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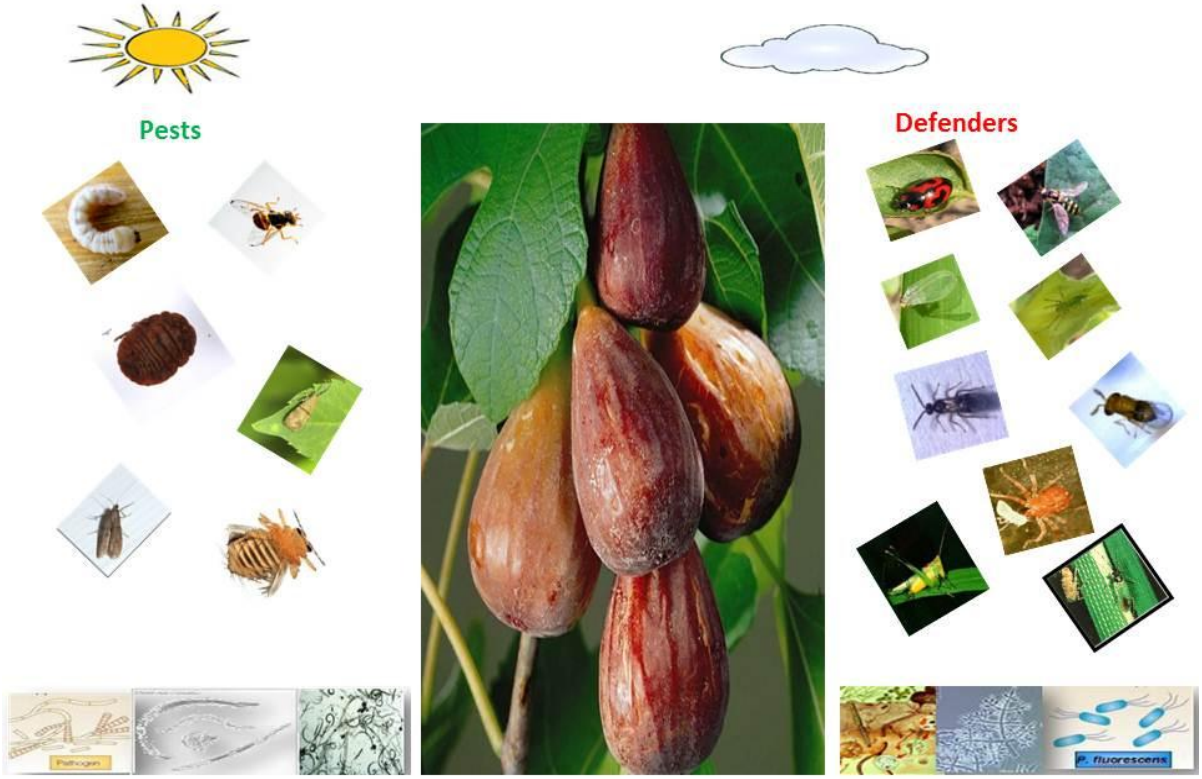
AESA BASED IPM PACKAGE
FIG



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The AESA based IPM-Fig, 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.

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FOREWORD

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

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

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

A Dalwai 25/06/2015

Dated: 25.06.2015

[Ashok Dalwai]

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FOREWORD

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

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

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

(Utpal Kumar Singh)

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PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

Contents

AESA BASED IPM PACKAGE FOR FIG

Fig - Plant description:

The common fig (*Ficus carica* L.; family: Moraceae) is native to the western Asia. It has been sought out and cultivated since ancient times, and is now widely grown throughout the temperate world, both for its fruit and as an ornamental plant. It is a gynodioecious (functionally dioecious), deciduous tree or large shrub, growing to a height of 7–10 m (23–33 ft), with smooth white bark. Its fragrant leaves are 12–25 cm (4.7–9.8 in) long and 10–18 cm (3.9–7.1 in) across, and deeply lobed with three or five lobes. The leaves are deply lobed and thick with a round surface and hairy inner surface. They have irregular teeth on the margins. The complex inflorescence consists of a hollow fleshy structure called the syconium, which is lined with numerous unisexual flowers. The common fig tree grows wild in dry and sunny areas, with deep and fresh soil; also in rocky areas, from sea level to 1,700 m. It prefers light and medium soils, requires well-drained soil, and can grow in nutritionally poor soil. Situated in a favorable habitat, old specimens when mature can reach a considerable size and form a large dense shade tree. The deep-rooted plant searches groundwater, in aquifers, ravines, or cracks in the rocks. The fig tree, with the water, cools the environment in hot places, creating a fresh and pleasant habitat for many animals that take shelter in its shade in the times of intense heat.

I. PESTS

A. Pests of National Significance

1. Insect pests

- **1.1. Stem borer: *Batocera rufomaculata* (De Geer) (Coleoptera: Cerambicidae)**
- **1.2. Fruit fly: *Bactrocera* spp. (Diptera: Tephritidae)**
- **1.3. Fig midge: *Anjeerodiplosis peshawarensis* Mani (Diptera: Cecidomyiidae)**
- **1.4. Mealybug: *Drosicha stibbingi* Green (Hemiptera: Coccidae)**
- **1.5. Coccid: *Pseudococcus lilacinus* Cokerell. (Hemiptea: Pseudococcidae)**

2. Diseases

- **2.1. Rust: *Cerotelium fici* (Castagne) Arthur**
- **2.2 Anthracnose: *Sphaceloma fici caricae* Wani & Thirum.**
- **2.3. Leaf spot: *Cylindrocladium scoparium* Morgan**

2.4 Alternaria rot (Surface mold): *Alternaria* spp., *Cladosporium herbarum* (Pers.) Link, *Ulocladium altum* (Preuss) Sacc.

2.5 Aspergillus rot: *Aspergillus* spp

2.6 Smut: *Aspergillus* spp.

2.7 Fig mosaic: Fig mosaic virus (FMV)

2.8 Leaf Blight: *Pellicularia kolerga* Cooke

2.9 Fig Rust: *Physopella fici* (Castagne) Arthur

3. Weeds

Broad leaf

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

3.2. Tick weed: *Cleome viscosa L.* (Capparaceae)

3.3 Horse Purslane: *Trainthema portulacastrum L.* (Aizoaceae)

3.4 Devil's Horsewhip: *Achyranthes aspera* L. (Amaranthaceae)

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

3.6 Creeping thistle: *Cirisium arvense* (L.)Scop (Asteraceae)

3.7 Spurge: *Euphorbia hirta* L. (Euphorbiaceae)

3.8 Spiny Amaranth: *Amaranthus spinosus* L. (Amaranthaceae)

Grasses

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

3.10 Crab grass: *Digiteria sanguinalis* (L.) Scop. (Poaceae)

3.11 Yellow foxtail: *Setaria glauca* (L.) P. Beauv. (Poaceae)

3.12 Bermuda grass: *Cynodon dactylon* (L.) Pers. (Poaceae)

3.13 Southern crab grass : *Digitaria ciliaris* (Retz.) Koeler (Poaceae)

Sedges

3.14 Purple nut sedge : *Cyperus rotundus* L. (Cyperaceae)

3.15 Umbrella sedge : *Cyperus difformis* L. (Cyperaceae)

4. Nematodes:

4.1. Root-knot nematode: *Meliodogyne* sp (Tylenchida: Meloidogynidae)

4.2. Sheath nematode: *Hemicycliophora* arenaria Raski (Tylenchida: Criconematidae)

4.3. Spiral nematodes: *Helicotylenchus multicinctus* (Cobb) Golden (Tylenchida: Hoplolaimidae)

4.4. Lance nematodes: *Hoplolaimus* sp. (Tylenchida: Hoplolaimidae)

4.5. Dagger nematode: *Xiphinema* sp. (Dorylaimida: Longidoridae)

5. Rodents

5.1. Soft furred orchard rat: *Rattus meltada* Gray (Rodentia: Muridae)

5.2. Indian mole rats/smaller bandicoot: *Bandicota bengalensis* Gray (Rodentia: Muridae)

5.3. Common house rat: *Rattus rattus* L. (Rodentia: Muridae)

B. Pest of Regional Significance:

1. Insect pests

1.1. Leaf roller: *Phycodes minor* Moore (Lepidoptera: Brachodidae)

1.2. Fig moth: *Ephestia cautella* Walker (Lepidoptera: Pyralidae)

1.3. Thrips: *Scirtothrips tabaci* (Thysanoptera: Thripidae)

1.4. Fig jassids: *Velucariae* sp

1.5. Scale: *Parlatoria oleae* Colvee (Hemiptera: Diaspididae)

1.6 Borer: *Aclees* sp. (Coleoptera: Curculionidae)

2. Disease

2.1. Mosaic disease (viral disease)

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 orchard 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 tree, how to analyze the orchard situation and how to make proper decisions for their tree management. This process is called the AESA. Participants of AESA will have to make a drawing on a large piece of white 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 tree. 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 tree

- Select a variety resistant/tolerant to major pests
- Select healthy planting materials
- Treat the planting materials 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 tree becomes too succulent and therefore susceptible to insects and diseases. If the dosage is too low, the tree 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 orchard regularly (climatic factors, soil and biotic factors)

Farmers should

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

(http://www.exotic-plants.de/auktionsbilder/Ficus_racemosa1.jpg)

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. Several studies have documented such compensation through increased growth and photosynthetic rate.

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

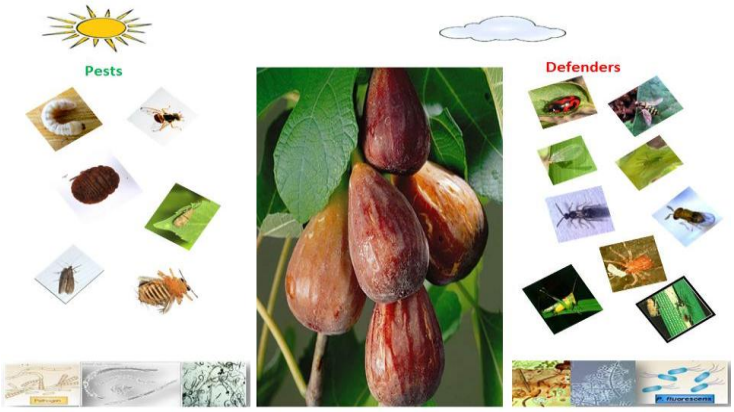
In orchard various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in tree orchard. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial and harmful insects. In this method, unfamiliar/unknown predators are collected in plastic containers with brush from the orchard 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 fig 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 orchard situation

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

The general rule to be adopted for management decisions relying on the P: D ratio is 2: 1. However, some of the parasitoids and predators will be able to control more than 2 pests. Wherever specific P: D ratios are not found, it is safer to adopt the 2: 1, as P: D ratio. Whenever the P: D ratio is found to be favourable, there is no need for adoption of other management

strategies. In cases where the P: D ratio is found to be unfavourable, the farmers can be advised to resort to inundative release of parasitoids/predators depending upon the type of pest. In addition to inundative release of parasitoids and predators, the usage of microbial biopesticides 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 trees. AESA farmers have learned to make these decisions based on observations and analysis viz. abiotic and biotic factors of the tree ecosystem. The past experience of the farmers should also be considered for decision making. However, as orchard 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 orchard in groups (about 5 farmers per group). Walk across the orchard and choose 10 orchards/ acre randomly. Observe keenly each of these plants and record your observations:
- Tree: 5-6 samples per tree (fruits/ leaves/ inflorescence /stem bark/roots/ soil/ insects, host plants) should be collected where, one sample from top, four samples from all the four sides (north, south, east, west) and one from bottom/soil, depending upon the requirement of study/observations and if necessary..
- Pests: Observe and count pests at different places on the tree.
- Defenders (natural enemies): Observe and count parasitoids and predators.
- Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
- Weeds: Observe weeds in the orchard and their intensity.
- Water: Observe the water situation in the orchard.
- Weather: Observe the weather condition.
- While walking in the orchard, 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 orchard situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the orchard 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 fig 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 tree management recommendation.
- The small groups then join each other and a member fig 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 orchard 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
- **Tree situation (e.g. for AESA):** Plant health; insect pests, diseases, weeds; natural enemies; soil condition; irrigation; weather conditions
- **Input costs:** Planting materialss; 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 orchard?
- What tree management aspect is most important at this moment?
- Is there a big change in tree 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 orchard between pests and defenders?
- Were you able to identify all pests and diseases?
- Do you think the tree is healthy?
- What management practices are needed at this moment?
- When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.
- Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest buildup?
- What problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.

Advantages of AESA over ETL

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

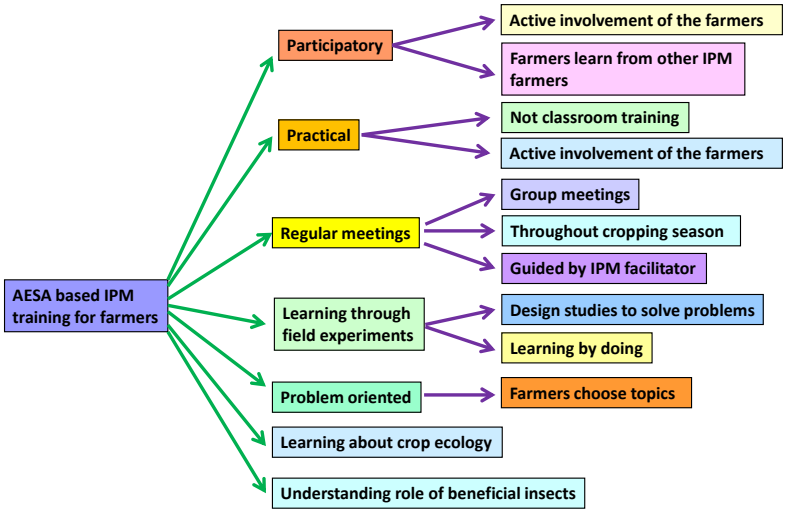
AESA and farmer orchard school (FFS)

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

Farmers can learn from AESA

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

FFS to teach AESA based IPM skills



B. Field scouting

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

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

Sampling in fruit crops:

A person doing sampling is known as an inspector or scout. The fruit crops are perennial in nature and before starting the surveillance process an inspector or scout who is going to implement the activity should know about the nature of crop as well as different crop stages and its growth stages. Knowing crop and its nature helps in identifying the important pests and diseases because the pests and diseases infest and infect, respectively, certain stage or part of the plant.

Sampling patterns:

Different methods of sampling are reported and being utilized for sampling in crops as well as in fruit plants such as random, scattered etc. However, some of them are specific to the crop/disease/pests and growth stage (some of them are to be utilized at initial stage and/or for subsequent plant growth stage). Also the sampling methods may differ based on the nature and requirement of the study such as estimating disease incidence and/or disease severity. For a common orchard study, the assessment methods should not only be easy and quick in use for a wide range of conditions, but also adequately reliable, reproducible, and accurate/precise. However, this is not always possible. Generally, in fruit crops the following sampling patterns are used:

- **Zig-zag pattern**. Sampling a fallow orchard or one with no obvious symptoms in the current crop to see the incidence as well as sampling of viral, wilt disease.
- **Circle pattern**. Sampling within the drip line of trees and shrubs and for powdery mildew, downy mildew and leaf spot diseases etc.
- **Star pattern**. Sampling from a damaged area.

Sampling frequency:

Sampling frequency or interval depends on pest generation interval or number of generations per year, potential for population increase between generations, stage of crop- pathogen infection etc. Generally, if initial survey is already implemented and some results are with the surveillance manager, then based upon the results of pest/disease incidence/intensity and weather parameters, the surveillance frequency/interval is decided to get comprehensive view of the pests and diseases development/population dynamics as well as biocontrol agent's population (if present in the crop ecosystem). In subsequent survey, monitoring for the pest, pathogen, and biocontrol agent must be carried out to get the following detailed information:

- **Relative pest measuring estimates:** Counting the representative samples in a given area.
- **Absolute pest measuring estimates:** Counting all individuals in a population in a given area which determine total pest population size in a given area. It is very effective pest surveillance research tool but very time consuming, therefore, not practical and/or not economically feasible.
- **Get an idea of number of pests per unit:** To estimate pests per plant and/or area to make the decision.
- **Get an idea of weather at the site:** Addition to the pest estimation, the prevailing weather conditions, which may affect pest development and/or population buildup, are observed and recorded.
- **Get an idea of biocontrol agents:** To strengthen the management strategies, biocontrol agent population size, if available, in a given area is to be determined.

C. Nematode extraction

Collect 100 to 300 cm3 (200-300 g) a 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. Ecological engineering for pest management is based on informed ecological knowledge rather than high technology approaches such as synthetic pesticides and genetically engineered trees (Gurr et al. 2004).

Ecological Engineering for Pest Management – Below ground:

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

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

Ecological Engineering for Pest Management – Above ground:

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

Natural enemies may require:

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

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

- Raise the flowering plants / compatible cash trees along the orchard border by arranging shorter plants towards main tree 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 orchard
- 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.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Select and plant appropriate companion plants which could be trap trees and pest repellent trees. The trap trees and pest repellent trees will also recruit natural enemies as their flowers provide nectar and the plants provide suitable microclimate.

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

Plants suitable for Ecological Engineering for Pest Management
Attractant plants

Cluster bean

Cowpea

Carrot

Sunflower

Buckwheat

French bean

Alfalfa

Maize

Mustard

***Coreopsis* spp.**

Cosmos

Dandelion

Anise

Caraway

Dill

Parsley

Repellent plants

***Ocimum* sp**

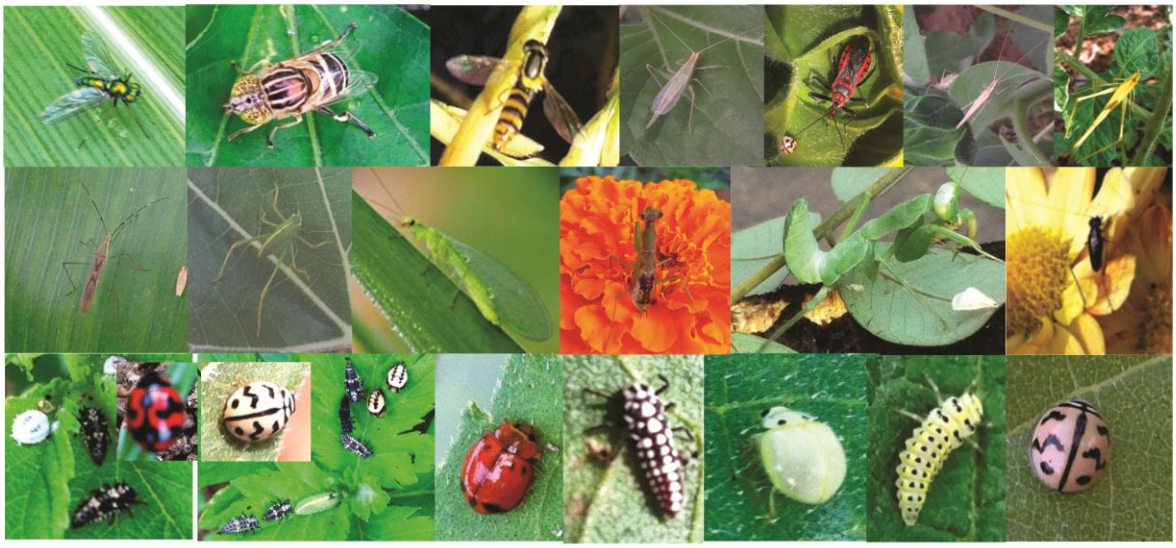
Peppermint

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

Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders

IV. CROP STAGE-WISE IPM

Management	Activity
Pre-sowing/Pre-planting*	
	<u>Common cultural practices:</u> • Timely planting should be done. • Orchard sanitation • Destroy the alternate host plants • Apply manures and fertilizers as per soil test recommendations
Nutrients	• Nutrient should be applied on the basis of soil test report and recommendation for the particular agro-climatic zone. • Adopt integrated nutrient management approach for supply of nutrients. • Prepare land by ploughing and harrowing. • Fig is planted in square system of planting at a spacing of 5 m x 5 m accommodating about 160 plants per acre. Pits of 0.6 cubic m are dug for planting the cuttings. • Fill the pits with top soil mixed with 25 kg FYM treated with *Trichoderma*.
Weeds	• Deep ploughing during summer Ploughing the field before planting to destroy existing weeds in the field.
Nematodes	**<u>Cultural control:</u>** • Use certified resistant planting materials • Clean planting materials by sieving or by using 2% salt water floatation to remove galls and prevent ear cockle diseases. • Galls can be separated by coarse sieve from the healthy planting materials • Winnowing or fanning • Brine flotation: 2% salt solution in place of plain water removes almost 100 % galls. • Deep ploughing of orchards during summer to control nematodes, • Soil solarization for control of soil borne pathogens and nematodes. • Apply well rotten farm yard manure only to discourage termite infestation. • Avoid late plantation
Planting*	
	<u>Common cultural practices:</u> • Use healthy and certified plants • Grow resistant/tolerant varieties. • Irrigation should be done by ring method to reduce possibility of diseases • Avoid growing in low-lying areas and flooding. • Do not delay irrigation until the tree exhibits moisture stress symptoms. **<u>Common mechanical practices:</u>** • Remove and destroy the diseased orchard.

<table>
<tr><td>Nutrients</td><td>• Planting is done in pits already filled with top soil and farm yard manure. The planting is generally done during June to September.
• Apply 20 g each of Azospirillum and Mycorrhizae per plant in pits at planting.</td></tr>
<tr><td>Weeds</td><td>• Use weed free planting materials for planting.
• Remove weeds from the pit, if any and then plant seedlings.</td></tr>
<tr><td colspan="2">Vegetative stage</td></tr>
<tr><td></td><td><u>Common cultural practices:</u>
• Intercultural and hand weeding
• Timely irrigation
• Avoid water logging
• Avoid water stress
• Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed
<u>Common mechanical practices:</u>
• Remove and destroy alternate wild hosts and weeds
• Use of pheromone traps @ 4-5/acre
• Installation of light trap @ 1/ acre
• Prune and burn all attacked shoot and branches.
<u>Common biological practices:</u>
• Conserve natural enemies through ecological engineering
• Augmentative release of natural enemies</td></tr>
<tr><td>Nutrients</td><td>• Apply manures and fertilizers (kg/tree/year) according to the age of plant as mentioned below;
<table>
<tr><th rowspan="2">Age (Year)</th><th colspan="5">Quantity of manures and fertilizers (kg/tree/year)</th></tr>
<tr><th>FYM</th><th>Neem Cake</th><th>Nitrogen</th><th>Phosphorous</th><th>Potassium</th></tr>
<tr><td>1</td><td>25</td><td>0.50</td><td>0.060</td><td>0.040</td><td>0.040</td></tr>
<tr><td>2</td><td>25</td><td>0.50</td><td>0.120</td><td>0.080</td><td>0.080</td></tr>
<tr><td>3</td><td>25</td><td>1.00</td><td>0.180</td><td>0.120</td><td>0.120</td></tr>
<tr><td>4</td><td>30</td><td>1.50</td><td>0.240</td><td>0.160</td><td>0.160</td></tr>
<tr><td>5th year onwards</td><td>35</td><td>2.00</td><td>0.300</td><td>0.200</td><td>0.200</td></tr>
</table>
• Manures and fertilizers should be applied in 20-30 cm deep and 30cms wide trench along the drip line of the tree.</td></tr>
<tr><td>Weeds</td><td>• Hoeing is recommended during the first year to check weed growth. Weeding should be done on regular basis especially around the plants.
• Earthing up is done before or after the onset of monsoon to avoid water-logging and also to help the plants to stand erect.
• To suppress the weeds between rows, leguminous trees and vegetables can be grown as intercrops during initial 5 years.
• Use straw or plastic Mulch to avoid weed growth and to maintain soil moisture for longer period</td></tr>
<tr><td>Stem borer</td><td><u>Cultural control:</u></td></tr>
</table>

	• Remove and destroy dead and severely affected branches of tree. • Remove alternative host like mango, moringa, silk cotton in the near vicinity. • Avoid injury at the base of trunk while pruning • Keep the orchard healthy following good agricultural practices. • Kill the stem borer larvae by inserting a flexible wire inside the hole and plug the hole with the cotton wick soaked in petrol or chloroform or kerosene and seal it with mud. **Mechanical control:** • Prune and burn all attacked shoot and branches during winter. **Biological control:** • Exclude alternatives host trees, such as silk cotton, fig tree and remove the infested branches from the garden to prevent the spread of the pest. • Use neem based biopesticide inside the hole. • Lantana camera leaf extracts @5%
Fruit fly	**Cultural control:** • Tree rotation, enhancement of soil quality, choice of resistant varieties, water management, monitoring/screening, orchard sanitation, mechanical barriers, post-harvest treatment. • Prior to harvest (30-40 days) collect and disposed off infested and fallen fruits to prevent further, multiplication and carry-over of population. • Ploughing of orchard during November-December to expose pupae to sun's heat which kills them. • Infestation is high, use bait splash on the trunk only once or twice at weekly interval. To prepare bait splash, mix 100 gm of jaggery in one litre of water • Managing fruit flies also reduces anthracnose disease and prevents late fruit fall. **Mechanical control:** • Collect and destroy the adult flies **Biological control:** • Rove beetles, weaver ants, spiders and birds and bats, • Release of parasitoids such as *Opius longicaudatus*, O. *vandenboschi*, *O. oophilus* and Bracon spp.
Fig midge	**Cultural control:** • Removal of Johnson grassy weed **Biological control:** • Neem seed kernel extract 5% • Parasitoids: *Aprostocetus* sp.

Mealy bug	**Cultural control:** • Prune affected shoots during winter. • Destroy ant colonies. • Grow attractant plants Bachelor's Buttons or cornflower (*Centaure acyanus*), coriander attract wasps. **Mechanical control:** • Collect and destroy the damaged leaves, twigs and stems • Use sticky barrier (5cm length) on trunk **Biological control:** • Coccinellids like *R. fumida*, chrysopid like *Chrysoperla zastrowii* silemi and drosophilid like *Cacoxenus perspicax*
Scale	**Cultural control:** • Collect the egg carrying female in mounds before spreading to hibernation places. **Biological control:** • Coccinellids, P. kenyae, Chilocorus sp., Hyperaspis, Scymnus, Cryptolaemus.
Leaf roller**	**Cultural control:** • Deep ploughing and soil solaraisation before planting. • Collect and burn all infested leaves. **Biological control:** • Conserve parasites such as *Apanteles angeleti, Trathala flavo-orbitalis and Cadurcia vanderwulpi* • Conserve predators such as lacewings, assassin bugs, and minute pirate bugs.
Thrips**	**Cultural control:** • Monitor the tree regularly. • Adult thrips can be monitored by mass trapping with coloured (blue, yellow or white) sticky traps or water traps in the nursery or orchard. • Ploughing and harrowing, and solarisation can kill pupae in the soil from previously infested trees. • Inter-cropping with tomatoes may reduce the populations of thrips **Biological control:** • Various biological control agents, including minute pirate bugs, *Orius* spp. (Hemiptera: Anthocoridae) and entomopathogenic nematodes, *Thripinema* spp. (Tylenchida: Allantonematidae).
Coccid**	**Cultural control:** • Sanitation is also important for reducing the pest population by disposing of fallen fruit, which may serve as hosts for the overwintering females. • Grow attractant plants for natural enemies: viz., sunflower family, carrot family plants, buckwheat. • Control ants and dust which can give the scale a competitive

	advantage **Mechanical control:** • Pruning of infested branches and twigs • Collection and destruction of pruned infested material. **Biological control:** • Olive scale is effectively controlled by two parasites *Aphytis maculicornis* and *Coccophagoides utilis*. • Parasitoids such as *Encarsia perniciosi* and *Aphytis diaspidis* cause effective parasitization. • Coccinellid predators such as *Chilocorus infernalis*, *Chilocorus rubidus, Pharoscymnus flexibilis* check the pest infestation to some extent. • Spray dormant oil in late winter before spring. • Apply mixture of manure compost tea, molasses and citrus oil. • Garlic-pepper tea also helps.
Fig moth**	**Mechanical control:** • Sieving, picking out, or winnowing, • It is important to destroy any insects found in the by-products or left-overs immediately. Larvae living inside the grain are only inadequately eliminated. **Biological control:** • Larval parasitoid, *Habrobracon hebetor* • Pupal parasitoid, *Antrocephalus mitys* • Spraying neem oil.
Fig jassids**	**Cultural control:** • Apply adequate amount of nitrogen **Mechanical control:** • See the common mechanical practices **Biological control:** • Conserve coccinellids like *Brumus suturalis, Chilochorus nigritus, Coccinella septumpunctata,Menochllus sexmaculata, Scemnus nubillus* • Predatory lygaeid *Geocoris tricolor* and *Anthocoris* sp., • Several mantids like *Eumantissa giglio, Cariagrion coromandeliorum, Ichneura* sp*., Dolichopus* sp. *and Therevia* sp. • Release predators viz., *Chrysoperla zastrowii* sillemi **Chemical control:** • Spraying of dimethoate 30% EC @ 594- 792 ml/acre diluted in 600-800 l of water
Rust	**Cultural control:** • Angle sprinklers and drip irrigation reduces disease incidence.
Anthracnose	**Cultural control:** • Eliminate other susceptible plants such as Johnson grass.

Leaf spot	**Cultural control:** • Proper irrigation with drip or micro sprinklers • Improved tree nutrition [nitrogen], etc.) reduces the disease incidence. • Avoid heavy tree pruning during the dormant period • Sandy soils and in some heavy soils, control has been achieved with preplant fumigation
Leaf mosaic**	**Cultural control:** • Clean cultivation by removing the weeds specially *Parthenium, Commelina* etc. both inside and neighbouring plots • Follow optimum plant population in the orchard • Remove the affected plants. • Control the mite vector
***Alternaria* rot**	**Cultural control:** • Rot can be minimized by picking fruit before it becomes overripe. • Reducing dust in orchards may also help to reduce the incidence of rot
***Aspergillus* rot**	**Cultural control:** • Avoid stressing trees by providing adequate irrigation. • Reducing dust in the orchard may help to reduce incidence of rots.
Smut	**Cultural control:** • Remove all old fruit an crop debris from orchard. • Try to reduce dust around trees.
Fig mosaic	**Cultural control:** • Do not collect propagation material from any trees showing symptoms of disease. • Controlling fig mites may help to reduce incidence of disease
Leaf Blight	**Cultural control:** • Sanitation
Maturity/Flowering stage	
Nutrients	• Apply recommended micronutrients, if deficiency is observed. • To correct the deficiency of Zinc and Boron micro-nutrients, apply $ZnSO_4$ (0.5%) and H_2BO_3 (0.1%) as foliar spray.
Weeds	• Remove weeds around the plants. • Use straw or plastic for mulching to avoid weed growth and to maintain soil moisture for longer period. • Whenever intercrop not grown between the rows of trees, slashing and mowing of weed may be adopted.
Stem borer, Fruit flies, Fig midge, Mealy bug, Coccid, Leaf roller**, **Thrips**, Scale**, Fig moth**, Fig jassids**, Rust, Antracnose, Leaf spot, Leaf mosaic**,**	• Same as mentioned in the above vegetative stage

Alternaria rot, Aspergillus rot, Smut, Fig mosaic, and Leaf Blight	
Reproduction/Fruiting stage	
Stem borer, Fruit flies, Fig midge, Mealy bug, Coccid, Leaf roller**, **Thrips**, Scale**, Fig moth**, Fig jassids**, Rust, Antracnose, Leaf spot, Leaf mosaic**, Alternaria rot, Aspergillus rot, Smut, Fig mosaic, and Leaf Blight**	• Same as mentioned in the above vegetative stage

Note: The pesticide dosages and spray fluid volumes are based on high volume spray.
** Pests of regional significance

V. RODENT PEST MANAGEMENT

Rodent management practices:

- Plough the orchards to demolish the rodent habitat and maintain weed free orchards to reduce alternate source of food and habitat
- Practice burrow smoking using natural smoking materials in ANGRAU/ NIPHM burrow fumigator for 2-3 min. for each burrow.

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 orchards 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/intertree.
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 orchards, adjacent "refuge" orchards, or habitat attractions within a treated orchard that facilitate immigration. These susceptible individuals may outcompete and interbreed with resistant individuals, diluting the resistant genes and therefore the impact of resistance.

VII. COMMON WEEDS

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

2. Tick weed: *Cleome viscosa L.* (Capparaceae)

3. Horse Purslane: *Trainthema portulacastrum L.* (Aizoaceae)

4. Devil's Horsewhip: *Achyranthes aspera* L. (Amaranthaceae)

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

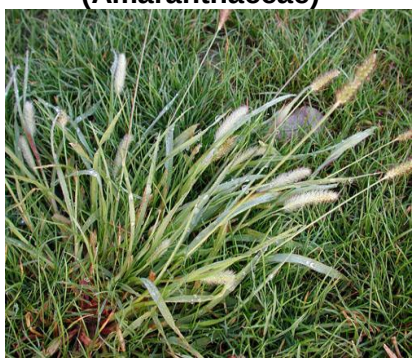
6. Creeping thistle: *Cirisium arvense* (L.)Scop (Asteraceae)

7. Spurge: *Euphorbia hirta* L. (Euphorbiaceae)

8. Spiny Amaranth: *Amaranthus spinosus* L. (Amaranthaceae)

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

10. Crab grass: *Digiteria sanguinalis* (L.) Scop. (Poaceae)



11. Yellow foxtail: *Setaria glauca* (L.) P. Beauv. (Poaceae)

12. Bermuda grass: *Cynodon dactylon* (L.) Pers. (Poaceae)

13. Southern crab grass: *Digitaria ciliaris* (Retz.) Koeler (Poaceae)

14. Purple nut sedge: *Cyperus rotundus* L. (Cyperaceae)

15. Umbrella sedge: *Cyperus difformis* L. (Cyperaceae)

VIII. DESCRIPTION OF INSECT PESTS

1. Stem borer

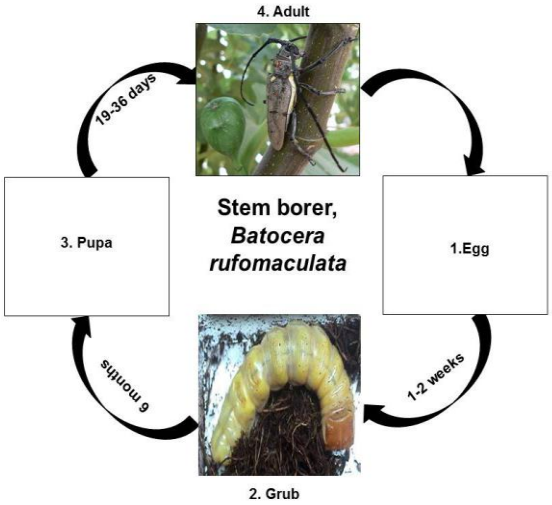
Biology:

Egg: The female cuts the tree bark and lays eggs singly into these cuts, laying a total of up to 200 eggs. Egg is a brownish-white cylinder, 6.2 mm, with narrowly rounded ends. On hatching the larvae start to tunnel into the sapwood of the trunk or branches.

Larva: Larval development takes about 2 years. As a very large species, the larval tunnel measuring 2 or 3 centimeters in width that is correspondingly large and very damaging to the tree. The larvae tunnel through the sapwood and because of their size, they make large tunnel which interfere with sap flow and affect foliage and fruit production.

Adult: The adult beetle emerges by a short tunnel running to the exterior and ending in a circular exit-hole. The maximum life recorded for the adult is eight months.

Life cycle:



http://www.whatsthatbug.com/wp-content/uploads/2009/01/mango_stem_borer_israel_judith.jpg

Damage symptoms:

- Grub tunnels in the sapwood on the trunk or branches
- Grub bore into the sap wood and making irregular tunnels.
- Feeding the vascular tissues
- interruption of nutrient and water transport on the tissue
- Drying of terminal shoot in early stage
- Frass comes out from several points and sometimes sap oozes out of the holes
- Wilting of branches or entire tree

*For management refer to page number 25

2. Fruit flies:

Biology:

Development from egg to adult under summer conditions requires about 16 days. The mature larva emerges from the fruit, drops to the ground, and forms a tan to dark brown puparium. Pupation occurs in the soil. About nine days are required for attainment of sexual maturity after the adult fly emerges. The developmental periods may be extended considerably by cool weather. Under optimum conditions, a female can lay more than 3,000 eggs during her lifetime,

but under orchard conditions from 1,200 to 1,500 eggs per female is considered to be the usual production. Apparently, ripe fruit are preferred for oviposition, but immature ones may also be attacked.

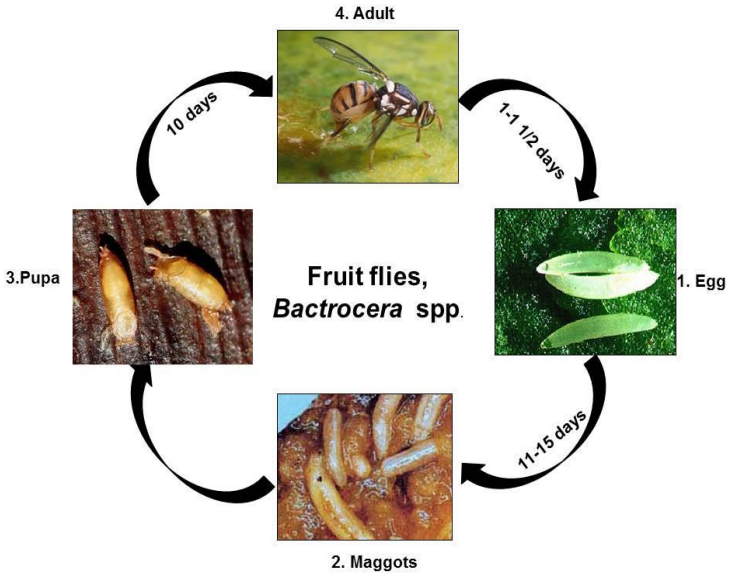
Egg: The white, elongate and elliptical egg measures about 1.17 x 0.21 mm and has a chorion without sculpturing

Larva: The third-instar, which has a typical maggot appearance, is about 10 mm in length and creamy white. The only band of spinules encircling the body is found on the first segment. The external part of the anterior respiratory organs, the spiracles, located one on each side of the pointed or head end of the larva, has an exaggerated and deflexed lobe at each side and bears many small tubercles. The caudal segment is very smooth. The posterior spiracles are located in the dorsal third of the segment as viewed from the rear of the larva.

Pupa: The mature larva emerges from the fruit, drops to the ground, and forms a tan to dark brown puparium about 4.9 mm in length.

Adult: The adult, which is noticeably larger than a house fly, has a body length of about 8.0 mm; the wing is about 7.3 mm in length and is mostly hyaline. The color of the fly is very variable, but there are prominant yellow and dark brown to black markings on the thorax. Generally, the abdomen has two horizontal black stripes and a longitudinal median stripe extending from the base of the third segment to the apex of the abdomen. These markings may form a T-shaped pattern, but the pattern varies considerably. The ovipositor is very slender and sharply pointed.

Life cycle:



http://entnemdept.ufl.edu/creatures/fruit/tropical/oriental_fruit_fly.htm

Damage symptoms:

- The damage to trees caused by fruit flies result from 1) oviposition in fruit and soft tissues of vegetative parts of certain plants, 2) feeding by the larvae, and 3) decomposition of plant tissue by invading secondary microorganisms.
- Larval feeding in fruits is the most damaging. Damage usually consists of breakdown of tissues and internal rotting associated with maggot infestation, but this varies with the

type of fruit attacked. Infested young fruit becomes distorted, callused and usually drop; mature attacked fruits develop a water soaked appearance. The larval tunnels provide entry points for bacteria and fungi that cause the fruit to rot. When only a few larvae develop, damage consists of an unsightly appearance and reduced marketability because of the egg laying punctures or tissue break down due to the decay.

Damage symptoms

Natural enemies of fruit flies:
Predators: Rove beetles, weaver ants, spiders and birds and bats
Parasitoids: *Opius longicaudatus, O. vandenboschi*, *O. oophilus* and *Bracon* spp.
*For management refer to page number 25

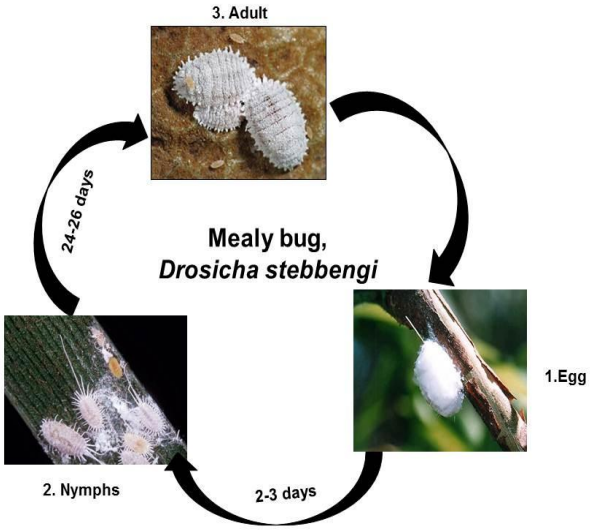
3. Mealybug:

Biology:
Eggs: The life cycle of *D. stebbingi* starts with egg laying in loose soil around infected trees. Between April and May, purple-colored eggs are laid in egg-sacs comprising mass of wax threads, in the loose soil around (within 2–3 m radius) the infested mango trees.

Nymphs: The nymphs emerge with the rise in temperature during January and travel up the trees via stem to feed on cell sap, adjacent to the fruiting parts. Therefore, heavy immature fruit falling occurs. Eggs hatch in December–January and nymphs start ascending the trees to succulent shoots and base of fruiting parts.

Adults: the flying males emerge to mate with the flightless mature females while crawling down to the ground for egg laying. Female and male appearance starts during March–April. Males are winged and short-lived after mating, and do not cause damage to the trees. *Drosicha stebbingie* has a total lifecycle of 24-26 days.

Life cycle:



Damage symptoms:

- Occurring primarily in older, well-shaded groves planted on heavy soils.
- They will feed on the roots, bark, foliage, and fruit. The mealybug injects toxic salvia while extracting plant sap resulting in defoliation, fruit discoloration, fruit splitting, and fruit drop.
- Mealy bugs usually gather in large numbers, causing premature leaf drop and twig dieback when they feed. Like psyllids, they secrete honeydew, which attracts black sooty mold

http://s2.hubimg.com/u/476895_f260.jpg

Natural enemies of mealybug:

R. fumida, *Chrysoperla zastrowii* silemi and *Cacoxenus perspicax*

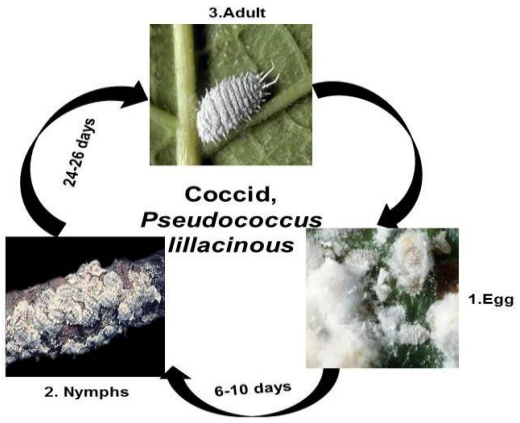
*For management refer to page number 26

4. Coccid:

Biology:

Adults: Adults are flat and oval, approximately 3mm in length, pale yellow and covered with wax. One female can lay an average of 200-300 eggs per cluster.

Life cycle:



http://cdn.c.photoshelter.com/img-get/I0000ewtyr_RkF_8/s/600/600/512070.jpg

Natural enemies of coccid:

Coccinellids, *P. kenyae*, *Chilocorus* sp., *Hyperaspis*, *Scymnus, Cryptolaemus.*

*For management refer to page number 27

5. Leaf roller:

Biology:

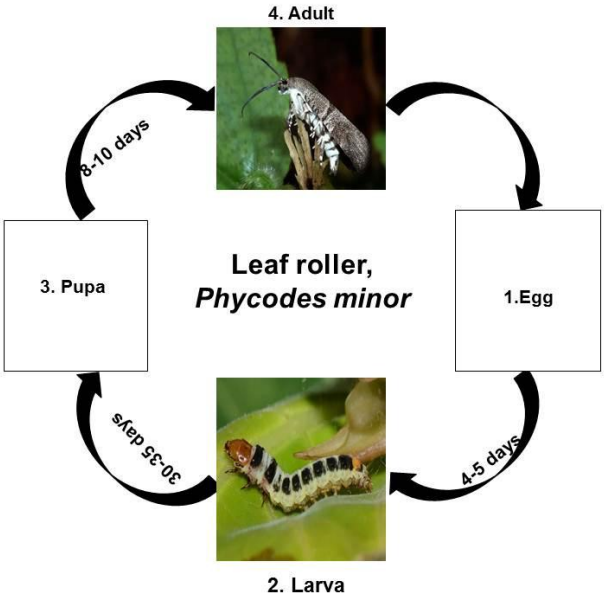
Eggs: They laid 3-81 eggs singly or in batches on either side of the leaves. Eggs hatched in 4.74-5.94 days

Larva: Larvae fed on the mesophyll gregariously (1st instar) or individually (later instars) under the silken webs spun by them. Larvae were full-grown in 30.60-35.87 days

Pupa: the pupal stage among the plant debris under the trees

Adult: This insect remained active from March to Sept. and passed through 4 overlapping broods. Moths lived for 3.6-10.57 days.

Life cycle:



http://i209.photobucket.com/albums/bb223/scorpionfly/TYMoth/Phycodesminor01.jpg 2. http://www.nbaii.res.in/insectpests/images/Phycodes-radiata2.jpg

Damage symptoms:

http://adamaskwhy.files.wordpress.com/2013/06/20130618-212017.jpg

Natural enemies of leaf roller:

Parasites: *Apanteles angeleti*, *Trathala flavo-orbitalis* and *Cadurcia vanderwulpi*

Predators: lacewings, assassin bugs, and minute pirate bugs.

*For management refer to page number 26

6.Fig moth:

Biology:

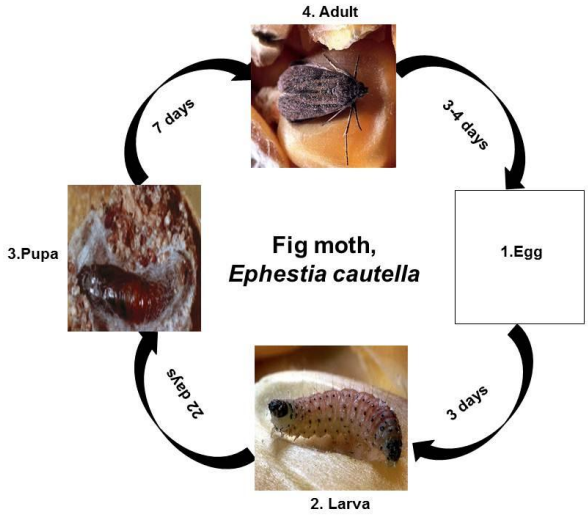
Eggs: The eggs are translucent yellow with a sculptured surface.

Larva: The larvae range from 1.5-15 mm in length and are light brown with dark brown spots with a sparse covering of hair.

Pupa: Pupae are dark-brown and found within a relatively light pupal case.

Adult: The adult forewings are greyish-brown with scattered darker patches. The wing span is 11-20 mm and both fore- and hind-wings have broadly rounded tips and short fringes of hairs.

Life cycle:



2. http://upload.wikimedia.org/wikipedia/commons/6/6d/Almond_moth.jpg
3. http://keys.lucidcentral.org/keys/v3/eafrinet/maize_pests/key/maize_pests/Media/Html/images/Cadra_cautella_Walker_1863_-_Tropical_Warehouse_Moth/cadra_cautella02.jpg
4. http://keys.lucidcentral.org/keys/v3/eafrinet/maize_pests/key/maize_pests/Media/Html/images/Cadra_cautella_Walker_1863_-_Tropical_Warehouse_Moth/cadra_cautella01.jpg

Natural enemies of fig moth:

Parasitoid: *Habrobracon hebetor, Antrocephalus mitys*

*For management refer to page number 27

7. Thrips:

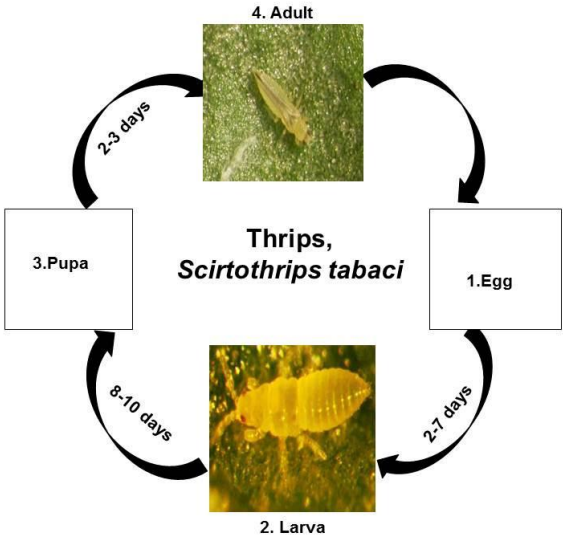
Biology:

Egg: The eggs are microscopic (0.075 mm long and 0.070 mm wide), kidney-shaped and creamy white in color. The eggs hatch between two to seven days, depending upon temperature. Larvae and adults tend to gather near the mid-vein or borders of the host leaf.

Larva: The two larval stages are completed in eight to ten days and the pupal stage lasts for 2.6-3.3 days.

Pupa: pupae are generally found on leaves, leaf litter or on the axils of leaves, in curled leaves or under the calyces of flowers and fruits.

Life cycle:



http://bugwoodcloud.org/images/768x512/5207025.jpg

Natural enemies of thrips:

Predators: minute pirate bugs, *Orius* spp.

*For management refer to page number 26

8. Scale:

Biology:

Egg: Eggs are laid under the female scale and are 0.2.0.3 mm long. Initially pale orange, they turn pink before hatching. Red eyespots are visible within the eggs before they hatch.

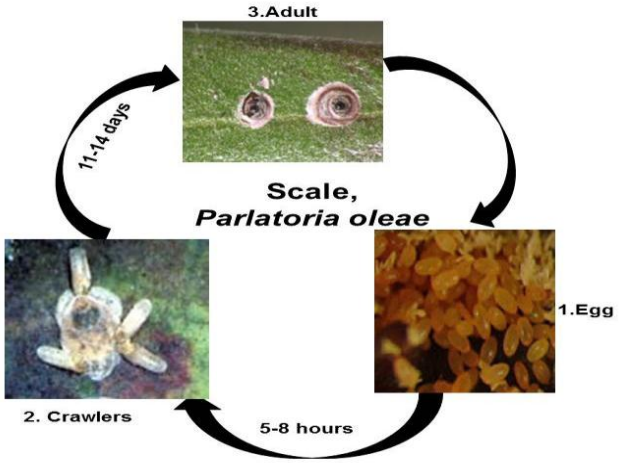
Crawlers: They are are light pink.orange with red or black eyes, 0.2.0.3 mm long. They are most abundant in summer (December). There is a second smaller generation in autumn (March-April). Crawlers can be dispersed by wind and workers, or on farm machinery. Although crawlers can wander for up to 36 hours, they usually settle within 2.3 hours. Once settled, (usually on the mid-rib of a leaf) crawlers shed their skin (moult). First instars are 0.6.0.8 mm long and 0.2.0.4 mm wide.

Adult

The ridges of the letter 'H' are distinct and are characteristic of black scale. When egg laying commences, the scale surface becomes smoother and darker, almost black. The female dies

after laying eggs, though the scale covering remains on the leaves or twigs. The size of adults is variable, 1.9-5 mm long, 1-4 mm wide and 1.2-2.5 mm high.

Life cycle:



1. http://archive.agric.wa.gov.au/objtwr/imported_images/fn486_figure4.jpg
2. http://www.forestryimages.org/images/768x512/5110075.jpg
3. http://archive.agric.wa.gov.au/objtwr/imported_images/fn486_figure1.jpg

Damage symptoms:

- The direct damage is caused by insertion of stylets during feeding by the nymphs, which can cause premature leaf drop and twig dieback.
- High populations can cause host death. Severe infestations may result in shoot or branch dieback
- When large populations of scale occur, sooty mold may become a problem due to the mold's growth on the large quantities of honeydew excreted by these scales

Natural enemies of Scale:

Parasites: *Aphytis maculicornis* and *Coccophagoides utilis*.
Parasitoids: *Encarsia perniciosi* and *Aphytis diaspidis*
Predators: *Chilocorus infernalis*, *Chilocorus rubidus*, *Pharoscymnus flexibilis*
For management refer to page number 26

Natural Enemies of Fig Insect Pests
Parasitoids

1. *Oobius agrili ,* **2. *Spathius agrili,*** **3. *Tetrastichus planipennisi***

4. ***Bathyaulax sp.,***

5. ***Opius compensans,***

6. ***Trybliographa daci***

7. ***Dirhinus giffardii***

8. ***Spalangia spp.,***

9. ***Trichopria sp.***

10. ***Cecidomyiids,***

11. ***Anagyrus***

12. ***Trathala flavo-orbitalis***

13. ***Bracon hebetor***

Predators

14. ***Dastarcus helophoroides***

15. Owl

16. Rove beetles

17. Red ant

18. Spider

19. Bird

20. Bat

21. ***Rodolia*** sp

22. ***Chrysoperla*** sp

23. ***Cacoxenus perspicax***

24. ***Cryptolaemus montrouzieri***

25. ***Chilocorus nigritus***

26. *Sumnius renardii*

27. Lacewings

28. Syrphid flies

29. *Spalgis epius*

30. Coccinellids

31. *Scymnus (Nephus) severini*

32. *Eublemma sp.*

1. http://www.mtu.edu/umc/services/pr-news/magazine/images/winter1011/image32565-scol.jpg
2. http://www.insectimages.org/images/768x512/5451604.jpg
3. http://www.discoverlife.org/IM/I_BUR/0000/mx/Tetrastichus_planipennisi,I_BUR2.jpg
4. http://upload.wikimedia.org/wikipedia/commons/5/53/Braconidae_Richard_Bartz.jpg
5. http://tribes.eresmas.net/fotos/ins/Hymenop/Ichneumon/Braconidae/Opiinae/Opius/O_lugens/opius_lugens_01_p04195_montoliu_1.jpg
6. http://www.nia.org.pk/soft/a10.jpg
7. http://flora.coa.gov.tw/graph/web_structure/284/284_00.jpg
8. http://perkinsltda.com.co/wp-content/themes/perkins/images/07.jpg

9. http://www.americaninsects.net/hy/42m-trichopria-sp-panama.jpg
10. http://jenny.tfrec.wsu.edu/opm/opmimages/PRFf17.jpg
11. http://nathistoc.bio.uci.edu/hymenopt/DSC_0087ab.jpg
12. http://image.digitalarchives.tw/ImageCache/00/64/76/7f.jpg
13. http://www.zipcodezoo.com/hp350/Habrobracon_hebetor_1.jpg
14. . http://www.diark.org/img/species_pict/large/Dastarcus_helophoroides/
15. http://upload.wikimedia.org/wikipedia/commons/3/39/Athene_noctua_(cropped).jpg
16. http://www.jeffpippen.com/naturephotos/staphylinid-beetle060701-3265spartaz.jpg
17. http://thumbs.dreamstime.com/x/weaver-ant-8537316.jpg
18. http://farm3.static.flickr.com/2466/3646849293_d888e05151_m.jpg
19. http://blogs.crikey.com.au/northern/files/2013/04/Fig-Birds-3.jpg
20. http://www.stevegettle.com/uploads/_aaa3609.jpg
21. http://www.organicgardeninfo.com/images/lady-beetle-rodolia-cardinalis.jpg
22. http://www.miradanatural.es/imagenes/galeria/7/735/grandes/1227050484.jpg
23. http://www.nbaii.res.in/Featured_insects/images/cacoxenus-perspicax4.jpg
24. http://www.tiptopbio.com/images/Cryptolaemus-Montrouzieri.jpg
25. http://keys.lucidcentral.org/keys/phoenix/ChilocorusSpeciesOfIndia/Chilocorus%20key/html/chinigmax1.jpg
26. http://www.nbaii.res.in/Featured_insects/images/rodolia-fumida3.jpg
27. http://www.royensoc.co.uk/sites/default/files/images/insect_lacewing.jpg
28. http://www.proprofs.com/flashcards/upload/q7001594.jpg
29. http://upload.wikimedia.org/wikipedia/commons/thumb/1/14/SpalgisEpius2.jpg/220px-SpalgisEpius2.jpg
30. http://upload.wikimedia.org/wikipedia/commons/f/f2/Coccinella_magnifica01.jpg
31. http://www.biolib.cz/IMG/THN/_92842.jpg
32. http://upload.wikimedia.org/wikipedia/commons/0/0c/Eublemma_sp._(Noctuidae_Eustrotiinae)_2.jpg

IX. DESCRIPTION OF DISEASES

1. Rust:

Disease symptoms:

- Rust generally develops late in the summer, and in years when disease is severe, it can cause the trees to defoliate in a matter of a few weeks. If this happens on a regular basis, the overall growth of the trees can be reduced and yields can be affected.
- Another consequence of defoliation is that if it occurs early in the summer, the trees will put out new growth that is then at risk of being damaged by early frosts. On the other hand, if defoliation occurs in the fall, the trees may go dormant earlier than usual, which then protects them from early frosts.
- Initially, symptoms of fig rust are visible as small, yellowish spots on the upper surface of the leaves. As these spots (or lesions) grow larger, they turn a reddish-brown color but remain relatively smooth.
- On the lower surface of the leaf, the lesions are a reddish-brown color and have a slightly raised, blister-like appearance. Heavily infected leaves often turn yellow or brown, particular y around the edges, and drop prematurely.

Survival and spread:

- The fungus mainly survives through teliospores (thick walled, resting spores) on leaves left in the orchard or on the soil surface.
- The disease spread by air-borne uredospores from infected tree.

Favourable conditions:

- Temperature ranging from 25.5 to 30.5° C with relative humidity of 86-92°c favours high intensity of rust.

file:///C:/Users/Guest/Desktop/pub3159FigRustHIGHRES.pdf

*****For the management refer page no 28

2. Anthracnose:

Disease symptoms:

- Anthracnose is a common plant fungal disease that can attack all plant parts during any growth stage.
- Anthracnose symptoms tend to be most conspicuous on the fig tree's leaves and ripe fruits. Anthracnose first appears on leaves as small black, yellow or brown spots.
- As the anthracnose disease progresses, these spots enlarge and merge to affect entire areas.
- This fig tree disease can also cause cankers to form on stems and petioles, resulting in severe defoliation and root rot.
- Infected fruit develop sunken, circular spots that might emit pink spores. The disease can be controlled by spraying aureofungin at 40 ppm in soap solution + 20 ppm CuS04.

Survival and spread:

- The disease spread by means of planting materials-borne and air-borne conidia and also through the infected plant debris.

Favourable conditions:

- Continuous rain.
- Temperature of 28-30˚C.
- High humidity.

http://www.examiner.com/images/blog/replicate/EXID56320/images/resized_Anthracnose1.jpg

*****For the management refer page no 28

3.Leaf spot:

Disease symptom:

- Initially minute brown spots appear on the leaves which enlarge into uniform or zonate, prominent, reddish brown lesions with dark brown margins.
- These lesions later coalesce to form irregular patches and affected leaves sheds earlier.
- The centre of the leaf become papery and drops off. Cobweb like mycelium spread over the lower surface of leaves and later on ultimately become powdery.

Survival and spread:

- The fungus overwinters as mycelium on infected plant residues and in dry conditions survives for 20 weeks in soil.
- The fungus is planting materials borne with 22.9% planting materials transmissible nature.

Favourable conditions:

- The disease is favoured by 25-27° C temperature and 12 hrs of wet foliage.
- The disease spreads rapidly in rainy season. Hot weather and frequent rains during the milk and wax stages of plant development favour infection.

https://c2.staticflickr.com/8/7021/6571662607_b5343a7f06_z.jpg

*****For the management refer page no 28

4. Leaf mosaic (virus):

Disease symptoms:

- Fig trees are also susceptible to fig mosaic,

- Symptoms appear in the form of large, yellowish spots on the leaves. These spots contrast sharply with the normal green foliage, creating a mottled effect.
- As the mosaic disease progresses, the spots become surrounded by a rust-colored ring, which is caused by the sub-epidermal or epidermal cells dying.
- Some fig tree varieties also develop mosaic lesions on the fruits. The fig mosaic virus also causes some tree species to suffer from premature fruit drop.

Survival and spread:

- Virus transmitted by thrips.
- Weed hosts serve as the natural reservoir for virus.

http://oregonstate.edu/dept/nurspest/Images/diseases/fig%20virus%207.JPG

*****For the management refer page no 28

5. Alternaria rot:

Disease symptoms

- Small, olive-green specks or sunken yellow-olive lesions covered in green spores on fruit.
- Water-soaked areas on fruit surface where figs touch.

Survival and spread

- Fungi over winter in plant debris.
- C. herbarum usually more common on green fruit, Alternaria spp. primarily a problem on ripe fruit.

Favourable condition

- It is favoured by warm wet weather

*For the management refer page no 28

6. Aspergillus rot:

Disease symptoms

- Internal tissue of figs bright yellow in color.
- Part or all of the interior turned to powdery mass of spores.

Survival and spread

- Disease emergence favors water-stressed trees.

Favourable condition

- It is favoured by warm wet weather

*For the management refer page no 28

7. Smut:

Disease symptoms

- Internal sections of fruit or entire inside of fruit discolored.
- Infected areas turn black and are covered with powdery black spores.

Survival and spread

- Fungus is transferred to fruit by some species of fly, thrips and beetle.
- Fig varieties with smaller ostioles (pores) on the fruit are less susceptible to the disease than those with large ostioles.

Favourable conditions:

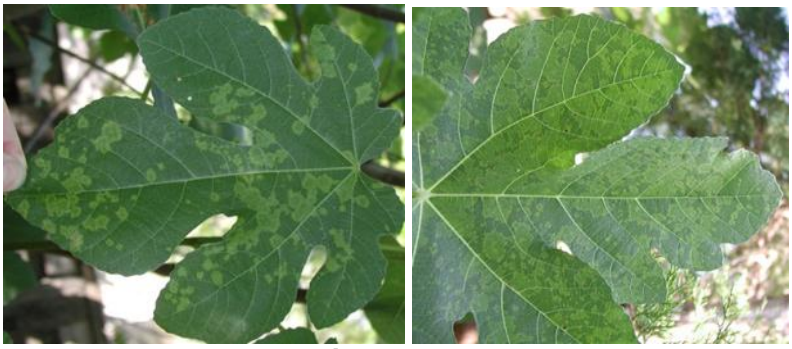
- Optimum environmental conditions for maximum infection include: temperatures between 20 and 25°C and slightly acidic soils favour the disease developments.

*For the management refer page no 28

8. Fig mosaic:

Disease symptoms:

- Yellow spots and mottling on foliage.
- Margins of spots are diffuse and blend gradually back into the green of the leaf.
- Spots may be distributed uniformly across the leaf surface or as irregular patches.
- Mature lesions develop a brown-red band around their margin.



Disease symptom

Transmission:

- Transmitted by fig mites or by grafting from infected tree

*For the management refer page no 28

9. Leaf Blight:

Disease symptom

- In early stages of infection, small areas in the leaves become yellow and appear water-soaked.
- With continual development, the upper surface becomes silvery white, and the lower surface becomes light brown and covered with a thin fungal web.
- In most cases, the leaves will turn brown and shrivel.
- It affects primarily the leaves but may develop on some fruit if it is new and a severely affected leaf or stem tip.

Survival and spread:

- **Primary :** The fungus survives in infected plant debris or in the soil
- **Secondary:** The spores are transported by water, wind, insects, other animals including man, and machinery.

Favourable conditions:

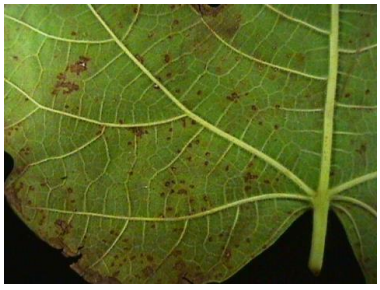
- Warm, rainy and wet weather

*For the management refer page no 28

10. Fig Rust:

Disease symptoms:

- The disease is first evident as small, angular, yellow-green flecks on the leaf.
- The spots do not become extremely large but do become more yellow and finally a yellowish-brown.
- The margin of the spot is reddish in color.
- On the upper surface the spots are smooth, while on the lower surface the spots appear as small blisters.
- Brown spores are released from the blisters at maturity.
- As infection continues, the leaves become more yellow, and finally they begin to die around the leaf margins.
- Eventually death and defoliation occur.
- Complete defoliation can occur in two or three weeks.
- Fig rust generally becomes a problem as the fruit reaches maturity.



Disease symptom

http://lyra.ifas.ufl.edu/LyraServlet?command=getImage&oid=3509355&width=480&height=360

Survival and spread:

- The pathogens reproduce and survive in spots on leaves or stems and in fallen plant host debris.

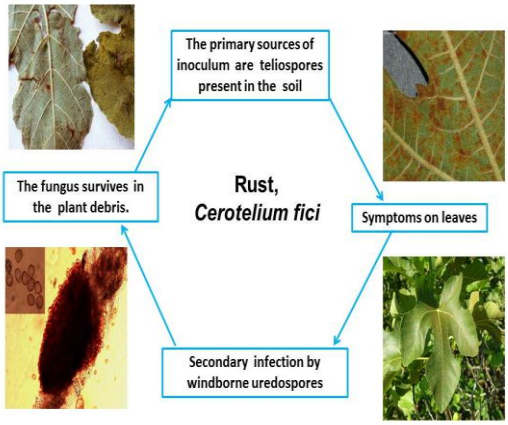
Favourable conditions:

- Frequent rains and warm weather are favorable conditions for these pathogens.
- For hosts, poor plant nutrition, poor soil drainage, and stagnant air are predisposing factors to infection by the algae.

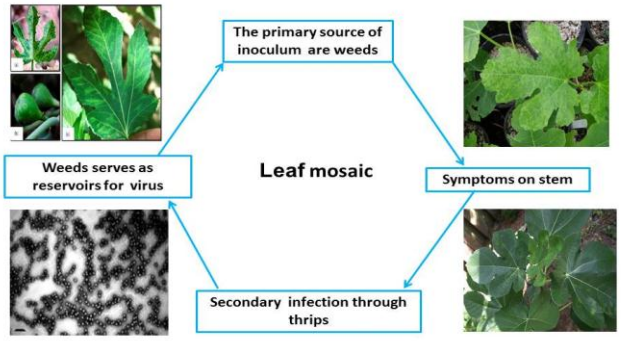
*For the management refer page no 28

DISEASE CYCLES

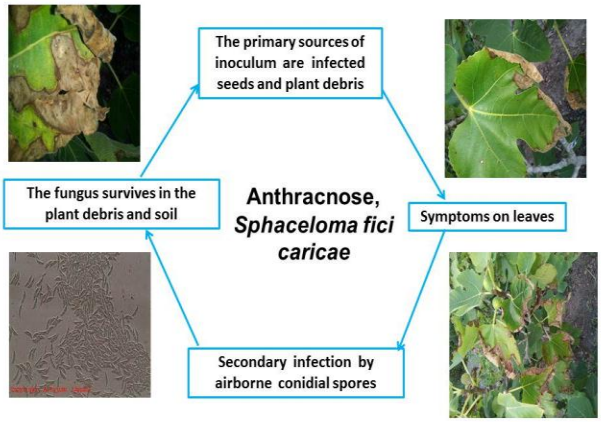
1. **Rust:**



2. **Leaf mosaic:**



3. **Antracnose:**



X. DESCRIPTION OF RODENT PESTS

1.Common house rat:

The black rat (*Rattus rattus*) is a common long-tailed rodent of the genus Rattus (rats) in the subfamily Murinae (murine rodents). The species originated in tropical Asia and spread through the Near East in Roman times before reaching Europe by the 1st century and spreading with Europeans across the world.

2. Soft furred orchard rat:

Distributed in Punjab, Uttar Pradesh southwards to western and southern India, also finds in foothills of eastern Himalayas. Found mostly in semi arid areas.
Small rodent (40-60gm) with soft fur, dorsum light grey and bicolored tail equal to the head and body.
Nocturnal and tonsorial with simple burrows.

3.Indian Mole Rats/Smaller Bandicoot

Commonly lives in cultivated plains and gardens and is one of the most destructive pests to trees and cultivation. It digs burrows with characteristic pile of earth around the entrance, hence its name. The burrow system is extensive and elaborate, consisting of numerous chambers (sleeping, storing etc), galleries and exits or 'bolt-holes', which are covered with loose earth, facilitating an easy escape during emergencies. The storage chambers are stocked with large amounts of grain, specially during harvest time. Usually one mole-rat is found in one burrow, except when there is a mother with young. It has a habit of erecting its long guard hairs scattered over the back and emitting harsh grunts when disturbed. It is a carrier of and spreads diseases such as plague, murine typhus, leptospirosis, salmonellosis and rat bite fever.

XI. SAFETY MEASURES

A. At the time of harvest:

The method of harvesting (hand vs mechanical) can significantly impact upon the composition and post-harvest quality of fruits. Mechanical injuries (such as bruising, surface abrasions and cuts) can accelerate loss of water and vitamin C resulting in increased susceptibility to decay-causing pathogens. Most fresh fruits and vegetables and all flowers are harvested by hand. Root trees (such as carrot, onion, potato, and sweet potato) and some commodities destined for processing (such as processing tomatoes, European plums, and tree nut trees) are mechanically harvested.

Management of harvesting operations, whether manual or mechanical, can have a major impact on the quality of harvested fruits and vegetables. Proper management procedures include selection of optimum time to harvest in relation to product maturity and climatic conditions, training and supervision of workers, and proper implementation of effective quality control. Expedited and careful handling, immediate cooling after harvest, maintenance of optimum temperatures during transit and storage, and effective decay-control procedures are important factors in the successful post-harvest handling of fruits.

Attention must be paid to all of these factors, regardless of the method of harvesting used. These factors are nevertheless more critical in the case of mechanically harvested commodities. It should be noted that any practice that reduces the number of produce handling steps will help minimize losses. Orchard packing (selection, sorting, trimming, and packaging) of produce at the time of harvest can greatly reduce the number of handling steps in preparation for marketing. Mobile orchard packing stations with adequate shading are used for those fruits (such as grapes and strawberries) and vegetables (such as broccoli, cauliflower and green beans) that do not require washing as part of their preparation for marketing.

B. During post-harvest storage:

Packing and packaging of fruits:

Preparation of produce for market may be done either in the orchard or at the packing house. This involves cleaning, sanitizing, and sorting according to quality and size,waxing and, where appropriate, treatment with an approved fungicide prior to packing into shipping containers. Packaging protects the produce from mechanical injury and contamination during marketing. Corrugated fiberboard containers are commonly used for the packaging of produce, although reusable plastic containers can be used for that purpose. Packaging accessories such as trays, cups, wraps, liners, and pads may be used to help immobilize the produce within the packaging container while serving the purpose of facilitating moisture retention, chemical treatment and ethylene absorption. Either hand-packing or mechanical packing systems may be used. Packing and packaging methods can greatly influence air flow rates around the commodity, thereby affecting temperature and relative humidity management of produce while in storage or in transit.

Temperature and relative humidity management:

Temperature is the most important environmental factor that influences the deterioration of harvested commodities. Most perishable horticultural commodities have an optimal shelf-life at temperatures of approximately 0 °C. The rate of deterioration of perishables however increases

two to three-fold with every 10 °C increase in temperature. Temperature has a significant effect on how other internal and external factors influence the commodity, and dramatically affects spore germination and the growth of pathogens. Temperatures either above or below the optimal range for fresh produce can cause rapid deterioration.

Cooling methods:

Temperature management is the most effective tool for extending the shelf life of fresh horticultural commodities. It begins with the rapid removal of orchard heat by using one of the cooling methods. Packing fresh produce with crushed or flaked ice provides rapid cooling, and can provide a source of cooling and high RH during subsequent handling. The use of crushed ice is, however, limited to produce that is tolerant to direct contact with ice and packaged in moisture-resistant containers.

Clean, sanitized water is used as the cooling medium for the hydrocooling (shower or immersion systems) of commodities that tolerate water contact and are packaged in moisture-resistant containers. Vacuum cooling is generally applied to leafy vegetables that release water vapor quickly, thereby allowing them to be rapidly cooled. During forced-air cooling on the other hand, refrigerated air is forced through produce packed in boxes or pallet bins. Forced-air cooling is applicable to most horticultural perishables. Precise temperature and RH management are required to provide the optimum environment for fresh fruits and vegetables during cooling and storage. Precision temperature management (PTM) tools, including time-temperature monitors, are increasingly being employed in cooling and storage facilities.

Refrigerated transport and storage:

Cold storage facilities should be appropriately designed, of good construction and be adequately equipped. Their insulation should include a complete vapor barrier on the warm side of the insulation; sturdy floors; adequate and well-positioned doors for loading and unloading; effective distribution of refrigerated air; sensitive and properly located controls; refrigerated coil surfaces designed to adequately minimize differences between the coil and air temperatures; and adequate capacity for expected needs. Commodities should be stacked in the cold room or the refrigerated vehicle with air spaces between pallets and room walls so as to ensure proper air circulation. Storage rooms should not be loaded beyond their capacity limit if proper cooling is to be achieved. Commodity temperature rather than air temperature should be measured in these facilities.

XII. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The orchard should be kept exposed to sun light at least for 2-3 weeks	Do not plant or irrigate the orchard after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2	Grow only recommended varieties.	Do not grow varieties that are not suitable for the season or the region.
3	Sow/plant early in the season	Avoid late sowing/planting as this may lead to reduced yields and incidence of diseases.
4	Always treat the planting materialss/planting material with approved biopesticides/chemicals for the control of planting materials borne diseases/pests.	Do not use planting materialss/planting material without planting materials treatment with biopesticides/chemicals.
5	Sow/plant in rows at optimum depths Under proper moisture conditions for better establishment.	Do not sow/plant planting materialss beyond 5-7 cm depth.
6	Apply only CIBRC recommended pesticides against a particular pest at the recommended dose, at the right time, with right methods with standard equipments e.g. Flat-fan or flood- jet nozzles for herbicides.	Non-recommended pesticides should not be applied in the Orchard field.
7	Maintain optimum and healthy plant stand.	Orchard plants should not be exposed to moisture deficit stress at their critical stages..
8	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
9	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
10	Conduct 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
11	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
12	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per orchard observation	Do not apply chemical pesticides within seven days of release of parasitoids.
13	In case of pests which are active during night such as *Spodoptera* spray	Do not spray pesticides at midday since, most of the insects are not active during

	recommended biopesticides/chemicals at the time of their appearance in the evening.	this period.
14	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
15	Follow the recommended procedure of trap tree technology.	Do not apply long persistent pesticides on trap tree, otherwise it may not attract the pests and natural enemies.

XIII. SAFETY PARAMETERS IN PESTICIDE USAGE

S. No	Pesticide Classification as per insecticide rules 1971 Colour of toxicity triangle	WHO classification of hazard	Symptoms of poisoning	First aid measures and treatment of poisoning	Safety interval (days)
1.	Dimethoate Highly toxic 	Class II Moderately hazardous	Mild-anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity	**First aid measures:** Rush to the nearest physician. **Treatment of poisoning:** For extreme symptoms of OP 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 of atropinization occur.	7 days

XIV. 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** expose to sunlight or rain water; **Do not** store 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. Equipment

1. Select right kind of equipment.
2. **Do not** use leaky and defective equipment
3. Select right kind of nozzles
4. **Do not** 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 orchard 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.

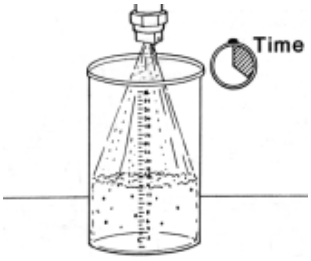
XV. PESTICIDE APPLICATION TECHNIQUES

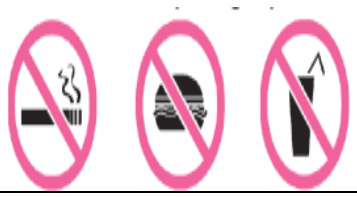
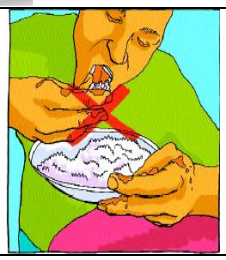
<table>
<tr><td colspan="4">Equipment</td></tr>
<tr><td colspan="4">Category A: Stationary, crawling pest/disease</td></tr>
<tr><td rowspan="2">Vegetative stage
i) for crawling and soil borne pests

ii) for small sucking leaf borne pests</td><td rowspan="2">Insecticides and fungicides</td><td rowspan="2">• 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</td><td> 
  </td></tr>
<tr><td>Reproductive stage</td><td>Insecticides and fungicides</td><td>• Lever operated knapsack sprayer (Droplets of big size)
• Hollow cone nozzle @ 35 to 40 psi
• Lever operating speed = 15 to 20 strokes/min</td><td>  </td></tr>
<tr><td colspan="4">Category B: Field flying pest/airborne pest</td></tr>
<tr><td>Vegetative stage
Reproductive stage
(Field Pests)</td><td>Insecticides and fungicides</td><td>• 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</td><td> 
  </td></tr>
<tr><td>Mosquito/ locust and spatial application (migratory Pests)</td><td>Insecticides and fungicides</td><td>• Fogging machine and ENV (Exhaust nozzle vehicle) (Droplets of very small size)
• Hot tube nozzle</td><td>   </td></tr>
<tr><td colspan="4">Category C: Weeds</td></tr>
</table>

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)	  

XVI. 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.	

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