सत्यमेव जयते

AESA BASED IPM Package

AESA based IPM – Apple

रा व स्वा प्र सं
N I P H M

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Rajendranagar, Hyderabad, Telangana

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NCIPM

National Centre for Integrated Pest Management
LBS Building, IARI Campus, New Delhi

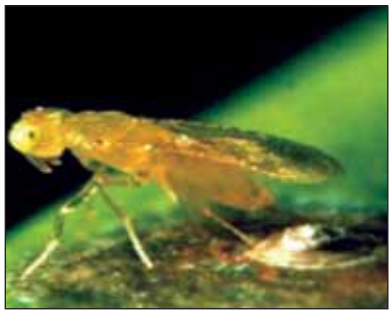
Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

Important Natural Enemies of Apple Insect Pests

Parasitoids

***Trichogramma* spp.**

***Encarsia* sp**



***Aphytis* sp**

Aphelinus mali

***Telenomus* sp**

***Brachymeria* sp**

Predators

Coccinellid

Syrphid fly

Lacewing

Parus major

Predatory thrips

Anthocorid bug

The AESA based IPM - Apple, 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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Front cover picture Model AESA chart for apple

Back cover picture Apple orchard

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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.

Date : 6.3.2014

(Avinash K. Srivastava)

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FOREWORD

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

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

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

(Utpal Kumar Singh)

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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 growing need to integrate AESA based IPM and principles of ecological engineering for pest management.

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

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

(K. SATYAGOPAL)

CONTENTS

AESA BASED IPM PACKAGE FOR APPLE

Apple plant description:

Production: World production of apples was 61,852,452 metric tons (MT) in 2010/2011 season. Apples are produced commercially in 98 countries with the top ten countries in the order of decrease in production are China (48%), USA (6%), Turkey (4%), Italy (3%), Poland (3%), India (3%), France (2%), Iran (2%), Brazil (2%), and Chile (2%).

Apple (*Malus domesticus*; Family: Rosaceae) is a small to medium sized tree with spreading canopy of generally 180-450 cm in cultivation (900 cm in wild). Tree size and shape is heavily dependent on rootstock and training system. Leaves are elliptical with serrate margins, dark green with light pubescence on underside.

Flowers: Petals are white when open, but have reddish-pink undersides when opening, hence the "pink" bloom stage. The ovary is inferior, embedded in the floral cup or hypanthium, containing 5 locules, usually 2 ovules per locule. The inflorescence is a cyme of 4-6 flowers, with the center flower opening first; the central flower is often called the "King bloom", and has the potential to produce a larger fruit than other flowers. Flowers are produced terminally from mixed buds (containing both leaves and flowers) on spurs, or to a lesser extent on long shoots. Spurs form on 2-yr-old and older wood, and generally grow only a fraction of an inch each year.

Pollination: Most cultivars are commercially self-unfruitful. Cross-incompatibility is rare, and most cultivars that bloom at the same time and are not sports of each other will serve as pollinizers, including crab apples. Single apple trees produce some fruit when self-pollinated because most cultivars are not totally self-incompatible. A few cultivars are pollen-sterile. Honey bees are the most effective pollinators.

Fruit: A special fruit type is given to apple and related fruits – the pome. The bulk of the fleshy edible portion derives from the hypanthium or floral cup, not the ovary. Seeds are relatively small and black, and mildly poisonous. Fruiting begins 3-5 years after budding, although a few fruit may be produced in the 2nd year. This varies with rootstock (dwarfing = more precocious) and cultural practices (excessive pruning = delay). Fruit are usually thinned to 1 per spur, with spurs spaced 4-6 inches apart for attainment of marketable size.

I. PESTS

A. Pests of National Significance

1. Insect and mite pests

1.1 San-Jose-scale: *Quadraspidiotus perniciosus* Comstock (Hemiptera: Diaspididae)
1.2 Woolly apple aphid: *Eriosoma lanigerum* Hausman (Hemiptera: Aphididae)
1.3 Apple leaf folder and fruit scrapper: *Archips termias* (Meyrick) (Lepidoptera: Tortricidae)
1.4 Root borer: *Dorysthenes hugelli* Redtenbacher (Coleoptera: Cerambycidae)
1.5 Apple stem borer: *Apriona cinerea* Cheverlot (Coleoptera: Cerambycidae)
1.6 Indian gypsy moth*: Lymantria obfuscate* Walker (Lepidoptera: Lymantridae)
1.7 Blossom thrips: *Thrips flavus* Schrank (Thysanoptera: Thripidae)
1.8 Spider mites: *Tetranychus urticae* Koch (Acarina : Tetranychidae)
1.9 European red mite: *Panonychus ulmi* Koch (Acarina : Tetranychidae)

2. Diseases

2.1 Apple scab: *Venturia inaequalis* (Cooke) Wint
2.2 *Marssonina* leaf blotch (pre mature leaf fall): *Marssonina coronaria* Ellis & Davis
2.3 Black rot and canker: *Botryosphaeria obtuse* Schw.
2.4 Collar rot: *Phytophthora cactorum* Lebert & Cohn
2.5 Powdery mildew: *Podosphaera leucotricha* Ellis & Everh
2.6 Sooty blotch and fly speck: *Gloeodes pomigena* Schwein., *Schizothyrium pomi* (Mont. & Fr.) Arx
2.7 Apple mosaic and other virus diseases: *Apple mosaic virus*, *Apple chlorotic leaf spot virus*

3. Nematode

3.1 Root-knot nematode: *Meloidogyne* spp.

4. Weeds

Broad leaf weeds

4.1 Lambs quarter: *Chenopodium album* L. (Chenopodiaceae)
4.2 Sweet clover: *Melilotus indica* (L.) All. (Fabaceae)
4.3 Fine leaf fumitory: *Fumaria parviflora* Lam. (Fumariaceae)
4.4 Corn spurry: *Spergula arvensis* L. (Caryophyllaceae)
4.5 Goat weed: *Ageratum conyzoides* L. (Asteraceae)
4.6 Creeping wood sorrel: *Oxalis corniculata* L. (Oxalidaceae)
4.7 Musk rose/rosehip: *Rosa moschata* Herrm. (Rosaceae)
4. 8 Brambles: *Rubus* spp. (Rosaceae)
4. 9 European barberry: *Berberis* spp. (Berberidaceae)
4. 10 Garden spurge: *Euphorbia hirta* L. (Euphorbiaceae)
4. 11 Lantana: *Lantana camara* L. (Verbenaceae)
4. 12 Common sorrel: *Rumex* spp. (Polygonaceae)
4.13 Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)

Grassy weeds

4.14 Canary grass: *Phalaris minor* Retz. (Poaceae)
4.15 Bermuda grass: *Cynodon dactylon (*Poaceae)

Sedges

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

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

B. Pests of Regional Significance

1. Insect pests

1.1 Apple fruit moth: *Argyresthia conjugella* Zeller (Lepidoptera: Yponomeutidae) (Himachal Pradesh)

1.2 Codling moth: *Cydia pomonella* Linnaeus (Lepidoptera:Tortricidae) (Jammu & Kashmir, Himachal Pradesh)

1.3 Tent caterpillar: *Malacosoma indica* Walker (Lepidoptera: Lasiocampidae) (Jammu & Kashmir)

1.4 Apple maggot: *Rhagoletis pomonella* (Walsh) (Diptera: Tephritidae)

2. Diseases

2.1 *Alternaria* leaf spot/blight: *Alternaria alternata* f. sp. *mali* (Fr.) Keissl. (Rajasthan, Himachal Pradesh)

2.2 Core rot: *Alternaria alternata* (Fr.) Keissl., *Trichothecium roseum* (Pers.) Link , *Fusarium* spp. etc.

2.3 Brown rot: *Monilinia* spp. (Delhi)

2.4 White root rot: *Rosellinia necatrix* Berl. ex Prill.

2.5 Seedling blight: *Sclerotium rolfsii* Sacc.

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 analyse field situations with regard to pests, defenders, soil conditions, plant health, the influence of climatic factors and their inter-relationship for growing healthy crop. Such a critical analysis of the field situations will help in taking appropriate decision on management practices. The basic componenets of AESA are:

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

Principles of AESA based IPM:

Grow a healthy crop

- Select a variety resistant/tolerant to major pests
- Treat the seeds/seedlings/planting material with recommended pesticides especially biopesticides
- Select healthy seeds/seedlings/planting material
- Follow proper spacing
- Soil health improvement (mulching and green manuring wherever applicable)
- Nutrient management especially organic manures and biofertilizers based on the soil test results. If the dosage of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dosage is too low, the crop growth is retarded. So, the farmers should apply an adequate amount for best results. The phosphatic fertilizers should not be applied each and every season as the residual phosphate of the previous season will be available for the current season also.
- Proper irrigation

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

Farmers should

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

Plant compensation ability

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

Understand and conserve defenders

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

Insect zoo

In orchard various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are

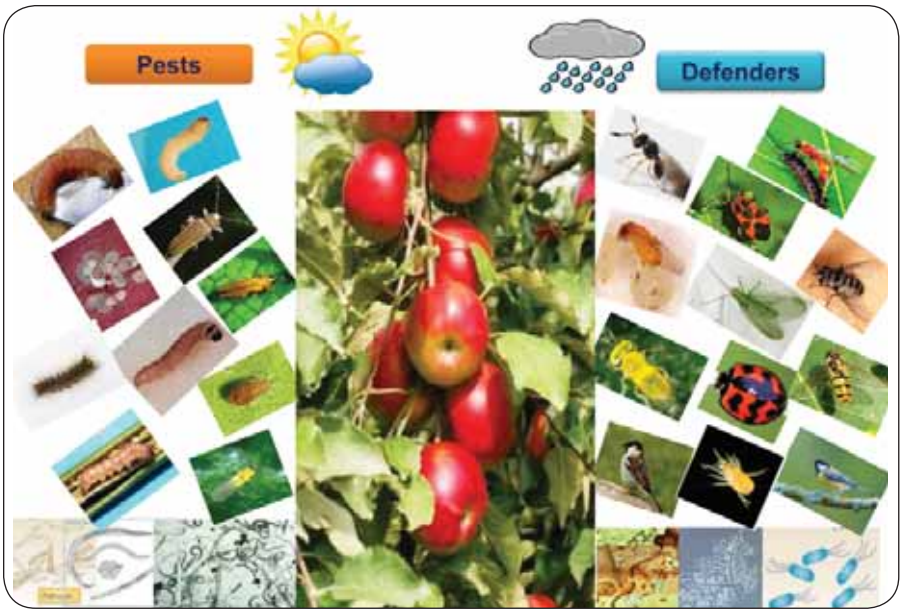
not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in orchard. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial and harmful insects. In this method, unfamiliar/unknown predators are collected in plastic containers with brush from the orchard and brought to a place for study. Each predator is placed inside a plastic bottle together with parts of the plant and some known insect pests. Insects in the bottle are observed for certain time and determined whether the test insect is a pest (feeds on plant) or a predator (feeds on other insects).

Pest: Defender ratio (P: D ratio):

Identifying the number of pests and beneficial insects helps the farmers to make appropriate pest management decisions. Sweep net, visual counts etc. can be adopted to arrive at the numbers of pests and defenders. The P: D ratio can vary depending on the feeding potential of natural enemy as well as the type of pest. The natural enemies of apple pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens. The important natural enemies of apple pests are given in ecological engineering table on page 13.

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.

Feeding/egg laying potential of different parasitoids/predators

Predators/ Parasitoids	Feeding potential/ Egg laying capacity
 Ladybird beetle	Predatory rate of adult coccinellid on aphids is 50 aphids per day
 Hover fly	1st instar larva can consume 15-19 aphids/day. 2nd instar larva can consume 45-52 aphids/day. 3rd instar larva can consume 80-90 aphids/day. In total life cycle they can consume approx. 400 aphids.
 Green lacewing	Each larva can consume 100 aphids, 329 pupae of whitefly and 288 nymphs of jassids during entire larval period
 Spider	5 big larvae/adults per day

Predators/ Parasitoids	Feeding potential/ Egg laying capacity
 Predatory mite	Predatory rate of adult is 20-35 phytophagous mites/female/day http://www.eduwebs.org/bugs/predatory_mites.htm
 *Bracon hebetor*	Egg laying capacity is 100-200 eggs/ female. 1-8 eggs/larva
 *Trichogramma* sp	Egg laying capacity is 20-200 eggs/ female.

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 trees/acre randomly. Observe the plant height, number of branches, crop stage, deficiency symptoms etc.

- Collect 5-6 samples/tree (fruits/leaves/flowers/inflorescence/stem bark/roots/soil/insects) i.e. one sample from top, four samples from all the four sides (North, South, East, West) and one from bottom/soil. Observe keenly each of these samples and record your observations:
    - Pests: Observe and count pests.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe and identify any visible disease symptoms and severity.
    - Weeds: Observe weeds in the field and their intensity.
    - Water: Observe the water situation of the field.
    - Weather: Observe the weather condition.
- While walking in the orchard, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the orchard situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a tree representing the orchard situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make an orchard management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on what field management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording

Farmers should record data in a notebook and drawing on a chart. Keeping records of what has happened help us making an analysis and draw conclusions

Data to be recorded

- **Plant growth (weekly)** : Height of plant ; Number of leaves
- **Crop situation (e.g. for AESA)** : Plant health ; Pests, diseases, weeds ; Natural enemies ; Soil 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 orchard?
- What crop management aspect is most important at this moment?
- Is there a big change in orchard situation compared to last visit? What kind of change?
- Is there any serious pest or disease outbreak?
- What is the situation of the beneficial insects?
- Is there a balance in the orchard between pests and defenders?
- Were you able to identify all pests and diseases?
- Do you think the orchard 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 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.

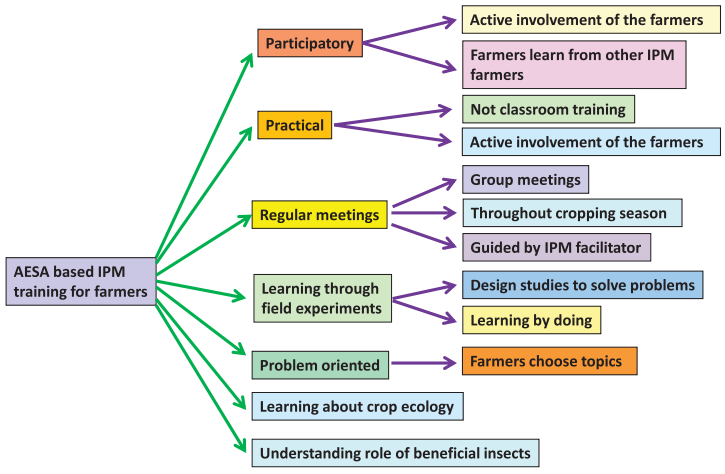
AESA and farmer field school (FFS)

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 this exercise. However, other farmers also can do field scouting in their own orchards at regular intervals to monitor the major pest situation.

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

Sampling in fruit crops:

In orchard, select five trees such that four are from four corners and one from the centre of the orchard. Two rows of trees alongside of boundary of orchard in all directions should not be selected for observations. The tree selection for pest observations during each weekly visit should be random. In each of the selected trees, the observations are to be made from four directions viz., East, South, West and North (make it a habit to start at East direction of a tree and follow anticlockwise direction). Use either beat or tap method for taking observations on pests samples.

For insect pests:

Woolly apple aphids, San Jose scales, and mites: Count and record the number of both nymphs and adults on five randomly selected leaves per plant.

Blossom thrips: Count and record the number of nymphs and adults of thrips present on five terminal leaves per plant (tapping method also can be used to count thrips).

***Apriona, Dorysthenes, Lymantria*:** Number of larvae of *Apriona* (stem borer), *Dorysthenes* (root borer) and *Lymantria* (foliage feeder) on individual plants should be counted using a suitable procedure.

For diseases:

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

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

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

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

For weeds:

The goal of weed scouting is to assess the infestation level of known weeds as pests and detect new weeds that may be at very low levels so that action can be taken to control or prevent them from becoming an economic concern. In some cases, early detection of a weed can make eradication possible.

Begin scouting as soon as weeds appear in the field and continue until freeze-up. Record stages of growth of all the weeds and the number of each weed species/square metre.

Frequently, all scouting patterns must be used since weed habitat can be very species specific. Each field usually requires a pattern for a uniform sample and samples in low areas and field margins or ditches to assess immediate or future risk from problem weeds left uncontrolled. Detailed counts of the number of weeds per square metre provide the ideal record of a weed problem. If this is not possible, the following rating system may be useful:

Group I - Wild oats, stinkweed, wild buckwheat, lamb's-quarters, redroot pigweed, hemp-nettle, smartweed, rape, wild mustard, Russian thistle, tartary buckwheat, cow cockle, shepherd's-purse, kochia.

Light	Medium	Heavy
1-10 plants/m^2	10-30 plants/m^2	More than 30 plants/m^2

Group II - Chickweed, green foxtail, corn spurry.

Light	Medium	Heavy
1-20 plants/m^2	20-70 plants/m^2	70 or over plants/m^2

Group III - Canada thistle, sow-thistle, dandelion

Light	Medium	Heavy
1-2 plants/m^2	2-10 plants/m^2	10 or over plants/m^2

These definitions can be used to help standardize ratings. With experience, infestations can be visually estimated. These groupings are based on the competitive characteristics and life cycles of these weeds.

C. Surveillance through pheromone trap catches for *Cydia, Argyresthia, Archips, Apriona, Dorysthenes*, and *Lymantria*:

Pheromone traps @ 4-5/acre have to be installed, if available, for *Cydia, Argyresthia, Archips, Apriona, Dorysthenes* and *Lymantria.* Install the traps for each species separated by a distance of >75 feet. Fix the traps to the supporting pole at the height of mid canopy. Change of lures should be made at 2-3 week interval (regular interval) or based on loss of lure efficacy. During each week of surveillance, the number of moths/trap/week should be counted and recorded year round. The trapped moths should be removed and destroyed after each recording.

D. Yellow/blue water pan and sticky traps

Set up yellow water pan/sticky traps for monitoring woolly apple aphids and blue water pan/sticky traps for blossom thrips at the height of mid canopy @ 4-5 traps/acre. Locally available empty tins can be painted yellow/blue and coated with grease/Vaseline/castor oil on outer surface may also be used.

E. Light traps

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

F. Nematode extraction

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

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

Natural enemies may require

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

Ecological engineering for pest management – Above ground:

- Raise the flowering plants / compatible cash crops along the orchard border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population
- Grow flowering plants on the internal bunds inside the orchard
- Not to uproot weed plants those are growing naturally like *Tridax procumbens, Ageratum* sp, *Alternanthera* sp etc. which act as nectar source for natural enemies,
- Not to apply broad spectrum chemical pesticides, when the P: D ratio is favourable. The plant compensation ability should also be considered before applying chemical pesticides.

Ecological engineering for pest management – Below ground:

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

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

Good insectary plants belonging to Leguminaceae, Graminaceae, Brassicaceae, Asteraceae etc. families


Mustard

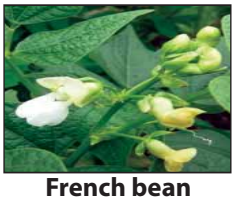

Sunflower


Buckwheat


Carrot


Alfalfa


Marigold


French bean


Maize/Corn


Cowpea


Spearmint

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

Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators

Biodiversity of natural enemies: Spiders

Flowering plants that attract natural enemies/repel pests

Natural enemies	Attractant/repellent/trap plants
Codling moth :	
Parasitoids: *Trichogramma embryophagum* (egg), *T. cacoeciaepallidum* (egg) etc. **Predators:** Birds (grey tit, *Parus major* and *Passer domesticus*)	• Nectar rich plants with small flowers i.e. anise, caraway, dill, parsley, mustard, sunflower, buckwheat (Braconid wasp and other wasps)
San Jose scale :	
Parasitoids: *Encarsia perniciosi* and *Aphytis* sp (nymphal and adult) etc. **Predators:** Coccinellid (*Chilocorus infernalis*, *Pharoscymnus flexibilis)* etc.	• Sunflower family, carrot family, buckwheat
Woolly apple aphid :	
Parasitoids: *Aphelinus mali (*nymphal and adult) **Predators:** Coccinellids (*Coccinella septempunctata*, *Menochilus sexmaculatus*), lacewings (*Chrysoperla zastrowi sillemi*), syrphid flies (*Syrphus confrator*, *Episyrphus balteatus*) etc.	• Attractant plants: Carrot family, sunflower family, buckwheat, alfalfa, cosmos (minute pirate bug and lacewing, syrphids, coccinellids) etc.
European red mite :	
Predators: Lacewings (*Chrysoperla zastrowi sillemi*), predatory mites (*Amblyseius fallacies* and *Zitzellia mali*), *Coccinellids* (*Stethorus punctum*) etc.	• Carrot family, bishop's weed (spider mite destroyer) • Sunflower family, marigold, buckwheat, spearmint (ladybird beetle) • Carrot family, sunflower family, buckwheat, alfalfa, shrubs (minute pirate bug) • French bean (predatory mites) Berseem clover, sub-terranean clovers (big eyed bugs)
Tent caterpillar :	
Parasitoids: Tachinid fly etc.	
Indian gypsy moth :	
Parasitoids: *Anastatuis kashmiriensis* (egg), *Telenomus* sp (egg), *Cotesia melanoscela* (larval), *Glyptapantelos indiensis* (larval), *G. flevicoxis* (larval), tachinid (*Pales* sp) (larval), *Brachymeria intermedia* (pupal), *B. lasus* (pupal) etc.	• Attractant plants: Carrot family, sunflower family, buckwheat, alfalfa, corn, shrubs (minute pirate bug and lacewing) • Nectar rich plants with small flowers i.e. anise, caraway, dill, parsley, mustard, sunflower, buckwheat and cowpea (Braconid wasp)
Blossom thrips :	
Predators: antlion, predatory thrips, coccinellids, anthocorids, lygaeids etc.	• French bean (predatory thrips) • Carrot family, sunflower family, marigold, buckwheat, spearmint (syrphid fly, lacewing, minute pirate bug, damsel bug and ladybird beetle)
Apple maggot :	
Parasitoids: *Diachasmimorpha* sp,	

A. Resistant/tolerant varieties

Scab resistant	Prima, Priscilla, Sir Prize, Jonafree, Florina, Macfree, Nova Easy Grow, Coop 12, Coop 13 (Redfree), Nova Mac, Liberty, Freedom, Firdous, Shireen, Emra, Red Free, Ambstraking, Ambroyal, Ambrich and Ambred
Powdery mildew	Maharaji Chunth, Golden Chinese (apple cultivars), Yantarka Altaskya, Dolgoe (crab apple cultivars)

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

IV. CROP STAGE-WISE IPM

Management	Activity
Pre planting*	
Nutrients	• Pits of 1 meter cube are dug in square system during summer season and kept open for controlling soil born pests. • Soils of different horizons should be analysed to know the inherent fertility and soil condition of the field. • The fertilizer dose should be based upon soil fertility, type of soil, kind and age of trees, cultural practices, climate and crop load. • Application of manures and fertilizers start right from planting of an orchard at the time of filling of pits. • In an orchard of optimal fertility, N, P and K may be applied in the ratio 70: 30: 70 g/year/tree.
Weeds	• Deep ploughing followed by cross harrowing the field before planting to destroy existing weeds in the field.
Planting*	
Nutrients	• Pits should be filled with a mixture of pond silt, red soil and farmyard manure. • Two-three kilos of bone meal or super phosphate per pit should be applied.
Weeds	• Adopt intercropping and recommended agronomic practices.
Pests, nematode, soil borne pathogens and other diseases	• Grow resistant/tolerant varieties viz.,: Emra, Red Free, Ambstraking, Ambroyal, Ambrich and Ambred in the endemic areas for controlling scab and Maharaji Chunth and Golden Chinese (apple cultivars),Yantarka Altaskya, Dolgoe (crab apple cultivars) for controlling powdery mildew disease
Scab and powdery mildew	• Use healthy infestation-free plants. • Aphids usually spread through infested stocks, avoid planting infested stocks.
Woolly apple aphid	• Use resistant root-stocks belonging to Malling Merton series. • Ecological engineering with buckwheat attracts parasitoid, *Aphelinus mali*
* Apply *Trichoderma* spp. and *Pseudomonas fluorescens* as root stock/planting material, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).	
Vegetative stage 1st year onwards	
Nutrients	• The dose should be stabilized (700: 350: 700 g N: P: K/tree) after 10 years of age. These applications may be supplemented with FYM @10 Kg per tree in the first year and increase as the age of the tree with a maximum of 100 Kg. • In off years, the fertilizer dose of NPK may be reduced to 500 g, 250 g and 400 g, respectively. In bearing trees, FYM along with P and K should be applied during December-January. Nitrogen is applied during February-March, 2 to

	3 weeks before bud break. The Nitrogen can be applied in two split doses, first dose 2-3 weeks before bud break and the second one, one month after flowering. • The fertilizers should be broadcasted in the tree basins 30 cm away from the tree trunk up to the canopy drip line and mixed well in the soil.
Weeds	**Cultural control:** • Regular weeding should be done in the tree basin. • Regular mowing of weeds between tree rows should be done to check the weeds. • Ploughing between tree rows. **Chemical control:** • Apply paraquat dichloride 24% SL @ 1300 ml in 280-400 l of water/acre as post-emergence and direct between rows at 2-3 leaf stage of weeds to control grasses and broad-leaved weeds in the orchards.
White rot/root rot**	**Chemical control:** • For root rot, make 5-10 trunk injections @ 2 g/tree
Reproductive	
Nutrients	• In case of any nutritional deficiency observed at flowering and fruiting, it should be corrected immediately by foliar application of that particular nutrient.
Weeds	• Keep the orchard weed free by adopting cultural practices as stated in vegetative stage.
Tight cluster stage	
San Jose scale	**Cultural control:** • Grow attractant flowers for natural enemies: viz., sunflower family, carrot family plants, buckwheat **Mechanical control:** • Pruning of infested branches and twigs • Collection and destruction of pruned infested material. **Biological control:** • Parasitoids such as *Encarsia perniciosi* and *Aphytis diaspidis* cause effective parasitization. • Coccinellid predators such as *Chilocorus infernalis, Chilocorus rubidus*, *Pharoscymnus flexibilis* check the pest infestation to some extent. **Chemical control:** • Spray malathion 50% EC @ 600-800 ml in 600-800 l of water/acre or oxydemetom-methyl 25% EC @ 1680-2240 ml in 600-800 l of water/acre or lime sulphur 22% SC @ 800-2000 ml/acre (use 2% pre-blossom and 1% post-blossom in conventional sprayers)
Phytophagous apple mites	**Biological control:** • Conserve predators such as *Chrysoperla zastrowi sillemi*, anthocorid bug, predatory mite (*Amblyseius fallacis*), coccinellid (*Stethorus punctum*) etc. **Chemical control:** • Spray bifenthrin 8% SC @ 200 ml in 160 l of water/acre or fenazaquin 10% EC @ 160 ml in 400 l of water/acre or hexythiozox 5.45% W/W EC @ 0.4 ml/l of water and use spray fluid of 10 l/tree or malathion 50% EC @ 600-800 ml in 600-800 l of water/acre or propargite 57% EC @ 0.5-1 ml/l of water and use spray fluid of 10 l/tree or spiromesifen 22.9% SC @ 120 ml in 400 l of water/acre

Stem borer	**Cultural control:** • Keep the orchard healthy following good agricultural practices. • Kill the stem borer larvae by inserting a flexible wire inside the hole and plug the hole with the cotton wick soaked in petrol and seal it with mud. **Mechanical control:** • Prune and burn all attacked shoot and branches during winter. **Chemical control:** • Spray dimethoate 30% EC @ 594-792 ml in 600-800 l of water/acre
Lepidopteran caterpillars (Indian gypsy moth)	**Mechanical control:** • Egg mass covered with yellowish hair which is easily visible should be hunted and destroyed (between August-March). • Put a burlap at the base of tree trunk to provide shelter for larvae during day time and examine frequently to destroy the larvae underneath the burlap
Scab	**Cultural control:** • Clean cultivation, collection and destruction of fallen leaves and pruned materials in winter to prevent the sexual cycle. • Collect and burn the infected plant debris • Follow proper trimming and pruning of twigs and branches followed by burning. • Apply urea (2 Kg/acre at pre-leaf fall stage spring and dolomitic lime (2.5 ton/acre) in autumn over fallen leaves to accelerate decomposition. **Chemical control:** • Spray bitertanol 25% WP @ 0.75 g/l of water and use spray fluid of 10 l/tree or captan 50% WP @ 1000 g in 300-400 l of water/acre or captan 75% WP @ 666.8 g/acre in water required to distribute 10-20 l/tree or carbendazim 50% WP @ 1000 g/acre and 10 l spray fluid/tree or chlorothalonil 75% WP@ 200 g in 100 l of water and 10 l of spray fluid/tree (recommended for use immediately after dormancy up to greentip stage) or difenaconazole 25 EC @ 15 ml in 100 l of water (spray volume depending upon the tree size and spray equipment used) or dithianan 75% WP @ 720 g in 920 l of water/acre or dodine 65% WP @ 0.75 g/l and use spray fluid of 10 l of spray fluid/tree or fenarimol 12% EC @ 40 ml in 100 l of water and 10 l of spray fluid/tree or flusilazole 40% EC @ 0.1 ml/l of water and 10 l of spray fluid/acre or hexaconazole 5% EC @ 50 ml/100 l of water (spray volume depending upon the tree size and spray equipment used) or mancozeb 75% WG @ 3 g/l of water and use spray fluid of 10 l/tree or myclobutanil 10% WP @ 0.4 ml/l of water and use spray fluid of 10 l/tree or penconazole 10% EC @ 50 ml in 100 l of water and 10 l of spray fluid/tree or sulphur 80% WG @ 750-1000 g in 300-400 l of water/acre or thiophanate methyl 70% WP @ 286 g in 300-400 l of water/acre or zineb 75% WP @ 600-800 g in 300-400 l of water/acre or ziram 80% WP @ 600-800 g in 300-400 l of water/acre
Pink bud stage	
Scab and core rot	• Same as above
Powdery mildew	**Cultural control:** • Sanitation of orchard • Resistant varieties • Removal of over wintering infected terminals by pruning (6-8" below the infection) is good for reducing the inoculum. • Practice trimming and pruning to reduce the humidity.

	Chemical control: • Spray aureofungin 46.15% w/v SP @ 0.5 ml/l of water and use spray fluid of 10 l/tree or dinocap 48% EC @ 3 ml/l of water and 10 l of spray fluid/tree or lime sulphur 22% SC @ 800-2000 ml/acre (use 2% pre-blossom and 1% post-blossom in conventional sprayers) or sulphur 80% WP @ 1000-2000 g in 300-400 l of water/acre
Mites, blossom thrips and Lepidopteran insects	**Cultural control:** • Apart from aforesaid practices, regular monitoring is mandatory for moths, • For codling moth: Use synthetic codlemone for mating disruption at a height of 6-8 feet or Dispensers should be deployed within 1 meter of the top of the canopy prior to spring emergence during late may to 3rd week of July. . **Biological control:** • Conserve coccinellids, anthocorids, lygaeid, predatory thrips etc. **Chemical control:** • For thrips, spray thiacloprid 21.7% SC @ 0.4-0.5 ml/l of water (spray fluid depends on the size of tree) • For mites, same as above
Petal fall/pea stage	
Scab, powdery mildew and *Alternaria* blight	• Same as above
San Jose scale, mites	• Same as above
Fruit development (Walnut size)	
Scab, *Marssonina* blotch and *Alternaria* blight	• Same as above
Phytophagous-mites	• Same as above
Fruit development (20 days after walnut stage)	
Woolly apple aphid	**Biological control:** • Conserve parasitoids such as *Aphelinus mali* • Conserve predators such as *Coccinella septumpunctata, Chrysoperla zastrowi sillemi*, *Menochilus sexmaculatus, Syrphus confrator* **Chemical control:** • Apply carbofuran 3% CG @ 166 g/tree or phorate 10% CG 100-150 g/tree or spray chlorpyrifos 20% EC @ 1500-2000 ml in 600-800 l of water/acre or malathion 50% EC @ 600-800 ml in 600-800 l of water/acre or oxydemetom-methyl 25% EC @ 600-800 ml in 600-800 l of water/acre or quinalphos 25% EC @ 1200-1600 ml in 200-400 l of water/acre
Scab, *Marssonina* blotch and *Alternaria* blight	• Same as above
Phytophagous-mites,	• Same as above.
Fruit development (20 days after above stage)	
Phytophagous-mites,	• Same as above.
Pre-harvest stage (20-25 days before harvest)	

Fruit scrapping caterpillar, other caterpillars, and mites	**Cultural control:** • Regular monitoring **Chemical control:** • Pre-harvest spray should be conducted 25 days before harvesting. • For mites, same as above.
Scab, *Marssonina* blotch, *Alternaria* blight, Sooty blotch and fly speck, Bitter rot and brown rot	• Cultural practices same as above **Chemical control:** • For sooty blotch, spray mancozeb 75% WG @ 3 g/l of water and use spray fluid of 10 l of spray fluid/tree • For fly speck, spray captan 75% WP @ 666.8 g/acre in water required to distribute 10-20 l/tree • For bitter rot, spray captan 75% WP @ 666.8 g/acre in water required to distribute 10-20 l/tree or difenoconazole 25 EC @ 15 ml in 100 l of water (spray volume depending upon the tree size and spray equipment used)
Post-harvest	
Scab, other diseases	• Same as above
Bitter rot, Brown rot	• Same as above
Woolly apple aphid	• Same as above
Dormant stage	
Scab and other foliar diseases	• Same as above
Black rot/Canker	**Mechanical control:** • Proper pruning should be done to avoid mechanical injury. **Biological control:** • Use *Trichoderma viride* or *T. harzianum* with neem cake
White rot/Root rot	**Chemical control:** • For root rot, make 5-10 trunk injections @ 2 g/tree
San Jose scale	• Same as above
Woolly apple aphid	• Same as above
Stem borer	• Same as above

- For root borer management install light traps @ 1 trap/acre and operate between 6 and 10 pm in the field to trap adults from May end to July.

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. NUTRITIONAL/PHYSIOLOGICAL DISORDERS


Figure 1

Necrotic leaf blotch - The disorder is characterized by the development of necrotic blotches or irregular areas of dead tissue in mature Leaves. A hormonal imbalance may be involved because symptoms are enhanced by gibberellins and reduced by abscisic acid. Foliar applications of zinc oxide also have been effective in reducing the severity of the disorder.

Lenticel breakdown – it is a physiological disorder affecting the surface of apples. Before the packing, there is little evidence of a problem; however, within a few days of packing, symptoms appear as dark brown pits in the fruit skin around the lenticels, reducing marketable yield. It usually occurs on the less sun-exposed side and along color margins. Early symptoms appear as small dimples. As firmness decreases, pits grow in size and depth. The flesh is not deeply affected except for a possible cavity directly under the pits. Generally, where symptom expression is low, relative calcium content in the peel is high and potassium content is low resulting in lower combined rations of [((K+Mg)/Ca) + (N/Ca)]. In contrast, where symptom expression is high, relative calcium content is generally lower and potassium higher.

VII. DESCRIPTION OF COMMON WEEDS

Broad leaf weeds

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

It is an annual weed found in agricultural fields. It is a polymorphous, non-aromatic, erect herb**,** 0.3-3 m tall with angled stems that are often striped green, red or purple. Leaves are variable in size and shape, lower leaves are toothed or irregularly lobes, 10-15 cm long, with petioles often as long as leaf blades. Flowers are green, borne in clusters forming a compact or loosely panicled axillary spike. Fruits utricle, seeds round, compressed, black and shining.

2. Sweet clover: *Melilotus indica* (L.) All. (Fabaceae)

It is a sweet-smelling erect herb, up to 10-60 cm high with hairless, spreading or erect stem. Leaves odd-1-pinnate; leaflets 1-2.5 cm, inverted, lance-shaped to wedge-shaped, generally sharply toothed on the broader part. Flowers yellow; appear in slender, compact racemes that are 1-2 inches in length. Plant bear papery, small, round, 2-3 mm long, yellow or grey, reticulately wrinkled and slightly hairy pods. Seeds 2 mm long; 1.5 mm wide; broadly oval, one side plane, the other side rounded; yellowish green; roughened by minute tubercles.

3. Fine leaf fumitory: *Fumaria parviflora* Lam. (Fumariaceae)

Annual herb, up to 60 cm tall. Stem Slender, much branched and succulent. Leaves 2-3 pinnatisect, 2-5 cm long, segments linear oblanceolate, apiculate. Flowers Purplish-red, spurred, in terminal or leaf opposed bracteate racemes. Fruits are rounded nuts, 2-3 mm in diameter, wrinkled when dry.

4. Corn spurry: *Spergula arvensis* L. (Caryophyllaceae)

A diffuse annual herb. Stem branched from the root, grooved. Leaves are in pseudo whorls, fleshy, linear-subulate, spreading. Flowers small, white. Fruits capsule rounded, five valved. Seeds are circular, thick lens shaped in cross section; margins winged with one small notch. Seeds are greyish black to black with margins usually light brown.

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

Ageratum conyzoides is native to Tropical America, especially Brazil. Herb 0.5–1 m. height, with ovate leaves 2–6 cm long, and flowers are white to mauve. Goat weed is a common tropical annual herbaceous weed. It is an erect softly hairy annual plant which grows up to a height of 2.5 feet. Oppositely arranged leaves are ovate to lance-like, coarsely rounded, and have toothed margin. Numerous pale blue or whitish flower heads are 6 mm across, often forming dense domed to flat-topped clusters in leaf axils or end of branches. Flowers most of the year. The stem is often red and has long white hairs.

1. http://www.cabi.org/isc/datasheet/3572, 2. http://www.flowersofindia.net/catalog/slides/Goat%20Weed.html

6. Creeping wood sorrel: *Oxalis corniculata* L. (Oxalidaceae)

These wood sorrels are perennial tap rooted herbs, bushy or mat forming, and 0.1-0.5 m tall. Branching from the base and often rooted at the nodes, the upper portion is ascending or weakly erect, smooth or hairy. The leaves are arranged alternately along the stems. A single long stalk arises from the axils of the leaf, from which extend three flower stalks, each with a single flower. The flowers are 7-11 mm wide and have 5 yellow petals. The fruit is a capsule, 1-1.5 cm long, cylindric, pointed apically, and 5-

ridged in cross section. The seeds are oval in outline, apically rounded, basally pointed, flattened in cross section, light brown, and have a surface distinctly transversely ridged.

http://www.cals.ncsu.edu/plantbiology/ncsc/containerWeeds/Oxalis_corniculata_stricta.htm

7. Rose hip: *Rosa moschata* (Herm) (Rosaceae)

Rosa moschata is a shrub (up to 3 m) with single white 5 cm flowers in a loose cyme or corymb, blooming on new growth from late spring until late autumn in warm climates, or from late summer onwards in cool-summer climates. The sepals are 2 cm long with slender points. The flowers have a characteristic "musky" scent, emanating from the stamens, which is also found in some of its descendants. The prickles on the stems are straight or slightly curved and have a broad base. The light- or greyish-green leaves have 5 to 7 ovate leaflets with small teeth; the veins are sometimes pubescent and the rachis possesses prickles. The stipules are narrow with spreading, free tips. Small, ovate fruits called hips are borne, turning orange-red in autumn.

http://en.wikipedia.org/wiki/Rosa_moschata

http://usa.weleda.com/ingredients/rosehip-rosa-moschata.aspx

8. Wild blackberry: *Rubus* spp. (Rosaceae)

Most species of wild blackberry, also called brambles, are important sources of food and cover for many birds and mammals. Several species, however, are also considered weeds. *Rubus* spp. nutlets or achenes generally have an ovate or half-circular shape. One side is usually more or less straight, while the rest is curved. Most species share a distinctive reticulated surface pattern on the endocarp with a straight, smooth "seam" around the perimeter of the seed. The surface patterning appears as a series of irregularly shaped cells separated by high ridges. This pattern makes identification of even fragments of "seeds" possible. However, although many species of *Rubus* share this surface pattern, a few species, like *Rubus acaulis* and *Rubus chaemorus*, have the same overall seed shape but smooth surfaces.

http://pnwhandbooks.org/plantdisease/raspberry-rubus-spp-ringspot

9. European barberry: *Berberis* spp. (Berberidaceae)

Berberis is a genus of about 450-500 species of deciduous and evergreen shrubs from 1–5 m tall with thorny shoots, found throughout the temperate and subtropical regions of the world (apart from Australia). It is a deciduous shrub growing up to 4 m high. The leaves are small oval, 2–5 cm long and 1–2 cm broad, with a serrated margin; they are borne in clusters of 2-5 together, subtended by a three-branched spine 3–8 mm long. The flowers are yellow, 4–6 mm across, produced on 3–6 cm long panicles in late spring. The fruit is an oblong red berry 7–10 mm long and 3–5 mm broad, ripening in late summer or autumn.

http://www.forestryimages.org/browse/detail.cfm?imgnum=5391933

10. Garden spurge: *Euphorbia hirta* L. (Euphorbiaceae)

Terrestrial, annual, erect herb, up to 60 cm tall. Taproot white or brown. Stem rounded, solid, hairy, with abundant milk sap. Stipules present. Leaves simple, not lobed or divided, opposite, sessile or stalked, elliptic, less than 2 cm long/wide, hairy on both sides, denser pilosity along the veins in the lower face, more scattered on the upper side; leaf base asymmetric, margin finely dentate, apex acute, base acute, 3-veined not to the top. Flowers unisexual, solitary or grouped together in an axillary cyme, stalked, petals absent. Fruit a capsule opening with 3 valves.

http://www.oswaldasia.org/species/e/euphi/euphi_01_en.html

11. Lantana: *Lantana camara* L. (Verbinaceae)

Lantana camara is a small perennial shrub which can grow to around 2m in height and forms dense thickets in a variety of environments. The leaves are egg-shaped, simple, arranged oppositely on the stem and have a strong odour when crushed. *L. camara* has small tubular shaped flowers which each have four petals and are arranged in clusters at the end of stems. Flowers come in many different colours including red, yellow, white, pink and orange which differ depending on location, age and maturity. The fruit of *L. camara* is berry-like and turns a deep purple colour when mature.

http://www.motherherbs.com/lantana-camara.html

http://www.terrain.net.nz/friends-of-te-henui-group/weeds/lantana.html

12. Common sorrel: *Rumex* spp. (Polygonaceae)

They are erect plants, usually with long tap roots. The fleshy to leathery leaves form a basal rosette at the root. The basal leaves may be different from those near the inflorescence. They may or may not have stipules. There are minor leaf veins. The leaf blade margins are entire or crenate. The usually inconspicuous flowers are carried above the leaves in clusters. The fertile flowers are mostly hermaphrodite, or they may be functionally male or female. The flowers and seeds grow on long clusters at the top of a stalk emerging from the basal rosette; in many species the flowers are green, but in some (such as sheep's sorrel, *Rumex acetosella*) the flowers and their stems may be brick-red. Each seed is a 3-sided achene, often with a round tubercle on one or all three sides.

http://swbiodiversity.org/seinet/taxa/index.php?taxon=Rumex

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

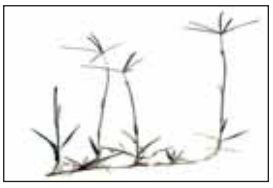
It is one of the worlds' worst weeds mostly found in uncultivated lands but now a - days it can be seen invading cropped fields. It is a short-lived annual herb with an extensive root system and erect shoot upto 2 m height. Upper half of the main stem becomes highly-branched at flowering with strips due to longitudinal grooves or ribs and they become woody with age. Leaves are pale green, deeply lobed and covered with fine soft hairs. Flowers are creamy-white occurring at the tips of the stems. Clusters of male and female florets are grouped as five-lobed flowers on the terminal branches of the flower stem and measure 4–6 mm in diameter. Seeds are achene small (1–2 mm), flattened, triangular and dark brown–black with two thin, white, spoon-shaped appendages.

Grassy weeds

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

A tufted annual bunchgrass, up to 1.8 meters in height. Stem is erect or horizontal with long, linear leaves. Ligule is an oblong hyaline membrane, about 2-5 mm long, often truncate and/or fringed; auricles absent, sheath smooth. Panicle more or less protruding or entirely protruding from the uppermost swollen leaf sheath, ovate to oblong, 5-8 cm long, green. Spikelets green, broadly lanceolate on short pedicels, shining, 4 -6 mm long, strongly laterally compressed.

15. Bermuda grass: *Cynodon dactylon* (L.) (Poaceae)



It is a perennial grass found on bunds and channels of cultivated fields. The rhizomes are mainly in the top 10 cm of the soil. They spread horizontally for several meters, with nodes at approximately 10 cm intervals, each with 2-3 scale leaves and a single axillary bud. In dense stands, shoots developing from buds on rhizomes or runners tend to be erect and quite short, up to 25 cm high, but develop into prostrate runners

under less dense conditions. Leaves are usually dull grey-green, flat, up to 15 cm long and finely parallel-ribbed on both surfaces, without a conspicuous midrib. Ligule is very short but with a conspicuous fringe of white hairs. The inflorescence is supported on a culm up to 25 cm high and consists of a single whorl of 3-7 narrow racemes, each 3-8 cm long.

Sedges

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

A perennial sedge, hard, fragrant, globose-ovoid tubers, up to 1.2 cm long and 0.3-0.7 cm in diameter; culms solitary or few together, sparsely tufted, erect, 10-75 cm tall, 3-angled at top. Leaves narrowly linear, sometimes longer than stem, 0.4-0.8 cm wide, dark green above, pale beneath. Inflorescence is a simple or compound umbel, rays 2-8, each up to 7.5 cm long, bearing short spikes of 3-10 spreading, red-brown spikelets. Nuts oblong to ovate-oblong, 3-sided, 1.3-1.5 mm long and 0.5-0.7 mm wide, maturing brown.

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

Annual sedge, sometimes behaving as a perennial with 8 to 60 cm high. The culms are tufted, triangular, smooth, green and 0.6-3.0 mm thick. The roots are numerous, short and yellowish-red. Leaves are linear-lanceolate, usually all shorter than the culm, 1-8 mm wide, flat, and rough on the margin and major ribs; leaf sheaths are green to reddish-brown, membraneous and envelope the culm at the base. Inflorescence is simple or compound, usually open, 1-20 cm long and 1-20 cm wide, with groups of spikes which are either attached directly to stem or on 0.5-15.0 cm long peduncles (rays). Spikelets are erect-spreading, crowded, 6-24-flowered, 2-13 mm long, 1.5-2.0 mm wide, golden to yellowish green. Nutlet, 1.0-1.5 mm long, 0.6-0.7 mm wide, obovate, triangular in cross section, dark-brown to almost black; the surface is almost smooth.

VIII. DESCRIPTION OF INSECT AND MITE PESTS

1) 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 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 cap stage); 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 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.

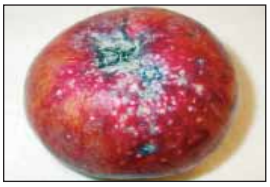
Life cycle:

1. http://www.ipm.ucdavis.edu/PMG/Q/I-HO-QPER-NM.008.html
2. http://www.ipm.ucdavis.edu/PMG/Q/I-HO-QPER-NM.017.html
3. http://www.ipm.ucdavis.edu/PMG/Q/I-HO-QPER-AD.021.html

Damage symptoms:

- 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" spots on the surface.

1.



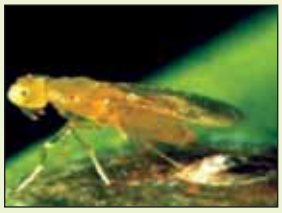
2.

1,2 http://www.ipm.iastate.edu/ipm/hortnews/2007/11-7/update.html

Parasitoids of San Jose scale:

1. *Encarsia* sp

2. *Aphytis* sp



1. http://www.syngenta.com/global/Bioline/en/products/allproducts/Pages/ Encarline-f.aspx
2. http://www.evergreengrowers.com/scale-control/aphytis-melinus-scale-control.html

Predators of San Jose scale:

1. Coccinellid

2. *Pharoscymnus flexibilis*

2. http://entnemdept.ufl.edu/creatures/beneficial/lady_beetles_new_to_fl.htm

*For management refer to page number 15

2) Woolly apple aphid:

Biology:

Native of Eastern United States. First noticed in 1909 in Shimla on nursery stocks imported from England. Reproduces parthenogenetically. There is partial migration from aerial parts to the roots of infested plant in December. Reverse migration from root to aerial parts takes place in April and May.

Eggs: The female laid a single, long, oval, cinnamon-colored egg almost as large as her body. The egg was laid in the crevices of bark.

Nymphs: Eggs hatched in the spring into wingless, parthenogenetic, viviparous stem mothers. Nymphs hibernate underground on the roots of the tree. When elms were prevalent, eggs were usually laid in fall in the cracks or crevices of bark. These fed on elm buds and leaves for two generations during May and June, causing the elm leaves to curl into a rosette. They then produced a winged third generation that migrated to apple. After establishing new colonies the migrants produced repeated generations during the summer.

Adult: Adult and nymph reddish brown in colour. Covered with waxy filaments. They fed in wounds on the trunk and branches of the tree. In fall, winged aphids developed in both the aerial and the root colonies. They flew back to the elm, where they gave birth to males and females. Both males and females were wingless. Each female produces 116 young ones in her life. 13 generations a year.

1. Nymphs

2. Adults

Damage symptoms:

- Nymphs and adults suck cell sap from bark of twigs and from underground parts.
- Underground feeding produces large knots on roots.
- Heavily infested plant have a short fibrous root system and yellowish foliage which can be easily uprooted.

Parasitoid of woolly apple aphid:

1. *Aphelinus mali*

1. http://jenny.tfrec.wsu.edu/opm/displayspecies.php?pn=980

Predators of woolly apple aphid:

1. Syrphid fly

2. Lacewing

3. Coccinellid

*For management refer to page number 14 & 17

3) European red mite:

This mite occurs on many deciduous fruits but is most injurious to apple.

Biology:

Egg: The European red mite overwinters as fertilized eggs. The environmental factors triggering winter egg production are diminishing food supply, temperature and photoperiod. The bulk of winter egg deposition occurs from mid to late August, but may continue until late September. Overwintering eggs are deposited in groups on roughened bark areas, especially around the base of buds and fruit spurs. These eggs may be so numerous that the infested areas take on a reddish cast. Egg hatch is closely correlated with bud development and first occurs when buds are in the tight cluster stage; hatch is better than 50% complete at the pink stage, and virtually 100% complete by the end of bloom. The first summer eggs as a rule can be found at petal fall or at latest by fruit set.

The summer eggs are globular and somewhat flattened (onion shaped. They are bright red to dark orange, and average 0.13 mm in diameter. The overwintering egg is deeper red and slightly larger, averaging 0.14 mm. The egg surface is ridged with the grooves running toward the top center from which a slender tapering stalk (0.1 mm) arises. The average incubation period of the summer eggs for each generation varies from 6.7 to 14.4 days, the shortest period being in mid-summer.

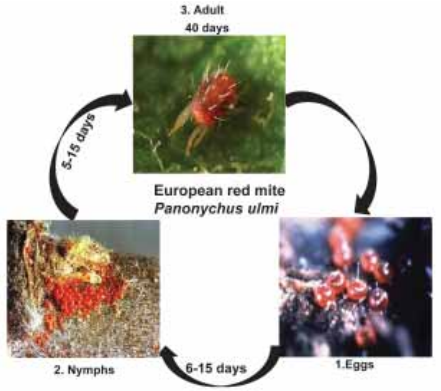
Nymph: The European red mite passes through 3 stages between egg hatch and adulthood. They are called the larva, protonymph and deutonymph. A quiescent or resting period precedes each molt to the following stage. The hatching larva is about 0.2 mm in length, light orange in color and 6 legged. All subsequent stages have 8 legs. With the exceptions of an increase in size and the ability to differentiate sexes in the deutonymphal stage, there are no conspicuous changes in structure or color between the nymphal instars. The average developmental time from eclosion to adulthood ranges from 5.5-15 days, depending on the generation.

Adult: There are 4-9 generations of the European red mite a year, depending on the locality and the length of the growing season. The sexes of the adults are readily differentiated. The female has a globular body which ranges in length from 0.38 to 0.40 mm, is velvety brown to brick red, and has 4 rows of dorsal setae or spines borne on raised white tubercles. The body color and setal pattern distinguish this species from all other plant feeding mites. The male is smaller, 0.26-0.28 mm in length, lighter in color and has a pointed abdomen and proportionately longer legs.

The rate of development is temperature dependent, being slower in the spring and fall and more rapid during the hot summer months. The first generation generally requires about 3 weeks developing, while summer generations may develop in 10 to 14 days. Reproduction can be both sexual and parthenogenetic. Unfertilized eggs give rise to males only, while mated females produce both sexes.

The average preoviposition period of females is about 2 1/2 days. Although some females in insectary studies have lived 39 days, the average life span is 18 days. The oviposition period averages 12.5 days with 18.8 eggs produced per female.

Life cycle:



1. http://archive.agric.wa.gov.au/PC_94923.html?s=1001
2. http://pnwhandbooks.org/insect/tree-fruit/apple/apple-spider-mite
3. http://www.agf.gov.bc.ca/cropprot/grapeipm/spidermites.htm

Damage symptoms:

- European red mite feeds on leaves.
- Severe mite injury produces browning and loss of colour in the leaves *i.e.* bronzing.

http://nysipm.cornell.edu/factsheets/treefruit/pests/erm80/erm80_fig5.asp

*For management refer to page number 15 & 17

Predators of European red mite:

1. Predatory mite

2. Coccinellid

3. Lacewing

1. http://www.evergreengrowers.com/mite-control.html

4) Codling moth:

The rate of development will vary with temperature, proceeding more rapidly in warmer weather and climates. Depending on the climate, codling moth can have two, three, and sometimes four generations per year.

Biology:

Egg: Eggs are deposited singly on apples and leaves. Each egg is about the size of a pin head and is translucent, gradually darkening as the egg nears hatching (Figure 6). Eggs hatch in six to 14 days, depending on temperature. Within 24 hours of hatching the larvae burrow into the fruit. The first instar larvae have a pink body with a black head and are approximately 1/10 inch in length. The number of eggs laid per female ranges from 30 to 70.

Larva: After the eggs hatch, young larvae seek out and bore into fruit or developing nuts. Codling moth overwinters as full-grown larvae within thick, silken cocoons under loose scales of bark and in soil or debris around the base of the tree. Larvae appears to be cannibalistics. Full grown larva pinkish or creamy white with brown head and pupates in the soil litter.

Pupa: After completing development they leave the fruit and drop from the trees to search out pupation sites and continue the life cycle in the soil or on debris under the tree; some crawl back up the tree to pupate in bark crevices. The larvae pupate inside their cocoons in early spring and emerge as adult moths mid-March to early April. The moths are active only a few hours before and after sunset, and they mate when sunset temperatures exceed 62°F.

Adult: Adults are about 1/2 to 3/4 inch long with mottled gray wings that they hold tentlike over their bodies. Their appearance blends well with most tree bark, making them difficult to detect. If you are trapping the adults, you can distinguish codling moth from other moths by the dark, coppery brown band at the tip of their wings. Adult forewings are dark grayish with waxy lines with a copper colored eye like circle toward margin.

Life cycle:

1. http://www7.inra.fr/hyppz/RAVAGEUR/6cydpom.htm
2. http://utahpests.usu.edu/ipm/htm/fruits/fruit-insect-disease/codling-moths06
3. http://jenny.tfrec.wsu.edu/opm/displayspecies.php?pn=5
4. http://ukmoths.org.uk/show.php?bf=1261

Damage symptoms:

- It is a direct pest and hence causes severe damage to the fruit.
- Neonate larva enters the fruit through calyx and feeds on seed.
- Infested fruits lose their shape and fall prematurely.
- 30 to 70 per cent apple fruits are rendered unmarketable.

http://fruitforum.wordpress.com/2011/12/18/codling-moth-larva-does-it-have-a-bail-outresponse/

*For management refer to page number 17

Parasitoid of codling moth:

Trichogramma embryophagum

Predators of codling moth:

1. *Parus major*

2. *Passer domesticus*

1. http://en.wikipedia.org/wiki/Great_Tit
2. http://www.ecowalkthetalk.com/blog/2011/03/11/mohammed-dilawar-world-sparrow day-march-20th/passer-domesticus-house-sparrow-photo-salim-ali-foundation/

5) Apple root borer:

Infests fruit and forest trees. Apple is the most preferred host. Adults attracted to light

Biology:

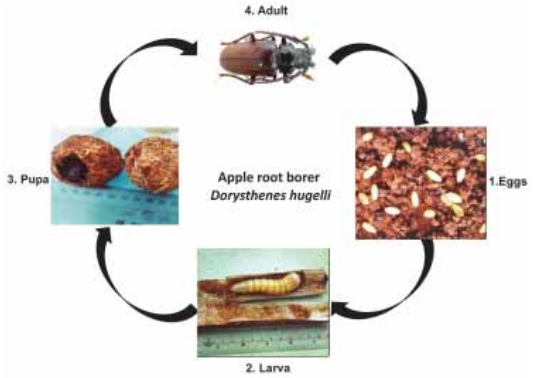
Egg: Female lays eggs singly or in small clusters in soil. Eggs are 1.3 mm in size. Newly laid eggs are white with a tinge of yellow and become dark brown before hatching.

Grub: Grubs feed on the root. Grub longevity 3.5 years. Grubs are eruciform, yellowish-white in colour and have 8–9 instars. Development period can be either 1 or 2 years. The exhibits 10 larval stages that develop over 20-21 months, with mature larvae almost reaching 80 mm in length and 12 mm in width.

Pupa: The pupae are about 48 mm long and usually found about 20–30 cm deep in the soil. Pupation inside earthen cell inside soil.

Adult: The adult beetle is chestnut red in color and bears long serrated antennae. Full grown grub is creamy white, 7.5-10 cm long.

Life cycle:

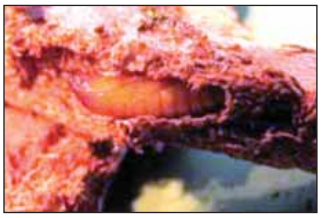


1,2,3 http://sugarresearch.org/wp-content/uploads/2009/08/issct-1.pdf
4. http://prioninae.eu/taxonomy/dorysthenes/huegelii

Damage symptoms:

- Grubs either bore or girdle around the roots.
- The leaves become small and the branches wither.
- Tree becomes shaky and may die.

1.



2.

1. http://aesgsf.free.fr/MON%20JARDIN/papillonsnuits/page108.html
2. http://www.omafra.gov.on.ca/english/crops/facts/apborers.htm

6) Apple stem borer:

Biology:

Egg: Female lays egg inside cavity on a shoot. Eggs are very difficult to see and are laid singly on the trunk of the tree.

Larva: Larvae of all three species are dirty white with a reddish-brown head and thoracic shield (area behind the head). Grub emerge in 7-8 days and start feeding by boring inside the stem. Grub longevity 2 years. Grub remains quiescent during winter and resume feeding in March.

Pupa: Pupae are small, yellow-brown and sometimes observed as pupal cases partially protruding from the adult exit holes in the trunk or infested burr knots. Pupation takes place inside a tunnel made in the woody tissue.

Adult: Adult clearwing moths possess transparent wings with striking dark markings along the margins. Adult beetles 35-50 mm long and grey in colour having long antennae.

Damage symptoms:

- Caused by grub and adult, grub more destructive.
- Grub makes a tunnel and reaches close to trunk of tree.
- Vitality and productivity of plant is greatly impaired.

*For management refer to page number 16

7) Indian gypsy moth:

Biology:

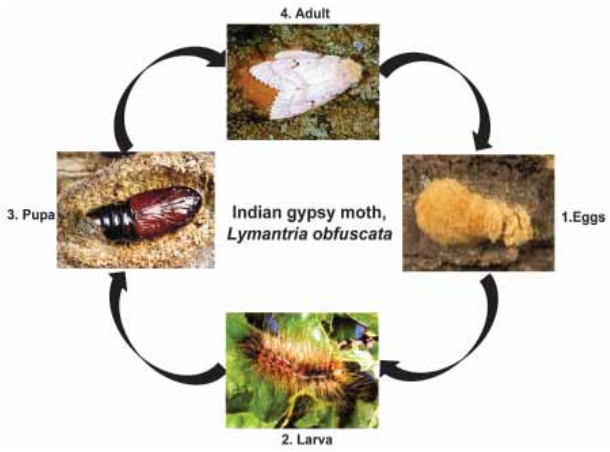
Egg: The egg mass is approximately 1.5 inches long and 0.75 inches wide. Eggs are attached to trees, houses, or any outdoor objects. The eggs hatch in spring (April) into caterpillars.

Larva: They have five pairs of blue dots followed by six pairs of red dots lining the back. 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. Older caterpillars are approximately 1.5 to 2.0 inches long. Larval period 66-100 days.

Pupa: In early summer (June to early July), Gypsy moth 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 Gypsy 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 Gypsy moths cannot fly. Females lay between 500 to 1,000 eggs in sheltered areas such as underneath the bark of trees. Both the adult female and male can be identified by the inverted V-shape that points to a dot on the wings. Gypsy moth has only one generation per year.

Life cycle:



1. http://urbanext.illinois.edu/gypsymoth/biology.cfm
2,3,4. http://urbanext.illinois.edu/gypsymoth/photos.cfm

Damage symptoms:

- Caterpillars are gregarious but voracious feeder.
- 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.

Parasitoids of Indian gypsy moth:

Egg parasitoid:
1. *Telenomus* sp

1.http://bugguide.net/node/view/428366

Larval parasitoids:
1. *Cotesia melanoscela* 2. *Glyptapantelos* sp

1.http://commons.wikimedia.org/wiki/File:Cotesia.melanoscela.-.lindsey.jpg
2. http://bio390parasitology.blogspot.in/2012/02/glyptapanteles-and-their-zombie.html

Pupal parasitoid:
***Brachymeria* sp.**

.http://commons.wikimedia.org/wiki/File:Cotesia.melanoscela.-.lindsey.jpg

*For management refer to page number 16

8) Blossom thrips:

Biology:

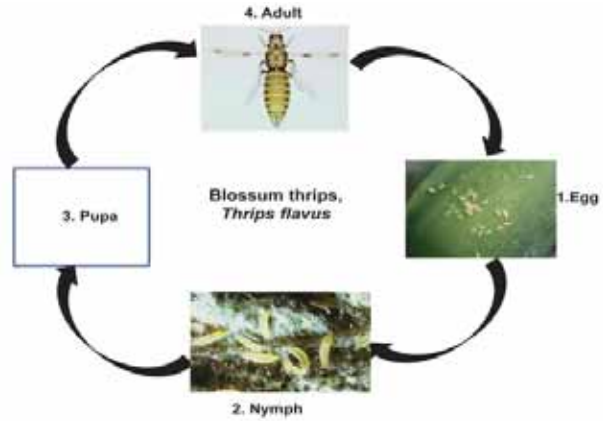
Egg: The eggs of thrips are deposited within plant tissues singly.

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 occure 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 symptoms:

- 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 distorced in the growing tips.

Predators of blossom thrips:

1. Ant Lion

2. Predatory thrips

3. Anthocorid bug

4. *Tropidothorax leucopterus*

5. Coccinellid

1.http://www.brisbaneinsects.com/brisbane_lacewings/Myrmeleontidae.htm, 2. http://bugguide.net/node/view/205042/bgpage, 3. http://www.britishbugs.org.uk/heteroptera/Anthocoridae/Anthocoris_nemoralis.html, 4. http://commons.wikimedia.org/wiki/File:Lygaeidae Tropidothorax_leucopterus.JPG

*For management refer to page number 17

9) Tent caterpillar:

Important pest of apple, in north western India being more serious in Shimla hills.

Biology:

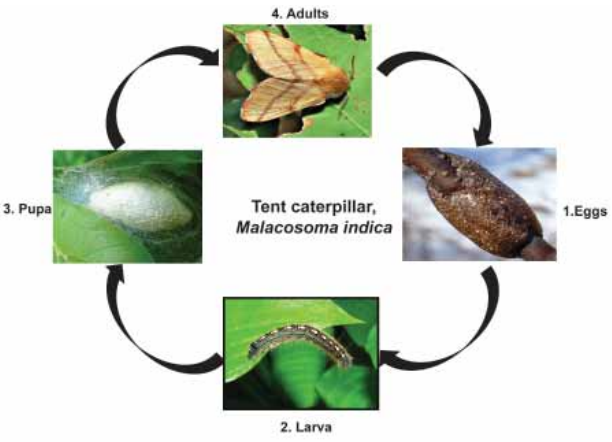
Eggs: In late spring or early summer, female moths deposit an egg mass encircling small twigs or on tree trunks. Egg masses are present on trees during most of the summer, fall and winter. The adult moth uses a sticky, frothy substance called spumaline as an adhesive to attach eggs to bark or twigs. Spumaline also is used as a hard protective covering around the egg mass. Pest in active 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. Caterpillar is progeny of a light reddish brown moth with two whitish stripes running across each of the forewings.

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. 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. Male are short lived and female may survive for 2 to 5 days.

Life cycle:



1,2,3,4. http://www.dec.ny.gov/docs/lands_forests_pdf/ftc02.pdf

Parasitoid of tent caterpillar:

Tachinid fly, *Pales* sp

http://en.wikipedia.org/wiki/File:Diptera-Tachinidae-Pales-pavida-201206040029.JPG

Damage symptoms:

- Caterpillars during the night rest at their nest and the day they feed 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.

Tent caterpillar webbing of apple leaves

1. http://www.slideshare.net/csapramod/integrated-pest-management12666835#btnNext

10) Apple maggot:

Apple maggots overwinter as pupae in the soil. Generally there is one generation a year, although there may be a partial second generation in warm years. Adults emerge in mid-June to early July; emergence usually peaks between mid- and late July and is over by late August.

Biology:

Egg: Females lay about 300 eggs over a 30-day life span. Female flies lay their eggs singly in apples and other fruits. This egg-laying activity begins in July and continues though early October. When laying each egg, the female makes a tiny puncture in the fruit and inserts the egg just below the skin. This initial fruit damage is easily overlooked, but eventually leads to fruit dimpling

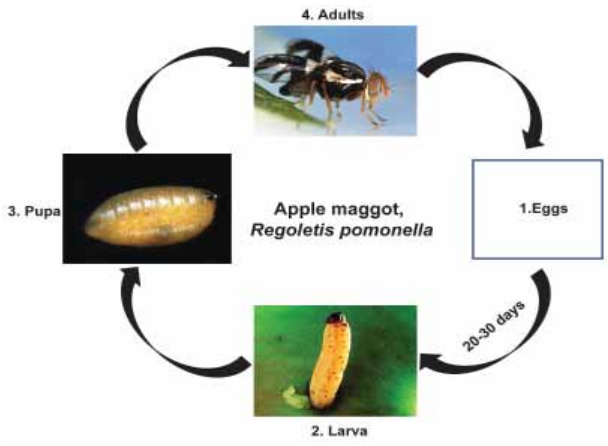
Maggot: Apple maggot eggs hatch in 3 to 7 days as small (less than 1/16 inch), cylindrical, cream coloured larvae known as maggots. Maggots lack legs and visible head capsules, but have dark mouth hooks that protrude from tapered heads. As apple maggots tunnel through the apple flesh, they leave characteristic winding brown trails that are best seen when the fruit is cut open. The first indication that a backyard apple tree is infested with apple maggot occurs when the homeowner discovers these brown trails in fruit at harvest. The maggots measure 1/4 inch long when fully mature. Fruit damaged by apple maggot becomes soft, rotten, and often drops from the tree. They feed within the apple and pass through three instars before completing developing in 20 - 30 days. Maggots are carrot shaped, white and legless.

Pupa: The apple maggot has one generation per year. Infested fruit fall to the ground; larvae leave the fruit, burrow into the soil, and molt into a fourth instar and then into a pupal stage to overwinter in the soil under the infested tree.

Adult: In early summer, apple maggot flies emerge from the soil and forage in the host tree canopy. There they feed on honeydew, bird droppings, and other sticky, sugary substances. An apple maggot flies measures 1/4 inch long. It has a black body, dark red eyes, black and creamy-white striped abdomen and a white spot on the thorax between the pair of transparent wings.

The black banding pattern on the wings is a key character to distinguish apple maggot from other fruit flies. The one exception is a snowberry maggot that feeds on snowberry bushes, but not on apples. Experts rely on microscopic examination to distinguish the apple maggot fly from the adult fly of the snowberry maggot.

Life cycle:



1. http://kids.britannica.com/comptons/art-136390/A-worm-in-an-apple-is-actually-the-larva-of?&articleTypeId=31
2. http://inspection.gc.ca/plants/plant-protection/insects/apple-maggot/fact-sheet/eng/1330366145611/1330366375524
3. http://en.wikipedia.org/wiki/Apple_maggot

Damage symptoms:

- Caused by maggots.
- Maggots are called "railroad" because they leaves brown winding trail just under fruit skin.
- Burrowing of maggot sometime reduce apple to a brown rotton mass.
- Premature fall of infested fruits.

1.

2.

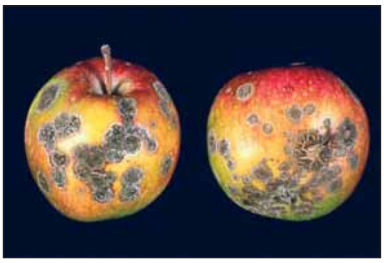
1. http://www.slideshare.net/csapramod/integrated-pest-management-12666835#btnNext
2. http://www.appleman.ca/korchard/magdimpl.htm

IX. DESCRIPTION OF DISEASES

1) Apple scab:

Disease symptoms:

- The disease usually noticed on leaves and fruits.
- Affected leaves become twisted or puckered and have black, circular spots on their upper surface.
- On the under surface of leaves, the spots are velvety and may coalesce to cover the whole leaf surface. Severely affected leaves may turn yellow and drop.
- Scab can also infect flower stems and cause flowers to drop.
- The lesions later become sunken and brown and may have spores around their margins.
- Infected fruit become distorted and may crack, allowing entry of secondary organisms.



Survival and spread:

- The pathogen survives through perithecia in the soil debris.

Favourable conditions:

- Suitable temperatures and moisture promote the release of *V. inaequalis* ascospores. This cycle of secondary infections continues throughout the summer, until the leaves and fruit fall from the tree at the onset of winter.

*For management refer to page number 14 & 16

2) *Marssonina* leaf blotch (pre mature leaf fall):

Disease symptoms:

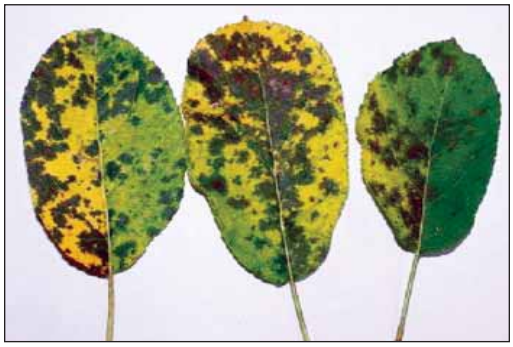
- The disease symptoms appears in form of dark green circular patches on upper surface of leaf giving rise to 5-10 mm brown leaf spots which become dark brown in due course.
- On maturity it also develops on lower surface of the leaf.
- Small black acervuli are visible on the surface of leaf.
- When lesions are numerous, they coalesce and to form large dark brown blotches and the surrounding areas turn yellow.

Survival and spread:

- The pathogen survived in infected leaf litter on orchard floor in the form of conidia and the sexual stage of pathogen *Diplocarpon mali* is also intercepted in nature.

Favourable conditions:

- This disease favoured by high rainfall and moderate temperature ranging from 20-22°C during the fruit development stages of apple.



Marssonina blotch on apple leaves (courtesy: Dr. J.N. Sharma)

3) Black rot canker:

Disease symptoms:

- Leaf symptoms first occur early in the spring when the leaves are unfolding.
- They appear as small, purple specks on the upper surface of the leaves that enlarge into circular lesions 1/8 to 1/4 inch (3-6 mm) in diameter.
- The margin of the lesions remains purple, while the center turns tan to brown. In a few weeks, secondary enlargement of these leaf spots occurs.
- Heavily infected leaves become chlorotic and defoliation occurs.
- As the rotted area enlarges, a series of concentric bands of uniform width form which alternate in color from black to brown. The flesh of the rotted area remains firm and leathery. Black pycnidia are often seen on the surface of the infected fruit.
- Lesions resulting in canker formation usually are associated with a wound in the bark.

https://www.google.co.in/search?q=black+rot+canker+of+apple&espv=210&es_sm=93&source=lnms

Survival and spread:

- The pathogen survives through ascospore (cysts) in the soil debris which is the source of primary infection.
- In the spring, the black pycnidia and perithecia release their respective conidia and ascospores and causes secondary infection.

Favourable conditions:

- 20-24°C temperature and moist situation is responsible for the disease development.
- Winter injury in plants is favourable for the development of the diseases.

*For management refer to page number 18

4) Collar rot:

Disease symptoms:

- *Phytophthora* collar rot attacks the lower 30 inches (76 cm) of apple trunks.
- Most infections start at the junction of a lateral root with the trunk.
- Infected bark becomes brown and is often soft and mushy or slimy when wet.
- Dark streaks often occur near the cambium and extend beyond the canker margin. If a canker enlarges for several years, only the marginal areas show the typical color and texture of newly killed tissue.
- The development of the canker is rapid, horizontally and vertically. The ultimate effect of collar rot is to girdle the affected limb, roots, or trunk, resulting in the death of that organ or of the entire tree.

https://www.google.co.in/search?q=collar+rot+of+apple&espv=210&es_sm=93&source=lnms&tbm=isch&sa

Survival and spread:

- Fungus overwinters as dormant resting spores or as mycelium within infected tissues. New infections occur when the pathogen releases motile spores that are carried via water to susceptible hosts.

Favourable conditions:

- Soils that are saturated from rain or over-watering provide the moist conditions necessary for *Phytophthora* spp. to thrive and spread.
- The lack of oxygen in saturated soils may also increase the rootstock's susceptibility to this disease

5) Powdery mildew:

Disease symptoms:

- Disease appearswhen the buds develop into new leaves and shoots.
- Small patches of white or grey powdery masses on under surface of leaves occur.
- Leaves grow longer and narrower than normal leaves and the margin is curled.
- Twigs covered with powdery mass.
- Affected fruits remain small and deformed and tend to develop roughened surface.

Courtesy by Dr. J. N. Sharma

Survival and spread:

- The fungus survives in the form of a resting mycelium or encapsulated haustoria in the buds and the secondary spread occur through wind borne conidia.

Favourable conditions

- Powdery mildew infections occur when the relative humidity (RH) is greater than 70%.
- Infections can occur when the temperature lies between 10 to 25°C.

*For management refer to page number 14, 16 & 17

6) Sooty blotch and fly speck:

Disease symptoms:

- *Sooty Blotch:* Sooty blotch appears as sooty or cloudy blotches on the surface of the fruit. The blotches are olive green with an indefinite outline.
- The blotches are usually one fourth of an inch in diameter or larger, and may coalesce to cover much of the fruit.
- The "smudge" appearance results from the presence of hundreds of minute, dark pycnidia that are interconnected by a mass of loose, interwoven dark hyphae.
- The sooty blotch fungus is generally restricted to the outer surface of the cuticle. In rare cases, the hyphae penetrate between the epidermal cell walls and the cuticle.
- *Flyspeck:* Groups of a few to 50 or more slightly raised, black and shiny round dots that resemble fly excreta, appear on the apple fruit.
- The individual "fly specks" are more widely scattered and much larger than the pycnidia of the sooty blotch fungus.
- The flyspecks are sexual fruiting bodies (pseudothecia) of the fungus, and are interconnected by very fine hyphae. The blemishes can be removed by vigorous rubbing or bleaching.

https://www.google.co.in/search?q=sooty+blotch+and+flyspeck+of+apple&espv=210&es_sm=93&s

Survival and spread:

- *Flyspeck:*In late spring, this fungus produces both ascospores and conidia that are wind-borne and survive into orchards from other plants.
- *Sooty blotch:*The pycnidia on host plants produce large numbers of spores (conidia) that ooze out of infections and collect in a gelatinous mass.

Favourable conditions

- Moist condition and 18 to27°C temperature are essential for infection and disease development.

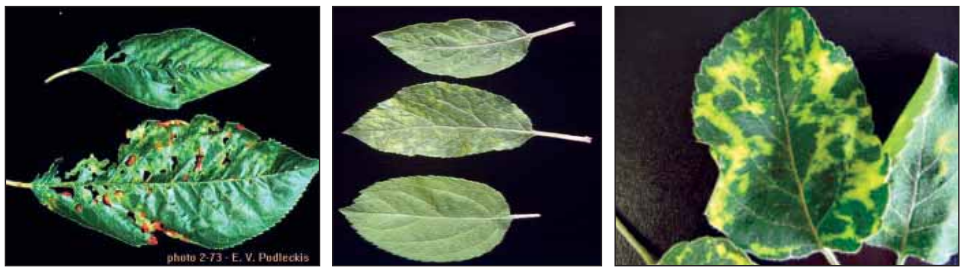
*For management refer to page number 18

7) Apple mosaic and other virus diseases:

Disease symptoms:

- Apple trees infected with apple mosaic virus develop pale to bright cream spots on spring leaves as they expand.
- These spots may become necrotic after exposure to summer sun and heat.
- Other viral diseases are symptomless in most commercial cultivars, but may cause symptoms in certain cultivars, scionl/ rootstock combinations, and ornamental varieties. Symptoms of apple chlorotic leaf spot virus may include chlorotic leaf spots, leaf distortion, chlorotic rings and line patterns, reduced leaf size, and stunting.
- Apple stem grooving virus produces symptoms on 'Virginia Crab' such as chlorotic leaf spots, stern grooving and pitting, union necrosis, and swelling of the stem above the graft union.

1. **2.** **3.**



1, 2. https://www.google.co.in/search?q=apple+mosaic+virus&espv=210&es_sm=93&sourc

3. Courtesy: Dr. J. N. Sharma

Transmission:

- Transmission of ApMV to *C. quinoa* and *C. sativus* was obtained under greenhouse conditions. *C. quinoa* reacted with mottling, whereas *C. sativus* showed chlorotic local lesions followed by systemic yellowing and stunting

8) Alternaria leaf spot/blight:

Disease symptoms:

- Leaf spots appear on the leaves in late spring and early summer. Initially, they are 1/8 to 1/4 inch in diameter, round, brown, and occasionally have a purple border.
- As spots age, they often turn tan to ash gray. Some spots undergo secondary enlargement, becoming irregularly shaped.
- Heavily infected leaves often abscise, resulting in defoliation. (Defoliation is greater when mites are present.) Fruit infections result in small, dark, raised pimple-like lesions associated with the lenticels.
- Twig lesions, which are somewhat sunken, round, blackish spots bordered by cracks, occur on susceptible cultivars such as Indo but have not been observed on Delicious.

Survival and spread:

- Primary infection occurs about one month after petal fall the following year.

Favourable conditions:

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

http://www.ces.ncsu.edu/fletcher/programs/apple/plantpath/ALTERfact.html

9) Core rot:

Disease symptoms:

- Common injuries that can lead to *Alternaria* rot include mechanical or chemical injury, sunscald, or chilling injury.
- Browning occurred most frequently with the occurrence rates of core rot.
- Infection can occur before or after harvest, although it is more commonly a post-harvest problem.

http://macperformanceguide.com/AppleCoreRot-intro.html

Survival and spread:

- The fungus is soil borne and Primary infection occurs by spores survives in the soil.

Favourable conditions:

Warm weather and high humidity favour the development of diseases.

10) Brown rot:

Disease symptoms:

- Enlarged rots are soft but not mushy.
- circular and medium brown during the early and medium stages of development.
- Decayed area enlarges, small black spots about 1/8 inch across gradually develop at the lenticels
- Entire fruit is decayed and under warm conditions turns black and develops a velvety sheen.
- In warm, moist conditions gray to tan fungal tufts develop, either in varying size patches or scattered over the decayed surface.

https://www.google.co.in/search?q=brown+rot+of+apple&espv=210&es_sm=93&source=lnm

Survival and spread:

- The fungus over-winters in mummified fruit on the ground or in the tree and in twig cankers.
- Secondary Infection: Spores produced on blighted blossoms provide a source of infection for ripening fruit

Favourable conditions:

- Prolonged wet weather during bloom may result in extensive blossom infection.
- Humid wet conditions are when the fruit trees are most at risk from infection.
- Young green fruit can be infected just before autumn, but the infection often remains inactive until near maturity of the fruit.

*For management refer to page number 18

11) White rot / root rot:

Disease symptoms:

- Infection can occur on large roots or at the tree collar.
- In fruit trees, the base of the trunk at soil level can show signs of a dark, wet rot, especially if kept moist by weeds or wet weather.
- As the disease progresses, the infected tissue becomes rotten. Trees develop a generally unthrifty appearance with leaf yellowing, cessation of root growth, small leaves, premature leaf fall and small, shrivelled fruit. Infected trees will eventually die.

Courtesy: Dr. J. N. Sharma

Survival and spread:

- The fungus survives in soil or plant debris which is the source of primary inoculums.

Favourable conditions:

- The disease is favoured by cool and moist soils.

*For management refer to page number 15

12) Seedling blight:

Damage symptoms:

- The most distinct symptoms and signs occur at the collar of the tree.
- Small, round, light brown to yellow resting structures of the pathogen, known as sclerotia, can be found appressed to or in the soil adjacent to infected trees.
- If conditions are moist, a white web-like mycelial growth may also be present.
- Affected cortical tissues in the collar of the tree are often shredded.

https://www.google.co.in/search?q=seedling+blight+of+apple&espv=210&es_sm

Survival and spread:

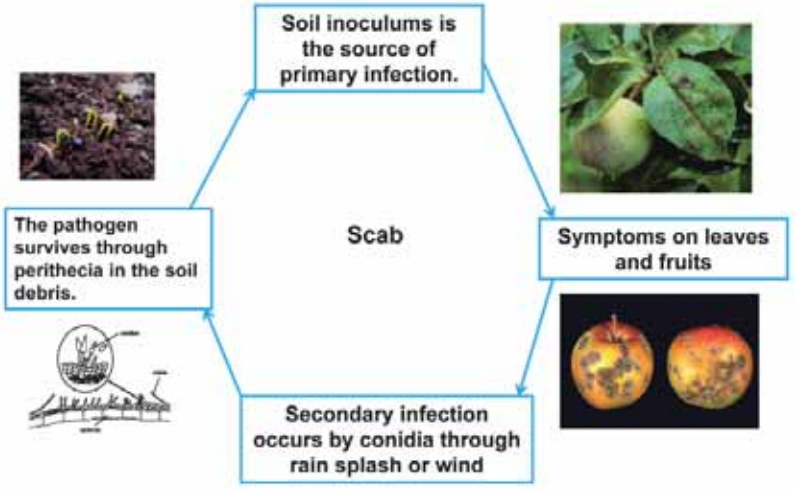
- The fungus survives in soil. Primary infection occurs by soil and secondary by conidia through rain or wind.

Favourable conditions:

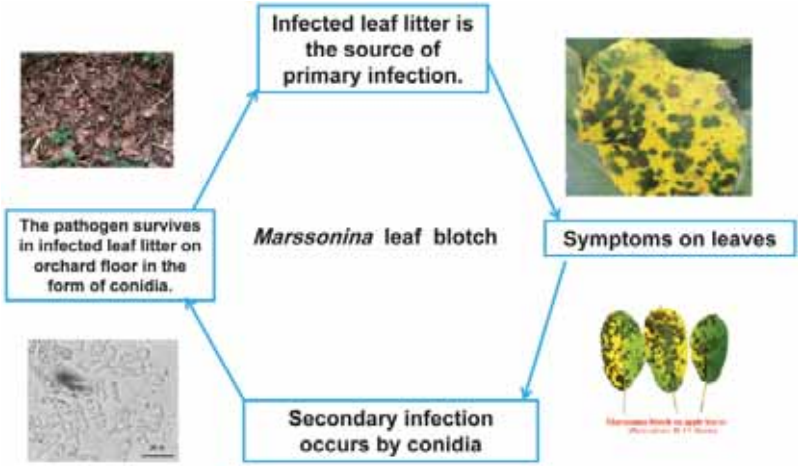
- High humidity, high soil moisture, cloudiness and low temperatures below 24° C for few days are ideal for infection and development of disease.

Disease cycles:

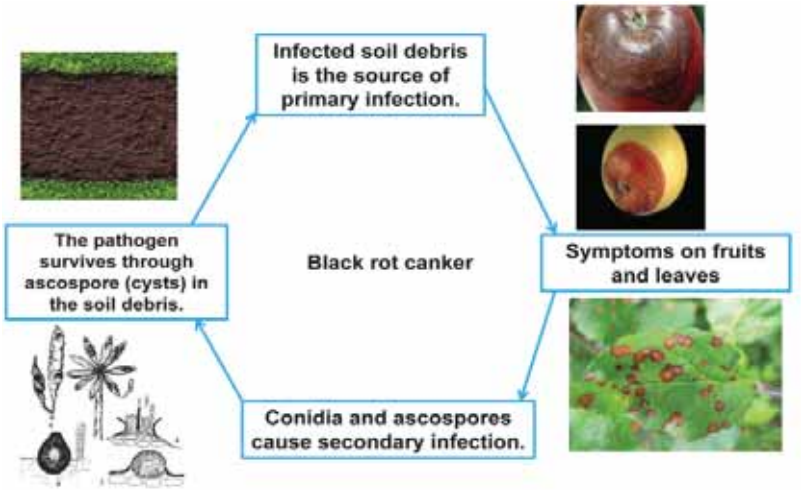
1. Scab



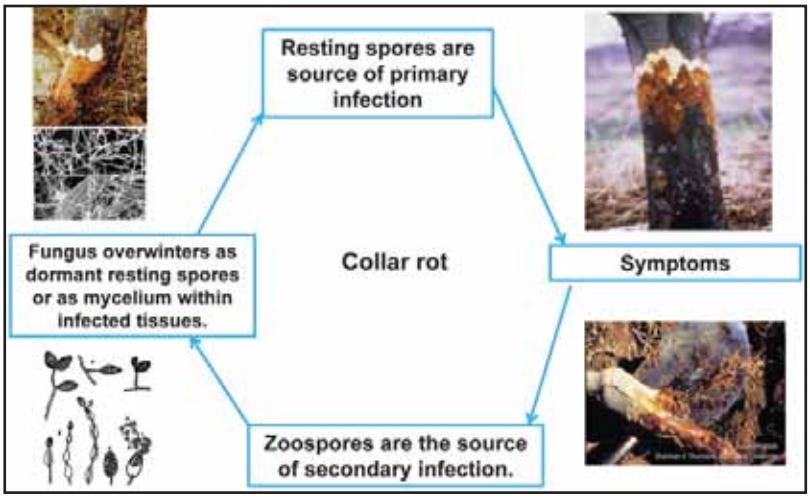
2. *Marssonina* leaf blotch



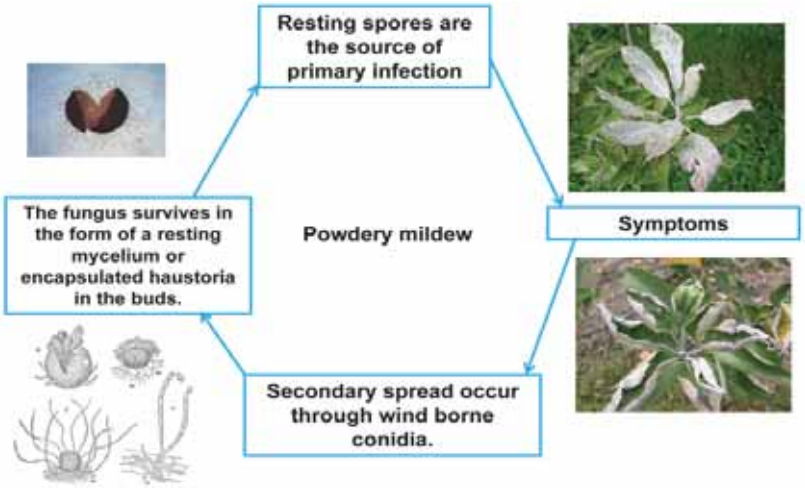
3. Black rot canker



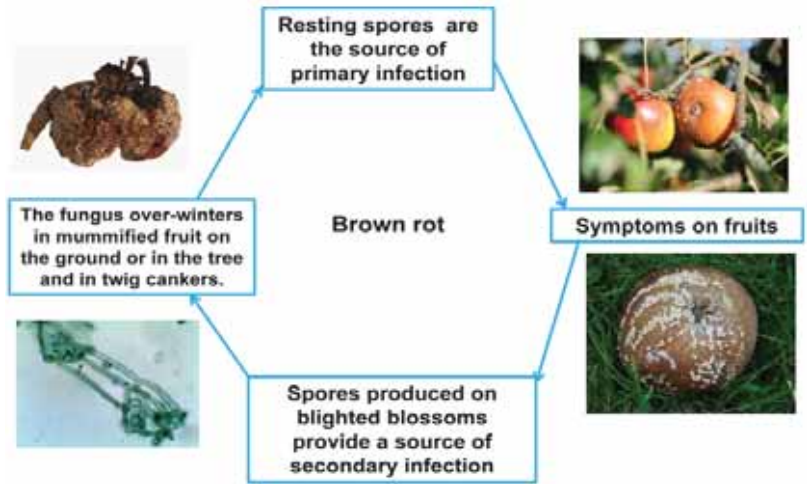
4. Collar rot



5. Powdery mildew



6. Brown rot



X. SAFETY MEASURES

A) At the time of harvest

Essentially, apples must always be picked with caution. Please don't just rip them off the branches. An apple is only ripe for harvesting when it can be picked easily, i.e. when the stalk of the apple comes away from the tree easily if you twist it. Further indications of an apple being ready to harvest are a wide and deep calyx and brown pips. Readiness for picking and eating differs, however, from variety to variety. While harvesting never pull the fruit off the tree. This will disturb the tree, usually causing other fruit to fall and can lead to significant bruising. This method can also result in fruit spurs being removed with the apples, reducing next year's crop potential.

One of the easiest picking techniques is the "rolling method". Using this method the apple is gently turned upside down on the spur. If the fruit is ready to pick it usually separates easily without disturbing other apples or the fruit spur. The thumb or another finger is often placed between the apple stem and the spur as the apple is rolled upwards. Set all apples carefully in the picking container. Do not drop the fruit or jostle the container. Fruit hitting other fruit or hitting the side of the container, causes bruising. People with large hands and/or long fingers may eventually be able to remove two apples at a time per hand. Do not encourage this practice until they master picking individual fruits bruise-free.

B) During post-harvest storage

It is important to keep apples in a cool, dark place with plenty of humidity. If there is insufficient humidity, you can increase it by putting containers of water in the place where the apples are being stored. Not all varieties of apple are suitable for storing. The apples should either be stored on fruit racks or in flat boxes. The boxes can be lined with wood shavings or corrugated paper. In the case of taller boxes, put corrugated paper between the layers of fruit to prevent pressure marks. Only store healthy and undamaged fruit. Maggot-ridden, overripe and outsized fruit cannot be stored for long and should be sorted out when harvesting. Apples without a stalk should be eaten early as they can rot quickly. Check your fruit store on a weekly basis and remove all rotten apples. Rotten pipfruit can 'infect' other fruit. This is due to emerging ethylene, a colourless gas, which ripens the other apples more quickly and, in some cases, spoils them. For precisely this reason apples should not be stored together with other fruit and vegetables. In order to prevent apples from drying out quickly, the boxes can be covered with a perforated film. Alternatively, apples can also be stored in perforated polythene bags since the release of ethylene is reduced by the bag. In all cases, stored pipfruit should be checked regularly so that rotten apples can be removed quickly.

Apples have a long storage life compared to other fruits and can be stored for a period of 4-8 months after harvesting. The fruits can be kept in cold storage at a temperature of about – 1.1 to 0 °C and 85-90% relative humidity.

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	Adopt inter-cropping of recommended crops.	Do not disturb the plant roots by adopting ploughing away from the pits.
3.	Grow only recommended varieties.	Do not grow susceptible varieties.
4	Always treat the seedlings with approved chemicals/bio products for the control of seed borne diseases/pests 	Do not use seedlings without seed treatment with biocides/chemicals.

5.	Plant in rows at optimum depths under proper moisture conditions for better establishment.	Do not plant seedlings beyond 5-7 cm depth.
6.	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.
7.	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.
8	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
9	Use micronutrient mixture after planting based test recommendations.	Do not apply any micronutrient mixture after planting without test recommendations.
10	Conduct AESA weekly in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only. 	Do not take any management decision without considering AESA and P: D ratio
11	Install pheromone traps at appropriate period. 	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
12	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per field observation 	Do not apply chemical pesticides within seven days of release of parasitoids.
13	Apply NPV of respective Lepidopteran moth if available at recommended dose when a large number of egg masses and early instar larvae are noticed. Apply NPV only in the evening hours after 5 pm. 	Do not apply NPV on late instar larva and during day time.
14	In case of pests which are active during night spray recommended biopesticides/chemicals at the time of their appearance in the evening.	Do not spray pesticides at midday since, most of the insects are not active during this period.
15	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, and other sucking pests harbouring the lower side of leaves. 	Do not spray pesticides only on the upper surface of leaves.
16	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
17	Follow the recommended procedure of trap crop technology.	Do not apply long persistent pesticides on trap crop, otherwise it may not attract the pests and natural enemies.

XII. SAFETY PARAMETERS IN PESTICIDE USAGE

S. No	Pesticide	Classification as per insecticide rules	Colour of toxicity triangle	WHO classification of hazard	First Aid measures	Symptoms poisoning	Treatment of poisoning	Waiting period from last application to harvest (days)
Organophosphate insecticides								
1	Dimethoate	Highly toxic		Class II Moderately hazardous		Mild-anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity	For extreme symptoms of OP poisoning, injection of atropine (2-4 mg for adults, 0.5-1.0 mg for children) is recommended. Repeated at 5-10 minute intervals until signs of atropinization occur.	5
2	Quinalphos	Highly toxic		Class II Moderately hazardous		Excessive salivation, sweating, rhinorrhea and tearing. Muscle twitching, weakness, tremor, incoordination. Hedache, dizziness, nausea, vomiting, abdominal cramps, diarrhea. - Respiratory depression, tightness in chest, wheezing, productive cough, fluid in lungs. - Pin-point pupils, sometimes with blurred or dark vision. - Severe cases: seizures, incontinence, respiratory depression, loss of consciousness.	For extreme symptoms of OP poisoning, injection of atropine (2-4 mg for adults, 0.5-1.0 mg for children) is recommended. Repeated at 5-10 minute intervals until signs of atropinization occur.	12

3	Chlorpyrifos	Highly toxic		Class II - Moderately Hazardous	Atrophine sulphate	Severe – diarrhoea, pinpoint and non - reactive pupils, respiratory difficulty, pulmonary edema, cyanosis, loss of sphincter control, convulsions, coma and heart block.	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, aminophylln, barbiturates Phenothiaznines	7
4	Oxydemeton-methyl	Highly toxic		Class I b- Moderately hazardous		Do-	Do-	20
5	Malathion	Moderately toxic		Class III slightly hazardous		Mild-anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity	For extreme symptoms of OP poisoning, injection of atropine (2-4 mg for adults, 0.5-1.0 mg for children) is recommended. Repeated at 5-10 minute intervals until signs of atropinization occur.	3
6	Phorate	Extremely toxic		Class I b highly hazardous	Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a doctor, do not give anything	Weakness, headache, tightness in chest, blurred vision, nonreactive pinpoint pupils, salivation, nausea, vomiting, diarrhea, and abdominal cramps.	Give atropine intramuscularly or intravenously, depending on severity of poisoning, 2 to 4 milligrams every 10 minutes until fully atropinized as shown by dilated	

					by mouth to an unconscious person		pupils, dry flushed skin and tachycardia. Twenty to thirty milligrams, or more, may be required during the first 24 hours. Never give opiates or phenothiazine tranquilizers.	60
Pyrethroid Insecticide								
7	bifenthrin	Highly toxic		Class II Moderately hazardous	Drink 1 or 2 glasses of water and induce vomiting by touching the back of the throat with a finger. Never induce vomiting or give anything by mouth to an unconscious person. Contact a medical doctor.	Symptoms of overexposure include bleeding from the nose, tremors and convulsions.	Gastric lavage using an endotracheal tube may be preferred to vomiting. Reversible skin sensations (paresthesia) may occur and ordinary skin salves have been found useful in reducing discomfort.	4
Carbamate insecticides								
8	Carbofuran	Extremely toxic		Class I b highly hazardous		Constriction of pupils, salivation, profuse sweating, muscle incordination, nausea, vomiting,diarrhea, epigastric pain, tightness in chest	Atropine injection-1-4 mg. repeat 2 mg when symptoms begin to recur (15-16 min interval) excessive salivation-good sign, more atropine needed	28

Other classes insecticides								
9	Propargite				Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious person	Corrosive. Causes irreversible eye damage. Causes skin burns. Harmful if swallowed. Harmful if absorbed through skin. Harmful if inhaled.	No specific antidote. Treatment is essentially symptomatic.	6
10	Fenazaquin			Class II Moderately hazardous	Immediately flush contaminated eyes with gently flowing water. Do not induce vomiting. If vomiting occurs, lean patient forward or place on the left side (head-down position, if possible) to maintain an open airway and prevent aspiration. Keep patient quiet and maintain normal body temperature. Obta			21
11	hexythiozox	Moderately toxic		Class III slightly hazardous				

Fungicides								
12	Mancozeb	Slightly toxic		Unlikely produce acute hazard		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose,throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic	10
13	Wettable sulphur	Slightly toxic		Unlikely to present acute hazard in normal use		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic	
14	Captan	Moderately toxic		Class III slightly hazardous		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose,throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic.	
15	Dinocap	Moderately toxic		Class III slightly hazardous		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic.	--
16	Carbendazim	Slightly toxic		Unlikely to present acute hazard in normal use		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic.	16
17	Difenoconazole	Slightly toxic		Unlikely to present acute hazard in normal use		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic.	15

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. Equipment

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

F. Precautions for applying pesticides

1. Apply only at recommended dose and dilution
2. **Do not** apply on hot sunny day or strong windy condition ; **Do not** just before the rains and after the rains ; **Do not** 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 sprayer
7. Avoid tank mixing of different pesticides

G. Disposal

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

XIV. PESTICIDE APPLICATION TECHNIQUES

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

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. Do not apply pesticides without protective clothing and wash clothes immediately after spray application.	
5.	Do not apply in hot or windy conditions.	
6.	Operator should maintain normal walking speed while undertaking application.	
7.	Do not smoke, chew or eat while undertaking the spraying operation	
8.	Operator should take proper bath with soap after completing spraying	
9.	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

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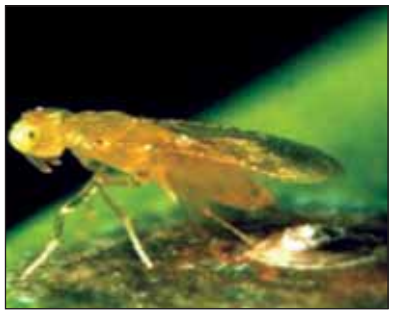
Important Natural Enemies of Apple Insect Pests

Parasitoids

***Trichogramma* spp.**

***Encarsia* sp**



***Aphytis* sp**

Aphelinus mali

***Telenomus* sp**

***Brachymeria* sp**

Predators

Coccinellid

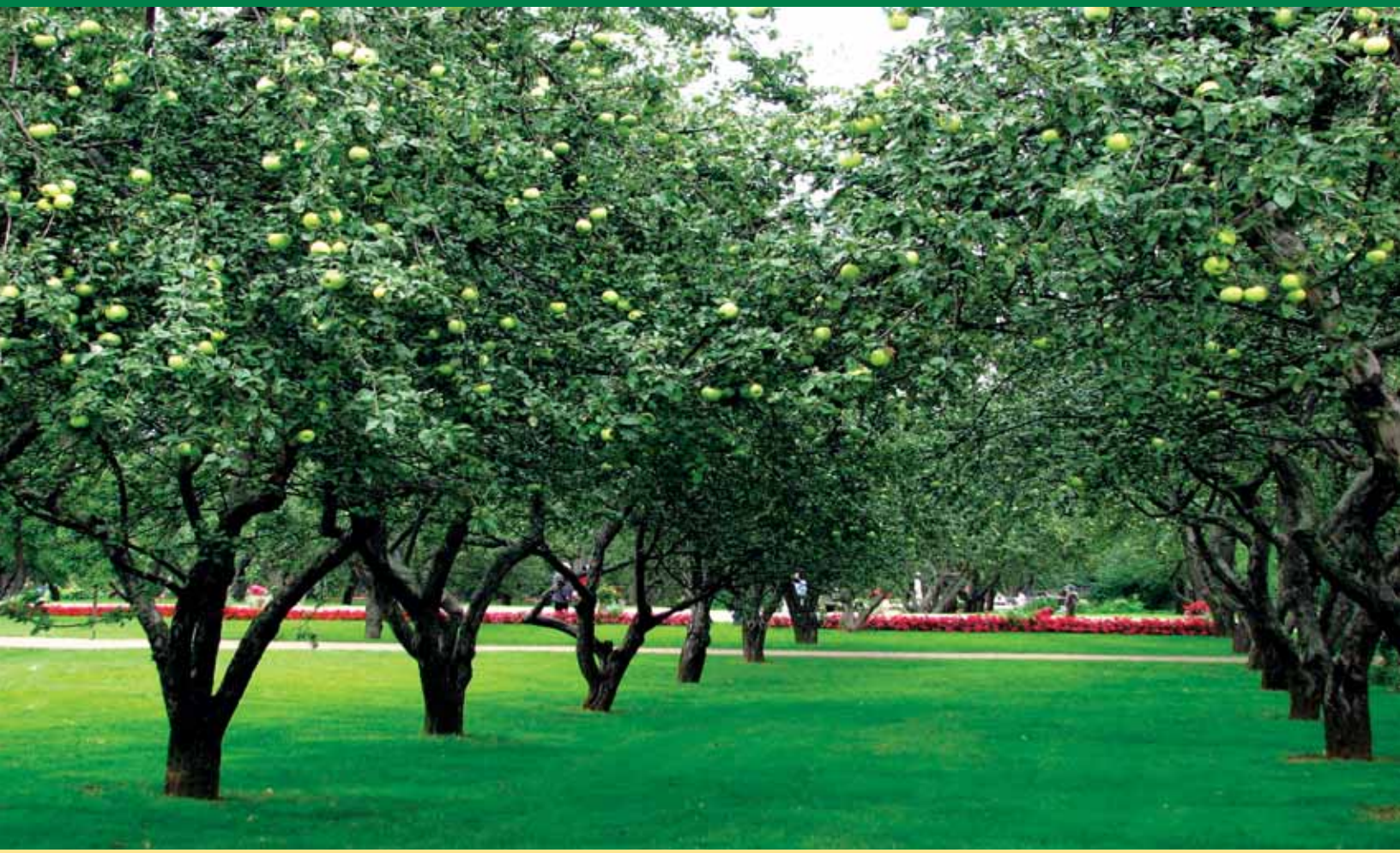
Syrphid fly

Lacewing

Parus major

Predatory thrips

Anthocorid bug



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