT

Rodents the starts eating the tubers in the young crops and ripened fruits in the mature stages	**Cultural control:** • Practice clean cultivation/maintain weed free plantations which reduces the harbouring/hiding points for rodents. • Practice trapping with locally available traps using lure @ 8-10 traps/acre. In areas, where *Rattus rattus* is a problem, wonder traps/multi-catch traps work better and enable to trap more animals into a single trap. • Identify live rodent burrows and smoke the burrows with burrow smoker for 2-3 minutes • Erect owl perches @ 5-6/acre to promote natural control of rodents **Chemical control:** • Practice poison baiting with anticoagulant, bromadiolone @0.005% (96 parts of broken rice + 2 parts of edible oil + 2 parts of 0.25% CB bromadiolone) on community approach. • DAY – 1: Close all the burrows in the plantations, plantation bunds, canal bunds and surrounding barren lands etc. • DAY – 2: Count the re-opened burrows and treat the burrows with Bromadiolone chemical bait packets @ 10 g/burrow. • DAY – 10: Observe the re-opened burrows and repeat baiting • In cases of high level of infestation (>50 live burrows/ac) practice poison baiting with zinc phosphide @ 2.0% on community approach. • PRACTICE PRE-BAITING TO AVOID BAIT SHYNESS • Day 1: Close all the burrows in the plantations, orchid bunds, canal bunds and surrounding barren lands etc. • Day 2: Count the re-opened burrows and practice pre-baiting @ 20 g/burrow (98 parts of broken tomato + 2 parts of edible oil) • Day 4: Observe the re-opened burrows and treat the burrow with zinc phosphide poison bait (96 parts of broken tomato + 2 parts of edible oil + 2 parts of zinc phosphide) @ 10g/ burrow. Collect the dead rats, if found any outside and bury them.

VI. INSECTICIDE RESISTANCE AND ITS MANAGEMENT

Insecticide resistance: Resistance to insecticides may be defined as 'a heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species' (IRAC). Cross-resistance occurs when resistance to one insecticide confers resistance to another insecticide, even where the insect has not been exposed to the latter product.

Causes of resistance development: The causes and rate at which insecticide resistance develops depend on several factors, including the initial frequency of resistance alleles present in the population, how rapidly the insects reproduce, the insects' level of resistance, the migration and host range of the insects, the insecticide's persistence and specificity, and the rate, timing and number of applications of insecticide made. For instance, insect pests that survive in large populations and breed quickly are at greater advantage of evolving insecticide, especially when insecticides are misused or over-used.

General strategy for insecticide resistance management: The best strategy to avoid insecticide resistance is prevention and including insecticide resistance management tactics as part of a larger integrated pest management (IPM) approach.

1) Monitor pests: Monitor insect population development in plantations to determine if and when control measures are warranted. Monitor and consider natural enemies when making control decisions. After treatment, continue monitoring to assess pest populations and their control.

2) Focus on AESA. Insecticides should be used only as a last resort when all other non-chemical management options are exhausted and P: D ratio is above 2: 1. Apply biopesticides/chemical insecticides judiciously after observing unfavourable P: D ratio and when the pests are in most vulnerable life stage. Use application rates and intervals as per label claim.

3) Ecological engineering for pest management: Flowering plants that attract natural enemies as well as plants that repel pests can be grown as border/intercrop.

4) Take an integrated approach to managing pests. Use as many different control measures as possible viz., cultural, mechanical, physical, biological etc. Select insecticides with care and consider the impact on future pest populations and the environment. Avoid broad-spectrum insecticides when a narrow-spectrum or more specific insecticide will work. More preference should be given to green labeled insecticides.

5) Mix and apply carefully. While applying insecticides care should be taken for proper application of insecticides in terms of dose, volume, timing, coverage, application techniques as per label claim.

6) Alternate different insecticide classes. Avoid the repeated use of the same insecticide, insecticides in the same chemical class, or insecticides in different classes with same mode of action and rotate/alternate insecticide classes and modes of action.

7) Preserve susceptible genes. Preserve susceptible individuals within the target population by providing unsprayed areas within treated plantations, adjacent "refuge" plantations, or habitat attractions within a treated plantation that facilitate immigration. These susceptible individuals may outcompete and interbreed with resistant individuals, diluting the resistant genes and therefore the impact of resistance.

VII. NUTRITIONAL DEFICIENCIES/ DISORDERS

1. Nitrogen deficiency: Severe N deficiency is rarely seen on old palms. Nitrogen deficiency is expressed in uniformly pale, yellow green leaflets and a sharply reduced growth rate. Midrib tissues become bright yellow, Nitrogen deficiency may also be caused by poor drainage.


2. Phosphorus deficiency: Phosphorus deficiency does not produce leaf symptoms in oil palm. However, the trunks of affected palms are narrow and tapered

3. Potassium deficiency: Potassium is the nutrient required by oil palm in largest amounts, and deficiency symptoms develop on most soils unless K fertilizer is applied. Continued K deficiency leads to a progressive decline in yield and plant health. A number of different symptoms indicate K deficiency or an imbalance of K with other elements. The most typical and widespread form of K deficiency is known as “confluent orange spotting” . The first signs of K deficiency are pale green spots on the pinnae of older fronds. In a more advanced stage, the rectangular spots become orange-yellow and transmit light when held up to the sky. Later, the tips of leaf pinnae start to dry up. In very severe cases, entire older fronds may dry up. Some palms show symptoms similar to K deficiency known as “genetic orange spotting”

4. Boron deficiency: Boron deficiency is expressed in a range of leaf symptoms. However, in all cases the distal end of leaflets at the tip of the frond are most affected. Pinnae are misshapen, stiff and brittle. “Hook leaf” is one typical symptom of B deficiency

5. Magnesium deficiency: Severe Mg deficiency results in the development of bright orange color in older fronds. The orange discoloration is very pronounced on the upper rank pinnae

exposed to sunlight, whilst lower rank and shaded pinnae remain green. Leaf veins also stay green for a longer period. Older fronds dry up and die under conditions of severe Mg deficiency. Planters should be able to distinguish between Mg and K deficiency and a healthy leaf

5. **Manganese deficiency:** Manganese (Mn) deficiency is not common, but has been reported on soils with high exchangeable Mg status and insufficiently compacted peat soils where palms are suffering from drought. Manganese deficiency shows as a yellowing of interveinal areas. In contrast to Mg deficiency, the symptoms are found on young rather than on older fronds. The symptoms are equally pronounced on upper (sun exposed) and lower (shaded) rank pinnae. Manganese deficiency can occur on peat and very sandy soils and is sometimes associated with high leaf Mg status.
6. **Zinc deficiency:** Zinc (Zn) deficiency is not common in oil palm but may be induced under high soil P status and occurs on ultrabasic and ultramafic soils with high soil pH. It is also believed to be a factor involved in the “Peat Yellows” condition found on peat soils. Zinc deficiency has also been reported on shallow peat soils overlying sand, particularly where large amounts of soluble P fertilizer have been applied. It appears as small, narrow white streaks on lower and mid-crown fronds. A different condition that produces blotchy leaf symptoms has also been identified tentatively as Zn deficiency.

7. **Iron deficiency –** Iron (Fe) deficiency is very rare in oil palm and occurs where soil pH is very high (i.e., more than 7.5). The deficiency has been observed where palms are grown over coral outcrops or on spots where white ant hills have been levelled. It is easily identified, as symptoms appear first on the youngest fronds, which appear droopy and show diffuse blotchy yellowing and white freckles.

8. **Copper deficiency:** Copper (Cu) deficiency is common on deep peat soils and occurs also

on very sandy soils. It appears initially as whitish yellow mottling of younger fronds. As the deficiency intensifies, yellow, mottled, interveinal stripes appear and rusty, brown spots develop on the distal end of leaflets. Affected fronds and leaflets are stunted and leaflets dry up. On sandy soils, palms recover rapidly after a basal application of 50 g CuSO4. On peat soils, lasting correction of Cu deficiency is difficult, as applied CuSO4 is rendered unavailable. A promising method to correct Cu deficiency on peat soil, developed by the authors, is to mix CuSO4 with clay soil and to form tennis-ball sized “copper mudballs” that are placed around the palm and that provide a slow-release source of available Cu.

http://www.nutricaodeplantas.agr.br/site/downloads/unesp_jaboticabal/omissao_palma1.pdf

9. **Other Micronutrients:** Micronutrient elements, iron, manganese and zinc are not generally found limiting in the nutrition of oil palm on acid soil conditions. Boron deficiency is occasionally found on young palms in the plantation showing a reduction of leaf area in certain leaves producing incipient ‘little leaf’, advanced ‘little leaf’ with extreme reduction of leaf area and bunching and reduction in the number of leaflets and ‘fish-bone’ leaf. The ‘fish-bone’ leaves are abnormally stiff with leaflets reduced to projections. Leaf malformations including ‘hook leaf’ and corrugated leaflets are some other associated symptoms. Soil application of 50 - 200 g borax decahydrate, per palm, depending on age, and severity of symptoms is practiced for correcting the malady

VIII. COMMON WEEDS

1.Crofton weed: *Eupatorium odoratum* L. (Asteraceae)

2. Sensitive plant: *Mimosa pudica* L. (Fabaceae)

3. Siam weed: *Chromolaena odorata* (L.) (Asteraceae)

4. Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)

5.Coat buttons: *Tridax procumbens* L. (Asteraceae)

6. Horse purslane: *Trianthema portulacastrum* L. (Aizoaceae)

7.Pigweed: *Amaranthus viridis* Hook. F. (Amaranthaceae)

8. Field bindweed: *Convolvulus arvensis* L. (Convolvulaceae)

9. Common purselane: *Portulaca oleracea* L. (Portualacaceae)

10. Painted spurge: *Euphorbia geniculata* Ortega (Euphorbiaceae)

11. False Mallow: *Malvastrum coromandelianum* (L.) Garcke (Malvaceae)

12.Goose grass: *Eleusine indica* (L.) Gaertner. (Poaceae)

13.Burmuda grass:*Cynodon dactylon* L. (Poaceae)

14. Cogon grass: *Imperata cylindrical* (L.) Raeusch. (Poaceae)

15. Rabbit/crow foot grass: *Dactyloctenium aegyptium* (L.) Willd (Poaceae)

16. Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)

17. Flat sedge: *Cyperus iria* L. (Cyperaceae)

IX. DESCRIPTION OF INSECT PESTS

1. Spindle bug:

Biology:

Egg: Eggs are laid singly between the leaflets of the spindle. The eggs hatch in 9 days.
Nymph: There are five nymphal stages and it is completed in 15-24 days. The light violet brown nymphs have greenish yellow border.
Adult: Adult bugs are brightly color red and black

Damage symptoms:

- Spindle bug - generally noticed in nursery seedlings and plantation planted young seedlings.
- Adults and nymphs of spindle bug live in the innermost two to three leaf axils.
- Suck sap from the spindle of leaves
- Necrotic lesions which later on turn into dry brown patches.
- In severe infestation the spindle fails, to open.

Natural enemies of Spindle bug:

Predators : Kingcrow, Ground beetles, Wasp, Spider

*For management refer to page number-22----------

2. Root grub:

Biology:

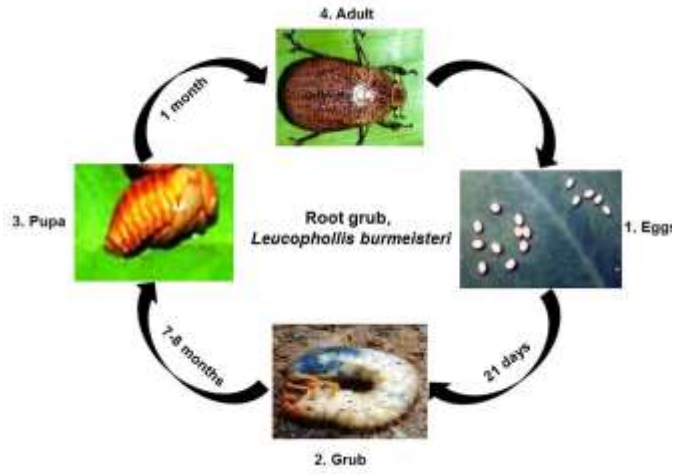
Egg: These beetles lay eggs in soil mostly up to 10 cm depth. Eggs hatch out in about three weeks.

Larva: The grub period with three instars is completed within 7 to 8 months.

Pupa: The pupation is in soil in cocoons of mud. This period lasts about one month.

Adult: The adult beetle is chestnut brown in color.

Life cycle:



http://etd.uasd.edu/ft/th9586.pdf

Damage symptoms:

- Root grubs or 'white' grubs occur mostly in sandy and sandy loam soils.
- They are voracious feeders on roots. Adult beetles emerge during May-June few days after receipt of pre-monsoon showers, between 6.30 to 7.30 PM.
- The early instar grubs feed on the roots of grasses and other humus. The second and third instar grubs of these beetles feed on tender and mature roots of the palm. In severe cases, the bole of the palm is also eaten up. They feed on roots of intercrops like banana, cocoa, tapioca, yams etc.
- In oilpalm seedlings, the feeding on roots results in dropping and drying of leaves
- Affected seedlings come off easily since the entire root system is usually eaten up. Palms with few years of infestation show a sickly appearance, with yellowing of leaves, tapering of stem, and reduction in yield.
- The palms may topple in case of severe loss of root system

Damage symptoms

http://etd.uasd.edu/ft/th9586.pdf
http://www.kissankerala.net:8080/KISSAN-CHDSS/English/Arecanut/pests/2.htm

Natural enemies of Root grub:

Parasitoids: Scoliids wasp
Predators: False vampire bats, Garden lizards,Wild boar
*For management refer to page number--23----------

3. Rhinoceros beetle:

Biology:

Egg: *O. rhinoceros* eggs are yellowish-white, measuring 3 mm in diameter and laid inside rotting vegetative matter. Initially oval in shape, they begin to swell about a week after laying and hatch within 11-13 days

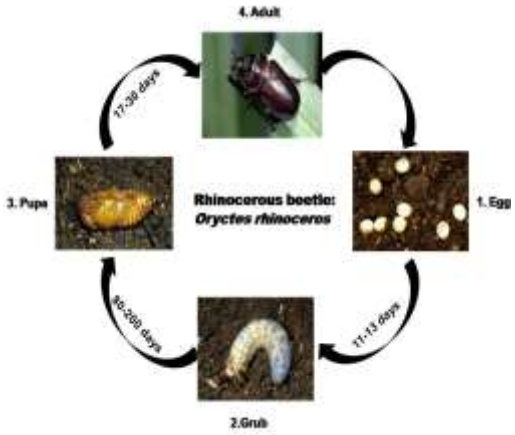
Grubs/larvae: The larval stages are usually yellowish-white in color and may grow to about 60-100 mm long. Development of the larva takes 80-200 days: first instar takes 10-21 days, second instar takes 12-21 days and third instar takes 60-125 days.

Prepupae: The prepupa is somewhat similar in appearance to the larval stage, except that it is smaller than the final larval instar. Shrivelled in appearance, it shakes its body actively when disturbed.

Pupae: Pupa is yellowish-brown in color and measures up to 50 mm in length. The pupal stage lasts 17-30 days.

Adults: Stout-looking adults, dark brown to black, shiny, 35-50 mm long and 20-23 mm wide, with a prominent horn on head. The males having a relatively longer horn than the female. The males can be differentiated more accurately by having a rounded shiny terminal abdominal segment while the female has a relatively hairier tail. Adults may live up to 6 months or more.

Life cycle:



1. http://advanceagripractice.in/rhinoceros-beetle/
2.3.4.5. http://www.cabi.org/cpc/datasheet/37974

Damage symptoms:

- *O. rhinoceros* adults feed in the crown region of both coconut and Oil palm.
- On oil palms they bore through petiole bases into the central unopened leaves. This causes tissue maceration and the presence of a fibrous frass inside the feeding hole is an indication of its activity within.
- Usually, a single attack is often followed by others on the same palm.
- These attacks subsequently produce fronds which have wedge-shaped gaps or the characteristic serrated cut (fan-shaped fronds)

Fan- shaped fronds

Unopened leaves

1.http://www.cabi.org/cpc/datasheet/37974
2.http://www.ipni.net/ppiweb/gseasia.nsf/$webindex/article=53C0AEEE48256EF3002A1904940D445D!opendocument

Natural enemies of Rhinoceros beetle:

Predators: Tiger beetle , Squirrels, Barn owl

*For management refer to page number--------25----------

4 Red palm weevil:

Biology:

Egg: Eggs are creamy white, oblong and shiny. The average size of an egg is 2.62 mm long and 1.12 mm wide. Eggs hatch in 3 days and increase in size before hatching

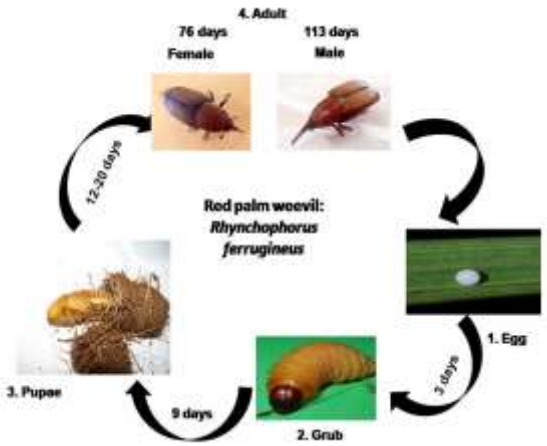
Grub/larva: The larvae can grow up to 35 mm long and can be recognised by the brown head and white body. The body is composed of 13 segments.

Prepupa: The prepupal stage lasts for about 3 days

Pupa: pupal period varies from 12-20 days. Pupae are first cream colored but later turn brown. The surface is shiny, but greatly furrowed and reticulated. The average length of pupae is 35 mm and the average width is 15 mm.

Adult: Adult weevils are reddish brown, about 35 mm long and 10 mm wide and are characterized by a long curved rostrum (snout). Dark spots are visible on the upper side of the middle part of the body. The head and rostrum comprise about one-third of the total length. In the male, the dorsal apical half of the snout is covered by a patch of short brownish hairs, the snout is bare in the female, more slender, curved and a little longer than the male. The longevity of the weevil ranges from 2-3 months, irrespective of the sex. In captivity, the maximum life span of the adult was 76 days for the female and 113 days for the male.

Life cycle:



1,2. http://advanceagripractice.in/red-palm-weevil/
3. http://www.agritech.tnau.ac.in/expert_system/coconut/coconut/coconut_pest%20and_diseases.html

4,5. http://www.cabi.org/cpc/datasheet/47472

Damage symptoms:

- It is very difficult to detect *R. ferrugineus* in the early stages of infestation. Generally, it is detected only after the palm has been severely damaged. Careful observation may reveal the following signs which are indicative of the presence of the pest
- Some holes in the crown or trunk from which chewed-up fibres are ejected. This may be accompanied by the oozing of brown viscous liquid
- Crunching noise produced by the feeding grubs can be heard when the ear is placed to the trunk of the palm
- A withered bud/crown.
- Chewed plant tissues in and around opening of tunnels with a typical fermented odor
- Fallen empty pupal cases and dead adults around a heavily infested palm
- Breaking of the trunk or toppling of the crown in case of severe and prolonged infestation.
- Drying of Offshoots in date palm

Holes on trunk

Ejected chewed-up fibres from trunk

1.http://www.cabi.org/cpc/datasheet/47472
2. http://www.agritech.tnau.ac.in/expert_system/coconut/coconut/coconut_pest%20and_diseases.html

Natural enemies of Red palm weevil:

Predators: *Dendrocitta vagabunda parvula*

*For management refer to page number------24----------

5. Caseworm:

Biology: *Pteroma pendula* was the dominant bagworm species infesting oil palm Plantation. This species had six instar stages. Dimorphism was observed in pupa and imago stages. Female emerged as apterous and vermiform-like, and male emerged as moth. *P. pendula* had a lifespan of 50.4 ± 1.8 days.

Damage symptoms:

- Holes on the leaves
- Occasional defoliation
- Cone shaped bags on the underside of leaves

Holes on leaves

Cone shaped bags

1.http://www.pestnet.org/SummariesofMessages/Crops/Plantationcrops/Coconutoilpalm/Insects/Bagworms/Bagworm,oilpalm,Malaysia.aspx
2.http://www.thestar.com.my/story.aspx/?file=%2f2012%2f11%2f21%2fsouthneast%2f12341030

Natural enemies of Caseworm:
Larval parasitoid: *Pediobius anomalus*
Predator: *Oecophylla smaragdina*

For management refer to page number---25---

Natural Enemies of Oil plam Insect Pests

Parasitoids:

1. Scoliids wasp

2. *Pediobius anomalus*

1.http://war.wikipedia.org/wiki/Pediobius1. http://war.wikipedia.org/wiki/Pediobius
2.http://www.pbase.com/rcm1840/image/85327393&gcmd=add_comment

Predators:

1.Kingcrow

2.Groundbeetles

3.Wasp

4.Spider

5. Robber fly

6. Reduviid bug

7. Praying mantid

8. Fire ants

9. Big eyed bugs **10. Pentatomid bug** **11. Earwigs** **12. Tiger beetle**




3. http://nagpurbirds.org/blackdrongo/picture/1639
4.http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
5.http://somethingscrawlinginmyhair.com/2011/09/17/yellowjacket-with-prey/
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11.http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/Ground%20Beetle%20-%20Pterostichus%20madidus.html

1. Squirrels **2. Barn owl** **3.*Dendrocitta vagabunda parvula***



1. http://www.uky.edu/Ag/CritterFiles/casefile/insects/beetles/tiger/tiger.htm
2.http://www.northrup.org/photos/grey-squirrel/
3. http://www.liveanimalslist.com/birds/barn-owl.php

X. DESCRIPTION OF DISEASES

1.Bud rot disease:

Disease symptoms:

- Palms of all ages are susceptible to the disease, but it is more severe in young palms of 5-20 years. The first indication of the diseases is seen on the central shoot of the tree (spindle)
- The heart leaf shows discolorations which become brown instead of yellowish brown. This is followed by drooping and breading off the heart leaf. With the progress of diseases, more number of leaves get affected with loss of lusture and turn pale yellow
- The entire base of the crown may be rotten emitting a foul smell, the central shoot comes off easily on slight pulling
- The leaves fall in succession starting from the top of the crown. The leaf falling and bunch shedding continue until a few outer leaves are left unaffected. But within few months the infection leads to complete shedding of leaves, within subsequent wilt and death of the tree

Disease symptoms

1.http://www.apsnet.org/publications/apsnetfeatures/Pages/OrnamentalPalms.aspx
2.http://itp.lucidcentral.org/id/palms/symptoms/Bud_Rot.htm

Favourable conditions:

- High rainfall, high atmospheric humidity (above 90 per cent), low temperature (18-20˚C) and wounds caused by tappper and *Rhinoceros* beetles.

Survival and spread:

- The disease spread is mainly through air-borne sporangia and zoospores.
- Rainfall also helps in spreading the diseases. Insects and tappers also help in the spread of the inoculum from diseased trees.

*For management refer to page number------26----------

2. Basal stem rot:

Disease symptoms:

- The trees in the age group of 10-30 years are easily attacked by the pathogen. The fungus is soil-borne and infects the roots The most usual symptoms are yellowing, withering and drooping of the outer fronds which remain hanging around the trunk for several months before shedding
- The younger leaves remain green for sometime and later turn yellowish brown
- The new fronds produced become successively smaller and yellowish in color which do not unfold properly

- Soft rot occurs in the bud with a bad newly formed leaves wither away. More often the spindle is blown off leaving the decapitated stem
- The wilting plants also show bleeding patches near the base of the trunk
- A brown gummy liquid oozes out from the cracks in the tree which slowly result in the death of outer tissues
- As the infection advances, fresh bleeding patches appear above the old once, up to 3-5 meters height
- The decay of the basal portion occurs slowly and tree succumbs to the diseases in 2-3 years
- In the advanced stages of infection, the fungus produces fruiting body (Bracket) along the side of the basal trunk
- The roots of wilting trees show discoloration and severe rotting

Disease symptom

http://agribiogreen.blogspot.in/2013_05_01_archive.html

Favourable conditions:

- Trees grown in sandy loam and sandy soils, water logging during severe rains, low soil moisture content during summer months and damages caused by weevils and beetles

Survival and spread:

- The primary infection is through basidiospores in the soil, which attack roots.
- The irrigation water and rain water also help in the spread of the fungus.

*For management refer to page number---------23----------

3. Stem wet rot:

Disease symptoms:

- The characteristic symptom is the exudation of reddish brown fluid from the cracks in the stem.
- The fluid trickles down to several feet on the stem and the exudates dries up forming a black crust.
- The tissues below the cracks turn yellow and decay. As the disease progresses, more area underneath the bark gets decayed and the bleeding patch extends further up.
- The vigour of the tree is affected and seed yield is reduced.
- The tree is not killed out right but become uneconomical to maintain. In extreme cases, the trees may become barren and die.

Reddish brown fluid from cracks in the stem

Disease symptom

http://nassau.ifas.ufl.edu/horticulture/gardentalk/palms.html

Favourable conditions:

- Copious irrigation or rainfall followed by drought, shallow loamy soils or laterite soil with clay or rock layer beneath the soil, poor maintenance of gardens and damages by *Diocalandra* and *Xyleborus* beetles.

Survival and spread:

- The fungus survies in the infected plant debris and soil as perithecia and conidia.
- The spread is mainly through wind-borne conidia.
- The irrigation and rain water also help in the disease spread.
- The beetles which feed on the diseased plants also help in transmission.

*For management refer to page number--------26----------

4. Bunch rot:

Disease symptoms

- In the early stages of infection, whitish or pinkish-white mycelial threads can be seen over the bunch surface, especially at the base of the subtending frond.
- The fungus penetrates the mesocarp of the fruit and causes a soft, brown, wet rot which is sharply defined from healthy tissues. If affected fruits are left on the palm, the rot ultimately dries out, leaving the fibrous tissues of the mesocarp with abundant mycelial growth of the pathogen.
- The mycelial threads spread to other bunches and grow over, and inside, the frond bases. In the later stages of infection, abundant fructifications can be seen on bunches which have been extensively colonized

Whitish or pinkish- white mycelia threads on Oil palm bunch

http://jaowoffice.weebly.com/1/archives/11-2011/1.html

Survival and spread:

- Resting spores capable of surviving in soil and plant tissues for several months

*For management refer to page number------26----------

5. Anthracnose:

Disease symptoms:

- This disease occurs in the nursery. It is recognized by regular or irregular brown to black leaf blotches surrounded by yellow halos, which develop along the margin, centre or tip of the leaves.
- It causes heavy seedling loss

Brown/black blotches on leaf

Disease symptom

http://www.scialert.net/fulltext/?doi=ppj.2013.169.175&org=11

Survival and spread:

- Resting spores in soil

Favourable conitions:

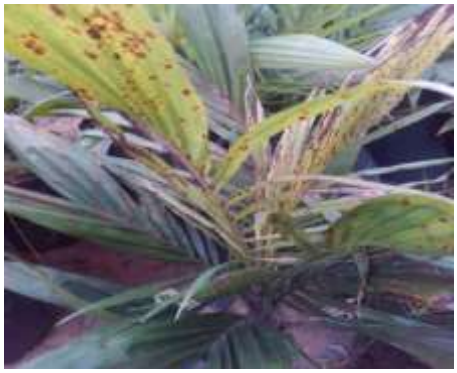
- High humidity, frequent rains and a temperature of 24-32oC favours the development of disease.

*For management refer to page number----21----------

6.Leaf spot:

Disease symptoms

- Tiny black spots on leaves which enlarge into 2 mm long elliptical, elongated lesions.
- Lesions may expand and be surrounded by black tissue and chlorosis between lesions.
- Lesions may be present on leaf petioles and rachis.



Infected leaves

http://s3.amazonaws.com/plantvillage/images/pics/000/002/694/large/leaf_spots.jpg?1396775415

Survival and spread:

- The pathogen is seed borne fungus and inoculums present in the seeds are source of primary infection.

- Fungus also survives on fruit and plant debris.

Favourable conditions:

- The disease is favoured by temperatures between 77 and 86 °F (25–30 °C), and by wet conditions.
- Infection occurs at optimum temperatures with 5.5 hours of wetting and an outbreak can become serious within two days of infection

*For management refer to page number---26----------

7.Bacterial bud rot/Spear rot:

Disease symptoms

- Parts of spear leaf petiole or rachi turning brown.
- Discoloration may be associated with a wet rot.
- Spear leaf may be wilted and/or chlorotic.
- Leaves may be collapsing and hanging from the crown.
- Infection of the bud results in buds becoming rotten and putrid, leading to death of the palm.

Survival and spread:

- Bacteria survive in crop debris and infect by water splash through damaged tissues.
- Worse in hot wet weather. The bacteria spread in contaminated water.

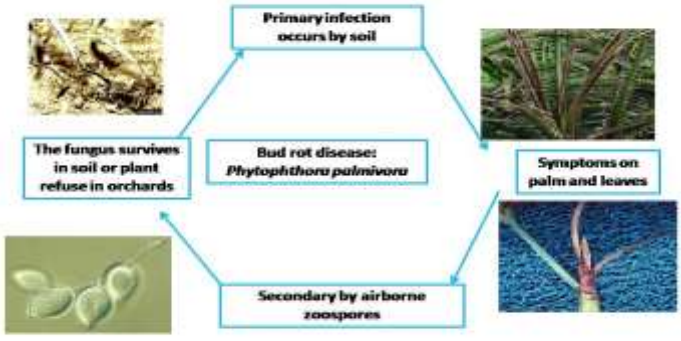
Favourable conditions:

• Higher temperatures and high humidity are ideal growing conditions for the bacteria

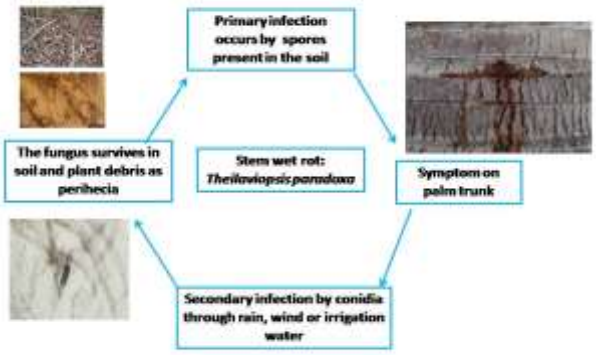
*For management refer to page number-----26----------

Disease cycles:

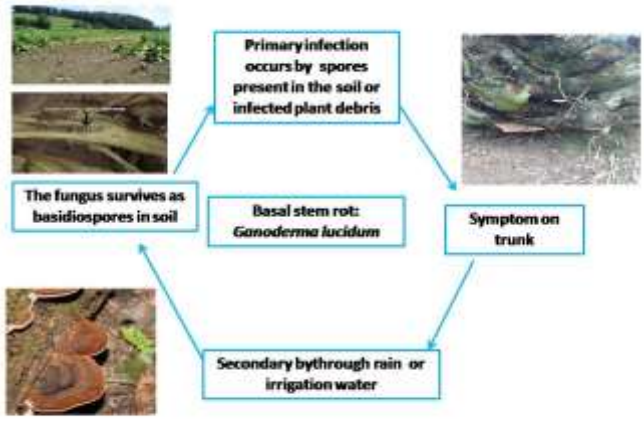
1. Bud rot disease:



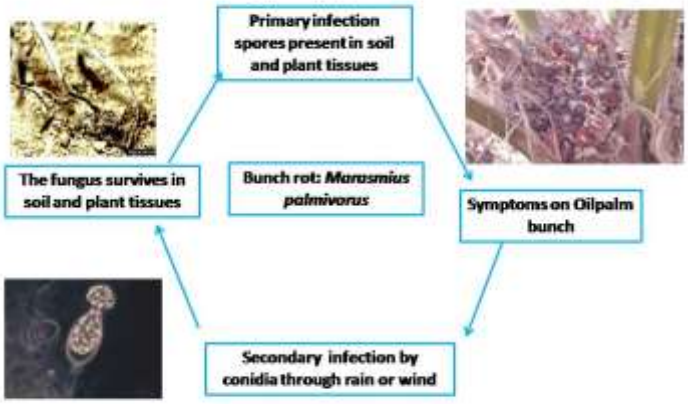
2. Stem wet rot:



3. Basal stem rot:



4. Bunch rot:



XI. DESCRIPTION OF RODENT PESTS

1) Lesser bandicoot:

Distribution and Identification:

Distributed throughout India and infests almost all crops. It is a robust rodent (200 to 300 g body weight) with a rounded head and a broad muzzle. Dorsum covered with grey-brownish rough hairs. Tail is naked, shorter than head and body. Breeds throughout the season and litter size 6-8 in normal conditions.

Burrows are characterized by the presence of scooped soil at the entrance and mostly burrow openings are closed with soil.

Damage symptoms:

Mostly damage occurs at fruiting stage. Bandicoots cut the raw and ripened fruits and hoard them in their burrows.

2. Soft furred field rat:

- Distributed in Punjab, Uttar Pradesh southwards to western and southern India, also finds in foothills of eastern Himalayas. Found mostly in semi arid areas.
- Small rodent (40-60gm) with soft fur, dorsum light grey and bicolored tail equal to the head and body.
- It is associated with *T. indica* and *Mus boodga* in northern part and with *Bandicota bengalensis* in southern part.
- Nocturnal and fossorial with simple burrows.
- Found majorly in rain-fed paddy and rice-sugarcane ecosystem.

3. House rat:

Distributed throughout India. Medium sized (80-120g) slender rodent. Commonly found in houses and on plantation crops. Very good climber with longer tail than head and body. Occasionally causes damage to tomato in certain pockets. Inhabitation on trees and other places and won't make any burrows in plantations

XII. SAFETY MEASURES

A. At the time of harvest

Change in colour and change in texture of the fruit. Ripening of fruits start from top downwards, nigrescens fruits turning reddish orange and the virescens (green) to reddish brown. While harvesting a stalk length of 5 cm alone should be left. Harvesting should be done at 10-12 days interval. During rainy season, harvesting should be done at closer interval of 6-7 days as ripening is hastened after hot summer. In young plantations, more bunches with less bunch weight will get and in adult plantations the bunch weight is more but the bunch number is less. The criteria used in determining the degree of ripeness based on the fruit detachment are as follows:

- Fallen fruits: 10 detached or easily removable fruits for young palms and 5 for adult palms
- Number of fruits detached after the bunch is cut; 5 or more fruits/Kg of bunch weight
- Quantity of detachment per bunch; fruit detachment on 25% of visible surface of bunch

XIII. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The plantation should be kept exposed to sun light at least for 2-3 weeks	Do not plant or irrigate the plantation after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
3.	Plant early in the season	Avoid planting sowing as this may lead to reduced yields and incidence of pests and diseases.
4.	Always treat the seeds with approved chemicals/bio products for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with biocides/chemicals.
5.	Sow in rows at optimum depths under proper moisture conditions for better establishment.	Do not sow seeds beyond 5-7 cm depth.
6.	Apply only CIBRC recommended pesticides against a particular pest at the recommended	Non-recommended pesticides should not be applied in the Plantation plantation.

	dose, at the right time, with right methods with standard equipments e.g. Flat-fan or flood- jet nozzles for herbicides.	
7.	Maintain optimum and healthy plant stand.	Plantation plants should not be exposed to moisture deficit stress at their critical stages.
8.	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
9.	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
10.	Conduct AESA weekly in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.	Do not take any management decision without considering AESA and P: D ratio
11.	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
12.	Release parasitoids only after noticing adult moth catches in the pheromone trap or as per plantation observation	Do not apply chemical pesticides within seven days of release of parasitoids.
13.	In case of pests which are active during night like spray recommended biopesticides/ chemicals at the time of their appearance during evening time.	Do not spray pesticides at midday since, most of the insects are not active during this period.
14.	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, whiteflies etc.	Do not spray pesticides only on the upper surface of leaves.
15.	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
16.	Follow the recommended procedure of trap crop technology.	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.

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