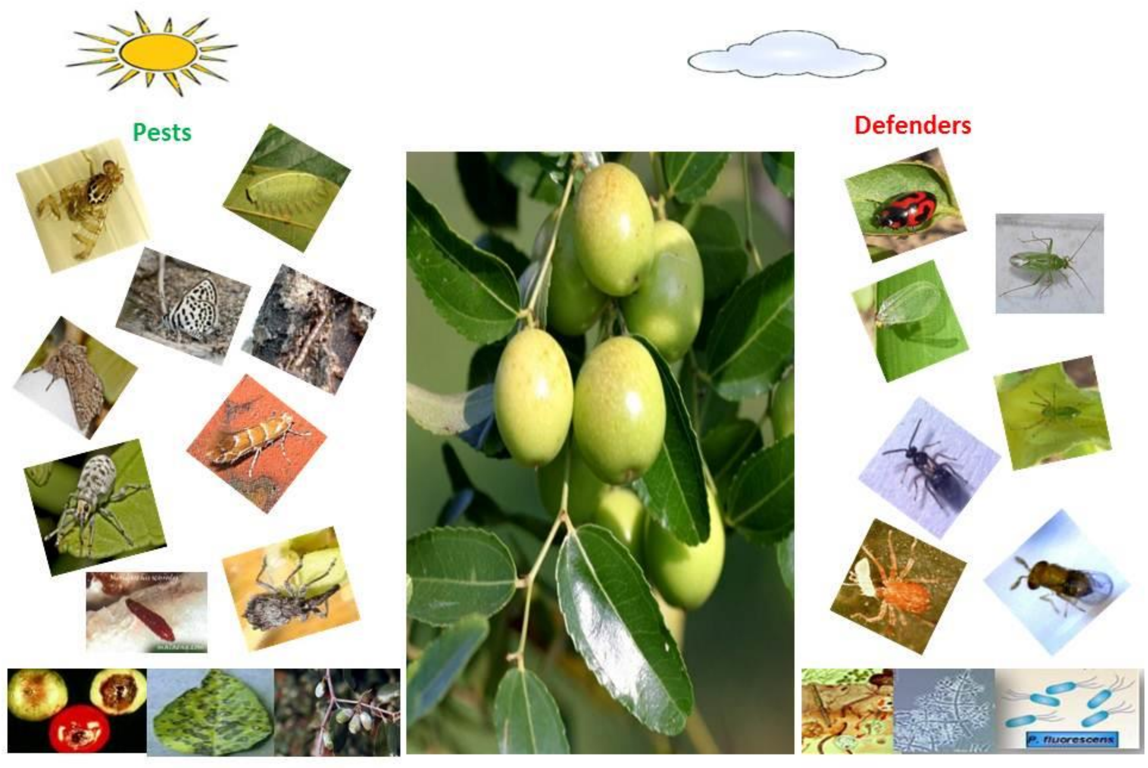
AESA BASED IPM PACKAGE
Ber



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

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Information on Region-wise Distribution of Pests Provided by:
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FOREWORD

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

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

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

AK Srivastava

Date: 6.3.2014

(Avinash K. Srivastava)

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FOREWORD

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

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

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

(Utpal Kumar Singh)

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PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

CONTENTS

AESA BASED IPM PACKAGE FOR BER

Ber- Plant description:

Ber (*Ziziphus mauritiana*; Family: Rhamnaceae) also known as Chinee Apple, Jujube, Indian plum and Masau is a tropical fruit tree species. *Z. mauritiana* is a spiny, evergreen shrub or small tree up to 15 m high, with trunk 40 cm or more in diameter; spreading crown; stipular spines and many drooping branches. The fruit is of variable shape and size. It can be oval, obovate, oblong or round, and that can be 1-2.5 in (2.5-6.25 cm) long, depending on the variety. The flesh is white and crisp. When slightly ripe, this fruit is a bit juicy and has a pleasant aroma. The fruit's skin is smooth, glossy, thin but tight.

It is a fast-growing tree with a medium life span that can quickly reach up to 10–40 ft (3 to 12 m) tall. *Z. mauritiana* is a medium sized tree that grows vigorously and has a rapidly developing taproot, a necessary adaptation to drought conditions. The species varies widely in height, from a bushy shrub 1.5 to 2 m tall, to a tree 10 to 12 m tall with a trunk diameter of about 30 cm. *Z. mauritiana* may be erect or wide-spreading, with gracefully drooping thorny branches, zigzag branchlets, thorn less or set with short, sharp straight or hooked spines. The leaves are alternate, ovate or oblong elliptic with rounded apex, with 3 depressed longitudinal veins at the base. The leaves are about 2.5 to 3.2 cm long and 1.8 to 3.8 cm wide having fine tooth at margin. It is dark-green and glossy on the upper side and pubescent and pale-green to grey-green on the lower side. Depending on the climate, the foliage of the *Z. mauritiana* may be evergreen or deciduous. The flowers are tiny, yellow, 5-petalled and are usually in twos and threes in the leaf axils. Flowers are white or greenish white and the fruits are orange to brown, 2–3 cm long, with edible white pulp surrounding a 2-locular pyrene.



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http://3.bp.blogspot.com/_3dg0cNjqC0U/TKv_OryZ2kI/AAAAAAAADMI/_ar_Aub7WRQ/s1600/ber-indian-fruit.jpg

I. PESTS

A. Pests of National Significance

1. **Insect and mite pests**
   - **1.1. Fruit fly: *Carpomyia vesuviana* Costa (Diptera: Tephritidae)**
   - **1.2. Fruit borer: *Meridarchis scyrodes* Meyr (Lepidoptera: Carposinidae)**
   - **1.3. Green slug caterpillar: *Thosea* sp. (Lepidoptera: Limacodidae)**
   - **1.4. Mite: *Larvacarus transitans* Ewing (Tetranychoidea: Tenuipalpidae)**
   - **1.5. Grey hairy caterpillar: *Thiacidas postica* Walker (Lepidoptera: Noctuidae)**

2. **Diseases**
   - **2.1. Fruit rot: *Alternaria* spp, *Phoma* spp., *Colletotrichum* spp., *Trichothecium* spp, *Cladosporium* spp.**
   - **2.2. Powdery mildew: *Oidium erysiphoides* f. sp. *ziziphi* Link**
   - **2.3. Sooty mould: *Capnodium* spp.**
   - **2.4. Leaf spot: *Isariopsis clavispora* Berk. & M.A. Curtis, *Cercospora* spp, *Cladosporium* spp Link**

3. **Weeds**

Broad leaf

- **3.1 Tick weed: *Cleome viscosa* L. (Capparidaceae)**
- **3.2 Coat buttons: *Tridax procumbens* L.(Asteraceae)**
- **3.3 Congress grass: *Parthenium hysterophorus* L. Asteraceae**
- **3.4 Horse Purslane: *Trainthema portulacastrum L.* (Aizoaceae)**
- **3.5 Lambs quarter: *Chenopodium album* L (Chenopodiaceae)**
- **3.6 Yellow sweet clover: *Melilotus indica* (L.) All. (Fabaceae)**
- **3.7 Spurge: *Euphorbia hirta* L. (Euphorbiaceae)**
- **3.8 Sorrel: *Reumex dentatus* L. (Acanthaceae)**
- **3.9 False amaranthus: *Digera arvensis* Forsk (Amaranthaceae)**
- **3.10 Common cocklebur: *Xanthium strumarium* L (Euphorbiaceae)**
- **3.11Puncture Vine: *Tribulus terrestris* L (Zygophyllaceae)**
- **3.12 Creeping thistle: *Cirsium arvense* (L.) Scop. (Asteraceae)**

Grassy weeds

- **3.13 Crabgrass: *Digitaria sanguinalis* (L.) Scop. Poaceae**
- **3.14 Yellow foxtail: *Setaria glauca* (L.) P. Beauv. (Poaceae)**
- **3.15 Bermuda grass: *Cynodon dactylon* (L.) Pers. Poaceae**
- **3.16 Torpedo grass: *Panicum repens* L. (Poaceae)**
- **3.17 Crows foot grass: *Dactyloctenium aegyptium* (L.) Willd (Poaceae)**

Sedge

- **3.18 Purple nutsedge: *Cyperus rotundus* L. Cyperaceae**
- **3.19 Yellow nut sedge: *Cyperus esculentus* L. Cyperaceae**

4. **Birds**
   - **4.1. Rose ringed parakeet: *Psittacula krameri* Scopoli (Psittaciformes: Psittaculidae)**

B. Pest of Regional Significance

1. Insect pests

- **1.1. Stone Weevil: *Aubeus himalayanus* Voss (Coleoptera: Curculionidae)**
- **1.2. Bark eating caterpillar: *Indarbela quadrinotata* walker (Lepidoptera: Metarbedelidae)**
- **1.3. Blue butterfly: *Tarucus theophrastus* (Fabricius) (Lepidoptera: Lycaenidae)**
- **1.4. Mite, *Eriophyes cernus* Mssee (Acari: Eriophyidae)**
- **1.5. Leaf miner: *Cameraria* spp (Lepidoptera: Gracillariidae)**
- **1.6. Grey weevil: *Myllocerus undecimpustulatus* Marshall Faust, *M. dentifer* (Fabricius), *M. blandus* Faust, *Amblyrrhinus poricolli* Schoenherr(Coleoptera: Curculionidae)**
- **1.7. Leaf eating caterpillar: *Euproctis* spp (Lepidoptera: Erebidae)**
- **1.8. Lac insect: *Kerria* sp**

2. Diseases.

- **2.1. Die back: *Phytophthora* spp.**
- **2.2. Black fruit spot: *Alternaria alternata* (Fr.) Keissl.**

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

A. AESA

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

Decision making in pest management requires a thorough analysis of the agro-ecosystem. Farmer has to learn how to observe the crop, how to analyze the field situation and how to make proper decisions for their crop management. This process is called the AESA. Participants of AESA will have to make a drawing on a large piece of paper (60 x 80 cm), to include all their observations. The advantage of using a drawing is that it requires the participants/farmers to observe closely and intensively. It is a focal point for the analysis and for the discussions that follow, and the drawing can be kept as a record.

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

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

Principles of AESA based IPM:
Grow a healthy crop

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

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

Farmers should

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

Photo taken by: S M Haldhar

Plant compensation ability

Compensation is defined as the replacement of plant biomass lost to herbivores and has been associated with increased photosynthetic rates and mobilization of stored resources from source organs to sinks (e.g., from roots and remaining leaves to new leaves) during active vegetative growth period. Plant tolerance to herbivory can arise from the interaction of a variety of plant traits and external environmental factors. The ability of the plant to compensate for the reduced acquisition of resources by the production of new organs or by remobilization of reserves may also mitigate biotic stress effects.

Understand and conserve defenders

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

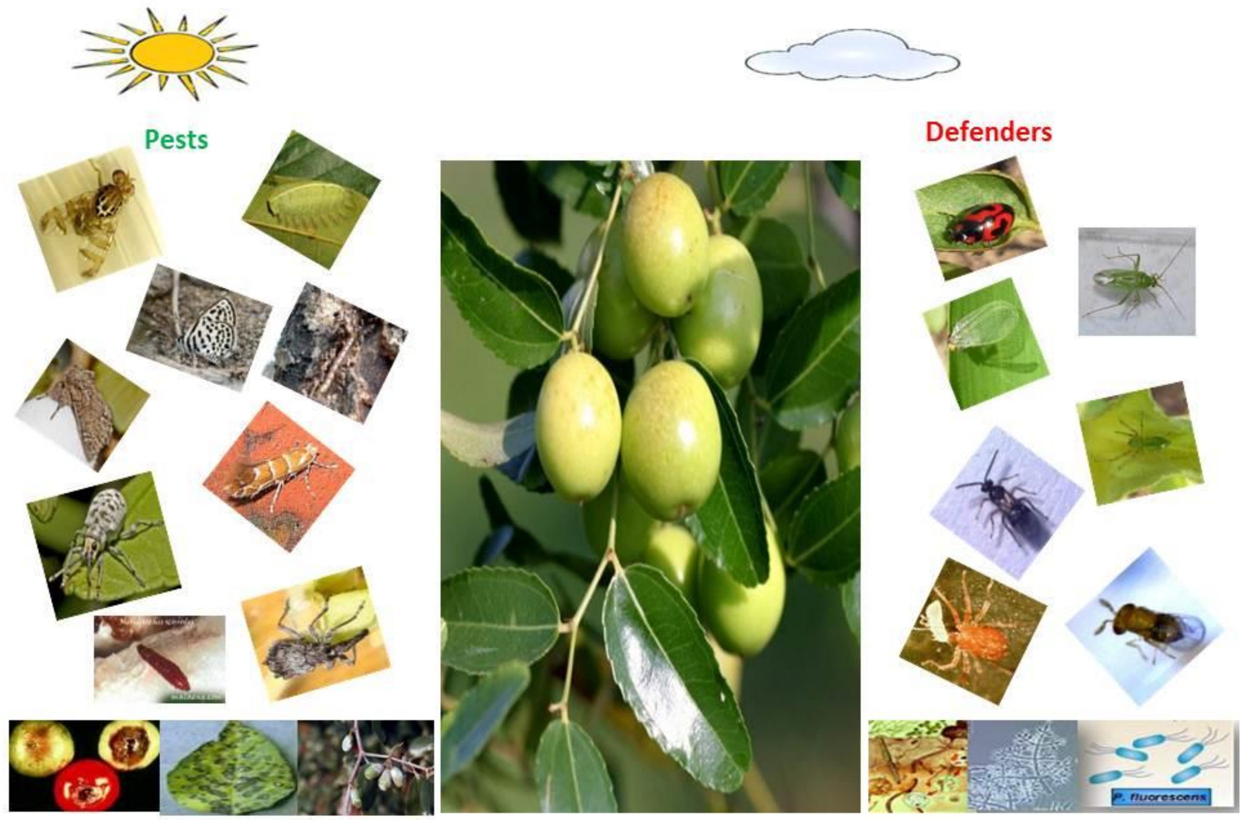
Insect zoo

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

Pest: Defender ratio (P: D ratio):
Identifying the number of pests and beneficial insects helps the farmers to make appropriate pest management decisions. Sweep net, visual counts etc. can be adopted to arrive at the numbers of pests and defenders. The Pest: Defender ratio (P: D ratio) can vary depending on the feeding potential of natural enemy as well as the type of pest. The natural enemies of Ber 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 field situations

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

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

Decision making

Farmers become experts in crop management

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

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

AESA methodology

- Go to the orchard in groups (about 5 farmers per group). Walk across the orchard and choose 10 orchards/acre randomly. Observe keenly each of these plants and record your observations:
- Tree: 5-6 samples per tree (fruits/ leaves/ inflorescence /stem bark/roots/ soil/ insects, host plants) should be collected where, one sample from top, four samples from all the four sides (north, south, east, west) and one from bottom/soil, depending upon the requirement of sturdy/observations and if necessary..
- Pests: Observe and count pests at different places on the tree.
- Defenders (natural enemies): Observe and count parasitoids and predators.
- Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
- Weeds: Observe weeds in the orchard and their intensity.
- Water: Observe the water situation in the orchard.
- Weather: Observe the weather condition.
- While walking in the orchard, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the field situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.

- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on what orchard management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording

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

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

Data to be recorded

- **Check the plant growth (weekly):** Number of leaves
- **Crop situation (e.g. for AESA):** Plant health; pests, diseases, weeds; natural enemies; soil condition; irrigation; weather conditions
- **Input costs:** Seeds; fertilizer; pesticides; labour
- **Harvest:** Yield (Kg/acre); price of produce (Rs./Kg)

Some questions that can be used during the discussion

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

Advantages of AESA over ETL

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

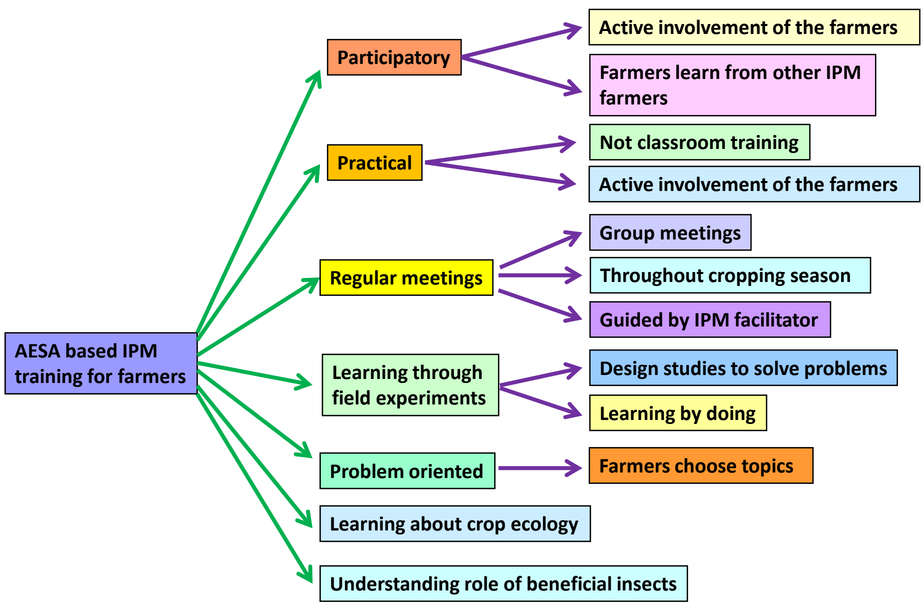
AESA and farmer field school (FFS)

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

Farmers can learn from AESA

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

FFS to teach AESA based IPM skills



B. Field scouting

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

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

For sucking pests:
Leaf miner: Count and record the number of both nymphs and adults on five randomly selected leaves per plant.
Fruit borer: Total number of fruits, damaged fruits 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). Always check plants that appear unhealthy. It is often necessary to wash the roots with water to examine them properly. If the roots are well developed, cut into them to examine the roots for internal infections (discolouration & signs). Count the total number of pseudostem damaged/infested/infected due to rot should be counted and incidence should be recorded.

Leaf sampling: Examine all leaves and or sheaths on each plant for lesions and determine the amount area of leaf infection. 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. Count the number of leaves (leaf area diameter)/plant infected due to disease and incidence should be recorded.

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

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

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

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

Ecological Engineering for Pest Management – Below Ground:

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

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

Ecological Engineering for Pest Management – Above Ground:

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

Natural enemies may require:

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

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

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

- Select and plant appropriate companion plants which could be trap crops and pest repellent crops. The trap crops and pest repellent crops will also recruit natural enemies as their flowers provide nectar and the plants provide suitable microclimate.

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

Plants suitable for Ecological Engineering for Pest Management

Attractant plants

Cowpea

Carrot

Sunflower

Buckwheat

French bean

Alfaalfa

Mustard

Cosmos

Anise

Caraway

Dill

Parsley


White Clover


Tansy


Yarrow


Marigold

Repellent plants


Ocimum sp


Peppermint/Spearmint

Barrier plant


Rye grass

Border plants

Maize **Sorghum**

Crop rotation plants

***Sesbania* sp.** ***Crotalaria* sp.** ***Gaillardia* sp.**

Castor **Desmodium** **Potato**

Trap plants


Tomato


Marigold


Pearl millets

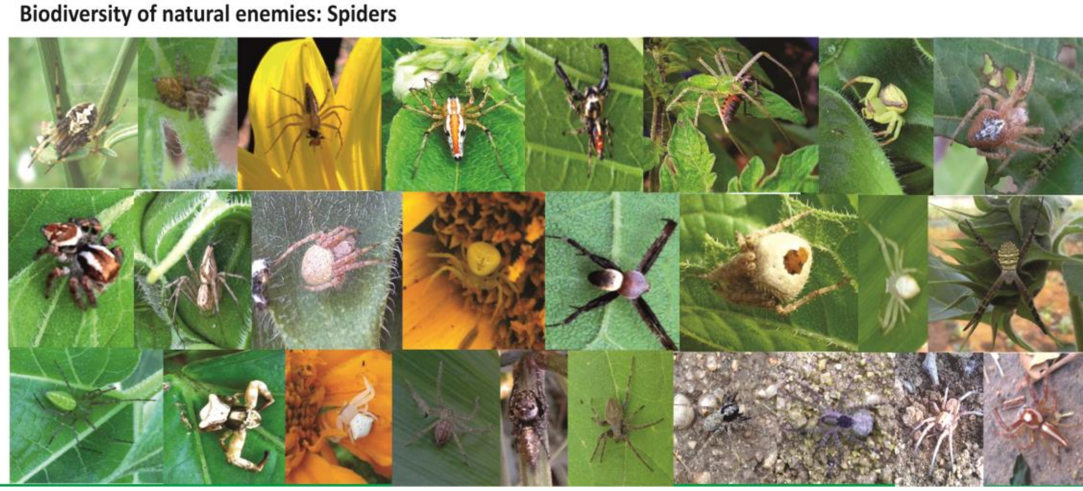
The flowering plants suggested under Ecological Engineering for pest management strategy are known as attractant plants to the natural enemies of the selected pests. The information is based on published research literature. However, the actual selection of flowering plants could be based on availability,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

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. Resistant/tolerant varieties

Pest	Resistant/tolerant varieties
Resistant to Powdery mildew	• Safeda selected, glory, Dhaka 1 and Dhaka – 2.
Resistant to Fruit borer	• Banarsi Pewandi, Ajmeri, Gola,Gurgaon and Jhajjar
Tolerant to Fruit fly	• Umran, Tikkadi

V. CROP STAGE WISE IPM

Management	Activity
Pre- planting*	
	<u>Common cultural practices:</u> • Deep ploughing of fields during summer. • Field sanitation, rogueing • Use resistant/tolerant varieties. • Grow the attractant, repellent plants around the field bunds. • Apply manures and fertilizers as per soil test recommendations
Nutrients	• Apply nutrients on the basis of soil test report and recommendation for the particular agro-climatic zone. • The pits of 60x60x60 cm size are dug during summer are dug in summer a month before planting. • Fill the pits with top soil mixed with 25 kg FYM treated with *Trichoderma* .
Weeds	• Ploughing, harrowing, leveling and removing the weeds before planting. •
Soil-borne pathogens, and resting stages of insects	**<u>Cultural control:</u>** • Deep summer ploughing of fields to exposes dormant stages (pupa and larva) and subsequently reduces their initial population build up.
Planting*	
	<u>Common cultural practices:</u> • Plant resistant varieties. • Practice field sanitation. • Timely planting with recommended spacing.
Nutrients	• Planting is done in pits already filled with top soil and farm yard manure. • Apply 20 g each of *Azospirullum* and mycorrhizae per plant at planting.

Weeds	• Use weed free seedlings for planting. • Remove existing weeds in and around the pits at the time of planting. •
Diseases and insect pests	**<u>Cultural control:</u>** • Grow resistant varieties *viz.,* Safeda selected, glory, Dhaka 1 and Dhaka – 2 resistant to powdery mildew, Banarsi Pewandi, Ajmeri, Gola,Gurgaon and Jhajjar resistant to fruit borer and Umran, Tikkady tolerant to fruit fly • Follow ring method for irrigation to reduce collar rot
Leaf spot	**<u>Cultural control:</u>** • Avoid planting in low-lying areas and flooding. • Do not delay irrigation until the crop exhibits moisture stress symptoms.
Die back**	**<u>Cultural control:</u>** • Scion wood selected for propagation should be free from infection • Prevent introduction of disease in newly planted orchards. **<u>Mechanical control:</u>** • Any infected portion be pruned immediately, followed by pasting with cow dung at the cut ends. • Pruning should be done in such a way that some healthy portion is also removed, to ensure complete eradication of pathogen (3 “below the infection site).
* Application of *Trichoderma harzianum*/ *viride* and *Pseudomonas fluorescens* for treatment of seed/seedling/planting materials in the nurseries and field application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).	
Vegetative stage	
	<u>Common cultural practices:</u> • Deep ploughing (two/three times) between rows to expose the hibernating pupae to sunlight and predatory birds. • Keep the orchard clean and healthy • Remove and destroy alternate wild hosts **<u>Common mechanical practices:</u>** • Prune diseased leaves and malformed panicles harbouring the pathogen to reduce primary inoculum load. • Remove and destroy the diseased orchard. • Remove plant debris • The infected branches should be collected and burnt • Remove the infected leaves in the lower rows. • Set up light trap@1trap/acre • Collect and destroy egg mass and larvae.

<table>
<tr><td></td><td>

- Use yellow sticky traps @ 4-5/acre

<u>Common biological practices:</u>

- Conserve natural enemies through ecological engineering
- Augmentative release of natural enemies

</td></tr>
<tr><td>Nutrients</td><td>

- Apply fertilizers according to the age of plant as mentioned below;

<table>
<tr><th>Manures & Fertilizers (per plant/year)</th><th>1st year</th><th>2nd year onwards</th></tr>
<tr><td>FYM</td><td>20 kg</td><td>50 kg</td></tr>
<tr><td>N</td><td>200 g</td><td>500 g</td></tr>
<tr><td>P</td><td>100 g</td><td>200 g</td></tr>
<tr><td>K</td><td>200 g</td><td>500 g</td></tr>
</table>

- The manures and fertilizers should be applied in 20-30 cm deep and 30 cm wide trench along the drip line of the tree.

</td></tr>
<tr><td>Weeds</td><td>

- Intercultural operations like ploughing, harrowing etc. should be done on regular basis especially around the plants.
- To suppress the weeds between rows, leguminous crops like green gram, mothbean, clusterbean, chickpea, cow pea and vegetables e.g. chillies can be grown as intercrops during initial 5 years.
- Use straw or black polyethylene ‘mulch’ to avoid weed growth and to maintain soil moisture for longer period.
- Use slashing and moving between the rows to control the weeds.

</td></tr>
<tr><td>Leaf spot</td><td>

- As mentioned above in the seedling stage

</td></tr>
<tr><td>Powdery mildew</td><td>

<u>Cultural control</u>:

- Spraying at full bloom needs to be avoided.
- Alkathene bands should be cleaned at regular interval

<u>Chemical control:</u>

- Spraying of carbendazim 50% WP @ 10 g diluted in 10 l water per tree.

</td></tr>
<tr><td>Blue butter fly</td><td>

<u>Cultural control</u>:

- Remove the infested leaves from the plant.

</td></tr>
<tr><td>Green slug Caterpillar</td><td>

<u>Cultural control:</u>

- Leaflets have to be observed for fresh incidence by cutting 1-2 leaf fronds.

</td></tr>
<tr><td>Grey hairy caterpillar</td><td>

<u>Cultural control:</u>

- Irrigate once to avoid prolonged mid-season drought to prevent pre-harvest infestation.

<u>Mechanical control:</u>

- Dig the pit of 1 inch depth between the orchids & dust to kill

</td></tr>
</table>

	the larvae in pits. **Biological control:** • Follow common biological practices.
Bark eating caterpillar**	**Cultural control:** • Remove frassy galleries and paint the bark. • Application of the solution, made up by mixing 1 lit of kerosene and 100 g soap in 9 lit of water to the holes effectively controls the bark eating caterpillar.
Mite	**Cultural control:** • Regular field monitoring & use sweep net in the morning hrs for monitoring of pest & defender population, barrier crops like mustard crop around the field. • Grow attractant plants like French bean • Plant tall border crops like maize, sorghum or millet to reduce pest population. **Biological control:** • .Follow common biological practices. • Plant tall border crops such as maize, sorghum etc. as barrier crops
Leaf miner**	**Cultural control:** • Avoid excess use of nitrogen. • Growing tomato or marigold as a trap crop. **Mechanical control:** • See the common mechanical practices **Biological control:** • Follow common biological practices.
Leaf eating caterpillar**	**Mechanical control:** • At early and smaller scale, pluck the leaves with egg masses and young caterpillars and destroy.
Lac insect**	**Mechanical control:** • Remove and destroy the infested dry part and scrap off the infested twig before treatment
Reproductive/ Fruiting stage	
Nutrients	• Spray 2% KNO_3 thrice at monthly intervals in January, February and March. • Apply recommended micronutrients, if deficiency symptoms are observed. • For the correction of Zinc and Boron deficiency, apply Zinc suphate @ 0.5% and Boric acid @ 0.1%, respectively as foliar spray.
Weeds	• Remove weeds around the plants. • Continue to use straw or black polyethylene mulch to avoid weed growth and to maintain soil moisture for longer period.

Fruit fly	**<u>Cultural control</u>:** • Clean cultivation/sanitation of orchards by picking and destroying the infested fruits should be done. • To escape egg laying on fruits, harvest at green and firm stage and do not allow the fruit to ripe on the tree. • Destroy the hibernating pupae by exposing them to bright sunlight and birds • Prior to harvest, collect and dispose off infested and fallen fruits to prevent further, multiplication and carry-over of population. • If infestation is heavy, bait splash on the trunk only, once or twice at weekly interval is recommended. To prepare bait splash, mix 100 g of jaggery in one litre of water and add 1 ml of deltamethrin by using an old broom. **<u>Mechanical control</u>:** • Male annihilation technique: Set up fly trap using methyl eugenol. Prepare methyl eugenol 1 ml/L of water + 1 ml of malathion solution. Take 10 ml of this mixture per trap and keep them at 25 different places in one ha between 6 and 8 AM. • Collect and destroy the adult flies. **<u>Biological control:</u>** • Follow common biological practices. • The extract of azadiractin 1% and *Ocimum sanctum* 1% were effective up to 10 days after spraying. Application of neem powder and tobacco leaf extracts would also significantly reduce *C. vesuviana* damage and they could be the potential candidates for organic cultivation of ber
Fruit borer	**<u>Cultural control:</u>** • Removal of wild *ber* trees around the *ber* orchard. Rack the soil under the tree or near the trees to destroy the maggots and pupae present in the soil. • Collection and proper destruction of infested fallen fruits. Harvest of fruits at immediate after maturity (green stage).
Stone weevil**	**<u>Cultural control:</u>** • The pest feeds only on the seed portion of developing fruits and arrest further development of attacked fruit. • The entry hole is healed up and closed while the exit hole can be clearly seen. • Collection and destruction of adult weevil immediately after detection can also reduce the population. Infested dropped fruits should be collected and burned to break the generation cycle.

Mite, Leaf eating caterpillar and Lac insect****	• As mentioned in the above vegetative stage
Fruit rot	**<u>Cultural control:</u>** • Using disease-free transplants is the most effective method for controlling. • Use of drip irrigation, limits the dispersal of the pathogen. • Plants are also more sensitive to infection under high fertility conditions. • Reduced nitrogen rates or the use of nitrate rather than ammonium nitrogen sources may also reduce
Powdery mildew	• As mentioned in the above vegetative stage
Sooty mould	**<u>Cultural control:</u>** • Pruning of affected branches and their prompt destruction prevents the spread of the disease
Birds	**<u>Mechanical control</u>:** • Use bird scarer **<u>Biological control</u>:** • Apply NSKE 5% on panicle to save the damage from birds

Note: The pesticide dosages and spray fluid volumes are based on high volume spray.

** Pests of regional significance

VI. INSECTICIDE RESISTANCE AND ITS MANAGEMENT

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

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

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

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

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

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

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

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

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

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

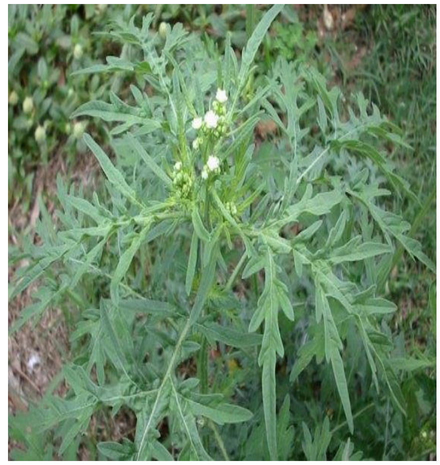
VII. Nutrient deficiency symptoms in Ber

Sr. no.	Deficiency symptoms
1.	**Nitrogen Deficiency** Leaves are smaller, dark olive green and have a dull appearance. They can fade to a dull orange. There is a tendency for the leaves to curl downward and the leaf petioles to become darker red. Brown spots develop interveinally on the under surface of the leaves.
2.	**Potassium Deficiency** The first symptoms are downward curling of the leaf, associated with a bronzing of the interveinal tissue. The interveinal tissue becomes a paler green and eventually dies, giving rise to interveinal scorch. In the final stages, the leaves wither to an ashy-gray color and fall. There may be a marginal scorch on the older leaves.
3	**Magnesium Deficiency** Mainly older leaves of plant affected by magnesium deficiency Interveinal chlorosis, yellow at the edges of older leaves, symptom progress up the plant.

VIII. DESCRIPTION OF COMMON WEEDS


1.Tick weed: *Cleome viscosa* L. (Capparidaceae)


2. Coat buttons: *Tridax procumbens* L.(Asteraceae)


3. Congress grass: *Parthenium hysterophorus* L. Asteraceae


4. Horse Purslane: *Trainthema portulacastrum* L. (Aizoaceae)


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


6. Yellow sweet clover: *Melilotus indica* (L.) All. (Fabaceae)


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


8.Sorrel: *Rumex dentatus* L. (Acanthaceae)


9.False amaranthus: *Digera arvensis* Forsk (Amaranthaceae)

10.Common cocklebur: *Xanthium strumarium* L (Euphorbiaceae)

11.Puncture Vine: *Tribulus terrestris* L (Zygophyllaceae)

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

13.Crabgrass:*Digitaria sanguinalis* (L.) Scop. Poaceae

14.Yellow foxtail: *Setaria glauca* (L.) P. Beauv. (Poaceae)

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

16.Torpedo grass: *Panicum repens* L. (Poaceae)

17.Crows foot grass: *Dactyloctenium aegyptium* (Poaceae)

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

19. Yellow nut sedge: *Cyperus esculentus* L. Cyperaceae

IX. DESCRIPTION OF INSECT AND MITE PESTS

1. Fruit fly

Biology:

- **Egg:** Female flies insert eggs under the skin of fruit in clusters of 10 to 50 about 1/25 to 1/8 inch below the fruit surface. The eggs measure about 1/25 by 1/250 inch and are white, elongate, and elliptical. They hatch in 1-1/2 days.
- **Larva:** The white larva is legless, and resembles an elongated cone. The mouth is at the pointed end of the body. There are 3 larval stages, or instars. The third instar is about 2/5 inch long. The entire larval stage lasts for 11-15 days.
- **Pupa:** When mature, larvae drop to the ground and pupate in the soil. The puparium is yellowish-brown and seed-like. Adults emerge in about 10 days.
- **Adult:** Generally, the abdomen has two horizontal black stripes and a longitudinal median stripe extending from the base of the third segment to the apex of the abdomen. These markings may form a "T" shaped pattern, but the pattern varies considerably. Females begin to lay eggs about 8 days after emergence from the puparium. Under optimum conditions, a female can lay more than 3,000 eggs during her lifetime, but under field conditions approximately 1,200 to 1,500 eggs per female is considered to be the usual production.

Damage symptom:

- Infestation starts with the onset of fruit setting.
- The excreta of the larva accumulate in the galleries, which may sometimes result in rotting of the fruit.
- Infested fruits become deformed and their growth becomes checked. A large number of such fruits drop off.

Life cycle:

http://ecoport.org/PDB/000020/20021.jpg

Natural enemies of fruit fly:

Parasitoids: *Fopius arisanus*, *Diachasmimorpha kraussi*

2.Green slug caterpillar:

Biology

Egg: Eggs are laid in groups and covered with hairs on the leaves. Egg period is 4-5 days.

Larva: Larva is stout, slug like ventrally flat, greenish body with white lines and four rows of spiny scoli tipped red or black; larval period is 40-45 days.

Pupa: It pupates in plant as cocoons covered with irritating spines and hairs

Adult: Adult moth is green with brown band at the base of each forewing.

Life cycle

https://c2.staticflickr.com/8/7164/6761408131_20b2796274.jpg

Damage symptom:

- Larva feeds on leaves voraciously leaving only the midrib and veins resulting in severe defoliation.

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

3. Mite:

Biology:

- **Egg:** Eggs are oval shaped and white in colour. Eggs are glued firmly on the leaf surface. Eggs large, obovate, flattened at the bottom; eggs hatches after 27-32 hours
- **Nymph:** Nymphs white in colour.
- **Adult:** Adults large, oval and broad and yellowish in colour. Females are yellowish and bigger than the males and they carrying the "female nymphs" on their back.

Life cycle:

Damage symptom:

- Mite is seen on young leaves especially the top two to three leaves and the bud.
- Affected leaves become rough and brittle and corky lines.
- Downward curling.
- Internodes get shortened.
- Mites produce galls in floral buds preventing fruit production.

Natural enemies of mite:

Predators: Predatory mites, predatory thrips, *Oligota* spp., *Orius* spp. (pirate bug), hover flies, mirid bug

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

4. Grey Hairy caterpillar:

Biology:

- **Egg:** Female lays eggs in masses on leaves.
- **Larva:** The larvae are pale yellow coloured with yellow hair over the body. They are polyphagous, feed on leaves and cause loss by way of defoliation. In severe cases only stems are left behind. In defoliated crops it also feeds on capsules.
- **Pupa:** Pupates in leaf litter close to the plants. There are several generation per year.

- **Adult:** Adult moth is reddish brown with black spots. Both the wings are pinkish and possess black spots

<u>Life cycle:</u>

Larva

Adult

http://www.nbair.res.in/insectpests/images/Thiacidas-postica3.jpg
http://www.africanmoths.com/images/Noctuidae/THIACIDINAE/thiacidas%20senex%201%20t.JPG

<u>Damage symptom:</u>

- Caterpillars feed on the young leaves and fruits.
- The older caterpillars spread in all directions and devour leaves and fruits and sometimes even tender shoots.
- They start eating new foliage as it grows after pruning and this is continued by overlapping generations.

<u>Natural enemies of grey hairy caterpillars:</u>

<u>Predators:</u> *Chrysoperla*   Coccinellids

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

5.Bark eating caterpillar: *Indarbela quadrinotata*

Biology:

- **Eggs:** Spherical eggs, usually singly, are laid in bark cracks. 350 eggs on bark in May-June, larval period is about 8-11 days. Number of generation : 1/year
- **Larva:** Larval period 8-10 months till about 3rd week of April. The larval stage is for about 10 months. The larva is brown to black, shiny, sparsely hairy and measures 4.5-5.0 cm before pupation.
- **Pupa:** Pupation inside larval tunnel, pupal period is about 21-41 days.
- **Adult:** Moth is creamy white with brown markings on the forewing. Moth longevity is 3 days.

<u>Damage symptom:</u>

- The caterpillars feed on the bark of the tree during night.
- They bore inside the trunk or main stems and eat through the bark in to the wood.
- The affected portion is covered with large silken webs.

- In case of severe infestation plants may die.

Ribbon like or pipe like webbings on the stem near forks or angles of branches

Life cycle:

Indarbela quadrinotata (bark eating caterpillar)
أكلة اللحاء

http://f.zira3a.net/attachments/2681d1276442377-bark-eating.jpg

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

6. Leaf miner:

Biology

- **Egg:** Egg are very tiny (about 1.0 mm long and 0.2 mm wide), greyish or yellowish white and slightly translucent. They are laid inside the leaf tissue, just below the leaf surface. In some instances eggs are laid below the epidermis of fruits/pods (e.g. peas). Eggs hatch in about 3 days.
- **Larva:** They are small yellow maggots (about 2 to 3 mm long when fully-grown). They are found feeding inside the leaf tissue, leaving a long, slender, winding, white tunnels (mines) through the leaf. They pass through 3 larval stages. After 5 to 7 days the maggots leave the mines and pupate either on the leaf surface or - more commonly - in the soil. In some cases, maggots pupate within the mines.
- **Pupa:** Pupae are very small, about 2 mm long and 0.5 mm wide) oval, slightly flattened ventrally with variable colour varying from pale yellow-orange to golden-brown. They have a pair of cone-like appendages at the posterior end of the body. Adults emerge 4 to 5 days after pupation.
- **Adult**: adults are small, about 2 mm long. They are greyish to black with yellow markings. Female flies are slightly larger than males. The life cycle varies with host and temperature. The average life cycle is approximately 21 days in warm conditions, but can be as short as 15 days. Thus, populations can increase rapidly.

Life cycle:

http://www.ipmimages.org/browse/detail.cfm?imgnum=5410738

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

7. Fruit borer:

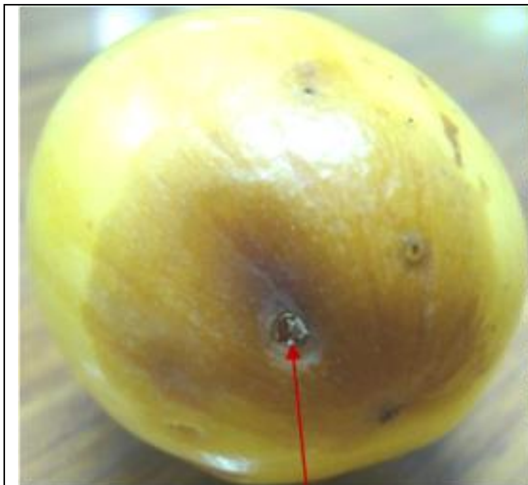
The fruit borer *Meridarchis scyrodes* is a serious pest in Southern states of India.

Biology:

- Adult fly is small dark brown in colour with fringed wings. Early instar larva is light yellowish and full-grown larva is red in colour.
- Female lays an average of 13.29 eggs and incubation period found to be 4-5 days. The larval and pupal stages completed in 14-18 and 8-9 days, respectively.
- Under laboratory conditions at 31 ± 1°C and 60-80% R.H and life cycle completes within 26-32 days.
- Longevity of adult male and female observed to be 3-4 and 4-5 days, respectively.

Damage symptoms:

- The pest causes up to 70% yield loss under severe infestation. The moths lay eggs on fruits at pea stage and upon hatching the newly emerged caterpillars bore into fruits and feed on the pulp near seed and accumulate fecal.
- The first and second instar larvae feeds on the fruit superficially but third to fifth instar larvae feeds internally and damages the pulp around the seed. At initial stages of fruit development, the full grown larvae found to feed on soft immature seed.



Larvae feeding inside the fruit

Damage symptoms of fruit borer

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

8. Stone weevil:

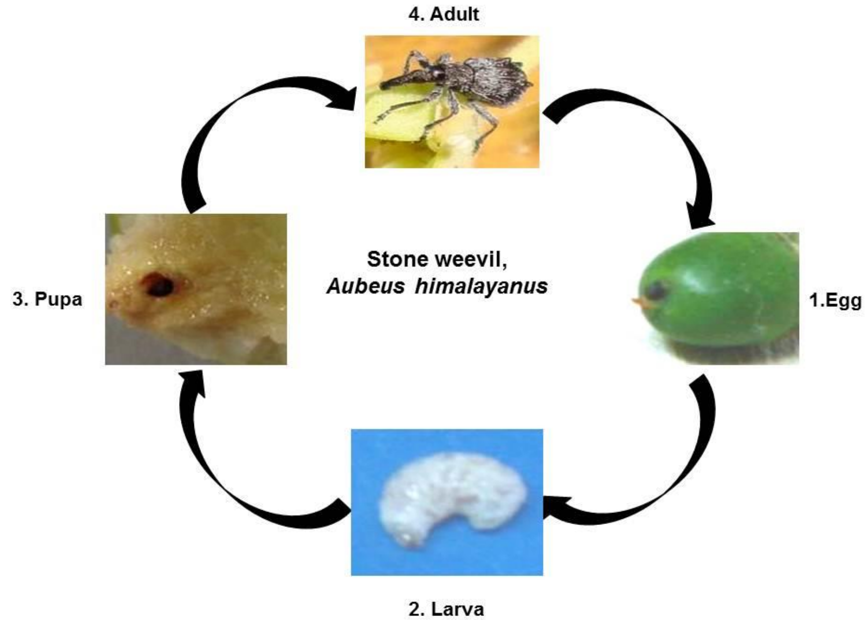
<u>Occurrence and distribution:</u>

- The stone weevil, *A. himalayanus* is recorded as a new pest of *ber*. At first it was recorded as a new pest of *ber* for the first time from Andhra Pradesh state of India.
- Later, from Rahuri, Maharashtra and Jobner, Rajasthan of India in 1996 and recently in Bikaner district of Rajasthan, India during 2010.
- Apart from India, the severe damage of this pest at early stage of fruit development has also been reported from Bangladesh.

<u>Biology:</u>

- The adult weevils are small dark in colour with snout. The grubs are white in colour with red marking on the bogy, which are present inside the seeds (Karuppaiah *et al*., 2010). The activity of adult beetle could be observed in the field during morning and evening hours and the biology of this pest is not studied so far.

<u>Life cycle:</u>



Damage symptoms:

- Grubs directly damage the fruits by tunneling inside seeds and adult weevil also blemishes mature fruit by ovi-punctures. The activity of adult beetle could be observed in the field during morning and evening hours.
- The adult female weevil lays their eggs mostly on the stylar end; rarely on the distal end of fruits and egg laid punctures covered with brown encrustation.
- Upon hatching, the grubs enter into seed by puncturing endocarp at immature stage and starts feeding on soft seed coat. Later it enters into endosperm moving downward. After entering the seed, it starts feeding on inner content of the seed, and pupates within the seed by making hallow galleries.
- The weevil completes its life within a single fruit. The developing soft seed was completely eaten away by the pest. At the time of fruit maturity, in the hollowed area, infested fruits had a grub, a pupa or an adult.
- The infestation occurs in all the fruit stages; however, it is prevalent in pea to pebble size fruits. Infested fruits are abnormal shape and nearly half portion of the fruit towards stalk turns reddish brown with rough surface and the remaining half portion towards stylar region remains greenish colour. Often, infested fruits fail to attain full maturity.

Egg laid mark a stylar end **Grub**

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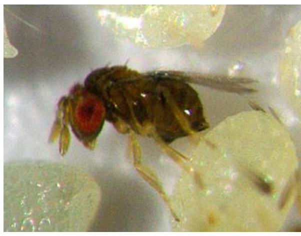
Natural Enemies of Ber Insect Pests

Parasitoids

Egg parasitoids



1. *Trichogramma*   2. *Tetrastichus* spp.   3. *Telenomus* spp

Egg-larval parasitoid

6. *Chelonus* spp.

Larval parasitoids




5. *Bracon* spp.   6. *Ichneumon* sp 7. *Carcelia* spp.   8. *Campoletis* spp

Nymphal/larval and adult parasitoids

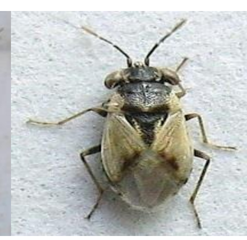
9. *Encarsia formosa*   10*. Eretmocerus* spp.

1. http://www.nbaii.res.in/Featured_insects/Trichogrammatids.php
2. http://www.pbase.com/image/135529248
3. http://baba-insects.blogspot.in/2012/02/telenomus.html
4. http://www.nbaii.res.in/Featured%20insects/chelonus.htm
5. http://www.nbaii.res.in/Featured%20insects/Bracon%20brevicornis.htm
6. http://www.organicgardeninfo.com/ichneumon-wasp.html
7. http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398
8. http://www.nbaii.res.in/Featured%20insects/Campoletis.htm
9. http://www.buglogical.com/whitefly-control/encarsia-formosa/
10. http://www.dongbufarmceres.com/main/mboard.asp?strBoardID=c_product01_en

Predators

1. Ground beetle   2. Ladybird beetle   3. Reduviid bug   4. Pentatomid bug

5. *Geocoris* spp.   6. Mirid bug   7. Big-eyed bug   8. Earwig

9. Fire ant   10. Spider   11. Robber fly   12. Lacewing

13. Preying mantid

14. Black drongo

15. Common mynah

1.http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/ Ground%20Beetle%20-%20Pterostichus%20madidus.html
4. http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asopinae/ Eocanthecona.htm
5. http://nathistoc.bio.uci.edu/hemipt/Dicyphus.htm
6. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html
7. http://bugguide.net/node/view/598529
8. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
9.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
11. http://www.warpedphotosblog.com/robber-fly-and-prey
13. http://spirit-animals.com/praying-mantis/
14. http://nagpurbirds.org/blackdrongo/picture/1639
15. http://www.flickr.com/photos/johnhallmen/2901162091/

X. DESCRIPTION OF DISEASES

1. Fruit rot:

<u>Disease symptom:</u>

***Phoma* fruit rot**

The disease appears on the ripening fruit. The infected fruits remain small and develop slightly depressed, dark brown spots near the stem ends. The lesions become irregular in shape and measure 15-25 mm in diameter.

***Alternaria* fruit rot**

Slightly depressed, brown to dark brown, circular lesions appear on the fruit. Sometimes concentric rings are also present on these spots. The smaller spots coalesce to form larger spots.

***Colletotrichum* fruit rot**

The disease appears at the start of ripening of the fruit in the form of small, slightly depressed, light brown, water-soaked lesions. These spots coalesce and enlarge. Under humid conditions, the acervuli are formed in masses on these spots.

***Trichothecium* fruit rot.** The disease is observed during the spring in the form of pink spots on the fruits. The fungus can survive in the soil for a long time. Fruits touching the soil may become infected and develop symptoms.

***Cladosporium* fruit rot**

The disease appears near the time of fruit ripening. Injured fruits become infected. The symptoms of the disease start from the tip of the fruit forming light brown to dark brown spots. Later, a greenish fungal growth is also seen on these spots.

<u>Transmission and favourable conditions:</u>

***Phoma* fruit rot**

- The fungus survives in plant debris, the primary source of infection.

***Alternaria* fruit rot**

- The fungus survives in debris and soil.
- The fruits touching the soil become infected and the disease spreads later by dissemination of spores through the air.

***Colletotrichum* fruit rot**

- Being saprophytic the pathogen survives in soil, along with the debris, for along period.
- This becomes the primary source of infection.
- The spores are present in the air and act as secondary sources of infection and are disseminated by rain splashes.

***Cladosporium* fruit rot**

- It is also spread by spores present in the air.
- The fungal spores survive in plant debris and soil, the primary sources of infection.

Infected leaf & fruits

http://agritech.tnau.ac.in/crop_protection/crop_prot_crop%20diseases_fruits_ber.html

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

2. Powdery Mildew:

<u>Disease symptom:</u>

- The symptoms of the disease are noticed on flowers and newly set fruits.
- The disease may appear earlier if conditions are favourable. The developing young leaves show a whitish powdery mass, which causes them to shrink and defoliate.
- The disease also appears in the form of white powdery spots on the surface of the fruits and later covers the whole fruit surface. The spots turn into light brown to dark brown discolouration. The infected area becomes slightly raised and rough.
- Affected fruits either drop off prematurely or become corky,cracked, misshapen and remain underdeveloped. Sometimes the whole crop is rendered unmarketable.

<u>Survival and spread:</u>

- The powdery mildew fungus overwinters in dormant buds. When conditions are favourable for growth of the fungus in spring, spores are produced, released, and cause new infections. Secondary spread of the disease can occur if spores are produced in these new infections

<u>Favourable condition:</u>

- The development of powdery mildew is favour by relative humidity around 80-85% and temperature range of 24-26°C.

Powdery mildew infection

http://www.apsnet.org/publications/imageresources/PublishingImages/2013/fi00182.jpg

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

3.Sooty mould:

Disease symptom:

- The disease is common in the orchards where mealy bug, scale insect and hopper are not controlled efficiently.
- The disease in the field is recognize by the presence of a black velvety coating, i.e., sooty mould on the leaf surface. In severe cases the trees turn completely black due to the presence of mould over the entire surface of twigs and leaves.
- The severity of infection depends on the honey dew secretion by the above said insects. Honey dew secretions from insects sticks to the leaf surface and provide necessary medium for fungal growth.

Survival and spread:

- The severity of infection depends on the honey dew secretions by the scale insects which provide the necessary medium for the fungal growth.
- Transmission occurs by air-borne ascospores.

Favourable conditions:

- High humidity and moist situation favours the development of disease.

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

4.Leaf spot:

Disease symptom:

Black leaf spot

The disease is characterised by sooty tuft-like circular to irregular black spots on the underside of the leaves. Later, it covers the entire lower surface giving a sooty appearance. The leaves show yellowish and brownish discolouration on the upper surface and drop prematurely.

***Cercospora* leaf spot**

The disease manifests itself in the form of circular to oval spots, measuring up to 4 mm in diameter, epiphyllous, yellow at first and turning brown surrounded by a darkbrown margin. The spots grow larger and become visible on both sides of the leaves. The infected leaves fall off. *Cercospora* leaf spot is also found on Chinese jujube, causing leaf yellowing.

Cladosporium leaf spot

The symptoms appear in the form of small, light brown to brown irregular spots on the lower surface of leaves. The disease starts on leaves closest to the soil surface, where the fungus occurs.

Transmission and favourable conditions:

Black leaf spot

- The fungus survives in plant debris and soil, which are the primary sources of infection.
- Secondary infection is initiated from spores present in the air.

***Cercospora* leaf spot**

- The fungus produces dark coloured stroma.
- It survives in debris and soil, the primary sources of infection.
- The spores are disseminated by wind.

Cladosporium leaf spot

- It is also spread by spores present in the air.
- The fungal spores survive in plant debris and soil, the primary sources of infection.

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

5.Die back

Disease symptom:

- The pathogen causing dieback, tip dieback, graft union blight, twig blight, seedling rot, wood stain, stem-end rot, black root rot, fruit rot, dry rot, brown rot of panicle etc. The disease is most conspicuous during October- November.

- It is characterized by drying back of twigs from top downwards, particularly in older trees followed by drying of leaves which gives an appearance of fire scorch. Internal browning in wood tissue is observed when it is slit open along with the long axis.

- Cracks appear on branches and gum exudes before they die out.

Survival and spread:

- Pathogens survive in plant debris which is the source of primary inoculums.

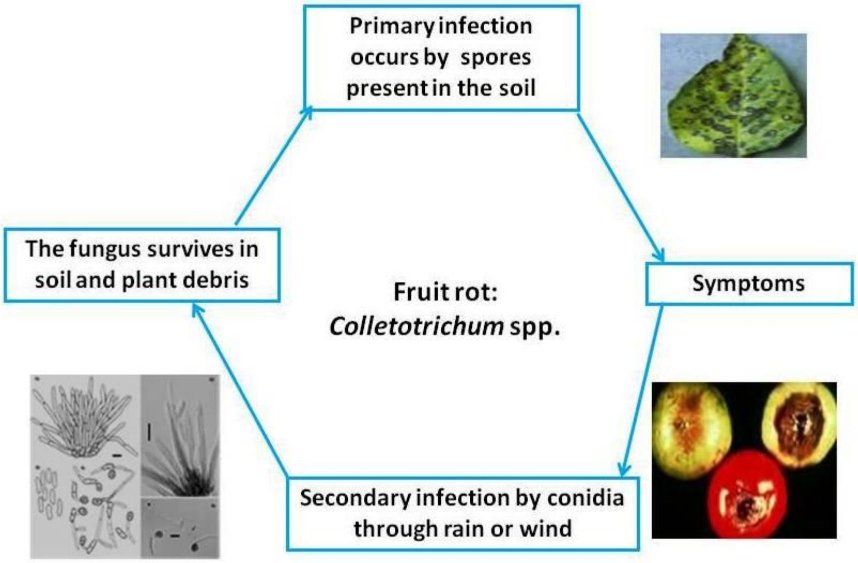
Favourable conditions:

- High humidity and moist conditions favours the development of disease. The disease is most common in October-November.

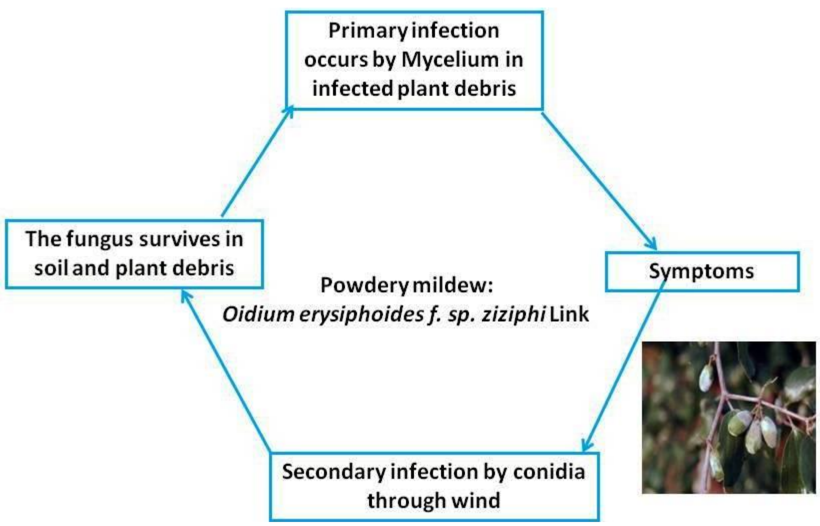
*****For the management refer page number............................

Disease cycles:

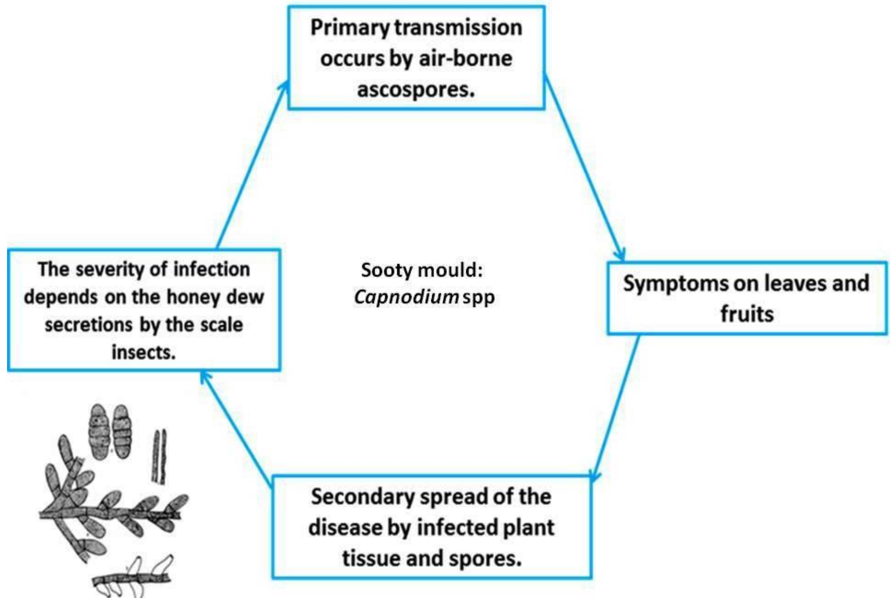
Fruit rot:



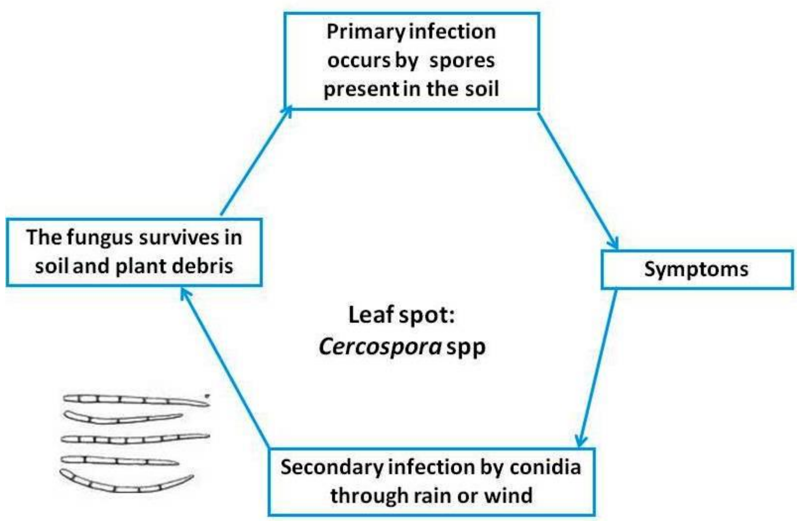
Powdery mildew:



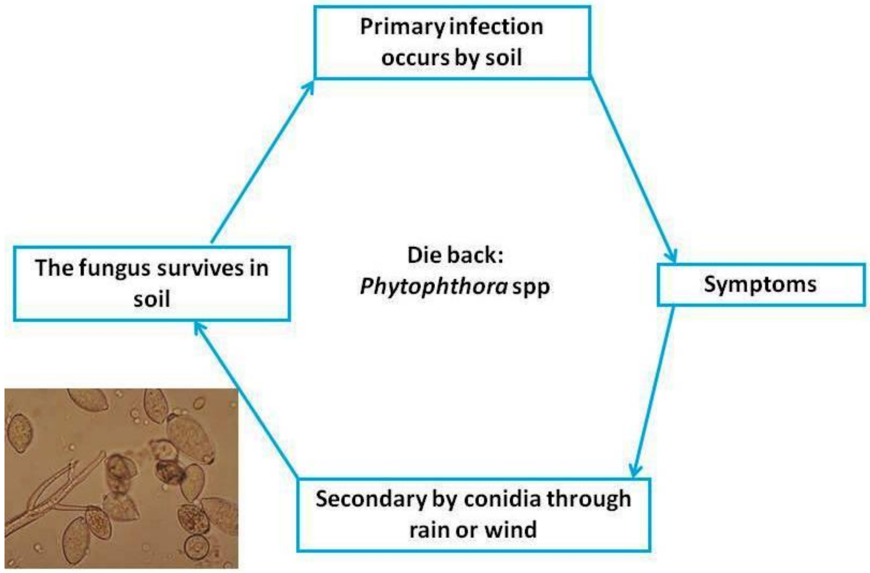
Sooty mould:



Leaf spot:



Die back:



XI DESCRIPTION OF BIRD

Rose-ringed parakeet:

Indian Rose-ringed Parakeets measure on average 40 cm (16 in) in length including the tail feathers. Their average single wing length is about 15–17.5 cm (5.9–6.9 in). The tail accounts for a large portion of their total length. The Rose-ringed Parakeet is sexually dimorphic. The adult male sports a red neck-ring and the hen and immature birds of both sexes either show no neck rings, or display shadow-like pale to dark grey neck rings.

In the wild, Rose-ringed Parakeets usually feed on buds, fruits, vegetables, nuts, berries and seeds. Wild flocks also fly several miles to forage in farmlands and orchards causing extensive damage.In India, they feed on cereal grains, and during winter also on pigeon peas. In Egypt, during spring they feed on mulberry and in summer they feed on dates and nesting inside palm trees as also attacking sunflower and corn fields.

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

XII. SAFETY MEASURES

A. At the time of harvest:

The most common method of harvesting ber fruits is by manually shaking or beating the tree branches to cause the ripe or mature fruits to fall to the ground. Sometimes a cloth is spread on the ground to facilitate collecting the fruits. Harvesting can also be carried out by mechanical shaking of the tree. Neither of these methods of harvesting is very satisfactory as they cause considerable damage to the fruit and the harvest includes a mixture of mature and immature fruit. Ber fruits ripen at different times even on a single tree and have a golden yellow appearance when they are fully ripe. Other more suitable methods of harvest include plucking the fruit using a clipper (an iron hook attached to along bamboo pole) and hand picking the individual fruit. Both these methods are more time consuming and more difficult and are therefore not favoured by local farmers. In well managed fruit orchards, manual picking ensures the harvest of fruits with the pedicels attached. Research has shown that fruits with the pedicel attached have a longer storage life (Pareek, 2001). Since ber fruits mature at different rates and do not ripen simultaneously, four to five or even up to seven pickings are needed to complete the harvest, especially for late maturing varieties such as Umran. This results in higher labour costs. The cumbersome picking operation and the associated costs could be markedly reduced by using suitable plant growth regulators. Indian researchers have investigated the effects of applying plant growth regulators prior to harvest on the maturity and subsequent ripening period of ber fruits. They have also looked at the ability of plant growth regulators to reduce spoilage during the pre-harvest and storage periods, and to improve the physico-chemical characteristics of the fruit. Ripening can be delayed and the number of pickings reduced by spraying with pre-harvest ethephon sprays (see Table 9.2). The application of the plant growth regulators can help to ensure early market returns or early and uniform ripening of fruits. A small stalk, attached to the fruit

Fruit growth and maturation

Ber requires a relatively long period of 150 to 190 days (22 to 27 weeks) after fruit set for fruit growth and maturation. Some cultivars grown in the Hissar region of the north of India can be harvested at 120 days after fruit set. The fruit growth period can be divided into three distinct phases:

1. the most active fruit growth phase during the first 6 to 7 weeks
2. slow growth rate for the middle eight weeks
3. active growth rate for the last 8 to 10 weeks.

Studies on the developmental physiology of fruit of the Umran cultivar in the Punjab illustrate the distinct physical and chemical changes during the growth and development of the fruit. Fruits of cultivar Umran attain the ripe stage in 190 days after fruit set. Fruit growth in terms of length and diameter showed three distinct phases. The increase in length was faster than the growth of the diameter during the first phase. Conversely, during the third phase, the increase in diameter was greater than the increase in length. That is, the fruits grew in length at the start of their growing period and ‘filled out’ during the final growth phase. The major chemical changes that take place during fruit growth and development are changes in the content of total soluble solids (TSS). The TSS increases from fruit set through to ripening. This increase is very pronounced during the latter stages of maturity. There is a corresponding decrease in acidity (an increase in pH) of the fruit pulp as the fruit ripens. When the fruit is physiologically mature, the fruit colour turns to dark green followed by ripening with a change in colour as the ripening process advances. The stalk end of the fruit starts to turn yellow and later turns to bright yellow and then brown at the end of ripening. There is a wide variation in the TSS (12.2 to19.2° Brix) and acidity (0.23 to 0.52 %) in different cultivars of the ripe fruit (Teaotia *et al*., 1974). Changes in the levels of other chemical components such as ascorbic acid, total phenolics and minerals during the maturation of ber fruits have been reported (Bal and Singh, 1987). The level of ascorbic acid gradually increased during growth and development (from 15 days after fruit set until 190 days). The total phenolics content increased initially, reached a peak in the developing fruits and later showed a fall as fruit maturity advanced.The calcium content showed a gradual downward trend up to 150 days and then remained constant until ripening. The phosphorus content showed a steady decline with the advancement of maturity. The iron content remained almost constant in the beginning and thereafter gradually decreased towards ripening.

Fruit drop and its control

Fruit drop is a major and serious problem in ber production. Generally the number of fruit set is very high, but the extent of fruit retention varies according to the cultivar type and on the level of production of endogenous plant hormones. Several studies have been made on fruit set, fruit drop and level of fruit retention. Sharma *et al.,* (1990) found that early maturing cultivars (that were eight years of age) were resistant to fruit drop while the late cultivars were the most susceptible to fruit drop. Garwal *et al.* (1993) observed a similar pattern, but also noticed that the fruit drop in later maturing cultivars (var.Sendbura and Narnaul) could be controlled by spraying the fruit with 10 ppm of NOXA growth regulator. This treatment resulted in the production of large size fruits with significantly higher total soluble solids and ascorbic acid content and lower acidity, total sugars and reducing sugar content than most other treatments.

Time of harvest and fruit yield

The time of harvest affects the storage life of fruits. For practical reasons,harvesting in the morning is generally preferred as the fruits are cool and turgid at this time of day and can be sold or further processed the same day. However,one study reported that fruits harvested at midday had a better storage life than those harvested in the morning or evening. This may be due to greater loss of water from the morning or evening harvested fruits (Pareek, 2001). Bal *et al.* (1995) reported that the pre-harvest spray of ethephon at a concentration of 300 ppm to ber trees induced uniform ripening of fruits, and the fruits harvested at optimum maturity could be stored for up to forty days at a temperature of 0 to 3.3° C and relative humidity of 85 to 90 %. Ber trees can produce fruit after the first year of planting from budded plants or after *in situ* budding in the field. However, during the first two years in the tropics, and three years in the sub-tropics, young plants are trained to develop into well balanced trees rather than for fruit production. Fruit production therefore starts from the third year in the tropics and the fourth year in the subtropics. Ber trees can become prime fruit bearers at an early age (i.e. from thefifth to sixth year under intensive management).The fruit yield per tree varies with cultivar, age of the tree, climate and locationof the tree. Seedling trees bear between 5000–10,000 fruits per year andsuperior grafted trees can bear up to 30,000 fruits. The best cultivar in India reportedly bears fruits that give an average of 66 fruits per kg and that yields 77 kg annually. Both fruit size and number can be increased by simple cultural treatment (www.hort.purdue.edu). Yields of 80 to 200 kg per mature (10 to 20 year old) tree have been reported in India for trees under irrigated conditions.Yields as low as 50-75 kg per tree have also been reported. In Israel, yields of 12 tons per hectare have been obtained from three year old ber trees (Pareek,2001). Water availability has a significant impact on yield. In rainfed agriculture, the yield can be as low as 80-100 kg per tree in semi-arid areas, while in arid areas it can fall to 50 kg per tree (see Pareek, 2001).Researchers in India (Kudachikar *et al.*, 2000) have investigated the effect of pruning the tree on fruit yield and quality. Pruning is considered to be one of the most important horticultural practices for the production and maintenance of regular fruit bearing, both in terms of quality and quantity of fruit. Ber fruits are borne in the leaf axils on the young growing shoots of the current season. The best time for pruning ber trees is during the hot and dry season when the tree sheds its leaves and becomes dormant after the harvesting of fruits (Sharma and Kore, 1990). The effects of severity of pruning on flowering, fruit setting, fruit yield and quality of ber fruits of different cultivars in different agro-climatic growing regions have been investigated by Bajwa *et al,* (1986), Bisla *et al.* (1991) and Kundu *et al,* (1994).Kundu *et al.* (1994) looked at pruning of thirteen year old Umran trees. When pruning was too severe and the planting distance close, flowering and fruit production was decreased. However, when the planting distance was wider,even though the pruning was severe, the percentage of fruit set increased. The percentage of fruit retention increased with increased planting distance and decreased pruning severity. Yadhav and Godara (1992) found that the best combination for ber trees was medium pruning combined with a planting distance of 7.2 m x 7.2 m or 9.6 m x 9.6 m. The fruit yield in un-pruned trees is often on a par with pruned trees, but the fruit quality is poor. Pruned trees tend to produce large fruits of good quality and with a significantly higher fruit weight. Researchers have investigated the effects of applying plant growth regulators prior to harvesting on fruit maturity, yield and quality. The application of calcium compounds such as calcium chloride and calcium nitrate (CCC) at 1.7 g per litre as a pre-harvest spray reduced the fruit weight loss,delayed colour development and maintained good quality ber fruits during storage (Gupta *et al*., 1987). Bankar and Prasad (1990) investigated the effects of pre-harvest spraying of ber fruit with gibberellic acid (GA3) and napthalein acetic acid (NAA) at three different rates (10, 20 and 30 ppm) either alone or in combination at two different times (at the time of flowering and at 15 days after flowering). They found that both growth regulators, at all concentrations and applied at both times, alone and in combination, increased the number of fruit set and decreased fruit drop (i.e. they increased fruit retention). The fruit weight and fruit length were both significantly increased by application of GA3 or NAA at 30 ppm concentration. The total soluble solids (TSS) content was improved by treatment with GA3. Masalkar and Wavhal (1991) reported that the pre-harvest application of GA3 (10-20 ppm) and ethephon (400 ppm) to ber trees of Umran cultivar improved the physico-chemical characteristics of ber fruits. Significant increase in fruit weight, fruit volume, pulp percentage, nonreducing sugars and ascorbic acid contents and lower stone percentage were obtained with treatments of GA3 alone, while ethephon treatment resulted in high TSS content and also improved the fruit colour to golden yellow. Other growth regulators have been tested; 2,4-D at 10-15 ppm and CCC at 100 ppm but CCC can reduce the size of fruits.

A. During post harvest:

Post harvest ripening

After harvest at the mature green to mature golden yellow stages, ber fruits start to ripen at ambient temperature. Ripening is signified by a change in colour from green or golden yellow to red or red brown. It takes place after 4 to15 days, depending upon cultivar and storage environment. The fruits are considered to have the best organoleptic qualities (taste and texture) when they are at the mature green to mature golden yellow stages.Therefore, attempts are made to delay the ripening process and prolong the keeping quality by modifying the storage environment. Plant growth regulators may be applied to ber fruits after harvest to accelerate the uniform rate of ripening and to reduce losses through post-harvest decay. Ethephon has been found to be the most effective growth regulator that accelerates the ripening and improves the quality of ber fruit (Kudachikar *et al.*,2000). Siddiqui and Gupta (1995) found that post-harvest dipping of ber fruits (cultivar Umran) at the colour turning stage in cycocel or chloromequot (500 or 1000 ppm) for 15 minutes, followed by storage in wooden boxes packed with newspaper at 25 ± 5° C significantly reduced the decay loss of fruits and retarded the ripening process, thereby extending the shelf-life of fruits.

Grading

The harvested fruits are usually at different stages of maturity and need to be sorted into different groups before they are sold, stored or further processed. They are sorted and graded according to maturity, size, shape and colour. First the fruits are sorted by hand. The under-ripe, over-ripe, damaged and misshapen fruits are removed. The under-ripe fruits are set aside and left to ripen. Over-ripe fruits are not desirable for fresh sales or processing and should be discarded. The remaining fruits are graded into two or three groups based on the size and colour of fruit. Grading can either be carried out manually or by passing through sieves of different mesh sizes. A grading standard for ber fruits is included in after grading, fruits for processing are washed using chlorinated water (100ppm), drained and used for further processing. Fruits for sale are packed and either stored or transported to market.

Packaging

After harvest, fruits are brought to the packing house or under shade for cleaning, packing or for post-harvest treatments to extend their shelf life. The fruits are packed either for controlled storage or for safe transport to local or distant markets. Correct and appropriate packaging of the fruit is essential for the safe transport of the fruits during transportation and storage. An ideal fruit package ensures that the fruit is completely protected from spoilage and physical damage. Pareek and Gupta (1988) suggest various types of container for packaging ber fruit depending upon the bulk of the fruits. During transport and storage, ber fruits are susceptible to damage and spoilage by infection with bacteria and fungi, especially if organic packing or cushioning material is used for packaging. Microbial damage can be reduced by spraying the fruit with anti-fungicides and anti-bacterial chemicals such as captaf, thiobendazole or Dithane M-45. Fruit can also be washed with washed with bleaching powder to reduce spoilage at a rate of 5 g bleach powder per kg of fruit. Diphenyl impregnated paper can also be used for packaging to reduce bacterial spoilage (Pareek, 2001). The use of chemical preservatives is not always desirable. It is preferable to pack ber fruits in non-organic materials, which avoids the need for chemicals. Perforated polythene bags (150 gauge), nylon nets or cardboard cartons can be used to package small quantities of 1-2 kg. For larger volumes of fruit of 10-20kg, gunny bags, cloth packages or wooden boxes with holes or slits are used.Baskets made from locally available materials such as bamboo can be used. Shredded paper is the best material to use for cushioning and protection during transport. For transportation, corrugated cardboard cartons of about 10 kg are the most suitable packaging material. For short distances, cheaper materials such as gunny bags, cloth or old boxes can be used provided that the fruit are cushioned and ventilation is provided. The best packages are nylon nets or perforated polythene bags for small quantities of about 1 to 3 kg fruit for retail sale.

Storage

Ber fruits are relatively perishable and have a shelf life of only four to five days at ambient temperatures. Transportation of ripe fruits to distant places is difficult and results in large post-harvest losses. Both pre-harvest and postharvest factors have been found to influence the storage life and post-harvest quality of ber fruits (Kudachikar *et al.*, 2000). Pre-harvest factors that influence the storage life include the following:

- pruning of the tree
- control of fruit drop by exogenous application of plant growth regulators
- the stage of maturity
- physico-chemical composition of the fruits at the time of harvest.

Post-harvest factors that influence storage life and fruit quality include the following:

- the use of plant growth regulators
- irradiation
- storage conditions

Storage experiments in India have demonstrated that slightly under-ripe fruits ripen and keep for eight days under wheat straw, seven days under leaves and four days in carbide (50 to 60 g) (www.hort.purdue.edu). Other studies in India (Kudachikar *et al*., 2000), demonstrated that the shelf life of ber fruits could be significantly extended by coating the fruits in wax, packing them in polyethylene bags and storing at 0 to 3.3° C and 0 to 4° C, up to 40 days and 21 days respectively. This is in comparison to untreated fruits that are stored at ambient temperature (30 to 35° C) and only have a maximum shelf life of seven days. The improved storage life at reduced temperatures gives potential for transporting ber over long distances, from the growing areas in North India to consumers in southern India, if refrigerated transport lorries are available.

Storage at room temperature

After harvest, ber fruits are usually stored at ambient temperature (25-35° C) until they are either sold or further processed. The fruit is often stored in heaps under shade or in storage rooms, but it is better to store in packages such as gunny bags, net bags, polythene bags and boxes. Depending upon cultivar and the storage conditions, fruit can be kept for 4 to 15 days without loss of organoleptic quality. During storage, the fruits lose weight and shrivel, change colour from green yellow or golden yellow to reddish brown and lose acidity and ascorbic acid (vitamin C), but gain in sweetness. Typical values for quality parameters of ber fruits (cultivar Umran) in storage are found Cool storage. The shelf life of fruits can be extended by storage in cool chambers. Cool chambers are simple, double walled structures made from locally available materials such as mud or brick. The space between the two walls is filled with sand or wood shavings that are kept cool by sprinkling with water. Cooling is achieved by evaporation of water from the walls of the chamber. With prolonged storage in a cool chamber, a high level of humidity can develop within the chamber which is conducive to spoilage in the fruit. Fruits have been stored successfully for 6 to 10 days in cool chambers without any loss in quality. However, the length of storage within a cool chamber very much depends on the cultivar, ambient and internal temperature, humidity level, quantity of fruit within the chamber and the maturity of the fruit at harvest. If cold storage is available, fruits can withstand temperatures as low as 10° C without any damage. At this temperature, the shelf life can be extended for 28 to 42 days depending upon cultivar. At temperatures of 13° C, fruits can be stored in perforated polythene bags and baskets for up to 3 weeks without any loss in quality (Pareek, 2001). At lower storage temperatures (at 0 to 4° C), the fruits become an unattractive brown colour.

Treatments to extend shelf life

Various treatments are available to extend the shelf life of fruits. Some of these are applied to the fruit whilst still on the tree while others are post-harvest treatments. The use of the various chemicals to extend the storage life of fruits should be carried out with caution, especially if the fruit is being sold as organic. Certain chemicals are not permissible for use on fruits that are destined for the organic market. National and international regulations should be consulted regarding the use of any chemical. All safety regulations regarding the dosage and application of spray and the use of the fruit after spraying, for example, the number of days that must elapse before the fruit is safe for consumption, should be observed.

XIII. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The field should be kept exposed to sun light at least for 2-3 weeks.	Do not plant or irrigate the field after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
3.	Always treat the seeds with approved chemicals/biopesticides for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with biopesticides/ chemicals.
4.	Sow in rows at optimum depths under proper moisture conditions for better establishment.	Do not sow seeds beyond 5-7 cm depth.
5.	Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
6.	Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition	Crops should not be exposed to moisture deficit stress at their critical growth stages.
7.	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
8.	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
9.	Conduct AESA weekly in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.	Do not take any management decision without considering AESA and P: D ratio
10.	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).

11.	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per field observation	Do not apply chemical pesticides within seven days of release of parasitoids
12.	In case of pests which are active during night spray recommended biocides/ chemicals at the time of their appearance in the night.	Do not spray pesticides at midday since, most of the insects are not active during this period.
13.	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, scales, thrips whiteflies, etc.	Do not spray pesticides only on the upper surface of leaves.
14.	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
15	Follow the recommended procedure of trap or border crops technology.	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.

XIV. SAFETY PARAMETERS IN PESTICIDE USAGE

S. No.	Pesticide Classification as per insecticide rules Colour of toxicity triangle	WHO classification of hazard	Symptoms poisoning	First Aid measures Treatment of poisoning	Waiting period from last application to harvest (days)
Insecticides					
1	Carbendazim Slightly toxic 	Unlikely to present acute hazard in normal use	Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	**First aid measures:** Rush to the nearest physician. **Treatment of poisoning:** No specific antidote. Treatment is essentially symptomatic.	-

XV. BASIC PRECAUTIONS IN PESTICIDES USAGE

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

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

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

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

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

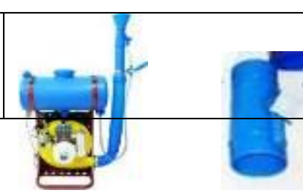
F. **Precautions for applying pesticides**
1. Apply only at recommended dose and dilution
2. **Do not** apply on hot sunny day or strong windy condition; **Do not** apply just before the rains and after the rains; **Do not** apply against the windy direction
3. Emulsifiable concentrate formulations should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

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

G. Disposal

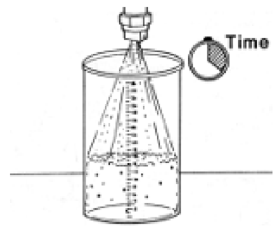
1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

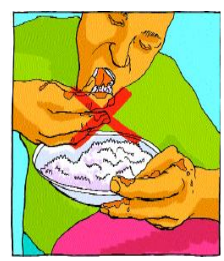
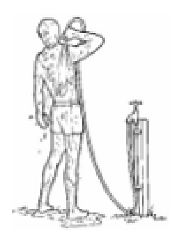
XVI. PESTICIDE APPLICATION TECHNIQUES

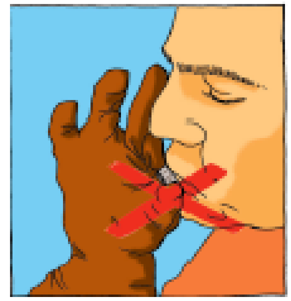
		Equipment	
Category A: Stationary, crawling pest/ disease			
Vegetative stage i) for crawling and soil borne pests ii) for small sucking leaf borne pests	Insecticides and fungicides	• Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min ***or*** • Motorized knapsack sprayer or mist blower (Droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle	 
Reproductive stage	Insecticides and fungicides	• Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min	
Category B: Field Flying pest/ airborne pest			
Vegetative stage	Insecticides and fungicides	• Motorized knapsack sprayer or mist blower (Droplets of small size)	

Reproductive stage *(Field Pests)*		• Airblast nozzle • Operating speed: 2/3rd throttle ***Or*** • Battery operated low volume sprayer (Droplets of small size) Spinning disc nozzle	 
Mosquito/ locust and spatial application *(migratory* Pests)	Insecticides and fungicides	• Fogging machine and ENV (Exhaust nozzle vehicle) (Droplets of very small size) • Hot tube nozzle	 
Category C: Weeds			
Post-emergence application	Weedicide	• Lever operated knapsack sprayer (Droplets of big size) • Flat fan or floodjet nozzle @ 15 to 20 psi • Lever operating speed = 7 to 10 strokes/min	    
Pre-emergence application	Weedicide	• Trolley mounted low volume sprayer (Droplets of small size) • Battery operated low volume sprayer (Droplets of small size)	  

XVII. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

1.	For application rate and dosage see the label and leaflet of the particular pesticide.	 
2.	It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.	 
3.	Clean and wash the machines and nozzles and store in dry place after use.	  
4.	It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides.	 
5.	Do not apply in hot or windy conditions.	

		 
6.	Operator should maintain normal walking speed while undertaking application.	
7.	Do not smoke, chew or eat while undertaking the spraying operation	   
8.	Operator should take **proper bath with soap** after completing spraying	  

9.	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

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