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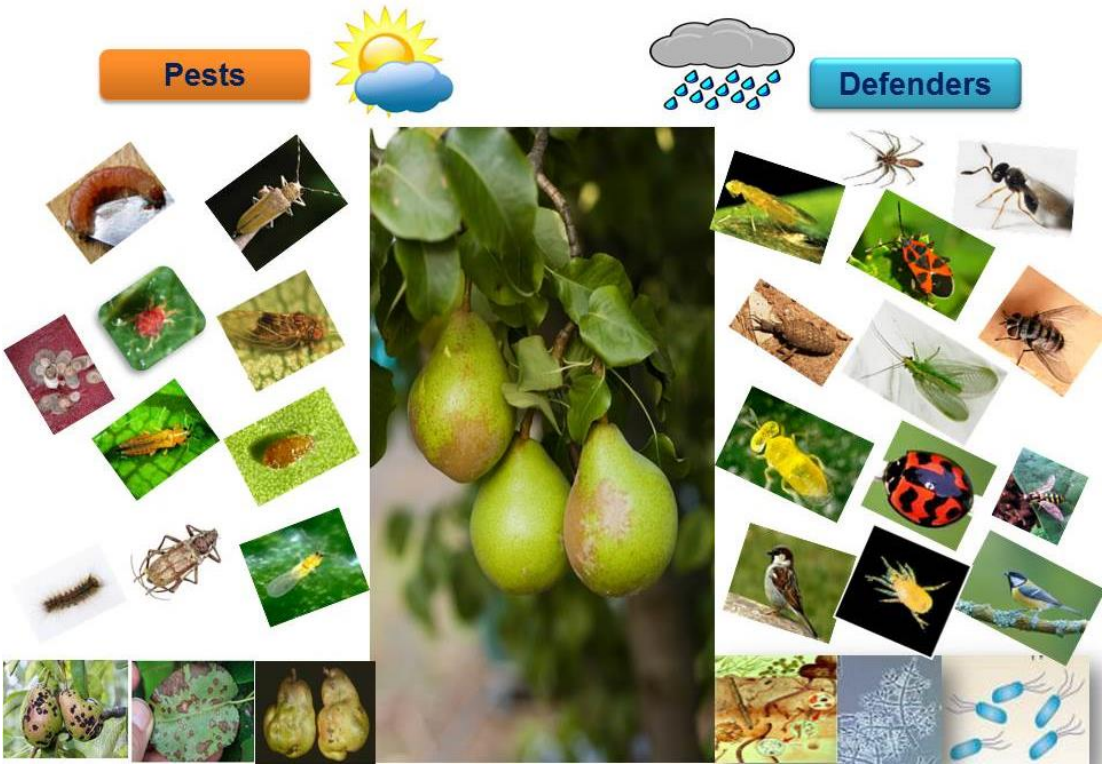
AESA BASED IPM PACKAGE

PEAR



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

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FOREWORD

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

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

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

Date: 6.3.2014

(Avinash K. Srivastava)

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FOREWORD

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

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

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

(Utpal Kumar Singh)

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PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

CONTENTS

AESA BASED IPM PACKAGE FOR PEAR

Pear-Plant description:

The pear (*Pyrus* sp. Family: Rosaceae) is any of several tree and shrub species of genus *Pyrus* in the family Rosaceae. It is also the name of the pomaceous fruit of these trees. Several species of pear are valued for their edible fruit, while others are cultivated as ornamental trees. The genus *Pyrus*is classified in subtribe Pyrinae within tribe Pyreae. The pear is native to coastal and mildly temperate regions of the Old World, from Western Europe and North Africa east right across Asia. It is a medium-sized tree, reaching 10–17 m (33–56 ft) tall, often with a tall, narrow crown; a few species are shrubby. The leaves are alternately arranged, simple, 2–12 cm (0.79–4.72 in) long, glossy green on some species, densely silvery-hairy in some others; leaf shape varies from broad oval to narrow lanceolate. Most pears are deciduous, but one or two species in southeast Asia are evergreen. The flowers are white, rarely tinted yellow or pink, 2–4 cm (0.79–1.57 in) diameter, and have five petals. Like that of the related apple, the pear fruit is a pome, in most wild species 1–4 cm (0.39–1.57 in) diameter, but in some cultivated forms up to 18 cm (7.1 in) long and 8 cm(3.1 in) broad; the shape varies in most species from oblate or globose, to the classic pyriform 'pear-shape' of the European pear with an elongated basal portion and a bulbous end. The fruit is composed of the receptacle or upper end of the flower-stalk (the so-called calyx tube) greatly dilated. Enclosed within its cellular flesh is the true fruit: five cartilaginous carpels, known colloquially as the "core". From the upper rim of the receptacle are given off the five sepals, the five petals, and the very numerous stamens.

I. Pests

A. Pests of National Significance

1. Insect Pests

1.1 San Jose-Scale: *Quadraspidiotus perniciosus* Comstock (Hemiptera: Diaspididae)

1.2 Cock Chaffer beetle: *Melolontha melolontha* Fab (Coleoptera: Scarabaeidae)

1.3 Pear psylla: *Cacopsylla pyricola* (Foerster) (Hemeptera: Psyllidae),
1.4 Green peach aphis: *Myzus persicae* (Sulzer) (Hemiptera: Aphididae)
1.5 Chaffer beetle: *Protactia neglecta* (Coleoptera: Melolonthidae)
1.6 Stem borer: *Aeolesthes sarta* Solsky (Coleoptera: Cerambycidae)
1.7 Root borer: *Dorysthenes huegelii* Redt. (Coleoptera: Cerambycidae)

2. Diseases

2.1 Scab: *Venturia pirina (Cooke) Wint*
2.2 Seedling blight: *Sclerotium rolfsii* Sacc.
2.3 Hairy root: *Agrobacterium rhizogenes* Conn
2.4 Crown gall: *Agrobacterium tumefaciens* Smith & Townsend
2.5 White root rot: *Dematophora necatrix* Berl. exPrill.
2.6 Collar rot: *Phytophthora cactorum* (Lebert& Cohn) J. Schröt
2.7 Powdery mildew: *Podosphaera leucotricha* (Ellis &Everh.) E.S. Salmon
2.8 Leaf spot*: Mycosphaerella* sp., *Alternaria* sp

3. Weeds

Broad leaf

1. Tropical spider wort: *Commelina benghalensis* L. (Commelinaceae)
2. Creeping wood sorrel: *Oxalis corniculata* L. (Oxalidaceae)
3. Goat weed: *Ageratum conyzoides* L. (Asteraceae)
4. Sowthistles: *Sonchus* spp. (Asteraceae)
5. Congress grass: *Parthenium hysterophorus* L. (Asteraceae)
6. Fine leaf fumitory: *Fumaria parviflora* L. (Fumariaceae)
7. Lambs quarter: *Chenopodium album* L. (Chenopodiaceae)
8. Spurge: *Euphorbia hirta* L. (Euphorbiaceae)
9. Common sorrel: Rumex dentatus L. (Polygonaceae)
10. Yellow sweet clover: *Melilotus indica* (L.) All. (Fabaceae)
11. Creeping Thistle: *Cirsium arvense* (L.) Scop (Asteraceae)

Grasses

12. Bermuda grass: *Cynodon dactylon* L. (Poaceae)
13. Cogon grass: *Imperata cylindrical* (L.) Raeusch. (Poaceae)
14. Blanket grass: *Axonopus compressus* (Sw.) Beauv. (Poaceae)
15. Large crabgrass: *Digitaria sanguinalis* L. (Scop.) (Poaceae)
16. Knot grass: *Paspalum distichum* L. (Poaceae)

Sedges

17. Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)
18. Flat sedge: *Cyperus iria* L. (Cyperaceae)

B. Pest of Regional Significance

1. Insect Pests:

1.1 Codling moth: *Cydia pomonella* L. (Lepidoptera: Tortricidae)
1.2 Thrips: *Taeniothrips sp.* (Thysanoptera: Thripidae)
1.3 Mites: *Eutetranychus orientalis* Klein, *Panonychus ulmi* Koch & *Tetranychus urticae* Koch (Arachnida: Tetranychidae)
1.4 Flat headed borer: *Sphenoptera lafertei* (Coleoptera: Buprestidae)
1.5 Leopard moth: *Zeuzeram multistrigata* (Lepidoptera: Cossidae)
1.6 Leaf roller: *Archips argyrospilus* Walker (Lepidoptera: Tortricidae)
1.7 Green weevil: *Phyllobuis* sp. (Coleoptera: Curculionidae)
1.8 May, June beetle: *Adoretus* sp. (Coleoptera: Scarabaeidae)
1.9 Green capsid: *Lygus pabulinus* Hahn (Hemiptera: Miridae)
1.10. Green aphis: *Aphis pomi* L. (Hemiptera: Aphididae)
1.12. Stik bug: *Euschistus conspersus* Uhler (Heteroptera: Pentatomidae),
1.13. Tent hairy caterpillar: *Malacosoma indica* Walker (Lepidoptera: Lasiocampidae)
1.14. Hairy caterpillar: *Euproctis* sp. (Lepidoptera: Lymantridae)
1.15. Bark eating caterpillar: *Indarbelaqua drinotata* Walker (Lepidoptera: Metarbelidae)
1.16. Fruit fly: *Bactrocera dorsalis* Hendel (Diptera:Tephritidae)

2. Diseases

2.1 Dieback: *Colletotrichum* spp.
2.2 Virus diseases
2.3 Mycoplasma diseases
2.4 Shoot/fruit blight and bark canker: *Botryodiplodia theobromae* Pat. and *Phoma glomerata* (Corda) Wollenw. & Hochapfel
2.5 Root rot and sapwood rot: *Polyporus palustris* Berkeley et Curtis, *Ganoderma lucidum* (Curtis) P. Karst, *Schizophyllum commune* Fries

3. Rodent pests:

3.1 Smaller bandicoot: *Bandicota bengalensis* L.
3.2 Soft furred orchard rat: *Melardia meltada* Thomas
3.3 Vole: *Alticola* sp.

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

A. AESA:

The IPM has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment ultimately affecting the interests of the farmers. The economic threshold level (ETL) was the basis for several decades but in modern IPM (FAO 2002) emphasis is given to AESA where farmers take decisions based on larger range of orchard observations. The health of a plant is determined by its environment which includes physical factors (i.e. sun, rain, wind and soil nutrients) and biological factors (i.e. sun, rain, sunshine hours, wind etc.). All these factors can play a role in the balance which exists between herbivore insects and their natural enemies. Understanding the intricate interactions in an ecosystem can play a critical role in pest management.

Decision making in pest management requires a thorough analysis of the agro-ecosystem. Farmer has to learn how to observe the crop, how to analyze the orchard situation and how to make proper decisions for their crop management. This process is called the AESA.

Participants of AESA will have to make a drawing on a large piece of paper (60 x 80 cm), to include all their observations. The advantage of using a drawing is that it requires the participants/farmers to observe closely and intensively. It is a focal point for the analysis and for the discussions that follow, and the drawing can be kept as a record.

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

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

Principles of AESA based IPM:

Grow a healthy crop

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

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

Farmers should

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

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

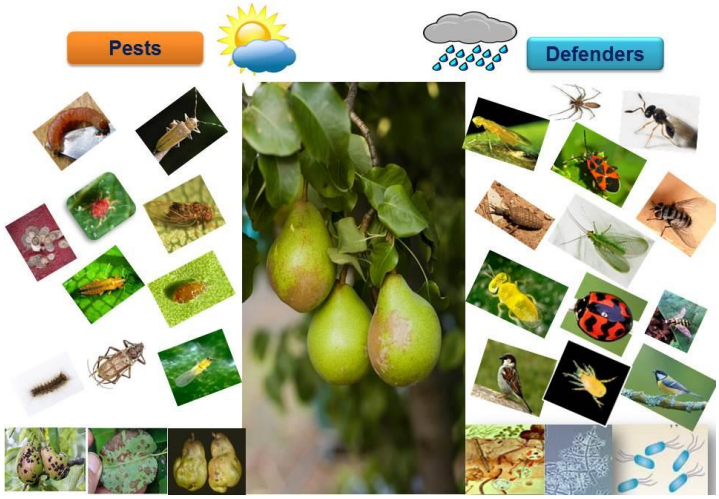
Insect zoo

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 pear insect pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens.

Model Agro-Ecosystem Analysis Chart

Date:
Village:
Farmer:



Decision taken based on the analysis of orchard situations

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

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

Decision making

Farmers become experts in crop management

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

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

AESA methodology

- Go to the orchard in groups (about 5 farmers per group). Walk across the orchard and choose 10 plants/acre randomly. Observe keenly each of these plants and record your observations:
    - Tree: 5-6 samples per tree (fruits/ leaves/ inflorescence /stem bark/roots/ soil/ insects, host plants) should be collected where, one sample from top, four samples from all the four sides (north, south, east, west) and one from bottom/soil, depending upon the requirement of sturdy/observations and if necessary..
    - Insect pests: Observe and count insect pests at different places on the tree.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
    - Rats: Count number of plants affected by rats.
    - Weeds: Observe weeds in the orchard and their intensity.
    - Water: Observe the water situation in the orchard.
    - Weather: Observe the weather conditions.
- While walking in the orchard, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the orchard situation in detail and present their observations
  and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the orchard situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on what orchard management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording

Farmers should record data in a notebook and drawing on a chart

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

Data to be recorded

- **Plant growth (weekly):** Height of plant; Number of branches

- **Crop situation (e.g. for AESA):** Plant health, Pests, diseases, weeds, Natural enemies, Soil conditions, Irrigation, Weather conditions
- **Input costs:** Seeds, Fertilizer, Pesticides, Labour
- **Harvest:** Yield (Kg/acre), Price of produce (Rs./Kg)

Some questions that can be used during the discussion

- Summarize the present situation of the orchard?
- What crop management aspect is most important at this moment?
- Is there a big change in crop situation compared to last visit? What kind of change?
- Is there any serious pest or disease outbreak?
- What is the situation of the beneficial insects?
- Is there a balance in the orchard between pests and defenders?
- Were you able to identify all pests and diseases?
- Do you think the crop is healthy?
- What management practices are needed at this moment?
- When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.
- Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest build-up?
- What problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.


Advantages of AESA over ETL

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

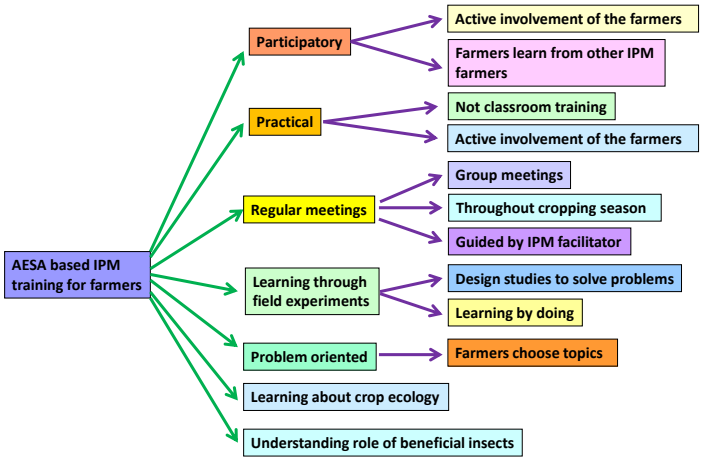
AESA and farmer orchard school (FFS)

AESA is a season-long training activity that takes place in the farmer orchard. It is season-long so that it covers all the different developmental stages of the 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
- Quantification of the damage or ETL
- Management of pests
- Water and nutrient management
- Influence of weather factors on pest buildup
- Role of natural enemies in pest management

FFS to teach AESA based IPM skills



B. Orchard scouting:

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

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

Sampling in fruit crops:

If someone is doing sampling he will be known as an inspector or scout. The fruit crops are perennial in nature and before starting the surveillance process an inspector or scout who is

going to implement the activity should know about the nature of crop as well as different crop stages and its growth stages. Knowing crop and its nature helps in identifying the important diseases and pest, because the diseases and pests are infect/infect certain stage or part of the crop plant.

Sampling patterns:

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

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

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

Sampling frequency:

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

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

For insect pests:

For aphids, San Jose scales and mites: Count and record the number of both nymphs and adults on five randomly selected leaves per plant.
For 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).
For *Cydia*: Total number of fruits, damaged fruits due to *Cydia* and number of larvae on individual plants should be counted and recorded.

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

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

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

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

C. Surveillance through pheromone trap catches for gypsy moth and codling moth: Pheromone traps for @ 4-5/acre have to be installed, if available. 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 destroyed and removed after each recording.

D. Yellow /blue sticky traps:
Set up yellow/blue sticky traps 1 foot above the canopy for monitoring aphids and thrips respectively @ 1 trap (15 X 7.5 cm)/5 trees. Locally available empty tins can be painted yellow/blue coated with grease/ Vaseline/castor oil on outer surface may also be used

as yellow sticky trap. Count the number of aphids on the traps daily and take the appropriate decision regarding management practices. .

E. Light traps:

Set up light traps 1 trap/acre 15 cm above the crop canopy for monitoring of hairy caterpillars, leaf roller and few beetles of stem/root borer. Light traps with exit option for natural enemies of smaller size should be installed and operate around the dusk time (6 pm to 10 pm).

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

Ecological Engineering for Pest Management – Below Ground:

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

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

Ecological Engineering for Pest Management – Above Ground:

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

Natural enemies may require:

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

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

- Raise the flowering plants / compatible cash crops along the field border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population

- Grow flowering plants on the internal bunds inside the field
- Not to uproot weed plants those are growing naturally such as *Tridax procumbens, Ageratum* sp, *Alternanthera* sp etc. which act as nectar source for natural enemies,
- Not to apply broad spectrum chemical pesticides, when the P: D ratio is favourable. The plant compensation ability should also be considered before applying chemical pesticides.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Select and plant appropriate companion plants which could be trap crops and pest repellent crops. The trap crops and pest repellent crops will also recruit natural enemies as their flowers provide nectar and the plants provide suitable microclimate.

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

Plants suitable for Ecological Engineering for Pest Management
Attractant plants

Cowpea

Carrot

Sunflower

Buckwheat

French bean

Alfalfa

Mustard **Cosmos** **Anise**

Caraway

Dill

Parsley

Marigold

Repellent plants

***Ocimum*spp**

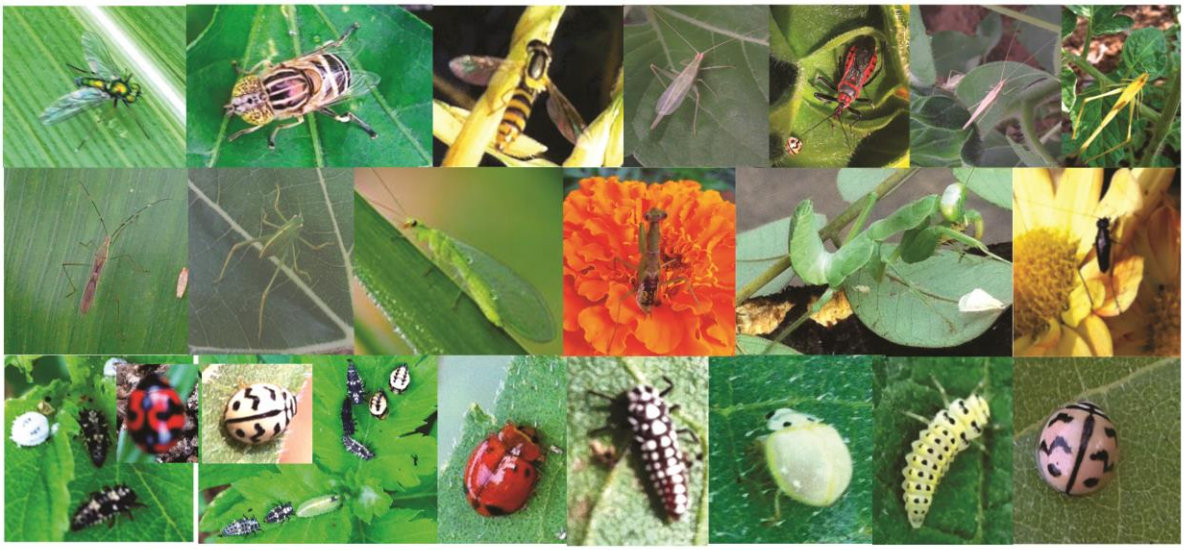
Peppermint/Spearmint

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.

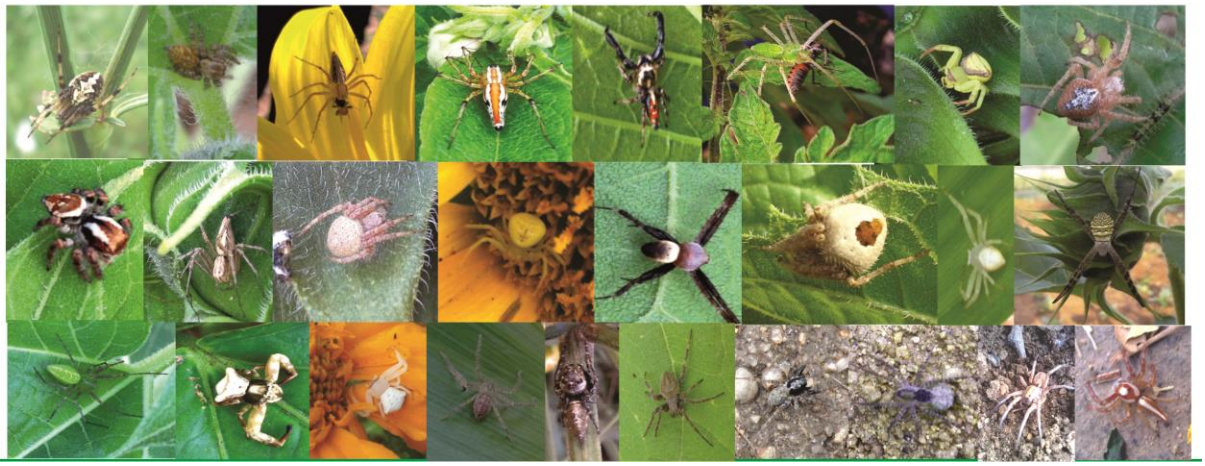
Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



IV. CROP STAGE-WISE IPM

Management	Activity
Pre-planting*	
	Common cultural practices: • Deep ploughing of field during summer. • Use resistant/tolerant varieties. • Apply manures and fertilizers as per soil test recommendations. • Grow the attractant and repellent around the orchard bunds.
Nutrients	• Nutrient should be applied on the basis of soil test report and recommendation for the particular agro-climatic zone. • Prepare land by ploughing and harrowing. • The pits are dug in summer about a fortnight before planting and left undisturbed for solarization. • Pits of about 1m x 1m x 1m size are dug at a distance of 6 to 8 meter in square system of planting.
Weeds	• Deep ploughing of field during summer
Soil borne pathogens, Resting stage of insects and other diseases	**Cultural control:** • Proper selection of cultivars, having commercial value and suitable for effective cross pollination be made. • Deep medium textured and well drained soils may be selected for cultivation of pear. However, they can withstand in soils having high water table and poor aeration.
Planting*	
Nutrients	• Planting is done in pits already filled with top soil and organic manure during the months of October to December. • Mycorrhiza culture @ 50 g per pit should be applied at the time of planting or a basket of soil taken from old pear orchard is added to each pit to ensure mycorrhizal association with pear roots. • At the time of planting, farm yard manures or compost is applied @ 40-50 Kg per plant.
Weeds	• Use weed free seedlings for planting. • Remove existing weeds in and around the pits at the time of planting.
Insects and soil borne pathogens	• Timely sowing should be done. • Plant material for laying quality fruit orchard should be obtained from registered nursery. • Avoid planting of saplings infested with scales, borers and diseases. • Don't grow the nursery at the same site every

	year. • Use of disease-resistant rootstock and scion for managing the collar rot. • For raising of nurseries, the soil selection be made which is free from pest infestation. • Delay planting until the soil is reasonably dry and plant before the buds begin to burst. • Growing of flowering plants especially marigold and maize on the peripheries will help in conservation of both predators and parasites. In rich soils, the fertilizer doses may be half or applied on the basis of leaf analysis report. • Make use of neem cakes while raising plant nurseries to ward off any soil pest.
*Apply *Trichoderma viride/harzianum* and *Pseudomonas fluorescens* as seed treatment and soil application (If Commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their orchards, registration is not required).	
Vegetative stage 1st year onward*	
	Common cultural practices: • Collect and destroy diseased and insect infected plant parts. • Provide irrigation at critical stages of the crop • Avoid water stagnation conditions. • Enhance parasitic activity by avoiding chemical spray, when larval parasitoids are observed. • Keep the orchards healthy following good agricultural practices. **Common mechanical practices:** • Collection and destruction of eggs and early stage larvae • Handpick the older larvae during early stages • The infested plant part may be collected and destroyed • Handpick the gregarious caterpillars and the cocoons which are found on stem and destroy them in kerosene mixed water. • Use yellow sticky traps for aphids and blue sticky traps for thrips @ 4-5 trap/acre. • Use light trap @ 1/acre and operate between 6 pm and 10 pm • Install pheromone traps @ 4-5/acre for monitoring adult moths activity (replace the lures with fresh lures after every 2-3 weeks) • Erecting of bird perches @ 20/acre for encouraging predatory birds such as King crow, common mynah etc. • Set up bonfire during evening hours at 7-8 pm **Common biological practices:** • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies
Nutrients	• Up to 6th year of age, 50 Kg FYM or compost along

	with 50 to 100 g N + 25 to 50 g P_2O_5 + 50 to 100 g K_2O per plant per year should be applied. • Nitrogen is applied in 2 splits, first half at 2-3 weeks before flowering and the remaining half a month later. • The fertilizers should be applied in 20-30 cm deep and 30cms wide trench along the drip line of the tree.
Weeds	**Cultural Control:** • Intercultural operations during the first year to check weed growth. • Tool weeding should be done on regular basis especially around the plants. • During the initial 2-4 years, to suppress the weeds between rows, leguminous crops like pea, bean, soybean, and cowpea and vegetables should be be grown • Use slashing and moving between the rows to control the weeds. • Use black polyethylene or straw or green mulches to suppress the weed growth between rows. • Mulching tree basins with 10-15 cm thick dry grass also checks weed growth
San Jose-Scale	• Adopt common cultural, mechanical and biological practices.
Chaffer beetle	**Cultural control:** • Collect and kill the beetles in kerosenized water. • Shake the non-bearing plant/trees over a cloth sheet at dusk and collect and destroy the beetles (defoliating and fruit eating).
Pear psylla	**Cultural control:** • To reduce the effects of pear decline, use Winter Nelis, Old Home X Farmingdale, or *Pyrus betulaefolia* seedlings for rootstock and maintain pear psylla populations at low levels.
Stem borer/root borer	**Cultural control:** • 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. • Maintain vigour of the tree to keep away borers infestation. **Mechanical control:** • See common practices as in vegetative stage..
Aphids	• See common practices as in vegetative stage.
Mite**	**Cultural control:** • Regular orchard monitoring for pest & defender population. • Plant should neither be forced to drought nor water

	lodging conditions. **Biological control:** • Release of 8 days old Anthocorid bug, *Blaptostethuspallescens.* • Neem oil (2%), NSKE (5%)
Thrips**	• See common practices as in vegetative stage.
Fruit fly	**Cultural control:** • Harvest the ripening fruits and do not allow the ripe fruits on the tree. • Regular removal of fallen fruits from the ground and bury the infested fruits at last at 60 cm depth. • Shallow ploughing with cultivator immediately after harvest is effective in exposing and killing the pupating larvae/pupae, which are mostly present 4-6 cm depth.
Shoot/fruit blight and bark canker	• Cankers on the trunk and in the crotches should be removed and the dead bark decorticated along with 2 cm of the healthy bark. All the dead wood and pruning bark should be destroyed. • Cover the wounds with a disinfectant solution and after this apply Bordeaux paste to them. After a week cover the dried paste with Bordeaux paint. The whole operation should be immediately followed by spraying the pruned and canker infected tree with Bordeaux mixture.
Root rot and sap wood rot	• Avoid deep ploughing to avoid injuries to the roots, through which the fungus attacks. Also avoid excessive irrigation during winter.
Leaf spot	**Cultural control:** • Prune the disease part and burn it. • Avoiding injury during harvest and packing.
Powdery mildew	**Cultural control:** • Avoid overcrowding of branches • Pruning cuts should be made close to the branches leaving no stubs. • Careful use of water and fertilizers input, especially nitrogen to minimize growth of large dense canopies. • Water only in the morning so that foliage will be dry by the evening. • Clip off mildewed twigs and destroy them.
Viral and phytoplasmal disease	• See common practices as in vegetative stage..

	• Control insect vectors psylla and aphids.
Flowering /Fruiting stage	
Nutrients	• After 6th year the nutrient rates are established at 50 kg FYM, 100 g N, 50 g P_2O_5 and 100g K_2O per plant per year. The farmyard manure should be applied during • December-January along with full dose of P and K. Nitrogen is applied in 2 splits. • The band application of nitrogenous fertilizers should be preferred over broadcasting. • Under rainfed conditions, apply N through 1 or 2 foliar sprays of urea (0.5%) after fruit set. • Apply recommended micronutrients, if symptoms are observed. Fruits are deformed under boron deficiency. • To avoid boron deficiency, apply boric acid @ 0.1% as foliar spray. • The deficiency of Zn and Fe on young foliage can easily be controlled by spraying 0.4 -0.5 % zinc sulphate and ferrous sulphate respectively during April.
Weeds	• Same as in vegetative stage .
Beetles and scale**	• Same as vegetative stage.
Borer and mites**	• Same as vegetative stage.
Codling moth and other insects**	**<u>Cultural control:</u>** • 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. • All loose bark of trees should be scraped off to remove overwintering sites for the caterpillars. • Vicinity of trees should be kept clean of packing cases and all other debris which are likely to shelter the overwintering caterpillars during August to mid October. • Bands of sacking (gunny bags) or corrugated cardboard about 150 mm. to 240mm. wid, can be tied round the tree trunks by late July till end of October to provide alternative over wintering sites for the caterpillars. • These bands should be removed during the first week of November and either burnt or immersed in a pail of boiling water or kerosenised water. • Fallen fruits should be collected throughout the season and buried deep in the soil. **<u>Biological control:</u>** • Release of exotic egg parasitoids *Trichogramma embryophagum* Htg. and

	Trichogramma cacoeciae pallidum Meir *Trichogramma chilonis (minutum)* at the rate of 20,000 adults per 50 pear trees/week should be undertaken from first fortnight of June to end of August. • For others see common practices.
Scab	**Cultural control:** • 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. • For others follow common practices.
Crown gall	**Cultural control:** • Plant certified disease-free rootstock, and when planting, take care to avoid injuring the roots and crown. • When cultivating around trees be careful to avoid injuring the crown and surface roots.
Collar rot, root rot	**Cultural control:** • Do not allow water to accumulate around tree crowns. • Provide adequate drainage, and avoid planting in heavy soils, low spots, and areas that flood frequently
Canker and die back**	**Mechanical control:** • Proper pruning should be done to avoid mechanical injury. • Keep the trees as free as possible from mechanical wounds, winter injury, crotch separation and cankers. • Cut wounds should be covered with superior white lead paint **Biological control**: • See common biological practices as stated in vegetative stage.
Fruit development (after 20 days of waltnut stage)	
Mites and aphids**	• **Same as above**
Scab and *Alternaria* leaf spot	• Same as above
Pre harvest stage (20-25 days before harvest)	
Caterpillars, moth, mites and scale**	• Same as above
Scab and *Alternaria* leaf spot	• Same as above
Postharvest and dormant stage	
Diseases	**Mechanical control:** • Take proper care in handling the fruits to avoid bruises.

	• Don't delay harvesting of fruits. • Keep the trees as free as possible from mechanical wounds, winter injury, crotch separation and cankers. • Collect and destroy the fallen fruits. • Apply Mashobra paste after cleaning the weeping wounds at the time of dormancy break for the control of bacterial gummosis. • Remove and destroy all the mummified fruits, dead fruits and pruning from the orchards.
Insects	**Mechanical control:** • Collection and destruction of egg masses of hairy caterpillars especially from the barks of shade trees grown in the vicinity of the orchards be ensured. • Staple burlap skirts around tree trunks infested with hairy caterpillars and collect the larvae and pupae from May to end of June and ensure their destruction. • Clean the stem borer hole with flexible wire & apply the recommended chemical.. • Remove the dead bark and frass and apply water proof paint on hard wood to avoid borer attack. • Complete collection and destruction of foliage and pruned wood in the orchards after leaf fall be made. • Pruning of suckers and water sprouts be ensured.

****Regional pests**

V. RODENT PEST MANAGEMENT

Rodents	**Cultural control:** • Practice clean cultivation/maintain weed free orchards which reduces the harboring/hiding points for rodents. • Practice trapping with locally available traps using lure @ 20-25 traps/ac. In areas, where bandicoot is a problem, wonder traps/multi-catch traps work better and enable to trap more animals in a single trap. • Identify live rodent burrows and smoke the burrows with burrow smoker for 2-3 minutes • Erect owl perches @ 12-15/ac to promote natural control of rodents **Chemical control:** • In cases of high level of infestation (>50 live burrows/ac) practice poison baiting with zinc phosphide @ 2.0% on community approach. PRACTICE PRE-BAITING TO AVOID

	BAIT SHYNESS Day 1: Close all the burrows in the orchards, orchard bunds, canal bunds and surrounding barren lands etc. Day 2: Count the re-opened burrows and practice pre-baiting @ 20 g/burrow (98 parts of broken rice + 2 parts of edible oil) Day 4: Observe the re-opened burrows and treat the burrow with zinc phosphide poison bait (96 parts of broken rice + 2 parts of edible oil + 2 parts of zinc phosphide) @ 10g/ burrow. Collect the dead rats, if found any outside and bury them.

VI. INSECTICIDE RESISTANCE AND ITS MANAGEMENT

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

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

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

1) **Monitor pests:** Monitor insect population development in fields to determine if and when control measures are warranted. Monitor and consider natural enemies when making control decisions. After treatment, continue monitoring to assess pest populations and their control.
2) **Focus on AESA.** Insecticides should be used only as a last resort when all other non-chemical management options are exhausted and P: D ratio is above 2: 1. Apply biopesticides/chemical insecticides judiciously after observing unfavourable P: D ratio and when the pests are in most vulnerable life stage. Use application rates and intervals as per label claim.
3) **Ecological engineering for pest management:** Flowering plants that attract natural enemies as well as plants that repel pests can be grown as border/intercrop.
4) **Take an integrated approach to managing pests.** Use as many different control measures as possible viz., cultural, mechanical, physical, biological etc. Select

insecticides with care and consider the impact on future pest populations and the environment. Avoid broad-spectrum insecticides when a narrow-spectrum or more specific insecticide will work. More preference should be given to green labeled insecticides.

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

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

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

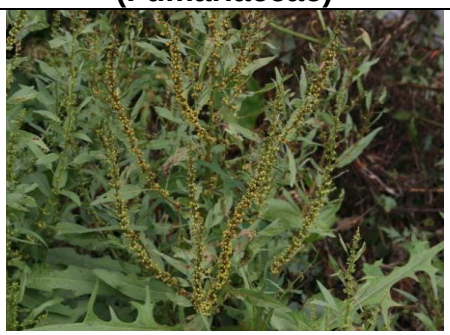
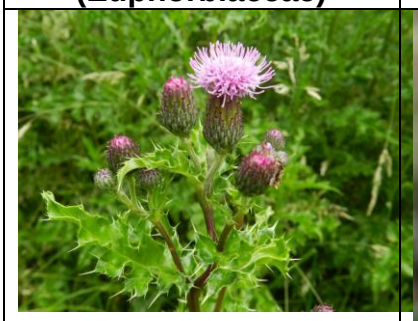
VII. Nutrient deficiency / physiological disorders

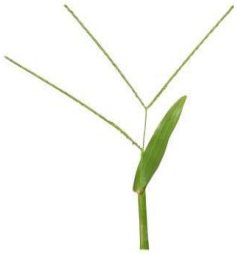
Nutrients.	Appearance
Nitrogen: Stunted growth of plants with pale green to light yellow color (chlorosis) appearing first on older leaves. Depending on the severity of deficiency, the chlorosis results in the drying and dropping of the older leaves. **Correction Measure:** Foliar spray of Urea @ 1-2 % at fortnightly intervals.	
Phosphorus: Symptoms appear on older leaves. The leaves are small and narrow with purplish or bronze discolouration. Leaves develop necrotic areas and fall off. **leaves have pinched, undulating margins.** **Correction Measure:** Foliar spray of DAP@2%.	
Potassium: Chlorosis along the edges of leaves (leaf margin scorching) occurs first in older leaves. Plants deficient in K will have weak stems with slow and stunted growth. The size and quality of fruits produces are poor which leading to reduced yield. **Correction Measure:** Soil application of K2O @ 2kg per tree or foliar spray of KCl@1-2%.	

Iron: Thin and smaller younger leaves with interveinalchlorosis. Green tinge at the base of mid rib. Later the leaves become pale or whitish and shed, older leaves remain green, fruits coarse light coloured. **Correction Measure:** Foliar spray of FeSO4@0.5% or Soil application of FeSO4@0.5kg/tree.	
Calcium: Symptoms first appear on the younger leaves and leaf tips. The growing tips of roots and leaves turn brown and die. Newly emerging leaves may stick together at the margins, which causes tearing as the leaves expand and unfurl. Younger leaves may be cupped and crinkled, with the terminal bud deteriorating. **Correction Measure:** soil application of gypsum @ 20 kg per tree.	

VIII. COMMON WEEDS

 **1. Tropical spiderwort: *Commelina benghalensis* L. (Commelinaceae)**	 **2. Creeping wood sorrel: *Oxalis corniculata* L. (Oxalidaceae)**	 **3. Goat weed: *Ageratum conyzoides* L. (Asteraceae)**
 **4. Sowthistles:**		 **6. Lambs quarter:**

***Sonchus* spp. (Asteraceae)**	**5. Fine leaf fumitory: *Fumaria parviflora* (Fumariaceae)**	***Chenopodium album* L. (Chenopodiaceae)**
 **7. Spurge: *Euphorbia hirta* L. (Euphorbiaceae)**	 **8. Common sorrel: *Rumex dentatus* L. (Polygonaceae)**	 **9. Yellow sweet clover: *Melilotus indica* (L.) All. (Fabaceae)**
 **10. Creeping Thistle: *Cirsium arvense* (L.) Scop (Asteraceae)**	 **11. Knot grass: *Paspalum distichum* L. (Poaceae)**	 **12. Crab grass: *Digiteria sanguinalis* (L.) Scop. (Poaceae)**
 **13. Congress grass: *Parthenium Hysterophorus* L. (Asteraceae)**	 **14. Bermuda Grass: *Cynodon dactylon* (L.) Pears.(Poaceae)**	 **15. Cogon grass: *Imperata cylindrica* (L.) Raeusch. (Poaceae)**

		
16. Blanket grass: *Axonopus compressus* (Sw.) Beauv. Poaceae	**17. Flat sedge: *Cyperus iria* L. (Cyperaceae)**	**18. Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)**

IX. DESCRIPTION OF INSECT AND MITES PESTS

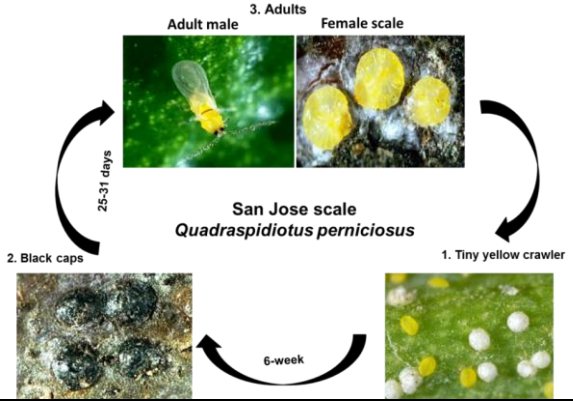
1. San Jose scale:

Biology:

Nymph: Female San Jose scales lay eggs which immediately hatch to colourless that emerge from under the edge of the scale covering. Each female lay birth to 200-400 eggs. 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. 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

Symptoms of damage:

- 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.

Damage symptoms:

1: http://entomology.tfrec.wsu.edu/pearent/crop_damage.htm

Natural enemies of San Jose Scale:

Parasitoids:*Encarsiaperniciosi*and *Aphytisdiaspidis*(proclia group) etc.
Predators: Coccinellid (*Chilocorus infernalis*, *Pharoscymnus flexibilis)* etc.

*For the management refer page no……..

2.Pear psylla:

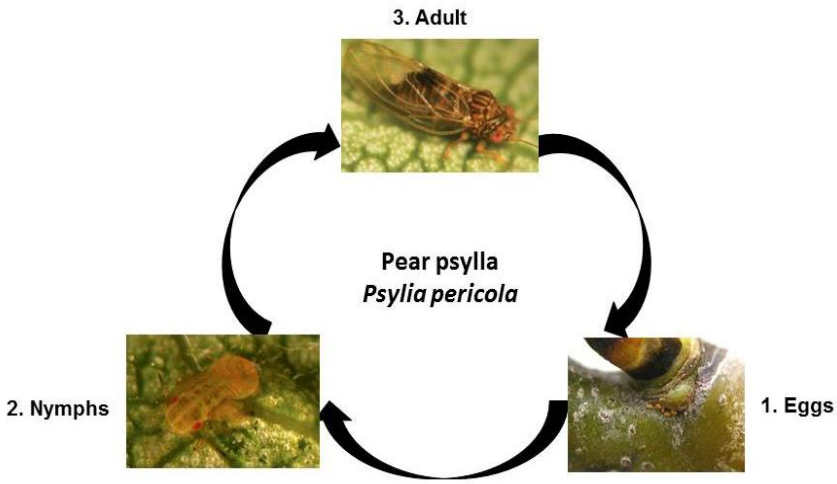
Biology:

Egg: Eggs are minute, oval, and creamy white to yellow. Eggs laid before buds open in spring, and through early fall, eggs are deposited in lines or rows on the terminals and fruit spurs after buds open, eggs are deposited along mid-veins and petioles of developing leaves and on stems and sepals of blossoms. Eggs hatch when foliage appears and continue throughout growing season.

Nymph: Early instars are about 1.6 mm long and light yellow; later instars are dark green to dark brown with wing pads and two conspicuous red eyes. Nymphs are cylindrical, but appear flattened and found on the undersides of leaves. Pass through five instars, which are generally covered by a drop of honeydew.Moves little at first but later instars move easily. Feeds and develops on new growth and water sprouts. Produces honeydew.

Adult: Adults are 4 mm long and red-brown to black; larger and darker than summer adults. It resembles miniature cicada with wings held roof-like over the abdomen. Hides under bark, under litter on the orchard floor, or in sites outside the orchard. Adults leave the pear trees in Oct.-Nov. for wintering sites and return about 6 weeks before bloom. Feed by sucking juice from the host tree. Begin laying eggs after buds begin to swell.

Life cycle:



http://utahpests.usu.edu/ipm/htm/fruits/fruit-insect-disease/pear-psylla07

Damage symptoms:

- Nymphs and adults suck sap primarily from the tender foliage of the new shoots and water sprouts. Feeding by nymphs produces a large amount of honeydew, which makes the tree sticky and promotes the growth of sooty mold (black fungus). The honeydew can run onto fruit causing dark russet blotches or streaks resulting in unmarketable fruit.

http://utahpests.usu.edu/ipm/htm/fruits/fruit-insect-disease/pear-psylla07

Natural enemies of Pear psylla:

Predators: Lacewings, ladybird beetle, minute pirated bugs, predatory mites, anthocorid bugs, Spiders etc.

*For the management refer page no……

3. Green peach aphid:

Biology:

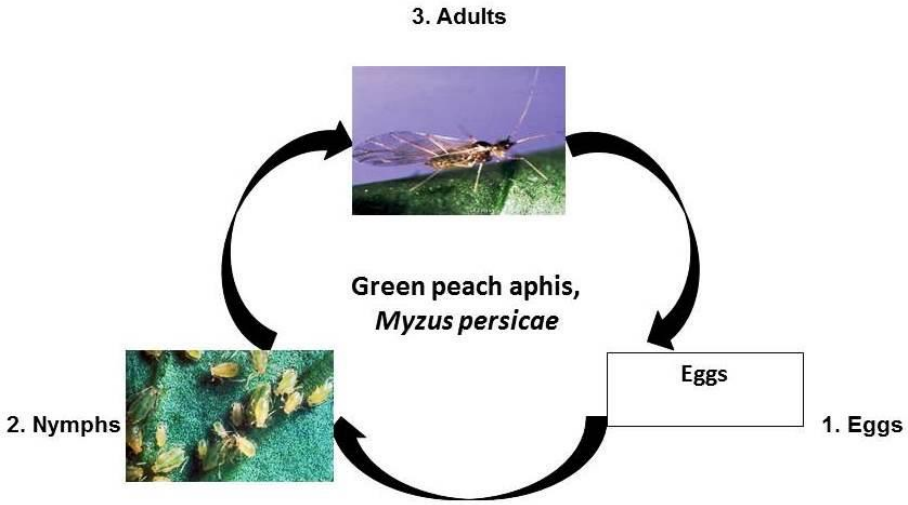
Egg: Eggs are deposited on *Prunus* spp. trees. The eggs measure about 0.6 mm long and 0.3

mm wide, and are elliptical in shape. Eggs initially are yellow or green, but soon turn black. Mortality in the egg stage sometimes is quite high.

Nymph: Nymphs initially are greenish, but soon turn yellowish, greatly resembling viviparous (parthenogenetic, nymph-producing) adults. There are four instars, with the duration of each averaging 2.0, 2.1, 2.3, and 2.0 days, respectively. Females gave birth to offspring six to 17 days after birth, with an average age of 10.8 days at first birth. The average length of life is about 23 days, but this was under caged conditions where predators were excluded. The daily rate of reproduction averaged 1.6 nymphs per female. The maximum number of generations observed annually during these studies was determined to be 20 to 21, depending on the year.

Adult: Up to 8 generations may occur on *Prunus* in the spring, but as aphid densities increase winged forms are produced, which then disperse to summer hosts. Winged (alate) aphids have a black head and thorax, and a yellowish green abdomen with a large dark patch dorsally. They measure 1.8 to 2.1 mm in length. Winged green peach aphids seemingly attempt to colonize nearly all plants available. They often deposit a few young ones and then again take flight. This highly dispersive nature contributes significantly to their effectiveness as vectors of plant viruses.

Life cycle:



http://entnemdept.ifas.ufl.edu/creatures/veg/aphid/green_peach_aphid.htm

Damage symptoms:

- Green peach aphids can attain very high densities on young plant tissue, causing water stress, wilting, and reduced growth rate of the plant.
- Prolonged aphid infestation can cause appreciable reduction in yield of root crops and foliage crops. Early season infestation is particularly damaging to potato, even if the aphids are subsequently removed.
- Contamination of harvestable plant material with aphids, or with aphid honeydew, also

causes loss. Blemishes to the plant tissue, usually in the form of yellow spots, may result from aphid feeding.

http://entnemdept.ifas.ufl.edu/creatures/veg/aphid/green_peach_aphid.htm

Natural enemies of Green peach aphis
Parasitoid: *Aphelinus* sp
Predators: Syrphid fly, lygaeid bug, Coccinellid, Lacewing

*For the management refer page no……

5. 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 emerges in 7-8 days and start feeding by boring inside the stem. Grub longevity 2 years. Grub remains quiescent during winter and resumes 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 beetles 35-50 mm long and grey in colour having long antennae.

Adult
http://www.zin.ru/animalia/coleoptera/eng/aeosardk.htm

Nature and symptoms of damage:

- 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 the management refer page no……

6. Root borer:

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

Biology:

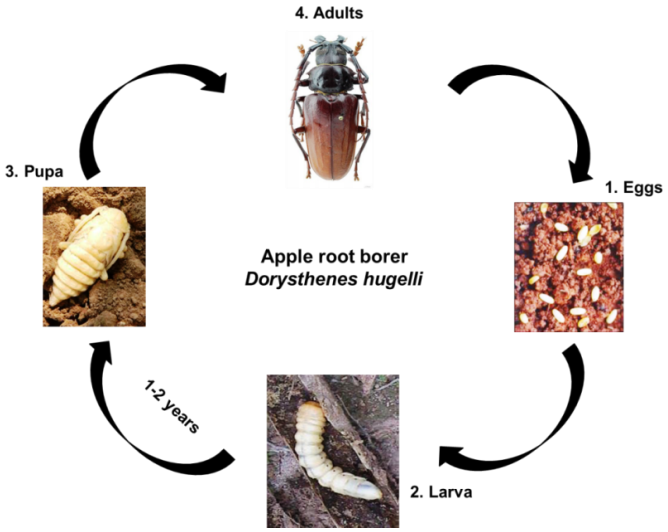
Egg: Female lays eggs singly or in small clusters in soil. Eggs are 1.3 mm in size. Newly laid eggs are white with a tinge of yellow and become dark brown before hatching.

Grub: Grubs feed on the root. Grub longevity 3.5 years. Grubs are cruciform, yellowish-white in colour. Development period ranges between 3-4 years. The full feed grub reach 80 mm 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 in earthen cell inside soil.

Adult: The adult beetle is chestnut red in color and bears long serrated antennae.

Life cycle:



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

Symptoms of damage:

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

*For the management refer page no……

7. 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:

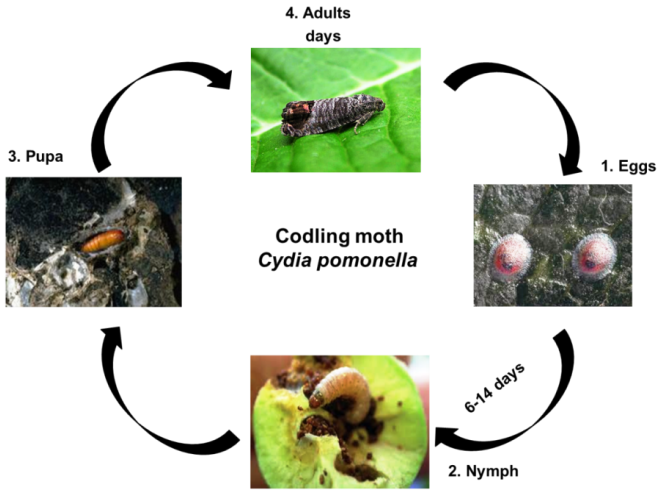
Egg: Eggs are deposited singly on pears and leaves. Each egg is about the size of a pin head and is translucent, gradually darkening as the egg nears hatching (Figure 6). Eggs hatch in six to 14 days, depending on temperature. Within 24 hours of hatching the larvae burrow into the fruit. The first instar 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

Symptoms of damage:

- 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 pear fruits are rendered unmarketable.

http://oxfordpomona.blogspot.in/2010/08/pest-codling-moth-damage-on-pears.htm

Natural enemies of Coding moth:

Parasitoids:*Trichogramma embryophagum, T. cacoeciaepallidum* etc.

Predators: Birds (grey tit, *Parus major* and *Passer domesticus*)

*For the management refer page no……

8. Thrips:

Biology:

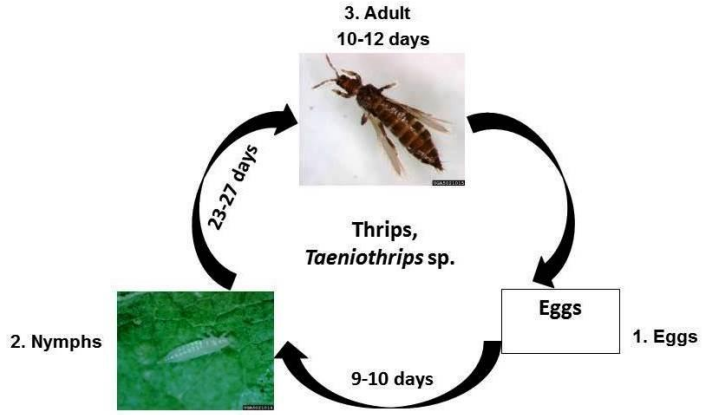
Egg: The eggs are deposited within plant tissues singly.

Nymph 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:

- Most species of plant feeding thrips, have rasping and sucking mouthparts.
- 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.

Natural enemies of thrips:

Predators: Antlion, predatory thrips, coccinellids, anthocorids, lygaeids etc.

*For the management refer page no……

9. Mites

Biology:

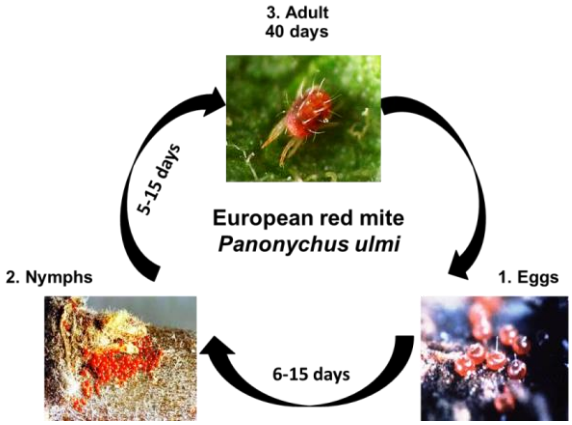
Egg: Overwintering eggs are deposited in groups on roughened bark areas, especially around the base of buds and fruit spurs. Egg hatch is closely correlated with bud development and first occurs when buds are in the tight cluster stage; hatch is better than 50% complete at the pink stage, and virtually 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: Nymphs consist of 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: The sexes of the adults are readily differentiated. The female has a globular bodywhich 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.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

Symptoms of damage:

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

Natural enemies of mites:

Predators: Coccinellid, Lacewing, Predatory mite, predatory thrips, spider etc.

*For the management refer page no……

Natural Enemies of Insect and Mite Pests of Pear

Parasitoids

Egg parasitoids

***1. Trichogramma* sp**

Nymphal/larval and adult parasitoids

2. *Aphidius*

***3. Aphelinus* sp**

4. *Encarsia* sp

5. Aphytis

2. http://biobee.in/products-and-services/solutions/bio-aphidius/
3. http://jenny.tfrec.wsu.edu/opm/displayspecies.php?pn=980
4. http://www.buglogical.com/whitefly-control/encarsia-formosa/
5. http://www.cnr.berkeley.edu/biocon/What%20is%20Biological%20Control.htm

Predators

1. Lacewing

2. Ladybird beetle

3. Reduviid bug

4. Spider

5. Robber fly **6. Fire ant** **7. Black drongo** **8. Common mynah**




9. Big-eyed bug **10. Earwig** **11. Ground beetle** **12. Pentatomid bug**




13. Preying mantis **14. Wasp** **15. *Oligota* spp.** **16. *Orius* spp.**




17. Hover fly **18. Mirid bug** **19. Lygaeid bug** **20. Ant lion *Liogryllus***


21. Predatory mite **22. Predatory thrips**

5. http://www.warpedphotosblog.com/robber-fly-and-prey
6.http://www.couriermail.com.au/news/queensland/queensland-launched-a-war-against-the-fire-ant-invasion-but-12-years-later-they8217re-still-on-the-march/story-fnihsrf2-1226686256021
7. http://nagpurbirds.org/blackdrongo/picture/1639
8. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
9. http://bugguide.net/node/view/598529
10. http://www.flickr.com/photos/johnhallmen/2901162091/
11.http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/ Ground%20Beetle%20-%20Pterostichus%20madidus.html
12. http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asopinae/ Eocanthecona.htm
13. http://spirit-animals.com/praying-mantis/
14. http://vegetableipm.tamu.edu/beneficial1/predatorywasp.html
15. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
16. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
18. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.htm
19 http://www.brisbaneinsects.com/brisbane_lacewings/Myrmeleontidae.htm
20 http://commons.wikimedia.org/wiki/File:Lygaeidae_-_Tropidothorax_leucopterus.JPG

21. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
22. http://biocontrol.ucr.edu/hoddle/persea_mite.html

X. DESCRIPTION OF DISEASES

1. 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.

1.

2.

3.

4.

Disease symptoms

1. http://www.keepers-nursery.co.uk/apple-pear-scab.htm
2. http://www.gardenworldimages.com/Details.aspx?ID=56556&TypeID=1
3.,4: http://pnwhandbooks.org/plantdisease/pear-pyrus-spp-scab

Survival and spread:

- The fungus overwinters in dead infected leaves and fruit on the ground, and less commonly on infected shoots on the tree. In spring around the time of bud burst air borne spores are released which land on young leaves, blossom or fruitlets infecting them. Once these primary infections are established they in turn release more spores which are

spread by wind or rain splash to young leaves elsewhere giving rise to secondary infections.

Favourable conditions:

- The disease develops mainly during wet weather and is most serious in wet regions.

2. Seedling blight:

Disease 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.

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.

*For the management refer page no……

3. Crown gall:

Disease symptoms

- Galls are usually restricted to the roots, lower stems and lower branches of infected plants. In some cases, however, crown gall may occur in the upper branches. Galls are somewhat spherical, lumpy and rough, varying in size from 1/2 inch to several inches in diameter.
- Affected plants may be stunted, produce small chlorotic leaves and become moresensitive to environmental stresses (particularly winter injury).
- Severely infected plants may decline and eventually die.
- This organism enters susceptible plants through fresh wounds made during transplanting, cultivating, grafting and pruning.

Survival and spread:

- Crown gall is caused by the soil-borne. Primary infection occurs through soil.

Favourable condition:

- High humidity and warm weather conditions favours the development of diseases.

1. 2. 3.

Disease symptoms

1,2,3: http://pnwhandbooks.org/plantdisease/pear-pyrus-spp-crown-gall

*For the management refer page no……

4. White 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.

http://www.whatgrowsthere.com/grow/2012/01/10/what-can-be-done-about-phytophthora/

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 the management refer page no……

5. Collar rot:

Disease symptoms:

- Phytophthora collar rot attacks the lower portion especially tree trunks extending to the roots.
- 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.

1. **2.**

Disease symptoms

1,2: http://www.omafra.gov.on.ca/IPM/english/tender/diseases-and disorders/phytophthora.html

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.

*For the management refer page no……

6. 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 are covered with powdery mass.
- Affected fruits remain small and deformed and tend to develop roughened surface.

1. **2.**

Disease Symptoms

1. http://pnwhandbooks.org/plantdisease/pear-pyrus-spp-powdery-mildew

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 the management refer page no……

7. Leaf spot*:*

Disease symptoms:

- Leaf spots appear on the leaves in late spring and early summer. Initially, they are 3-5 mm to 1/4 inch in diameter, round, brown, and occasionally have a purple border.
- As spots age, they often turn tan to ash grey. Some spots undergo secondary

enlargement, becoming irregularly shaped.

- Heavily infected leaves often abscise, resulting in defoliation. Fruit infections result in small, dark, raised pimple-like lesions associated with the lenticels.

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.

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

*For the management refer page no……

9. Canker:

Disease symptoms:

- Lesions resulting in canker formation usually are associated with a wound in the bark.
- 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.
- On the fruits, a series of concentric bands of uniform width form which alternate in color from black to brown. The flesh of the rotted fruits remains firm and leathery. Black pycnidia are often seen on the surface of the infected fruit.

http://www.donsgarden.co.uk/pests/385

Survival and spread:

- The pathogen survives through ascospore (cysts) in the soil debris which is the source of primary infection.
- In the summer, 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 favourable for the disease development.
- Winter injury in plants is helps the development of the diseases.

*For the management refer page no……

10. Viral diseases:

Disease symptoms:

- 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.
- Pear 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.
- Under specific climatic conditions, the disease appears in noncertified 'Bosc', to some extent in 'Anjou', and occasionally in 'Comice' and 'Bartlett', causing a fruit pitting stone pit and deformity. Light or moderate fruit symptoms may be confused with pitting from tarnished plant bug damage, boron deficiency, or corky spot

1. 2. 3.

Disease Symptoms

1:http://pnwhandbooks.org/plantdisease/node/3668/print
1,2:http://www.agf.gov.bc.ca/cropprot/tfipm/virus.htm

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

*For the management refer page no……

11. *Phytoplasmal* disease:

Disease symptoms:

- Poor shoot and spur growth, dieback of shoots, upper rolling of leaves, reduced leaf and fruit size, and premature leaf drop characterize pear decline. Sudden tree collapse can result from tissue damage at the graft union on highly susceptible rootstocks such as *Pyrus serotina* or *P. ussuriensis*, but slow decline of trees is more common.
- Trees on tolerant rootstocks may show mild to moderate symptoms that occasionally become severe if very high psylla populations occur in conjunction with other tree stress.

Transmission:

- The phytoplasma organism that causes pear decline is carried by pear psylla. Psylla transmits the disease when it feeds on the pear foliage. The expression of disease depends on rootstock susceptibility, tree vigor, and psylla numbers. The organism apparently does not multiply in pear trees as well as it does in pear psylla.

http://healthyplants.wsu.edu/blog/news/pear-decline-disease-experiment-2/

*For the management refer page no……

12. Bitter rot:

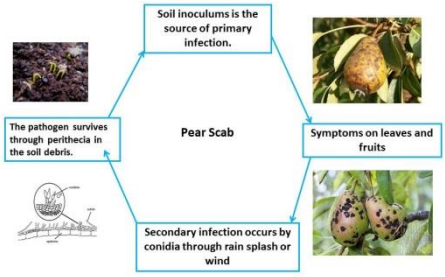
Disease symptoms:

- The fungus attacks pears and enters the fruit through uninjured skin.
- Infected fruit are characterized by a firm rot which forms a circular light brown spot. With age the spots become almost black and have a saucer-shaped depression.
- The organism overwinters in decayed fruit and in cracks on the old bark. A broken limb or twig will serve as an overwintering site.
- Symptoms are first noticeable in mid to late July. A temperature of 30 ºC and light rain favor development of the rot.

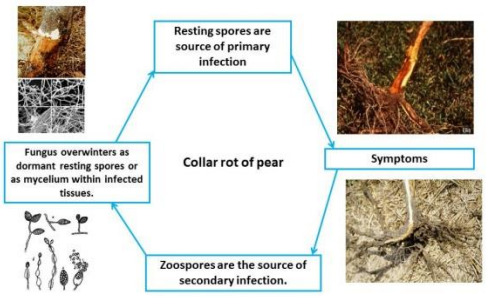
*For the management refer page no……

Disease cycle:

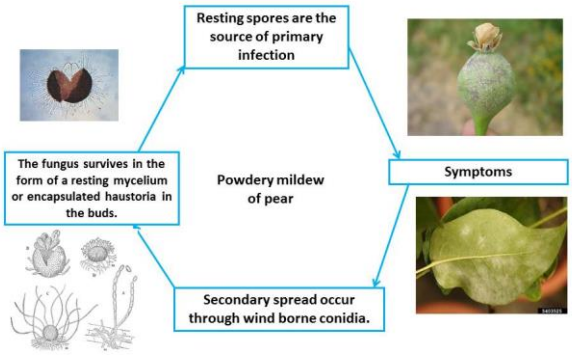
1. Pear scab:



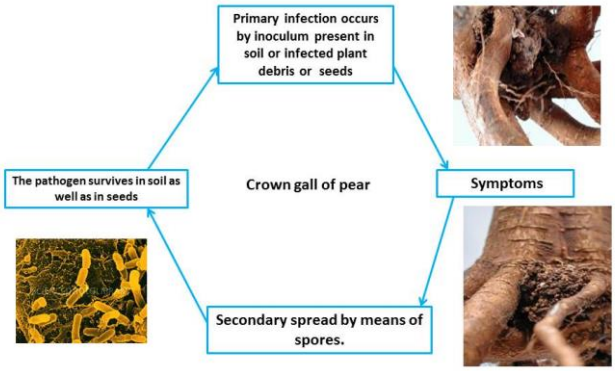
2. Collar rot of pear:



4. Powdery mildew:



5. Crown gall of pear:



XI. SAFETY MEASURES

A) At the time of harvest:

Essentially, pear must always be picked with caution. Please don't just rip them off the branches. A pear is only ripe for harvesting when it can be picked easily, i.e. when the stalk of the pear comes away from the tree easily if you twist it. Further indications of pear 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 pears, reducing next year's crop potential. One of the easiest picking techniques is the "rolling method". Using this method the pear is gently turned upside down on the spur. If the fruit is ready to pick it usually separates easily without disturbing other pears or the fruit spur. The thumb or another finger is often placed between the pear stem and the spur as the pear is rolled upwards. Set all pears 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 pears 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 pears 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 pears are being stored. Not all varieties of pear are suitable for storing. The pear 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 fruits maggot-ridden, overripe and outsized fruit cannot be stored for long and should be sorted out when harvesting. Pears without a stalk should be eaten early as they can rot quickly. Check your fruit store on a weekly basis and remove all rotten pears. Rotten pipfruit can 'infect' other fruit. This is due to emerging ethylene, a colourless gas, which ripens the other pears more quickly and, in some cases, spoils them. For precisely this reason pears should not be stored together with other fruit and

vegetables. In order to prevent pears from drying out quickly, the boxes can be covered with a perforated film. Alternatively, pears 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 pears can be removed quickly. Pears 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.

XII. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The 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.
3.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
4	Sow early in the season	Avoid late sowing as this may lead to reduced yields and incidence of white grubs and diseases.
5	Always treat the seeds with approved chemicals/bio products for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with biocides/chemicals.
6.	Sow in rows at optimum depths under proper moisture conditions for better establishment.	Do not sow seeds beyond 5-7 cm depth.
7.	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.
8.	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.
9	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
10	Use micronutrient mixture after sowing based on test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
11	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
12	Install pheromone traps at appropriate period.	Do not store the pheromone lures at

		normal room temperature (keep them in refrigerator).
13	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.
16	Spray pesticides thoroughly to treat the undersurface of the leaves.	Do not spray pesticides only on the upper surface of leaves.
17	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
18	Follow the recommended procedure of trap crop technology.	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.

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. Don't blow/clean clogged nozzle with mouth. Use old tooth brush tied with the sprayer and clean with water.
5. Do not use same sprayer for weedicide and insecticide.

F. Precautions for applying pesticides

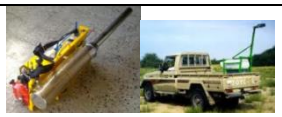
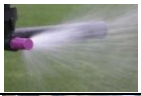
1. Apply only at recommended dose and dilution
2. **Do not** apply on hot sunny day or strong windy condition; **Do not** apply just before the rains and after the rains; **Do not** apply against the windy direction
3. Emulsifiable concentrate formulations should not be used for spraying with battery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

G. Disposal

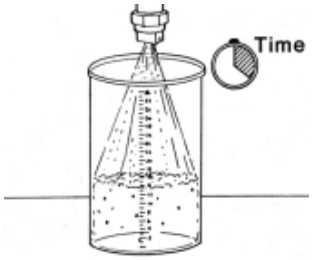
1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

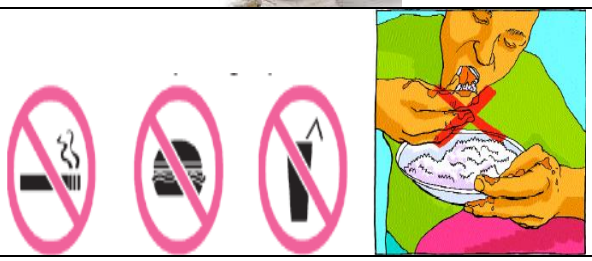
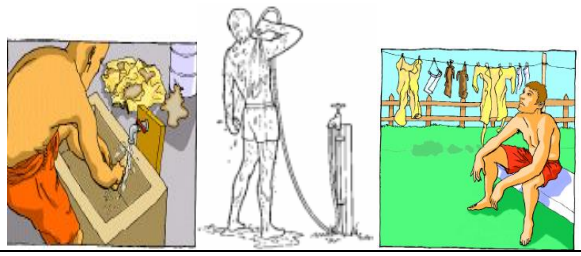
XIV. PESTICIDE APPLICATION TECHNIQUES

Equipment			
Category A: Stationary, crawling pest/disease			
Vegetative stage i) for crawling and soil borne pests	Insecticides and fungicides	• Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15	

ii) for small sucking leaf borne pests		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 **properbath with soap** after completing spraying	
9.	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

XVI. REFERENCES

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
4. http://entomology.tfrec.wsu.edu/pearent/crop_damage.htm
5. **http://utahpests.usu.edu/ipm/htm/fruits/fruit-insect-disease/pear-psylla07**
6. http://entnemdept.ifas.ufl.edu/creatures/veg/aphid/green_peach_aphid.htm
7. **http://entnemdept.ifas.ufl.edu/creatures/veg/aphid/green_peach_aphid.htm**
8. http://www.zin.ru/animalia/coleoptera/eng/aeosardk.htm
9. http://sugarresearch.org/wp-content/uploads/2009/08/issct-1.pdf
10. http://prioninae.eu/taxonomy/dorysthenes/huegelii
11. http://www7.inra.fr/hyppz/RAVAGEUR/6cydpom.htm
12. http://utahpests.usu.edu/ipm/htm/fruits/fruit-insect-disease/codling-moths
13. http://jenny.tfrec.wsu.edu/opm/displayspecies.php?pn=5
14. http://ukmoths.org.uk/show.php?bf=1261
15. http://oxfordpomona.blogspot.in/2010/08/pest-codling-moth-damage-on-pears.htm

16. http://entnemdept.ufl.edu/creatures/veg/melon_thrips.htm
17. http://1.agrifish.dk/thrips_palmi.aspx?ID=13246
18. http://archive.agric.wa.gov.au/PC_94923.html?s=1001
19. http://pnwhandbooks.org/insect/tree-fruit/apple/apple-spider-mite
20. http://www.agf.gov.bc.ca/cropprot/grapeipm/spidermites.htm
21. http://www.dec.ny.gov/docs/lands_forests_pdf/ftc02.pdf
22. http://www.someoneelseskitchen.com/2009_08_01_archive.htm
23. http://www.keepers-nursery.co.uk/apple-pear-scab.htm
24. http://www.gardenworldimages.com/Details.aspx?ID=56556&TypeID=1
25. http://pnwhandbooks.org/plantdisease/pear-pyrus-spp-scab
26. http://pnwhandbooks.org/plantdisease/pear-pyrus-spp-crown-gall
27. http://www.whatgrowsthere.com/grow/2012/01/10/what-can-be-done-about-phytophthora/
28. http://www.omafra.gov.on.ca/IPM/english/tender/diseases-and disorders/phytophthora.html
29. **http://pnwhandbooks.org/plantdisease/pear-pyrus-spp-powdery-mildew**
30. http://www.ces.ncsu.edu/fletcher/programs/apple/plantpath/ALTERfact.html
31. **http://pnwhandbooks.org/plantdisease/node/3668/print**
32. **http://www.agf.gov.bc.ca/cropprot/tfipm/virus.htm**
33. http://healthyplants.wsu.edu/blog/news/pear-decline-disease-experiment-2/
34. http://biobee.in/products-and-services/solutions/bio-aphidius/
35. http://jenny.tfrec.wsu.edu/opm/displayspecies.php?pn=980
36. http://www.buglogical.com/whitefly-control/encarsia-formosa/
37. http://www.cnr.berkeley.edu/biocon/What%20is%20Biological%20Control.htm
38. http://www.warpedphotosblog.com/robber-fly-and-prey
39. http://www.couriermail.com.au/news/queensland/queensland-launched-a-war-against-the-fire-ant-invasion-but-12-years-later-they8217re-still-on-the-march/story-fnihsrf2-1226686256021
40. http://nagpurbirds.org/blackdrongo/picture/1639
41. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
42. http://bugguide.net/node/view/598529
43. http://www.flickr.com/photos/johnhallmen/2901162091/
44. http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/ Ground%20Beetle%20-%20Pterostichus%20madidus.html
45. http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asopinae/ Eocanthecona.htm
46. http://spirit-animals.com/praying-mantis/
47. http://vegetableipm.tamu.edu/beneficial1/predatorywasp.html
48. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
49. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
50. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.htm
51. http://www.brisbaneinsects.com/brisbane_lacewings/Myrmeleontidae.htm
52. http://commons.wikimedia.org/wiki/File:Lygaeidae_-_Tropidothorax_leucopterus.JPG
53. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
54. http://biocontrol.ucr.edu/hoddle/persea_mite.html