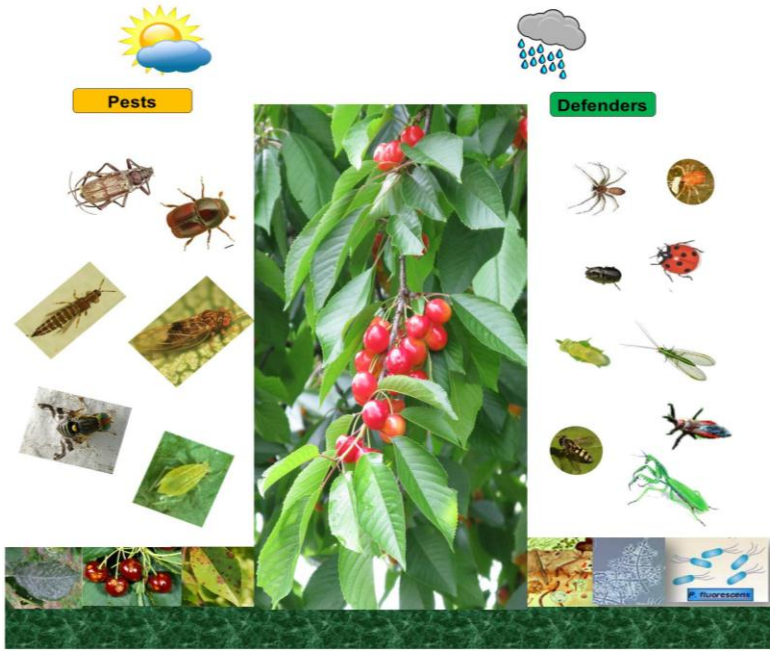
सत्यमेव जयते

AESA BASED IPM PACKAGE

CHERRY



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

National Institute of Plant Health Management
Rajendranagar, Hyderabad, Telangana

Department of Agriculture and Cooperation
Ministry of Agriculture & Farmers welfare
Government of India

The AESA based IPM – Cherry 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.

NIPHM Working Group:

Chairman : Dr. Satyagopal Korlapati, IAS, Director General
Vice-Chairmen : Dr. S. N. Sushil, Plant Protection Advisor
: Dr. P. Jeyakumar, Director (PHM)

Core Members :

1. Er. G. Shankar, Joint Director (PHE), Pesticide Application Techniques Expertise.
2. Dr. O. P. Sharma, Joint Director (A & AM), Agronomy Expertise.
3. Dr. Satish Kumar Sain, Assistant Director (PHM), Pathology Expertise
4. Dr. Dhana Raj Boina, Assistant Director (PHM), Entomology Expertise.

Contributions by DPPQ&S Experts:

1. Shri. Ram Asre, Additional Plant Protection Advisor (IPM),
2. Shri. R. Murali, Deputy Director (Entomology),
3. Dr. Sanjay Arya, Deputy Director (Plant Pathology),
4. Dr. Subhash Kumar, Deputy Director (Weed Science)

Contributions by External Experts:

1. Director of Research/Representatives, Punjab Agriculture University, Ludhiana
2. Directorate of Research, Bihar Agricultural University, Sabour, Bihar-813210
3. Director of Research/Representatives Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli-415712, Dist-Ratnagiri.
4. Dr. Arun Prasad Bhagat, Associate Professor, Bihar Agricultural University, Sabour, Bhagalpur
5. Dr. S N. Ray, Associate Professor, Bihar Agricultural University, Sabour, Bhagalpur
6. Dr. P.D. Kamala Jayanthi, National Fellow, Division of Entomology & Nematology, ICAR - Indian Institute of Horticultural Research, Hessaraghatta Lake P.O, Bengaluru – 560 089

अपर सचिव
भारत सरकार
कृषि मंत्रालय
(कृषि एवं सहकारिता विभाग)
कृषि भवन, नई दिल्ली- 110001

सत्यमेव जयते

Ashok Dalwai
Additional Secretary
Government of India
Ministry of Agriculture
(Department of Agriculture
& Cooperation)
Krishi Bhawan, New Delhi-110001

FOREWORD

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

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

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

A Dalwai 25/06/2015

Dated: 25.06.2015

[Ashok Dalwai]

संयुक्त सचिव
भारत सरकार
कृषि मंत्रालय
(कृषि एवं सहकारिता विभाग)
कृषि भवन, नई दिल्ली- 110001

सत्यमेव जयते

Joint Secretary
Government of India
Ministry of Agriculture
(Department of Agriculture & Cooperation)
Krishi Bhawan, New Delhi-110001

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)

Dr.K. SATYAGOPAL IAS
Director General
Telephone : +91-40- 24015346,
E-mail : dgniphm@nic.in
Tele-Fax : +91-40- 24015346,

National Institute of Plant Health Management
Department of Agriculture & Cooperation
Ministry of Agriculture
Government of India

Rajendranagar,
Hyderabad- 500030.
http://niphm.gov.in

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

Cherry-Plant description

I. Pests

A. Pests of National Significance

1. Insect pests

2. Diseases

3. Weeds

B. Pests of Regional Significance

1. Insect pests

II. Agro-Ecosystem Analysis (AESA) based Integrated Pests Management (IPM)

A. AESA

B. Orchards scouting

C. Yellow pan water trap/ sticky traps

E. Light traps

F. Nematode extraction

III. Ecological engineering for pest management

IV. Stage-wise IPM

V. Insecticide resistance and its management

VI. Common weeds

VII. Description of insect pests

VIII. Description of diseases

IX. Safety measures

A. At the time of harvest

B. During post-harvest storage

X. Do's and Don'ts in IPM

XI. Safety parameters in pesticide usage

XII. Basic precautions in pesticide usage

XIII. Pesticide application techniques

XIV. Operational, calibration and maintenance guidelines in brief

XV. References

AESA BASED IPM PACKAGE FOR CHERRY

Cherry-Plant description:

The cherry (*Prunus avium* Linn.; Family: Rosaceae) is a deciduous tree growing to 15–32 m height, with a trunk up to 1.5 m in diameter. Young trees show strong apical dominance with a straight trunk and symmetrical conical crown, becoming rounded to irregular on old trees. The bark is smooth purplish-brown with prominent horizontal grey-brown lenticels on young trees, becoming thick dark blackish-brown and fissured on old trees. The leaves are alternate, simple ovoid-acute, 7–14 cm long and 4–7 cm broad, glabrous matt or sub-shiny green above, variably finely downy beneath, with a serrated margin and an acuminate tip, with a green or reddish petiole 2–3.5 cm long bearing two to five small red glands. The tip of each serrated edge of the leaves also bear small red glands.
The fruit is a drupe 1–2 cm in diameter (larger in some cultivated selections), bright red to dark purple when mature in midsummer, edible, variably sweet to somewhat astringent and bitter to eat fresh. Each fruit contains a single hard-shelled stone 8–12 mm long, 7–10 mm wide and 6–8 mm thick, grooved along the flattest edge; the seed (kernel) inside the stone is 6–8 mm long.

I. PESTS

A. Pests of National Significance

1. Insect pests:

- **1.1 Stem borer: *Aeolesthes sarta* Solsky (Coleoptera: Cerambycidae)**
- **1.2 Round headed borer: *Macrotoma crenata* Lameere (Coleoptera: Cerambycidae)**
- **1.3 Shot hole borer/pin hole borer: *Scolytus nitidus* Schedl (Coleoptera: Scolytidae)**
- **1.4 Indian gypsy moth/Kashmir willow defoliator/hairy caterpillar: *Lymantria obfuscata* Walk. (Lepidoptera: Lymantriidae)**

2. Diseases

- **2.1 Leaf spot/shot hole/brown rot: *Cercospora circumcissa* Sacc; *C. rubrotincta* Ellis & Everh**
- **2.2 Bacterial gummosis: *Pseudomonas* sp.**
- **2.3 Silver leaf canker: *Chondrostereum purpureum* (Pers.) Pouzar**
- **2.4 White root rot: *Dematophora necatrix* Berl. ex Prill**
- **2.5 Whiskers rot: *Rhizopus stolonifer* (Ehrenb.: Fr.) Vuill.**
- **2.6 Collar rot/root rot: *Phytophthora* sp.**
- **2.7 *Coryneum* blight/shot hole: *Stigmina carpophila* (Lév.) M.B. Ellis**
- **2.8 Powdery mildew: *Podosphaera clandestine* (Wallr.) Lév.**
- **2.9 Crown Gall: *Agrobacterium tumefaciens* Smith & Townsend**
- **2.10 *Prunus* Necrotic Ringspot: Virus**

3. Weeds

Broadleaf

- **3.1. Lambs quarter: *Chenopodium album* L. (Chenopodiaceae)**
- **3.2. Tropical spiderwort: *Commelina benghalensis* L. (Commelinaceae)**
- **3.3. Creeping wood sorrel: *Oxalis corniculata* L. (Oxalidaceae)**
- **3.4. Goat weed: *Ageratum conyzoides* L. (Asteraceae)**
- **3.5. Sow thistles: *Sonchus* spp. (Asteraceae)**
- **3.6. Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)**
- **3.7. Mock strawberry: *Duchesnea indica* (Andr). Focke (Rosaceae)**
- **3.8. Musk rose/rosehip: *Rosa moschata* Herrm. (Rosaceae)**
- **3.9. Brambles: *Rubus* spp. (Rosaceae)**
- **3.10. Common purslane: *Portulaca oleracea* L. (Portulacaceae)**

Grasses

- **3.11. Bermuda grass: *Cynodon dactylon (L.) Perse.* (Poaceae)**
- **3.12 Canary grass: *Phalaris minor* Retz. (Poaceae)**
- **3.13. Cogon grass: *Imperata cylindrica* (L.) Raeusch. (Poaceae)**
- **3.14. Large crabgrass: *Digitaria sanguinalis* L. (Scop.) (Poaceae)**
- **3.15. Knot grass: *Paspalum distichum* L. (Poaceae)**
- **3.16. Wire grass: *Eleusine indica* L. (Poaceae)**
- **3.17. Coutch grass: *Elymus repens* L. Gould. (Poaceae)**

Sedges

- **3.18. Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)**
- **3.19. Annual sedge: *Cyperus compressus* L. (Cyperaceae)**

B. Pest of Regional significance

1. Insect pests

1.1 Leaf roller/tiger moth: *Panaxia principalis* Kollar (Lepidoptera: Noctuidae)

1.2 Mealy plum aphid: *Hyalopterus arundinis* Geoffroy (Hemiptera: Aphididae)

1.3 Case bearer caterpillar: *Coleophora nigricella* Stephens (Lepidoptera: Coleophoridae)

1.4 Pear psylla: *Psylla pyricola* (Foerster) (Hemiptera: Psyllidae)

1.5 Defoliating beetles: *Adoretus* sp. & *Brahmina* sp. (Coleoptera: Scarabaeidae)

1.6 Root borer: *Dorysthenes hugelii* Redt. (Coleoptera: Scarabaeidae)

1.7 Green peach aphid: *Myzus persicae* Sulzer (Hemiptera: Aphididae)

1.8 Chaffer beetle: *Protaetia impavida* Jonson (Coleoptera: Scarabaeidae)

1.9 Blossom thrips: *Thrips flavus* Schrank (Thysanoptera: Thripidae)

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 planters. The economic threshold level (ETL) was the basis for several decades but in modern IPM (FAO 2002) emphasis is given to AESA where planters take decisions based on larger range of orchard observations. The health of a plant is determined by its environment which includes physical factors (i.e. soil, rain, sunshine hours, wind etc.) and biological factors (i.e. pests, diseases and weeds). All these factors can play a role in the balance which exists between herbivore insects and their natural enemies. Understanding the intricate interactions in an ecosystem can play a critical role in pest management.

Decision making in pest management requires a thorough analysis of the agro-ecosystem. Farmers have to learn how to observe the tree, how to analyze the orchard situation and how to make proper decisions for their tree management. This process is called the AESA. Participants of AESA will have to make a drawing on a large piece of paper (60 x 80 cm), to include all their observations. The advantage of using a drawing is that it requires the participants/planters 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 planters to analyze the orchard situations with regards to pests, defenders, soil conditions, plant health and the influence of climatic factors and their relationship for growing a healthy tree. The basic components of AESA are:

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

Principles of AESA based IPM:

Grow a healthy tree:

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

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

Planters should:

- Monitor the situation of 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.)

Plant compensation ability:

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

Understand and conserve defenders:

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

Insect zoo:
In orchard various types of insects are present. Some are beneficial and some may be harmful. Generally planters are not aware about it. Predators (friends of the planters') which feed on pests are not easy to observe in tree orchard. Insect zoo concept can be helpful to enhance planters' 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 planters 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 cherry 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 planters 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:

Planters become experts in tree management:

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

- Planters are capable of improving farming practices by experimentation
- Planters can share their knowledge with other planters

AESA methodology:

- Go to the orchard in groups (about 5 planters per group). Walk across the orchard and choose 20 plants/acre randomly. Observe keenly each of these plants and record your observations:
    - Plant: Observe the plant height, number of leaves, tree stage, deficiency symptoms etc.
    - Insect pests: Observe and count insect pests at different places on the plant.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
    - Weeds: Observe weeds in the orchard and their intensity.
    - Water: Observe the water situation of 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 situations 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 tree 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:

Planters should record data in a notebook and drawing on a chart.

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

Data to be recorded:

- **Plant growth (weekly):** Height of plant, number of leaves.
- **Tree situation (e.g. for AESA):** Plant health; pests, diseases, weeds; natural enemies; soil condition; irrigation; weather conditions.
- **Input costs:** Planting materials; fertilizer; pesticides; labour;
- **Harvest:** yield (Kg/acre); price of produce (Rs./Kg)

Some questions that can be used during the discussion:

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

Advantages of AESA over ETL:

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

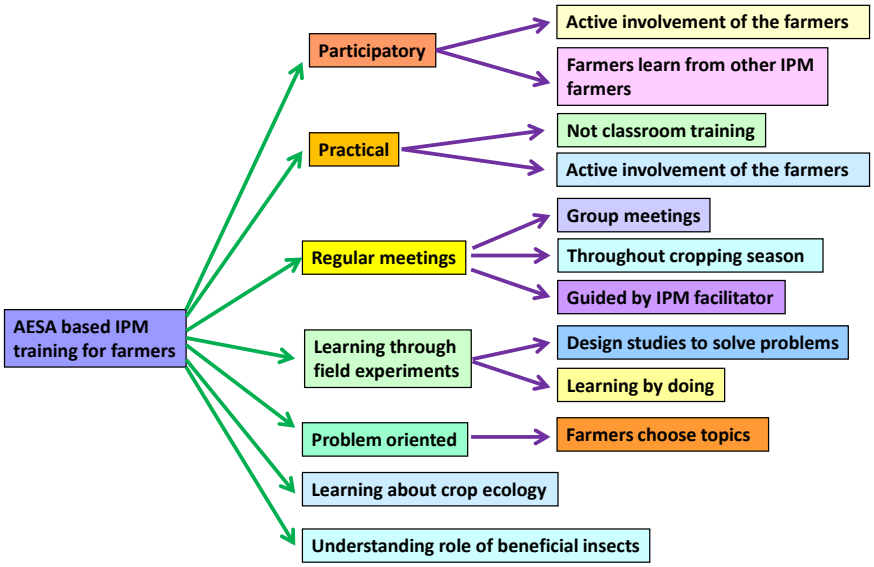
AESA and farmer field school (FFS):

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

Planters can learn from AESA:

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

FFS to teach AESA based IPM skills:



B. Orchard scouting:

AESA requires skill. So only the trained planters can undertake this exercise. However, other planters also can do orchard scouting in their own orchards at regular intervals to monitor the major insect pests, diseases, weeds etc., situation.

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

Sampling in fruit crops:

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

Sampling patterns:

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

However, this is not always possible. Generally, in fruit crops the following sampling patterns are used:

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

Sampling frequency:

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

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

For insect pests:
Aphids and thrips: Count and record the number of both nymphs and adults on five randomly selected leaves/plant.
Caterpillars and borers: Total number of fruits, damaged fruits and stems/shoots due to insect pests 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.

Field scouting for weeds: Scouting is all about early detection. And when it comes to weed detection, sooner is always better. The key to successful weed management is identifying resistance early, when the infestation can still be controlled. Timely scouting is key to making appropriate management decisions. Scout fields early and often to keep weeds under control. In-season scouting should begin shortly after planting to evaluate weed control efficacy and to determine if additional control is needed. Continue to monitor weed sizes and populations throughout the season. Failure to scout and apply post herbicides in a well-timed manner could reduce the efficacy and increase the risk of herbicide resistance

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

D. Light traps:
Set up light traps @ 1 traps/acre 15 cm above the tree canopy for monitoring and mass trapping of nocturnal insects. Light traps with exit option for natural enemies of smaller size should be installed and operate between 6 pm and 11 pm. Light trap catches should be counted and kill the pests and release the natural enemies.

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

Ecological Engineering for Pest Management – Below ground:

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

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

Ecological Engineering for Pest Management – Above ground:

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

Natural enemies may require:

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

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

- Raise the flowering plants / compatible cash crops along the 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 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

Repellent plants

***Ocimum* spp.**

Peppermint

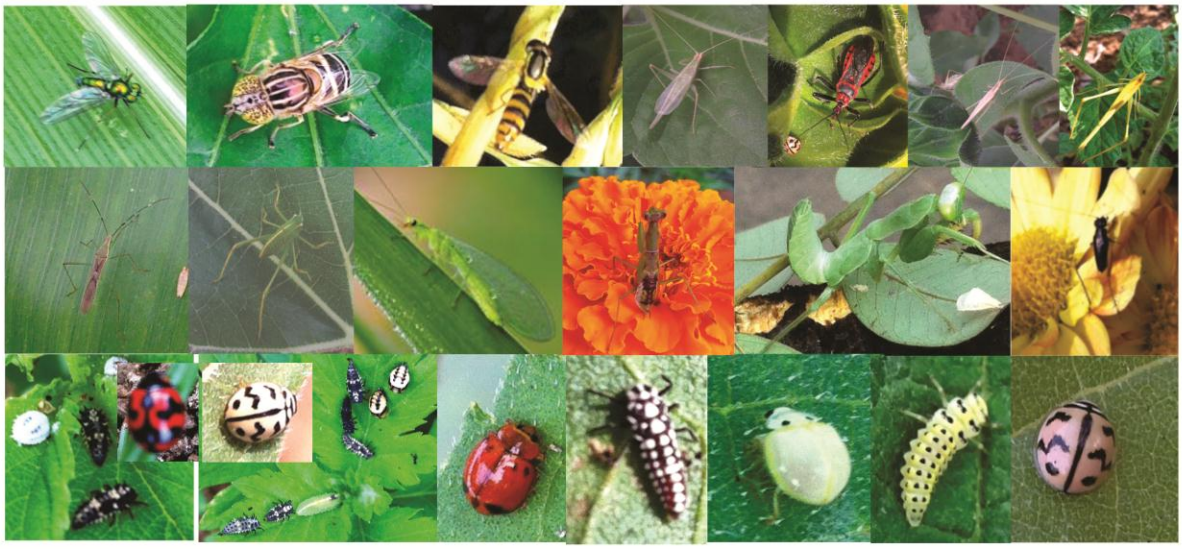
Marigold

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: • Timely planting should be done. • Use resistant and non –infected planting material • Proper field selection should be made for raising the orchards of cherry. • Avoid planting of saplings infected with scales, borer and disease • Make use of balanced dose of chemical fertilizers and avoid excessive use of nitrogen which should be used in split doses only. • Grow the attractant, repellent, and trap crops around the orchard bunds. • Plant tall border crops like maize, sorghum for the management of aphids and thrips. • French bean acts as an attractant plant for predatory thrips. • Grow ecological engineering plants.
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. • Pits of 1m x 1m x 1m size are dug at a distance of 6 m on contour lines or in square system of planting. • Pits are filled with a mixture of top soil, 35-40 Kg farmyard manure and half Kg super phosphate one month before planting.
Weeds	• Deep summer ploughing
Soil borne fungus, resting stages of insects and weeds	**Cultural control:** • **Soil solarization:** Cover the beds with polythene sheet of 45 gauge (0.45 mm) thickness for three weeks before sowing for soil solarization which will help in reducing the soil-borne pests. **Biological control:** • Apply neem cake @ 100 Kg/acre at the time of transplanting for reducing borer damage as well as to reduce the soil borne diseases while preparing the nurseries.
Planting*	
Nutrients	• Planting is done in December-January in pits already filled with farm yard manure. • Add mycorrhiza culture @ 50 g/pit or a basket of soil taken from old cherry orchard to ensure mycorrhiza association with seedling roots.
Weeds	• Plough the field before the planting • Use weed free seedlings for planting. • Remove weeds from the pits before planting.
Diseases and insect pests	• Select resistant varieties.

Vegetative stage	
	Common cultural practices: • Collect and destroy diseased and insect infected plant parts. • Apply white wash impregnated with glue regulairly on the tre trunks to avoid sun burn and winter injury. • 2-3 bee colonies/ha should be provided on each orchard at the time of bloom. • Proper irrigation should be adopted. • Trees should neither be forced to drought nor wate lodging conditions. • Rogue out infected plants • Avoid water lodging at tree base and improve darinage of the orchards. • Maintain vigour of the tree to keep away shot hole/pin hole borers, bark beetles and other pest infestation. • Keep the trees as free as possible from mechanical wounds, winter injury, crotch separation and canker. • Proper pruning of the trees be made for obtaining quality fruits and good yield. • Pruning cuts should be made close to the branches leaving no stubs. • Cut wound should be covered with superior white lead pants. • Solarization of nursery beds should be under taken to destroy soil pests. • Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed. **Common mechanical practices:** • Collection and destruction of eggs and early stage larvae • Handpick the older larvae during early stages of plant • The infested shoots and seed capsules 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 for thrips @ 4-5 trap/acre. • Use light trap @ 1/acre and operate between 6 pm and 10 pm • Erect 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. • Ladybird beetle, *Adalia* sp, *Synharmonia* sp, *Exochomus* sp, *Stethorus* sp @ 30-50 adults/infested tree.

<table>
<tr><td></td><td>• Lacewing and Syrphus sp. @ 10-20 first instar larvae/tree</td></tr>
<tr><td>Nutrients</td><td>• Since fruit development and vegetative growth occurs simultaneously, it has high demand for mineral nutrients.
• The amount of manure and fertilizer to be applied is influenced by the age or size of tree, soil types, fertility, cultural practices and anticipated fruit yield.
• For achieving higher yields of quality product, generally nutrients should be applied according to the age of plant using organic and inorganic sources as mentioned below;
<table>
<tr><th rowspan="2">Age of tree (years)</th><th rowspan="2">Farm Yard Manure (Kg)</th><th colspan="3">Fertilizers (grams per plant)</th></tr>
<tr><th>Calcium Ammo. Nitrate (CAN)</th><th>Super Phosphate (SSP)</th><th>Muriate of Potash</th></tr>
<tr><td>1-3</td><td>10-20</td><td>200-600</td><td>160-480</td><td>100-300</td></tr>
<tr><td>4-6</td><td>25-35</td><td>800-1200</td><td>640-960</td><td>400-600</td></tr>
<tr><td>7-9</td><td>35-50</td><td>1400-1800</td><td>1120-1440</td><td>700-900</td></tr>
<tr><td>10th year and above</td><td>60</td><td>2000</td><td>1600</td><td>1000</td></tr>
</table>
• Farmyard manure should be applied in December along with a full dose of super phosphate and muriate of potash.
• 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.</td></tr>
<tr><td>Weeds</td><td>• Mulch the tree basin in April with 10 to 15 cm thick dry grass or hey to reduce weeds and conserve the soil moisture
• Grow green mannuring crops e.g. bean, pea, red clover or white clover in the tree basins to manage the weed and improve soil texture and fertility.
• Us slashing and mowing between the rows to control the weeds.</td></tr>
<tr><td>Root borer**</td><td>• Follow common cultural, mechanical and biological practices.
<u>Cultural control:</u>
• Avoid growing Malvaceous crops in sequence.
• For others follow common cultural practices.

<u>Mechanical control:</u>
• Collect and destroy the grubs of root borer while preparing basin.
• Destroy the affected seedlings.

<u>Biological control:</u>
• Spray NSKE 5%</td></tr>
<tr><td>Stem borer/ round headed borer</td><td>• Follow common cultural, mechanical and biological practices.
<u>Cultural control:</u>
• Follow common cultural control.

<u>Mechanical control:</u>
• Clean the stem borer hole with flexible wire and plug the hole with</td></tr>
</table>

	mud/cow • Cover the exposed part of the stem with dry grass or gunny bag once a month from March to October. **Biological control:** • Spray NSKE 5%
Shot hole borer/pin head borer	• Follow common cultural, mechanical and biological practices. **Cultural control:** • Maintaining trees in a sound and vigorous condition with sufficient fertilizers, water, and sunburn prevention will keep uninfested tree limbs from becoming damaged and prevent attack by this beetle. • Pruning can be helpful in eliminating areas in older trees infested with shot hole borer. • Severely infested trees should be removed. • Burn or remove all infested wood from the orchard before the growing season starts. • Do not leave pruned limbs or stumps (healthy or infested) near orchards (for example, woodpiles) as beetles can emerge from these materials before they dry out and then migrate into orchards. **Biological control:** • Spray NSKE 5%
Aphids, mealy plum aphid, green peach aphid**	• Follow common cultural, mechanical and biological practices.
Hairy caterpillar, case bearer caterpillar**	• Follow common cultural, mechanical and biological practices. **Mechanical control:** • Stapling burlap skirts around tree trunks infested with hairy caterpillars and collection of larvae and pupae from May to end of June and ensure their destruction.
Leaf roller/tiger moth**	• Follow common cultural, mechanical and biological practices.
Pear psylla**	• Follow common cultural, mechanical, and biological practices.
Defoliating beetles, chaffer beetle**	• Follow common cultural, mechanical and biological practices **Cultural control:** • Maintain vigour by providing sufficient and balanced nutrients and avoid water stressing of the trees **Mechanical control:** • Collect and kill the beetles in kerosennized water. • Shake the non-bearing plants/trees over a cloth sheet at dusk and collect and destroy the beetles.
Blossom thrips	• Follow common cultural, mechanical and biological practices.
Leaf spots/shot hole/brown rot	• Follow common cultural, mechanical and biological practices. • For resistant/tolerant varieties consult nearest KVKs/SAUs/ICAR Institutes.

	Mechanical control: • Removal and proper disposal and burning the infected leaves **Chemical control:** • Lime sulphur 22% SC @ 0.8-2.0 l/acre • Captan 50% WP @ 1 Kg in 300-400 l of water/acre • Captan 75% WP @ 0.67 Kg in 6-8 l of water/acre
Bacterial gummosis	• Follow common cultural, mechanical and biological practices. • For resistant/tolerant varieties consult nearest KVKs/SAUs/ICAR Institutes. **Cultural control:** • Ensure that a suitable cherry variety and rootstock is chosen based on geographic location and environmental conditions to prevent stress to tree which predisposes tree to canker disease
Silver leaf canker	• Follow common cultural, mechanical and biological practices. • For resistant/tolerant varieties consult nearest KVKs/SAUs/ICAR Institutes. **Mechanical control:** • To control the disease, prune at the first sign of silvering. Make the cut below the diseased area into healthy wood. • Cover pruning wounds that are larger than 1.5cm with pruning sealer. • Remove and bury or burn all infected branches, leaves and twigs. This will help to reduce the amount of disease the following year.
White root rot, Fruit/whisker rot	• Follow common cultural, mechanical and biological practices. • For resistant/tolerant varieties consult nearest KVKs/SAUs/ICAR Institutes. **Cultural control:** • Establish a dry zone and prevent soil movement or water runoff from that site. **Mechanical control:** • Uproot and dispose of infected trees. • Remove immediately adjacent trees that may also be infected. • Remove as many root pieces from soil as possible and trench around the infected site to break root grafts.
Root rot/collar rot	• Follow common cultural, mechanical and biological practices. • For resistant/tolerant varieties consult nearest KVKs/SAUs/ICAR Institutes. **Cultural control:** • Cherry trees should be planted in well-draining soil to minimize the frequency and duration of water saturated soil • Trees should be propagated from resistant rootstock; Rootstocks vary in susceptibility to the different *Phytophthora* species; none are resistant to all pathogenic species of the fungus. • Good soil drainage and more frequent but shorter irrigations reduce the risk of root and crown rot. • Avoid locations with a history of *Phytophthora* root and crown rot, especially when planting susceptible rootstocks. • Plant new orchards on berms to improve drainage at the crown area

	and design the irrigation system so that the trunk and crown of the tree is not wet by sprinklers. • Be sure to verify that *Phytophthora* is the causal agent before treating a new planting with fungicides, because a number of factors or pest problems can cause poor growth and death of trees.
Powdery mildew	• Follow common cultural, mechanical and biological practices. • For resistant/tolerant varieties consult nearest KVKs/SAUs/ICAR Institutes. **Cultural control:** • Keep proper spacing during sowing which promote good air circulation around tree canopies to lower humidity
***Coryneum* blight/shot hole**	• Follow common cultural, mechanical and biological practices. • For resistant/tolerant varieties consult nearest KVKs/SAUs/ICAR Institutes. **Cultural control:** • Diligent sanitation and water management can provide adequate control where the incidence of shot hole is low. • Avoid overhead sprinklers or use a low angle to avoid wetting foliage. **Mechanical control:** • Prune and dispose of infected tissue as soon as it appears. • After leaf drop, inspect plants carefully and prune infected buds and twigs with lesions.
Crown rot/gall	• Follow common cultural, mechanical and biological practices. • For resistant/tolerant varieties consult nearest KVKs/SAUs/ICAR Institutes.
***Prunus* nectrotic ringspot virus**	• Follow common cultural, mechanical and biological practices. • For resistant/tolerant varieties consult nearest KVKs/SAUs/ICAR Institutes. **Cultural control:** • Use nursery stock that has been tested and found to be free of all known viruses. • If propagating your own trees, use both virus-indexed bud wood and virus-certified rootstock. • Infected pollen should not be introduced into healthy orchards during pollination. • Establish new plantings in blocks, the larger the better,and preferably at some distance from older orchards. • Rogue infected trees in new virus-indexed orchards, but it is not economical to rogue or replant mature infected orchards unless trees are infected with the rugose strain. • Complete orchard removal should be considered. • Thermotherapy (24 to 32 days at 38°C) and/or apical meristem culture have been used to eliminate various viruses.
Reproductive/fruiting stage	
Nutrients	• Half dose of N is applied in spring before flowering and the other half dose of N is applied one month later. Fertilizers are applied in tree basin about 30 cm away from the tree trunk.

	• The band application of nitrogenous fertilizers should be preferred over broadcasting. • Apply recommended micronutrients, if deficiency symptoms are observed.
Weeds	• Remove weeds around the plants/tree basin. • Use straw or plastic mulch to avoid weed growth and to maintain soil moisture for longer period. • Mulching tree basins with 10-15 cm thick dry grass also checks weed growth.
Borers	• Same as in vegetative stage
Diseases	• Same as in vegetative stage **Cultural control:** • Collect and destroy fallen fruits.

Note: The dosages of pesticides are based on high volume sprayer
**Regional Pests

V. INSECTICIDE RESISTANCE AND ITS MANAGEMENT

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

Causes of resistance development: The causes and rate at which insecticide resistance develops depend on several factors, including 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.

3) Take an integrated approach to managing pests. Use as many different control measures as possible. 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.

4) Time applications correctly. Apply insecticides when the pests are most vulnerable. Use application rates and intervals recommended by the manufacturer, university insect management specialist, county Extension agent, or crop consultant.

5) Mix and apply carefully. While applying insecticides care should be taken for proper application of insecticides in terms of dose, volume, timing, coverage, using techniques recommended by the manufacturer etc.

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

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

VI. COMMON WEEDS

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

2. Tropical spiderwort: *Commelina benghalensis* L. (Commelinaceae)

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

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

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

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

7. Mock strawberry : *Duchesnea indica* (Andr). Focke (Rosaceae)

8. Musk rose/rosehip: *Rosa moschata* Herrm. (Rosaceae)

9. Brambles: *Rubus* spp. (Rosaceae)

10. Common purslane: *Portulaca oleracea* L. (Portulacaceae)

11. Bermuda Grass: *Cynodon dactylon* (L.) Pers. (Poaceae)

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

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

14. Large crabgrass: *Digitaria sanguinalis* L. (Scop.) (Poaceae)

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

16. Wire grass : *Eleusine indica* L. (Poaceae)

17. Couch grass: *Elymus repens* L. Gould. (Poaceae)

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

19. Annual sedge : *Cyperus compressus* L. (Cyperaceae)

Source:
http://megagriculture.gov.in/PUBLIC/package_of_practice/temperate_fruits.aspx
http://www.fruitipedia.com/cherry Prunus avium.htm
http://en.wikipedia.org/wiki/Sonchus
http://skuast.org/site/Templates%20HTML/extension/package.pdf
Naidu, V.S.G.R. 2012, *Hand Book on Weed Identification* Directorate of Weed Science Research, Jabalpur, India Pp 354.

VII. DESCRIPTION OF INSECT PESTS

1) Stem borer:

Biology:

Eggs: White, 3–4 mm long. Usually 1 to 3 eggs are laid per niche and females may lay a total of 240 to 270 eggs. The development of larvae within the egg lasts 9 to 17 days.
Larva: Pale yellowish, covered with golden hairs, 60–70 mm long, with black mandibles.
Pupa: The following spring, the larvae resume feeding and construct tunnels deep into the wood. At the end of July, they prepare pupation cells protected by double plugs made from borings. Pupation occurs in these cells and about two weeks later adults appear.
Adult: The adult of *A. sarta* has an elongated dark grey-brown body, 28–47 mm long, with

elytra covered with short silvery hairs (Fig. 1). Shiny silvery spots form two irregular bands crossing the elytra. The male is usually smaller than the female. The male has antennae 2.5 times as long as the body, whereas the female antennae are shorter than the body.

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

Damage symptoms:

- Large emergence holes in trunks and large branches, and borings at the basis of infested trees, are indications of the presence of the pest. The adult beetles are conspicuous and may be seen sitting on the trunks. Branch and tree dieback is easily detected by seeing wilting and drying leaves.
-

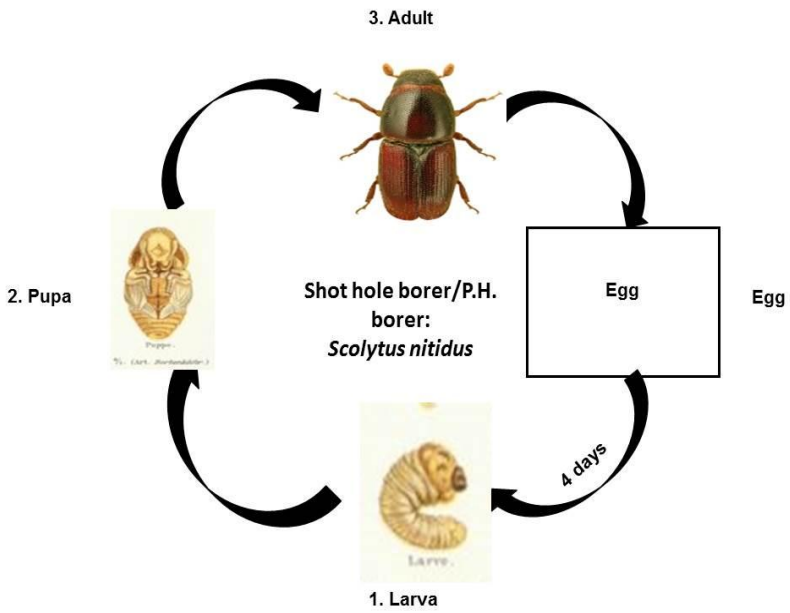
*For management refer to page number 24, 25

2) Shot hole borer/pin hole borer:

Biology:

Eggs: The female lays 52 eggs on an average. The eggs hatch in 5 to 7 days.
Larva: The larvae have 5 instars and complete their development in 38 to 50 days constructing larval galleries 5-8 cm in length.
Pupa: The larvae pupate for 6-18 days and finally the adults emerge to attack new suitable trees.
Adults: The adults live for 45-60 days and the total life-span of this species ranges from 97 to 124 days. This common shot-hole borer overwinters in larval stage on trees. The copulation takes place at the entrance hole. The maternal gallery is one armed longitudinal, in average 4.6 cm long.

Life cycle:



1,2: http://sv.wikipedia.org/wiki/Scolytus
4. http://coleoptera.ksib.pl/kfp/search.php?taxonid=200055&l=en

Natural enemies of shot hole/pin hole borer:

Parasitoids: *Rhaphitelus maculatus, Eurytoma morio, Eupelmus vindex*, *Cheiropachus quadrum*, *Spathius* sp, *Macromesus harithus, Heydenia indica, Eupelmus vindex, Eupelmus kashmiricus* and *Eupelmus valsus*

Predators: *Monomorium minutum* , *Tetramorium christiei*, *Polemistus* sp., big-eyed bug, earwig, ground beetle, pentatomid bug.

Entomopathognic fungi: *Aspergillus versicolor, Penicillium aurantiogriseum* and *Geosmithia putterillii*.

*For management refer to page number 25

3) Pear psylla:

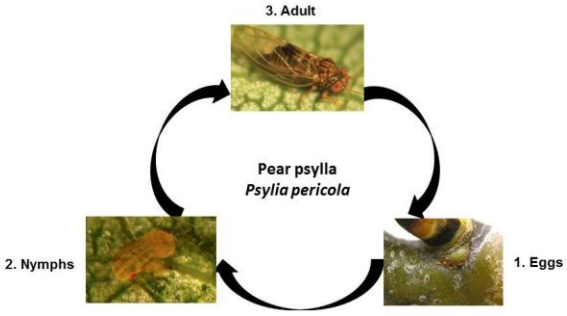
Biology:

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 are hatch when foliage appears and continues 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://oregonstate.edu/dept/nurspest/pear_sawfly%20clup4.html

Natural enemies of psylla:

Predators: Lacewings, ladybird beetles, minute pirated bugs, predatory mites, anthocorid bugs, spiders

*For the management refer page no 25

4) Green peach aphid:

Biology:

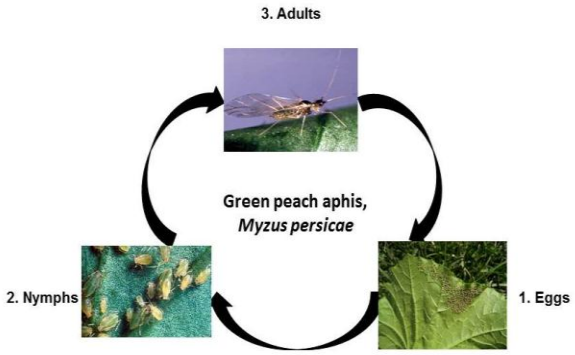
Egg: Eggs are deposited on *Prunus* spp. trees. The eggs measure about 0.6 mm long and 0.3 mm wide, and are elliptical in shape. Eggs initially are yellow or green, but soon turn black. Mortality in the egg stage sometimes is quite high.

Nymph: Nymphs initially are greenish, but soon turn yellowish, greatly resembling viviparous (parthenogenetic, nymph-producing) adults. They are of 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 was 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 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 and foliage.
- 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://www.forestryimages.org/browse/detail.cfm?imgnum=5360713

Natural enemies of green peach aphid:

Parasitoid: *Aphidius* spp., *Aphelinus mali* etc.

Predators: Aphid midge (*Aphidoletis aphidimyza*), syrphid fly, big-eyed bug, ladybird beetles, lacewings, mirid bugs, spiders, robber fly, praying mantis etc.

*For the management refer page no 25

5) Thrips:

Biology:

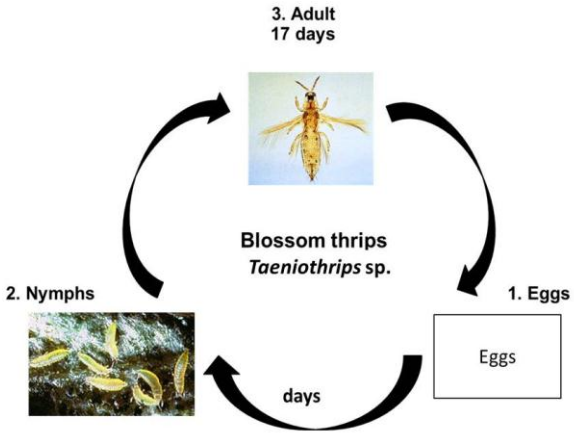
Egg: The eggs are deposited within plant tissues singly.

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

Adult: After emergence, the adults move to the growing parts of the plants such as young leaves, flowers, or young fruits, where they feed and lay eggs (about 200 eggs per female). Adults are usually found on young leaves, while larvae are found on lower or older leaves. At

25°C, the life cycle is completed in approximately 17 days. Adults are winged sucking rasping insects ranging from 5-14 mm in length. Their slender bodies are shiny pale or black with silver stripes Life cycle completed in 11-43 days. Produce many generations in a year heaviest damage occur in spring. In colder region, life cycle is longer with fewer generations.

Life cycle:



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

Damage symtpoms:

- Most species of plant feeding thrips, have piercing and rasping 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:

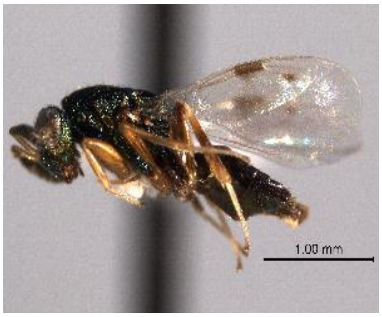
Parasitoids: *Thripobius semiluteus*
Predators: Predatory mite, predatory thrips, hover fly, mirid bug**,** *Oligota* spp., *Orius* spp etc.

*For the management refer page number 26

Natural Enemies of Cherry Insect Pests

Parasitoids

Larval parasitoids:



1. *Rhaphitelus maculatus*

2. *Eupelmus vindex*

3. *Spathius* sp.

4. *Diachasmimorpha longicaudata*

5. *Fopius arisanus*

Nymphal/adult parasitoids

6. *Thripobius semiluteus*

7. *Aphelinus mali*

8. *Aphytis* sp

1. http://www.boldsystems.org/index.php/Taxbrowser_Taxonpage?taxid=206313
2. http://www.biolib.cz/en/taxonsubtaxa/id64789/
3. http://www.pbase.com/splluk/image/144532674
4. http://www.spc.int/pacifly/control/biocontrol.htm
5. http://www.tephritid.com/digital.php?act=page&pid=28&id=25
6. http://www.entocare.nl/english/products_thrips.htm
7. http://jenny.tfrec.wsu.edu/opm/displayspecies.php?pn=980
8. http://gipcitricos.ivia.es/ahytis-melinus-debach.html

Predators

1. Lacewing

2. Ladybird beetle

3. Predatory thrips

4. Spider

5. Robber fly

6. Red ant

7. Black drongo

8. Common mynah

9. Big-eyed bug

10. Earwig

11. Ground beetle

12. Pentatomid bug

13. Preying mantis

14. *Oligota* spp.

15. *Orius* spp.

16. Hover fly

17. Mirid bug

18. Predatory mite

3. http://biocontrol.ucr.edu/hoddle/persea_mite.html
4. http://www.warpedphotosblog.com/robber-fly-and-prey

4. 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
6. http://nagpurbirds.org/blackdrongo/picture/1639
7. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
6. http://bugguide.net/node/view/598529
9. http://www.flickr.com/photos/johnhallmen/2901162091/
10.http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/ Ground%20Beetle%20-%20Pterostichus%20madidus.html
11. http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asopinae/ Eocanthecona.htm
12. http://spirit-animals.com/praying-mantis/
13. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
14. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
17. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.htm
18. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies

VIII. DESCRIPTION OF DISEASES

1) Leaf spot/shot hole:

Disease symptoms:

- *Cercospora* leaf spot is a fungal disease that occurs on leaves when plants are under stress.
- The fungus can develop both in seedbeds and after plants have been transplanted into bags.
- Brown spots on leaves gradually expanding with reddish brown margin.
- Spots occur on the both leaf.
- Then there are many spots on leaves appear to have been burnt.

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

Leaves showing disease symptoms

1. http://en.wikipedia.org/wiki/Cherry_leaf_spot
2. http://www.extension.umn.edu/garden/yard-garden/fruit/integrated-pest-management-for-home-stone-fruit-growers/cherry-leaf-spot/
3. http://msue.anr.msu.edu/news/cherry_leaf_spot_and_tart_cherries_prior_to_harvest

Survival and spread

- The pathogen survives in the soil as well as in plant debris.

Favourable conditions:

- Lack of air movement. Soil too wet and too much shade or too much sun favour the development of disease.
- Lack of nitrogen and potassium.

*For management refer to page number 26

2) Bacterial gummosis:

Disease symptoms:

- Cankers on twigs at bases of flower and leaf buds, in pruning wounds or at the base of spurs which exude amber colored gum
- Cankers spread upwards and form sunken areas in winter; if pathogen enters dormant buds they may be killed or open normally in Spring before collapsing in early Summer; infected buds may be symptomless



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

Stems showing gummosis

1. http://commons.wikimedia.org/wiki/File:Bacterial_Canker_-_Gummosis_on_Cherry.JPG
2. http://www.growfruitandveg.co.uk/grapevine/attachments/feeling-fruity/5503d1218563249-gummy-cherry-tree-img_0331_2_3.jpg
3. http://www.growfruitandveg.co.uk/grapevine/attachments/feeling-fruity/5502d1218563233-gummy-cherry-tree-img_0329_1_3.jpg

Survival and spread:

- *Pseudomonas syringae* survives on plant surfaces, is spread by splashing rain, and is favored by high moisture and low temperatures in spring.
- The disease is worse in low or sandy spots in the orchard. Vigorous trees are less susceptible to bacterial canker, while young trees, 2 to 8 years old, are most affected. The disease rarely occurs in first year of planting, and is uncommon in nurseries.

Favourable conditions:

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

*For management refer to page number 26

3) Silver leaf canker:

Disease symptoms:

- Silver Leaf is a fungal disease and its name refers to the silver luster of leaves that occurs on some hosts.
- First sign of the disease is twig and branch die-back. Leaves that are affected may later start to show brown areas in the middle and at the edges.
- Toxins produced by the fungus affect leaves, and on some hosts it may kill branches or entire trees. Diagnosis can be confirmed by cutting through a branch that is at least 2.5cm (1in) in diameter, wetting the cut surface and checking it for a brown stain in the wood.

Disease symptoms

http://www.garden.ie/gardeningtroubles.aspx?id=678

Survival and spread:

- The fungus survives in the soil as well as in twig canker.

Favourable conditions:

- High soil moisture and temperature.

*For management refer to page number 26

4) White root rot:

Disease symptoms:

- Yellow foliage, shriveled fruit, and little or no new growth are symptoms of *Dematophora* root rot.
- Cottony, white mycelia cover small feeder roots, and roots decay.
- Mycelia grow into soil and upward in the tree, forming small, pale patches under or in bark of major roots, the root crown, and lower trunk, which eventually decay.
- Older mycelium becomes gray or black. The fungus can also cause a purple canker in wood at the root crown of young trees.
- Diseased trees will defoliate and always die prematurely, usually within 1 to 3 years of initial infection.

Survival and spread:

- **Primary**: Soil, seed, water
- **Secondary**: Conidia through rain splash or wind

Favourable conditions:

- Wet and water lodged soil, heavy rain and 14-17 ºC helpful for disease development.

*For the management refer to page number 26

5) Collar rot:

Disease symptoms:

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

Stem showing collar rot

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

Survival and spread:

- Pathogen overwinters in infected trees, or in colonized fallen plant debris.

Fabourable conditions:

- Fungus favours cool (10-16 ºC) wet soil.

*For the management refer to page number 26

6) *Coryneum* blight/shot hole:

Disease symptoms:

- First symptoms of infection appear as small red spots on young leaves which enlarge and become purple with a tan-white center.
- The spots then drop out of the leaf blade to leave a “shothole.” Severe leaf infections produce numerous holes and give the affected leaves a very tattered appearance.
- Fruit infections begin as purple-red spots on the fruit skin as early as shuck-split and may occur as late as at harvest.

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

Leaves and fruits showing disease symptoms

1. http://pnwhandbooks.org/plantdisease/cherry-flowering-prunus-spp-shothole-coryneum-blight
2. http://utahpests.usu.edu/htm/utah-pests-news/summer08/coryneum-blight
3. http://www.agf.gov.bc.ca/cropprot/tfipm/coryneum.htm

Survival and spread:

- The fungus typically overwinters on infected dormant buds and in small twig cankers.

Favourable conditions:

- Temperatures of 70-80°F and wet weather splashed and wind-blown rain favours the development of disease.

*For the management refer to page number 27

7) Powdery mildew:

Disease symptoms:

- Light colored circular lesions on leaves inside tree canopy which develop a powdery appearance; lesions may coalesce to cover leaf.
- If infection is severe, leaves may blister and infected shoots may be distorted and stunted; infected fruits may have slightly depressed areas on the surface containing

fungal hyphae (filamentous fungal structures).


1. **2.**

Leaves and fruits showing disease symptoms

1. http://utahpests.usu.edu/ipm/htm/advisories/treefruit/articleID=14050
2. http://www.agf.gov.bc.ca/cropprot/tfipm/mildew.htm

Survival and spread:

- The fungus overwinters in buds on twigs and as chasmothecia, which are spore-containing structures, on the bark of twigs and branches.
- Secondary spores produced in spring spread the fungus to new growth.

Favourable conditions:

- Infections can be severe in commercial orchards during years of low rainfall, high humidity, and warm temperatures (70 to 80°F).

*For the management refer to page number 27

8) Crown gall:

Disease symptom:

- Rough, abnormal galls develop on roots or trunk. Galls are not hard, but soft and spongy.
- The centers of older galls decay. Young trees become stunted; older trees often develop secondary wood rots.


http://www.aphotofungi.com/images/diseases/plant_b_rhizobium%20radiobacter_25-01-07_2.jpg
http://www.science.oregonstate.edu/bpp/Plant_Clinic/images/cherry,%20crown%20gall123-012.jpg

Survival and spread:

- The batceria survives in the soil.

Favourable conditions:

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

*For management refer to page number 27

9) *Prunus* necrotic ringspot virus:

Disease symptom:

- Symptoms Shock symptoms, followed by chronic symptoms, are produced in trees not already infected.
- The occurrence of shock symptoms apparently depends on climatic conditions.
- The number of virus strains and the difference in tolerance of host species results in unlimited variations in symptoms.
- Symptoms generally consist of chlorosis, necrosis, leaf deformity, and stunting. Entire plants may be affected, or only a portion may show symptoms.
- Normal PNRSV symptoms consist of a few rings or chlorotic areas that may develop into severe necrotic spotting and a shothole appearance.
- Careful inspection of sweet cherry trees in late spring may reveal scattered older leaves or entire spurs with necrotic spotting or etched rings.
- Sometimes one branch will show tattered leaves or symptoms of the rugose mosaic strain.
- Yield on trees infected with the normal strain is reduced about 5%.


http://pnwhandbooks.org/plantdisease/sites/default/files/images/chryPNRS.JPG
http://pnwhandbooks.org/plantdisease/sites/default/files/images/290.jpg

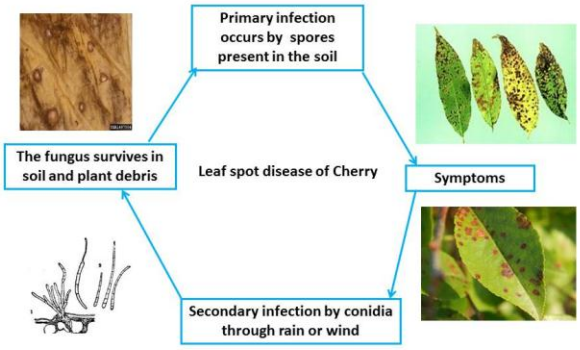
Survival and spread:

- Virus spreads through transmission by vectors
- Weed hosts serve as natural virus reservoirs.
- Long and continuous dry spell increases the disease incidence.

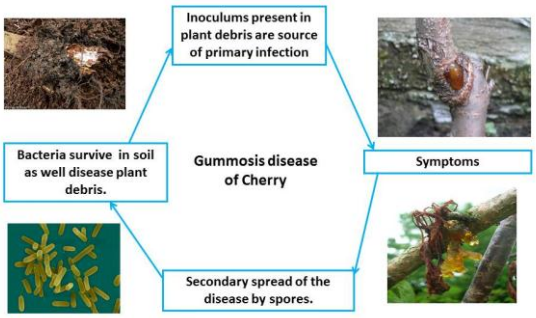
*For management refer to page number 27

Diseases cycle:

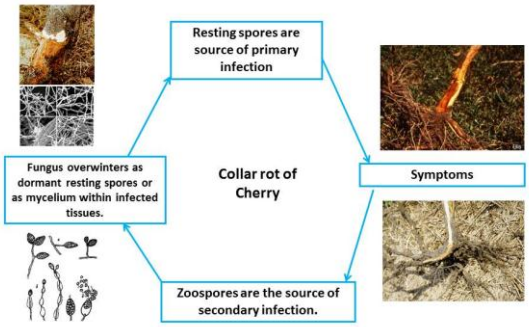
1. Leaf spot disease:



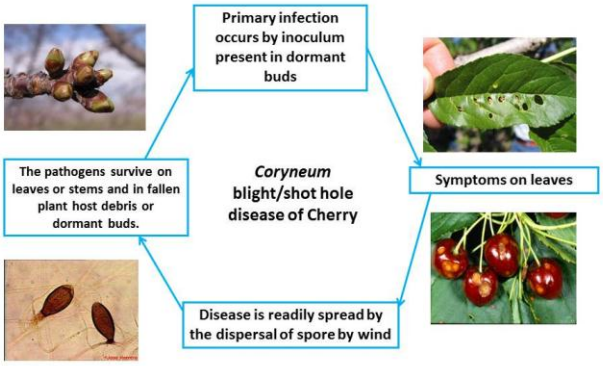
2. Bacterial gummosis:



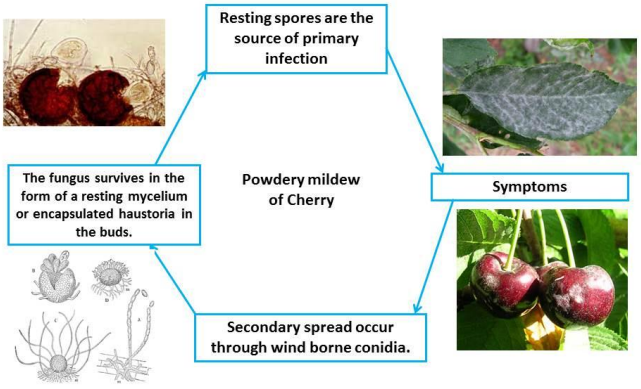
3. Collar rot:



4. Blight disease:



5. Powdery mildew:



IX. SAFETY MEASURES

A. At the time of harvest:

All varieties will begin to produce fruit in their second season. In some cases, ever-bearers may bear small berries in their first autumn. In early summer, berries will ripen over a time of about 2 weeks. It is needed to pick berries every couple of days. Try to harvest berries on a sunny day when they are dry. Don't tug too hard on your berries when picking.

B. During post-harvest storage

Berries can be kept refrigerated for about 5 days. If the fruit is to be made into preserves, it should be done straight off the plant. Berries can be frozen. Make a single layer of berries on a cookie sheet. When frozen, place into airtight bags.

X. DO'S AND DON'TS

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done in vacant space between plants on bright sunny days during the months of May and June.	Do not allow the plants to reach flowering stage in the field and do not irrigate the plant base for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds, if any.
2.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
3	Always treat the planting materials with approved chemicals/biopesticides for the control of seed borne diseases/pests.	Do not use planting materials without treatment with biopesticides/chemicals.
4.	Plant the seedlings in rows at optimum depths under proper moisture conditions for better establishment.	Do not plant seedlings beyond 5-7 cm depth.
5.	Apply only CIBRC recommended pesticides against a particular pest at the recommended dose, at the right time, with right methods with standard equipments e.g. Flat-fan or flood- jet nozzles for herbicides	Non-recommended pesticides should not be applied in the Orchard field.
6	Maintain optimum and healthy plant stand.	Orchard plants should not be exposed to moisture deficit stress at their critical stages.
7	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
8	Use micronutrient mixture after planting based on test recommendations.	Do not apply any micronutrient mixture after planting without test recommendations.
9	Conduct weekly AESA in the morning preferably before 9 a.m. Take decision on pest management practices based on AESA and P: D ratio only.	Do not take any pest management decision without considering AESA and P: D ratio
10	Install pheromone traps, if available, at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
11	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per field observation.	Do not apply chemical pesticides within seven days of release of parasitoids.
12	Apply NPV, if available, at recommended dose when a large number of egg masses and early instar larvae are noticed. Apply NPV only in the evening hours after 5 pm.	Do not apply NPV on late instar larva and during day time.
13	In case of pests which are active during night spray recommended biopesticides/pesticides at the time of their appearance in the evening.	Do not spray biopesticides/pesticides at midday since, most of the insects are not active during this period.
14	Spray pesticides thoroughly to treat the undersurface of the leaves.	Do not spray pesticides only on the upper surface of leaves.

15	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
16	Follow the recommended procedure of trap crop technology.	Do not apply long persistent pesticides on trap crop; otherwise it may not attract the pests and natural enemies.

XI. SAFETY PARAMETERS IN PESTICIDE USAGE

S. No	Pesticide classification as per insecticide rules 1971 Colour of toxicity triangle	WHO classification of hazard	Symptoms of poisoning	First aid measures and treatment of poisoning	Safety interval (days)
Fungicide					
1	Captan Slightly toxic	Class III Slightly hazardous	Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic.	

XII. BASIC PRECAUTIONS IN PESTICIDE USAGE

A. Purchase
   1. Purchase only just required quantity e.g. 100, 250, 500, 1000 g/ml for single application in specified area.
   2. **Do not** purchase leaking containers, loose, unsealed or torn bags; **Do not** purchase pesticides without proper/approved labels.
   3. While purchasing insist for invoice/bill/cash memo

B. Storage
   1. Avoid storage of pesticides in house premises.
   2. Keep only in original container with intact seal.
   3. **Do not** transfer pesticides to other containers; **Do not** expose to sunlight or rain water; **Do not** store weedicides along with other pesticides.
   4. Never keep them together with food or feed/fodder.
   5. Keep away from reach of children and livestock.

C. Handling
   1. Never carry/ transport pesticides along with food materials.
   2. Avoid carrying bulk pesticides (dust/granules) on head shoulders or on the back.

D. Precautions for preparing spray solution
   1. Use clean water.
   2. Always protect your nose, eyes, mouth, ears and hands.
   3. Use hand gloves, face mask and cover your head with cap.
   4. Use polythene bags as hand gloves, handkerchiefs or piece of clean cloth as mask and a cap or towel to cover the head (Do not use polythene bag contaminated with pesticides).
   5. Read the label on the container before preparing spray solution.
   6. Prepare the spray solution as per requirement
   7. **Do not** mix granules with water, **Do not** eat, drink, smoke or chew while preparing solution
   8. Concentrated pesticides must not fall on hands etc. while opening sealed container. **Do not** smell pesticides.
   9. Avoid spilling of pesticides while filling the sprayer tank.
   10. The operator should protect his bare feet and hands with polythene bags

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

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

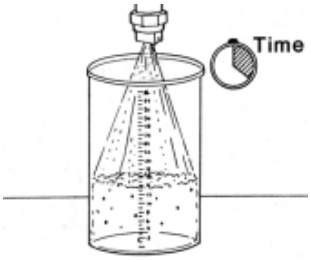
XIII. PESTICIDE APPLICATION TECHNIQUES

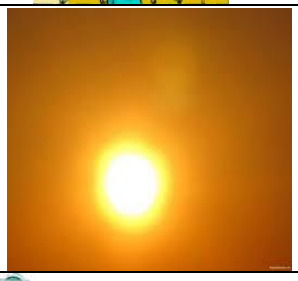
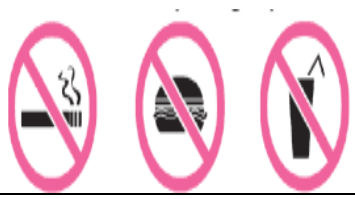
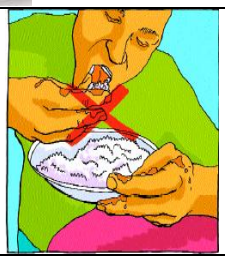
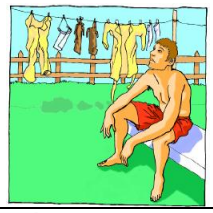
<table>
<tr><td colspan="4">Equipment</td></tr>
<tr><td colspan="4">Category A: Stationary, crawling pest/disease</td></tr>
<tr><td rowspan="2">Vegetative stage
i) for crawling and soil borne pests

ii) for small sucking leaf borne pests</td><td rowspan="2">Insecticides and fungicides</td><td rowspan="2">• Lever operated knapsack sprayer (Droplets of big size)
• Hollow cone nozzle @ 35 to 40 psi
• Lever operating speed = 15 to 20 strokes/min
or
• Motorized knapsack sprayer or mist blower (Droplets of small size)
• Airblast nozzle
• Operating speed: 2/3rd throttle</td><td> 
  </td></tr>
<tr><td>Reproductive stage</td><td>Insecticides and fungicides</td><td>• Lever operated knapsack sprayer (Droplets of big size)
• Hollow cone nozzle @ 35 to 40 psi
• Lever operating speed = 15 to 20 strokes/min</td><td>  </td></tr>
<tr><td colspan="4">Category B: Field flying pest/airborne pest</td></tr>
<tr><td>Vegetative stage
Reproductive stage
(Field Pests)</td><td>Insecticides and fungicides</td><td>• Motorized knapsack sprayer or mist blower (Droplets of small size)
• Airblast nozzle
• Operating speed: 2/3rd throttle
Or
• Battery operated low volume sprayer (Droplets of small size)
Spinning disc nozzle</td><td> 
  </td></tr>
<tr><td>Mosquito/ locust and spatial application (migratory Pests)</td><td>Insecticides and fungicides</td><td>• Fogging machine and ENV (Exhaust nozzle vehicle) (Droplets of very small size)
• Hot tube nozzle</td><td>   </td></tr>
</table>

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)	

XIV. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

1.	For application rate and dosage see the label and leaflet of the particular pesticide.	 
2.	It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.	 
3.	Clean and wash the machines and nozzles and store in dry place after use.	
4.	It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides.	

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

XV. REFERENCES

- http://www.zin.ru/animalia/coleoptera/eng/aeosardk.htm
- http://sv.wikipedia.org/wiki/Scolytus
- http://coleoptera.ksib.pl/kfp/search.php?taxonid=200055&l=en
- http://utahpests.usu.edu/ipm/htm/fruits/fruit-insect-disease/pear-psylla07
- http://oregonstate.edu/dept/nurspest/pear_sawfly%20clup4.html
- http://entnemdept.ifas.ufl.edu/creatures/veg/aphid/green_peach_aphid.htm
- http://www.forestryimages.org/browse/detail.cfm?imgnum=5360713
- http://www.cdfa.ca.gov/plant/pdep/target_pest_disease_profiles/guava_fruit_fly_profile.html
- http://www.fightthefruitfly.org/information.html
- http://www.agf.gov.bc.ca/cropprot/tfipm/fruitfly.htm
- http://entnemdept.ufl.edu/creatures/veg/melon_thrips.htm
- http://1.agrifish.dk/thrips_palmi.aspx?ID=13246
- http://www.cabi.org/portfolio/compendia/normal/coccvir3.img
- http://somethingscrawlinginmyhair.com/2010/09/18/scale-insects-on-plum-with-ants/
- http://northernwoodlands.org/articles/article/european_fruit_lecanium_parthenolecanium_corni
- http://www.boldsystems.org/index.php/Taxbrowser_Taxonpage?taxid=206313
- http://www.biolib.cz/en/taxonsubtaxa/id64789/
- http://www.pbase.com/splluk/image/144532674
- http://www.spc.int/pacifly/control/biocontrol.htm
- http://www.tephritid.com/digital.php?act=page&pid=28&id=25
- http://www.entocare.nl/english/products_thrips.htm
- http://jenny.tfrec.wsu.edu/opm/displayspecies.php?pn=980
- http://gipcitricos.ivia.es/ahytis-melinus-debach.html
- http://biocontrol.ucr.edu/hoddle/persea_mite.html
- http://www.warpedphotosblog.com/robber-fly-and-prey
- 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
- http://nagpurbirds.org/blackdrongo/picture/1639
- http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
- http://bugguide.net/node/view/598529
- http://www.flickr.com/photos/johnhallmen/2901162091/
- http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/ Ground%20Beetle%20-%20Pterostichus%20madidus.html
- http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asopinae/ Eocanthecona.htm
- http://spirit-animals.com/praying-mantis/
- http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
- http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
- http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.htm
- http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
- http://en.wikipedia.org/wiki/Cherry_leaf_spot
- http://www.extension.umn.edu/garden/yard-garden/fruit/integrated-pest-management-for-home-stone-fruit-growers/cherry-leaf-spot/
- http://msue.anr.msu.edu/news/cherry_leaf_spot_and_tart_cherries_prior_to_harvest
- http://commons.wikimedia.org/wiki/File:Bacterial_Canker_-_Gummosis_on_Cherry.JPG
- http://www.growfruitandveg.co.uk/grapevine/attachments/feeling-fruity/5503d1218563249-gummy-cherry-tree-img_0331_2_3.jpg
- http://www.growfruitandveg.co.uk/grapevine/attachments/feeling-fruity/5502d1218563233-gummy-cherry-tree-img_0329_1_3.jpg
- http://www.garden.ie/gardeningtroubles.aspx?id=678
- http://www.omafra.gov.on.ca/IPM/english/tender/diseases-and disorders/phytophthora.html
- http://pnwhandbooks.org/plantdisease/cherry-flowering-prunus-spp-shothole-coryneum-blight
- http://utahpests.usu.edu/htm/utah-pests-news/summer08/coryneum-blight
- http://www.agf.gov.bc.ca/cropprot/tfipm/coryneum.htm
- http://utahpests.usu.edu/ipm/htm/advisories/treefruit/articleID=14050
- http://www.agf.gov.bc.ca/cropprot/tfipm/mildew.htm
- http://megagriculture.gov.in/PUBLIC/package_of_practice/temperate_fruits.aspx
- http://www.fruitipedia.com/cherry Prunus avium.htm
- http://en.wikipedia.org/wiki/Sonchus
- http://skuast.org/site/Templates%20HTML/extension/package.pdf
- Naidu, V.S.G.R. 2012, *Hand Book on Weed Identification* Directorate of Weed Science Research, Jabalpur, India pp 354.