AESA BASED IPM PACKAGE

AESA based IPM – Coconut

Directorate of Plant Protection
Quarantine and Storage
N. H. IV, Faridabad, Haryana

National Institute of
Plant Health Management
Rajendranagar, Hyderabad, Telangana

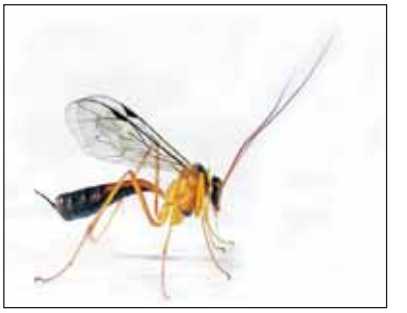
Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

Important Natural Enemies of Coconut Insect Pests

Parasitoids

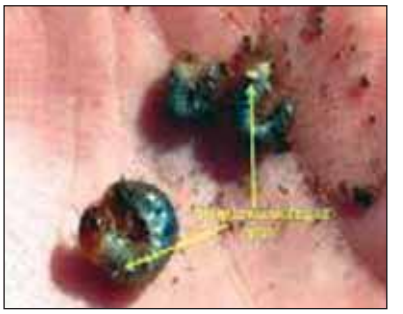
Bethylid fly

Bracon spp.



Ichneumonid wasp

Goniozus nephantidis



Typhia spp.

Eulophid wasp

Predators

Red ant

Hover fly

Lacewing

Reduviid bug

Ground beetle

Spider

The AESA based IPM - Coconut, was compiled by the NIPHM working group under the Chairmanship of Dr. Satyagopal Korlapati, IAS, DG, NIPHM, and guidance of Shri. Utpal Kumar Singh, IAS, JS (PP). The package was developed taking into account the advice of experts listed below on various occasions before finalization.

NIPHM Working Group :

Chairman : Dr. Satyagopal Korlapati, IAS, Director General

Vice-Chairmen : Dr. S. N. Sushil, Plant Protection Advisor

: Dr. P. Jeyakumar, Director (PHM)

Core Members :

1. Er. G. Shankar, Joint Director (PHE), Pesticide Application Techniques Expertise.
2. Dr. O.P. Sharma, Joint Director (A & AM), Agronomy Expertise.
3. Dr. Dhana Raj Boina, Assistant Director (PHM), Entomology Expertise.
4. Dr. Satish Kumar Sain, Assistant Director (PHM), Pathology Expertise.
5. Dr. M. Narsi Reddy, Assistant Scientific Officer (PHM), Entomology Expertise.

Other Members :

1. Dr. N. Srinivasa Rao, Assistant Director (RPM), Rodent Pest Management Expertise.
2. Dr. B.S. Sunanda, Assistant Scientific Officer (PHM), Nematology Expertise.

Contributions by DPPQ&S Experts:

1. Shri. Ram Asre, Additional Plant Protection Advisor (IPM),
2. Dr. K.S. Kapoor, Deputy Director (Entomology),
3. Dr. Sanjay Arya, Deputy Director (Plant Pathology),
4. Dr. Subhash Kumar, Deputy Director (Weed Science)
5. Dr. C.S. Patni, Plant Protection Officer (Plant Pathology)

Contributions by External Experts:

1. Dr. S. Gangopadhyay, Head, Department of Plant Pathology & Dean, PGS, S.K. Rajasthan Agricultural University, Bikaner-334006, Rajasthan.
2. Dr. Raghavendra Mesta, Professor & Head, Department of Plant Pathology, University of Horticultural Sciences, Sector No 60, Navanaga, Bagalkot – 587102, Karnataka.
3. Dr. Venkateshalu, Professor & Head, Department of Entomology, University of Horticultural Sciences, Sector No 60, Navanaga, Bagalkot – 587102, Karnataka.
4. Dr. Suresh D. Ekabote, Associate Professor, COH, Hiriyur.
5. Dr. K. Rajashekarappa, Assistant Professor, COH, Hiriyur.

Citation Satyagopal, K., S.N. Sushil, P. Jeyakumar, G. Shankar, O.P. Sharma, D.R. Boina, S.K. Sain, M.N. Reddy, N.S. Rao, B.S. Sunanda**,** Ram Asre, K.S. Kapoor, Sanjay Arya, Subhash Kumar, C.S. Patni, S. Gangopadhyay, R. Mesta, Venkateshalu, S.D. Ekabote, K. Rajashekarappa, 2014. AESA based IPM package for Coconut. pp 38.

Front cover picture Model AESA chart for Coconut

Back cover picture Coconut plantation

Published by National Institute of Plant Health Management, Rajendranagar, Hyderabad – 500 030

Copies: 1,000; September, 2014.

For internal circulation only. Not for sale.

Contact APPA - IPM, Directorate of Plant Protection, Quarantine & Storage, CGO Complex, NH IV, Faridabad, Haryana - 121 001.
Tel : 0129 2413020, e-mail: ppa@nic.in

Printed at Balaji Scan Pvt. Ltd., A.C. Guards, Hyderabad.
Tel : 040-23303424, balajiscan.com; bsplpress@gmail.com

अपर सचिव
भारत सरकार
कृषि मंत्रालय
(कृषि एंव सहकारिता विभाग)
कृषि भवन, नई दिल्ली - 110001

सत्यमेव जयते

Avinash K Srivastava
Additional Secretary
Government of India
Ministry of Agriculture
(Department of Agriculture & Cooperation)
Krishi Bhawan, New Delhi - 110 001

FOREWORD

Intensive agricultural practices relying heavily on chemical pesticides are a major cause of wide spread ecological imbalances resulting in serious problems of insecticide resistance, pest resurgence and pesticide residues. There is a growing awareness world over on the need for promoting environmentally sustainable agriculture practices.

Integrated Pest Management (IPM) is a globally accepted strategy for promoting sustainable agriculture. During last century, IPM relied substantially on economic threshold level and chemical pesticides driven approaches. However, since the late 1990s there is conscious shift to more ecologically sustainable Agro-Eco System Analysis (AESA) based IPM strategies. The AESA based IPM focuses on the relationship among various components of an agro-ecosystem with special focus on pest-defender dynamics, innate abilities of plant to compensate for the damages caused by the pests and the influence of abiotic factors on pest buildup. In addition, Ecological Engineering for pest management - a new paradigm to enhance the natural enemies of pests in an agro-ecosystem is being considered as an important strategy. The ecological approach stresses the need for relying on bio intensive strategies prior to use of chemical pesticides.

Sincere efforts have been made by resource personnel to incorporate ecologically based principles and field proven technologies for guidance of the extension officers to educate, motivate and guide the farmers to adopt AESA based IPM strategies, which are environmentally sustainable. I hope that the AESA based IPM packages will be relied upon by various stakeholders relating to Central and State government functionaries involved in extension and Scientists of SAUs and ICAR institutions in their endeavour to promote environmentally sustainable agriculture practices.

Date : 6.3.2014

(Avinash K. Srivastava)

संयुक्त सचित
भारत सरकार
कृषि मंत्रालय
(कृषि एवं सहकारिता विभाग)
कृषि भवन, नई दिल्ली - 110001

Joint Secretary
Government of India
Ministry of Agriculture
(Department of Agriculture & Cooperation)
Krishi Bhawan, New Delhi - 110001

FOREWORD

IPM as a holistic approach of crop protection based on the integration of multiple strategies viz., cultural, physical, mechanical, biological, botanical 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, through 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 sine show 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)

National Institute of Plant Health Management
Department of Agriculture & Cooperation
Ministry of Agriculture
Government of India

Dr. K. SATYAGOPAL, IAS
Director General
Telephone : +91-40-24015346,
E-mail : dgniphm@nic.in
Tele-Fax : +91-40-24015346

Rajendranagar
Hyderabad-500030
http://niphm.gov.in

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 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, through 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)

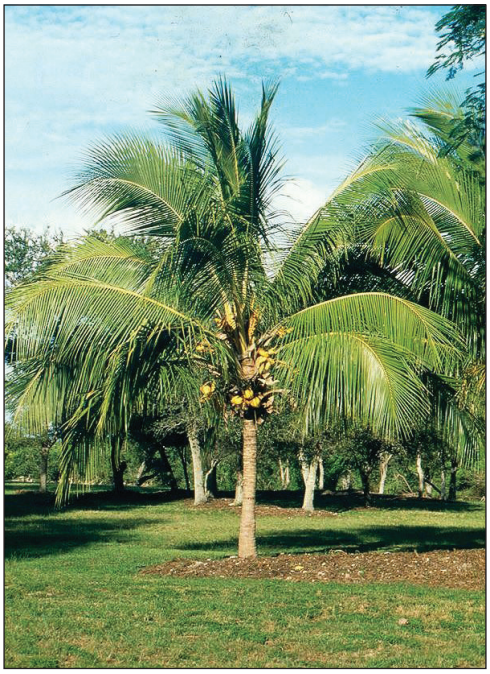
CONTENTS

AESA BASED IPM PACKAGE FOR COCONUT

Coconut plant description:

The coconut tree (*Cocos nucifera* L.; Family: Arecaceae) is a tropical plant from the palm family grown primarily for its fruit, coconuts. The tree is native to the South Pacific region and is widely cultivated in all the tropical regions of the world, growing particularly well in coastal areas. The fruit of the tree is the most utilized nut in the world and the tree itself is the most important member of the palm family. Coconut trees have distinct growth traits. The single-trunked tree has a mature height of 80 to 100 feet. The dwarf-sized varieties tend to grow much shorter. The straight, columnar trunk is light gray in color and often develops a swollen base with maturity. Certain cultivars have curved or slightly leaning trunks. The trunk diameter generally remains a consistent 10 to 13 inches from the base to the top. Foliage grows on top of the trunk. The yellowish-green leaves are 8 to 18 feet long with a width of 3 to 5 feet. The tree sheds and produces 10 to 15 leaves every year. The feathery-textured foliage is pinnate and grows on 3- to 5-foot long, spineless stalks. At the age of 4 to 6 years, coconut trees start to produce flowers in the form of canoe-like inflorescences. Inflorescences are 2 to 3 feet in length. The light yellow, smaller male flowers grow at the ends of the branchlets while the larger female flowers grow at the base.

The ovoid fruit is about 15 inches long and 12 inches wide. A thick, fibrous husk covers the fruit or the nut within. The nut, which is 10 to 12 inches long, has a diameter of 6 to 8 inches with distinct sunken holes, referred to as eyes, at one end. Immature nuts have white, gelatinous flesh that gradually matures to a 1-inch thick meat called copra. The inner nut contains a watery liquid called coconut milk. Younger fruit has more milk that gradually dries to create the meat in mature nuts. The coconut tree starts to bear fruit within six to 10 years of seed germination. The full production age is achieved at 15 to 20 years. A healthy coconut tree continues to produce a full harvest until the age of 80 years, with a count of 50 to 200 fruits per tree over the course of a lifetime. Fruit count is affected by cultivar and climatic conditions. It takes about a year for the fruit to reach maturity on tree. Coconut palms continue to flower and fruit throughout the year.



I. PESTS

A. Pests of National Significance

1. Insect and mite pests
   - 1.1 Rhinoceros beetle: *Oryctes rhinoceros* Guest (Coleoptera: Scarabaeidae)
   - 1.2 Red palm weevil: *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculionidae)
   - 1.3 Black headed caterpillar: *Opisina arenosella* Walker (Lepidoptera: Xylorictidae)
   - 1.4 Eriophyid mite: *Aceria guerreronis* Keifer (Acarina: Eriophyidae)
   - 1.5 Termite: *Odontotermes* sp (Isoptera: Termitidae)

2. Diseases
   - 2.1 Bud rot: *Phytophthora palmivora* Butler
   - 2.2 Stem bleeding: *Thielaviopsis paradoxa* De Seynes
   - 2.3 Leaf rot: *Exserohilum rostratum* & *Colletotrichum gleosporioides* Drechsler
   - 2.4 Cadang cadang disease: *Coconut cadang-cadang viroid* (CCCVd)

3. Weeds

   Broadleaf
   - 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 Coatbuttons: *Tridax procumbens* L. (Fabaceae)
   - 3.6 Pigweed: *Amaranthus viridis* Hook. F. (Amaranthaceae)
   - 3.7 Common purselane: *Portulaca oleracea* L. (Portualacaceae)
   - 3.8 Field bindweed: *Convolvulus arvensis* L. (Convolvulaceae)

   Grasses
   - 3.9 Cogon grass: *Imperata cylindrica* (L.) Raeusch. (Poaceae)
   - 3.10 Goose grass: *Eleusine indica* (L.) Gaertner. (Poaceae)
   - 3.11 Burmuda grass: *Cynodon dactylon* (Poaceae)

   Sedges
   - 3.12 Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)
   - 3.13 Flat sedge: *Cyperus iria* L. (Cyperaceae)

4. Nematodes
   - 4.1 Burrowing nematode: *Radopholus similis*

5. Rodents
   - 5.1 Palm civet: *Vivera zibatha* (Carnivora: Viverridae)
   - 5.2 Black rat: *Rattus rattus* Linnaeus (Rodentia: Muridae)
   - 5.3 Indian gerbil: *Tatera indica* Hardwicke (Rodentia: Muridae) (nursery/seedling)
   - 5.4 The lesser bandicoot or Indian mole-rat: *Bandicota bengalensis* Hardwicke (Rodentia: Muridae)

B. Pests of Regional Significance

1. Insect pests
   - 1.1 Cock chafer beetle: *Leucopholis coneophora* Burm (Coleoptera: Scarabaeidae)
   - 1.2 Coreid bug: *Paradasynus rostratus* (Hemiptera: Heteroptera)

2. Diseases
   - 2.1 Tanjavur wilt: *Ganoderma lucidum* Lingzhi or Reishi
   - 2.2 Root wilt: *Phytoplasma* sp
   - 2.2 Papery leaf blight: *Pestalotia palmarum* Cooke

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

A. AESA:

The IPM has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment ultimately affecting the interests of the farmers. 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 orchid 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 orchid 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 orchard 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
- Select healthy seeds/seedlings/planting material
- Treat the seeds/seedlings/planting material with recommended pesticides especially biopesticides
- Follow proper spacing
- Soil health improvement (mulching and green manuring wherever applicable)
- Nutrient management especially organic manures and biofertilizers based on the soil test results. If the dosage of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dosage is too low, the crop growth is retarded. So, the farmers should apply an adequate amount for best results. The phosphatic fertilizers should not be applied each and every season as the residual phosphate of the previous season will be available for the current season also.
- Proper irrigation

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

Farmers should:

- Monitor the field situations of the plantation at least once a week (soil, water, plants, pests, natural enemies, weather factors etc.)
- Make decisions based on the plantation situation and pest: defender ratio (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 and 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) during active vegetative growth period. Plant tolerance to herbivory can arise from the interaction of a variety of plant traits and external environmental factors.

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:

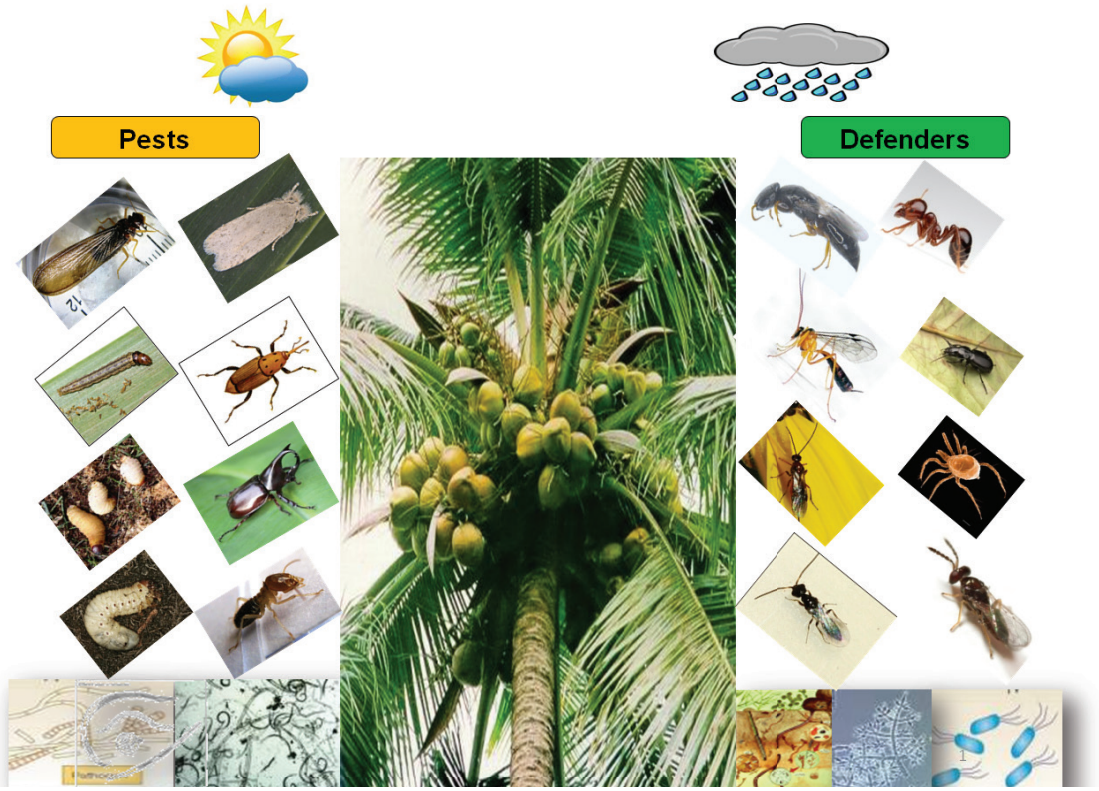
In orchards various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in plantation. Insect zoo concept can be helpful to enhance farmers' skill to identify 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 coconut insect 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 field situations

Soil conditions	**:**
Weather conditions	**:**
Diseases types and severity	**:**
Weeds types and intensity	**:**
Rodent damage (if any)	**:**
No. of insect pests & damage severity	**:**
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 and biochemical biopesticides such as insect growth regulators, botanicals 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 field 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 field in groups (about 5 farmers per group). Walk across the field and choose 20 plants/acre randomly. Observe keenly each of these plants and record your observations:
    - Plant: Observe the plant height, number of leaves, plant stage, deficiency symptoms, number of nuts etc.
    - Insect pests: Observe and count insect 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 field and their intensity.
    - Water: Observe the water situation of the field.
    - Weather: Observe the weather condition.
- While walking in the field, 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 field situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field 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 field 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:

- Keeping records of what has happened help us making an analysis and draw conclusions

Data to be recorded:

- **Plant growth (weekly):** Height of plant; number of leaves
- **Crop situation (e.g. for AESA):** Plant health; pests, diseases, weeds; natural enemies; soil conditions; 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.
- 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 field 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 are the 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.

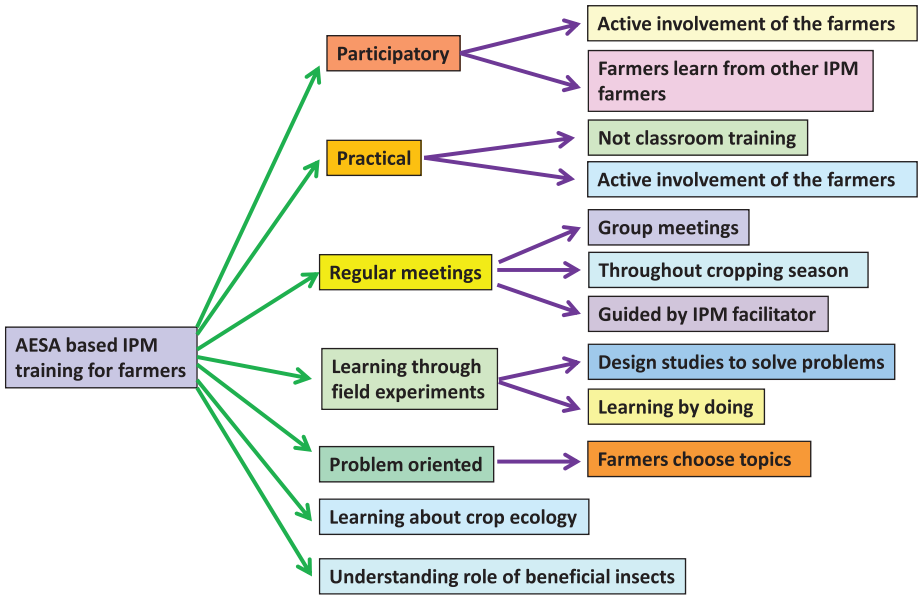
AESA and farmer field school (FFS):

AESA is a season-long training activity that takes place in the farmer field. 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
- Decision making process.

FFS to teach AESA based IPM skills:



B. Plantation scouting:

AESA requires skill. So only the trained farmers can undertake this exercise. However, other farmers also can do plantation scouting in their own plantation at regular intervals to monitor the situation of major pests.

Surveillance on pest occurrence at the main plantation should commence soon after plant establishment and at weekly intervals thereafter. In each plantation, select five spots randomly. Select five random plants at each spot for recording counts of insects as per procedure finalized for individual insects.

1. Rapid roving survey (RRS):

In the beginning of crop season, survey routes are required to be identified in the pest and disease endemic areas to undertake the rapid roving survey (RRS). During survey the observations are to be made at every 5 - 10 Km distance in the pre-selected route at 10-15 days intervals depending upon pest and diseases situation. Record the Incidence of pest, diseases and defenders population at each spot in 5 plants at random 12 spots per ha.

2. Plantation scouting:

Based on the observation of RRS the farmers at village level are to be mobilized to undertake plantation scouting. During plantation scouting farmers may record insect pest, disease and defenders populations once in 10-15 days in their own fields as per AESA approach. The State Department of Agriculture should make all effort by using different media, mode and publicity to inform the farmers the need for the plantation scouting in the specific crop areas having indication of pest or disease build up.

For diseases:

Whenever scouting, be aware that symptoms of plant disease problems may be caused by any biotic factors such as fungal, bacterial, viral pathogens or abiotic factors such as weather, fertilizers, nutrient deficiencies, pesticides and abiotic soil problems. In many cases, the cause of the symptom is not obvious. Close examination, and laboratory culture and analysis are required for proper diagnosis of the causal agent of disease. 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, bacterial ooze etc. Specific and characteristic symptoms of the important plant diseases are given in description of diseases section.

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). It is often necessary to wash the roots with water to examine them properly. If the roots are well developed, cut them to examine the roots for internal infections (discolouration & signs). Count the total number of roots damaged/infested/infected due to rot should be counted and incidence should be recorded.

Leaf sampling: Examine all leaves of each plant for lesions. 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. Determine the percent area of leaf infection by counting the number of leaves (leaf area diameter)/plant infected due to disease and incidence should be recorded.

Stem, flower and nut sampling: Carefully examine the stem, flower, and nut of plants for symptoms and signs of fungal or bacterial diseases. The stem, flower, and nut should be split or taken apart and examined for discoloration caused by fungi and bacteria. Count the number of stems, flowers and nuts infected due to disease and percent disease incidence should be recorded.

C. Surveillance through pheromone trap catches for *Oryctes, Rynchophorus* and *Opisina*:

Pheromone (aggregation) traps for *Oryctes*, *Rhynchophorus* @ 1/100 ha have to be installed. Fix the traps for each species at a height of 0.6 to 1 m above the ground attached to the plant. Pheromone traps for *Opisina* @ 4-5/acre have to be installed, if available. Install the traps separated by a distance of >75 feet in the vicinity of the field. Fix the traps to the supporting pole at mid height of the plant. Change of lures should be made at 2-3 week interval (regular interval). During each week of surveillance, the number of moths or beetles/trap should be counted and recorded year round. The trapped beetles and moths should be removed and destroyed after each recording.

D. Light traps:

Set up light traps 1 trap/acre at mid height of the plant for monitoring and mass trapping of insects. 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).

E. Nematode extraction:

Collect 100 to 300 cm^3 (200-300 g) representative soil sample. Mix soil sample and pass through a coarse sieve to remove rocks, roots, etc. Take a 600 cc subsample of soil, pack lightly into a beaker uniformly. Place soil in one of the buckets or pans half filled with water. Mix soil and water by stirring with paddle; allow to stand until water almost stops swirling. Pour all but heavy sediment through 20-mesh sieve into second bucket; discard residue in first bucket; discard material caught on sieve. Stir material in second bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 60 mesh sieve to collect cysts into first bucket; discard residue in second bucket. Stir material in first bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 325-mesh sieve into second bucket; discard residue in first bucket. Backwash material caught on 325-mesh sieve (which includes small to mid-sized nematodes and silty material) into 250-ml beaker. More than 90% of the live nematodes are recovered in the first 5-8 mm of water drawn from the rubber tubing and the sample is placed in a shallow dish for examination.

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. The cultural practices are informed by ecological knowledge rather than on high technology approaches such as synthetic pesticides and genetically engineered crops (Gurr et al. 2004 a, b).

Natural enemies may require:

1. Food in the form of pollen and nectar for adult natural enemies.
2. Shelter such as overwintering sites, moderate microclimates etc.
3. Alternate hosts when primary hosts are not present.

Ecological engineering for pest management – Above ground:

- 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* sp, *Alternanthera* sp 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.

Ecological engineering for pest management – Below ground:

- Keep soils covered year-round with living vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermincompost, crop residue which enhance below ground biodiversity.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Apply balanced dose of nutrients using biofertilizers.
- Apply mycorrhiza and plant growth promoting rhizobacteria (PGPR)
- Apply *Trichoderma viride/harzianum* and *Pseudomonas fluorescens*as seed/seedling/planting material, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

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

Ecological Engineering Plants

Attractant plants


Carrot


Marigold


Anise


Sunflower


Buckwheat


French bean


Alfalfa


Mustard


Parsley


Caraway


Coreopsis spp.


Dill

Repellent plants


Ocimum spp.


Peppermint

Intercrop


Sun hemp

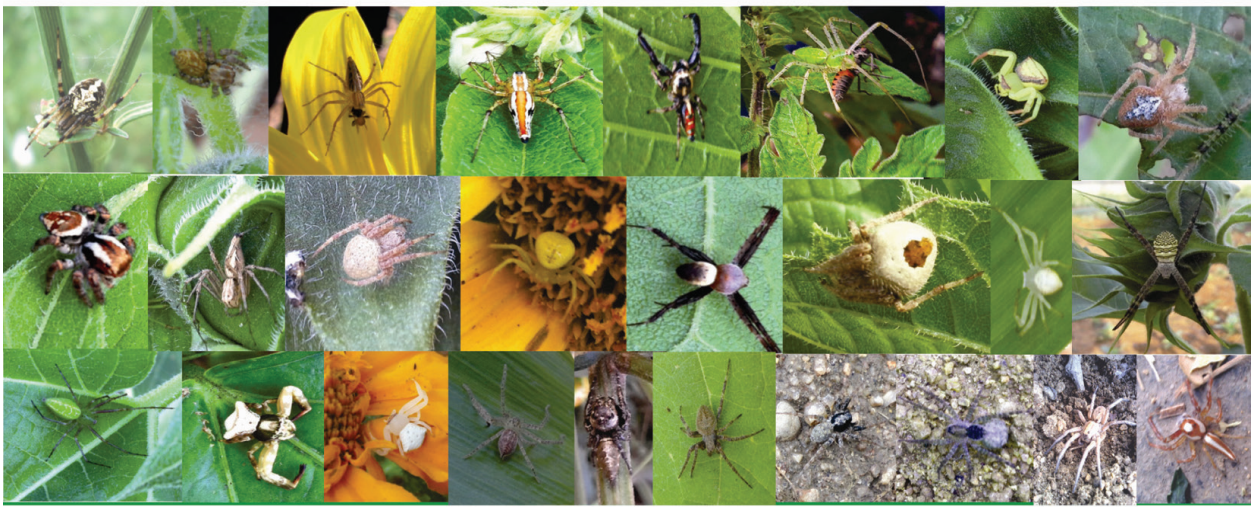
The flowering plants suggested under Ecological Engineering for pest management strategy are known as attractant plants to the natural enemies of the selected pests. The information is based on published research literature. However, the actual selection of flowering plants could be based on availability,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



A. Resistant/tolerant varieties:

Pest/disease	Tolerant/resistant variety*
Resistance to root (wilt) disease	Kalpa Raksha
Root (wilt) disease	Kalpa Sree
Root (wilt) disease	Kalpa Sankara (CGD x WCT)
Eriophyid mite	Kalpa Haritha

***For detailed and updated information nearest KVK, State Department, SAU / ICAR Institute may be contacted**

IV. CROP STAGE-WISE IPM

Management	Activity
Nursery stage	
	Common cultural practices: • Select good mother palm for obtaing seedlings i.e. it must be of 20 years of age, yield more than 80 nuts/annum. • Provide proper shade, irrigation & drainage. • Rogue out diseased seedling. • Employ locally made rat traps. • Use resistant/tolerant varieties. • Sow the ecological engineering plants. • Removal and destruction of alternate host weeds.
Weed	• Hand weeding and timely mulching.
Nematodes	**Cultural control:** • Use of less susceptible, tolerant cultivars or hybrids of coconut and intercrops in infested areas. • Avoid use of banana as a shade crop in coconut nurseries. **Biological control:** • Application of cow dung, FYM, oil cakes and green manure to the basins. • *Crotolaria juncea* may be cultivated in the basin and interspaces and used as green manure. • Incorporate leaves and tender stem of *Crotolaria juncea, Pueraria javanica* and *Glyricidia maculata* into the soil in Sep-Oct.
Pre-planting stage	
	Cultural control: • Prepare proper pits. • Timely planting should be done. • Maintain proper spacing. • Fill the pit with FYM, red earth and sand mixture.

Management	Activity
Weeds	**Cultural control:** • Prepare beds of 1-1.5 m width and of convenient length with 75 cm space between beds. • In areas where drainage is poor, prepare raised beds (10-20 cm height) • Select good mother palm i.e. must be of 20 years of age, yield more than 80 nuts/annum, etc.
Soil borne pathogens, wilt, nematodes and resting stages of insect pests	**Cultural control:** • Deep ploughing of fields during summer. • Early sowing of the crop prevents it from nematode infestation • Liming the soil to pH 6.0-7.0, as well as reducing nitrogen levels in the soil, significantly reduces wilt.
Growth stage	
	Common cultural practices: • Provide timely irrigation, organic manure, fertilizer as per the recommended dose, drainage, weeding, mulching, interculture etc. **Common mechanical practices:** • Set up light traps following the first rains in summer and monsoon period to attract and kill the adult beetles. • Cut and burn disease affected portions of palms, buttons, wilted palms and dead palms. **Common biological practices:** • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies
Nutrients	• For coconut mite affected plants with 50 Kg FYM, 0.52 Kg N /acre, 2 Kg SSP/ 3.5 Kg MOP, 1 Kg gypsum & 50 g of Borax
Rhinoceros beetle and cock chafer beetle**	**Cultural control:** • Collect and destroy the various life stages of the beetle from the manure pits (breeding ground of the pest) whenever manure is lifted from the pits. **Mechanical control:** • During peak period of population build up, the adult beetle may be extracted from the palm crown using GI hooks. • Install aggregation pheromone traps away from the main plantation. • Set up pheromone trap for rhinoceros beetle @ 1 trap/100 ha by fixing it to the plant at 0.6 to 1 m height to trap and kill the beetles. **Biological control:** • Release of *Baculovirus oryctes* inoculated adult rhinoceros beetle @ 6 beetles/acre reduces the leaf and crown damage caused by this beetle. • Soak castor cake at 1 Kg in 5 l of water in small mud pots and keep them in the coconut gardens to attract and kill the adults. • Apply mixture of either neem seed powder + sand (1: 2) @ 150 g/palm or neem seed kernel powder + sand (1: 2) @ 150 g/palm in the base of the 3 inner most leaves in the crown.

Management	Activity
Bud rot	**Cultural control:** • Adopt proper spacing and avoid over-crowding in bud rot prone gardens. **Chemical control:** • Spray copper oxy chloride 50% WP @ 1 Kg in 300-400 l of water/acre on the crown of the neighbouring palms as a prophylactic measure before the onset of monsoon.
Leaf rot	• Follow common cultural, mechanical and biological practices **Mechanical control:** • Remove the rotten portions from the spear and the two adjacent leaves.
Mature palm	
Rhinoceros beetle	• Same as in growth stage
Coconut eriophyid mite	**Cultural control:** • Grow intercrop (sun hemp, four crops/year) and shelter belt with *Casuarina* all around the coconut garden to check further entry. • Apply urea 1.3 Kg, super phosphate 2.0 Kg and muriate of potash 3.5 Kg/palm/year. • Increased quantity is recommended to increase the plant resistance to the mite. • Soil application of micro nutrients such as borax 50 g + gypsum 1.0 Kg + manganese sulphate 0.5 Kg/palm **Chemical control:** • Fenpyroximate 5%EC @ 10 ml/l (spray fluid volume as required)
Red palm weevil	**Cultural control:** • Avoid the cutting of green leaves. If needed, they should be cut about 120 cm away from the stem in order to prevent successful inward movement of the grubs through the cut end. **Mechanical control:** • Set up pheromone trap for red palm weevil @ 1 trap/100 ha by fixing it to the plant at 0.6 to 1 m height to trap and kill the beetles. • Coconut log traps: Setting up of attractant traps (mud pots) containing sugarcane molasses 2½ Kg or toddy 2½ l (or pineapple or sugarcane activated with yeast or molasses) + acetic acid 5 ml + yeast 5 g + longitudinally split tender coconut stem/ logs of green petiole of leaves of 30 numbers in one acre to trap adult red palm weevils in large numbers.
Leaf eating caterpillar / black headed caterpillar	• Follow common cultural, mechanical and biological practices. **Cultural control:** • As a prophylactic measure, the first affected leaves may be cut and burnt during the beginning of the summer season.

Management	Activity
	Chemical control • Cut sharply at an angle and insert the root in the insecticidal solution containing monocrotophos 36% WSC @ 10 ml + water 10 ml in a 7 x 10 cm polythene bag.
Coreid bug**	• Follow common cultural, mechanical and biological practices. **Mechanical control:** • Set up light traps to trap and collect adult bug.
Termites	• Follow common cultural, mechanical and biological practices. **Cultural control:** • Copious irrigation and drenching nurseries or basin of transplanted seedlings. **Mechanical control:** • Digging the termitaria and destruction of the queen is the most important in termite management. **Biological control:** • Spray neem oil 5% (50 ml/l) once on the base and up to 2 m height of the trunk for effective control. • Entomopathogenic nematodes (EPNs) can be sprayed at the rate of 100 million nematodes per acre, in termite infested fields OR • EPN infected cadavers of *Galleria/Corcyra* larvae containing live infective juveniles (IJs) are implanted in soil at plant bases at the rate of four cadavers per plant during May/ June and/or September for termite control.
Bud rot	• Follow common cultural, mechanical and biological practices. • Same as in growth stage.
Leaf rot	• Follow common cultural, mechanical and biological practices. • Same as in growth stage.
Stem bleeding	• Follow common cultural, mechanical and biological practices. **Cultural control:** • Along with 50 Kg organic manure, apply 5 Kg neem cake containing the antagonistic fungi, *Trichoderma* culture to the basin during September. • Provide adequate irrigation during summer and drainage during rainy season along with recommended fertilizer. **Mechanical control:** • Destroy the chiselled materials by burning. • Avoid any mechanical injury to trunk. **Biological control:** • Apply neem cake at the rate of 5 Kg/palm in the basin along with other organics.

Note: The pesticides dosages and spray fluid volumes are based on high volume sprayer.

** Pest of regional significans.

Nutrients management:

Regular manuring from the first year of planting is essential to achieve higher productivity. For coconut 20-50 Kg organic manure should be applied/palm/year with the onset of southwest monsoon, when soil moisture content is high. Different forms of organic manures such as compost, FYM, bone meal, fish meal, blood meal, neem cake, groundnut cake etc. could be made use for this purpose. In addition to this the following fertilizer schedule is recommended.

The fertiliser schedule recommended for the palm at different stages is as follows:

Quantity of fertilizer to be applied (g)						
Age of palm	Nutrient dosage	Nitrogen		Phosphorus		Potasium
		Ammonium sulphate	Urea	Super phosphate (single)	or Ultraphos/ rock phosphate	Muriate of potash
1. General recommendation: (a) Average management:						
3 months	1/10 of full dose	165	75	95	60	115
1 year	1/3 of full dose	550	250	320	200	380
2 year	2/3 of full dose	1100	500	640	400	760
3 year onwards	full dose	1650	750	950	600	1140
(b) Good management:						
3 months	1/10 of full dose	250	110	180	115	200
1 year	1/3 of full dose	800	360	590	380	670
2 year	2/3 of full dose	1675	720	1180	760	1340
3 year onwards	full dose	2000	1080	1780	1140	2010
2. Hybrid and high yielding palms: (a) Under irrigated condition:						
3 months	1/10 of full dose	490	220	280	180	335
1 year	1/3 of full dose	1625	720	930	600	1110
2 year	2/3 of full dose	3250	1450	1850	1200	2220
3 year onwards	full dose	4880	2170	2780	1800	3330

(b) Under rainfed condition:
Same as that of good management under general recommendation.
The full adult dose recommended for the rainfed tall is 0.34 Kg N, 0.17 Kg P and 0.68 Kg K. For the hybrids and irrigated talls the general recommendation is 0.5 Kg N, 0.34 Kg P and 1.0 Kg K subject to changes in accordance with soil test and/or foliar analysis data.

In addition to the above dose of fertilizers two to three Kg of finally ground dolomite lime stone or 0.5 Kg. Magnesium sulphate/palm/year is also recommended for use in acidic soils, light sandy soils and in root wilt affected tracts in Kerala. The dolomite may be broadcasted prior to the onset of monsoon in the basins and forked in and should not be applied along with other fertilizers. There is however no harm in applying magnesium sulphate along with other fertilizers.

http://www.coconutboard.nic.in/package1.htm#manure

V. RODENT PEST MANAGEMENT

Palm civet, Black rat, Indian gerbil, The lesser bandicoot:	
Rodents damage tender nuts by forming characteristic holes. Shed nuts can be seen at the base of the palm.	**Cultural control:** • Practice clean cultivation/maintain weed free fields 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:** • 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 fields, orchidbunds, 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 fields 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 fields, adjacent "refuge" fields, or habitat attractions within a treated orchid 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

1. Nitrogen: Nitrogen deficiency is typically caused by insufficient nitrogen in the soil. Nitrogen deficiency begins as a uniform light green discoloration / yellowing (uniform chlorosis) of the oldest leaves. Yellowing starts from tip to base of the lower leaves and will proceed up. As the deficiency progresses, younger leaves will also become discoloured. Older leaves are golden yellow colour. Growth virtually stops when N deficiency is severe and become shedding of leaves.

Correction measure: Foliar application of 2% urea thrice at fortnightly interval or soil application of 1-2 Kg urea / tree or root feeding of 1% urea 200 ml twice a year.

2. Phosphorus: Deficiency occurs in acid and alkaline soils. Purple coloration in leaves (in severe cases may leaves turn yellow before drying prematurely). Sluggish growth. Leaves stay upright. Premature leaf shedding. The growth, leaf size and leaf number reduced. The root growth is restricted if phosphorus deficiency is recorded.

Correction measure: Foliar spray of DAP 2% twice at fortnightly interval or soil application of FYM 5 Kg/tree. Root feeding of 1% DAP 2 ml twice a year.

3. Boron: Boron deficiency is caused by insufficient boron in the soil. It may be caused by soil drying and high soil pH, while temporary boron deficiency is caused by heavy leaching. Symptoms always occur on newly emerging leaves, and remain visible on these leaves as they mature and are replaced by younger leaves. One of the earliest symptoms of boron deficiency on coconut palm is leaf wrinkling and manifested as sharply bent leaflet tips, commonly called "hook leaf". These sharp leaflet hooks are quite rigid and cannot be traightened out without tearing the leaflets. Leaves have a serrated zigzag appearance. One of the most common symptoms of boron deficiency is the failure of newly emerging spear leaves to open normally. In a chronic stage, multiple unopened spear leaves may be visible at the apex of the canopy. Boron deficiency also occurs in inflorescence and nuts. The inflorescence and nuts are become necrotic.

Correction measure: Application of borax/sodium tetraborate 0.2% (2 g/l of water), (75-100 ml/seedling), borax/ sodium tetraborate/octaborate 15-20 g/plan.

4. Manganese: The newest leaves of manganese deficient palms emerge chlorotic with longitudinal necrotic streaks. As the deficiency progresses, newly emerging leaflets appear necrotic and withered on all but basal portions of the leaflets. This withering results in a curling of the leaflets about the rachis giving the leaf a frizzled appearance ('frizzle top'). On new leaves of manganese-deficient palm, necrotic leaflet tips fall off and the leaf has a signed appearance. In severely manganese deficient palms, growth stops and newly emerging leaves consist solely of necrotic petiole stubs.

Correction measure: Soil application of $MnSO_4$ @ 10 Kg/acre

5. Magnesium: Magnesium deficiency appears on the oldest leaves of palms as broad chlorotic (yellow) bands along the margins with the central portion of the leaves remaining distinctly green. In severe cases leaflet tips may become necrotic. Older leaves become bronzed and dry appearance. Leaflets show necrosis and turn to reddish brown with translucent spots yellowing starts at the tip and spreads to the base.

Correction measure: Soil application of $MgSO_4$ 1-2 Kg/tree/year. Root feeding of 200 ml of 0.2% $MgSO_4$ twice a year

6. Sulphur: Typical symptoms are yellowish-green or yellowish-orange leaflets. Older leaves are remaining green. Leaves droop as the stem becomes weak. In older palms, leaf number and size are reduced. Sometimes an apron of dead fronds develops around the stem due to weakness of the rachis. Nuts may fall prematurely. Copra is rubbery and of poor market quality.

Correction measure: Soil application of gypsum 2 - 5 kg/tree/year. Root feeding of 0.2% gypsum

7. Iron: Iron deficiency usually appears on palms growing in poorly aerated soils or those that have been planted too deeply. Water logged soils and deep planting effectively suffocate the roots and reduce their effectiveness in taking up nutrients such as iron. The main symptom of iron deficiency is chlorosis or yellowing between the veins of new leaves (uniform chlorotic new leaves as the deficiency progresses, the tips become necrotic and leaf size reduced).

Correction measure: Application of $FeSO_4$ 0.25 to 0.5 Kg/tree/year

8. Zinc: Zinc deficiency is characterized by formation of small leaves wherein the leaf size is reduced to 50%. Leaflets become chlorotic, narrow and reduced in length. In acute deficiency, flowering is delayed. Zinc deficiency will also lead to button shedding. Its occurs mostly in saline soils.

Correction measure: Soil application of $ZnSO_4$ @ 10 Kg/acre

9. Calcium: Young leaves exhibit narrow white bands at margins. Interveinal chlorosis. Rusty appearance in leaf margin. Rolling up of leaves. Occurs only in acid soil.

Correction measure: Soil application of lime based on lime requirement and root feeding of 1% calcium nitrate.

10. Copper: Coppery bluish leaf. Rolling of terminal leaves due to loss of turgor. Leaves appear to be bleached grey. Fail to produce flowers.

Correction measure: Soil application of $CuSO_4$ @ 10 Kg/acre.

VIII. COMMON WEEDS

1. Cogon grass:
Imperata cylindrica (L.)
(Poaceae)

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

3. Burmuda grass:
Cynodon dactylon
(Poaceae)

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

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

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

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

8. Coat buttons:
***Tridax procumbens* L.**
(Fabaceae)

9. Pigweed:
Amaranthus viridis
Hook. F. (Amaranthaceae)

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

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

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

IX. DESCRIPTION OF INSECT, MITE AND NEMATODE PESTS

1) Rhinoceros beetle:

Biology:

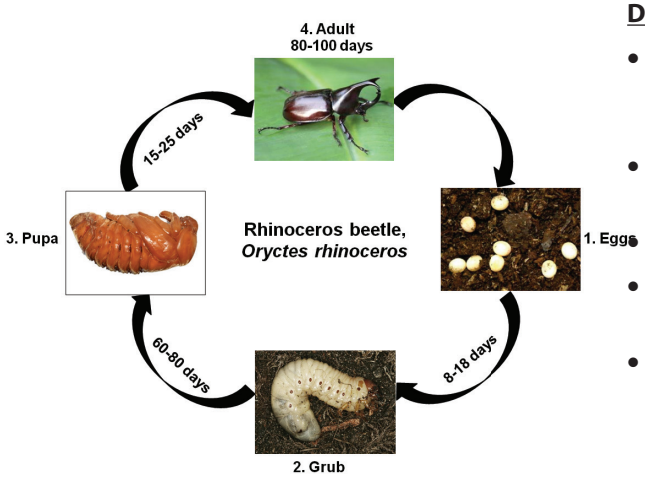
Egg: Females lays 140 - 150 oval creamy white eggs in manure pits or decaying vegetable matter at a depth of 5 to 15 cm. Egg period is 8 to 18 days.

Grub: Grub is stout, sluggish, white "C"-shaped with pale brown head and found at a depth of 5 to 30 cm.

Pupa: Grub pupates in earthen cells at a depth of 0.3 to 1 m

Adult: Adult beetle is stout, brownish black or black and has a long horn projecting dorsally from the head in male. Horn is short in female.

Life cycle:



Damage symptoms:

- The adult beetle bores into the unopened fronds and spathes. Damage by the pest leads to 10 to 15% loss in yield.
- The attacked frond when fully opened shows characteristic triangular cuts.
- Central spindle appears cut or toppled
- Fully opened fronds showing characteristic diamond shaped cuttings
- Holes with chewed fibre sticking out at the base of central spindle.

1. http://rhinotrap.weebly.com/uploads/1/3/7/4/13744050/5183236; jpg?1349635765; 2. http://www.biolib.cz/IMG/GAL/93047.jpg; 3. http://www.biolib.cz/IMG/GAL/93036.jpg; 4. http://www.moonlight123.co.uk/uploads/media/Oryctes%20rinoceros.jpg

1. Holes with chewed fibre sticking out in central spindle

2. Triangular cuts on leaves

1, 2 http://www.agritech.tnau.ac.in/expert_system/coconut/coconut/coconut_pest%20and_diseases.html

Natural enemies of rhinoceros beetle:

Predator: Reduviid bug

*For management refer to page number 14

2) Red palm weevil:

Biology:

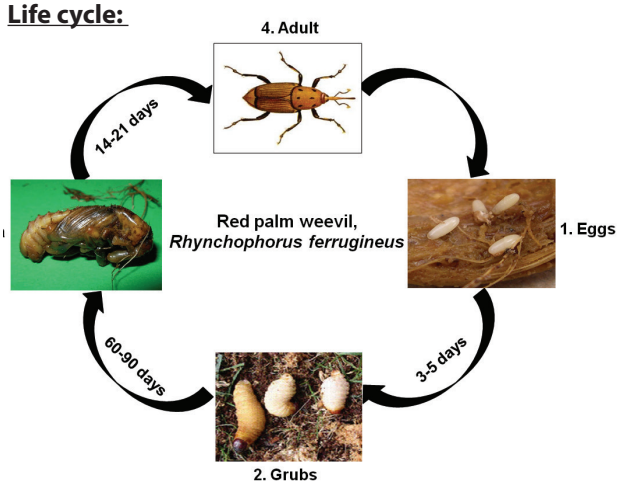
Egg: Oval and creamy white in colour. Eggs laid in scooped out small cavities, wounds and other cut injuries on the trunk

Grub: Light yellowish grub without legs. Stout, fleshy and apodous with a conical body bulged in middle and tapering towards the end

Pupa: The full frown larva pupates inside the stem and fibrous cocoon made out of fibrous strands

Adult: Reddish brown weevil has six dark spots on thorax. Male has conspicuous long snout has a tuft of hairs

Life cycle:



1.http://www1.montpellier.inra.fr/rhynchophorus/images/rhynchophorus_oeuf_peltier.jpg;2.http://www.aomidoribiocontrol.com/AoM25/images/plagas/Rhynchophorus_ferrugineus_larvae.jpg;3.http://img3.wikia.nocookie.net/_cb20120713030721/entomophagy/images/4/4f/Rhynchophorus_ferrugineus_pupa.jpg;4.http://upload.wikimedia.org/wikipedia/commons/e/e1/Rhynchophorus_ferrugineus.jpg

Damage symptoms:

Red palm weevil is one of the most destructive pests of coconut, oil palms and ornamental palms

- The hole can be seen on the stem with chewed up fibres protruding out.
- Many times reddish brown liquid can be seen oozing out from the hole.
- The grubs cause damage inside the stem or crown by feeding on soft tissues and often cause severe damage especially when a large number of them bore into the soft, growing parts. In case of severe infestation the inside portion of trunk is completely eaten and become full of rotting fibres.
- In case of young palms the top withers while in older palms the top portion of trunk bends and ultimately breaks at the bend (wilting).
- Sometimes the gnawing sound produced by the feeding grubs inside will also be audible.
- In the advanced stage of infestation yellowing of the inner whorl of leaves occur. The crowns falls down or dry up later when palm is dead.

1. Holes on the trunk

2. Chewed up fibrous matter from the hole

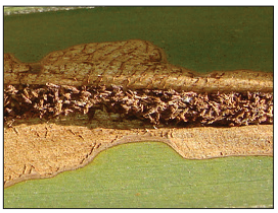
1,2.http://www.agritech.tnau.ac.in/expert_system/coconut/coconut/coconut_pest%20and_diseases.html

*For management refer to page number 15

3) Black headed caterpillar:

Biology:

Larva: Caterpillar is greenish brown with dark brown head and prothorax, and a reddish mesothorax. It has brown stripes on the body.



Pupa: It pupates inside the web itself in a thin silken cocoon

Adult: Greyish white in colour;

Female: Females are with long antenna and three faint spots on the forewings

Male: Males are with fringed hairs in hind wings in apical and anal margin.

Damage symptoms:

- The coconut trees of all ages are attacked.
- Dried up patches on leaflets of the lower leaves, only three or four youngest leaves at the center of the grown remain green.
- Galleries of silk and frass on underside of leaflets.
- In case of severe infestation the whole plantations present a scorched appearance.

Galleries of silk and frass seen on underside of leaves

Natural enemies of black headed caterpillars:

Parasitiods: *Bracon* spp., *Ichneumon* spp., *Goniozus nephantidis, Brachymeria* spp. etc.

Predators: Reduviid bug, spider, red ant, earwig, ground beetle etc.

*For management refer to page numbers 15, 16

4) Coconut eriophyid mite:

Biology:

Mites are usually found under the bracts of fertilized female flowers and do not infest the unfertilized flowers. This mite is very minute in size measuring 200 – 250 micron in length and 36 – 52 micron in width with two pairs of legs. Nymph and adult are pale in colour with elongate body and worm like appearance. The life cycle of this mite, which consists of egg, two larval instars and an adult stage, is completed in 7 -10 days.

Damage symptoms:

- The earliest symptom on 2-3 month old buttons is pale yellow triangular patches seen below the perianth.
- Later, these patches become brown. Severely affected buttons may fall. As the buttons grow, brown patches lead to black necrotic lesions with longitudinal fissures on the husk.
- Oozing of the gummy exudation from the affected surface of the nuts.
- Uneven growth results in distortion and stunting of nuts leading to reduction in copra yield. In severe cases, the nuts are malformed with cracks and hardened husk.

1. Yellow patches on leaves

2. Brown colour patches on nuts

Natural enemies of coconut eriophyid mite:

Predators: *Phytoseiid* mites, ladybug beetles, syrphid flies, minute pirate bug**,** *Oligota* spp., lacewing

*For management refer to page number 15

1,2. http://www.agritech.tnau.ac.in/expert_system/coconut/coconut/coconut_pest%20and_diseases.html

5) Termite:

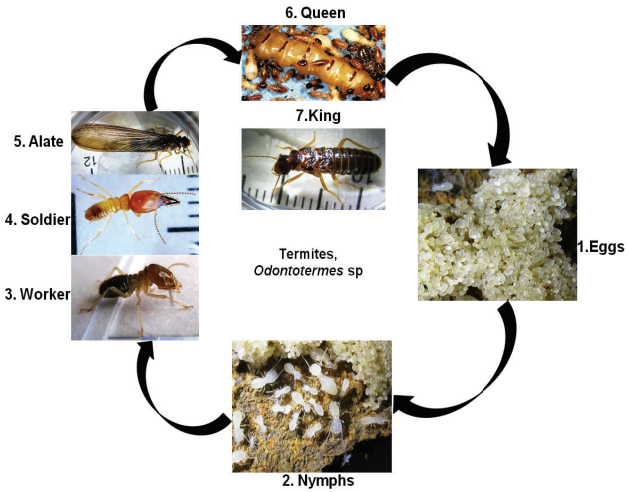
Biology:

Egg: Dull, kidney shaped and hatches in 30-90 days.

Nymph: Moult 8-9 times and are full grown in 6-12 months.

Adult: Creamy coloured tiny insects resembling ants with dark coloured head.

Life cycle:



1-7, http://www.termitenewyorkcity.com/more-about-termites/life-cycle/

Damage symptoms:

- Termites are likely to cause damage to transplanted seedlings particularly in the earlier stage (wilting of seedlings).
- Base of trunks plastered with runways made of soil and fibres.

Termite symptoms - soil runway made at the base of the trunk

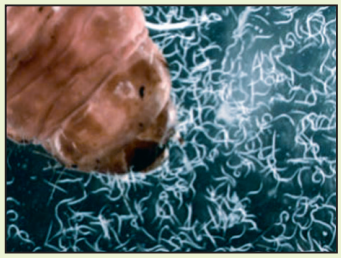
http://www.agritech.tnau.ac.in/expert_system/coconut/coconut/coconut_pest%20and_diseases.html

Biological control of termites through EPNs:

EPNs seek out and kill all stages of harmful soil-dwelling insects. They can be used to control a broad range of soil-inhabiting insects and above-ground insects in their soil-inhabiting stage of life. The IJs emerge from cadaver, search for termites, infect, kill and again multiply and remain in the moist soil. Termites which are major pests in sugarcane can be managed by using EPNs effectively. EPN can be produced even at farmer level using either *Galleria* or *Corcyra* as a host.

Mass multiplication of EPNs

Emergence of EPNs



Termite killed by EPNs

*For management refer to page number 16

6) Nematode:

Among nematodes**,** burrowing nematode (*Radopholus similis*) damages the roots of coconut. Burrowing nematode populations survive under field conditions for six months in moist soil (27 to 36°C) and one month in dry soil (29 to 39°C), whereas it survives for 15 months in moist soil (25.5 to 28.5°C) and 3 months in dry soil (27 to 31°C) under greenhouse conditions. The nematode survives in roots of stumps of felled coconut palms up to six months.

Damage symptoms:

- The nematode infested coconut palms exhibit general decline, yellowing, button shedding, and reduction in leaf size.
- The symptoms on roots are more specific.
- Elongated orange colour lesions are seen on tender and semi hard roots.
- Consequent to nematode parasitization and multiplication these lesions enlarge and coalesce to cause extensive rotting of roots.
- Tender roots on heavy infestation become spongy in texture.

*For management refer to page number 13

Natural Enemies of Coconut Insect Pests

Parasitoids

Larval parasitoids

1. Bethylid fly

2. *Bracon* spp.

3. Ichneumonid wasp

4. *Goniozus nephantidis*

5. *Typhia* spp.

Pupal parasitoids

6. Eulophid wasp

1.http://bugguide.net/node/view/266241/bgimage;2.http://nathistoc.bio.uci.edu/hymenopt/Braconid2.htm; 3. http://www.creepycrawlies.info/ichneumonid-wasps.htm;4.http://www.nbaii.res.in/Featured%20insects/goniozus_nephantidis.htm;5.https://www.google.co.in/search?q=typhia+parasitic+wasp=210&es_sm=93&tbm=isch&biw=1280&bih=699&oq=typhia+parasitic; 6. http://bugguide.net/node/view/17772

Predators

1. Phytoseiid mites

2. Ground beetle

3. Red ant

4. Reduviid bug

5. *Oligota* spp.

6. *Orius* spp.

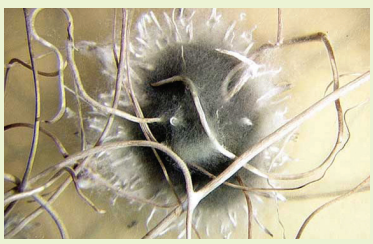
7. Hover fly

8. Mirid bug

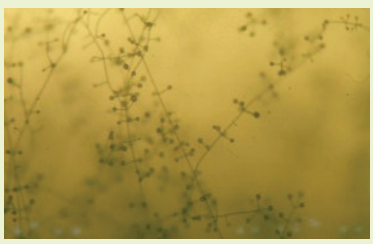
9. Lacewing

1. http://itp.lucidcentral.org/id/mites/invasive_mite/Invasive_Mite_Identification/key/0_Glossary/Mite_Glossary.htm; 2. http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/Ground%20Beetle%20-%20Pterostichus%20madidus.html; 3. http://en.wikipedia.org/wiki/Dragonfly; 5. http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33; 6. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg; 7. http://freepages.misc.rootsweb.ancestry.com/~larsonmorgan/flies/flies.html; 8. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html

Entomopathogenic fungi



1. *Hirsutella thompsonii*



2. *Verticillium lecanii*

1. http://forum.beemaster.com/index.php?topic=3319.0; 2. http://website.nbm-mnb.ca/mycologywebpages/Moulds/Verticillium.html

X. DESCRIPTION OF DISEASES

1) Bud rot:

Disease symptoms:

- Palms of all age are liable to be attacked but normally young palms are more susceptible, particularly during monsoon when the temperature is low and humidity is very high. In seedlings, the spear leaf turns pale and comes off with a gentle pull.
- The earlier symptom is the yellowing of one or two younger leaves. Black spots appear on spindle leaves. Basal tissues of the leaf rot quickly and can be easily separated from the crown. Infection spreads to the older leaves, causing sunken leaf spots covering the entire leaf blade.
- Spot margins are irregular and water soaked, and when the leaves are unfolded the characteristic irregular spots are conspicuous on the blade.
- In the later stages the spindle withers and drops down.
- The tender leaf base and soft tissues of the crown rot into a slimy mass of decayed material emitting foul smell.
- Ultimately the entire crown falls down and the palm dies.

Disease symptoms

*For management refer to page numbers 15, 16

1.http://www.agritech.tnau.ac.in/expert_system/coconut/coconut/coconut_pest%20and_diseases.html

2) Stem bleeding:

Damage symptoms:

- Stem bleeding is characterized by the exudation of a dark reddish brown liquid from the longitudinal cracks in the bark and wounds on the stem trickling down for a distance of several inches to several feet.
- The lesions spread upwards as the disease progresses.
- The liquid oozing out dries up and turns black. The tissues below the lesions become rotten and turn yellow first and later black.
- In advanced cases, the interior of affected trunks are hollow due to decay of interior tissues. As a result of extensive damage in the stem tissue, the outer whorl of the leaves turn yellow, dry and shed prematurely.
- The production of bunches is affected adversely. Nut fall is also noticed.
- The trunk gradually tapers at the apex and crown size becomes reduced in chronic cases.

Exudation of reddish-brown liquid through cracks on a coconut trunk

*For management refer to page number 16

http://www.agritech.tnau.ac.in/expert_system/coconut/coconut/coconut_pest%20and_diseases.html

3) Leaf rot:

Disease symptoms:

- The first symptom is the appearance of water-soaked brown lesions in the spear leaves of root-wilt affected palms.
- Gradually these spots enlarge and coalesce resulting in extensive rotting.
- As the leaf unfurls the rotten portions of the lamina dry and get blown off in wind, giving a 'fan' shape to the leaves.
- Sometimes, the symptom becomes very acute and the spear fails to unfurl.

1. Brown colour spots

2. Fan like appearance of leaves enlarge resulting in rotting

*For management refer to page numbers 15, 16

4) Tanjore wilt:

Disease symptoms:

- Initial symptoms of Thanjavur wilt (*Ganoderma* wilt) start with withering, yellowing and drooping of the outer whorl of leaves.
- This is followed by exudation of reddish brown liquid through cracks at the base of the trunk and oozing spread upward. The tissues on the bleeding spots are soft to touch.
- Decaying of tissues at bleeding point and rotting of the basal portion of the stem.
- The bark turns brittle and often gets peeled off in flakes, leaving open cracks and crevices. The internal tissues are discoloured and disintegrated, emitting a bad smell.
- Bracket formation at the base of the trunk. *Ganoderma* appears at the base of the trunk. Ultimately the palm dies off

Disease symptoms

1. http://www.agritech.tnau.ac.in/expert_system/coconut/coconut/coconut_pest%20and_diseases.html

* For the management refer page number 14

5) Root (wilt):

Disease symptoms:

- The root (wilt) affected coconut are susceptible to diseases such as leaf rot and pests such as rhinoceros beetle and red palm weevil.
- Chance of confusing the pests and disease symptom with the root (wilt) disease



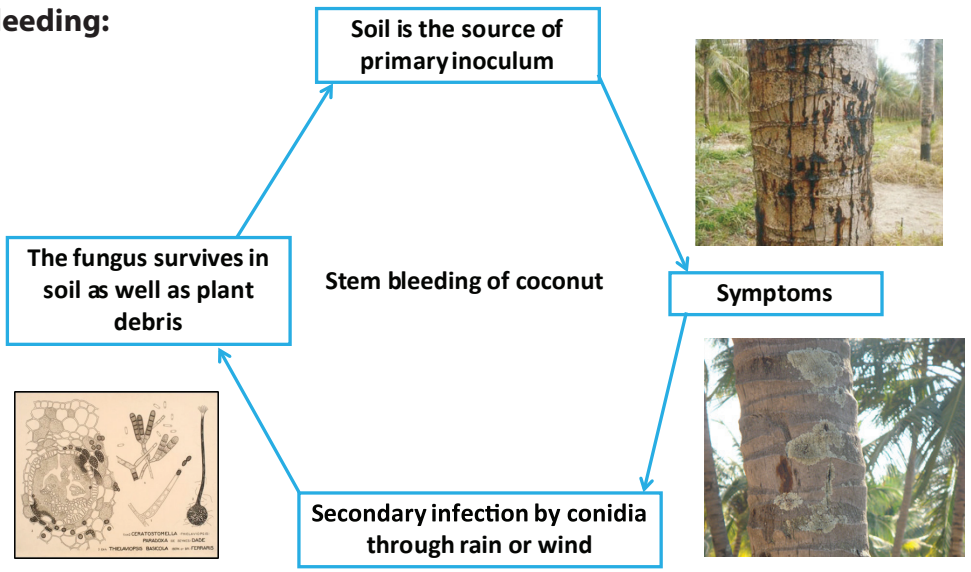
Disease symptoms

1. http://advanceagripractice.in/root-wilt-disease/

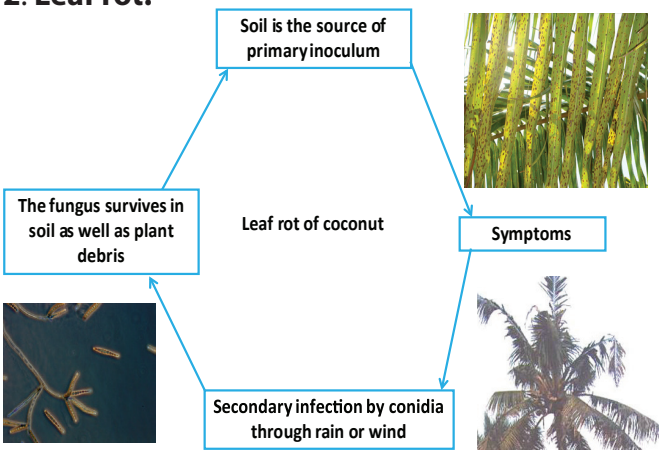
* For the management refer page number 14

Disease cycles:

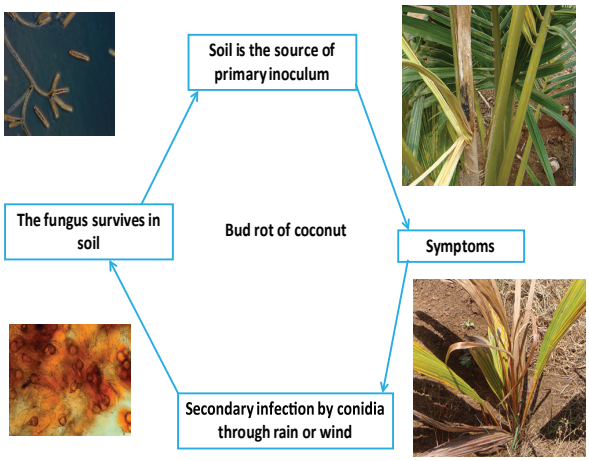
1. Stem bleeding:



2. Leaf rot:



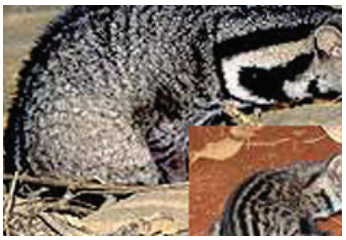
3. Bud rot:



XI. DESCRIPTION OF RODENT PESTS

1) Palm civet:

Distribution and identification: Indian civets have large bodies that are gray or brown in colour. Body length is about 34 inches with a tail length of 13 inches. They have black spots on the body as well as black and white stripes on the sides of the neck. In most cases there are two white stripes and three black stripes. The tail has a number of black rings around it. Limbs are black and the forefeet contain lobes of skin on the third and fourth digit that protect the retractile claws. Males are slightly larger than females.



1. Palm Civet

2. Symptoms of palm civet

* For the management refer page number 18

2. Rat:

Distribution and identification: A slender rat with large hairless ears, the ship rat (*Rattus rattus*) may be grey-brown on the back with either a similarly coloured or creamish-white belly, or it may be black all over. The uniformly-coloured tail is always longer than the head and body length combined. Its body weight is usually between 120 and 160 g but it can exceed 200 g. Rats damage tender nuts by forming characteristic holes. Shed nuts can be seen at the base of the palm.

Symptoms of rat damage

* For the management refer page number 18

XII. SAFETY MEASURES

A. At the time of harvest:

It usually takes 12 months for a nut to mature from pollination to harvest. Husk colour is the best indicator of coconut maturity. To attain good quality products, it is advisable that coconuts be harvested at the right maturity. Thus, only nuts that are partially or completely brown should be harvested. Nuts harvested at the tenth month or colour-break stage, should be stored or seasoned for some time to increase copra and oil yield. To obtain maximum copra and oil recovery, nuts must be harvested when fully ripe. At this age of maturity, the estimated age is from 11 to 12 months. Although this stage is ideal for copra-production, in practice, green and immature nuts (about ten months old) are sometimes included during harvest especially as harvesters are paid on a per nut basis in certain countries.

Immature nuts when converted into copra will produce rubbery copra with low oil recovery. Rubbery copra is also susceptible to insect and mould attack due to its high moisture content. Immature nuts should therefore be segregated for seasoning for about two to four weeks. Seasoning is done under a shed, preferably with a concrete or wooden floor.

http://www.fao.org/fileadmin/user_upload/inpho/docs/Post_Harvest_Compendium_Coconut.pdf

B. During post-harvest storage:

Copra to be dried to 6% moisture by sun drying or by using copra driers. The storage period of copra can be increased up to 6 months by storing the copra in polythene tar coated gunny bags. For household storage the nuts may be kept in vertical position.

De-husking: Manual dehusking with the help of an iron rod driven to the ground is strenuous and skill oriented. Presently mechanical devices are used for de-husking.

Copra processing: The optimum moisture content in copra is 5-6 percent. Sun drying, smoke drying, kiln drying and indirect hot air drying are commonly used drying methods.

(i) Sun drying: Traditional system of copra drying is by spreading the cups (split open coconut) on any open surface for sun drying. It takes about 8 days for sun drying. The deposition of dirt and dust on wet meat during sun drying results in deterioration of copra quality. Further, cloudy weather and low atmospheric temperature also reduce the quality of copra.

(ii) Solar dryer: Use of a closed type solar dryer avoids the quality deterioration of copra due to deposition of dirt. Drying time is reduced to 3-4 days. A batch type of solar cabinet dryer with a capacity of 100 nuts developed at CPCRI takes only 3 days for drying.

(iii) Indirect drying:

1. Small holder copra dryer: An indirect copra dryer of 400 nuts per batch capacity (using agricultural waste as fuel) developed at CPCRI is gaining popularity among coconut growers. The dryer requires only 3 sq m for housing and could be carried by 2-3 persons. The drying time required per batch is 36 hours spread over 4 days. Kerala Agro Industries Corporation (KAICU) is manufacturing this type of dryer.

2. Large holder copra dryer: Large size copra dryer, the capacity of 3500-4000 nuts is developed at CPCRI. The unit is suitable for large holding and copra processing societies.

3. Smoke free copra dryer for medium holding: CPCRI has developed this with a capacity of 1000 nuts per batch. This can dry coconut in 24 hours. It has got unique furnace where in the fuel used is only shell.

4. Electrical copra dryer: CPCRI has developed an electrically operated dryer with forced hot air circulation. Its capacity 1000 nuts per batch with a drying time of 28 hrs.

(iv) Ball copra: Ball copra is of superfine quality and commands a premium price in the market. It is prepared by storing fully mature nuts for 10-12 months, when kernal will get detached from the shell. CPCRI has developed dryer to prepare ball copra in shorter time by giving different heat treatments.

(v) Copra grading: The copra is graded in the order of its market value. The grading is mainly based on moisture content, foreign matter and black copra. The maximum limits for them are 10 per cent, 2 per cent and 5 per cent respectively. However, the good quality copra should have the following requirements:

http://www.agritech.tnau.ac.in/expert_system/coconut/coconut/coconut_harvest_postharvest.html

XIII. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Select the good mother palm i.e. must be of 20 years of age yield more than 80 nuts/annum, has 30 to40 fully opened leaves in the crown carries at least 12 bunches of nuts, has nut weighted not less than 600 g/nut.	Don't collect seed nuts from palms with long, thin and pendulous inflorescence stalk, which provide long, narrow, small sized or barren fruits, which shed immature nuts in large numbers which are alternate bearers,
2.	Collect mature nuts (11 to 12 month old) from selected mother palm between Feb. and May.	Don't collect immature nuts as a seed nut.
3.	Store the seed nuts with the stalk end up over a layer of sand in a shed or pit. Up to 5 layers of nuts can be arranged one over the other for a period of 60 days or till the husk is well dried before sowing.	Avoid overcrowding in storage
4.	Prepare seed bed of 1.3 m width and of convenient length.	Don't prepare too wider seed bed
5.	Sow the seed nut during the May June with the commencement of mansoon.	Avoid planting before Sept. in low lying area.
6.	Sow the seed nut vertically with stalk end-up with spacing of 30 cm.	Avoid horizontal sowing and too close/wide planting.
7.	Provide adequate shade to the nursery during summer months.	Avoid raising nursery in open area
8.	Remove seed nut that have not germinated within 5 months.	Avoid un-germinated seed nut of the seed bed.
8.	Do weeding, irrigation timely	Avoid untimely excess or low irrigation.
9.	Transplant 9-12 months old seedling in main orchid during April if irrigation facility earliest otherwise during May following the receipt of pre-monsoon showers maintaining proper spacing.	Don't transplant seedlings below 9 months and after12 months old
10.	Irrigate @ 45 l of water/seedling once in four days during summer months and 200 l of water once in 4 days for adult palms. Through drip irrigation apply 30-35 l of water/palm/day.	Irrigation should not be excessive
11.	Remove soil accumulating at the collar region of the seedlings during rain.	Avoid soils accumulating at the collar region of the seedling
12.	Keep the pits weed free.	Avoid weeds in the pits
13.	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
14.	Use micronutrient mixture after sowing based on test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
15.	Conduct weekly AESA 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
16.	Take out and kill rhinoceros beetle from the attacked palm using a beetle hook.	Dead rats located after anticoagulant application should be buried in soil
17.	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per orchard observation	Do not apply chemical pesticides within seven days of release of parasitoids.
18.	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
19.	Follow the recommended procedure of trap crop technology.	Do not apply long persistent pesticides on trap crop; otherwise it may not attract the pests and natural enemies.

XIV. SAFETY PARAMETERS IN PESTICIDE USAGE

Sl. No.	Pesticide Classification as per insecticide rules 1971 Colour of Toxicity triangle	WHO classification of hazard	Symptoms of poisoning	First aid measures; Treatment of poisoning
Organophosphate insecticides				
1	Monocrotophos Extremely toxic 	Class I a-Extremely hazardous	Mild- anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity	**First aid measures:** Remove the person from the contaminated environment. In case of (a) Skin contact - Remove all contaminated clothings and immediately wash with lot of water and soap (b) Eye contamination - Wash the eyes with plenty of cool and clean water; (c) Inhalation - Carry the person to the open fresh air, loosen the clothings around neck and chest, and (d) Ingestion - If the Victim is fully conscious, induce vomiting by tickling back of the throat. Do not administer milk, alcohol and fatty substances. In case the person is unconscious make sure the breathing passage is kept clear without any obstruction. Victim's head should be little lowered and face should be turned to one side in the lying down position. In case of breathing difficulty, give mouth to mouth or mouth to nose breathing. Medical aid: Take the patient to the doctor / Primary Health Centre immediately along with the original container, leaflet and label. **Treatment of poisoning:** For extreme symptoms of O.P poisoning, injection of atropine (2·4 mg., for adults, 0..5·1.0 mg for children) is recommended, repeated at 5·10 minute intervals until signs atropinization occur.
Fungicides				
2	Copper oxychloride Moderately toxic 	Class III - Slightly hazardous		

XV. BASIC PRECAUTIONS IN PESTICIDE USAGE

A. Purchase

1. Purchase only just required quantity e.g. 100, 250, 500, 1000 g/ml for single application in specified area.
2. Do not purchase leaking containers, loose, unsealed or torn bags; Do not purchase pesticides without proper/approved labels.
3. While purchasing insist for invoice/bill/cash memo

B. Storage

1. Avoid storage of pesticides in house premises.
2. Keep only in original container with intact seal.
3. Do not transfer pesticides to other containers; Do not store expose to sunlight or rain water; Do not weedicides along with other pesticides
4. Never keep them together with food or feed/fodder.
5. Keep away from reach of children and livestock.

C. Handling

1. Never carry/ transport pesticides along with food materials.
2. Avoid carrying bulk pesticides (dust/granules) on head shoulders or on the back.

D. Precautions for preparing spray solution

1. Use clean water.
2. Always protect your nose, eyes, mouth, ears and hands.
3. Use hand gloves, face mask and cover your head with cap.
4. Use polythene bags as hand gloves, handkerchiefs or piece of clean cloth as mask and a cap or towel to cover the head (Do not use polythene bag contaminated with pesticides).
5. Read the label on the container before preparing spray solution.
6. Prepare the spray solution as per requirement
7. Do not mix granules with water; Do not eat, drink, smoke or chew while preparing solution
8. Concentrated pesticides must not fall on hands etc while opening sealed container. Do not smell pesticides.
9. Avoid spilling of pesticides while filling the sprayer tank.
10. The operator should protect his bare feet and hands with polythene bags

E. Equipments

1. Select right kind of equipment.
2. Do not use leaky and defective equipments
3. Select right kind of nozzles
4. Don't blow/clean clogged nozzle with mouth. Use old tooth brush tied with the sprayer and clean with water.
5. Do not use same sprayer for weedicide and insecticide.

F. Precautions for applying pesticides

1. Apply only at recommended dose and dilution
2. Do not apply on hot sunny day or strong windy condition; Do not apply just before the rains and after the rains; Do not apply against the windy direction
3. Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer
4. Wash the sprayer and buckets etc with soap water after spraying
5. Containers buckets etc used for mixing pesticides should not be used for domestic purpose
6. Avoid entry of animals and workers in the field immediately after spraying
7. Avoid tank mixing of different pesticides

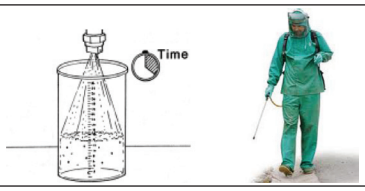
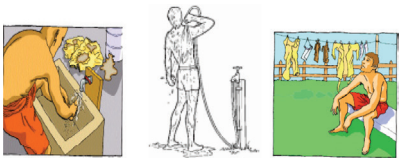
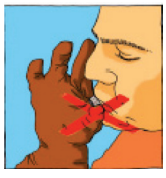
G. Disposal

1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

XVI. PESTICIDE APPLICATION TECHNIQUES

Equipment			
Category A: Stationary, crawling pest/disease			
Vegetative stage i) For crawling and soil borne pests ii) For small sucking leaf borne pests	Insecticides and fungicides	• Lever operated knapsack sprayer (droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min *or* • Motorized knapsack sprayer or mist blower (droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle	 
Reproductive stage	Insecticides and fungicides	• Lever operated knapsack sprayer (droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min	
Category B: Field flying pest/airborne pest			
Vegetative stage Reproductive stage *(Field Pests)*	Insecticides and fungicides	• Motorized knapsack sprayer or mist blower (droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle *Or* • Battery operated low volume sprayer (droplets of small size) • Spinning disc nozzle	 
Mosquito/ locust and spatial application *(migratory* Pests)	Insecticides and fungicides	• Fogging machine and ENV (exhaust nozzle vehicle) (droplets of very small size) • Hot tube nozzle	 
Category C: Weeds			
Post-emergence application	Weedicide	• Lever operated knapsack sprayer (droplets of big size) • Flat fan or floodjet nozzle @ 15 to 20 psi • Lever operating speed = 7 to 10 strokes/min	 
Pre-emergence application	Weedicide	• Trolley mounted low volume sprayer (droplets of small size) • Battery operated low volume sprayer (droplets of small size)	 

XVII. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

1.	For application rate and dosage see the label and leaflet of the particular pesticide.	
2.	It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.	
3.	Clean and wash the machines and nozzles and store in dry place after use.	
4.	It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides. Do not apply pesticides without protective clothing and wash clothes immediately after spray application.	
5.	Do not apply in hot or windy conditions.	
6.	Operator should maintain normal walking speed while undertaking application.	
7.	Do not smoke, chew or eat while undertaking the spraying operation	
8.	Operator should take proper bath with soap after completing spraying	
9.	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

XVIII. REFERENCES

- http://www.agritech.tnau.ac.in/expert_system/coconut/coconut/coconut_nutrient_management.html
- http://agritech.tnau.ac.in/agriculture/agri_nutrientmgt_coconut.html
- http://www.pca.da.gov.ph/coconutrde/images/gen7.pdf
- http://lee.ifas.ufl.edu/Hort/GardenPubsAZ/PalmNutritionFertilizers.pdf
- http://www.agritech.tnau.ac.in/expert_system/coconut/coconut/coconut_harvest_postharvest.html
- http://cpcri.gov.in/index.php?option=com_content&view=article&id=116&Itemid=142
- http://www.coconutresearchcenter.org/Good%20Practice%20for%20Coconut%20Water.pdf
- http://www.fao.org/fileadmin/user_upload/inpho/docs/Post_Harvest_Compendium_Coconut.pdf
- http://www.agritech.tnau.ac.in/expert_system/coconut/coconut/coconut_harvest_postharvest.html
- http://coconutboard.nic.in/
- http://www.coconutresearchcenter.org/
- https://cisr.ucr.edzu/pdf/rpw_icar_goa_pamphlet.pdf
- http://www.jeb.co.in/journal_issues/201405_may14/paper_05.pdf
- Gurr, GM, Wratten, SD and Altieri MA (2004a) Ecological Engineering for Pest Management Advances in Habitat Manipulation for Arthropods. CSIRO PUBLISHING, Collingwood, Australia.
- Gurr GM, Wratten SD and Altieri MA (2004b) Ecological Engineering: a new direction for pest management. AFBM Journal 1: 28-35.

Ecological Engineering Plants for Coconut

Carrot

Sunflower

***Ocimum* spp.**

***Coreopsis* spp.**

Spearmint

Mustard

Parsley

Dill

French bean

Anise

Buckwheat

Caraway

Directorate of Plant Protection
Quarantine and Storage
N. H. IV, Faridabad, Haryana

National Institute of
Plant Health Management
Rajendranagar, Hyderabad, Telangana

Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

Balaji Scan Pvt. Ltd., Tel : 040-2330 3424