



AESA BASED IPM PACKAGE

Persimmon



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FOREWORD

One of the fallouts of green revolution based on intensive use of inputs including agrochemicals has been its 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.

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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)

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AESA BASED IPM PACKAGE FOR PERSIMMON

Persimmon - Plant description:

Persimmon (*Diospyros kaki* Thunb.; Family: Ebenaceae) is the edible fruit and the most widely cultivated species is the Asian persimmon. The color of the ripe fruit of the cultivated strains range from light yellow-orange to dark red-orange depending on the species and variety. The size varies from 1.5 to 9 cm in diameter, and are spherical, acorn-, or pumpkin-shaped. The calyx generally remains attached to the fruit after harvesting, but becomes easy to remove once the fruit is ripe. Persimmon plants form a low head & develop a framework of strong branches. In general, cultivars differ markedly in vigour and growth habit. Some cultivars are dwarf and highly precocious, whereas others are vigorous, upright and late maturing. Pruning is done during winter season when trees are dormant, especially in January. Like the tomato, persimmons are not popularly considered to be berries, but in terms of botanical morphology the fruit is in fact a berry.



I. PESTS

A. Pests of National Significance

1. Insect and mite pests

- 1.1. Mealybug: *Pseudococcus longispinus* (Targioni-Tozetti) (Hemiptera: Pseudococcidae)
- 1.2. Scales: *Parthenolecanium corni* Bouché (Hemiptera: Coccidae) & *Hemiberlesia rapax* Comstock (Hemiptera: Diaspididae)
- 1.3. Fruit fly: *Bactrocera dorsalis* Hendel (Diptera: Tephritidae)
- 1.4. Twig girdlers & borers: *Chrysobothris mali* Horn (Coleoptera: Buprestidae)
- 1.5. Persimmon psylla: *Trioza diospyri* (Ashmead) (Hemiptera: Psyllidae)
- 1.6. Leaf rollers: *Hypocala rostrata* Fabricius (Lepidoptera: Erebididae)
- 1.7. Mites: *Orthotydeus* sp. (Trombidiformes: Tydeidae)
- 1.8. Thrips

2. Diseases

- 2.1. Crown gall: *Agrobacterium radiobacter* Beijerinck and van Delden
- 2.2. Root rot: *Dematophora necatrix* (Hartig)
- 2.3. Cercospora leaf spot: *Cercospora kaki* Ellis & Everhart
- 2.4. Circular leaf spot: *Mycospharella nawae* Hiura & Ikata
- 2.5. Bitter rot or anthracnose: *Gloeosporium kaki* Hori
- 2.6. Leaf spots: *Alternaria alternata* (Fr.) Kessl.
- 2.7. Post-harvest fruit rot: *Penicillium cyclopium* Westling
- 2.8. Anthracnose: *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc.

3. Weeds

Broadleaf

- 3.1. Lambs quarter: *Chenopodium* spp. L. (Chenopodiaceae)
- 3.2. Tropical spiderwort: *Commelina benghalensis* L. (Commelinaceae)
- 3.3. Creeping wood sorrel: *Oxalis corniculata* L. (Oxalidaceae)
- 3.4. Goat weed: *Ageratum conyzoides* L. (Asteraceae)
- 3.5. Sow thistles: *Sonchus* spp. (Asteraceae)
- 3.6. Congress grass: *Parthenium hysterophorus* L. (Asteraceae)

Grasses

- 3.7. Bermuda grass: *Cynodon dactylon* L. (Poaceae)
- 3.8. Wild oat: *Avena ludoviciana* (L.) Nees. (Poaceae)
- 3.9. Canary grass: *Phalaris minor* Retz. (Poaceae)
- 3.10. Cogon grass: *Imperata cylindrica* L. Raeusch. (Poaceae)
- 3.11. Large crabgrass: *Digitaria sanguinalis* L. (Scop.) (Poaceae)
- 3.12. Knot grass: *Paspalum distichum* L. (Poaceae)

Sedges

- 3.13 Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)
- 3.14 Yellow nutsedge: *Cyperus esculentus* L. (Cyperaceae)

4. Nematode

- 4.1. Root-knot nematode: *Meloidogyne* spp (Tylenchida: Meloidogynidae)

6. Rodents

- 5.1 Indian mole rat/smaller bandicoot: *Bandicota bengalensis* Gray (Rodentia: Muridae)
- 5.2 Soft furred field rat: *Milaridia meltada* Gray (Rodentia: Muridae)
- 5.3 Field mouse: *Mus booduga* Gray (Rodentia: Muridae)

II. AGRO-ECOSYSTEM ANALYSIS (AESAs) 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 crop, how to analyze the orchard situation and how to make proper decisions for their crop management. This process is called the AESA. Participants of AESA will have to make a drawing on a large piece of paper (60 x 80 cm), to include all their observations. The advantage of using a drawing is that it requires the participants/farmers to observe closely and intensively. It is a focal point for the analysis and for the discussions that follow, and the drawing can be kept as a record.

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

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

Principles of AESA based IPM:

Grow a healthy crop

- Select a variety resistant/tolerant to major pests
- Select healthy certified seed/seedling/plating material
- Treat the seeds with recommended pesticides especially bio-pesticides
- Follow proper spacing
- Soil health improvement (mulching and green manuring wherever possible)
- Nutrient management especially organic manures and biofertilizers based on the soil test results. If the dosage of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dosage is too low, the crop growth is retarded. So, the farmers should apply an adequate 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
- Crop rotation

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 Pest (P): Defender (D) ratio
- Take direct action when needed (e.g. collect egg masses, remove infested plants etc.)



Plant compensation ability

Compensation is defined as the replacement of plant biomass lost to herbivores and has been associated with increased photosynthetic rates and mobilization of stored resources from source organs to sinks (e.g., from roots and remaining leaves to new leaves) during active vegetative growth period. Plant tolerance to herbivory can arise from the interaction of a variety of plant traits and external environmental factors. 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 crop field. 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 persimmon 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 of the orchard

- 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 crops. AESA farmers have learned to make these decisions based on observations and analysis viz. abiotic and biotic factors of the crop ecosystem. The past experience of the farmers should also be considered for decision making. However, as 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 20 plants/ 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
 - Insect pests: The tremendous differences in tree size and structure among orchards of different ages, cultivars or training systems also present substantial barriers to develop sampling schemes that are universally applicable. Many sampling techniques have been discarded because of the laboriousness of the technique or the lack of accompanying decision making rule. Traps of all sorts have gained widespread popularity, since the onus is on the insect to come to the trap, rather than the sampler to seek out and count the insect. The development of selective traps, often to the species level has been a tremendous boost to their use in orchard IPM.
 - Defenders (natural enemies): Observe and count parasitoids and predators.
 - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
 - Rats: Count number of plants affected by rats.
 - Weeds: Observe weeds in the orchard and their intensity.
 - Water: Observe the moisture level/situations of the soil.
 - Weather: Observe the weather condition.

- While walking in the field, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the 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 next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on what 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 branches/ leaves
- **Crop situation (e.g. for AESA):** Plant health; pests, diseases, weeds; natural enemies; soil condition; irrigation; weather conditions
- **Input costs:** Seeds/seedlings; 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 field?
- What crop management aspect is most important at this moment?
- Is there a big change in crop situation compared to last visit? What kind of change?
- Is there any serious pest or disease outbreak?
- What is the situation of the beneficial insects?
- Is there a balance in the orchard between pests and defenders?
- Were you able to identify all pests and diseases?
- Do you think the crop is healthy?
- What management practices are needed at this moment?

- When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.
- Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest buildup?
- What are the problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.



Advantages of AESA over ETL

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

AESA and farmer orchardschool (FFS)

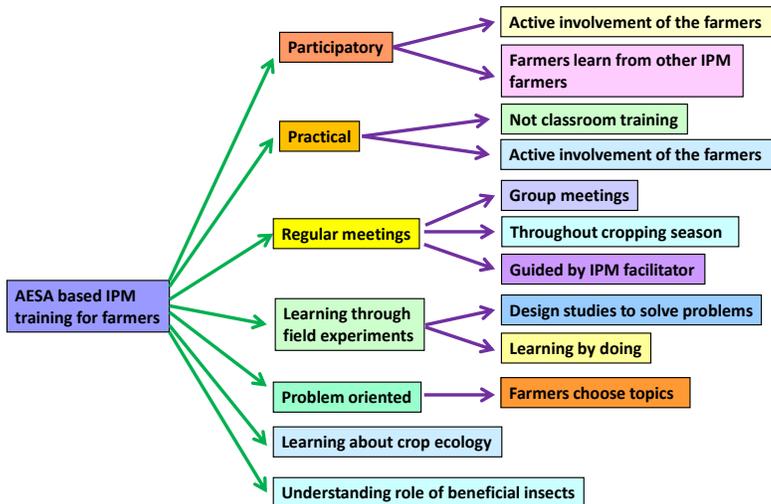
AESA is a season-long training activity that takes place in the farmer field. It is season-long so that it covers all the different developmental stages of the crop and their related management practices. The process is always learner-centered, participatory and relying on an experiential learning approach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

Farmers can learn from AESA

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



FFS to teach AESA based IPM skills



B. Orchard scouting

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

Surveillance on pest occurrence in the orchard should commence soon after crop establishment and at weekly intervals thereafter. Insect pests: The tremendous differences in tree size and structure among orchards of different ages, cultivars or training systems also present substantial barriers to develop sampling schemes that are universally applicable. Many sampling techniques have been discarded because of the laboriousness of the technique or the lack of accompanying decision making rule. Traps of all sorts have gained widespread popularity, since the onus is on the insect to come to the trap, rather than the sampler to seek out and count the insect. The development of selective traps, often to the species level has been a tremendous boost to their use in orchard IPM.

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:** In 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.

For insect pests:

Scales, psylla and mealybugs: Count and record the number of both nymphs and adults on five randomly selected leaves/twigs per plant.

Twig girdler and borer: The number of girdles on five randomly selected twigs per plant should be counted and recorded.

Leaf roller and fruit flies: Total number of fruits, damaged fruits due to fruit fly and number of leaf roller damaged leaves and number of leaf roller larvae on individual plants should be counted and recorded.

For diseases:

Whenever scouting, be aware that symptoms of plant disease problems may be caused by any biotic factors such as fungal, bacterial, viral pathogens or abiotic factors such as weather,

fertilizers, nutrient deficiencies, pesticides and abiotic soil problems. In many cases, the cause of the symptom is not obvious. Close examination, and laboratory culture and analysis are required for proper diagnosis of the causal agent of disease. Generally fungal diseases cause the obvious symptoms with irregular growth, pattern & colour (except viruses), however abiotic problems cause regular, uniform symptoms. Pathogen presence (signs) on the symptoms can also be observed like fungal growth, bacterial ooze etc. Specific and characteristic symptoms of the important plant diseases are given in description of diseases section.

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

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

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

C. Surveillance through pheromone trap catches for fruit fly:

Pheromone traps for fruit fly @ 4-5/acre have to be installed, if available.

Fix the traps to the supporting pole at a height of mid plant canopy. Change of lures should be made at 2-3 week interval (regular interval). During each week of surveillance, the number of flies/trap/week should be counted and recorded year round. The trapped flies should be removed after each recording.

D. Yellow/blue pan water/sticky traps

Set up yellow pan water/sticky traps 15 cm above the canopy for monitoring psylla @ 4-5 traps/acre. Locally available empty tins can be painted yellow and coated with grease/Vaseline/castor oil on outer surface may also be used.

E. Light traps

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

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

Ecological engineering for pest management has recently emerged as a paradigm for considering pest management approaches that rely on the use of cultural techniques to effect habitat manipulation and to enhance biological control. Ecological engineering for pest management is based on informed ecological knowledge rather than high technology

approaches such as synthetic pesticides and genetically engineered crops (Gurr et al. 2004a, b).

Ecological Engineering for Pest Management – Below ground:

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

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

Ecological Engineering for Pest Management – Above ground:

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

Natural enemies may require:

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

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

- Raise the flowering plants / compatible cash crops along the orchard border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population
- Grow flowering plants on the internal bunds inside the field
- 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 crops and pest repellent crops. The trap crops and pest repellent crops will also recruit natural enemies as their flowers provide nectar and the plants provide suitable microclimate.

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

Plants suitable for Ecological Engineering for Pest Management

Attractant plants



Cluster bean



Cowpea



Carrot



Sunflower



Buckwheat



French bean



Alfalfa



Maize



Mustard



Coreopsis spp.



Cosmos



Dandelion

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

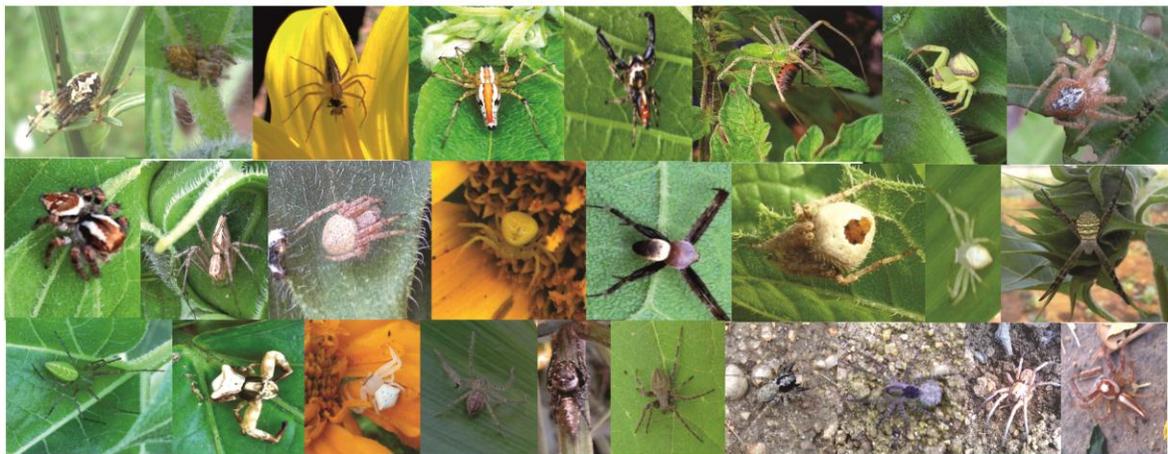
Biodiversity of natural enemies: Parasitoids



Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



IV. CROP STAGE-WISE IPM

Management	Activity
Pre-planting*	
	<p><u>Common cultural practices:</u></p> <ul style="list-style-type: none"> • Destroy the alternate host plants • Sow the ecological engineering plants • Sow sorghum/maize/pearl millet in 4 rows all around the main crop as guard/barrier crop • Deep summer ploughing of orchard reduces the incidence of weed, mealy bug and soil-borne pathogens. • Seed nuts must be collected during peak period of harvest and sun dried for two to three days. • Medium size nuts (7-9 gm) may be selected to get vigorously growing seedlings. • Seed nuts should be soaked overnight in water before sowing. • Sow the soaked nuts in the polythene bags filled with potting mixture. • Seedlings will be ready for grafting 40-50 days after germination. • Arrange proper shade, irrigation & drainage. • Rogue out diseased seedling. • Arrange locally made rat traps.
Nutrients	<ul style="list-style-type: none"> • Nutrient should be applied on the basis of soil test report and recommendation for the particular agro-climatic zone. • Prepare land by ploughing and harrowing. • Pits of 1m x 1m x 1m size are dug at a distance of 6 m on contour lines or in square system of planting.
Weeds	<ul style="list-style-type: none"> • Persimmon orchards are maintained under permanent sod with a clean basin management. • The basins are kept clean by hand-weeding. • Ploughing the orchard before planting to destroy existing weeds in the field.
Nursery sowing to Planting*	
	<ul style="list-style-type: none"> • Persimmon is grafted on the seedling rootstock before buds breaks. Prior to sowing, seeds are stratified at temperature (1-5°C) for 90 days and sown in the nursery in March-April. After one year, seedlings attain graftable size. It can also be propagated by shield budding in the month of August. <p><u>Common mechanical practices:</u></p> <ul style="list-style-type: none"> • Remove new sprouts emerging from root stock at frequent intervals. • Shift the grafts frequently from one place to another to prevent them from striking roots into the ground.
Nutrients	<ul style="list-style-type: none"> • Planting is done in December January in pits already filled with farm yard manure. • Add mycorrhiza culture @ 50 grams per pit or a basket of

	soil taken from old Persimmon orchard to ensure mycorrhiza association with seedling roots.
Weeds	<ul style="list-style-type: none"> • In the nursery, remove the weeds by hand from time to time • Use weed free seedlings for planting. • Remove weeds from the pits before planting. • Grow the recommended intercrops/ cover crop between the rows of Persimmon
Pests, soil-borne pathogens	<ul style="list-style-type: none"> • Follow common cultural, mechanical and biological practices (See page no. 22) <p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Well decomposed farm yard manure coupled with <i>Trichoderma viride/ harzianum</i> should be used. • Nursery beds should be raised.. • Nursery beds should be fumigated with 4% formalin <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Destruction of termetorium along with queen.
Vegetative state*	<p><u>Common cultural practices:</u></p> <ul style="list-style-type: none"> • Collect and destroy crop debris • Collect and destroy disease infected and insect damaged plant parts • Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed • Remove weed plants • Provide timely irrigation, organic manure, fertilizer as per the recommended dose, drainage, weeding, mulching, interculture etc. <p><u>Common mechanical practices:</u></p> <ul style="list-style-type: none"> • Handpick the older larvae during early stages of plant • Collect and destroy plant parts infested with insect pest and diseases • Handpick the gregarious caterpillars and the cocoons which are found on stem and destroy them in kerosene mixed water. • Use yellow sticky traps @ 4-5 trap/acre • Use light trap @ 1/acre and operate between 6 pm and 10 pm • Install pheromone traps @ 4-5/acre for monitoring fruit fly activity (replace the lures with fresh lures after every 2-3 weeks) • Erecting of bird perches @ 20/acre for encouraging predatory birds such as King crow, common mynah etc. • Set up bonfire during evening hours at 7-8 pm <p><u>Common biological practices:</u></p> <ul style="list-style-type: none"> • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies
Nutrients	<ul style="list-style-type: none"> • The amount of manure and fertilizer to be applied is influenced by the age or size of tree, soil types, fertility,

	<p>cultural practices and anticipated fruit yield.</p> <ul style="list-style-type: none"> • During vegetative growth, apply 4 t FYM per acre per year in December. • The manure should be applied in 20-30 cm deep and 30cms wide trench along the drip line of the tree.
Weeds	<ul style="list-style-type: none"> • Mulching tree basin in April with 10-15 cm thick hay helps control weeds and conserves soil moisture. • Green manuring crops like beans, pea, red clover and white clover-can also be grown in tree basins to improve soil texture and fertility. • Use slashing and mowing between the rows to control the weeds, if cover crops are not grown
Mealybug	<ul style="list-style-type: none"> • Follow common cultural, mechanical and biological practices (See page no.22) <p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Removal of weeds and alternate host plants like hibiscus, okra, custard apple, guava etc in and nearby vineyards throughout the year. • Deep ploughing in summer or raking of soil in vineyards helps to destroy its nymphal stages and minimizing the incidence. <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Remove and destroy the loose bark. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Release exotic predator, <i>Cryptolaemus montrouzieri</i> @ 10 beetles/vine
Scales	<ul style="list-style-type: none"> • Follow common cultural, mechanical and biological practices (See page no. 22) <p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Prune heavily infested plant parts to open the tree canopy and destroy' them immediately. • Prune infested parts (branches and twigs) preferably during summer. • These should be placed in a pit constructed on one corner of the orchard. Allow branches and twigs to dry until the parasites escape. • Burn the remaining debris. • Removal of attendant ants may permit natural enemies to control the insect. • monitor and when the eggs and crawlers (immatures) are present
Twig girdlers & borers	<ul style="list-style-type: none"> • Follow common cultural, mechanical and biological practices (See page no. 22) <p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • During September and October the adult female deposits her eggs by piercing the bark below the buds on terminal twigs. After oviposition the female girdles the stem which

	<p>may later fall to the ground.</p> <ul style="list-style-type: none"> • Infested twigs should be gathered and destroyed. • Select and apply horticultural spray oils according to label directions. Crawler sprays should be applied from late May through early June. Repeat applications may be needed. Be sure to follow label directions. Prune and destroy heavily infested twigs and branches.
Persimmon psylla	<ul style="list-style-type: none"> • Follow common cultural, mechanical and biological practices (See page no. 22) <p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Galls with nymphs should be collected and destroyed. <p><u>Biological control</u></p> <ul style="list-style-type: none"> • Conserve the predators like black ladybird beetle, purplish pirate bug, brown lacewing, tiny parasitic wasp.
Leaf rollers	<ul style="list-style-type: none"> • Follow common cultural, mechanical and biological practices (See page no. 22) <p><u>Biological control</u></p> <ul style="list-style-type: none"> • Conserve the biocontrol agents such as tachinid flies and ichneumonid wasps, which parasitize the larvae.
Mites	<ul style="list-style-type: none"> • Follow common cultural, mechanical and biological practices (See page no. 22) <p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Proper irrigation scheduling reduces the water stress and also increases the humidity thereby reducing the mite population <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Several predatory insects and spiders feed on mites but the most efficient natural predators of mite pests are predatory mites.
Crown gall	<ul style="list-style-type: none"> • Follow common cultural, mechanical and biological practices (See page no. 22) • For resistant/tolerant varieties consult nearest SAUs/ICAR Institutes/KVKs <p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Trees in fruit and nut orchards can be maintained over long periods if the trees became infected at maturity. Diseased trees will bear crop, but with age the trees will become unthrifty and suffer dehydration as their root system becomes progressively infected. The removal of infected trees and vines is costly in loss in time and in money.
Root rot	<ul style="list-style-type: none"> • Follow common cultural, mechanical and biological practices (See page no. 22) • For resistant/tolerant varieties consult nearest SAUs/ICAR Institutes/KVKs <p><u>Cultural control:</u></p>

	<ul style="list-style-type: none"> To cure slightly affected plants, dig out the soil from around the roots and allow them to dry. Prune infected roots down to healthy tissue and replant the persimmon in a new area. Water sparsely.
Cercospora leaf spot	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 22) For resistant/tolerant varieties consult nearest SAUs/ICAR Institutes/KVKs <p><u>Cultural control:</u></p> <ul style="list-style-type: none"> Remove the infected leaves from the plant Crop rotation plays a key component in reducing Cercospora leaf spot inoculum level from over-wintering in plant debris and in soils.
Circular leaf spot	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 22) For resistant/tolerant varieties consult nearest SAUs/ICAR Institutes/KVKs <p><u>Cultural control:</u></p> <ul style="list-style-type: none"> Rake up and destroy fallen leaves before the first snowfall to eliminate locations where pathogens can survive to re-infect the plant the following growing season. Do not overcrowd plants — use size at maturity as a spacing guide when planting. Prune trees or shrubs to increase light penetration and improve air circulation throughout the canopy. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> Wet conditions promote disease, so avoid or redirect lawn and landscape sprinklers that wet the lower canopy of the tree.
Bitter rot or anthracnose	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 22) For resistant/tolerant varieties consult nearest SAUs/ICAR Institutes/KVKs <p><u>Cultural control:</u></p> <ul style="list-style-type: none"> Taking cuttings from symptom-free plants will greatly reduce the risk of disease spread in container stock. Collecting fallen disease leaves and removing blighted blooms are also suggested.

Leaf spots	<ul style="list-style-type: none"> • Follow common cultural, mechanical and biological practices (See page no. 22) • For resistant/tolerant varieties consult nearest SAUs/ICAR Institutes/KVKs <p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Because the fruit crown covers the blossom tissues preharvest sprays are generally ineffective. Good orchard management practices, such as field sanitation (removal of old fruit and dead branches), may reduce the incidence of the disease. Infected, healthy-appearing fruit may be dropped to the ground by gently shaking the tree at the time of harvest. • Avoid water stress and overwatering that may result in fruit cracking.
Reproductive state*	
Mealybug	<ul style="list-style-type: none"> • Same as in vegetative state
Scales	<ul style="list-style-type: none"> • Follow common cultural, mechanical and biological practices (See page no. 22) <p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Prune heavily infested plant parts to open the tree canopy and destroy' them immediately. • Prune infested parts (branches and twigs) preferably during summer. • These should be placed in a pit constructed on one corner of the orchard. Allow branches and twigs to dry until the parasites escape. • Burn the remaining debris. • Removal of attendant ants may permit natural enemies to control the insect.
Persimmon psylla	<ul style="list-style-type: none"> • Same as in vegetative state
Leaf rollers	<ul style="list-style-type: none"> • Same as in vegetative state
Mites	<ul style="list-style-type: none"> • Same as in vegetative state
Maturation state*	
Nutrients	<ul style="list-style-type: none"> • In the bearing orchards, apply 8 tonnes of FYM per acre in alternate years. • Apply 30 kg N, 25 kg P₂O₅ and 25 kg K₂O per acre per year. • Half dose of N is applied in spring before flowering and the other half one month later. • Fertilizers are applied in tree basin about 30 cm away from the tree trunk. • The band application of nitrogenous fertilizers should be preferred over broadcasting. • Apply recommended micronutrients, if symptoms are observed.
Weeds	<ul style="list-style-type: none"> • Remove weeds around the plants. • Use straw or plastic Mulch to avoid weed growth and to maintain soil moisture for longer period.

	<ul style="list-style-type: none"> Mulching tree basins with 10-15 cm thick dry grass also checks weed growth. During the initial 2-4 years, peas, beans and cowpea enrich the soil and give economic returns also.
Fruit fly	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 22) <p><u>Cultural control:</u></p> <ul style="list-style-type: none"> 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. If infestation is heavy, bait splash on the trunk only, once or twice at weekly interval is recommended. To prepare bait splash, mix 100 gm of jaggery in one litre of water and add 1 ml of deltamethrin by using an old broom. Managing fruit flies also reduces anthracnose disease and prevents late fruit fall. <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> Male annihilation technique: Set up fly trap using methyl eugenol. Prepare methyl eugenol 1 ml/l of water + 1 ml of malathion solution. Take 10 ml of this mixture per trap and keep them at 25 different places in one ha between 6 and 8 am. Collect and destroy the adult flies. Use methyl eugenol pheromone trap @4/acre <p><u>Physical control:</u></p> <ul style="list-style-type: none"> Hot water treatment of fruit at 48 ± 1 °C for 4-5min.
Mealybug	<ul style="list-style-type: none"> Same as in vegetative state
Scales	<ul style="list-style-type: none"> Same as in vegetative state
Twig girdlers & borers	<ul style="list-style-type: none"> Same as in vegetative state
Persimmon psylla	<ul style="list-style-type: none"> Same as in vegetative state
Post-harvest	
Post-harvest fruit rot	<ul style="list-style-type: none"> Treat the fruits after harvest with 2 mM salicylic acid
Twig girdlers & borers	<ul style="list-style-type: none"> Same as in vegetative state

V. INSECTICIDE RESISTANCDE AND ITS MANAGEMENT

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

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

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

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

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

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

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

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

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

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

VI. COMMON WEEDS



1. Lambs quarter:



2. Tropical spiderwort:



3. Creeping wood: sorrel

***Chenopodium* spp. L.
(Chenopodiaceae)**



***Commelina benghalensis*
L. (Commelinaceae)**



***Oxalis corniculata* L.
(Oxalidaceae)**



4. Goat weed: *Ageratum conyzoides* L. (Asteraceae)



5. Sow thistles: *Sonchus* spp. (Asteraceae)



6. Congress grass: *Parthenium hysterophorus* L. (Asteraceae)



7. Bermuda grass: *Cynodon dactylon* (Poaceae)



8. Wild oat: *Avena ludoviciana* (L.) Nees. (Poaceae)



9. Canary grass: *Phalaris minor* Retz. (Poaceae)



10. Cogon grass: *Imperata cylindrica* (L.) Raeusch. (Poaceae)



11. Large crab grass: *Digitaria sanguinalis* L. (Scop.) (Poaceae)



12. Knot grass: *Paspalum distichum* L. (Poaceae)





13. Purple nutsedge: *Cyperus rotundus* L. Cyperaceae



14. Yellow nut sedge : *Cyperus esculentus* L. (Cyperaceae)

1. http://wnmu.edu/academic/nspages/gilflora/chenopodium_incanum.jpg
2. http://keyserver.lucidcentral.org/weeds/data/080c0106-040c-4508-8300-0b0a06060e01/media/Images/Commelina_benghalensis/commelina%20benghalensis10.jpg
3. http://www.fireflyforest.com/images/wildflowers/plants/Oxalis_corn_300.jpg
4. <http://www.nzenzeflowerspauwels.be/AgerCony.jpg>
5. [http://upload.wikimedia.org/wikipedia/commons/b/bd/Gewone_melkdistel_bladrozet_\(Sonchus_oleraceus\).jpg](http://upload.wikimedia.org/wikipedia/commons/b/bd/Gewone_melkdistel_bladrozet_(Sonchus_oleraceus).jpg)
6. [http://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/images/Parthenium_hysterophorus_\(Parthenium_Weed\)/parthenium_hysterophorus86.jpg](http://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/images/Parthenium_hysterophorus_(Parthenium_Weed)/parthenium_hysterophorus86.jpg)
7. http://www.tropicalforages.info/key/Forages/Media/Html/images/Cynodon_dactylon/Cynodon_dactylon_05.jpg
8. http://upload.wikimedia.org/wikipedia/commons/6/60/Avena_sterilis_Habitus_2010-5-08_DehesaBoyaldePuertollano.jpg
9. http://calphotos.berkeley.edu/imgs/512x768/0000_0000/0106/0988.jpeg
10. <http://www.prota4u.org/plantphotos/Imperata%20cylindrica.full.05.jpg>
11. [http://upload.wikimedia.org/wikipedia/commons/f/fa/Harig_vingergras_plant_\(Digitaria_sanguinalis\).jpg](http://upload.wikimedia.org/wikipedia/commons/f/fa/Harig_vingergras_plant_(Digitaria_sanguinalis).jpg)
12. http://upload.wikimedia.org/wikipedia/commons/4/45/Paspalum_distichum_04.jpg
13. http://upload.wikimedia.org/wikipedia/commons/a/ac/Nutgrass_Cyperus_rotundus02.jpg
14. http://twig.tamu.edu/yellow_nutsedge_cyperus_esculentus_l_006.jpg

VII. DESCRIPTION OF INSECT PESTS

1) Mealy bug:

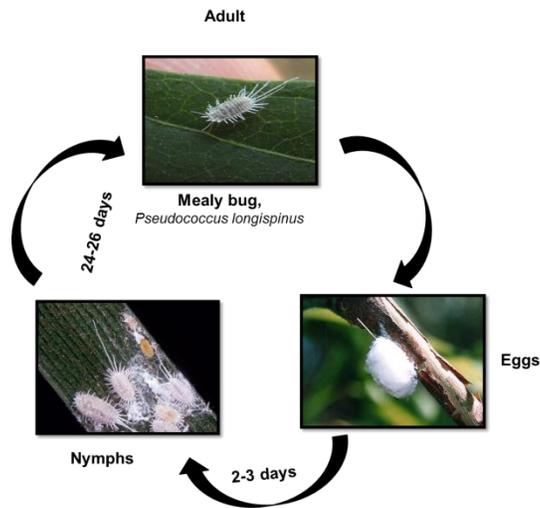
Biology:

Egg: The long-tailed mealybug reproduces sexually, each female laying 75-200 eggs (the number being dependent on the host plant)

Nymphs: The nymph is similar to the larger adult female except that the filaments around the edges are shorter.

Adult: The body of the female is yellow, with a dorsal brownish stripe and covered by white waxy dust. The body is elongated, 2.5-4.0 long, with 17 pairs of marginal wax filaments. The anal pair, which is longest, may exceed the pest's entire length (hence its vernacular name). Antennae 8-segmented.

Life cycle:



Damage symptoms:

- Longtailed mealybugs feed by sucking out plant sap from leaves and stems. Honeydew and sooty mold further disfigure infested plants, which may eventually be killed.
- These pests also secrete a fluffy white wax which also detracts from the appearance of infested plants.



Damage symptoms

Natural enemies of mealybug:

Parasitoids: *Anagyrus nigricornis*

Predators: Brown lacewing.

*For the management refer page no 24

2) Scales:

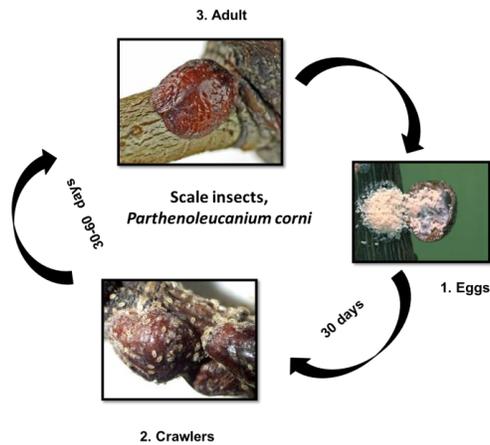
Biology:

Egg: female scale can lay about 1,000 or more eggs, and populations can build quickly.

Crawler: Crawlers hatch from early June through mid-July. Crawlers move to the leaves where they settle near leaf veins. In late August, crawlers move back to the twigs. Newly hatched crawlers are initially white and become yellow with age.

Adult: Male scale mate with females in early spring and then die

Life cycle:



Damage symptoms:



Damage symptom

<http://m3.i.pbase.com/v3/59/68959/2/44554863.maplescale2.jpg>

- The large number of new crawlers produced each generation can lead to
- copious honeydew production and a high probability that sooty mold fungus will
- disfigure host plants and foliage of adjacent plant species. Dieback of limbs and
- branches may become apparent, and the infested plant may become weakened.

Natural enemies of scales:

Predators: Minute pirate bugs, lacewings, ladybird beetles, predaceous midges and parasitoid wasps feed on these scale insects.

*For the management refer page no 24

3) 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.

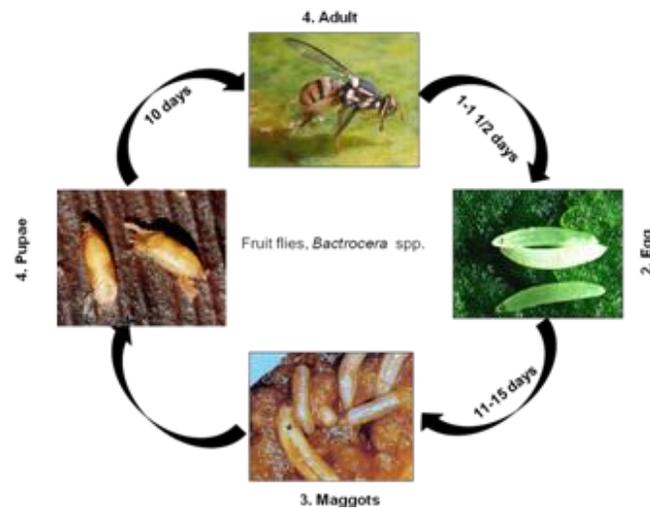
Egg: The white, elongate and elliptical egg measures about 1.17 x 0.21 mm and has a chorion without sculpturing

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 prominent 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 crops 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 symptom

Natural enemies of fruit flies:

Parasitoids: Tiny wasps (e.g. *Bracon* spp.)

Predators: Rove beetles, weaver ants, spiders and birds and bats,

*For the management refer page no 28

4) Twig girdlers & borers:

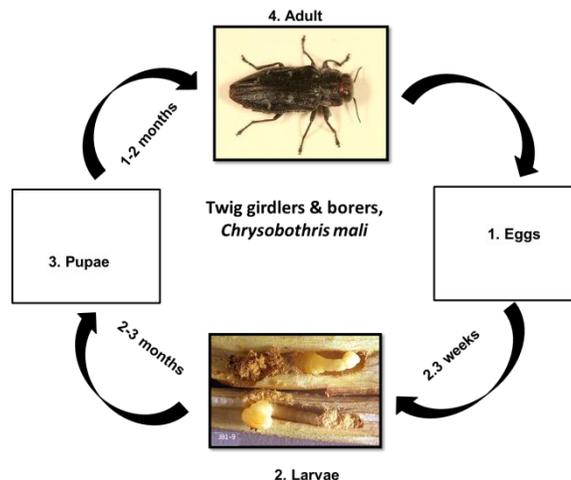
Biology:

Egg: The female beetle lays her yellow disk-like wrinkled eggs in cracks in the bark of trees, nearly always selecting a tree that is unhealthy, or a spot on a healthy tree where the bark has been injured, i.e. by sunscald or a bruise. The eggs are laid from May to August

Larva: Varies from yellowish white to yellow and 15 to 18 mm long when mature. Thoracic segments--not head, as name implies--greatly enlarged and flattened. Abdomen bent back, making larva look like hook when exposed in feeding burrow.

Pupa: The pupae overwinter within the galleries where they transform into adults which emerge from late spring through summer.

Life cycle:



Damage symptoms:

Natural enemies of twig girdlers & borers:

Adult feeding may cause some defoliation, but the major damage to the plant is caused by larval feeding which creates galleries (mines) between the bark and the wood. The galleries are

usually filled with coarse, excelsior-like fibers. The galleries, which nearly always begin on the sunny side of the tree, may extend completely around the tree thus girdling and killing the tree or infested branches. A full-grown larva may bore from 1 to 2 inches deep in the wood of the tree. Bark exterior to the galleries or mines may die and peel off. Sap may exude from these dark colored dead areas of bark. The darkened areas of bark and fine bits of sawdust protruding through the bark indicate the presence of wood boring larvae.



Damage symptom

<http://bugwoodcloud.org/images/768x512/3057081.jpg>

Natural enemies of twig girdlers & borers::

Parasitoids: *Spathius floridanus*, *Atanycolus charus*, *Atanycolus femoratae*, *Atanycolus rugosiventris*

Parasite: *Pediculoides ventricosus*

*For the management refer page no 24

5) Persimmon psylla:

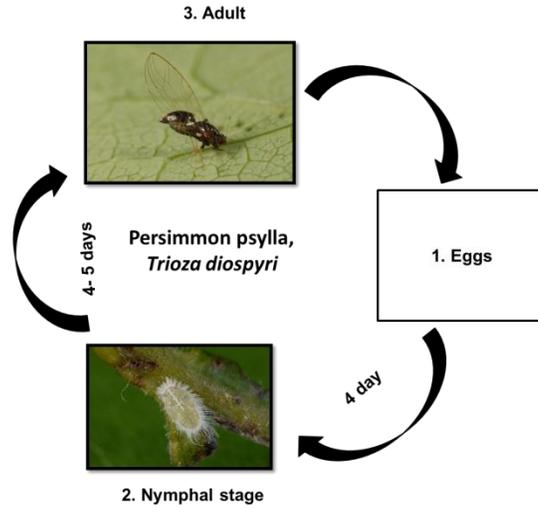
Biology:

Egg: The elongate-ovate eggs of the persimmon psylla are found lying flat on the succulent growth of the persimmon. They are about .01 inch in length with the larger end curved down and attached while a short pointed portion curves away from the support at the smaller end. The eggs are pale white, turning to yellow or brownish yellow before hatching. They are laid singly, usually rather uniformly arranged in rows along the margin of the leaf, on the surface of the leaf, or on the petiole or stem. They may also be found very generally scattered over these areas. Sometimes they are found scattered or grouped in the axils of the leaves or around dormant buds.

Nymph: The nymph is fringed on the margins with long hairs as in other species of *Trioza*. It is covered with a white powder.

Adult: The adult ranges in length from 3.5 mm to 4.5 mm. Its color is generally shining black except that the middle and hind tibiae, all tarsi, general processes, and antennae except for the tip, are whitish. Key characters include the hind tibiae with three inner apical spines, antennae distinctly longer than width of head, top of head and thorax sparsely covered with long pubescence, black color, and the medial cell of forewing much larger than cubital.

Life cycle:



Damage symptoms:

- The persimmon psylla causes leaves and shoots to become stunted, twisted, and curled. The female psylla lay eggs at the margin of the underside of the leaf. When the nymphs hatch they feed and inject toxins which cause the leaf to curl (pocketing) around them, making control difficult.
- Nymphs are found in the pocketings, together with white waxy filaments, cast skins, and "honeydew" which ants will often feed on.
- Although a light infestation would have little effect on tree vigor, homeowners would become concerned, especially if the infestation became moderate to severe. Perhaps the most dollar loss occurs to nurserymen who either apply preventive sprays or find tree values lowered when leaves of these trees become infested and distorted.



Damage symptom

http://entnemdept.ufl.edu/creatures/fruit/persimmon_psylla.htm

Natural enemies of persimmon psylla:

Parasitoids: Syrphid, ladybird beetles
Parasite: *Psyllaephagus trioziphagus*
 *For the management refer page no 25

Natural Enemies of persimmon Insect Pests

Predators



1. *Chrysoperla*



2. Coccinellid



3. Reduviid bug



4. Spider



5. Robber fly



6. Red ant



7. Black drongo



8. Common mynah



9. Big-eyed bug



10. Earwig



11. Ground beetle



12. Pentatomid bug
(Eocanthecona furcellata)



13. Praying mantis



14. *Geocoris* spp.



15. Predatory mite



16. Predatory thrips



17. *Oligota* spp.



18. *Orius* spp.



19. Hover fly



20. Mirid bug

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VIII. DESCRIPTION OF DISEASES

1) Crown gall:

Disease symptoms:

- Large galls (swellings) develop around the crown with smaller marble-size galls on larger roots.
- Bacterium enters plants by way of wounds from the soil.
- If the disease progresses too far the plant will turn yellow and become stunted and sickly.



Disease symptoms

<https://uconnladybug.files.wordpress.com/2011/04/dsc02076.jpg>

Survival and spread:

- Bacterium survives in the soil and infected crop debris.

Favourable conditions:

- High humidity and warm conditions favour the development of disease.

*For the management refer page no 25

2) Root rot:

Disease symptoms:

- The *Phytophthora* fungus causes crown, foot and root rot. Dark areas of sunken bark called cankers form on the trunk; these cankers exude a dark sap that leaves stains or streaks.
- The leaves change colors and fall from the tree, the branches and twigs die, and eventually the entire tree fails.

Survival and spread:

- The pathogens survive in the soil and crop debris.

Favourable conditions:

- Water logged area around the tree may cause this disease.



Disease symptom

*For the management refer page no 25

3) *Cercospora* leaf spot

Disease symptoms:

- Small, dark brown spots on both leaf surfaces. The spots are limited by the veins and so become angular in shape. Severely affected leaves fall readily

Survival and spread:

- This disease may spread through affected plant parts

Favourable conditions:

- Temperature of 25°C coupled with approximately 70 % Relative Humidity



Disease symptom

*For the management refer page no 26

4) Circular leaf spot

Disease symptoms:

- Although not deadly to adult trees, leaf spot does cause black spots to appear on the surface of leaves, and may sometimes affect fruit as well.
- It can also lead to early dropping of leaves

Survival and spread:

- The fungus infects during rainy season
- Spread through infested leaf.

Favourable conditions:

- Temperature ranging from 25.5 to 30.5° C with relative humidity of 86-92% favours this disease.



Disease symptom

<http://davisenterprise.s3.amazonaws.com/files/2011/05/persimmonoedema6W.jpg>

*For the management refer page no 26

5) Bitter rot:

Disease symptoms:

- Spot occurs on the surface of leaves and fruit as well.
- It can also lead to early dropping of leaves and fruits

Survival and spread:

- It may spread through infested parts

Favourable conditions:

- Continuous rain, Temperature 28-30°C and high humidity favours the development of disease



Disease symptom

<http://1.bp.blogspot.com/-o8lgGLtgTYo/U9ffvk1cZ0I/AAAAAAAAAdM/pNLft0bn2P8/s1600/Bitter+rot+mummy-6150.jpg>

*For the management refer page no 26

6) Leaf spot:

Disease symptoms:

- Depressed, dark lesions appear on the leaves, causing them to drop early.
- Once this disease infects the tree it is difficult to get rid of it in one season.

Survival and spread:

- Infected leaves and twigs during the growing season and in the fall. Prune the tree in winter to increase air circulation and remove infected branches

Favourable conditions:

- High humidity.



Disease symptom

<http://www.eattheweeds.com/wp-content/uploads/2011/08/PersimmonLeaves01-e1380651340273.jpg>

*For the management refer page no 27

7) Post-harvest fruit rot:

Disease symptom:

- Disease symptoms were irregular brownish and soft lesions mainly located under and surrounding the fruit calyx (stem-end) that expanded rapidly at room temperature and turned to dark brown or black colour producing apparent and in some cases abundant white to grey mycelium.

Survival and spread:

- Spreading through infested fruits.

Favourable conditions:

- Fruits are susceptible to chilling injury, temperature and storage time.



Disease symptom

http://www.postharvest.biz/_images/newscompany/77131/7402_newscompany.jpg

*For the management refer page no 28

8. Anthracnose

Disease symptom

- Appears as black spots on leaves, may fall from bottom upwards.
- Other symptoms may include black sunken spots on leaf stalks and lesions on bark.

Survival and spread:

- Pathogens survive in infected plant debris.

Favourable conditions:

- Infections are much more obvious on the flowers and fruit. Outbreaks are common after warm wet weather.
- During the rainy season, the rain water trickling through the diseased leaves is richly laden with the spores of the pathogens to cause further infections.

*For the management refer page no 26

XI. SAFETY MEASURES

A. At time of harvest:

Persimmon fruits are harvested when they have attained yellow to reddish color but are still firm. The fruits are clipped from the tree which shears leaving the calyx attached to the fruit together with a short stem. More care is needed to avoid bruising. Persimmon fruits mature in mid-September, although the period of maturity varies among the different varieties. If fruits are harvested too early, they develop poor color, sweetness and flavour.

B. During Post- harvest storage:

Fruits after harvesting should be wrapped individually in paper and packed in a single layer crate. Persimmons soften at room temperature. Ripe persimmons are delicious. Flesh is sweet and jelly like. As persimmons are delicate, it is essential to minimize handling as much as possible. Brix level at maturity in different varieties varies between 14` and 17`C.

The persimmon trees start bearing 4-5 years after planting. However, dwarf and semi-dwarf cultivars start bearing 2-3 years after planting. Mature trees of fuyu are capable of

producing 50kg fruit/ plant. Jiro cultivar has recorded over 80 kg plant, whereas in the Hachiya, the yield is over 100kg/plant. The decrease in astringency during growth and maturation of astringent cultivars and disappearance of astringency from non-astringent varieties are most striking. This reflects in the tannin content of fruits. Various methods have been suggested to remove the astringency from the astringent cultivars, however, most of these results in partial softening of fruits. Treatment of the fruit with carbon dioxide has been the most successfully developed technique till date. Dipping of fruits in 500 ppm Ethephon solution for two minutes helps in removing the astringency in cultivar Hachiya and the fruits are ready for consumption within 2-3 days of storage. The persimmons are also allowed to sweeten naturally after harvesting from the plants at room temperature, although they can be held in firm condition for 2-3 months at 30`-32`C and 85-90% relative humidity. Average freezing point of flesh is 28.2`C.

Persimmons are graded by size and quality. During grading and packing, handling should be kept minimum to avoid bruising. The most popular packages for persimmons are single layer trays commonly used for stone fruits.

So far, there is no specific market in India. Fruits are marketed to the local markets from where they are sent to distant markets. Fruits to be shipped should be well shaped, plump, smooth, highly colored with unbroken skin and with stem cap attached. The fruits should be displayed in a single layer at the sales counter, nested in a wrapping paper to avoid bruising.

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 white grubs and diseases.
4	Always treat the seeds with approved biopesticides/chemicals for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with biopesticides/chemicals.
5.	Sow/plant in rows at optimum depths Under proper moisture conditions for better establishment.	Do not sow/plant seeds 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 tree 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	Spray pesticides thoroughly to treat the under surface of the leaves.	Do not spray pesticides only on the upper surface of leaves.
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 crop technology.	Do not apply long persistent pesticides on trap crop, otherwise it may not attract the pests and natural enemies.

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