



AESA BASED IPM PACKAGE **MANGO**



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**National Institute of
Plant Health Management**
Rajendranagar, Hyderabad, Telangana

Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

Important Natural Enemies of Mango Insect Pests

Parasitoids



Polynema spp.



Gonatocerus sp



Tetrastichus sp



Fopius arisanus



Diachasma morpha kraussi



Hormius sp

Predators



Dicyphus hesperus



Chrysoperla spp.



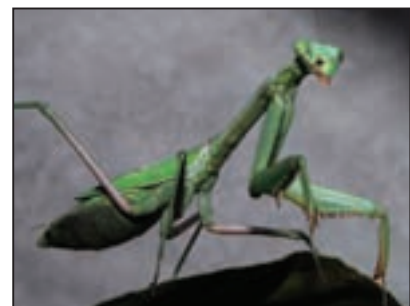
Ladybird beetle



Red ant



Spider



Preying mantis

The AESA based IPM - Mango, 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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Citation Satyagopal, K., S.N. Sushil, P. Jeyakumar, G. Shankar, O.P. Sharma, S.K. Sain, D.R. Boina, M.N. Reddy, B.N. Sunanda, Ram Asre, R. Murali, K.S. Kapoor, Sanjay Arya, Subhash Kumar, C.S. Patni, S.D. Rangaswamy, L. Hanumantharaya, S. Gangopadhyay, Poonam Srivastava, K. P. Singh, Surajit Khalko, Nripendra Laskar, Ayon Roy, Tapan Kumar Hath, L.V. Ghetiya, N. Sathyanarayana and S. Latha. 2014. AESA based IPM package for Mango. pp 56.

Front cover picture Model AESA chart for Mango

Back cover picture Mango Orchard

Published by National Institute of Plant Health Management, Rajendranagar, Hyderabad – 500 030

Copies: 1,000; November, 2014

For internal circulation only. Not for sale.

Contact APPA - IPM, Directorate of Plant Protection, Quarantine & Storage, CGO Complex, NH IV, Faridabad, Haryana - 121 001.
Tel : 0129 2413020, e-mail: ppa@nic.in

Printed at **Balaji Scan Pvt. Ltd.,**
A.C. Guards, Hyderabad.
Tel : 040-23303424
e-mail: bsplpress@gmail.com
www.balajiscan.com

अपर सचिव
भारत सरकार
कृषि मंत्रालय
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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 (AESAs) based IPM strategies. The AESA based IPM focuses on the relationship among various components of an agro-ecosystem with special focus on pest-defender dynamics, innate abilities of plant to compensate for the damages caused by the pests and the influence of abiotic factors on pest buildup. In addition, Ecological Engineering for pest management - a new paradigm to enhance the natural enemies of pests in an agro-ecosystem is being considered as an important strategy. The ecological approach stresses the need for relying on bio intensive strategies prior to use of chemical pesticides.

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

Date : 6.3.2014


(Avinash K. Srivastava)

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FOREWORD

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

During the late 90s FAO started advocating Agro-Ecosystem Analysis (AESAs) based IPM. Experience in different countries have 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 growing need to integrate AESA based IPM and principles of ecological engineering for pest management.

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

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

(K. SATYAGOPAL)

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AESA BASED IPM PACKAGE FOR MANGO

Mango-Plant description:

The mango (*Mangifera indica* L.; Family: Anacardiaceae) is a perennial woody plant native to South and Southeast Asia, from where it has spread to the different part of the world to become one of the most cultivated fruits in the tropics. The leaves are evergreen, alternate, simple, 15–35 cm long, and 6–16 cm broad; when the leaves are young they are orange-pink, rapidly changing to a dark, glossy red, then dark green as they mature. The flowers are produced in terminal panicles 10–40 cm long; each flower is small and white with five petals 5–10 mm long, with a mild, sweet odor suggestive of lily of the valley. It is cultivated for edible juicy stone fruits. Mango trees grow up to 35–40 m tall, with a crown radius of 10 m. The trees are long-lived, as some specimens still fruit after 300 years. In deep soil, the taproot descends to a depth of 6 m, with profuse, wide-spreading feeder roots; the tree also sends down many anchor roots, which penetrate several feet of soil. Over 400 varieties of mangoes are known, many of which ripen in summer, while some give double crop. The fruit takes three to six months to ripen. The ripe fruit varies in size and color. Cultivars are variously yellow, orange, red, or green, and carry a single flat, oblong pit that can be fibrous or hairy on the surface, and which does not separate easily from the pulp. Ripe, unpeeled mangoes give off a distinctive resinous, sweet smell. Inside the pit 1–2 mm thick is a thin lining covering a single seed, 4–7 mm long. The seed contains the plant embryo. Mangoes have recalcitrant seeds; they do not survive freezing and drying.



I. PESTS

A. Pests of National Significance

1. Insect and mite pests

- 1.1 Mango hopper: *Idioscopus clypealis* Lethierry; *I. nitidulus* Walker and *Amritodus atkinsoni* Lethierry; *Idioscopus niveosparsus* Leth together (Hemiptera: Cicadellidae)
- 1.2 Mango mealybug: *Drosicha mangiferae* Green (Hemiptera: Pseudococcidae)
- 1.3 Fruit fly: *Bactrocera dorsalis*, Hendel; *B. correcta* Bezzi and *B. zonata* Saunders (Diptera: Tephritidae)
- 1.4 Inflorescence midge: *Erosomyia indica* Grover, *Dasineura amraramanjarae* Grover, *Procytiphovra mangiferae* Bitancourt & Jenkins and *Procontare niamatteiana* (Diptera: Cecidomyiidae)
- 1.5 Stem borer: *Batocera rufomaculata* DeGeer (Coleoptera: Cerambycidae)
- 1.6 Bark eating caterpillar: *Indarbela quadrinotata* Walker (Lepidoptera: Metarbelidae)
- 1.7 Stone weevil: *Sternonchus mangiferae* Fabricius (Coleoptera: Curculionidae)
- 1.8 Red ant: *Oecophylla smaragdina* (Hymenoptera: Formicidae)
- 1.9 Eriophyid mite: *Aceria mangiferae* (Acarina: Eriophyidae)
- 1.10 Termite: *Odontotermes obesus*; *Microtermes obesi* (Isoptera: Termitidae)

2. Diseases

- 2.1 Powdery mildew: *Oidium mangiferae* Berthet
- 2.2 Anthracnose: *Colletotrichum gloeosporioides* Ston, Spaul and Schrenk
- 2.3 Die back: *Botryodiplodia theobromae* Pat. (*Lasiodiplodia theobromae* (Pat.) Griffon & Maubl.)
- 2.4 Sooty mould: *Meliola mangiferae* Earle (*Capnodium mangiferae* Cke. & Brown)
- 2.5 Mango malformation complex: *Fusarium mangiferae* Wollenweber & Reinking
- 2.6 Gummosis: *Lasiodiplodia theobromae* (Pat.) Griffon and Mauble (Synonyms: *Botryodiplodia theobromae* Pat., *Physalospora rhodina* Cooke, perfect stage of *Botryodiplodia theobromae* Pat.)
- 2.7 Post harvest disease
 - 2.7.1 Anthracnose: *Colletotrichum gloeosporioides* (Penz.) Penz. and Sacc
 - 2.7.2 *Aspergillus* rot/black mould rot: *Aspergillus niger* Van Tiegh
 - 2.7.3 Stem end rot: *Lasiodiplodia theobromae* Pat. Griffon & Maubl.

3. Weeds

Broad leaf

- 3.1 Pigweed: *Amaranthus viridis* Hook. F. (Amaranthaceae)
- 3.2 Common purselane: *Portulaca oleracea* L. (Portulacaceae)
- 3.3 False amaranth: *Digera arvensis* Forssk. (Amaranthaceae)
- 3.4 Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)
- 3.5 Goat weed: *Ageratum conyzoides* L. (Asteraceae)
- 3.6 Coat buttons: *Tridax procumbens* L. (Asteraceae)
- 3.7 Spanish needles: *Bidens pilosa* L. (Asteraceae)
- 3.8 Silk leaf: *Lagascea mollis* Cav. (Asteraceae)
- 3.9 Madras leaf-flower: *Phyllanthus madraspatensis* L. (Euphorbiaceae)
- 3.10 Dendrophthae: *Loranthus longiflorus* Desr. (Loranthaceae)

Grasses

- 3.11 Bermuda grass: *Cynodon dactylon* (L.) Pers. (Poaceae)
 3.12 Barnyard grass: *Echinochloa crusgalli* (L.) Beauv. (Poaceae)

Sedges

- 3.13 Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)
 3.14 Flat sedge: *Cyperus iria* L. (Cyperaceae)

B. Pests of Regional Significance**1. Insect pests**

- 1.1 Scale insects: *Chloropulvinaria polygonata* Cockerell, *Aspidiotus destructor* Signoret (Hemiptera: Coccidae) (Uttar Pradesh, Karnataka)
 1.2 Shoot borer: *Chlumetia transversa* Walker (Lepidoptera: Noctuidae) (Karnataka, Rajasthan, Maharashtra, Himachal Pradesh, Bihar, Uttar Pradesh, Gujarat)
 1.3 Shoot gall psylla: *Apsylla cistellata* Buckton (Hemiptera: Psyllidae) (Bihar, Uttar Pradesh)
 1.4 Leaf webber: *Orthaga euadrusalis* Walker (Lepidoptera: Pyralidae) (Tamil Nadu)
 1.5 Thrips: *Scirtothrips dorsalis* Hood (Gujarat, West Bengal) *Caliothrips indicus*, *Rhipiphorothrips cruentatus* (Thysanoptera: Thripidae)
 1.6 Red spider mite: *Oligonychus mangiferus* Rahman and Sapra (Acari: Tetranychidae) (Bihar)

2. Diseases

- 2.1 Phoma blight: *Phoma glomerata* (Cords) Woll. Hochapf (Uttar Pradesh)
 2.2 Bacterial canker: *Xanthomonas campestris* pv. *mangiferae-indicae* (Maharashtra)
 2.3 Red rust: *Cephaleuros virescens* Kunze
 2.4 Scab: *Elsinoe mangiferae* Bitancourt and Jenkins = anamorph: *Sphaceloma mangiferae* Bitancourt and Jenkins
 2.5 Root rot & damping off: *Rhizoctonia solani* Kuhn

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

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

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

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

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

Principles of AESA based IPM:

Grow a healthy crop:

- Select a variety resistant/tolerant to major pests
- Select healthy seeds/seedlings/ planting material
- Treat the seeds/seedling/planting material with recommended pesticides especially biopesticides
- Follow proper spacing
- Soil health improvement (mulching and green manuring whenever 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 orchard regularly (climatic factors, soil and biotic factors):

Farmers should:

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



Plant compensation ability:

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

Understand and conserve defenders:

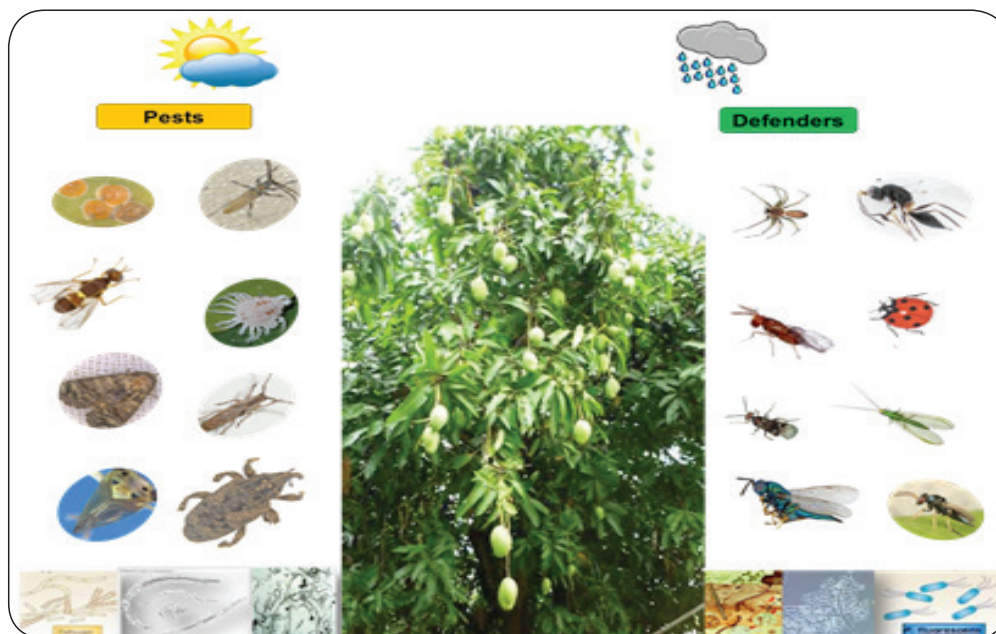
- Know defenders/natural enemies to understand their role through regular observations of the agro-ecosystem
- Avoid the use of chemical pesticides especially with broad-spectrum activity

Model Agro-Ecosystem Analysis Chart

Date:

Village:

Farmer:



Decision taken based on the analysis of field situations of the orchard

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 :

Insect zoo:

In orchard various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in 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 P: D ratio can vary depending on the feeding potential of natural enemy as well as the type of pest. The natural

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

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 of orchard 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 field and choose 20 plants/ acre randomly. Observe keenly each of these plants and record your observations:
 - Tree: 5-6 samples per tree (fruits/ leaves/ inflorescence /stem bark/roots/ soil/ insects, host plants) should be collected where, one sample from top, four samples from all the four sides (north, south, east, west) and one from bottom/soil, depending upon the requirement of sturdy/observations and if necessary.
 - Insect pests: Observe and count insect pests at different places on the plant.
 - Defenders (natural enemies): Observe and count parasitoids and predators.
 - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
 - Weeds: Observe weeds in the field and their intensity.
 - Water: Observe the water situation of the field.
 - Weather: Observe the weather condition.
- While walking in the orchard, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the field situation of the orchard 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 conditions, 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 field management is required in the AESA plot.

- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording:

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

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

Data to be recorded:

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

Some questions that can be used during the discussion:

- Summarize the present situation of the orchard.
- What crop management aspect is most important at this moment?
- Is there a big change in 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 are the problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.

Advantages of AESA over ETL:

One of the problems of the ETL is that it is based on parameters that are changing all the time, and that are often not known. The damage or losses caused by a certain density of insects cannot be predicted at all. In ETL the due recognition of the role of natural enemies in decreasing pest population is ignored. 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 orchard. It is season-long so that it covers all the different developmental stages of the crop and their related management practices. The process is always learner-centered, participatory and relying on an experiential learning approach and therefore it has become an integral part of FFS.

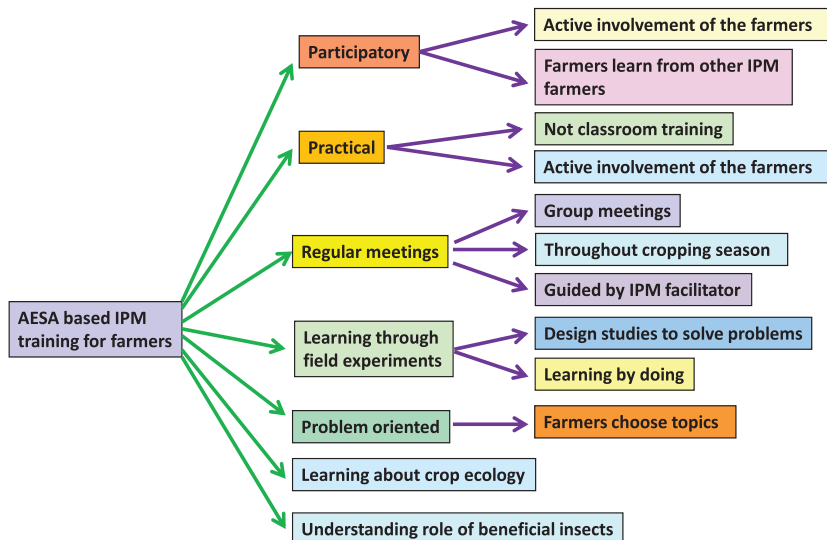


Farmers can learn from AESA:

- Identification of pests and their nature of damage
- Identification of natural enemies
- Management of pests

- Water and nutrient management
- Influence of weather factors on pest buildup
- Role of natural enemies in pest management

FFS to teach AESA based IPM skills:



B. Field scouting:

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

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

Sampling in fruit crops:

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

Sampling patterns:

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

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

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

Sampling frequency:

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

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

For insect pests:

Mealybug: Count and record the number of both nymphs and adults on five randomly selected leaves per plant.

Leaf webber: Count the number of webs formed in each direction, thus covering the whole tree.

Scale insects: Number of scale infested shoots per five tender shoots from each of the four directions of the selected tree should be counted

Defoliator/ borers: Count the number of young and grown up larvae on each plant and record.

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

C. Surveillance through pheromone trap catches:

Pheromone traps for fruit fly @ 4-5/acre have to be installed, if available. Install the traps for each species separated by a distance of >75 feet in the vicinity of the selected. Fix the traps to the supporting pole at mid canopy height. Change of lures should be made at 2-3 week interval (regular interval). During each week of surveillance, the number of fruit fly/trap/week should be counted and recorded year round. The trapped fruit fly should be removed and destroyed after each recording.

D. Yellow/blue sticky traps:

Set up yellow sticky traps 1 foot above the canopy for monitoring mango hopper and shoot gall psylla and blue sticky trap for monitoring thrips @ 4-5traps (15 X 7.5 cm)/acre. Locally available empty tins can be painted yellow/blue and coated with grease/ Vaseline/castor oil on outer surface may also be used as yellow/blue sticky trap. Count the number of mango hopper/gall psylla thrips on the traps daily and take up the intervention when the population exceeds approximately 100 per trap.

E. Light traps

Set up light traps 1 trap/acre 1 foot 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 a, b).

Ecological Engineering for Pest Management – Below Ground:

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

- 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 orchard border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population
- Grow flowering plants inside the orchard
- Not to uproot weed plants those are growing naturally such as *Tridax procumbens*, *Ageratum* sp, *Alternanthera* sp etc. which act as nectar source for natural enemies

- Not to apply broad spectrum chemical pesticides, when the P:D ratio is favourable. The plant compensation ability should also be considered before applying chemical pesticides.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Select and plant appropriate companion plants which could be trap crops and pest repellent crops. The trap crops and pest repellent crops will also recruit natural enemies as their flowers provide nectar and the plants provide suitable microclimate.

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

Plants Suitable for Ecological Engineering for Pest Management



Cluster bean



Carrot



Sunflower



Buckwheat



French bean



Alfalfa



Mustard



Cosmos



Anise



Caraway



Dill



Chrysanthemum sp



Dandelion



Cowpea



Maize

Repellent plants



***Ocimum* sp**



Peppermint/Spearmint

Border plants



Sorghum



Maize

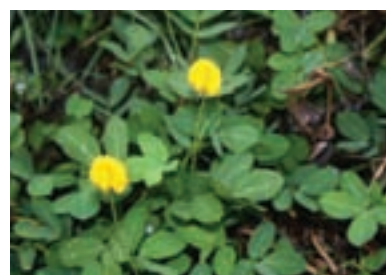


Bajra

Intercrops



Blackgram



Groundnut

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

Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids



Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



IV. CROP STAGE - WISE IPM

Management	Activity
Pre-planting*	
	<p>Common cultural practices:</p> <ul style="list-style-type: none"> • Destroy the alternate host plants • Sow the ecological engineering plants • Sow sorghum/maize/pearl millet in 4 rows all around the main crop as a guard/barrier crop • Plough deep after harvest to bury the pupae. • Deep summer ploughing of field reduces the incidence of mealybug, soil-borne pathogens & weeds. • Seed nuts must be collected during peak period of harvest and sun dried for two to three days. • Medium size nuts (7-9 gm) may be selected to get vigorously growing seedlings. • Seed nuts should be soaked over night in water before sowing. • Sow the soaked nuts in the polythene bags filled with potting mixture. • Seedlings will be ready for grafting 40-50 days after germination. • Irrigate the orchards as and when required • Provide proper shade, irrigation & drainage. • Rogue out diseased seedling. • Employ locally made rat traps. • Use resistant/tolerant varieties
Nutrients	<ul style="list-style-type: none"> • The plantation of mango should be taken up at the beginning of the monsoon (June- July). In areas with heavy rainfall, planting should be done at the end of rainy season. • The pits of 1m x 1m x 1m size should be dug during summer. • Nutrient should be supplied on the basis of soil test report and recommendation for the particular agro-climatic zone. • To improve the texture of soils, add adequate tank silt and FYM. Sowing of the green manure crop (20 Kg sun hemp/10 Kg Dhaincha/acre) with the onset of monsoon and incorporating 45 days after sowing.
Weeds	<ul style="list-style-type: none"> • Plough the field in summer/ before planting to destroy existing weeds in the field.
Planting*	
	<p>Common mechanical practices:</p> <ul style="list-style-type: none"> • Remove new sprouts emerging from root stock at frequent intervals. • Shift the grafts frequently from one place to another to prevent them from striking roots into the ground.
Nutrients	<ul style="list-style-type: none"> • At the time of planting, fill up the pits with well decomposed farmyard manure @ 25 Kg per pit mixed with top soil, <i>Trichoderma</i> and VAM @ 50 g inoculates / plant.
Weed	<ul style="list-style-type: none"> • Use weed free seedling for planting. • Remove existing weeds in and around the pits at the time of planting. • Provide plastic or straw mulch around the seedling to prevent weed growth and to conserve moisture.
Pests, soil-borne pathogens (damping off, root rot)	<p>Cultural control:</p> <ul style="list-style-type: none"> • Well decomposed farm yard manure coupled with <i>Trichoderma viride/harzianum</i> should be used. • Nursery beds should be raised. • Nursery beds should be fumigated with 4% formalin <p>Chemical control:</p> <ul style="list-style-type: none"> • Drenching of the planting pits with chlorpyrifos 20 EC @ 5 ml/l of water

Termites	<p>Cultural control:</p> <ul style="list-style-type: none"> • Deep ploughing of fields during summer. Three summer ploughings at 10 days interval reduce juvenile population. • Apply well rotten FYM only to discourage termite infestation. • Avoid late sowing of crops. • For termite and shoot fly destroy the crop residues which form the sources of infestation. • Use of crude oil emulsion to destroy the termite colony in the termatorium. <p>Mechanical control:</p> <ul style="list-style-type: none"> • Dismantle termitaria (termite mounds) around field and kill the termite queen. <p>Biological control:</p> <ul style="list-style-type: none"> • Apply neem cake @ 80 Kg/acre. • Entomopathogenic nematodes (EPNs) can be sprayed at the rate of 2.5 lakh nematodes / sq. mt. in termite infested area. 								
<p>* Application of <i>Trichoderma harzianum/viride</i> and <i>Pseudomonas fluorescens</i> for treatment of seed/seedling/planting materials in the nurseries and field application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).</p>									
Vegetative stage									
	<p>Common cultural practices:</p> <ul style="list-style-type: none"> • Collect and destroy crop debris • Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed • Remove weed plants • Provide timely irrigation, organic manure, fertilizer as per the recommended dose, drainage, weeding, mulching, interculture etc. <p>Common mechanical practices:</p> <ul style="list-style-type: none"> • Handpick the older larvae during early stages • Collect and destroy disease infected and insect damaged plant parts • Handpick the gregarious caterpillars and the cocoons which are found on stem and destroy them in kerosene mixed water. • Use yellow/blue sticky traps @ 4-5 trap/acre • Use light trap @ 1/acre and operate between 6 pm and 10 pm • Install pheromone traps @ 4-5/acre for monitoring adult fruit fly activity (replace the lures with fresh lures after every 2-3 weeks) • Erecting of bird perches @ 20/acre for encouraging predatory birds such as King crow, common mynah etc. • Set up bonfire during evening hours at 7-8 pm <p>Common biological practices:</p> <ul style="list-style-type: none"> • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies 								
Nutrients	<p>The following table gives the details of nutrients to be applied (depending upon the age of plants) :</p> <table border="1" data-bbox="579 1629 1290 1798"> <thead> <tr> <th>Age of the plant (in years)</th><th>Nutrients to be applied per plant</th></tr> </thead> <tbody> <tr> <td>1*</td><td>100 g N, 50 g P₂O₅, 100 g K₂O</td></tr> <tr> <td>10</td><td>1 Kg N, 500 g P₂O₅, 1 Kg K₂O</td></tr> <tr> <td>11</td><td>-do-</td></tr> </tbody> </table> <p>*The doses applied in the subsequent years should be increased every year upto 10 years in the multiple of the first year's dose.</p>	Age of the plant (in years)	Nutrients to be applied per plant	1*	100 g N, 50 g P ₂ O ₅ , 100 g K ₂ O	10	1 Kg N, 500 g P ₂ O ₅ , 1 Kg K ₂ O	11	-do-
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	<ul style="list-style-type: none"> Fertilizers should be applied in two split doses, one half immediately after the harvesting of fruits in June/July and the other half in October, in both young and old orchards followed by watering. Fertilizers should be applied through placement in circular trenches around the trunk. For the 10 years age and above trees the fertilizer should be applied at 1.5 m away from the trunk. Manures and fertilizers should be generally done in the beginning of monsoon. Irrigation should be given after the application of fertilizers.
Weeds	<ul style="list-style-type: none"> Regular weeding is important during the young stage of plants. Break the crust with hand hoe each time after 10-15 irrigations are applied. Plough the area between the basins at least three times in a year i.e. during the pre-monsoon, post-monsoon period and in the last week of November. Integrated weed management including cover crops, judicious use of herbicides, intercropping and hand weeding wherever necessary should be adopted.
Mango leaf hopper	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) <p>Cultural control:</p> <ul style="list-style-type: none"> Pruning of dense orchards in the month of December, orchard sanitation and field sanitation. Keep the nursery area clean, free of weeds and grasses to keep away the grasshoppers. Removal of weeds and alternate host plants like hibiscus, custard apple, guava etc. Avoid dense plantings, maintained open canopy; prune overcrowded overlapping branches after rainy season. Avoid excess use of nitrogenous fertilizers. Smoking of orchards by burning of crop residues/cow dung cake during evening hours. <p>Biological control:</p> <ul style="list-style-type: none"> Application of bio-agents, <i>Metarhizium anisopliae</i> @ 1×10^8 cfu/ml or <i>Beauveria bassiana</i> @ 10^8 cfu/ml on tree trunk once during off season and twice at 7 days interval during flowering season. <p>Chemical control:</p> <ul style="list-style-type: none"> Buprofezin 25% SC @ 1.25ml/ l of water, 5-15 l per tree or deltamethrin 2.8% EC @ 0.03-0.05% (0.33 to 0.5 ml /l) as per spray field requirement or dimethoate 30% EC @ 990-1320 ml in 600-800 l of water/ acre or imidacloprid 17.8% SL @ 3ml / l, 10 l/ tree or lambda-cyhalothrin 5% EC @ 0.5-1.0 ml/ l of water or malathion 50% EC @ 900-1200 ml in 600-800 l of water/acre or monocrotophos 36% SL @ 600-800 ml in 200-800 l of water/acre or oxydemeton-methyl 25% EC @ 600-800 ml in 600-800 l of water/acre
Bark-eating caterpillar	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) <p>Cultural control:</p> <ul style="list-style-type: none"> Keep orchard clean and healthy. Cut dried branches
Stem borer	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15)
Leaf webber	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) <p>Mechanical control:</p> <ul style="list-style-type: none"> Pruning of overcrowded and overlapping branches. Mechanical removal of infested webs by leaf web removing device and burning them.
Mango mealybug	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) <p>Cultural control:</p> <ul style="list-style-type: none"> Flooding of orchard with water in the month of October kill the eggs. Ploughing of orchard in November. Raking of soil around tree trunk to expose the eggs to natural enemies and sun, removal of weeds Fastening of alkathene sheet (400 gauge)/grease band of 25 cm wide afterwards mud plastering of trunk at 30 cm above the ground in the middle of December. In July –August destruction of infested fallen leaves with scales

	<p>Biological control:</p> <ul style="list-style-type: none"> Raking of soil around tree trunk to expose the eggs to natural enemies and sun, removal of weeds and releasing 10-15 grubs Releasing 10-15 grubs of coccinellid predator, <i>C. montrozieri</i>, per tree. <p>Chemical control:</p> <ul style="list-style-type: none"> Dimethoate 30% EC@ 990-1320 ml in 600-800 l of water/acre or monocrotophos 36% SL@ 600-800 ml in 200-800 l of water/acre (do not use at fruiting stage)
Powdery mildew	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) For resistant / tolerant varieties consult ICAR Institute / KVK's / SAU's. <p>Cultural control:</p> <ul style="list-style-type: none"> Spraying at full bloom needs to be avoided. <p>Mechanical control:</p> <ul style="list-style-type: none"> Prune diseased leaves and malformed panicles harbouring the pathogen to reduce primary inoculum load. <p>Chemical control:</p> <ul style="list-style-type: none"> Azoxystrobin 23% SC @ 100 ml (0.1%)/100 l of water depending on the size of the tree canopy or carbendazim 46.27% SC @ 0.1% or 100 ml/100 l Water, depending on the size of tree or dinocap 48% EC @ 5 g in 10 l of water/tree or hexaconazole 5% EC@ 0.1%(100ml/100 l) depending on the size of tree or hexaconazole 5 % SC @ 0.2% or 200ml/100 l water as required depending on size of tree and plant protection equipment used or penconazole 10% EC@ 50ml/100 l water 50ml/100 l water, 10 l/ tree or sulphur 55.16 % SC@ 0.30% or 300 ml/100 l water (as required) or sulphur 80% WP@ 1.252 Kg in 300-400 l of water/acre or sulphur 80% WG@ 0.7-1.0 Kg in 300-400 l of water/acre
Anthraxnose	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) For resistant / tolerant varieties consult ICAR Institute / KVK's / SAU's. <p>Cultural control:</p> <ul style="list-style-type: none"> Diseased leaves, twigs, gall midge infected leaves and fruits, should be collected and burnt. Covering the fruits on tree, 15 days prior to harvest with news or brown paper bags. <p>Chemical control:</p> <ul style="list-style-type: none"> Azoxystrobin 23% SC@ 100 ml (0.1%)/100 l of water depending on the size of the tree canopy or copper oxy-chloride 50% WG @ 0.24% or 240 g/100 l water as required depending upon PP equipment
Dieback	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) For resistant / tolerant varieties consult ICAR Institute / KVK's / SAU's. <p>Cultural control:</p> <ul style="list-style-type: none"> Scion wood selected for propagation should be free from infection Every care should be taken to prevent introduction of disease in newly planted orchards. <p>Mechanical control:</p> <ul style="list-style-type: none"> Any infected portion should immediately be pruned, followed by spraying/ pasting of copper oxy-chloride or 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).
Bacterial canker	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) For resistant / tolerant varieties consult ICAR Institute / KVK's / SAU's. <p>Cultural control:</p> <ul style="list-style-type: none"> Regular inspection of orchards, sanitation and seedling certification are recommended as preventive measures. Mango stones for raising seedlings (root stock) should always be taken from healthy fruits. Use of wind-breaks helps in reducing brushing/ wounding and thus reduces chance of infection.

Red rust	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) For resistant / tolerant varieties consult ICAR Institute / KVK's / SAU's. <p>Cultural control:</p> <ul style="list-style-type: none"> If vigour of plant is maintained by balanced nutrients, the disease is less. As the disease starts on the onset of rain, it is desired to spray fungicide copper oxy-chloride twice during the month of July/ August at 15 days intervals.
Phoma blight	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) For resistant / tolerant varieties consult ICAR Institute / KVK's / SAU's. <p>Cultural control:</p> <ul style="list-style-type: none"> The affected branches should be collected and burnt. Balanced nutrition provides resistance to phoma blight.
Reproductive stage	
Nutrients	<ul style="list-style-type: none"> Fertilizers should be applied in two split doses, one half immediately after the harvesting of fruits in June/July and the other half in October, in both young and old orchards followed by watering. Wherever irrigation is available it is advantageous to apply half of the recommended dose of fertilizers after fruit set. Foliar application of 3 % urea in sandy soils is recommended before flowering. Micro-nutrients may be applied as per the requirement in the form of foliar sprays, if deficiency symptoms are observed. For the correction of micronutrient deficiency, spraying of $ZnSO_4$ 5 g, Boron 2 g and 10 g urea per liter of water is recommended at the onset of monsoon. Spraying of KNO_3 @ 10 g/l during November helps in opening of the flower bud and uniform flowering.
Weeds	<ul style="list-style-type: none"> Remove weeds around the plants. Use straw or plastic mulch to avoid weed growth and to maintain soil moisture for longer period.
Leaf hopper, leaf webber, mealybug	<ul style="list-style-type: none"> Same as in vegetative stage.
Scale insects	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) <p>Cultural control:</p> <ul style="list-style-type: none"> Prune heavily infested plant parts to open the tree canopy and destroy them immediately. Prune infested parts (branches and twigs) preferably during summer. These should be placed in a pit constructed on one corner of the orchard. Allow branches and twigs to dry until the parasites escape. Burn the remaining debris. Removal of attendant ants may permit natural enemies to control the insect. <p>Chemical control:</p> <ul style="list-style-type: none"> Malathion 50% EC @ 900-1200 ml in 600-800 l of water/acre
Inflorescence midge	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) <p>Cultural control:</p> <ul style="list-style-type: none"> Deep ploughing of orchard in October- November to expose pupae and diapausing larvae to sun's heat which kills them.
Stone weevil	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) <p>Cultural control:</p> <ul style="list-style-type: none"> Collection and destruction of infested and fallen fruits at weekly interval till fruit harvest. Ploughing of orchard after harvest to expose hibernating adults, reduce infestation levels. Destroy all left over seeds in the orchard and also in the processing industries.

Shoot gall psylla	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) <p>Cultural control:</p> <ul style="list-style-type: none"> Galls with nymphs should be collected and destroyed.
Shoot borer	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) <p>Cultural control:</p> <ul style="list-style-type: none"> Attacked shoots should be clipped off and destroyed. Clean hole and pour kerosene/petrol/crude oil or formalin into the stem borer hole and subsequently close entrance of the tunnel by plugging with cotton wool and paste the mud. <p>Chemical control:</p> <ul style="list-style-type: none"> Monocrotophos 36% SL @ 600-800 ml in 200-800 l of water/acre
Diseases	<ul style="list-style-type: none"> Same as in vegetative stage
Sooty mould	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) For resistant / tolerant varieties consult ICAR Institute / KVK's / SAU's. Pruning of affected branches and their prompt destruction prevents the spread of the disease.
Stem end rot	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) For resistant / tolerant varieties consult ICAR Institute / KVK's / SAU's. <p>Cultural control:</p> <ul style="list-style-type: none"> Avoid harvesting of immature fruits and cool fruits immediately after harvest and store in well ventilated containers.
Gummosis	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) For resistant / tolerant varieties consult ICAR Institute / KVK's / SAU's. <p>Cultural control:</p> <ul style="list-style-type: none"> The diseased bark / portion should be removed or cleaned and pasted with cow dung paste.
Mango malformation	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) For resistant / tolerant varieties consult ICAR Institute / KVK's / SAU's. <p>Cultural control:</p> <ul style="list-style-type: none"> The floral malformed panicles/ vegetative malformed shoots should be pruned and burnt which reduces the incidence of malformation. Application of NAA (200 ppm) in the first week of October (Before bud differentiation stages) followed by de-blossoming in the late December or January reduces the incidence of malformation.
Maturation stage	
Mango shoot caterpillar	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) <p>Cultural control:</p> <ul style="list-style-type: none"> Keep orchard clean and healthy.
Fruit fly	<ul style="list-style-type: none"> Follow common cultural, mechanical and biological practices (See page no. 14, 15) <p>Cultural control:</p> <ul style="list-style-type: none"> Prior to harvest (30-40 days) collect and dispose off infested and fallen fruits to prevent further multiplication and carry-over of population. Ploughing of orchard during November-December to expose pupae to sun's heat which kills them. If infestation is heavy, bait splash on the trunk only, once or twice at weekly interval is recommended. To prepare bait splash, mix 100 gm of jaggery in one litre of water and add 1 ml of deltamethrin by using an old broom. Managing fruit flies also reduces anthracnose disease and prevents late fruit fall. <p>Mechanical control:</p> <ul style="list-style-type: none"> 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. Use methyl eugenol pheromone trap @ 4/acre <p>Physical control:</p> <ul style="list-style-type: none"> Hot water treatment of fruit at 48 ± 1 °C for 4-5 min.

Diseases	<ul style="list-style-type: none"> Same as in vegetative stage
Postharvest diseases	
Anthraxnose (<i>C. gloeosporioides</i>), stem end rot (<i>L. theobromae</i>), <i>Aspergillus</i> rot	<p>Physical control:</p> <ul style="list-style-type: none"> Hot water treatment at 52 °C for 4-5 min. Fruits should be sprayed with the mixture of bio-inoculants. <p>Botanical control:</p> <ul style="list-style-type: none"> Postharvest dip treatment of fruits with botanical fungicides could also control the diseases during storage.

Note: The pesticides dosage and spray fluid volumes are based on high volume sprayer. The recommended pesticides are as per CIBRC list updated 31.10.2014.

**Pests of regional significance.

V. INSECTICIDE RESISTANCE AND ITS MANAGEMENT

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

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

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

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

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

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

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

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

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

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

VI. NUTRITIONAL DEFICIENCIES

Nutrients

Nitrogen: Yellow undersized leaves, severe retardation of growth, twigs become yellow in color. Fruits smaller and mature early. Leaves small with general yellowing.

Correction Measure: Foliar sprays of urea 2% at weekly intervals till disappearance of the deficiency symptom.

Phosphorus: Retarded growth premature dropping of older leaves partial die-back from the tip small green younger leaves are borne at the tips of the branches. Some branches show die back. Leaf tip necrosis and premature abscission of leaves.

Correction Measure: Soil application of single super phosphate or foliar application of ortho phosphoric acid 0.5 % thrice.

Potassium: Darkening of leaves, reduced growth and vigour. Appearance of white, yellow or orange chlorotic spots in older leaves and distributed irregularly over both under and upper leaf surfaces. Necrotic areas develop along the leaf margins. Poor growth of roots. Die back with tip burn with small leaves.

Correction Measure: Foliar spray of KCl @ 2% at weekly interval till the symptom disappear.

Calcium: Abnormal growth of young leaves and growing points resembling boron deficiency severe deficiency leads to death of the bud.

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

Sulphur: Symptoms first appear on young leaves with fading of green colour. Growth is stunted. Leaf tip remains green and with severe deficiency the whole leaf turns yellow.

Correction Measure: Soil application of gypsum @ 100 Kg / acre or application of ammonium sulphate @ 100g/plant.

Boron: Deficiency is common in high rain fall areas, high temperature, soil acidity and calcareous soils. Fruits become brown in colour. Flesh may become soft and watery which cracks down to the centre.

Correction Measure: Application of 2-4 Kg Borax / acre or a foliar spray of 0.25% Borax at 10 days interval or solubor at 300 g/ 100 l of water.

Symptoms



Iron: Symptoms are first seen in the youngest leaves. Initially the smallest veins remain green, which produces a reticulate pattern of green veins on yellow leaves. The leaves eventually turn completely chlorotic but there is no associated necrosis.

Correction Measure: Soil application of FeSO_4 2 Kg/ha or foliar spray of FeSO_4 @ 0.5% at weekly intervals.



Manganese: Deficiency appears on the middle of the plant. Interveinal chlorosis of leaves. Reduced growth leaf symptoms appear very late leaves show a yellowish green background with a fine network of green veins on the upper surface and disappearing after a few weeks mature leaves thicker and blunted. Specks of light grey to grayish brown colour appear under mid deficiency.

Correction Measure: Weekly foliar spray of 2% MnSO_4 .



Zinc: Leaf blade thickens leaf shape is distorted leaf margin up or down the tip may curve back interveinal areas leaves are usually smaller thickened leaf blade brittle spaced leaves show a rosette appearance. Some twigs die back flower panicles of trees showing little leaf symptoms are usually small irregular in shape drooping spikes

Correction Measure: Soil application of ZnSO_4 @ 4 Kg/ acre or foliar spray of ZnSO_4 @ 0.5%.



http://agritech.tnau.ac.in/agriculture/plant_nutri/Mango_nitrogen.html

VII. PHYSIOLOGICAL DEFICIENCIES

1. Black tip (Chimney disease):

Symptoms:

- Symptoms become visible when the mango fruits attain some size.
- Small etiolated area develops near the distal end of the fruit which gradually spreads, turns nearly black and covers the tip of the fruit completely.
- The black area remains hard and the growth of the fruit is checked

Management:

- It can be minimized by the spray of borax (1%). The first spray should be done positively at pea stage followed by two more sprays at 15 days interval.
- Planting of mango orchard in north-south direction and 5-6 km away from the brick kilns reduce the incidence.



2. Internal necrosis (Boron deficiency):

Symptoms:

- First, water soaked grayish spots develop on the lower side of the fruit.
- Later, the spots enlarge and develop into dark brown necrotic area. The internal tissue starts disintegrating.
- The pericarp and mesocarp is disintegrated exposing the flesh.
- Yellow coloured droplets also come out and such affected fruits drop easily.

Management:

- Foliar spray of borax (1%) at pea stage followed by two more sprays at 15 days interval.
- Application of 250 g boron per tree (10-15 year old) around the tree basin.



3. Fruit clustering (Jhumka):

Symptoms:

- This abnormality is characterized by formation of several fruitlets at the tip of panicle.
- The fruitlets are darker green in colour and their shape is slightly curved than the normal fruits.
- These fruits generally hang for more time compared to some normal fruits, which subsequently drop due to other fruit drop reasons.
- However these fruitlets do not grow more and later drop. The fruits do not have formation of seeds.

Management:

- During flower opening stage spray of insecticides and fungicides should be avoided.
- Population of pollinators should be kept more during flowering season.
- Pollinizing cultivars should be planted in the orchard.



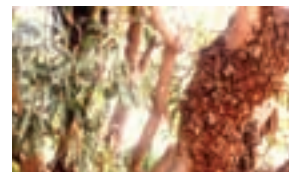
4. Woody stem gall (Cause not known):

Symptoms:

- Woody galls of 10-15 inches diameter are formed on limbs and branches.
- The galls are abundant on CVS, Chinnasuvarnarekha, Langra varieties and moderate in Neelam variety.

Management:

- Remedy lies in removal of galls using saw and applying Bordeaux paste to cut surface.



5. Red nose / soft nose (Cause not known):

Symptoms:

- The malady is severe in late maturing Neelam and Mallika varieties particularly in delayed harvest leading to substantial loss.
- The fruits with red nose are unfit for export. Numerous red nosed fruits are seen on tree during fag end of summer with onset of showers.
- Red nose gradually becomes soft and rot

Management:

- Timely harvesting of fruit.
- Proper nutrition to the plant.



6. Fruit tumors (Cause not known):

Symptoms:

- Tumors of pea to marble size develop on fruit and are very ugly to look at.
- The stylar end part is much affected while stem end is practically free from tumors

Management:

- Removal of affected fruits from the tree and buried in the soil.



Source: agropedia.labs.iitk.ac.in/.../micronutrient...

VIII. COMMON WEEDS



1. Pigweed: *Amaranthus viridis* Hook. F. (Amaranthaceae)



2. Common purselane: *Portulaca oleracea* L. (Portulacaceae)



3. False amaranth: *Digera arvensis* Forsk. (Amaranthaceae)



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



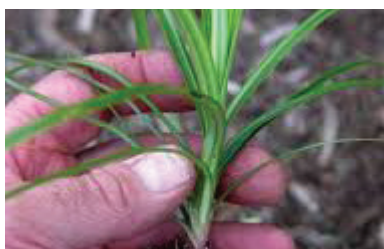
5. Goat weed: *Ageratum conyzoides* L. (Asteraceae)



6. Barnyard grass: *Echinochloa crusgalli* (L.) Beauv. (Poaceae)



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



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



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



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



11. Spanish needles: *Bidens pilosa* L. (Asteraceae)



12. Silk leaf: *Lagascea mollis* Cav. (Asteraceae)



13. Madras leaf-flower: *Phyllanthus madraspatensis* L. (Euphorbiaceae)



14. Dendrophthae: *Loranthus longiflorus* Desr. (Loranthaceae)

IX. DESCRIPTION OF INSECT PESTS

1) Mango hopper:

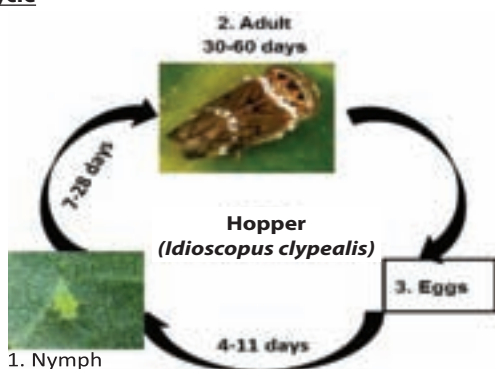
Biology

Egg: Females lay more eggs and nymphs develop faster during the flowering and fruiting period. Eggs hatch in two to three days and nymphs develop between 12 to 20 days

Nymph: The nymphs are greenish with black or brown markings, cannot fly and move rapidly on the plant

Adult: Adult mango leafhoppers are golden-brown or dark brown, wedge-shaped insects about 4-5 mm in length which look rather like a small cicada. When disturbed, the adults jump off the plant with a clicking sound, fly a short distance and then quickly resettle on the plant

Life cycle



Damage symptoms:

- The wedged shaped nymphs and adult insects puncture and suck sap of tender parts, reducing vigour of plants and particularly destroying the inflorescence and causing fruit drop.
- Heavy puncturing and continuous draining of sap causes curling and drying of infested tissue.
- They also damage the crop by excreting a sweet sticky substance facilitates the development of sooty mould



1. Hoppers damaging inflorescence



2. Fruit drop by hoppers

1,2: <http://www4.schoolnet.lk/edusoft/agriculture/grade/more.php?sub=Mango%20Hopper&main=main21>

Natural enemies of mango hopper:

Parasitoids: *Polynema* spp., *Gonatocerus* sp, *Tetrastichus* sp etc.

Predators: *Mallada boninensis*, *Plexippus paykullii* etc.

*For management refer to page number 16.

2) Mango mealybug:

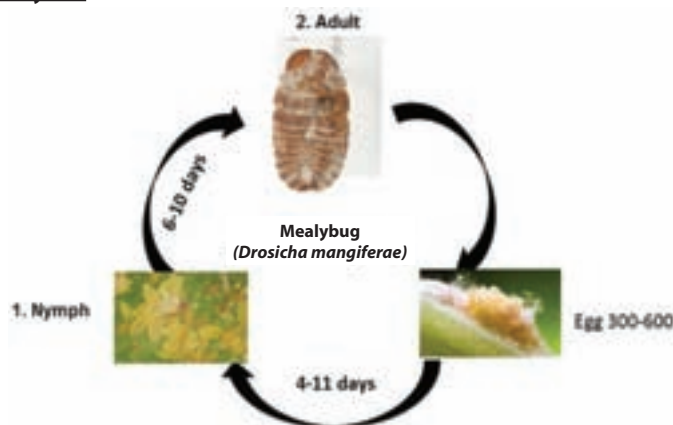
Biology:

Egg: Females lay their eggs directly on the host in a fluted ovisac that is attached to the body of the adult female. Inseminated eggs produce hermaphrodites and uninseminated eggs produce males.

Nymph: The first instar nymphs are also called as crawlers, which are mobile. They settle on the plants, start sucking the sap and form the colonies.

Adult: In general they have 3 female instars and 5 male instars, but unlike most other scale insects, the prepupa is quite mobile and although it may have wing buds, the legs and antennae are well developed. Females actually are hermaphrodites that frequently inseminate themselves. Adult males mate with females, but it is not clear if their sperm are used for reproduction.

Life cycle:



Damage symptoms:

- The adult bugs are covered with whitish powder and colonize between bark of tree trunk, young shoots and panicles
- The nymphs' ascent the trees and settle on inflorescence causing flower drop, affecting fruit set.
- They also excrete honey dew, a sticky substance, which facilitates development of sooty mould



1. Shoot infested



2. Fruits infected

1,2: <http://nhm.nic.in/Horticulture/IPM%20for%20Mango.pdf>

Natural enemies of mealybug:

Parasitoids: *Allotropa citri*, *Praleurocerus viridis*, *Leptomastrix dactylopii* etc.

Predators: *Menochilus sexmaculatus*, *Rodolia fumida*, *Cryptolaemus montrosieri*, *Symnus coccivora*, *Mallada boninensis*, *Spalgis epeus* etc. *For management refer to page number 16.

3) Fruit fly:

Biology:

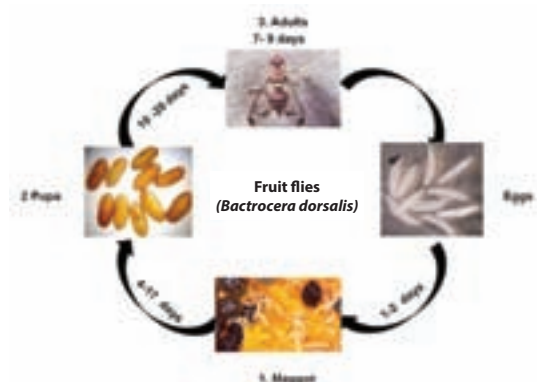
Egg: Female flies insert eggs under the skin of fruit in clusters of 10 to 50 about 1/25 to 1/8 inch below the fruit surface. The eggs measure about 1/25 by 1/250 inch and are white, elongate, and elliptical. They hatch in 1-1/2 days.

Maggot: The white maggot 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 maggot stage lasts for 11-15 days.

Pupa: When mature, maggot 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. Ripe fruit are preferred for egg laying, but immature ones may be also attacked.

Life cycle:



Damage symptoms:

- The female punctures outer wall of mature fruits with the help of its pointed ovipositor and insert eggs in small clusters inside mesocarp of mature fruits.
- On hatching, the maggots feed on fruit pulp and the infested fruits start rotting due to further secondary infection



1.



2.

Damage symptoms

1. <http://tnau.ac.in/eagri/eagri50/ENTO331/lecture16/003.html> ; 2. http://archive.agric.wa.gov.au/PC_92665.html

Natural enemies of fruit fly:

Parasitoids: *Fopius arisanus*, *Diachasmimorpha kraussii* etc.

*For management refer to page number 19.

4) Inflorescence midge:

Biology:

Egg: Eggs are single on floral parts like tender inflorescence axis newly set fruit or tender leaves encircling the inflorescence. The eggs hatch within 2-3 days

Maggot: The minute maggots penetrate the tender parts where the eggs have been laid and start feeding on them. The mature larvae drop down into the soil for pupation. The larval period varies from 7-10 days, while pupal period varies from 5-7 days

Pupa: Pupae are yellowish-brown and 1-2 mm long, with male pupae generally smaller than females.

Adult: Adults are small midges with a wing length of 1.0-1.5 mm. Eye facets are circular, but further apart laterally than in other genera and the tarsal claws are toothed, which is unusual in Cecidomyiini. The ovipositor is protrusible but relatively short and the terminal cerci are fused to form a single lobe. The male gonocoxites are elongate and, unlike those of other Cecidomyiini, have a short mesobasal lobe

Damage symptom:

- The larvae tunnel the axis of inflorescence and destroy it completely.
- Damage by *E. indica* causes bending and drying of the inflorescences.
- Second attack starts at fruit setting as young maggots bore into these tender fruits which slowly turn yellow and finally drop.
- Third attack is on tender 'new leaves encircling inflorescence.

- The most damaging one is first attack in which the entire inflorescence is destroyed.
- The inflorescence shows stunted growth and its axis bends, at the entrance point of larva



1. Panicle damaged by midge

2. Twig damaged by midge

1,2: <http://nhm.nic.in/Horticulture/IPM%20for%20Mango.pdf>

Natural enemies of Inflorescence midge:

Parasitoids: *Tetrastichus* sp., *Platygaster* sp., *Systasis dasyneurae*, *Aprostocetus* spp. etc.

*For management refer to page number 18.

5) Stem borer:

Biology:

Egg: The eggs are brownish-white, cylindrical, and 6 x 2 mm, with narrowly rounded ends. They are normally placed into an incision, about 25 mm long, cut in the bark by the mandibles.

Larva: Newly-hatched, first-instar larvae are about 10 mm long. Fully grown larvae may reach 100 mm long, but more commonly reach about 60-80 mm long. The grub is subcylindrical, weakly flattened dorsoventrally, and yellowish-white, with the head dark brown and sclerotized, without obvious legs. The larva is described in detail by Duffy (1968) who also provided a key to separate out all known Oriental cerambycid larvae.

Pupa: It is robust, about 80 mm long, with some short, reddish setae on labrum and bases of mandibles and antennae. Sides of prothorax with strong tubercle. Basal four abdominal segments with reddish hairs forming transverse interrupted band dorsally, segments five to seven with sparse setae. Apical segment ending with a spine on a strong subvertical acute prominence.

Adult: Typical cerambycid beetles, recognized by the long antennae reaching to at least the end of the body and the tarsi, the same on all legs, with apparently four segments excluding the claws, but with the third segment strongly bilobed and almost concealing the very small fourth segment at the base of the true fifth, claw-bearing segment. Length ca 25-55 mm. Covered with grey to yellowish pubescence on a dark brown to pitchy surface. Head held vertically downwards, maxillary palpi tapering apically. Antennae inserted on distinct prominences forming a shallow V-shape on the top of the head.

Damage symptoms:

- Grub tunnels in the sapwood on the trunk or branches
- Grub bore into the sap wood and making irregular tunnels.
- Feeding the vascular tissues
- Interruption of nutrient and water transport on the tissue
- Drying of terminal shoot in early stage
- Frass comes out from several points and sometimes sap oozes out of the holes
- Wilting of branches or entire tree



Infestation of borer on tree trunk

*For management refer to page number 16.

6) Bark eating caterpillar:

Biology:

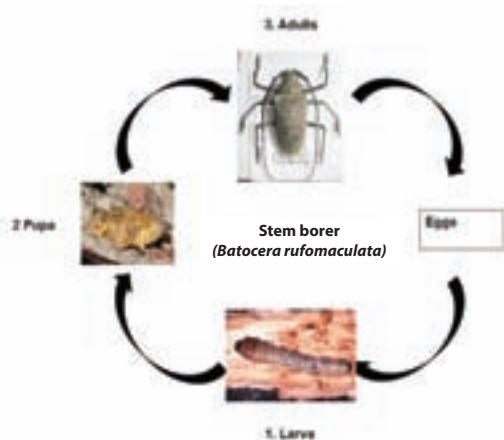
Egg: Adult females emerge in summer and lays 15-25 spherical eggs in clusters under loose bark of the trees, usually singly. Eggs hatch in 8-10 days.

Larva: The larval stage is for 10 months. Pupation takes place inside the bore hole. The full grown caterpillar is dirty brown in colour and is about 35-45 mm in length. Larvae make webs and feed making zigzag galleries on the wood filled with frass and excreta and later bores inside the wood.

Pupa: About 10 mm long, it feeds at first in the meristem and later penetrates deep. Pupation takes place inside the bore hole. Pupal stage is 3-4 months

Adult: Male: Head and thorax are rufous. Forewing is pale-rufous (reddish brown) with numerous dark-rufous bands of strigae; there is a spot at the end of the cell. The abdomen and hindwings are fuscous (brownish gray). Female: Head, thorax and abdomen are ochreous-white. Forewings are ochreous-white with markings as in the male. Hindwings are pale, slightly suffused with fuscous, with numerous obsolescent brown striga.

Life cycle:



Damage symptoms:

- Caterpillars bore into the trunk or junction of branches
- Caterpillars remain hidden in the tunnel during day time and come out at night, feed on the bark.
- Larvae construct galleries and move in it.
- Affected plant show dried galleries on the stem and shoots.
- Webbing consists of wooden frass and faecal pellets of larvae hanging outside the tunnel.
- Heavy infestations retard the growth of tree and affect the fruits yield.



<http://agropedialabs.iitk.ac.in/agrilore/?q=node/2898>

*For management refer to page number 16.

7) Stone weevil:

Biology:

Egg: Eggs are elliptical, about 0.8 mm long and 0.3 mm wide and are creamy-white in colour when freshly laid. They are laid singly in small cavities made by the female in the skin of young fruits. There are reports that eggs may also be laid into inflorescences. The female then covers each egg with a brown exudate and cuts a very small crescent-shaped area (0.3 mm) in the fruit, near the back end of the egg. The wound creates a sap flow, which hardens and covers the egg with a protective coating. Several eggs may be laid in each fruit. Incubation requires 5 to 7 day

Larva: Larvae are white grubs with a curved body, brown heads and legless. Newly hatched larvae are extremely slender and elongated and about 1 mm long. Mature larvae are about 17 mm long. After hatching, the larva burrows through the flesh of the fruit and into the seed where they feed until pupation. The development of the larva is usually completed within the maturing seed, but also very occasionally within the flesh.

Pupa: Pupae are whitish when newly formed, but change to a very pale red colour just before the adult emerges. They are about 8 mm long and 7 mm wide. Pupation takes place in the seed within the stone of the fruit

Adult: Adults are weevils with a compact body, about 8 mm long. They are usually active at dusk. Adults can fly, but they are not known to be strong fliers. They pretend to be dead when touched or disturbed. Females start egg laying 3 to 4 days after mating, when the fruit is about marble-size. Adult weevils feed on mango leaves, tender shoots or flower buds. They can live for two years.

Damage symptoms:

- Grub makes zigzag tunnels in pulp and eats unripe tissue and bore into cotyledons
- Fruit dropping at marble stage and oviposition injuries on marble sized fruits.
- Tunnelled cotyledons in mature fruit by grubs.



Symptom



Grub



Adult on Mango

<http://www.infonet-biovision.org/default/ct/100/pests>

Natural enemies of mango nut weevil:

Predators: *Rhizoglyphus* sp, *Camponatus* sp., *Oecophylla smaragdina* etc.

*For management refer to page number 18.

8) Shoot gall psyllid:

Biology:

Egg: Adult female lays 80-100 eggs on either side of the midrib of a single leaf. Freshly laid egg looked like a rectangular block with rounded corners. The incubation period ranges between 191-211 days.

Nymph: Freshly hatched nymph is yellowish in colour, but changed in size and colour with time. There were six nymphal instars. Each instar moults after duration of about one month except 2nd nymphal instar, which moulted 2-3 weeks after hatching. Only one generation occur in a year. The nymphal period is about five to six months

Adult: Adult emergence starts from fourth week of February and continue up to third week of March.

Damage symptoms

- Nymphs emerge during August-September and suck cell sap from adjacent buds.
- As a result of feeding, buds develop into hard conical green galls .
- The galls are usually seen during September-October.
- Consequently there is no flowering and fruit setting. Nymphs pass winter inside the galls



Infestation of shoot gall psylla Nymphs of *Apsylla cistellata*

Natural enemies of shoot gall psyllid:

Parasitoids: Tiny parasitic wasp, *Inostemma apsyllae* etc.

Predators: Ladybird bee, purplish pirate bug, brown lacewings etc.

*For management refer to page number 19.

9) Leaf webber:

Biology:

Egg: The eggs are very small and dull-greenish in colour, and are laid in a scattered manner on the leaves. Adults lays upto 30-50 yellowish green eggs singly near the leaf veins. Egg period is 4 days.

Larva: There are five larval instars. Larval development takes place in 15 days during July and 33 days in November, when the temperature is comparatively low. After November the larvae hibernate in tough, silken, waterproof cocoons in the soil.

Pupa: Long brown pupae in white silken cocoons remain attached to leaves. The pupal period lasts 4-5 days, but at 25°C, the pupal period is prolonged to 14-16 days.

Adult: The head and thorax of the adult moth are grey with a slight olive-green tinge. The abdomen is fuscous (brownish-grey). The forewings are yellowish-white with an olive tinge and slight rufous (reddish-brown) and fuscous (brownish-grey) irroration with black specks at the base and middle of cell. The hindwings are fuscous, the cilia rufous, and underside with indistinct medial curved line. In general, the moth is medium-sized with a wingspan of 31 mm and body length of 14 mm. The male is slightly smaller than the female.

Damage symptoms:

- Initially caterpillars feed on leaf surface gregariously by scrapping, later they make web of tender shoots and leaves together and feed within.
- Several caterpillars may be found in a single webbed up cluster of leaves



Larvae web up leaves into clusters and feed within

Natural enemies of leaf webber:

Parasitoids: *Brachymeria lasus*, *Hormius* sp., *Pediobius bruchicida* etc.

Predators: Carabid beetle, reduviid bug etc.

*For management refer to page number 16.

10) Shoot borer:

Biology:

Egg: The eggs were laid in masses on the fruit apex and hatched after 3 to 4 days

Larva: Development of the larvae is rapid. The larvae pass through five instars at the rate of approximately one instar each day. The feeding period lasts 5-6 days, after which the caterpillars move from the leaves to search for pupation sites in cracks or crevices in the bark, or in the soil at the base of the tree

Pupa: The pre-pupal and pupal stages lasted from 2 to 3 and 9 to 14 days, respectively

Adult: Adult moths are stout grayish brown in colour with wings having wavy lines and measure about 17.5 mm with expanded wings. Hind wings are light in colour.

Damage symptoms:

- Larvae bore into young tender leaves during August and freshly hatched caterpillar bore into mid rib.
- After a couple of days, they bore into tender shoots near the growing point tunneling downward, throwing their excreta resulting in dropping of leaves and wilting of terminal shoots



Damage symptoms

http://www.actahort.org/members/showpdf?booknr=291_48

Natural enemies of shoot borer:

Parasitoids: *Bracon greeni* etc.

*For management refer to page number 19.

Natural Enemies of Mango Insect Pest

Parasitoids

Egg parasitoids



1. *Polynema* spp.



2. *Gonatocerus* sp



3. *Tetrastichus* sp

Larval parasitoids



4. *Fopius arisanus*



5. *Diachasma morpha kraussi*



6. *Hormius* sp



7. *Pediobius bruchicida*



8. *Tetrastichus* spp.



9. *Bracon greeni*



10. *Aprostocetus* spp.

Pupal parasitoids



11. *Brachymeria lasus*

Nymphal and adult parasitoids



12. Tiny parasitic wasp



13. *Inostemma apsyllae*



14. *Platygaster* sp.



15. *Systasis dasyneurae*

1. <http://www.nps.gov/media/photo/gallery.htm?id=5FF8FFF8-1DD8-B71C-072E5FF3ED680884>; 2. <http://biocontrol.ucr.edu/irvin/gwssbiocontrol.html>; 3. <http://www.pbase.com/tmurray74/image/125304607>; 4. <http://www2.hawaii.edu/~messing/projects.htm>; 5. <https://www.spc.int/pacify/Control/Biocontrol.htm>; 6. http://tribes.eresmas.net/fotos/ins/Hymenop/Ichneumon/Braconidae/Hormiinae/Hormius/H_moniliatus/hormius_moniliatus_01_p05219_juncosa_1.jpg; 7. <http://www.waspweb.org/Chalcidoidea/Eulophidae/Entedoninae/Pediobius/index.htm>; 8. <http://www.pbase.com/tmurray74/image/125304607>; 9. <http://www.flickr.com/photos/king777/6965853794/>; 10. <http://bugguide.net/node/view/679101>; 11. <http://www.rkmp.co.in/content/brachymeria-lasus-walker>; 12. <http://bugguide.net/node/view/205018/bgimage>; 13. http://species.wikimedia.org/wiki/File:Inostemma_boscii.jpg; 14. <http://www.pbase.com/tmurray74/image/122701891>; 15. <http://www.nbaii.res.in/Pteromalidae/gallery.php>

Predators



1. *Mallada boninensis*



2. *Plexippus paykullii*



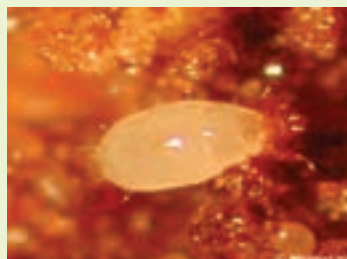
3. *Menochilus sexmaculatus*



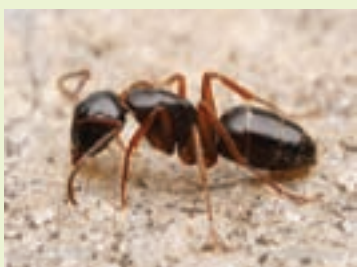
4. *Rodolia fumida*



5. *Cryptolaemus montrosieri*



6. *Rhizoglyphus* sp



7. *Camponatus* sp



8. *Oecophylla smaragdina*



9. Purplish pirate bug



10. Brown lacewing



11. Carabid beetle



12. Reduviid bug

1. <http://www.nabg-nbail.res.in/patent.php?key=1>; 2. http://www.eurospiders.com/Plexippus_paykullii.htm; 3. <http://cyy4993.blogspot.in/2012/11/beetle-coccinellidae-coccinella.html>; 4. http://www.nbail.res.in/Featured_insects/Rodolia-fumida.php; 5. <https://uribotanicalgardens.wordpress.com/tag/biocontrol/>; 6. <http://wiki.cannaweed.com/index.php/Rhizoglyphus>; 7. <http://www.naturephoto-cz.com/ant-camponotus-fallax-photo-4381.html>; 8. <http://www.cabi.org/cpc/?compid=1&dsid=16434&loadmodule=datasheet&page=868&site=161>; 9. <http://extension.umd.edu/hgic/insects/predators-minute-pirate-bugs>; 10. <http://www.oanimals.com/Insect/Brown-Lacewing/Micromus/sp.html>; 11. http://www.biology.ualberta.ca/bsc/news16_2/alvar.htm

X. DESCRIPTION OF DISEASE

1) Powdery mildew:

Disease symptoms:

- The characteristic symptom of the disease is the white superficial powdery fungal growth on leaves, stalks of panicles, flowers and young fruits.
- The affected flowers and fruits drop pre-maturely reducing the crop load considerably or might even prevent the fruit set.
- The fungus parasitizes young tissues of all parts of the inflorescence, leaves and fruits.
- Young leaves are attacked on both the sides but it is more conspicuous on the grower surface. Often these patches coalesce and occupy larger areas turning into purplish brown in colour

Survival and spread:

- The powdery mildew fungus overwinters in dormant buds. When conditions are favorable 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

Favourable conditions:

- Rains or mists accompanied by cooler nights during flowering are congenial for the disease spread.



1.



2.



3.

Disease symptoms

1,2,3: https://www.google.co.in/search?q=powdery+mildew+of+mango+disease+cycle&espv=210&es_sm=93&source=lnms&tbm=isch&sa=X&ei=638QU4WdCMGKrQf3hoDQAQ&ved=0CAc

*For management refer to page number 17.

2) Anthracnose:

Disease symptoms:

- The disease causes serious losses to young shoots, flowers and fruits. It also affects fruits during storage.
- The disease produces leaf spot, blossom blight, withertip, twig blight and fruit rot symptoms. Tender shoots and foliage are easily affected which ultimately cause 'dieback' of young branches. Older twigs may also be infected through wounds which in severe cases may be fatal.
- Depending on the prevailing weather conditions blossom blight may vary in severity from slight to a heavy infection of the panicles. Black spots develop on panicles as well as on fruits. Severe infection destroys the entire inflorescence resulting in no setting of fruits. Young infected fruits develop black spots, shrivel and drop off.
- Fruits infected at mature stage carry the fungus into storage and cause considerable loss during storage, transit and marketing.

Survival and spread:

- Fungus survives in dead twig and other host for long time which is the source of primary infection.

Favourable conitions:

- High humidity, frequent rains and a temperature of 24-32 °C favours the development of disease.



1.

2.

Disease symptoms

1,2: https://www.google.co.in/search?q=anthracnose+of+mango+disease+cycle&espv=210&es_sm=93&source=lnms&tbn=isch&sa=X&ei=638QU4WdCMGKrQf3hoDQAQ&ved=0CAc

*For management refer to page number 17.

3. Dieback:

Disease symptoms:

- 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. When graft union of nursery plant is affected, it usually dies

Survival and spread:

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

Favourable conditions:

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



1.

2.

3.

Disease symptoms

1,2,3: https://www.google.co.in/search?q=die+back+of+mango+disease+cycle&espv=210&es_sm=93&source=lnms&tbn=isch&sa=X&ei=638QU4WdCMGKrQf3hoDQAQ&ved=0CAc

*For management refer to page number 17.

4) *Phoma* blight:

Disease symptoms:

- The symptoms of the disease are noticeable only on old leaves. Initially, the lesions are angular, minute, irregular, yellow to light brown, scattered over leaf lamina.
- As the lesions enlarge their colour changes from brown to cinnamon and they become almost irregular.
- Fully developed spots are characterized by dark margins and dull grey necrotic centres. In case of severe infection such spots coalesce forming patches measuring 3.5-13 cm in size, resulting in complete withering and defoliation of infected leaves.

Survival and spread:

- The pathogen is seed borne fungus and inoculum present in the seeds are source of primary infection. Fungus also survives on glumes, fruit and plant debris.

Favourable conditions:

- Rainy seasons favour the development of disease.



1.



2.

Disease symptoms

*For management refer to page number 18.

5) *Bacterial canker*:

Disease symptoms:

- The disease is noticed on leaves, leaf stalks, stems, twigs, branches and fruits, initially producing water soaked lesions, later turning into typical canker.
- On leaves, water soaked irregular satellite to angular raised lesions measuring 1-4 mm in diameter are formed. These lesions are light yellow in colour, initially with yellow halo but with age enlarge or coalesce to form irregular necrotic cankerous patches with dark brown colour.
- On fruits, water-soaked, dark brown to black coloured lesions are observed which gradually developed into cankerous, raised or flat spots. These spots grow bigger usually up to 1 to 5 mm in diameter, which covers / almost the whole fruit.
- These spots often, burst extruding gummy substances containing highly contagious bacterial cells.

Survival and spread:

- In lesions on plant parts and can also survive for long periods in diseased plant tissues.

Favourable conditions:

- Spring session is responsible for the development of diseases.



1.



2.



3.

Disease symptoms

1,2,3: [https://www.google.co.in/search?q=\)+Bacterial+canker+of+mango&espv=210&es_sm=93&source=Inms&sa=X&ei=UqERU6eEAsizrAelqoCgCw&ved=0CAgQ_AUoAA&biw=1280&bih=656&dpr=1](https://www.google.co.in/search?q=)+Bacterial+canker+of+mango&espv=210&es_sm=93&source=Inms&sa=X&ei=UqERU6eEAsizrAelqoCgCw&ved=0CAgQ_AUoAA&biw=1280&bih=656&dpr=1)

*For management refer to page number 17.

6) Red rust:

Disease symptoms:

- Red rust disease, caused by an alga, has been observed in mango growing areas. The algal attack causes reduction in photosynthetic activity and defoliation of leaves thereby lowering vitality of the host plant.
- The disease can easily be recognized by the rusty red spots mainly on leaves and sometimes on petioles and bark of young twigs and is epiphytic in nature.
- The spots are greenish grey in colour and velvety in texture. Later, they turn reddish brown. The circular and slightly elevated spots sometimes coalesce to form larger and irregular spots. The disease is more common in closely planted orchards.

Survival and spread:

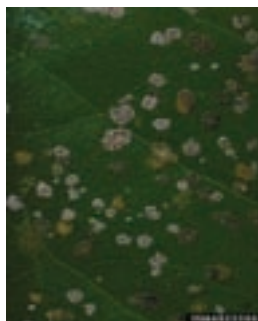
- The pathogens reproduce and survive in spots on leaves or stems and in fallen plant host debris.

Favourable conditions:

- Frequent rains and warm weather are favorable conditions for these pathogens. For hosts, poor plant nutrition, poor soil drainage, and stagnant air are predisposing factors to infection by the algae



1.



2.

Disease symptoms

1,2: [https://www.google.co.in/search?q=\)+Bacterial+canker+of+mango&espv=210&es_sm=93&source=Inms&sa=X&ei=UqERU6eEAsizrAelqoCgCw&ved=0CAgQ_AUoAA&biw=1280&bih=656&dpr=1](https://www.google.co.in/search?q=)+Bacterial+canker+of+mango&espv=210&es_sm=93&source=Inms&sa=X&ei=UqERU6eEAsizrAelqoCgCw&ved=0CAgQ_AUoAA&biw=1280&bih=656&dpr=1)

*For management refer to page number 18.

7) Sooty mould:

Disease symptoms:

- The disease is common in the orchards where mealybug, 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.
- Disease is spread by air-borne ascospores.

Favourable conditions

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



1.

2.

Disease symptoms

1,2: https://www.google.co.in/search?q=+sooty+mould+of+mango&espv=210&es_sm=93&source=Inms&sa=X&ei=UqERU6eEAsizrAelqoCgCw&ved=0CAgQ_AUoAA&biw=1280&bih=656&dpr=1

*For management refer to page number 19.

8) Mango malformation:

Disease symptoms:

- Vegetative malformation: Vegetative malformation is pronounced in young seedlings. The affected seedlings develop vegetative growths which are abnormal growth, swollen and have very short internodes.
- Floral malformation: The flower buds are transformed into vegetative buds and a large number of small leaves and stems, which are characterized by appreciably reduced internodes and give an appearance of witches' broom. The flower buds seldom open and remain dull green.

Survival and spread

- The disease is mainly spread via infected plant material. Mango malformation disease spreads slowly within affected orchards.
- The mango bud mite, *Aceria mangiferae*, has been associated with mango malformation disease as wounds from the mites' feeding activity are thought to facilitate fungal infection.

Favourable conditions:

- Moist weather favours the development of disease.



1.

2.

Disease symptoms

1,2: https://www.google.co.in/search?q=sooty+mould+of+mango&espv=210&es_sm=93&source=Inms&sa=X&ei=UqERU6eEAsizrAelqoCgCw&ved=0CAgQ_AUoAA&biw=1280&bih=656&dpr=1

*For management refer to page number 19.

9) Gummosis:

Disease symptoms:

- The disease is characterized by the presence of profuse oozing of gum on the surface of the affected wood, bark of the trunk and also on larger braches but more common on the cracked branches.
- In severe cases, droplets of gum trickle down on stem, bark turn dark brown with longitudinal cracks, rots completely and the tree dries up because of cracking, rotting and girdling effects

Survival and spread:

- Pathogen survives in disease plant debris.

Favourable conditions:

- Warm weather favours the development of disease.



1.

2.

3.

Disease symptoms

1,2,3: https://www.google.co.in/search?q=gummosis+disease+of+mango&espv=210&es_sm=93&source=Inms&tbn=isch&sa=X&ei=JqoRU7yAGcnUrQfSsoD4Aw&ved=0CAcQ_AUoATgK&bi

*For management refer to page number 19.

10) Root rot & damping off:

Disease symptoms:

- The disease is characterized by sudden dropping of leaves after the emergence of seedlings from the soil.
- During prolonged rainy and humid weather, infection occurs at / or below the ground level with circular to irregular water soaked patches.
- These patches enlarge and ultimately girdle the entire base of the seedlings.

Survival and spread:

- Disease is soil borne and pathogen survives in soils of orchards. Primary infection occurs by soil and secondary by conidia through rain or wind.

Favourable conditions:

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



1. Root Rot



2. Damping-off

1,2: https://www.google.co.in/search?espv=210&es_sm=93&source=Inms&tbm=isch&sa=X&ei=JqsRU9_VHMjprAell4HIAg&ved=0CAkQ_AUoAQ&biw=1280&bih=656&q=root%20rot%20and%20damping%20of%20mango#q=root+rot+mango&tbm=isch&facr

*For management refer to page number 14.

11) Scab:

Disease symptoms:

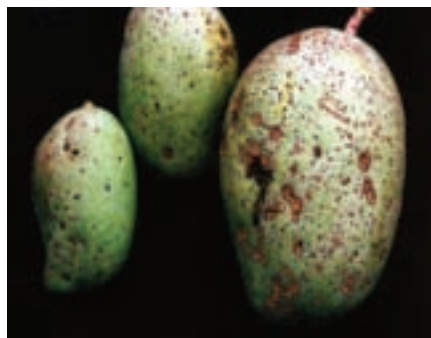
- The scab fungus attack leaves, panicles, blossoms, twigs, bark of stems and mango fruits. Spots are circular, slightly angular, elongated, 2-4 mm in diameter, brown but during rainy season, lesions differ in size, shape and colour.
- Symptoms produced by the disease are very much like those of anthracnose.
- On young fruits, the infection is grey to grayish brown with dark irregular margins. As the fruit attains in size, spots also enlarge and the centre may become covered with the crack fissure and corky tissues.

Survival and spread:

- The pathogen survives in the form of resting spore in the soil debris.

Favourable conditions:

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



1.



2.

Disease symptoms

1,2: https://www.google.co.in/search?q=scab+of+mango&espv=210&es_

12) Postharvest diseases:

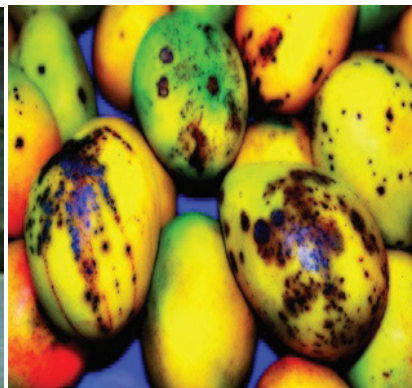
- The mango fruit is susceptible to many postharvest diseases caused by anthracnose (*C. gloeosporioides*) and stem end rot (*L. theobromae*) during storage under ambient conditions or even at low temperature. Aspergillus rot is another postharvest disease of mango.



1.



2.



3.

Fruits showing anthracnose symptoms

1,2,3: https://www.google.co.in/search?q=anthracnose+of+mango&espv=210&es_sm=93&source=Inms&tbm=isch&sa=X&ei=_H0QU-jEMMfGrAe8gYGoAQ&ved=0



1.



2.



3.

Stem end rot

Aspergillus rot

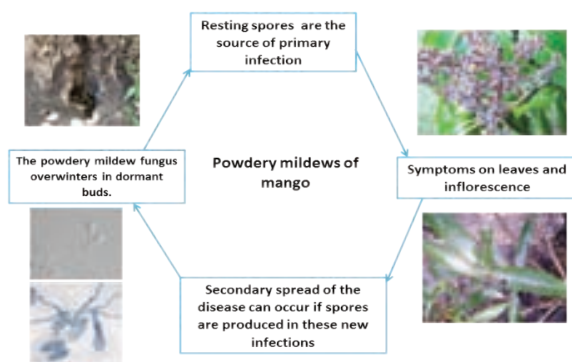
1,2: https://www.google.co.in/search?q=stem+end+rot+of+mango&espv=210&es_sm=93&source=Inms&tbm=isch&sa=X&ei=IK4RU5OUMoSFrgeimIDYDQ&ved=0CAkQAUoAQ&biw=1280&bih=656#fac

3: https://www.google.co.in/search?q=aspergillus+rot+in+mango&espv=210&es_sm=93&source=Inms&tbm=isch&sa=X&ei=k7ARU67dEcePrQeYooH4Bg&v

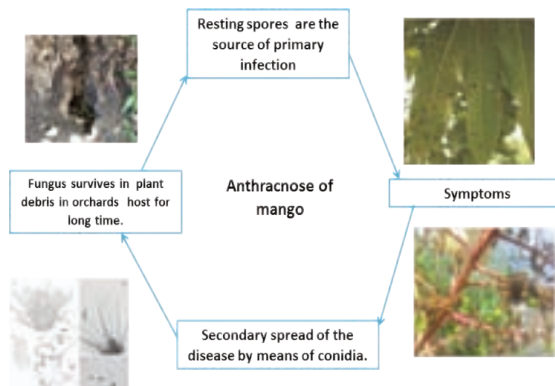
*For management refer to page number 20.

Life cycles:

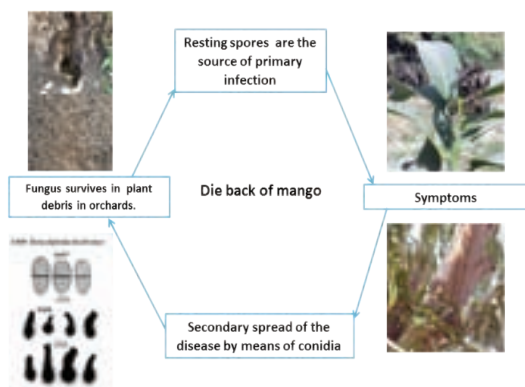
1) Powdery mildew:



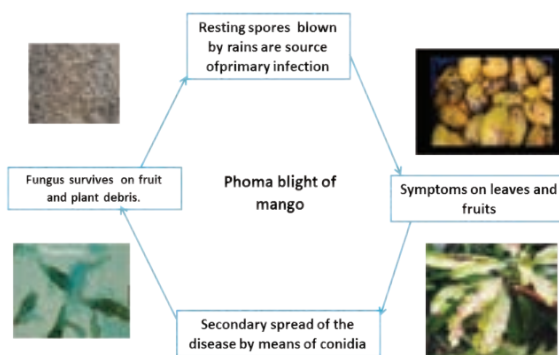
2) Anthracnose:



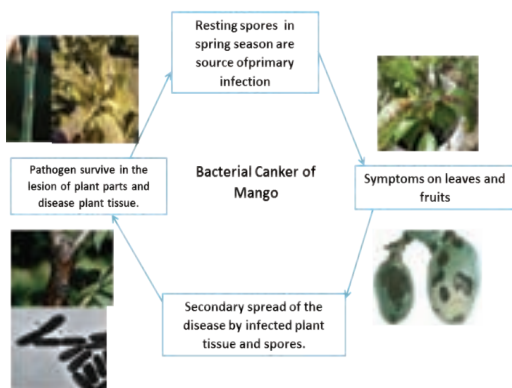
3) Dieback:



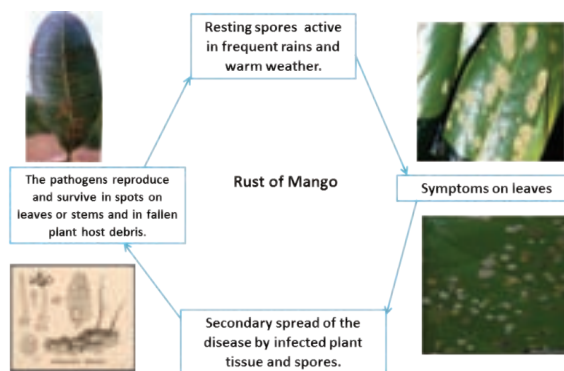
4) Phoma blight:



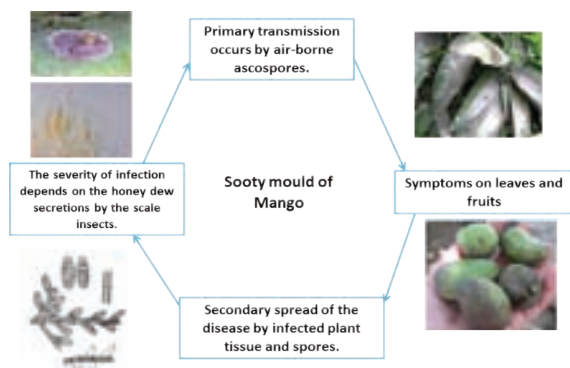
5) Bacterial canker:



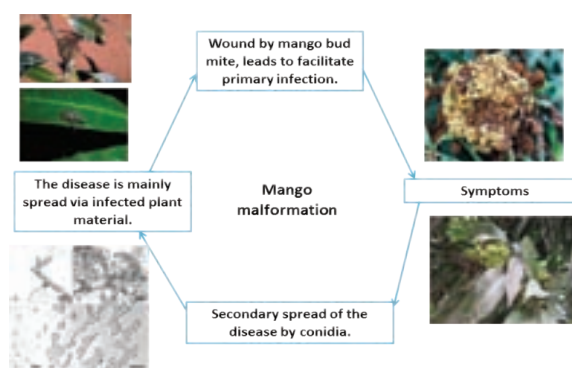
6) Red rust:



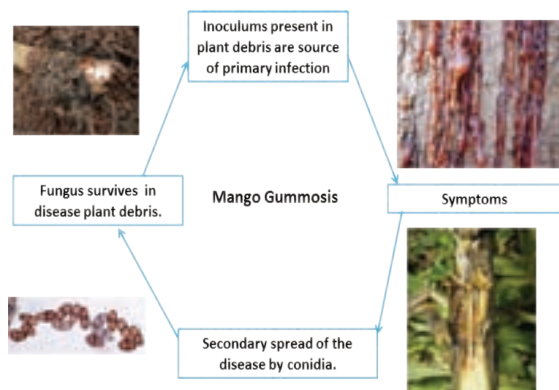
7) Sooty mould:



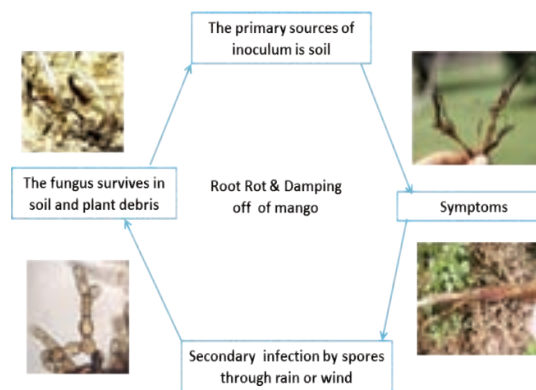
8) Mango malformation:



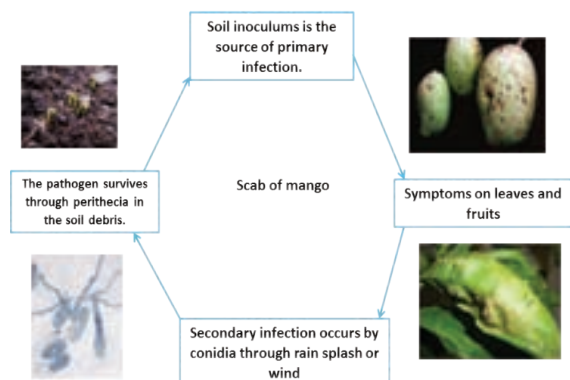
9) Gummosis:



10) Root rot & Damping off:



11) Scab:



XI. SAFETY MEASURES

A. At the time of harvest:

The following precautions should be taken during harvesting.

- Harvesting should be done by using appropriate instruments like clippers or by carefully twisting and pulling the fruit from the tree.
- The harvesting under wet conditions should be avoided, since wet fruits are more susceptible to microbial growth and soil particles may cling to wet crops, exposing them to soil-borne rot organisms.
- Harvesting of fruits is best in the late morning, because the oil glands of these fruits are full in the early morning, causing immediate discolouration.
- Stems left on the fruit should be cut off closely because they can puncture other fruit, causing post harvest decay and fruit spoilage.
- The tree should never be shaken to harvest the fruits. The fruits should not be allowed to fall on the soil to avoid the mechanical injury that makes fruit more prone to decay.
- After harvesting, the fruits should never be left in direct sunlight and must be kept in the shade.
- The contact of fruits with the soil should be avoided and should be kept carefully into padded field crates, well-ventilated plastic containers, or picking bags.
- Picking bags should either strapped around the waist or put over the shoulder.
- Picking bags should be designed to empty from the bottom so that fruits can roll out of the sack onto the bottom of a larger field container or atop fruits already present.

Maturity:

External colour, appearance, pulp colour and soluble solids content are the reliable indicators for judging the fruit maturity. At the time of maturity, stone becomes hard and pulp colour changes from white to cream. In few varieties, at maturity stage, fruits sink in water

Maturity Indices:

The maturity indices are as under :

- Color change from green to yellow.
- Development of "shoulders" on the stem end of the fruit.
- Fruit flesh turns from white to yellow starting at the endocarp and progressing outward to the skin during maturation.
- Stone becomes hard and pulp colour changes from white to cream.
- In few varieties fruits sink in water (Langra, Chousa)
- In case of Alphonso Mangoes, the fruit is considered mature when the shoulder outgrows the stem and the external colour becomes light green with a yellowish red blush.
- The harvest maturity in Dashehari and Langra cultivars reaches 12 weeks after fruit set. In Chausa and Mallika it takes about 15 weeks.
- The best way to observe maturity in mango is the colour of the pulp, which turns cream to light yellow on maturity and hardening of stone.

Few facts about the maturity of mango:

- Mango fruits need 120 to 140 days after fruit set to mature
- When a few semi-ripe fruits fall from tree –traditionally it is considered as maturity stage
- Picking fruits when their specific gravity is 1.01-1.02 gives good quality fruits
- Sinking of fruits in water indicates full maturity
- Fruits dipping in water have specific gravity >1.02
- Fruits dipping in 2.5% salt solution but floating in 5% salt solution: specific gravity 1.02-1.04
- Fruits dipping in 5% salt solution have specific gravity >1.04 and are over matured

Four maturity stages:

- a. Fruit shoulders are in line with stem end and the colour is olive green
- b. Shoulders outgrow the stem-end and colour is olive green
- c. Shoulder outgrow-stem end and colour becomes light

- d. Flesh becomes soft and blush develops

Fruits harvested at any of the above stages ripen well but those harvested at second and third stage give best taste and flavour

- When a few semi-ripe fruits fall from the tree, it is traditionally considered that the fruits are mature for harvest.
- If immature mangoes are picked, fruits develop white patches or air pockets and this effects taste and flavour, whereas over-mature fruits lose their storage life. Such fruits present numerous problems during handling.
- It is desirable to pick the fruits at the correct stage of maturity to facilitate ripening, distant transportation and maximum storage life, and thus to increase their quality and market value

B. During post-harvest storage:

Nearly, 20-25 per cent of fruits are wasted due to faulty post-harvest practices during harvesting, packaging, storage, grading etc. This wastage can be reduced to some extent through proper and scientific methods

Like post-harvest management, the pre-harvest and subsequent harvesting of the fruits also play an important role in enhancing the shelf life and quality of the fruits.

1. Pre-harvest factors influencing the post-harvest management:

The pre-harvest cultural practices like use of fertilizers, pest control, growth regulators, climatic conditions like wet and windy weather and tree conditions influence the fruit potentiality for storage by modifying physiology, chemical composition and morphology of fruits. The spray of calcium is found useful in delaying ripening of mangoes which improves the storage life and increased marketability.

2. Storage:

- Mango fruits are able to respond metabolically to the environment under which it is stored.
- Various methods are employed to extend the storage life of mangoes.
- They are low temperature storage, subatmospheric pressure storage, controlled atmospheric storage, irradiation and use of chemicals.

a. Low temperature storage:

- Low temperature storage is one of the most effective means of extending the shelf life of mangoes.
- It reduces the rate of respiration and lowers the rate of ethylene evolution.
- The storage periods of 18-21 and 23-26 days, respectively are for ripe and mature green Carabao and Pico mangoes at 10 °C various cultivars of mango are stored at 12 °C and ripened them subsequently.
- The ripening was retarded more effectively in immature than in mature Amelie and Kent fruits, whereas Sensation mangoes ripened rapidly during storage, regardless of fruit maturity at harvest.
- Fruits are stored at 12 °C for 33, 28, 21 and 15 days, respectively.
- The development of beta-carotene is slower at 16-20 °C than at 20-28 °C in many Florida mango varieties and suggested a temperature of 20-22 °C and 85-90% RH for storage and proper ripening of mangoes to obtain acceptable quality.
- That precooled Langra and Dashehari fruits could be stored successfully at 7 and 9 °C and 85-95% RH for 35-45 and 25-35 days, respectively.
- These fruits, after removal from cool store, ripened to a satisfactory palatability without affecting the sugars, though carotenoids development was low.
- Surface waxing coupled with low temperature storage of mango fruits reduced respiration, prolonged shelf life and also lessened spoilage.
- Carabao mango could be stored for 17-24 days 7.2-10 °C and 85-90% RH with 5.1% loss, Pico mango for 17 days with 6.2% loss at same temperature and relative humidity and Raspuri mango for 4 weeks at 8.3 °C and 85-90% RH with 6.8% loss.
- Bangalora, Khuddus, Neelum, Pedda, Raspuri, Safeda mangoes could be stored for 4-7 weeks at 7-9 °C at 85-90% RH and Alphonso mango for upto 4 weeks at 8-10 °C and 85-90% RH.
- Alphonso from India could be stored for 7 weeks at 7-9 °C and 90% RH. Julie mango could be stored for 2 weeks at 11-12 °C and 90% RH and Zill mango for 3 weeks at 10 °C and 90% RH.

- Dashehari mango at 12 °C has a shelf life of 21 days and subsequently 6 days at ambient condition with around 75-85% RH.
- Chilling injury occurs in Dashehari mango when stored at 10 °C and 75-85% RH for more than 14 days.
- Mallika mango could be stored in marketable condition for 10 and 21 days at room and low (12 °C and 85-90% RH) temperatures, respectively.

b. Chilling Injury:

- Storage of mango fruits for longer periods below a critical temperature level causes chilling injury.
- The chilling injury manifests as definite pitting on the surface, darkening and softening of the tissues.
- The chilling injury causes leakage of metabolites such as amino acids, sugars and minerals from the cells.
- There is an increased invertase and decreased amylase activities in chill injured fruits.
- The fruits show chilling injury symptoms after 10 days of storage at 4 and 8 °C, and succinate oxidation capacity of mitochondria decreased. 4% calcium chloride impregnated at 350 mm Hg or 200 mm Hg subatmospheric pressure is effective in controlling the chilling injury in Baneshan mangoes upto 3 weeks.
- Observation of chilling injured Baneshan mango fruits tissues showed that in the initial stages of injury, the damage was restricted to the surface of the fruit in the form of discoloured pits without affecting pulp beneath.
- However, with the advancement of damage, at the later stages both the peel and pulp appeared to be damaged more because of microbial attack (secondary infection) through the damaged (pitted) skin.
- Histological observations revealed that chilling injury damaged the cuticle and epidermis and exposed the sugar rich mesocarp for attack by micro-organisms.

c. Controlled-atmosphere storage:

- Controlled atmosphere (CA) or modified atmosphere (MA) storage, either alone or coupled with refrigerated storage has been recommended for various fruits and vegetables.
- Keitt mangoes are stored for 20 days at 13 °C in an atmosphere of 5% CO₂ and 5% O₂. Mango has a fairly low tolerance to CO₂.
- At 15% CO₂ level, the fruits did not develop normal red colour, although the flavour was good.
- Haden mangoes could be stored for 6 weeks under 2% oxygen and either 1 or 5% carbondioxide at 10-11 °C.
- Optimum concentrations for Julie and Amelie mangoes have been reported as 5% oxygen and 5% carbondioxide at 11 °C for 4 weeks.
- Controlled atmosphere storage at oxygen levels of 1% resulted in the production of off-flavours and skin-discolouration, but storage at 12 °C with 5% carbondioxide and 5% oxygen was possible for 20 days.
- Storage at 8 °C with 10% carbondioxide and 6% oxygen was successful for 4 weeks for Haden and 6 weeks for Carlotta, Jasmin and San Querino.
- Controlled atmosphere storage in 10-15 °C with 5% oxygen or with 5-10% carbondioxide and 3-5% oxygen had a fair effect on storage but was not being used commercially.
- In controlled atmosphere storage, trials to control infestation of fruitfly in mango fruits, it was found that fruits exposed to 50% carbondioxide with 2% oxygen for 5 days or 70-80% carbondioxide with less than 0.1% oxygen (modified atmosphere storage) for 4 days did not suffer adverse effects when they were subsequently ripened in air.
- Lower levels of CO₂ (10 and 20%) in combination with 5% O₂ were, however, effective in reducing ethylene production during 3 weeks of CA storage at 12°C without affecting subsequent ripening in air.
- The above findings clearly indicate a great prospect in shipping mangoes by sea under CA storage.

d. Hypobaric storage:

- It is a type of CA storage with emphasis on reducing the pressure exerted on the storage material.
- This method not only reduces O₂ concentration but also increased the diffusion of C₂H₄ by evacuating it from the tissues of the fruit, consequently extending the storage life.
- The fruits stored at 100 and 75 mm Hg started to ripen after 25-35 days as against control after 16 days.
- Pressure 152 mm Hg is optimum for storage of cultivars Irwin, Tommy Atkins and Kent for 3 weeks at 130 C and 90-100% RH.

e. Low cost storage:

- Evaluation of zero energy cool chambers at different locations of the country was found to be satisfactory for short term storage of mangoes.

- The major advantage of cool chamber storage of mangoes was the maintenance of fruit firmness by lowering the physiological loss in weight (PLW) and other metabolic processes.
- Eventually, 3-4 days more shelf life of mature green mangoes could be obtained in cool chamber storage as compared to ambient condition storage.
- Further, a 500 ppm bavistin dip helped in checking the microbial infection.

f. Irradiation:

- Extensive studies have been conducted to determine the effect of r-radiation on the shelf life extension of mango.
- The optimum radiation dose for Alphonso mango is 25 K rad, giving an extension in shelf life of 6 to 8 days at ambient temperature.
- The response of Kensington Pride mango to r-irradiation which caused delay in ripening of less mature mangoes, characterised by inhibition of skin colour, degreening and slow reduction of titrable acidity, while the fruits at climacteric stage was uneffected.
- The lower dose levels of irradiation in combination with other treatments to induce delayed ripening and reduced post harvest spoilage.
- A combination of hot water treatment (55 °C for 5 minutes) followed by 30 Gy irradiation was found to be the best treatment in terms of shelf life extension and quality of mangoes.
- After this treatment, mangoes had a storage life of 38 days (at 15 °C), 28% rotting and no irradiation injury.
- Irradiation can be used as a post harvest treatment to disinfest fruits off insects.
- It was observed that 300 Gy control mango seed weevil while 150 Gy was shown to control 11 species of Tephritidfruitfly and 75 Gy prevents the adults emerging from the fruits but more work is needed.
- Doses of irradiation in excess of 600 Gy caused lenticel spotting, surface discolouration and retardation of ripening of Kensington Pride mangoes, but irradiation at this level contributed to only minor improvements in disease control.

Source: <http://agmarknet.nic.in/preface-mango.pdf>

3. Post harvest treatments:

a. Hot water treatment:

Mangoes may be immersed in hot water before storage or marketing to control diseases.

1. A common disease of fruit, which can be successfully controlled in this way, is anthracnose, caused by infections of the fungus *Colletotrichum* spp.
2. Treat the mangoes at 53 °C for 5 minutes and or 51-55 °C for 30 minutes.
3. The hot water treatment had little or no effect on the quality of marketable life of the fruits.
4. In subsequent work, hot water treatment of mangoes to control fruit fly and anthracnose increased the rate of shriveling and the change in total soluble solids: acid ratio and reduced the fruit firmness and acidity during subsequent storage.
5. Exposure of Julie mangoes to 55 °C for 5 min resulted in scorch.
6. In other work, the skin colour of mangoes was improved by both hot water and vapour heat treatment.
7. Hot water containing fungicide can also be effective in the control of stem end rot caused by the fungus *Dothiorella dominicana*.

b. Vapour heat treatment (VHT)




- Vapour heat treatment was developed to control infections of fruit flies in fruit post-harvest.
- A recommended treatment of mangoes is 43 °C in saturated air for 8 hours then holding the temperature for further 6 hrs.
- Fruit fly in Carabao mangoes can be controlled by exposing the mangoes to high humidity hot air i.e. 46 °C and 95% RH and above.
- The exposure time was judged by placing a temperature probe alongside the fruit seed and when it had reached 46 °C, they were kept under those conditions for 10 minutes.
- By exposing Carabao mangoes to a core temperature of 46 °C for 10 minutes by VHT resulted in significant reduction in both anthracnose and stem-end rot.




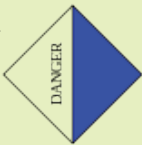
Source: http://www.ikisan.com/crop%20specific/eng/links/ap_mangoPost%20Harvest%20Technology.shtml

XII. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The field should be kept exposed to sun light at least for 2-3 weeks	Do not plant or irrigate the field after ploughing, at least for 2-3 weeks, to allow desiccation of bulbs and/or rhizomes of perennial weeds.
2.	Adopt inter-cropping of recommended crops.	Do not disturb the plant roots by adopting ploughing away from the pits.
3.	Grow only recommended varieties.	Do not grow susceptible varieties.
4	Always treat the seedlings with approved chemicals/ bio products for the control of seed borne diseases/ pests	Do not use seedlings without seed treatment with bio-pesticides/chemicals.
5	Plant in rows at optimum depths under proper moisture conditions for better establishment.	Do not plant seedlings beyond 5-7 cm depth.
6	Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
7	Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition	Crops should not be exposed to moisture deficit stress at their critical growth stages.
8	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
9	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
10	Conduct weekly AESA in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.	Do not take any management decision without considering AESA and P: D ratio
11	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
12	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per field observation	Do not apply chemical pesticides within seven days of release of parasitoids.
13	Apply NPV of respective Lepidopteran moth if available at recommended dose when a large number of egg masses and early instar larvae are noticed. Apply NPV only in the evening hours after 5 pm.	Do not apply NPV on late instar larva and during day time.
14	In case of pests which are active during night spray recommended biopesticides/chemicals at the time of their appearance in the evening.	Do not spray pesticides at midday since, most of the insects are not active during this period.
15	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, and other sucking pests harbouring the lower side of leaves.	Do not spray pesticides only on the upper surface of leaves.
16	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
17	Follow the recommended procedure of trap crop technology.	Do not apply long persistent pesticides on trap crop, otherwise it may not attract the pests and natural enemies.

XIII. SAFETY PARAMETERS IN PESTICIDE USAGE

S. No.	Pesticide Classification as per insecticide rules 1971 Colour of toxicity triangle	WHO classification of hazard	Symptoms of poisoning	First aid measures and treatment of poisoning	Safety interval (days)
1.	Dimethoate Highly toxic 	Class II Moderately hazardous	Mild-anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity	First aid measures: Rush to the nearest physician. Treatment of poisoning: For extreme symptoms of OP poisoning, injection of atropine (2-4 mg for adults, 0.5-1.0 mg for children) is recommended. Repeated at 5-10 minute intervals until signs of atropinization occur.	-
2.	Imidacloprid Highly toxic 	— do —	Harmful if swallowed, absorbed through skin or inhaled. Avoid breathing vapor or spray mist. Causes moderate eye irritation.	First aid measures: Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious Person Treatment of poisoning: No specific antidote. Treatment is essentially symptomatic.	3
3.	Chlorpyrifos Highly toxic 	— do —	Severe – diarrhoea, pinpoint and non - reactive pupils, respiratory difficulty, pulmonary edema, cyanosis, loss of sphincter control, convulsions, coma and heart block.	First Aid measures: Atrophine sulphate Treatment of poisoning: For ingestion lavage stomach with 5 % sodium bicarbonate, if not vomiting. For skin contact, wash with soap and water (eyes – wash with isotonic saline). Wear rubber gloves while washing contact areas. In addition to atropine give 2 – PAM (2 – pyridine aldoximemethiodide). 1 g and 0.25g for infants intravenously at slow rate over a period of 5 minutes and administer again periodically as indicated. More than one injection may be required. Avoid morphine, theophylline, aminophyllin, barbiturates Phenothiazines.	

4.	Monocrotophos Extremely toxic 	Class I b Highly hazardous	— do —	— do —	
5.	Oxydemeton-methyl Highly toxic 	Class II - Moderately hazardous	— do —	— do —	
6.	Malathion Moderately toxic	Class III Slightly hazardous	Mild-anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity	For extreme symptoms of OP poisoning, injection of atropine (2-4 mg for adults, 0.5-1.0 mg for children) is recommended. Repeated at 5-10 minute intervals until signs of atropinization occur.	
7.	Copper oxychloride Moderately toxic 	Class III Slightly hazardous	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	
8.	Carbendazim Moderately toxic 	Unlikely to present acute hazard in normal use	Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin, allergic manifestations etc.	First aid measures: Rush to the nearest physician. Treatment of poisoning: No specific antidote. Treatment is essentially symptomatic	

XIV. BASIC PRECAUTIONS IN PESTICIDE USAGE

A. Purchase

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

B. Storage

1. Avoid storage of pesticides in house premises.
2. Keep only in original container with intact seal.
3. **Do not** transfer pesticides to other containers; **Do not** store expose to sunlight or rain water; **Do not** 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
7. Avoid tank mixing of different pesticides










G. Disposal

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

XV. PESTICIDE APPLICATION TECHNIQUES

Equipment			
Category A: Stationary, crawling pest/disease			
Vegetative stage i) For crawling and soil borne pests	Insecticides and fungicides	<ul style="list-style-type: none">Lever operated knapsack sprayer (droplets of big size)Hollow cone nozzle @ 35 to 40 psiLever operating speed = 15 to 20 strokes/min orMotorized knapsack sprayer or mist blower (droplets of small size)Airblast nozzleOperating speed: 2/3rd throttle	
ii) For small sucking leaf borne pests			
Reproductive stage	Insecticides and fungicides	<ul style="list-style-type: none">Lever operated knapsack sprayer (droplets of big size)Hollow cone nozzle @ 35 to 40 psiLever operating speed = 15 to 20 strokes/min	
Category B: Field flying pest/airborne pest			
Vegetative stage Reproductive stage (Field Pests)	Insecticides and fungicides	<ul style="list-style-type: none">Motorized knapsack sprayer or mist blower (droplets of small size)Airblast nozzleOperating speed: 2/3rd throttle OrBattery operated low volume sprayer (droplets of small size)Spinning disc nozzle	
Mosquito/ locust and spatial application (migratory Pests)			
Category C: Weeds			
Post-emergence application	Weedicide	<ul style="list-style-type: none">Lever operated knapsack sprayer (droplets of big size)Flat fan or floodjet nozzle @ 15 to 20 psiLever operating speed = 7 to 10 strokes/min	
Pre-emergence application	Weedicide	<ul style="list-style-type: none">Trolley mounted low volume sprayer (droplets of small size)Battery operated low volume sprayer (droplets of small size)	

XVI. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

1.	For application rate and dosage see the label and leaflet of the particular pesticide.	
2.	It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.	
3.	Clean and wash the machines and nozzles and store in dry place after use.	
4.	It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides. Do not apply pesticides without protective clothing and wash clothes immediately after spray application.	
5.	Do not apply in hot or windy conditions.	
6.	Operator should maintain normal walking speed while undertaking application.	
7.	Do not smoke, chew or eat while undertaking the spraying operation	
8.	Operator should take proper bath with soap after completing spraying	
9.	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

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Plants Suitable for Ecological Engineering in Mango Orchard



Cluster bean



Sunflower



***Ocimum* spp.**



Cosmos



Spearmint



Mustard



Marigold



Carrot



Sorghum



Cowpea



Buckwheat



Maize



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