



AESA BASED IPM PACKAGE Peach



Pests



Defenders



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



**रा ब स्वा प्र सं
NIPHM**

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The AESA based IPM –Peach (*Prunus persica*), 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

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

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

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

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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 PEACH

Peach- Plant description:

The peach (*Prunus persica*: Family: Rosaceae) is a deciduous tree, native to Northwest China, in the region between the Tarim Basin and the north slopes of the Kunlun Shan mountains, where it was first domesticated and cultivated. It bears an edible juicy fruit also called a peach.

The species name *persica* refers to its widespread cultivation in Persia, whence it was transplanted to Europe. It belongs to the genus *Prunus* which includes the cherry and plum. The peach is classified with the almond in the subgenus *Amygdalus*, distinguished from the other subgenera by the corrugated seed shell.

Prunus persica grows to 4–10 m (13–33 ft) tall and 6 in. in diameter. The leaves are lanceolate, 7–16 cm (2.8–6.3 in) long, 2–3 cm (0.79–1.18 in) broad, pinnately veined. The flowers are produced in early spring before the leaves; they are solitary or paired, 2.5–3 cm diameter, pink, with five petals. The fruit has yellow or whitish flesh, a delicate aroma, and a skin that is either velvety (peaches) or smooth (nectarines) in different cultivars. The flesh is very delicate and easily bruised in some cultivars, but is fairly firm in some commercial varieties, especially when green. The single, large seed is red-brown, oval shaped, approximately 1.3–2 cm long, and is surrounded by a wood-like husk. Peaches, along with cherries, plums and apricots, are stone fruits (drupes). There are various heirloom varieties, including the Indian peach, which arrives in the latter part of the summer.



I PESTS

A. Pests of National Significance

1. Insect pest

- 1.1 Stem borer: *Aeolesthes sarta* Solsky (Coleoptera: Cerambycidae)
- 1.2 Flat headed borers: *Chrysobothris mali* Eschscholtz (Coleoptera: Buprestidae) & *Capnodis tenebrionis* Linne (Coleoptera: Buprestidae)
- 1.3 Peach tree borer: *Synanthedon exitiosa* Say (Lepidoptera: Sesiidae)
- 1.4 Defoliating beetle: *Protactia neglecta* & *Adoretus* sp. (Coleoptera: Scarabaeidae)
- 1.5 Hairy caterpillar: *Lymantria obfuscata* Walker (Lepidoptera: Lymantriidae)
- 1.6 San Jose-scale: *Quadraspidiotus perniciosus* Comstock (Hemiptera: Diaspididae)
- 1.7 Apricot brown scale: *Lecanium corni* (Bouché) (Hemiptera: Coccidae)
- 1.8 Peach leaf curl aphid: *Brachycaudus helichrysi* Kaltentbach (Hemiptera: Aphididae)

2. Diseases

- 2.1 Frosty mildew: *Cercospora persica* (Sacc.) Sacc
- 2.2 Peach leaf curl: *Taphrina deformans* (Berk.) Tul
- 2.3 Leaf spot: *Phyllosticta cerasicola* Speg.
- 2.4 Powdery mildew: *Sphaerotheca pannosa* (Wallr.) Lév, *Podosphaera leucotricha* (Ellis & Everh.) E.S. Salmon
- 2.5 Coryneum blight/shot hole: *Wilsonomyces carpophilus* (Lév.) M.B. Ellis
- 2.6 Silver leaf and canker: *Chondrostereum purpureum* (Pers.) Pouzar
- 2.7 White root rot: *Dematophora necatrix* Berl. ex Prill
- 2.8 Whisker rot: *Rhizopus stolonifer* Ehrenb
- 2.9 Peach rust: *Tranzschelia discolor* (Fuckel) Tranz.
- 2.10 Collar rot: *Phytophthora* sp. & *Pythium* sp
- 2.11 Bacterial canker and gummosis: *Pseudomonas syringae* pv. *Morsprunorum* (Wormald) Yong
- 2.12 Brown rot: *Sclerotinia fructicola* (G. Winter) Rehm & *S. fructigena* (J.Schröt.) Norton

B. Pest of Regional Significance

1. Insect pests

- 1.1 Green peach aphid: *Myzus persicae* Sulzer (Hemiptera: Aphididae)
- 1.2 Tent caterpillar: *Malacosoma indica* Walker (Lepidoptera: Lasiocampidae)
- 1.2 Leaf rollers: *Archips argyrospilus* & *subsidiaria* sp Walker (Lepidoptera: Tortricidae)
- 1.3 Peach twig borer/Apricot fruit borer: *Anarsia lineatella* Zeller (Lepidoptera: Gelechiidae)
- 1.4 Root borer: *Dorystenes hugelli* Ridt (Coleoptera: Cerambycidae)
- 1.5 Conspere sting bug: *Euschistus conspersus* Uhler (Hemiptera: Pentatomidae)
- 1.6 Peach fruit fly: *Bactrocera zonata* (Saunders), *B. ciliates* & *B. dorsali* Hendel (Diptera: Tephritidae)
- 1.7 Green capsid: *Lygus pabulinus* Franz and Wagner (Hemiptera: Miridae)
- 1.8 Blue beetle: *Haltica semipicens* (Coleoptera)

- 1.9 Blossom thrips: *Taeniothrips* spp, *Frankliniella dampfi* Priesner (Thysanoptera: Thripidae)
- 1.10 Rose chaffer beetle: *Macrodactylus subspinosus* Fabricius (Coleoptera: Scarabaeidae)
- 1.11 Oriental fruit moth: *Grapholitha molester* Busck (Lepidoptera: Tortricidae)
- 1.12 Peach stem aphid/ Brown Peach aphid/Peach black aphid: *Pterochlorus persicae* Cholodkovsky (Hemiptera: Aphididae)
- 1.13 Chaffer beetle: *Adoretus* spp (Coleoptera: Scarabaeidae)
- 1.14 Plum lakeworm: *Cremastopsychae pendula* de Joannis
- 1.15 Codling moth: *Cydia pomonella* Li (Lepidoptera: Tortricidae)
- 1.16 Mealy plum aphid: *Hyalopterus pruni* Geoffroy (Hemiptera: Aphididae)

2. Weeds

Broad leaf weeds

- 2.1 Tropical spiderwort: *Commelina benghalensis* L. Commelinaceae
- 2.2 Creeping wood sorrel: *Oxalis corniculata* L. Oxalidaceae
- 2.3 Goat weed: *Ageratum conyzoides* L. Asteraceae
- 2.4 Sowthistles: *Sonchus* spp. Asteraceae
- 2.5 Congress grass: *Parthenium hysterophorus* L. Asteraceae
- 2.6 Pig weed: *Amaranthus viridis* L (Amaranthaceae)
- 2.7 Lambs Quarter: *Chenopodium album* (Chenopodiaceae)
- 2.8 Spurge: *Euphorbia hirta* L (Euphorbiaceae)
- 2.9 Sorrel: *Rumex dentatus* L (Polygonaceae)
- 2.10 Creeping thistle: *Cirsium arvense* (L.) Scop. (Asteraceae)

Grassy weeds

- 2.11 Bermuda grass: *Cynodon dactylon* (L.) Pers. Poaceae
- 2.12 Cogon grass: *Imperata cylindrica* (L.) Raeusch. Poaceae
- 2.13 Blanket grass: *Axonopus compressus* (Sw.) Beauv. Poaceae
- 2.14 Large crabgrass: *Digitaria sanguinalis* L. (Scop.) Poaceae
- 2.15 Knot grass: *Paspalum distichum* L. Poaceae
- 2.16 Canary grass: *Phalaris minor* Retz. Poaceae
- 2.17 Crow foot grass: *Dactyloctenium aegyptium* (L.) Willd. Poaceae

Sedges

- 2.18 Purple nut sedge: *Cyperus rotundus* L. Cyperaceae
- 2.19 Flat Sedge: *Cyperus iria* L. Cyperaceae

3. Termites: White ants (Blattodea: Termitidae)

- 4. Root knot nematodes: *Meloidogyne incognita* (Tylenchida: Heteroderidae)

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 field 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 field 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 field situations with regards to pests, defenders, soil conditions, plant health and the influence of climatic factors and their relationship for growing a healthy crop. The basic components of AESA are

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

Principles of AESA based IPM:

Grow a healthy crop

- Select a variety resistant/tolerant to major pests.
- Select healthy seeds/seedlings/planting materials
- Treat the seeds/seedlings/plant 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 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.

Observe the field regularly (climatic factors, soil and biotic factors)

Farmers should

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



Plant compensation ability

Compensation is defined as the replacement of plant biomass lost to herbivores 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. The ability of the plant to compensate for the reduced acquisition of resources by the production of new organs or by remobilization of reserves may also mitigate biotic stress effects.

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 field 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 field 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 number 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 Peach pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens.

Model agro-ecosystem analysis chart

Date:
Village:
Farmer:



Decision taken based on the analysis of field situations

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

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

Decision making

Farmers become experts in crop management

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

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

AESA methodology

- Go to the 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 sturdy/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.
- 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 field situation in detail and present their observation and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.

- Formulate a common conclusion. The whole group should support the decision on what 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

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

Data to be recorded

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

Some questions that can be used during the discussion

- Summarize the present situation of the 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 field between pests and defenders?
- Were you able to identify all pests and diseases?
- Do you think the crop is healthy?
- What management practices are needed at this moment?
- When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.
- Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest buildup?
- What problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.



Advantages of AESA over ETL

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

AESA and farmer field school (FFS)

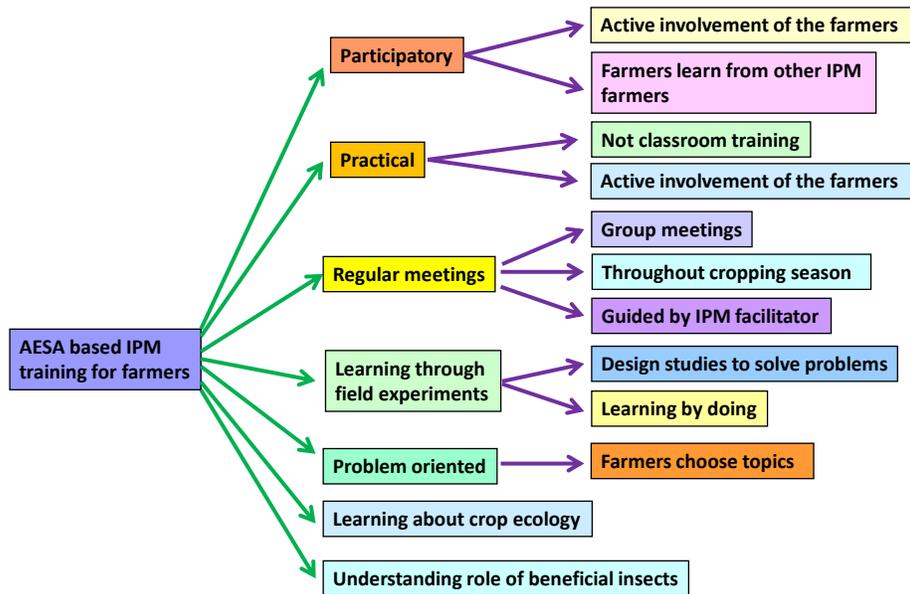
AESA is a season-long training activity that takes place in the farmer field. It is season-long so that it covers all the different developmental stages of the crop and their related management practices. The process is always learner-centered, participatory and relying on an experiential learning approach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

Farmers can learn from AESA

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

FFS to teach AESA based IPM skills





B. Field scouting

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

Sampling in fruit crops:

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 diseases and pest, because the diseases and pests are infect/infect certain stage or part of the crop plant.

Sampling patterns:

Different methods of sampling are reported and being utilized for sampling in crops as well as in fruit plants like aggravated, random, scattered etc. However, some of them are specific to the crop/disease/pests and some of them are to be utilized at initial stage and or for subsequent plant growth stage. Also the sampling methods may differ based upon the nature and requirement of the study like estimating disease incidence and or disease severity.

However, for a common field studies the assessment methods should be easy and quick in use for a wide range of conditions, but also adequately reliable and reproducible, accurate and precise. Generally this is not always possible. In fruit crops generally following sampling

patterns are used:

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

- 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 too but very time consuming, not practical and or economically feasible.
- Get an idea of pests per unit: The sampling to be organized to estimate the per plant and or area to make the decision.
- Get an idea of weather in the site: In addition to the pest estimation the prevailing weather conditions which may affect pest development and or population buildup must be observed and recorded.
- Get an idea of biocontrol agents: More importantly to strengthen the management strategies biocontrol agent population size if available in a given area should be determined.

Nematode extraction

Collect 100 to 300 cm³ (200-300 g) representative soil sample. Mix soil sample and pass through a coarse sieve to remove rocks, roots, etc. Take a 600 cc subsample of soil, pack lightly into a beaker uniformly. Place soil in one of the buckets or pans half filled with water. Mix soil and water by stirring with paddle; allow to stand until water almost stops swirling. Pour all but heavy sediment through 20-mesh sieve into second bucket; discard residue in first bucket; discard material caught on sieve. Stir material in second bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 200-mesh sieve into first bucket; discard residue in second bucket. Backwash material caught on 200-mesh sieve (which includes large nematodes) into 250-ml beaker. 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. Mix the contents of both the beakers and pass it through 325 mesh sieve. Backwash materials caught on 325 mesh sieve into a beaker. Prepare tissue paper-wire gauze fitting and pour the contents of the beaker on to the tissue paper-wire gauze fitting carefully place the fitting on a water filled petridish. After 24 hours, examine suspension of petridish under a stereoscopic microscope for presence of nematodes.

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

Ecological Engineering for Pest Management – Below Ground:

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

- Crop rotations with leguminous plants which enhance nitrogen content.
- Keep soils covered year-round with living vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance below ground biodiversity of beneficial microbes and insects.
- Application of balanced dose of nutrients using biofertilizers based on soil test report.
- Application of biofertilizers with special focus on mycorrhiza and plant growth promoting rhizobia (PGPR)
- Application of *Trichoderma harzianum/ viride* and *Pseudomonas fluorescens* for treatment of seed/seedling/planting materials in the nurseries and field application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

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 field 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



Cowpea



Carrot



Sunflower



Buckwheat



French bean



Alfaalfa



Mustard



Cosmos



Anise



Caraway



Dill



Parsley



White Clover



Tansy



Yarrow



Marigold

Repellent plants



***Ocimum* sp**



Peppermint/Spearmint

Barrier plant



Rye grass

Border plants



Maize

Sorghum

Crop rotation plants



***Sesbania* sp.**



***Crotalaria* sp.**



***Gaillardia* sp.**



Castor



Desmodium



Potato

Trap plants



Tomato



Marigold



Pearl millets

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.

IV. CROP STAGE WISE IPM

Management	Activity
Pre- planting*	
	<p><u>Common cultural practices:</u></p> <ul style="list-style-type: none"> • Deep ploughing of fields during summer. • Field sanitation, rogueing • Use resistant/tolerant varieties. • Grow the attractant, repellent plants around the field bunds. <p>Apply manures and fertilizers as per soil test recommendations</p>
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. • The pits are dug in summer about a fortnight before planting and left undisturbed for solarization. • Pits of about 1m x 1m x 1m size are dug at a distance of 4 to 5 meter in square system of planting. • Under high density planting pits may be dug at a spacing of 4m x 1m.
Weeds	<ul style="list-style-type: none"> • Ploughing, harrowing, leveling and removing the weeds before planting.
Termite	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Digging of termatoria and destroy the queen. <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Locate and destroy the termite colony. • Collect and destroy the termite affected setts from the field.
Planting*	
	<p><u>Common cultural practices:</u></p> <ul style="list-style-type: none"> • Use healthy and certified plants • Grow resistant/tolerant varieties • Plant early maturing cultivars i.e, Prabhat, Partap, Florida Prince, Early Grande, Flordasun and Shan-e-Punjab for fruit fly. • Irrigation should be done by ring method to reduce possibility of collar rot • Avoid plating in low-lying areas and flooding. • Do not delay irrigation until the crop exhibits moisture stress symptoms. <p><u>Common mechanical practices:</u></p> <ul style="list-style-type: none"> • Remove and destroy the diseased orchard.
Nutrients	<ul style="list-style-type: none"> • Planting is done in pits already filled with top soil and organic manure during the months of December- January.

	<ul style="list-style-type: none"> • <i>Mycorrhiza</i> culture should be applied at the time of planting or a basket of soil taken from old peach orchard is added to each pit to ensure mycorrhizal association with peach roots. • At the time of planting, manures and fertilizers are applied @ 50 Kg FYM or compost, 20 g N + 15 g P + 15 g K per plant.
Weeds	<ul style="list-style-type: none"> • Use weed free seedlings for planting. • Remove existing weeds in and around the pits at the time of planting. • During the initial 2-4 years, grow the intercrop like pea, bean, soybean, and cowpea.
Soil borne diseases and nematodes	<ul style="list-style-type: none"> • Resistant varieties • Use healthy infestation-free plants. • Application of neem cake @ 80 Kg/acre for nematode control.
<p>*Application of <i>Trichoderma harzianum / viride</i> and <i>Pseudomonas fluorescens</i> for treatment of seed/seedling/planting materials in the nurseries and field application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).</p>	
Vegetative stage	
	<p><u>Common cultural practices:</u></p> <ul style="list-style-type: none"> • Deep summer ploughing between the rows. • Timely irrigation • Avoid water logging • Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed <p><u>Common mechanical practices:</u></p> <ul style="list-style-type: none"> • Remove and destroy alternate wild hosts and weeds • Remove and destroy the dead hearts along with larvae • Installation of light trap @ 1/ acre • Prune and burn all attacked shoot and branches. <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"> • Apply fertilizers according to the age of plant @ 20 g N + 15 g P + 15 g K per plant in first year and doubling the dose each year till a stabilised dose is reached at 6th years. • Apply manures @ 50kg per plant in Dec.- January every year along with full dose of P and K. • The fertilizers 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"> • Deep ploughing during the first year to check weed growth. Tool weeding on regular basis especially around the plants. • Frequent tilling/ploughing up to 10 cm depth during winter. • To suppress the weeds between rows, leguminous crops and

	vegetables can be grown as intercrops in the initial years. Use slashing and moving between the rows to control the weeds.
Stem borer	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Keep orchard clean and healthy. • Clean hole and insert cotton wool soaked in emulsion of kerosene or petrol in each hole and plug them with mud. <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Follow common mechanical practices as stated above
Peach tree borer	<p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Follow common mechanical control
Defoliating beetles	<p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Use of plastic-lined trenches, propane flamers and vacuums.
Hairy caterpillar	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Irrigate once to avoid prolonged mid-season drought. <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Dig the pit of 1 inch depth between the fields & dust to kill the larvae in pits.
Peach Leaf curl, aphid	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • In the early stages, wash away the aphids with a sharp spray of water from a hose pipe. • Put on a pair of gloves and crush them between your fingers. • Prune curled leaves and destroy them. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Sprays based on natural pyrethrum/pyrethrins • Conserve predators such as lacewing and ladybird beetle. • Companion Planting - Plant yellow/orange nasturtium around the base of fruit trees to attract aphids and lure them away, or alternatively repel aphids by planting strong smelling herbs such as chives, garlic, marigold, and tansy under your trees. <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Spray oxydemeton – methyl 25% EC @13320 gm/acre • Spray carbofuran 3% CG @600-800ml diluted in 600-800 l of water/acre
Apricot brown scale	<p><u>Biological Control:</u></p> <ul style="list-style-type: none"> • Conserve parasites such as <i>Coccophagus</i>, <i>Encyrtus</i>, and <i>Metaphycus</i> spp. • Parasitized nymphs are almost black and have convex covers; unparasitized nymphs are flat.
San Jose scale	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Grow attractant plants for natural enemies: viz., sunflower family, carrot family plants and buckwheat

	<p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • See the common mechanical control <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Parasitoids such as <i>Encarsia perniciosi</i> and <i>Aphytis diaspidis</i> cause effective parasitization. • Coccinellid predators such as <i>Chilocorus infernalis</i>, <i>Chilocorus rubidus</i>, <i>Pharoscyrnus flexibilis</i>
Green peach aphid** & Peach black aphid**	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Abiotic factors such as rain and wind reduce aphid infestations. • Prune curled leaves or new shoots and dispose them. • Adopt the ecological engineering strategy by planting the attractant and repellent plants. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Conserve the natural enemies such as <i>Aphidius</i> spp., <i>Aphelinus</i> sp., Syrphid flies, rove beetle, aphid midge, predatory thrips, damsel bug, green lace wing, ladybird beetle and Braconid wasp.
Tent Caterpillar**	<p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Egg mass covered with yellowish hair are collected and destroyed (between August-March). • Put a burlap at the base of tree trunk to destroy the larvae underneath the burlap
Leaf roller**	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Delay dormant treatments and bloom time applications for other pests help keep leaf roller populations under control. • Regular monitoring each season is important so that prompt action can be taken. <p><u>Biological control</u></p> <ul style="list-style-type: none"> • Conserve parasitessuch as <i>Macrocentrus</i>, <i>Apanteles</i> and <i>Exochus</i> attack leaf roller larvae. • Conserve predators such as lacewings, assassin bugs, and minute pirate bugs.
Green capsid**	<p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Grow rootstock suckers, especially at the edges of orchards where the pest is removed.
	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • See the common cultural practices <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • See the common mechanical practices
Root borer**, Conspere sting bug**	<ul style="list-style-type: none"> • Follow common cultural and mechanical practices.
Blossom thrips**	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • See common cultural practices <p><u>Biological control:</u></p>

	<ul style="list-style-type: none"> • Conserve coccinellids, anthocorids, lygaeid, predatory thrips etc. for controlling blossom thrips
Chaffer beetle**	<p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Removing the rose chafer beetle from the plants mechanically • Place them in a bucket of soap water to kill them once removed from the plant. • Drench the soil with insect parasitic nematodes to kill the larvae.
Plum lake worm**	<p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • The young caterpillars can be manually killed as they collect on the underside of leaves or crawl down on the tree trunks at night. Kill these caterpillars before sunrise early in the morning
Frosty mildew	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Spraying at full bloom needs to be avoided. • Alkathene bands cleaned at regular interval <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Prune diseased leaves and malformed panicles harbouring the pathogen to reduce primary inoculum load.
leaf curl	<p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • To maintain tree vigor by thinning more fruit than normal, reducing drought stress with irrigation. <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Spray lime sulphur @ 0.8 - 2 lit/acre
Leaf spot	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Proper irrigation with drip or micro sprinklers • Improved tree nutrition [nitrogen, etc.) reduce the disease incidence. • Avoid heavy tree pruning during the dormant period • Sandy soils and in some heavy soils, control has been achieved with pre-plant fumigation.
Shot hole	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Buds can be protected from shot hole during the dormant season (mid-November to mid-December) by a fungicide application before the long winter rains begin.
Powdery mildew	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Spraying at full bloom needs to be avoided. • Alkathene bands cleaned at regular interval <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Prune diseased leaves and malformed panicles harbouring the pathogen to reduce primary inoculum load. <p><u>Chemical control:</u></p>

	<ul style="list-style-type: none"> • Spray lime sulphur @ 0.8 - 2 lit/acre
Silver canker	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Pruning is carried out during periods of dry weather between harvest and leaf fall. • Before pruning it is good orchard practice to clean up any dead wood which may be lying around the orchard environment.
White root rot	<ul style="list-style-type: none"> • Remove and destroy white root infested plants. All roots, litter and debris from infected plants must also be removed and destroyed. • Creating a trench with a shovel around infected areas prevent water runoff from distributing the fungal pathogen to nearby plants. • Preparing the soil before planting with soil solarisation.
Peach rust	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Angle sprinklers and drip irrigation reduces disease incidence.
Collar rot	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Pruning diseased wood, removing fruit mummies facilitates light penetration and air circulation. • Good soil drainage and more frequent but shorter irrigations reduce root and crown rot. <p><u>Biological control</u></p> <ul style="list-style-type: none"> • Use of biopesticides like <i>Trichoderma</i> spp., <i>Pseudomonas fluorescens</i>, <i>Bacillus subtilis</i>
Bacterial canker and gummosis	<p>Before the commencement of rains apply Mashobra Paint after clearing the wound. Repeat the treatment on the new lesions in the following months.</p>
Brown rot	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Avoid injury during picking • Select healthy unbruised fruits for marketing <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Collect and destroy the fruit mummies by burning or burying them in the soil. • The infected twigs and cankers should be cut out and burnt. <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Spray lime sulphur @ 0.8 - 2 lit/acre
Flowering stage	
Nutrients	<ul style="list-style-type: none"> • Nitrogen is applied in 2 splits, first half at 2-3 weeks before flowering and the remaining half a month later. • The fertilizers 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"> • Same as vegetative stage
Flat headed borer	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Wrap or paint the tree trunk above and 1 inch below the soil line with white, water-based paint or whitewash to protect the trunk from sunburn and flat headed borer invasions. • Prune infested wood and burn or remove it from the orchard
Hairy caterpillar, Peach leaf curl aphid, Apricot brown scale, San jose scale and Tent caterpillar**	Same as mentioned in the above vegetative stage
Peach twig borer	<p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Mating disruption is most effective in orchards with low moth populations that are not close (a mile) to other untreated peach twig borer hosts or almond orchards. • Install pheromone traps in orchards <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Conserve natural enemies such as gray field ant, <i>Formica aerata</i>,
Root borer**, Conspire sting bug**, Blossom Thrips**, Chaffer beetle**, Frosty mildew, Leaf spot, Powdery mildew, Silver canker, White root rot, Peach rust and Collar rot	Same as mentioned in the above vegetative stage
Fruiting stage	
Nutrient Management	<ul style="list-style-type: none"> • For mature trees, a mixture of 40 kg farmyard manure, 500gN, 250 g P₂O₅ and 200 g K is recommended. The farmyard manure should be applied during December-January along with full dose of P and K. Nitrogen is applied in 2 parts, first half at 2-3 weeks before flowering and the remaining half a month later. • The band application of nitrogenous fertilizers should be preferred over broadcasting.

	<ul style="list-style-type: none"> • Under rainfed conditions, apply N through 1 or 2 foliar sprays of urea (0.5%) after fruit set. • Apply recommended micronutrients, if symptoms are observed. Fruits are deformed under boron deficiency. • To avoid boron deficiency, apply H₂BO₃ (0.1%) as foliar spray.
Weed Management	<ul style="list-style-type: none"> • Remove weeds around the plants. • Use straw or black polyethylene Mulch to avoid weed growth and to maintain soil moisture for longer period. • Mulching tree basins with 10-15 cm thick dry grass also checks weed growth.
Flat headed borer, Hairy caterpillar, San jose scale, Root borer** and Tent caterpillar**	Same as mentioned in the above flowering stage
Peach fruit fly**	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Harvest the ripening fruits and do not allow the ripe fruits on the tree. • Regular removal of fallen fruits from the ground and bury the infested fruits atleast at 60cm depth. • Shallow ploughing with cultivator immediately after harvest is effective in exposing and killing the pupating larvae/pupae, which are mostly present at 4-6 cm depth. • If 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 <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Hot water treatment of fruit at 48 ± 1 °C for 60 min. • Collect and destroy the adult flies • Use pheromone traps@4-5/acre <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Release of parasitoids such as <i>Opius longicaudatus</i>, <i>O. vandenboschi</i> and <i>O. oophilus</i>.
Peach twig borer** and Chaffer beetle**	Same as mentioned in the earlier stage
Oriental fruit moth**	<u>Mechanical control:</u>

	<ul style="list-style-type: none"> • Set up pheromone traps@4-5/acre <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • The parasite <i>Macrocentrus ancyliivorus</i> is a common parasite of oriental fruit moth larvae • Planting of attractant plants such as sunflower
Frosty mildew, Leaf spot, Powdery mildew and Silver canker	Same as mentioned in the above vegetative stage
Whisker rot	<p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Preventing skin cuts and punctures during harvest and packing is of prime importance in controlling <i>rhizopus</i> rot. • Clean containers and good housekeeping in the packing shed and storage reduce the rot. • Store fruit at or below 39°F, the fungus does not grow at temperatures below 40°F.
Peach rust and Collar rot	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. INSECTICIDE RESISTANCE AND ITS MANAGEMENT

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

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

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

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

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

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

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

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

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

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

VI. NUTRIENT DEFICIENCY SYMPTOMS IN PEACH

Nutrients
<p>Nitrogen: Stunted growth of plants with pale green to light yellow color (chlorosis) appearing first on older leaves. Depending on the severity of deficiency, the chlorosis results in the drying and dropping of the older leaves.</p> <p>Correction Measure: Foliar spray of Urea @ 1-2 % at fortnightly intervals.</p>
<p>Phosphorus: Symptoms appear on older leaves. The leaves are small and narrow with purplish or bronze discolouration. Leaves develop necrotic areas and fall off.</p> <p>Correction Measure: Foliar spray of DAP@2%.</p>
<p>Potassium: Chlorosis along the edges of leaves (leaf margin scorching) occurs first in older leaves. Plants deficient in K will have weak stems with slow and stunted growth. The size and quality of fruits produces are poor which leading to reduced yield.</p> <p>Correction Measure: Foliar spray of KCl@1-2%.</p>
<p>Magnesium: Yellowish blotch near the base of leaf, midrib and the outer edge. The leaves become entirely yellow and defoliate.</p> <p>Correction Measure: Foliar spray of MgSO₄@1-2%.</p>
<p>Sulphur: Younger leaves are chlorotic with evenly, light coloured veins. Plant growth is retarded</p>

and maturity is delayed. Plant stems are stiff, thin and woody. Symptoms may be similar to N deficiency and are most often found in sandy soils.

Correction Measure: Soil application of gypsum @100kg/ acre.

Iron: Thin and smaller younger leaves with interveinal chlorosis. Green tinge at the base of mid rib. Later the leaves become pale or whitish and shed, older leaves remain green, fruits coarse light coloured.

Correction Measure: Foliar spray of FeSO₄@0.5%.

Manganese: Symptoms first appear as chlorosis in young tissues. Unlike iron chlorosis symptoms, Mn chlorosis shows up as tiny yellow spots.

Correction Measure: Foliar spray of MnSO₄ @1% at fortnightly interval.

VII. COMMON WEEDS



1. Tropical spider wort:
Commelina benghalensis L.
Commelinaceae



2. Creeping wood sorrel:
Oxalis corniculata L.
Oxalidaceae



3. Goat weed: *Ageratum conyzoides* L. Asteraceae



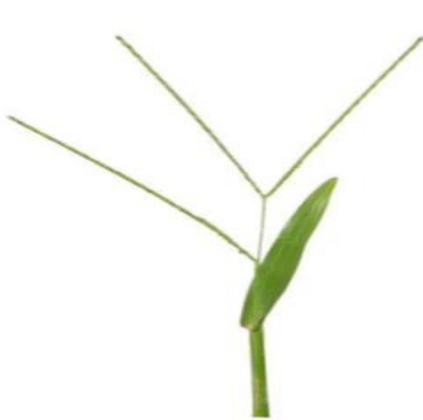
4. Congress gras: *Parthenium hysterophorus* L. Asteraceae



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



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



7. Blanket grass: *Axonopus compressus* (Sw.) Beauv. Poaceae



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



9. Knot grass: *Paspalum distichum* L. Poaceae



10. Sow thistles: *Sonchus* spp. Asteraceae



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



12. Pig weed: *Amaranthus viridis* L (Amaranthaceae)



13. Creeping thistle: *Cirsium arvense* (L.) Scop. (Asteraceae)



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



15. Common sorrel: *Rumex dentatus* L (Polygonaceae)



16. Lambs quarter: *Chenopodium album* L (Chenopodiaceae)



17. Flat sedge: *Cyperus iria* L Cyperaceae



18. Canary grass: *Phalaris minor* (Poaceae)



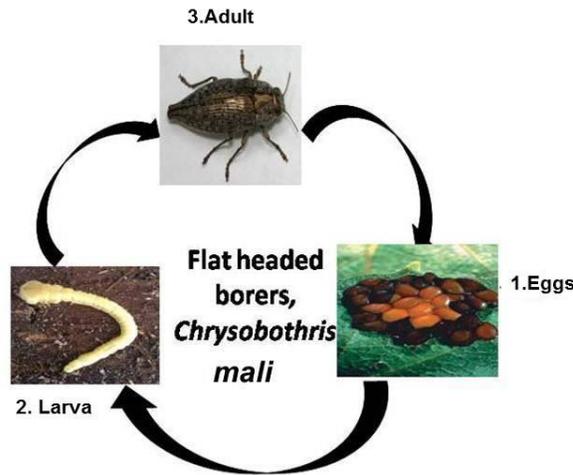
19. Crow foot grass: *Dactyloctenium aegyptium* (L.) Willd. Poaceae

VIII. DESCRIPTION OF INSECT PESTS

Flat headed borers:

Biology: Flat headed borers overwinter as larvae inside the tree, and emerge as adult beetles in June-August (India). Adults lay eggs on bark crevices and the newly hatched larvae immediately bore through the bark to feed in the phloem layer.

Life cycle:



1. file:///C:/Users/Guest/Desktop/135FlatheadedAppletreeBorer%20(1).pdf

2. <http://2.bp.blogspot.com/IXTtFPxmRw/TxQzyucOT4I/AAAAAAAAAbk/UOyWNstZQ1U/s1600/flatheaded+borer.jpg>

3. <http://somethingscrawlinginmyhair.com/wp-content/uploads/2013/02/Dicera.dorsal.jpg>

Damage symptoms:

- Flat headed borers are attracted to diseased or injured limbs of trees, such as those affected by sunburn, scale insects, bacterial canker, or major pruning cuts.
- The beetles lay eggs in the injured area. Eggs hatch and the larvae excavate large caverns just beneath the bark and bore tunnels deep into the heartwood of the tree.
- Excavations are usually filled with finely powdered sawdust. Injury by this borer will cause the sap to flow, and the affected area will appear as a wet spot on the bark. Later, these areas may crack and expose the mines.
- Feeding by flat headed borers may cause a portion of the bark on older trees to die, or it may girdle and kill young trees. This borer can be particularly damaging to new grafts in established orchards

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

2. Hairy caterpillar:

Hairy caterpillar populations will go through cycles in which the populations will increase for several years then decline, and then increase again. Area-wide outbreaks can occur for up to ten years, but generally population densities in localized areas remain high for two to three years.

Biology:

Egg: The eggs are covered with a dense mass of tan or buff-colored hairs. The egg mass is approximately 1.5 inches long and 0.75 inches wide. The eggs are the overwintering stage of the insect. Eggs are attached to trees, houses, or any outdoor objects. The eggs hatch in spring (April) into caterpillars.

Larva: Hairy caterpillars are easy to identify, because they possess characteristics not found on other leaf-feeding caterpillars. They have five pairs of blue dots followed by six pairs of red dots lining on the back side. In addition, they are dark-colored and covered with hairs. Young caterpillars primarily feed during the day whereas the older caterpillars feed at night. When present in large numbers, the older caterpillars feed day and night. Young caterpillars spread to new locations by crawling to the tops of trees, where they spin a silken thread and are caught on wind currents. Older caterpillars are approximately 1.5 to 2.0 inches long. Larval period 66-100 days.

Pupa: In early summer (June to early July), hairy caterpillars enter a pupal or transitional stage. The pupae are dark brown, shell-like cases approximately two inches long and covered with hairs. They are primarily located in sheltered areas such as tree bark crevices or leaf litter.

Adult: Adult moths emerge from the pupae in 10 to 14 days. Females have white to cream-colored wings, a tan body, and a two-inch wingspan. Female moths cannot fly. Females lay between 500 to 1000 eggs in sheltered areas such as underneath the bark of trees. Males, which are smaller than females, with a 1.5-inch wingspan, are dark-brown and have feathery antennae. Both the adult female and male can be identified by the inverted V-shape that points to a dot on the wings. Moth has only one generation per year.

Life cycle:



<http://www.nbair.res.in/insectpests/images/Lymantria-obfuscata1.jpg>

Damage symptom:

- Caterpillars are gregarious and voracious feeders.
- They eat voraciously on leaves at night time.
- Under heavy infestation entire leaf is eaten sparing only hard vein.
- Defoliation of host completely results in failure of fruit formation.

Natural enemies of hairy caterpillar:

Parasitoids: *Telenomus* sp, *Cotesia melanoscela*, *Glyptapantelos* sp, Tachinid (*Pales* sp), *Brachymeria* sp

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

3.Defoliating beetles:

Biology:

Egg: Females lay eggs (app. 60) in August and the eggs develop into larvae after 12 days and are especially attracted to compost and manure piles. The eggs are whitish in appearance and be easily found over the soil.

Larva: They have head and legs. They live on soil surface and have a length of 2 inches. Their life includes three instars of which first and second get completed by autumn and the final in the spring season of second year. At rest they curl into C shape. When the larvae get matured they become 2 inches long and become cream coloured. The body of larvae is stiff with brown hairs at the back of the thorax. These hairs are used for locomotion. They form hollow cells in the soil and pupate there.

Pupa: After a few days it reaches a size of 12-50 mm. They develop by June- July. Its duration extends from 25-27 days. The pupae are of size 15 X 25 mm. They are whitish at initial stages and further change to cream coloured as that of larvae stage. At the maturing stages they slightly shift the colour to green.

Adult: They develop by June- November. They lay their eggs in soil. They are white coloured and large sized approximately range about 12-50 mm in size. They feed on organic matter in soil surfaces. Adults are velvet green in colour. They occupy brownish bands around the edge of the wings and a bright metallic green at the ventral side. Adult females are 17 X 25 mm and adult males are 13 X 22 mm size. At the head portion they are equipped with horn like projections for penetrating into the fruit skin. Adults are tremendous fliers.

Life cycle:



<http://chigaku.ed.gifuu.ac.jp/chigakuhp/html/kyo/seibutsu/doubutsu/09kochu/kogane/akacha/01.JPG>

Damage symptoms:

- The plant part affected mainly includes flower parts like pollen, nectar and petals, fruit and larvae damage roots.

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

4. Peach leaf curl aphid:

Biology:

- Both winged and wingless forms breed parthenogenetically. The nymphal period lasts for 7-9 days. Adults live for 2-3 weeks and produce 8-22 nymphs per day. Entire life cycle takes 22-25 days. It has 12-14 generations per year.

Life cycle:



1,2,3;https://www.google.co.in/search?q=damage+of+tobacco+by+aphid&espv=210&es_sm=122&source=lnms&tbm=isch&sa=X&ei=mc8BU_yMCNGsrAeb5YHIDA&ved=0CAcQ_AUoAQ&b

Damage symptoms:

- Damage is severe because the aphid colonizes young shoots, buds, grafts and young plants.
- Nymphs and adults suck the sap from leaves, shoots and fruits
- Yellowing of leaves
- Wilting of terminal shoots

Favourable conditions:

- Spring-time attacks are the most deleterious.

Natural enemies of leaf curling aphid:

Predators: *Scymnus*, *Chilomenes sexmaculatus*, *Chrysoperla zastrow sillemi* and other coccinellids, Preyingmantids, ladybird beetles, Predatory mite and parasitic wasps

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

5. Apricot brown scale:

Biology:

Egg: The eggs are pink to dark red and they are laid under the adult female scale's wax covering.

Nymph: The first instars are called crawlers. Crawlers are pink and as soon as they hatch, the first instars disperse, find a suitable feeding place and settle. The wax scale females develop through the second and third instars before becoming adults. The wax covering secreted around them gives them a star-like appearance. Nymphs are found on the leaves and twigs

Adult: The adult scales are elliptical, reddish brown with short anal process. The adult female is coated with a thick layer of pinkish-white wax. Inside the wax, the body of the adult female is reddish. Adults are mostly found on twigs and branches. The size of the female is about 2 to 4 mm in length and 1 to 3.5 mm in width. Males are not known in this species



<http://agronomija.rs/wp-content/uploads/2013/12/Lecanium-corni.jpg>
<http://agronomija.rs/2013/sljivina-stitasta-vas-lecanium-corni/>

Damage symptoms:

The direct damage is caused by insertion of stylets into 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 apricot brown scale:

Predator: ladybugs, lacewings and mites

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

6. San Jose-scale:

Pest of 700 different species of fruits, shrubs and ornamental plants. Pest is active from March

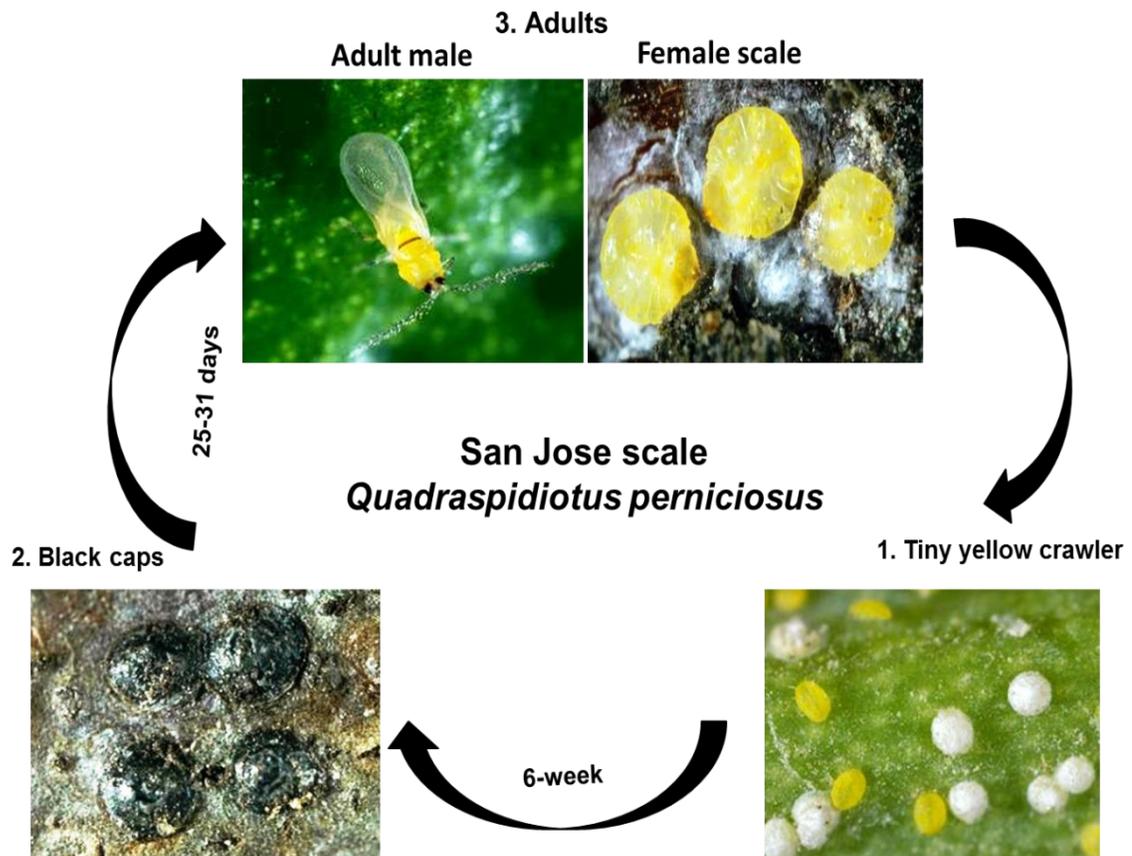
to December. Passes winter black cap stage in tree bark.

Biology:

Nymph: Female San Jose scales give birth to living young ones that emerge from under the edge of the scale covering. Each female gives birth to 200-400 nymphs. These tiny yellow crawlers wander in a random fashion until they find a suitable place to settle. Immediately upon settling, the crawlers insert their mouthparts into the host plant and begin feeding and secreting a white waxy material (white capstage); eventually the waxy covering turns black and is known as the black cap stage. Later the covers turn various shades from gray to black.

Adult: Immature male and female scales are indistinguishable until the first molt. At this time, the male scale covering begins to elongate, while the females remain circular. Males molt a total of four times. Following the final molt, adult male scales emerge from the scale covering as tiny, yellow winged insects. They mate with the females who remain under the scale covering. Female insect body covered with grey scales. Yellow lemon coloured female is visible when covering is lifted. Female scales are very prolific and over a 6-week period can produce approximately 400 young. San Jose scale produce living young ones called crawlers; most other scales produce eggs. Crawlers move around for a short period in search of a suitable place to settle. It takes 25 days for males to mature and 31 days for females. Five to six generations in a year.

Life cycle:



1. <http://www.ipm.ucdavis.edu/PMG/Q/I-HO-QPER-NM.008.html>

Damage symptom:

- Nymph and female scales attack all above ground parts.
- Feeding site turns into a characteristic purplish red colour.
- Initially growth of plant is checked but as scale increases in number plant may die.
- Fruits will have distinct “measles” like spots on the surface.

Natural enemies of san jose scale:

Parasitoids: *Encarsia perniciosi*, *Aphytis diaspidis*

Predators: Coccinellid, *Pharoscymnus flexibilis* & *Chilocorus bijugus*

*For the management refer page no.....

7) Tent caterpillar:

Biology:

Egg: In late spring or early summer, female moths deposit an egg mass encircling small twigs or on tree trunks. Egg masses are present on trees during most of the summer, fall and winter. The adult moth uses a sticky, frothy substance called spumaline as an adhesive to attach eggs to bark or twigs. Spumaline is used as a hard protective covering around the egg mass. Pest inactive from March – May, passes 9 month of year in egg stage. Female lays the eggs in broad bands consisting of 200 to 400 eggs.

Larva: Caterpillars hatch from the eggs in early spring about the time host plants leaf out. The tent caterpillar feed on new leaves, forming small webs within a few days after hatching and enlarging the webs as they grow. The web or tent is most often in a crotch of small limbs, and serves as a refuge for the larvae during the night and during rainy spells. Larvae move from the tents to feed on leaves, so damage can be found for some distance around the web. Tent caterpillars feed in groups, and thus concentrate their defoliation. The tent caterpillars form conspicuous, large webs that are easily recognized. Molting, or skin shedding, occurs several times as the larvae grow. The larvae do not live in these small webs at other times.

Pupa: During the last stage of larval development, which occurs in late spring, larvae wander considerable distances and may feed on a variety of tree, shrubs and even herbs before finding a site for pupation, or cocoon spinning. Cocoons are formed in the web, under bark, in dead plant material on the ground, or inside a rolled leaf. Cocoons are loosely constructed of silk and have a white or yellowish crystalline substance scattered throughout the mass. Cocoons should not be handled since the crystalline substance may cause skin irritation, especially to people with allergies.

Adult: Adult tent caterpillars are brown and yellowish moths with two diagonal markings on the front wings. Caterpillar is progeny of a light reddish brown moth with two whitish stripes running across each of the forewings. Their wingspread is about 1 inch. They are attracted to lights and can occasionally be very abundant. The moths live for only a few days, during which they mate and lay eggs. Adults do not feed. There is only one generation of tent caterpillars per year. Males are short lived and female may survive for 2 to 5 days.

Damage symptom:

- Caterpillars during the night rest at their nest and the day feeding on leaves.
- In severe infestation, the entire plant may be defoliated and subsequently the caterpillar may feed on bark of twigs.
- When severe infestation, 40 -50 per cent plants in orchard may be defoliated producing a poor harvest.



Damage symptom

1. <http://www.slideshare.net/csapramod/integrated-pest-management-12666835#btnNext>

Natural enemies of tent caterpillar:

Parasitoid: Tachnid fly, *Pales* sp

*For the management refer page number.....

8) Blossom thrips:

Biology:

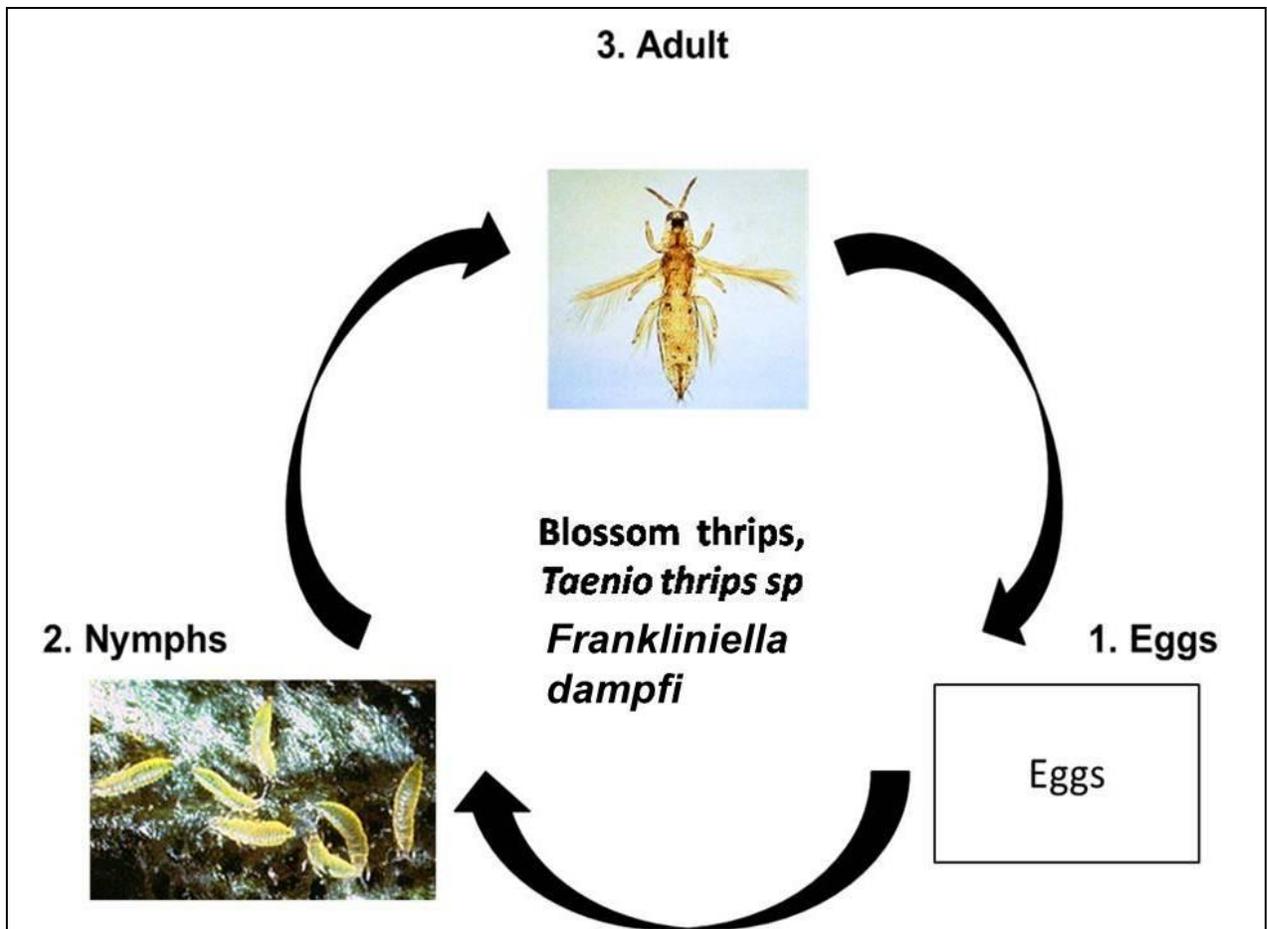
Egg: The eggs of thrips are deposited within plant tissues singly.

Larva and pupa: Larvae have two stages, which feed on plant tissues. The second instar larvae, when mature, fall to ground, where they molt to prepupae and pupae in the soil.

Adult: After emergence, the adults move to the growing parts of the plants such as young leaves, flowers, or young fruits, where they feed and lay eggs (about 200 eggs per female). Adults are usually found on young leaves, while larvae are found on lower or older leaves. At 25°C, the life cycle is completed in approximately 17 days. Adults are winged sucking rasping insects ranging from 5-14 mm in length. Their slender bodies are shiny pale or black with silver stripes.

Life cycle completed in 11-43 days. Produce many generations in a year heaviest damage occur in spring. In colder region, life cycle is longer with fewer generations.

Life cycle:



2. http://entnemdept.ufl.edu/creatures/veg/melon_thrips.htm
 3. http://1.agrifish.dk/thrips_palmi.aspx?ID=13246

Damage symptom:

- Most species of plant feeding thrips, have piercing and sucking mouthparts.
- Both nymphs & adults lacerate all floral parts and delicate and unfolding of leaves of vegetative buds. Consequently brown spots develops
- The surface of the leaf develops a crinkled silvery appearance as a result of damage to cells below the surface.
- Lightly-infested plants show silvery feeding scars on the under surface of leaves, especially alongside the mid rib and veins.
- Heavily-infested plants show silvering and browning of leaves, stunting of young leaves and terminal growth, with fruit scarred and deformed.
- Developing leaves become distorted in the growing tips.
- Heavily infested flowers bears sticky and faded appearance with indication of early senescence.

Natural enemies of blossom thrips:

Predators: Coccinellid, Predatory thrips, Anthocorid bug, *Tropidothorax leucopterus* (Lygaeid bug)

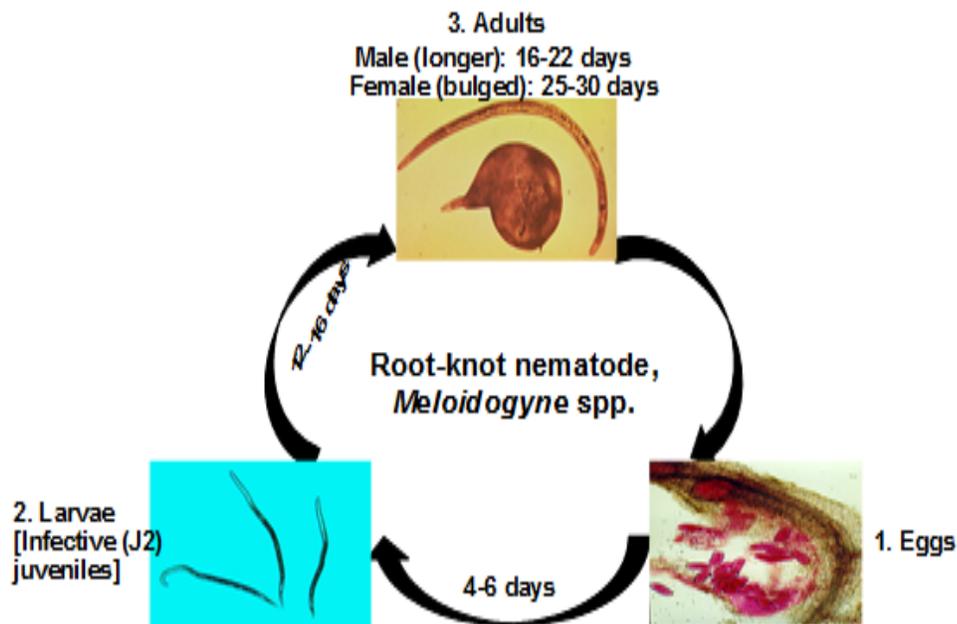
*For the management refer page number.....

Root-knot nematode

- Most species of plant parasitic nematodes have a relatively simple life cycle consisting of the egg, four larval stages and the adult male and female. They are microscopic in size.
- Development of the first stage larvae occurs within the egg where the first moult occurs. Second stage larvae hatch from eggs to find and infect plant roots or in some cases foliar tissues.
- Under suitable environmental conditions, the eggs hatch and new larvae emerge to complete the life cycle within 4 to 8 weeks depending on temperature.
- Nematode development is generally most rapid within an optimal soil temperature range of 70 to 80°F.

Life cycle:

Life stages are microscopic in size



1. <http://keys.lucidcentral.org/keys/sweetpotato/key/Sweetpotato%20Diagnoses/Media/Html/TheProblems/Nematodes/RootKnotNematode/Root-knot.htm>
2. <http://nematology.umd.edu/rootknot.html>
3. http://www.cals.ncsu.edu/pgg/dan_webpage/Introduction/Images/pyroform.htm

Damage symptoms:

- Infected plants in patches in the field
- Formation of galls on host root system is the primary symptom
- Roots branch profusely starting from the gall tissue causing a '**beard root**' symptom

- Infected roots become knobby and knotty
- In severely infected plants the root system is reduced and the rootlets are almost completely absent. The roots are seriously hampered in their function of uptake and transport of water and nutrients
- Plants wilt during the hot part of day, especially under dry conditions and are often stunted
- Seedlings infected in nursery do not normally survive transplanting and those surviving have reduced flowering and fruit production
- Nematode infection predisposes plants to fungal and bacterial root pathogens

Survival and spread:

Primary: Egg masses in infected plant debris and soil or collateral and other hosts like Solonaceous, Malvaceous and Leguminaceous plants act as sources of inoculum

Secondary: Autonomous second stage juveniles that may also be water dispersed

Favourable conditions:

- Loamy light soils

*For management refer to page no-----

Natural Enemies of Peach Insect Pests

Parasitoids

Egg parasitoids



1. *Trichogramma*



2. *Tetrastichus* spp.



3. *Telenomus* spp

Egg-larval parasitoid



4. *Chelonus* spp.

Larval parasitoids



5. *Bracon* spp.



6. *Ichneumon* spp.



7. *Carcelia* spp



8. *Campoletis* spp.



9. *Apanteles* sp



10. *Hyposoter exiquae*



11. *Lespesia* sp.



12. *Microgaster* sp.

Pupal parasitoid



13. *Brachymeria euploea*

Nymphal/larval and adult parasitoids



14. *Chrysocharis* sp



15. *Aphidius*



16. *Diglyphusisaea*



17. *Gronotoma micromorpha*

2 <http://www.pbase.com/image/135529248>

3 <http://baba-insects.blogspot.in/2012/02/telenomus.html>

4 <http://www.nbaii.res.in/Featured%20insects/chelonus.htm>

- 6 <http://www.organicgardeninfo.com/ichneumon-wasp.html>
 7 http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398
 8. <http://www.nbaii.res.in/Featured%20insects/Campoletis.htm>
 9 <http://www.european-lepidopteres.fr/Videos-parasites-Apanteles.html>
 10. <http://www.biologie.uni-hamburg.de/lehre/bza/molnews/jasmon/jasmonate.htm>
 11. <http://www.wright.edu/~john.stireman/research%20interests.html>
 12. <http://www.commanster.eu/commanster/Insects/Bees/SuBees/Microgaster.rufipes.html>
 13 <http://www.nhm.ac.uk/researchcuration/research/projects/chalcidoids/database/media.dsm1?MAGENO=chalc519&VALGENUS=Brachymeria&VALSPECIES=euploaeae>
 14. http://baba-insects.blogspot.in/2012/05/blog-post_21.html
 15 <http://biobee.in/products-and-services/solutions/bio-aphidius/>
 16 <http://www.evergreengrowers.com/diglyphus-isaea-114.html>
 17 http://www.ento.csiro.au/science/Liriomyza_ver3/key/Eucoilidae_Key/Media/Html/ gironotoma_sp.html

Predators



1. Lacewing

2. Ladybird beetle

3. Reduviid bug

4. Spider



5. Robber fly

6. Fire ant

7. Black drongo

8. Common mynah



9. Big-eyed bug

10. Earwig

11. Ground beetle

12. Pentatomid bug



13. Preying mantid

14. *Geocoris* spp.

15. Predatory mite

16. Predatory thrips



17. *Oligota* spp.



18. *Orius* spp.



19. Hover fly



20. Mirid bug



21. *Brosicus punctatus*, 22. *Liogryllus bimaculatus*

5. <http://www.warpedphotosblog.com/robber-fly-and-prey>
6. <http://www.couriermail.com.au/news/queensland/queensland-launched-a-war-against-the-fire-ant-invasion-but-12-years-later-they8217re-still-on-the-march/story-fnihsrf2-1226686256021>
7. <http://nagpurbirds.org/blackdrongo/picture/1639>
8. <http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/>
9. <http://bugguide.net/node/view/598529>
10. <http://www.flickr.com/photos/johnhallmen/2901162091/>
11. <http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/Ground%20Beetle%20-%20Pterostichus%20madidus.html>
12. http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asopinae/Eocanthecona.htm
13. <http://spirit-animals.com/praying-mantis/>
14. <http://nathistoc.bio.uci.edu/hemipt/Dicyphus.htm>
15. <http://www.dragonfli.co.uk/natural-pest-control/natural-enemies>
16. http://biocontrol.ucr.edu/hodde/persea_mite.html
17. http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33
18. [http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_\(cropped\).jpg](http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg)
20. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html
21. <http://en.wikipedia.org/wiki/Brosicus>
22. <http://lapastbknk.blogspot.in/2012/09/ramai-ramai-melirik-budi-daya-jangkrik.html>

IX. DESCRIPTION OF DISEASES

1. Frosty mildew:

Disease symptom:

- Irregularly shaped necrotic lesions were observed on leaves in orchard.
- The main signs and symptoms were expressed as conical white to cream coloured tufts of the causal fungus on the brown lesions, followed by premature defoliation.



Infected fruits

<http://www.paghat.com/images/peaches-junend.jpg>

Favourable condition:

- Relative humidity 100% and temperature is 18°C

*For the management refer page number.....

2. Powdery mildew:

Disease symptom:

- Powdery mildew appears as web like white growth on fruit, leaves, and stems. Older lesions on fruit are scabby.
- yellowing or distortion of leaves, stunted shoot growth, reduced yield
- White powdery residue, which is a mixture of the fungal mycelium and spores on leaves and fruit.



Infected fruit and leaf

<https://utahpests.usu.edu/plugins/work/blogger/17/images/tf-2012/08-27/peach/powderymildew-peach.jpg>

http://pnwhandbooks.org/plantdisease/sites/default/files/imagecache/image_lightbox/images/PeachPowderyMildewCloseLeaves.jpg

Survival and spread:

- *Sphaerotheca pannosa* does not overwinter on peach. Primary inoculum comes from infected roses in spring. Remove nearby roses to reduce sources of inoculum.

Favourable conditions:

- The disease is more under dry condition to the end of the winter months.

*For the management refer page number.....

3.Coryneum blight/shot hole:

Disease symptom:

- Infections on leaves will develop small round purple to tan lesions that are seldom 1/4 of an inch in diameter.
- Infected tissues can become raised and scurfy and will often drop out as the diseased tissue cannot expand with the growing leaf.
- Lesions can be circular to slightly ellipsoid. These diseased leaf tissues will tear along the lesion margins and may hang on at one attached point, but eventually drop out giving the shot hole appearance.
- Infected buds will often develop a canker that can expand to girdle the twig and kill it.
- Often infected buds will show signs of gumming.
- These infected buds are easily recognized as they are often darker than healthy non-infected buds.
- Infection on fruit often appears first as small purple spots that become white to gray lesions, often accompanied by gumming.
- Infections on fruit degrades their quality and often will result in the loss of the fruit.



Infected fruit and leaves

<http://utahpests.usu.edu/plugins/work/blogger/17/images/tf-2012/09-27/coryneum-peach-2012.JPG>
<http://2.bp.blogspot.com/-LHX1tLnsh7w/UpOYetg6 6l/AAAAAAAAAFw8/vocfhnJIVmk/s1600/coryneum+blight+shothole+on+peach.JPG>

Transmission and favourable conditions:

- The fungus survives within infected buds and on twigs. Spores are rain splashed, and disease increases during the rainy season. Fruit infection is favored by wet spring weather.
- Shot hole is often confused in coastal orchards with fog spot. Fog spot, however, does not cause leaf lesions, and the lesions it causes on fruit have a red margin.
- The fungal pathogen can infect a suitable host if moisture is continuous for 24 hours or longer at 36 °F, meaning that infections can occur when host plants are still dormant.

*For the management refer page number.....

4.Silver leaf and canker:

Disease symptom:

- Silver Leaf causes dieback of a tree, branch by branch. Leaves appear silvery and a brown stain is produced in the inner tissue.
- The silvery leaves themselves are not infectious; their abnormal appearance is caused by toxins produced by the fungus in the wood of stems and branches.
- Often the fungus is not visible on the exterior, even on trees showing pronounced silvering.
- However, as the infected branches die, the fungus bursts through the bark and appears at the surface.
- The bracket-like toadstools are often numerous and more or less overlapping, varying in size from 8mm to 5cm across. Silver Leaf is often confused with False Silver Leaf, a common disorder which as the name suggests looks like Silver Leaf at first glance.
- Leaves are silvery, but the effect appears all over the tree rather than progressively along a branch.
- A cut branch reveals that the staining of Silver Leaf disease is absent. The cause of False Silver Leaf is starvation, cold weather or irregular watering.



Infected tree

<http://s3.amazonaws.com/plantvillage/images/pics/000/001/934/large/1436085-SMPT.jpg?1383750600>

Transmission and favourable conditions:

- The airborne spores of this fungus are released from the bracket-shaped fruiting bodies found on dead branches.
- These spores infect healthy branches through wounds, especially pruning cuts.
- The fungus grows down into the wood and kills it, producing a dark stain.
- Spores are released mainly in the autumn and winter months under damp conditions.

*For the management refer page number.....

5.White root rot:

Disease symptom:

- Yellow foliage, shriveled fruit, and little or no new growth are symptoms of

Dematophora root rot.

- Cottony, white mycelia cover small feeder roots, and roots decay. Mycelia grow into soil and upward in the tree, forming small, pale patches under or in bark of major roots, the root crown, and lower trunk, which eventually decay.
- Older mycelium become grey or black. The fungus can also cause a purple canker in wood at the root crown of young trees.
- Diseased trees will defoliate and always die prematurely, usually within 1 to 3 years of initial infection.

Transmission and favourable conditions:

- The fungus persists for years in buried wood and organic matter in soil.
- It spreads to nearby trees through root grafts and can also be moved longer distances in infected soil or wood.
- Spores apparently are not important in causing disease



Infected tree

http://www.clemson.edu/extension/peach/afg_columns/images/afg_sept_05.jpg
<http://www.growables.org/information/LowChillFruit/peach.htm>

*For the management refer page number.....

6. Whisker rot:

Disease symptom:

- *Rhizopus* rot begins much like brown rot as a small, brown, circular spot--but with a detectable difference.
- The skin of *Rhizopus* rot-infected fruit slips readily from the underlying flesh, while the skin of brown-rotted areas is tough and leathery.
- At normal temperatures, the small spots of *Rhizopus* rot enlarge rapidly and can involve the entire fruit in 24 to 48 hours.
- A white, whiskery mold appears on the surface of infected fruits, spreading to nearby fruit and the walls of the container.
- By this time, the fruit tends to leak and to smell like vinegar. Finally, tiny, black, spherical structures are produced on stalks above the white mold.
- Each of these contains thousands of spores that are released to float in the air. At this stage, the mold looks mostly black.
-

Transmission and favourable conditions:

- An injury through the fruit skin must be present for the first infections to occur, and injuries as tiny as the prick of a pin are sufficient.
- In packed fruit or clustered ripe fruit on trees, the fungus can spread over the uninjured skin from an infected nearby fruit and eventually cause a rot.

- High temperatures and humidities favour the rapid growth of the fungus and the decay of the fruit.



Damage symptom

<http://www.agf.gov.bc.ca/cropprot/tfipm/images/rhizopus.jpg>

http://www.caf.wvu.edu/kearneysville/disease_descriptions/disease_images/ab25.jpg

*For the management refer page number.....

7.Collar rot:

Disease symptom:

- Symptom expression depends upon how much of the root or crown tissues are affected and how quickly they are destroyed.
- Generally, crown rots advance rapidly and trees collapse and die soon after the first warm weather of spring.
- Leaves of such trees wilt, dry, and remain attached to the tree. Chronic infections, usually of the roots, cause reduction in growth and early senescence and leaf fall.
- These trees may be unthrifty for several years before succumbing to the disease.
- *Phytophthora* infections typically kill young trees because their root systems and crown areas are small compared to those of mature trees.

Transmission and favourable conditions:

- Periods of 24 hours or more of saturated soil favor *phytophthora* infections.
- Conversely, good soil drainage and more frequent but shorter irrigations reduce the risk of root and crown rot.
- These fungi are more active in soils with high moisture and in temperatures ranging from 55 F- 70 F (13 to 21 C).



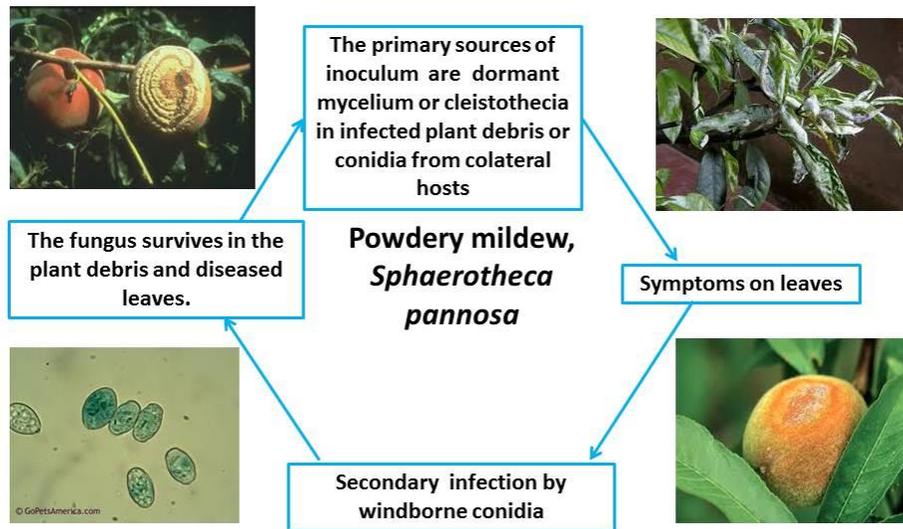
Infected tree

<https://utahpests.usu.edu/admin/images/uploads/UtahPests/tree-fruit-advisory/2007/08-22/phytophthora-bark.jpg>

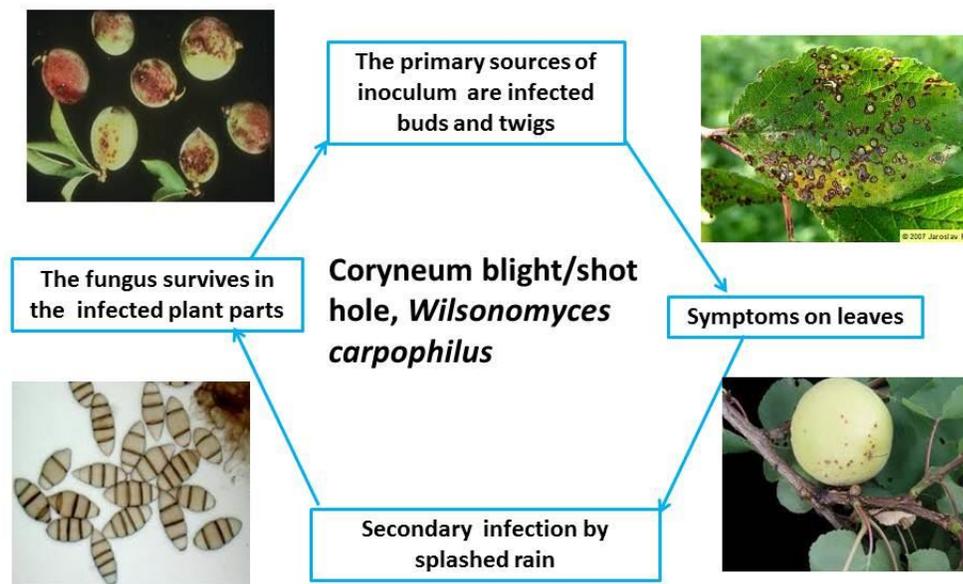
*For the management refer page number.....

Disease cycles:

1. Powdery mildew:



2. Coryneumblight/shot hole:



X. SAFETY MEASURES

A. At the time harvest:

The method of harvesting (hand vs mechanical) can significantly impact upon the composition and post-harvest quality of fruits and vegetables. 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 crops (such as carrot, onion, potato and sweet potato) and some commodities destined for processing (such as processing tomatoes, European plums, and tree nut crops) 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. Field 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 field 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. Post- harvest storage:

Packing and packaging of fruits:

Preparation of produce for market may be done either in the field or at the packinghouse. 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 field 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 hydro-cooling (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 airspaces 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.

XI. 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 field should be kept exposed to sun light at least for 2-3 weeks.	Do not plant or irrigate the field after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
3.	Always treat the seeds with approved chemicals/biopesticides for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with biopesticides/chemicals.
4.	Sow in rows at optimum depths under proper moisture conditions for better establishment.	Do not sow seeds beyond 5-7 cm depth.
5.	Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with

		soil, sand or urea.
6.	Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition	Crops should not be exposed to moisture deficit stress at their critical growth stages.
7.	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
8.	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
9.	Conduct AESA weekly in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.	Do not take any management decision without considering AESA and P: D ratio
10.	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
11.	Release parasitoids only after noticing adult moth catches in the pheromone trap or as per field observation	Do not apply chemical pesticides within seven days of release of parasitoids
12.	In case of pests which are active during night spray recommended biocides/ chemicals at the time of their appearance in the night.	Do not spray pesticides at midday since, most of the insects are not active during this period.
13.	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, scales, thrips, etc.	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.
16	Follow the recommended procedure of trap or border crops technology.	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.

XII. SAFETY PARAMETERS IN PESTICIDE USAGE

S. No.	Pesticide Classification as per insecticide rules Colour of toxicity triangle	WHO classification of hazard	Symptoms poisoning	First Aid measures Treatment of poisoning	Waiting period from last application to harvest (days)
Insecticides					
1	Carbofuran Extremely toxic 	Class I b highly hazardous	Constriction of pupils, salivation, profuse sweating, muscle incoordination, nausea, vomiting, diarrhea, epigastric pain, tightness in chest	Treatment of poisoning: Atropine injection-1-4 mg. repeat 2 mg when symptoms begin to recur (15-16 min interval) excessive salivation- good sign, more atropine needed	-
2	Oxydemeton-methyl Highly toxic 	Class Ib Moderately Hazardous	Severe – diarrhoea, pinpoint and non-reactive pupils, respiratory difficulty, pulmonary edema, cyanosis, loss of sphincter control, convulsions, coma and heart block.	First Aid measures: Atrophine sulphate Treatment of poisoning: For ingestion lavage stomach with 5 % sodium bicarbonate, if not vomiting. For skin contact, wash with soap and water (eyes – wash with isotonic saline). Wear rubber gloves while washing contact areas. In addition to atropine give 2 – PAM (2 – pyridine aldoximemethiodide). 1 g and 0.25g for infants intravenously at slow rate over a period of 5 minutes and administer again periodically as indicated. More than one injection may be required. Avoid morphine, theophylline, aminophyllin, barbiturates Phenothiazines	7 days

XIII. BASIC PRECAUTIONS IN PESTICIDES 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. Equipments

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

F. Precautions for applying pesticides

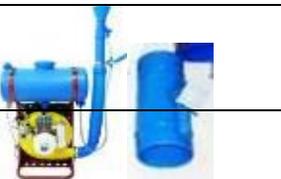
1. Apply only at recommended dose and dilution
2. **Do not** apply on hot sunny day or strong windy condition; **Do not** apply just before the rains and after the rains; **Do not** apply against the windy direction.
3. Emulsifiable concentrate formulations should not be used for spraying with battery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

6. Avoid entry of animals and workers in the field immediately after spraying

G. Disposal

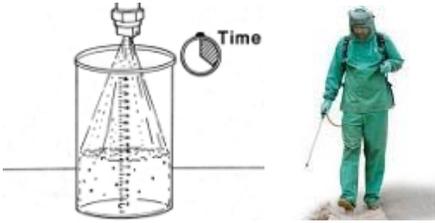
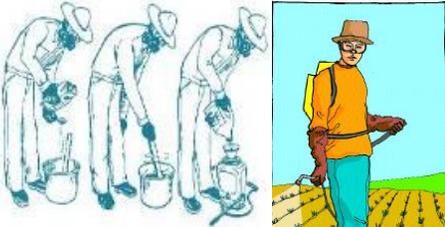
1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

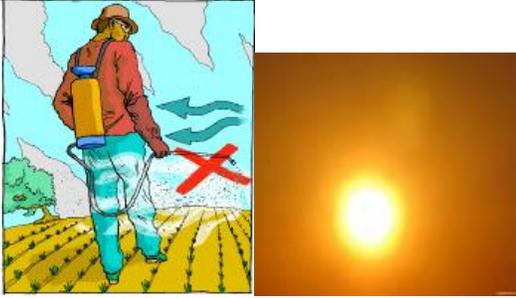
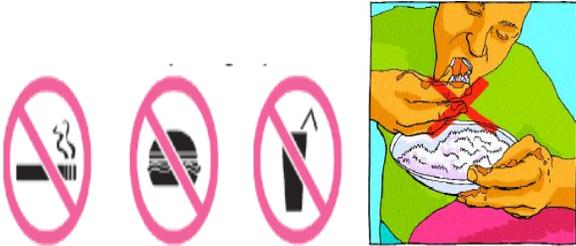
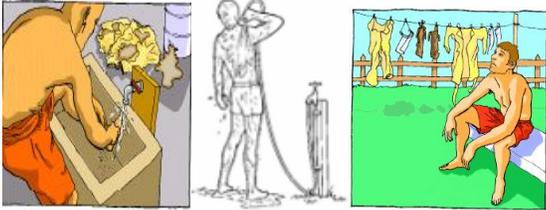
XIV. PESTICIDE APPLICATION TECHNIQUES

		Equipment	
Category A: Stationary, crawling pest/ disease			
Vegetative stage i) for crawling and soil borne pests	Insecticides and fungicides	<ul style="list-style-type: none"> • Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min 	
		<ul style="list-style-type: none"> • Motorized knapsack sprayer or mist blower (Droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle 	
Reproductive stage	Insecticides and fungicides	<ul style="list-style-type: none"> • Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min 	
Category B: Field Flying pest/ airborne pest			
Vegetative stage	Insecticides and fungicides	<ul style="list-style-type: none"> • Motorized knapsack sprayer or mist blower (Droplets of small size) 	

Reproductive stage <i>(Field Pests)</i>		<ul style="list-style-type: none"> • Airblast nozzle • Operating speed: 2/3rd throttle Or • Battery operated low volume sprayer (Droplets of small size) • Spinning disc nozzle 	
Mosquito/ locust and spatial application <i>(migratory Pests)</i>	Insecticides and fungicides	<ul style="list-style-type: none"> • Fogging machine and ENV (Exhaust nozzle vehicle) (Droplets of very small size) • Hot tube nozzle 	
Category C: Weeds			
Post-emergence application	Weedicide	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Trolley mounted low volume sprayer (Droplets of small size) • Battery operated low volume sprayer (Droplets of small size) 	 

XV. 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.	
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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