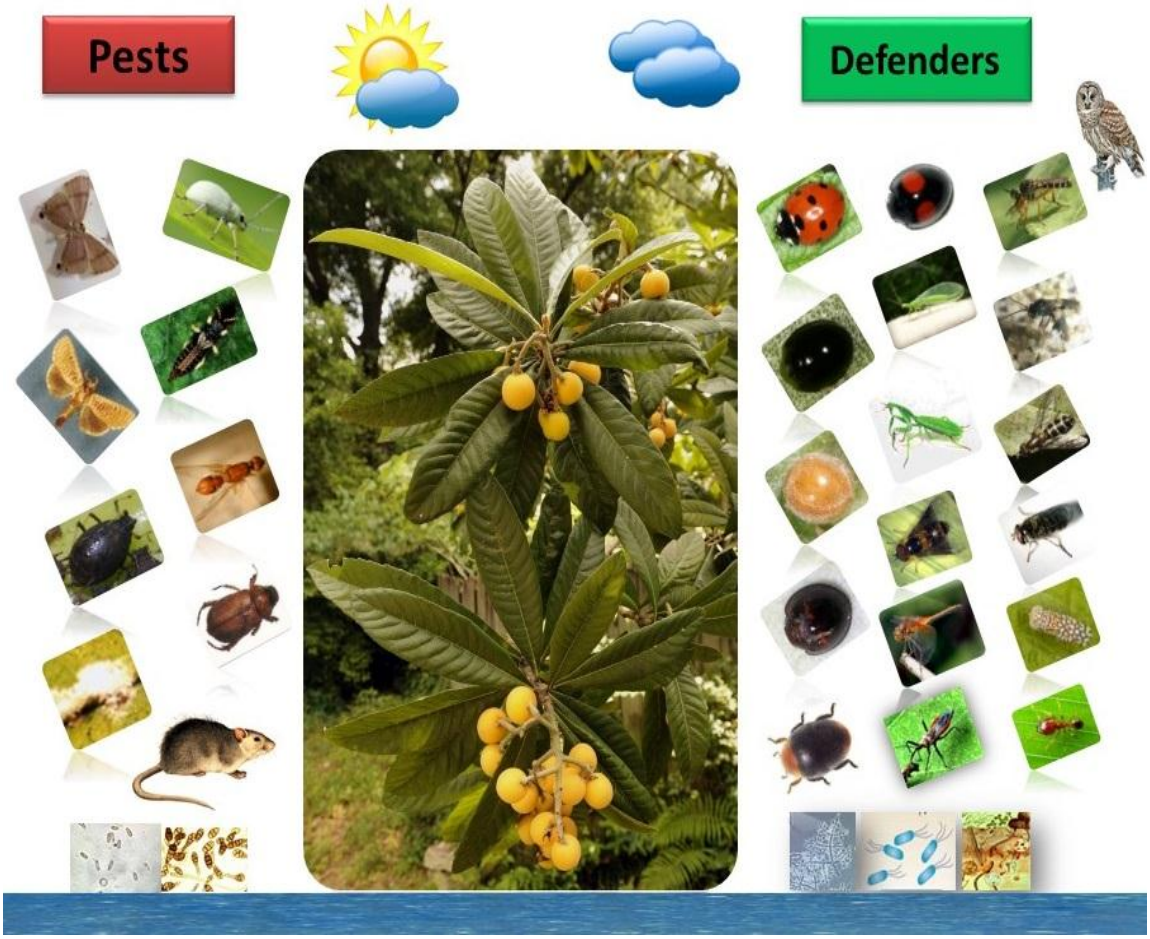
सत्यमेव जयते

AESA BASED IPM PACKAGE
LOQUAT



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

National Institute of Plant Health Management
Rajendranagar, Hyderabad, Telangana

Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

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

NIPHM Working Group:

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

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

Other Members:

1. Dr. Sakthivel, Assistant Scientific Officer (RPM), Rodent Expertise.

Contributions by DPPQ&S Experts:

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

Contributions by External Experts:

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

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

सत्यमेव जयते

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

FOREWORD

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

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

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

A Dalwai 25/06/2015

Dated: 25.06.2015

[Ashok Dalwai]

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

सत्यमेव जयते

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

FOREWORD

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

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

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

(Utpal Kumar Singh)

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

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

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

PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

CONTENTS

AESA BASED IPM PACKAGE FOR LOQUAT

Loquat -Plant description

The loquat (*Eriobotrya japonica*) is a large evergreen shrub or small tree with a rounded crown, short trunk and woolly new twigs. The tree can grow 20-30 feet height, but is usually much smaller than this (about 10 feet). Loquats are easy to grow and are often used as an ornamental. Their boldly textured foliage adds a tropical look to the garden and contrast well with many other plants. Because of the shallow root system of the loquat, care should be taken in mechanical cultivation not to damage the roots. Loquat leaves are generally elliptical- lineolate, 5 to 12 inches long and 3 to 4 inches wide. They are dark green and glossy on the upper surface, whitish or rusty-hairy beneath, thick and stiff, with conspicuous parallel, oblique veins. The new growth is sometimes tinged with red. The leaves are narrow in some cultivars and broad in others. Small, white, sweetly fragrant flowers are borne in fall or early winter in panicles at the ends of the branches. Before they open, the flower clusters have an unusual rusty-woolly texture. Loquat fruits, growing in clusters, are oval, rounded or pear-shaped, 1 to 2 inches long with a smooth or downy, yellow or orange, sometimes red-blushed skin. The succulent, tangy flesh is white, yellow or orange and sweet to sub acid or acid, depending on the cultivar. Each fruit contains three to five large brown seeds.

The loquat is normally pollinated by bees. Some cultivars are self-infertile and others are only partially self-fertile. Flowers of the early and late flushes tend to have abnormal stamens and very little viable pollen. Thinning of flowers and young fruits in the cluster, or clipping off all or part of flower and fruit clusters is sometimes done to enhance fruit size. Under moist conditions the loquat tends to develop an alternate-bearing pattern, which can be modified somewhat by cluster thinning in heavy production years. For the highest quality fruit the clusters are sometimes bagged to protect from sunburn and eliminate bird damage.

I. PESTS

A. Pests of National Significance

1. Insect and mite pests

1.1 Fruit fly: *Bactrocera dorsalis* (Hend.) (Diptera: Tephritidae)
1.2 Bark eating caterpillar: *Indarbela quadrinotata* Walker (Lepidoptera: Cossidae)
1.3 Scale: *Coccus viridis* (Green) (Hemiptera: Coccidae)
1.4 Aphid: *Toxoptera aurantii* Boyer de Fonscolombe (Hemiptera: Aphididae)
1.5 Thrips: *Heliothrips* spp. Bouché (Thysanoptera: Thripidae)
1.6 Chafer beetle: *Adoretus duvauceli* Blanchard (Coleoptera: Scarabaeidae)
1.7 Grey weevil: *Myllocerus discolor* Boheman (Coleoptera: Curculionidae)
1.8 Pomegranate butterfly: *Deudorix epijarbas* (Moore) (Lepidoptera: Lycaenidae)

2. Diseases

2.1 Shoot/fruit blight and bark canker: Phoma glumerata (Corda) Wollenw & Hochapfel
2.2 Crown rot: *Phytophthora* spp. (Mont.) de Bary
2.3 Root rot/ white rot: *Polyporus paustis* P. Micheli ex Adans
2.4 Wither tip: *Colletotrichum gloeosporioides* (Penz.) Penz. and Sacc.
2.5 Collar rot: *Sclerotium* sp. Sacc. & *Diplodia* spp. Fr.
2.6 Twig blight and canker: *Cytospora chrysosperma* Pers
2.7 Die back: *Cytospora eriobotryae* Curzi
2.8 Leaf spot: *Entomosporium* sp
2.9 Fire Blight: *Erwinia amylovora* (Burrill 1882) Winslow
2.10 Scab: *Spilocaea* spp., *Venturia* spp.

3. Weeds

Broadleaf

3.1 Lambs quarter: *Chenopodium spp.* L. (Chenopodiaceae)
3.2 Scarlet pimpernel: *Anagallis arvensis* L. (Primulaceae)
3.3 Creeping wood sorrel: *Oxalis corniculata* L. (Oxalidaceae)
3.4 Goat weed: *Ageratum conyzoides* L. (Asteraceae)
3.5 Coat buttons: *Tridax procumbens* L. (Asteraceae)
3.6 Congress grass: *Parthenium hysterophorus* L. (Asteraceae)
3.7 Tropical spiderwort: *Commelina benghalensis* L. (Commelinaceae)
3.8 Painted spurge: *Euphorbia geniculata* Ortega (Euphorbiaceae)
3.9 False Mallow: *Malvastrum coromandelianum* (L.) Garcke (Malvaceae)

Grasses

3.10 Bermuda grass: *Cynodon dactylon* L. Pers. (Poaceae)
3.11 Cogon grass: *Imperata cylindrica* (L.) Raeusch. (Poaceae)
3.12 Large crabgrass: *Digitaria sanguinalis* L. (Scop.) (Poaceae)
3.13 Knot grass: *Paspalum distichum* L. (Poaceae)
3.14 Rabbit/crow foot grass: *Dactyloctenium aegyptium* (L.) Willd (Poaceae)
3.15 Yellow foxtail: *Setaria glauca* (L.) P. Beauv. (Poaceae)

Sedges

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

4. Rodents

4.1 Indian mole rat: *Bandicota bengalensis* (Gray) (throughout India)
4.2 Soft furred field rat: *Millardia meltada* (Gray) (throughout India)
4.3 Vole: *Alticola* spp.

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

A. AESA

The IPM has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment ultimately affecting the interests of the farmers. The economic threshold level (ETL) was the basis for several decades but in modern IPM (FAO 2002) emphasis is given to AESA where farmers take decisions based on larger range of orchard observations. The health of a plant is determined by its environment which includes physical factors (i.e. 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 orchard situation and how to make proper decisions for their crop management. This process is called the AESA. Participants of AESA will have to make a drawing on a large piece of white paper (60 x 80 cm), to include all their observations. The advantage of using a drawing is that it requires the participants/farmers to observe closely and intensively. It is a focal point for the analysis and for the discussions that follow, and the drawing can be kept as a record.

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

- Plant health at different stages
- Built-in compensation abilities of plants
- 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/seedlings/planting material with recommended pesticides especially biopesticides
- Follow proper spacing
- Soil health improvement (mulching and green manuring wherever applicable)
- Nutrient management especially organic manures and biofertilizers based on the soil test results. If the dosage of nitrogenous fertilizers is too high the crop becomes too succulent and

therefore susceptible to insects and diseases. If the dosage is too low, the crop growth is retarded. So, the farmers should apply an adequate amount for best results. The phosphatic fertilizers should not be applied each and every season as the residual phosphate of the previous season will be available for the current season also.

- Proper irrigation
- Crop rotation

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

Farmers should

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

http://www.miao-expo.com/en/photo/pics/20121127/1353994925.jpg

Plant compensation ability

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

Understand and conserve defenders

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

Insect zoo

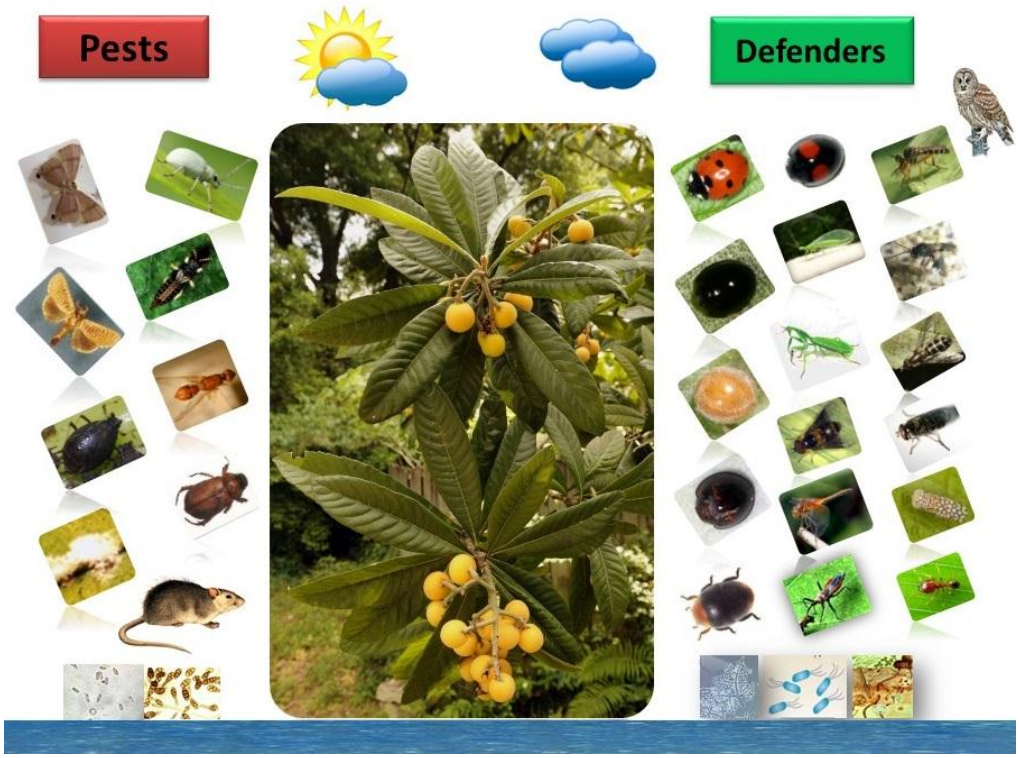
In orchard various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in crop orchard. Insect zoo concept can be helpful to enhance farmers' skill to identify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

Pest: Defender ratio (P: D ratio):

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

Model agro-ecosystem analysis chart

Date:
Village:
Farmer:



Decision taken based on the analysis of orchard situations

Soil conditions :
Weather conditions :
Diseases types and severity :

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

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

Decision making

Farmers become experts in crop management

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

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

AESA methodology

- Go to the orchard in groups (about 5 farmers per group). Walk across the orchard and choose 20 plants/ acre randomly. Observe keenly each of these plants and record your observations:
    - Plant: Observe for the plant health, number of branches, crop stage, deficiency symptoms etc.
    - Pests: Observe and count 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.
    - Rats: Count number of plants affected by rats.
    - Weeds: Observe weeds in the orchard and their intensity.
    - Water: Observe the water situation of the orchard.
    - Weather: Observe the weather condition.

- While walking in the orchard, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.

- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the orchard situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the orchard situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on what orchard management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording

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

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

Data to be recorded

- **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 orchard between pests and defenders?
- Were you able to identify all pests and diseases?
- Do you think the crop is healthy?
- What management practices are needed at this moment?
- When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.
- Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest 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.

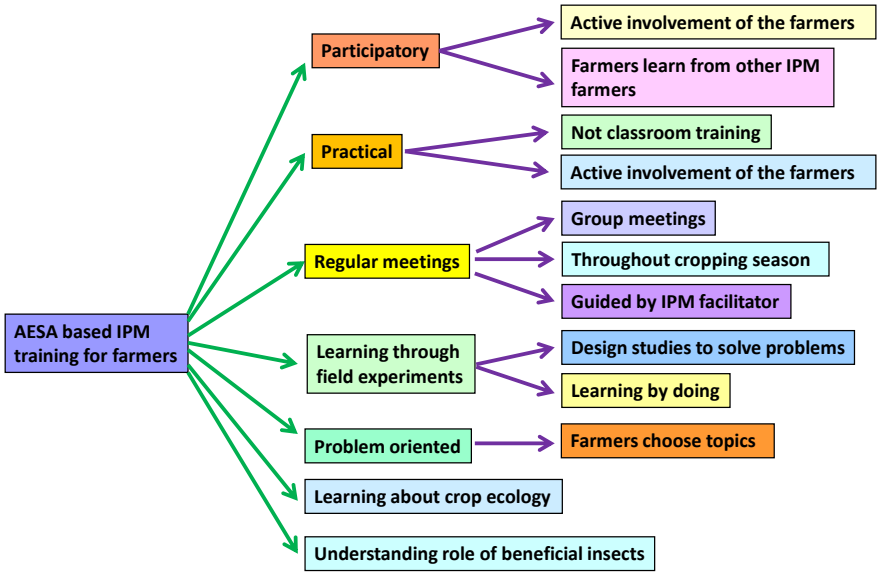
AESA and farmer orchard school (FFS)

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

Farmers can learn from AESA

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

FFS to teach AESA based IPM skills



B. Orchard scouting

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

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

Sampling in fruit crops:

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

Sampling patterns:

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

- **Zig-zag pattern**. Sampling a fallow orchard or one with no obvious symptoms in the current crop to see the incidence as well as sampling of viral, wilt disease.

- **Circle pattern**. Sampling within the drip line of trees and shrubs and for powdery mildew, downy mildew and leaf spot diseases etc.
- **Star pattern**. Sampling from a damaged area.

Sampling frequency:

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

- **Relative pest measuring estimates:** Counting the representative samples in a given area.
- **Absolute pest measuring estimates:** Counting all individuals in a population in a given area which determine total pest population size in a given area. It is very effective pest surveillance research tool but very time consuming, therefore, not practical and/or not economically feasible.
- **Get an idea of number of pests per unit:** To estimate pests per plant and/or area to make the decision.

For insect pests:
Aphids and scales: Count and record the number of both nymphs and adults on five randomly selected leaves per plant.
Thrips: Count and record the number of nymphs and adults of thrips present on five terminal leaves per plant (tapping method also can be used to count thrips).
Bark eating caterpillar: The number of galleries on five randomly selected twigs per plant should be counted and recorded.
Pomegranate butterfly and fruit fly: Total number of fruits, damaged fruits on individual plants should be counted and recorded.

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

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

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

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

C. Surveillance through pheromone trap catches for bark eating caterpillar, pomegranate butterfly, and fruit fly:

Pheromone traps for insects viz., bark eating caterpillar, pomegranate butterfly, and 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 orchard. Fix the traps to the supporting pole at a height of one foot above the plant canopy. Change of lures should be made at 2-3 week interval (regular interval). During each week of surveillance, the number of moths/trap/week should be counted and recorded year round. The trapped moths should be removed and destroyed after each recording.

D. Yellow/blue pan water/sticky traps

Set up yellow and blue plan water/sticky traps for aphids and thrips, respectively @ 4-5 traps each/acre. Locally available empty tins can be painted yellow/blue and coated with grease/Vaseline/castor oil on outer surface may also be used.

E. Light traps

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

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

Natural enemies may require

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

Ecological engineering for pest management – Above ground:

- Raise the flowering plants / compatible cash crops along the orchard border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population
- Grow flowering plants on the internal bunds inside the orchard
- Not to uproot weed plants those are growing naturally 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.

Ecological engineering for pest management – Below ground:

- Crop rotations with leguminous plants which enhance nitrogen content.
- Keep soils covered year-round with living vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance below ground biodiversity.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Apply balanced dose of nutrients using biofertilizers.
- Apply mycorrhiza and plant growth promoting rhizobacteria (PGPR)

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

Plants Suitable for Ecological Engineering for Pest Management
Attractant plants

Cluster bean

Cowpea

Carrot

Sunflower

Buck wheat

French bean

Alfalfa

Maize

Mustard

***Coreopsis* spp.**

Cosmos

Dandelion

Repellent plants

***Ocimum* sp**

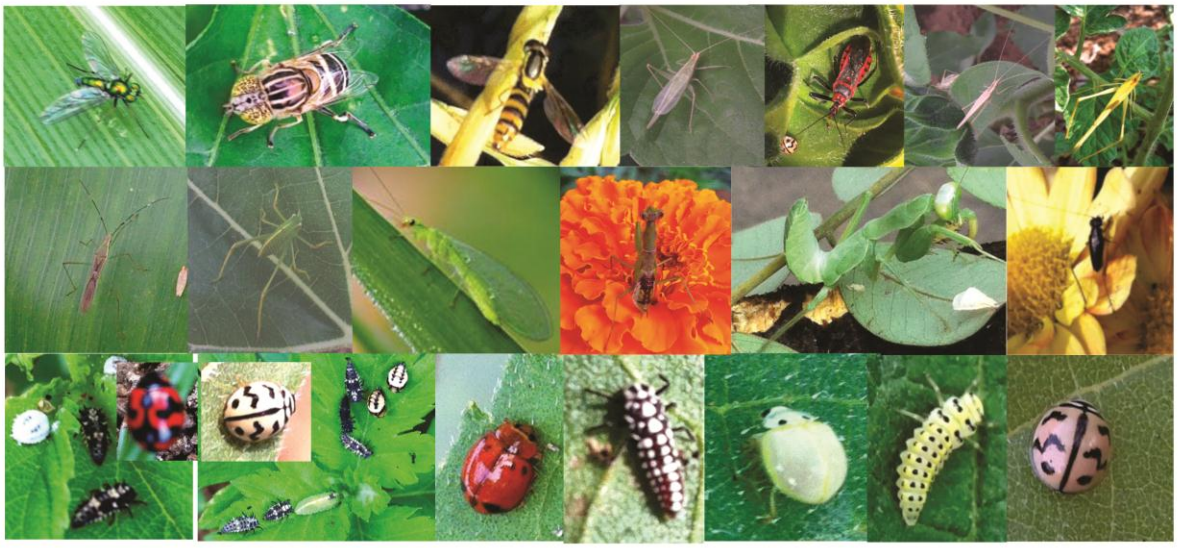
Peppermint

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-sowing / Pre-Planting *	
	Common cultural practices: • Timely planting should be done. • Orchard sanitation • Destroy the alternate host plants • Take proper soil sample and get soil test report prior to planting.
Nutrients	• Nutrient should be applied on the basis of soil test report and recommendation for the particular agro-climatic zone. • Pits of 0.75 cubic meter size are dug in summer at a distance of 6 to 8 m and left exposed to sunlight. • Pits are filled with a mixture of 30 cm top soil, 40-50 kg farmyard manure and 200 g Single Super Phosphate.
Weeds	• Deep ploughing during summer • Ploughing the orchard before planting to destroy existing weeds in the orchard
Soil borne pathogens, resting stages of insects	**Cultural control:** • Grow resistant/tolerant varieties. • Deep summer ploughing of orchards to control resting stages of insect pests. • Avoid excessive watering and provide proper drainage in the orchard.
Planting stage*	
	Common cultural practices: • Use healthy, certified and weed-free seeds for raising nursery.
Nutrients	• Planting is done in mid-August or mid-February in pits already filled with farm yard manure and top soil. • Add mycorrhiza culture @ 50 grams per pit or a basket of soil taken from old Loquat orchard to ensure mycorrhiza association with seedling roots. • Nutrient should be provided as per soil test recommendations.
Weeds	• Use weed free seedlings for planting. • Remove weeds from the pits before planting. • Intercropping with short duration cover crops should be done to suppress weeds between rows.
Vegetative state	
	Common cultural practices: • Destroy crop debris • Provide irrigation at critical stages of the plant • Avoid water logging • Avoid water stress condition. **Common mechanical practices:** • Collection and destruction of eggs and early stage larvae • Handpick the older larvae during early stages • The infested plant parts collect and destroyed

	Common biological practices: • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies
Nutrients	• Loquat needs heavy fertilization for luxuriant growth and bumper fruiting. A fertilizer dose of 750g N, 300g P and 750g K per year to a young plant should be given upto 3 years age. • Full dose of FYM, Phosphorous and Potash and half dose of N should be applied. Nitrogen should be applied in the month of February. • The nutrients should be applied in 20-30 cm deep and 30 cm wide trench along the drip line of the tree.
Weeds	• Mulching tree basin in April with plastic or straw mulch helps control weeds and conserves soil moisture. • Green manuring and leguminous vegetables crops like bean, pea, red clover and white clover should be grown to control weeds between vine rows as well as to improve soil texture and fertility. • Whenever intercrop not grown between the rows of trees, slashing and mowing of weed may be adopted.
Fruit fly	**Cultural control:** • Hoeing of the tree basins should be done to expose the pupae to their natural enemies. • Collect the infected fruits and dump in deep pits.
Aphid	**Cultural control:** • Collect and destroy the damaged plant parts • Maintain adequate aeration by proper training and pruning • Use yellow sticky traps @ 4-10 traps /acre
Pomegranate butterfly	**Cultural control:** • The fruits if screened with polythene or paper bags may escape infestation. • Removal and destruction of all the affected fruits. **Mechanical control:** • Remove weeds of compositeae family • Detect and remove early infestation by periodically looking for drying branches.
Thrips	**Cultural control:** • Sprinkle water over the seedlings to check the multiplication of thrips
Scale insects	**Cultural control:** • Collect and destroy damaged leaves • Apply well rotten sheep manure @ 4 t/ acre in two splits or poultry manure in 2 splits • Control ants and dust which can give the scale a competitive advantage.
Chafer beetle	**Mechanical control:** • Collection and destruction of adults beetle by handpicking in day time • Setup light trap in the night.

Shoot/ fruit blight and bark canker	**Mechanical control:** • The canker should be removed and the dead bark decorticated along with 2 cm of healthy bark. • The dead-wood and pruning's should be destroyed. • The wounds should be covered with a disinfectant solution
Crown rot	**Cultural control:** • Remove the severely infested trees and use them as fire wood. • Remove the diseased bark during the dry season by extending the cut an inch beyond the diseased zone on all sides. • Control of the disease is reliant on good water management. • Loquat should be planted in well-draining soils where water does not pool after rain or irrigation; • Plants should be allowed to dry out between irrigations
Root rot/ white rot	**Cultural control:** • Do not allow irrigation water to come in contact with the stem. **Mechanical control:** • Digout decayed roots and cut them completely right from the collar region • Treat the cut end of the roots immediately with disinfectant solution • Avoid deep houng and interculture to obviate injuries to the roots, through which fungus attacks.
Collar rot	• Follow common cultural, mechanical and biological practices
Wither tip	**Cultural control:** • Avoid planting susceptible varieties. **Mechanical control:** • Prune dead twigs before flowering, and regularly remove infected fruit and dead leaves.
Leaf spot	**Cultural control:** • Remove and dispose of spotted leaves • Do not water overhead as this spreads the fungus spores and favors infection. • Reduce humidity around plants by providing adequate space between them and by pruning lower branches. • Removing groundcovers beneath shrubs and mulching or maintaining bare soil instead**.**
Fire Blight	• Follow common cultural, mechanical and biological practices
Scab	**Cultural control:** • Clean cultivation • Apply urea (2 Kg/acre at pre-leaf fall stage spring and dolomitic lime (2.5ton/acre) in autumn over fallen leaves to accelerate decomposition**.** **Mechanical control:** • Collection and destruction of fallen leaves and pruned materials in winter to prevent the sexual cycle. • Collect and burn the infected plant debris. • Follow proper trimming and pruning of twigs and branches followed

	by burning.
Reproductive/maturity stage	
Nutrients	• In the bearing orchards, apply 50 kg FYM per plant every year along with other fertilizers. • A fertilizer dose of 1kg N, 0.5 kg P and 0.5kg K per plant per year should be given. • Fertilizers should be applied in basins away from the tree trunk on drip line. • Apply recommended micronutrients, if deficiency symptoms are observed. • Micronutrient deficiency should be corrected by foliar spray of particular micronutrient.
Weeds	• Remove weeds around the plants. • Use straw or plastic Mulch to avoid weed growth and to maintain soil moisture for longer period. • Remove left over weeds from the orchard to avoid further spread of weed seeds.
Fruit fly	**Cultural control:** • Prior to harvest (30-40 days) collect and disposed 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. **Mechanical control:** • Male annihilation technique: Set up fly trap using methyl eugenol. Prepare methyl eugenol 1 ml/l of water + 1 ml of malathion solution. • Take 10 ml of this mixture per trap and keep them at 25 different places in one ha between 6 and 8 am. • Collect and destroy the adult flies. **Physical control:** • Hot water treatment of fruit at 48 ± 1 ºC for 4-5min. **Biological control:** • Use methyl eugenal pheromone trap@4/acre
Bark eating caterpillar	**Cultural control:** • Remove and destroy dead and severely affected branches of the tree

	• Remove alternate host, silk cotton and other hosts
Shoot/ fruit blight and bark canker,Crown rot, Root rot/white rot, Collar rot,Wither tip, Leaf spot, Fire Blight, Scab	• Same as in vegetative stage

V. RODENT PEST MANAGEMENT

- ❖ Disturb and destroy the habitat (burrows) of the rodents by practicing clean cultivation
- ❖ Minimize the alternate food sources and secured habitation by removing the weeds and crop residues in/ around the orchards
- ❖ Practice burrow smoking using paddy straw or other natural smoking materials in 'ANGRAU/ NIPHM burrow fumigator' for 2-3 minutes for each burrow.
- ❖ Encourage the establishment of natural predator like barn owls by establishing barn owl perches/ wooden boxes in and around the crop orchards.
- ❖ Practice burrow smoking as individual and community, preferably on a campaign approach.
- ❖ Organize community rodent control campaigns using rodenticide poison baits through packeting and pocketing, before crop entering into reproductive phase (i.e. before P.I.). The optimum time for organizing mass rodent control campaigns will be 6 weeks after transplanting.

Action plan for rodent management using rodenticide poison baits

- ❖ Practice poison baiting with anticoagulant, bromadiolone @0.005% (96 parts of broken rice + 2 parts of edible oil + 2 parts of 0.25% CB bromadiolone) on community approach.

  DAY – 1: Close all the burrows in the orchards, orchard bunds, canal bunds and surrounding barren lands etc.

  DAY – 2: Count the re-opened burrows and treat the burrows with Bromadiolone chemical bait packets @ 10 g/burrow.

  DAY – 10: Observe the re-opened burrows and repeat baiting

- ❖ In cases of high level of infestation (>20 live burrows/acre) practice poison baiting with zinc phosphide @ 2.0% on community approach. PRACTICE PRE-BAITING TO AVOID BAIT SHYNESS

  DAY – 1: Close all the burrows in the orchards, orchard bunds, canal bunds and surrounding barren lands etc.

  DAY – 2: Count the re-opened burrows and practice pre-baiting @ 20 g/burrow (98 parts of broken rice + 2 parts of edible oil)

  DAY – 4: Observe the re-opened burrows and treat the burrow with zinc phosphide poison bait (96 parts of broken rice + 2 parts of edible oil + 2 parts of Zinc phosphide) @ 10g/ live burrow. Collect the dead rats, if found any outside and bury them.

If any residual population is found, practice anti-coagulant poison susceptible individuals within the target population by providing unsprayed areas within treated orchards, adjacent "refuge" orchards, or habitat attractions within a treated orchard that facilitate immigration. These susceptible individuals may outcompete and interbreed with resistant individuals, diluting the resistant genes and therefore the impact of resistance.

❖ Non Chemical poison bait: boil handful of wheat with pieces of bark of *Gliricidia sepium* and allow them to ferment overnight. Use the wheat grains as rat poison. Wheat grains may be wrapped in cloth dipped in the container for boiling. For a few minutes & may be taken out the next day.

VI. INSECTICIDE RESISTANCDE 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 orchards 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 orchards, adjacent "refuge" orchards, or habitat attractions within a treated orchard that facilitate immigration. These susceptible individuals may outcompete and

interbreed with resistant individuals, diluting the resistant genes and therefore the impact of resistance.

VII. COMMON WEEDS

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

2.Scarlet pimpernel: *Anagallis arvensis* L. (Primulaceae)

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

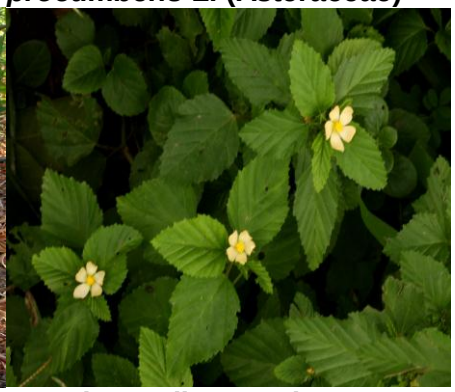
4. Creeping wood sorrel: *Oxalis corniculata* L. (Oxalidaceae)

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

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

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

8. Painted spurge: *Euphorbia geniculata* Ortega (Euphorbiaceae)



9. False mallow: *Malvastrum coromandelianum* (L.) Garcke (Malvaceae)

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

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

12. Rabbit/crow foot grass: *Dactyloctenium aegyptium* (L.) Willd (Poaceae)

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

14. Crab grass: *Digiteria sanguinalis* (L.) Scop. (Poaceae)

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

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

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

VIII. DESCRIPTION OF INSECT PESTS

1) Fruit fly*:*

Biology:

Development from egg to adult under summer conditions requires about 16 days. The mature larva emerges from the fruit, drops to the ground, and forms a tan to dark brown puparium. Pupation occurs in the soil. About nine days are required for attainment of sexual maturity after the adult fly emerges. The developmental periods may be extended considerably by cool weather. Under optimum conditions, a female can lay more than 3,000 eggs during her lifetime, but under field conditions from 1,200 to 1,500 eggs per female is considered to be the usual production. Apparently, ripe fruit are preferred for oviposition, but immature ones may also be attacked.

Egg:

The white, elongate and elliptical egg measures about 1.17 x 0.21 mm and has a chorion without sculpturing

Larva:

The third-instar, which has a typical maggot appearance, is about 10 mm in length and creamy white. The only band of spinules encircling the body is found on the first segment. The external part of the anterior respiratory organs, the spiracles, located one on each side of the pointed or head end of the larva, has an exaggerated and deflexed lobe at each side and bears many small tubercles. The caudal segment is very smooth. The posterior spiracles are located in the dorsal third of the segment as viewed from the rear of the larva.

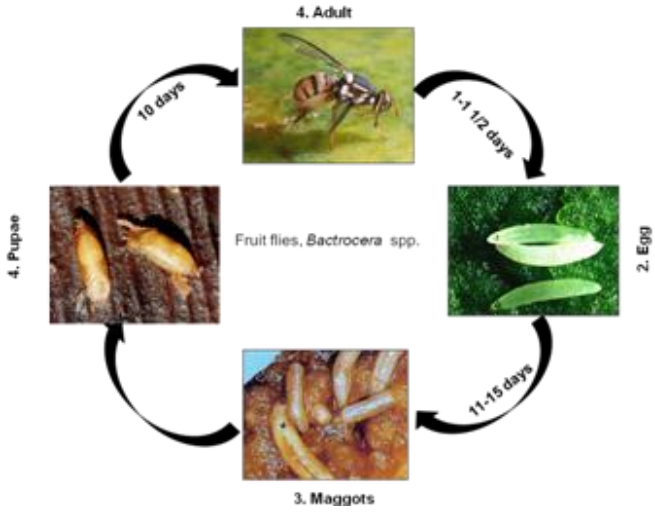
Pupa:

The mature larva emerges from the fruit, drops to the ground, and forms a tan to dark brown puparium about 4.9 mm in length.

Adult:

The adult, which is noticeably larger than a house fly, has a body length of about 8.0 mm; the wing is about 7.3 mm in length and is mostly hyaline. The color of the fly is very variable, but there are prominant yellow and dark brown to black markings on the thorax. 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. The ovipositor is very slender and sharply pointed.

Life cycle:



http://entnemdept.ufl.edu/creatures/fruit/tropical/oriental_fruit_fly.htm

Damage symptoms:

- The damage to crops caused by fruit flies result from 1) oviposition in fruit and soft tissues of vegetative parts of certain plants, 2) feeding by the larvae, and 3) decomposition of plant tissue by invading secondary microorganisms.
- Larval feeding in fruits is the most damaging. Damage usually consists of breakdown of tissues and internal rotting associated with maggot infestation, but this varies with the type of fruit attacked. Infested young fruit becomes distorted, callused and usually drop; mature attacked fruits develop a water soaked appearance. The larval tunnels provide entry points for bacteria and fungi that cause the fruit to rot. When only a few larvae develop, damage consists of an unsightly appearance and reduced marketability because of the egg laying punctures or tissue break down due to the decay.

https://exposure.imgix.net/production/photos/taphwwtdvnxko6r6urdcsrkm4j6pqfr4cqm8/original.jpg?fm=pjpg&auto=format

Natural enemies of fruit flies:

Parasitoids: *Diachasmimorpha longicaudata*, *D. tryon*, *D. kraussi, Fopius arisanus*.

*For management refer page number___22 & 24_____

2) Thrips:

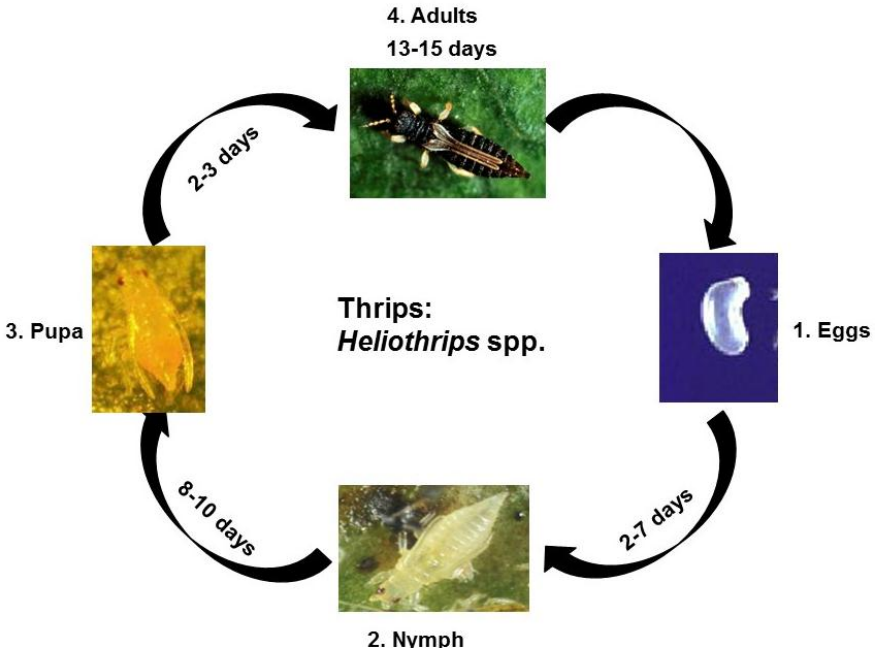
Biology:

Egg: White, elongate and banana-shaped. Females insert eggs inside plant tissues above the soil surface. The eggs are microscopic.

Larva: Two larval instars, pre-pupa (3rd instar), and pupa (4th instar). Mature larvae approximately 1 mm (0.04 in.) in length. Whitish larval stage with red eyes; turn yellowish in color with maturity but retain red eyes. Pre-pupa and pupa are whitish to slightly yellow. Larvae resemble adults, but wingless. The larval abdomen is up-turned and has a dot of excrement on it. The excrement can cause spotting on the leaves.

Adult: 1.3 - 1.7 mm in length. Blackish-brown body with lighter posterior abdominal segments and white legs. Abdomen golden in newly emerged adults. Four translucent wings with numerous fringes surrounding each wing, folded back over the thorax and abdomen when at rest. Antennae have eight segments.

Life cycle:



http://www.hiddenvalleyhibiscus.com/forum/index.php?action=dlattach;topic=439.0;attach=1778
http://entnemdept.ufl.edu/creatures/orn/thrips/greenhouse_thrips06.jpg
http://169.237.77.3/news/images/heliothripshaemorrhoidalislarge.jpg

Damage symptoms:

Thrips uses its mouth-parts to rasp the leaf surface, rupture the epidermal cells, and feed on exuding cell contents. Feeding spots turn yellow then brown, and the surrounds become silvery where air enters the emptied cells

Natural enemies of thrips:

Parasitod: *Thripobius semiluteus*

Predators: Predatory mite, predatory thrips, hover fly, mirid bug etc.

*For management refer page number_22_

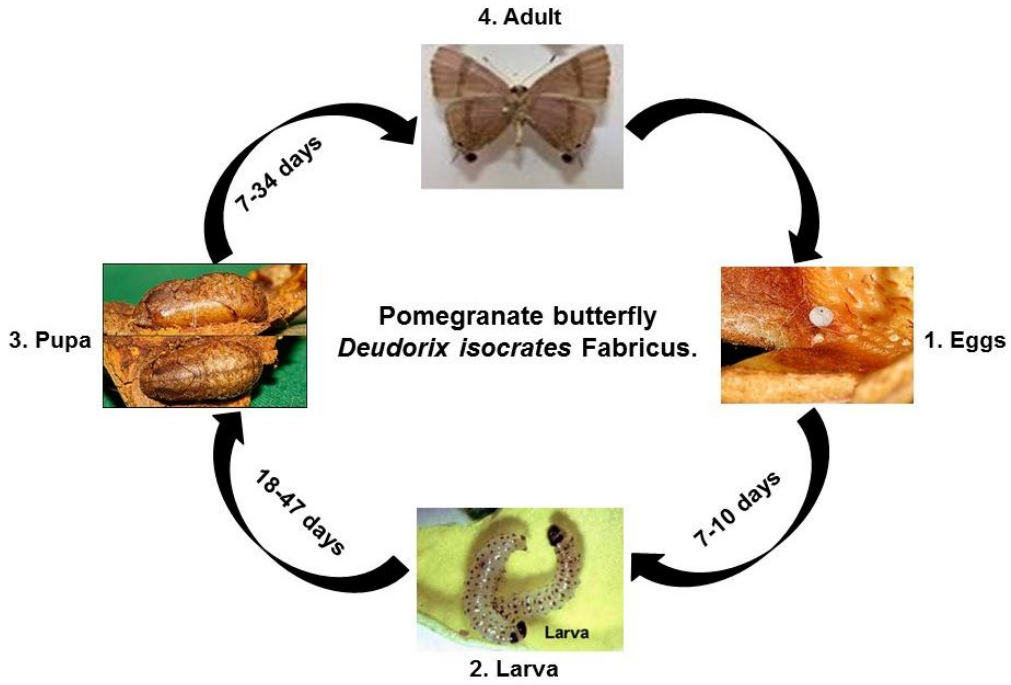
3) Pomegranate butterfly:

Biology:

- **Eggs**: Eggs are laid singly on tender leaves, stalks and flower buds.
- **Larvae -** Dark brown, short and stout, covered with short hairs, larval period lasts for 18-47 days.

- **Pupa**: Development occurs either inside the damaged fruits or on the stalk holding it. Pupal period lasts for 7-34 days. Total life cycle is completed in 1 to 2 months**.**
- **Adult -** bluish brown butterfly, Female – V shaped patch on forewing

Life cycle:



http://flickrhivemind.net/Tags/isocrates/Interesting

Damage symptoms:

- Caterpillar/larva bores into young fruits.
- Feeds on internal contents (pulp and seeds) making the fruit hollow from inside.
- Fruit rotting and dropping.

Natural enemies of pomegranate butterfly:

Parasitoids: *Trichogramma chilonis, Tetrastichus* spp., *Telenomus* spp., *Chelonus blackburni*, *Carcelia* spp. *Campoletis chlorideae, Bracon* spp.

Predators: *Chrysoperla,* Rove beetles, Spiders, Coccinellids, Robber fly, Dragonfly, Reduviid bug, Praying mantis, Fire ants, Big eyed bugs, Pentatomid bug, Earwigs, Ground beetles, common mynah and King crow

*For management refer to page number---------22----------

4) Bark eating caterpillar:

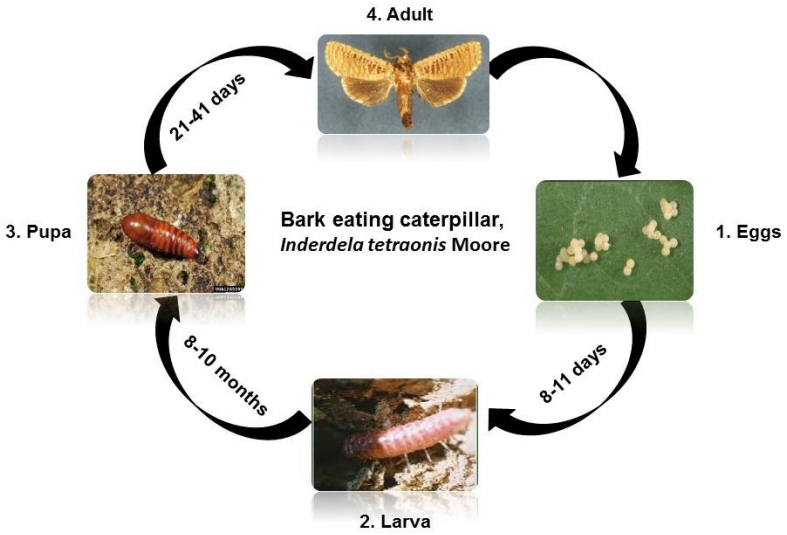
Biology:

- **Eggs:** Eggs are laid under loose bark or in cracks and crevices in clusters of 15-25 from April to June. Eggs hatch in 8-11 days. Eggs are oval in shape and reddish in colour.
- **Larva:** Caterpillars are pinkish white with brown spots and are about 40mm long. Larval duration is of 8-10 months.
- **Pupa:** Pupae are chestnut-brown in colour and 22 to 28 mm long, Pupal period is 21- 41

days. Total life cycle lasts 4-5 months in south India and more than a year in north India. One generation per year.

- **Adult:** Moths are white with pairs of small black dots on thorax, numerous small black spots and streaks on fore wings and few black spots on posterior edges of hind wings.

Life cycle:



Damage symptoms:

- The infestation of the pest may be identified by the presence of irregular tunnels and patches covered with silken web consisting of excreta and chewed up wood particles on the shoots, branches, stem and main trunk.
- Holes on the trunk, Wood dust and faecal matter hanging in the form of a web around the affected portion.
- Severe damage can result in the death of attacked stem. Blackish larva can be observed underneath the fresh webbing.
- Shelter holes may also be seen particularly at the joints of shoots and branches.
- The young shoots dry and die away giving sickly look to the plant.

Damage of bark eating caterpillar

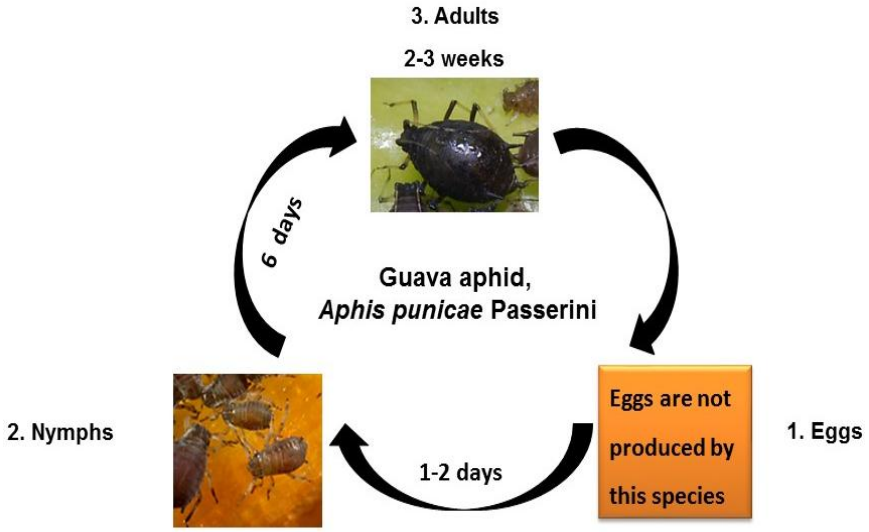
http://media.al.com/living_impact/photo/12202359-large.jpg

*For management refer to page number-----24----------

5) Aphid:

Biology: The development of this aphid is temperature dependent. At 25˚C a generation (nymph to adult) may take as little as 6 days. In cooler temperatures (below 15˚C), a generation may take as long as 20 days. Higher temperatures also reduce development rate, at 30˚C populations of this aphid will sharply decline. Generations are continuous throughout the year in Hawaii.
Egg: Eggs are not produced by this species. Females give birth to living young.
Nymph: There are four nymphal stages of this aphid. The first stage is approximately 1/36 inch in length and the last about 1/17 inch. They are without wings and brownish in color.
Adult: Only females are found. They are oval, shiny black, brownish-black or reddish brown in color, either with or without wings, measuring 1/25 to 1/12 inch in body length and having short black-and-white banded antennae. Winged individuals tend to have darker abdomens and be slightly thinner. The incidence of winged individuals is dependent on the population density and leaf age. Reproduction is partheneogenic or non sexual. Females start reproducing soon after becoming adults. They produce 5 to 7 live young per day, up to a total of about 50 young per female.

Life cycle:



http://influentialpoints.com/Images/Toxoptera_aurantii_aptera_and_nymphs_on_Camellia_in_Heathfieldjpg
http://influentialpoints.com/Guests/on_aloe-1-03-08-13_1.jpg

Damage symptoms:

- Aphid sucks sap and weakens attacked tissue.
- In the spring, it is very harmful to fruits, causing flower buds to drop off. The abundant honeydew it produces attracts ants and allows the development of sooty moulds.

Natural enemies of Aphid:

Parasitods: *Aphidius colemani, Praon volucre, Lysiphlebus fabarum, Lysiphlebus testaceipes, Diaeretiella rapae*

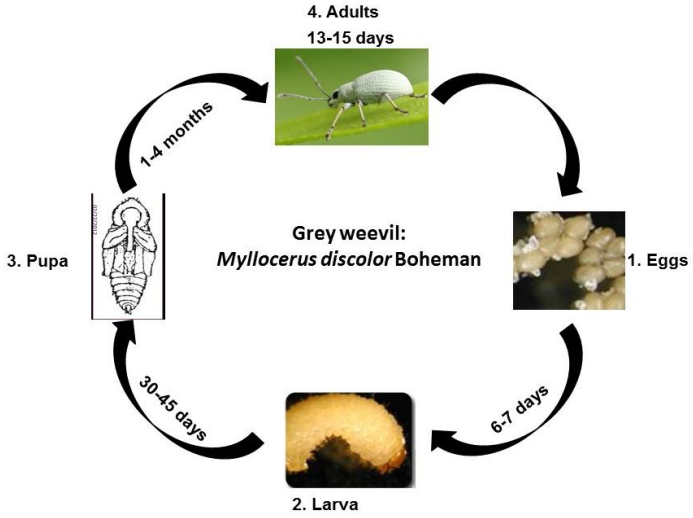
Predators: *Allobaccha nubilipennis, Episyrphus balteatus, Chrysoperla carnea, Coccinella septempunctata, Betasyrphus serarius, Paragus tibialis, Ischiodon scutellaris, Dideopsis aegrota*
*For management refer to page number-------22----------

6) Grey weevil:

Biology:
Egg: Small, ovid and cream colored
Grub: C shaped, creamy white with brown heads and legeless

Pupa: Creamy white and resemble adults, and are found in earthern cells in the soil
Adult: Whitish grey with an irregular pattern of dark spots dorsally. The snout is short and quadrate and slightly expanded towards the apex. The antennae are clubbed and elbowed

Life cycle:



http://www.nabg-nbaii.res.in/insectinfo/images/fieldorchardindent/INI035A_I1.jpg
http://www.agritech.tnau.ac.in/expert_system/ragi/images/weevil_p.png

Damage symptoms:

Adults feed on leaf edge and cutting U shaped pattern and thus defoliate the plants, grubs feeds on the roots.

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

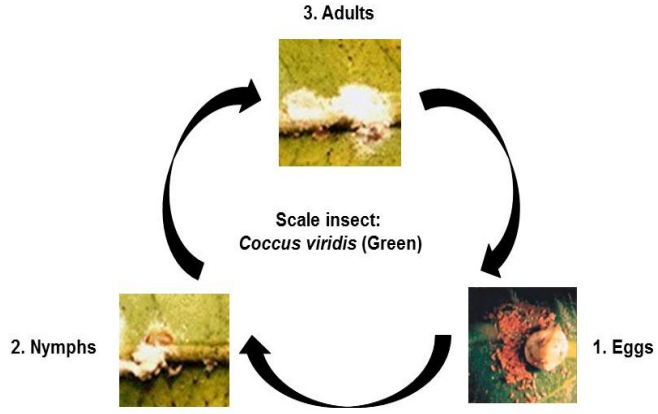
7) Scale:

Biology:

Larva: Flat, oval, yellowish green, moving slowly.

Adult: Only females known. Immobile, usually settled at underside of leaf, close to central vein or near tips of green shoots. Flat, oval (about 3 x 2 mm), green with irregular loop of blackish spots showing through middle of dorsum.

Life cycle:



http://www.cabi.org/portfolio/compendia/normal/coccvir3.img

Damage symptoms:

http://www.cabi.org/portfolio/compendia/normal/coccvir3.img

Natural enemies of Scale:

Parasitods: *Anicetus annulatus, Cerapteroceroides similis, Coccophagus cowperi, Marietta leopardina, Encyrtus lecaniorum*

Predators: *Chilocorus cacti, Chilocorus melanophthalmus, Chilocorus nigrita, Cryptolaemus montrouzieri* and *Jauravia pallidula*

*For management refer to page number------22----------

8) Chafer beetle:

Biology:

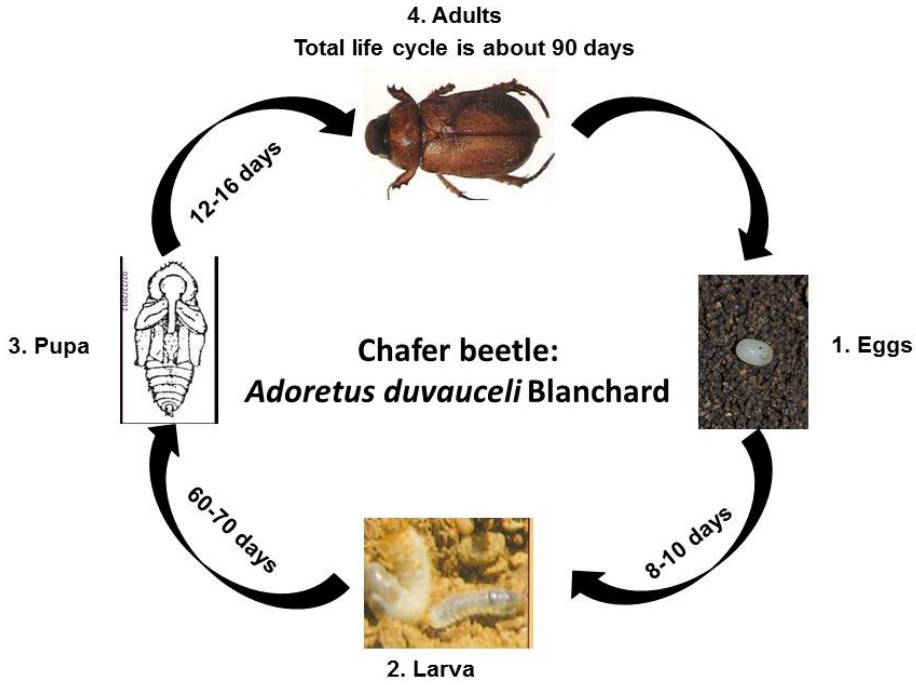
Eggs: About 50 eggs laid by a single female in soil at 5-10 cm depth. Eggs hatch in 8-10 days

Larva: Full gown larvae are C shaped. The larvae remains in the soil and eat the roots. Larval period is 60-70 days.

Pupa: Pupation takes place in the soil at 20-30 cm depth. Pupal period is 12- 16 days.

Adult: **A**dult beetle emerge with onset of rains during May – June. They are active at night and mate. They hide during daytime. Life cycle is completed in about 90 days.

Life cycle:



Damage symptoms:

- Both adults and larvae are destructive. Adult beetle start feeding from the periphery of leaves and tender shoots at night.
- The larvae cut the roots in certain cases, the damage is serious.

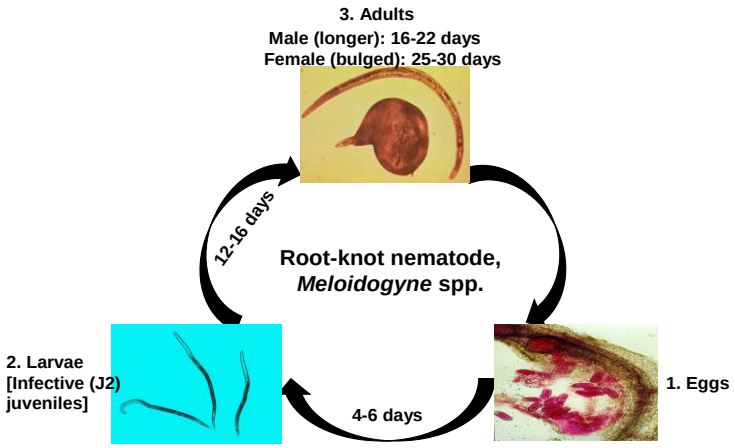
*For management refer to page number------22----------

9) Root-knot Nematode:

Biology:

- Most species of plant parasitic nematodes have a relatively simple life cycle consisting of the egg, four larval stages and the adult male and female.
- Development of the first stage larvae occurs within the egg where the first molt occurs. Second stage larvae hatch from eggs to find and infect plant roots or in some cases foliar tissues.
- Under suitable environmental conditions, the eggs hatch and new larvae emerge to complete the life cycle within 4 to 8 weeks depending on temperature.
- Nematode development is generally most rapid within an optimal soil temperature range of 70 to 80°F.

Life cycle:



1.http://keys.lucidcentral.org/keys/sweetpotato/key/Sweetpotato%20Diagnotes/Media/Html/TheProblems/Nematodes/RootKnotNematode/Root-knot.htm
2. http://nematology.umd.edu/rootknot.html
3. http://www.cals.ncsu.edu/pgg/dan_webpage/Introduction/Images/pyroform.htm

Damage symptoms:

- Formation of galls on host root system is the primary symptom
- Roots branch profusely starting from the gall tissue causing a 'beard root' symptom
- Infected roots become knobby and knotty
- In severely infected plants the root system is reduced and the rootlets are almost completely absent. The roots are seriously hampered in their function of uptake and transport of water and nutrients
- Plants wilt during the hot part of day, especially under dry conditions and are often stunted
- Nematode infection predisposes plants to fungal and bacterial root pathogens

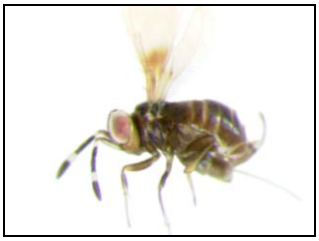
Survival and spread:

Primary: Egg masses in infected plant debris and soil or collateral and other hosts like Solonaceous, Malvaceous and Leguminaceous plants act as sources of inoculums.
Secondary: Autonomous second stage juveniles that may also be water dispersed.
Favourable conditions:
Loamy light soils.
*For management refer to page number----------

Natural Enemies of Loquat Insect Pests

Parasitoids

Egg parasitoid



Larval parasitoids

2. *Anicetus annulatus*

3.*Cerapteroceroides similis*

4. *Thripobius semiluteus*

5. Braconid wasp

6.*Trigonospila brevifacies*

7. *Bracon* spp.

8. *Goniozus jacintae*

9. *Encarsia* sp

Nymphal and adult parasitoids

10. *Praon volucre*

11. *Lysiphlebus fabarum*

12. *Lysiphlebus testaceipes*

13. *Diaeretiella rapae*

14. *Aphidius colemani*

15. *Aphelinus chaonia*

16. *Coccophagus cowperi*

17. *Marietta leopardina*

18. *Encyrtus lecaniorum*

1. http://cache.ucr.edu/~heraty/Azotinae/1801touched.jpg
2. http://mushi-akashi.cocolog-nifty.com/photos/uncategorized/2012/02/12/_dsc06872.jpg
3. http://www.entocare.nl/english/foto's/foto's%20website%20oud/Thripobius_ad_urs.jpg
4. http://bugguide.net/images/cache/0H6RLHERTZIZ2LLZULJL2LFL6LYLWLLZ3ZKR2L0RULZZTZFLWLIZALFL9LHZFZ0RHH7Z1LJLWLIRYZRZ2LJLELFLNL.jpg
5. https://encrypted-tbn2.gstatic.com/images?q=tbn:ANd9GcTGdT49NT_1NyNsDQLnSagOcCH1Y869iq7zWM_P7D3rS6e6MYSr
6. http://www.gipsa.usda.gov/VRI/Images/Insects/IN-BRACON-HEBETER-(PARASITOID).jpg
7. http://www.nbaii.res.in/Featured%20insects/Bracon%20brevicornis.htm
8. http://www.zsm.mwn.de/hym/i/encarsia.jpg
9. *http://www.viridaxis.com/wp-content/themes/viridaxis/images/menu-praon.jpg*
10. http://4.bp.blogspot.com/-HdQWHbLKvKE/T09tEY_5del/AAAAAAAAAmQ/6hj3QpfRxiE/s1600/Lysiphlebus%2Bfabarum.JPG
11. http://www.ideal.es/granada/prensa/noticias/200804/29/fotos/012D2ALM-LLL-P1_1.jpg
12. http://nathistoc.bio.uci.edu/hymenopt/DSC_0022b.jpg
13. http://www.cabi.org/portfolio/compendia/normal/1c61989a.img
14. *http://ponent.atspace.org/fotos/ins/Hymenop/Chalcid/Aphelinidae/Aphelinus/A_semiflavus/P4177/aphelinus_semiflavus_04_p04177_montoliu_1.jpg*
15. http://www.nbaii.res.in/Featured_insects/images/coccophagus-cowperi1.jpg
16. http://www.nbaii.res.in/Featured_insects/images/marietta-leopardina5.jpg
17. *http://www.oekolandbau.de/fileadmin/redaktion/Bildarchiv/Pflanzenbau/nutzorganismen/encyrtus_lecaniorum.jpg*

Predators

1. ***Chilocorus cacti***

2. ***Chilocorus melanophthalmus***

3. ***Coccinella septempunctata***

4. ***Chilocorus nigrita***

5. ***Cryptolaemus montrouzieri***

6.***Jauravia pallidula***

7. **Predatory mite**

8. ***Phytoseiulus persimilis***

9. ***Scolothrips sexmaculatus***

10. **Spider**

11. **Mirid bug**

12. **Lacewing**

13. ***Allobaccha nubilipennis***

14. ***Betasyrphus serarius***

15. ***Ischiodon scutellaris***

16. ***Episyrphus balteatus***

17. ***Paragus tibialis***

18. ***Dideopsis aegrota***

1. http://bugguide.net/images/raw/EZZL6ZLL4ZZL4ZSLCHXHBHIHYHWHAZNHWZ7LBZ8LBZ4L9ZEHFH7HCHSLOHNHBZEHVZ5LJHMHPZ8H1H.jpg
2. https://upload.wikimedia.org/wikipedia/commons/7/7f/Chilocorus_bipustulatus.jpg
3. *http://www.kerbtier.de/Pages/Fotos/FotoLargeN/Coccinellidae/Coccinella-septempunctata-n.jpg*
4. http://www.biolib.cz/IMG/GAL/198043.jpg
5. *http://www.coccinellidae.cl/paginasWebTribus/Cryptolaemini/Chinitas/Cryptolaemus_montrouzieri.jpg*
6. *http://www.angelfire.com/bug2/j_poorani/pallidula.jpg*
7. http://www.ahw.me/p1/anystis_baccarum01_03b_1,4mm.jpg
8. http://www.ipm.ucdavis.edu/PMG/NE/IMAGES/phytoseiulus_persimilis.jpg
9. http://www.ipm.ucdavis.edu/PMG/IMAGES/S/I-TS-SSEX-AD.026.jpg
10. ---
11. http://www.britishbugs.org.uk/heteroptera/Miridae/Miridae_images/b_angulatus_3.jpg
12. *http://micropics.org.uk/Chrysopidae/Chrysoperla/carnea/side.jpg*
13. *http://homepage2.nifty.com/syrphidae/bacc_chry/chr_sp1f.jpg*
14. *http://wapichan.cocolog-nifty.com/photos/uncategorized/2011/02/04/1.jpg*
15. *http://www.cabi.org/portfolio/compendia/normal/Isch_sc2.img*
16. *http://www.cabi.org/portfolio/compendia/normal/syrph_ba.img*
17. *https://farm4.staticflickr.com/3300/4578808606_5b5cb631e3.jpg*
18. *http://www.nbaii.res.in/Featured_insects/images/dideopsis-aegrota2.jpg*

IX. DESCRIPTION OF DISEASES

1) Shoot/fruit blight and bark canker

Disease symptoms:

- The symptoms of the disease are observed 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.
- In case of severe infection such spots coalesce forming patches resulting in complete withering and defoliation of infected leaves

Survival and spread:

- The disease spreads through the seeds of affected fruits. The incidence is wide spread during rainy season.

Favourable conditions:

- The optimum temprature between 20 - 25 °C, 95% relative humidity.

*For management refer to page number----23 & 25----------

2) Crown rot:

Disease symptoms:

- Symptoms of crown rot include rapid wilting and dying of trees during the first warm weather of the season, as well as leaves changing color to dull green or yellow.
- The disease can affect loquat trees of any age, but typically affects younger trees that do not have fully developed root systems and crown areas.

Survival and spread:

- The pathogen survives as oospores on the affected plant tissues in soil and on weed hosts.

Favourable conditions:

- Atmospheric temperature in the range of 10-20 °C and relative humidity 90% favours disease development.

*For management refer to page number-----23 & 25----------

3) Die back:

Disease symptoms:

- Sunken lesions on infected tissue.
- The cankers are perennial and continue to enlarge each year.

- The fungus slowly invades and girdles limbs or trunks.
- The result is a dead limb above the infection site.
- Black pycnidia of *Cytospora* can easily be seen emerging from infected bark with use of a hand lens.
- The pycnidia are roundish and pinhead in size.
- They are scattered in the cankered area.

Survival and spread:

- During wet weather, sticky masses of orange-yellow conidia are extended in long tendrils. These conidia are wind disseminated to injured tissue where they germinate and infect host tissue

Favourable conditions:

- Atmospheric temperature in the range of 10-20 °C and relative humidity 90% favours disease development.

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

4) Root rot/ white rot:

Disease symptoms:

- The bark and the wood of the root including the root collar is affected.
- The decayed wood is pinkish to dull violet in colour whereas in the advanced stages, small, white, elongated pockets appear and they form a mass of spongy white fibres.
- The affected tree begins to show symptoms of wilt, early leaf fall and increase in the fruit-set.
- The fruiting bodies conks which may grow up to 30 cm or more in diameter usually appear when the rot is fairly well advanced.
- They are either hidden by the litter or lie exposed on the surface of the soil.

Favourable conditions:

- Disease emergence favored by continually damp soil

Survival and spread:

- The fungal pathogen survives on diseased wood and roots below ground for many years.

*For management refer to page number----23 & 25----------

5) Wither tip:

Disease symptoms:

- The die back often progressed slowly and caused leaves to wilt, turn yellow and drop off
- Twigs and branches appeared to have been scorched by fire.
- Drying of twig from tip to down ward.
- When twig were dry, minute brown to black, slightly raised, clumped pustules are observed which acervuli of the fungus.
- Dry twigs are ash colored.
- Affected fruit showed tar stain symptoms.

Favourable conditions:

- The temperature range for disease development 10-30˚C and the relative humidity 95-97%.

Survival and spread:

- The inoculum remains on dried leaves defoliated branches and mummified flowers.

*For management refer to page number--------23 & 25----------

6) Collar rot:

Disease symptoms:

- The lower portion of the stem is affected from the soil borne inoculum (sclerotia).
- Decortication is the main symptom.

- Exposure and necrosis of underlying tissues may lead to collapse of the plant.
- Near the ground surface on the stem may be seen the mycelia and sclerotia.
- Lack of plant vigour, accumulation of water around the stem, and mechanical injuries help in development of this disease.

Favourable conditions:

- Most severe in warm to hot, wet or humid conditions

Survival and spread:

- Sclerotia survive in soil for long periods.
- Infects through the base of the stem from hyphae from sclerotia.
- Secondary infection can be more severe where plant residues are on the soil surface.

*For management refer to page number---23 & 25----------

7) Leaf spot:

Disease symptom:

- Tiny reddish spots, sometimes surrounded by a yellow halo, appear on the leaves of infected plants, usually on older growth.
- These spots darken and enlarge as the leaves mature.
- Spore-forming bodies eventually appear in the center of the spots.
- These dark fruiting bodies may appear to be covered with a glossy membrane, beneath which white masses of spores may be visible.
- Infected plants may prematurely drop many leaves.

***Entomosporium* leaf spot**

Survival and spread:

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

Favourable conditions:

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

*For management refer to page number—23 & 25----------

8) Fire Blight:

Disease symptom:

- Branch and trunk canker symptoms can appear as soon as trees begin active growth.
- The first sign is a watery, light tan bacterial ooze that exudes from cankers (small to large areas of dead bark that the pathogen killed during previous seasons) on branches, twigs, or trunks.
- The ooze turns dark after exposure to air, leaving streaks on branches or trunks.
- However, most cankers are small and inconspicuous; thus infections might not be noticed until later in spring when flowers, shoots, and/or young fruit shrivel and blacken.
- The amount of fruit loss depends upon the extent and severity of the disease.

Flower clusters infected with fire blight bacteria

Branches infected with fire blight.

http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7414.html

Survival and spread:

- Splashing rain or insects transmit the bacteria to nearby blossoms or succulent growing shoots.
- Once blossoms are contaminated with the bacteria, honey bees become efficient carriers of the pathogen.

Favourable conditions:

- Spread of the pathogen are rainy or humid weather with day time temperatures from 75° to 85°F, especially when night temperatures stay above 55°F.

*For management refer to page number------23 & 25----------

9) Scab:

Disease symptom:

- Olive green to black, circular, scabby or velvety spots appear on infected leaves, which may yellow or redden and drop prematurely.
- Scabby spots, often more sunken, may appear on fruit, which may crack or shrivel and drop.
- Shoots may die back if the disease is severe.

Survival and spread:

- The pathogen survives through perithecia in the soil debris.

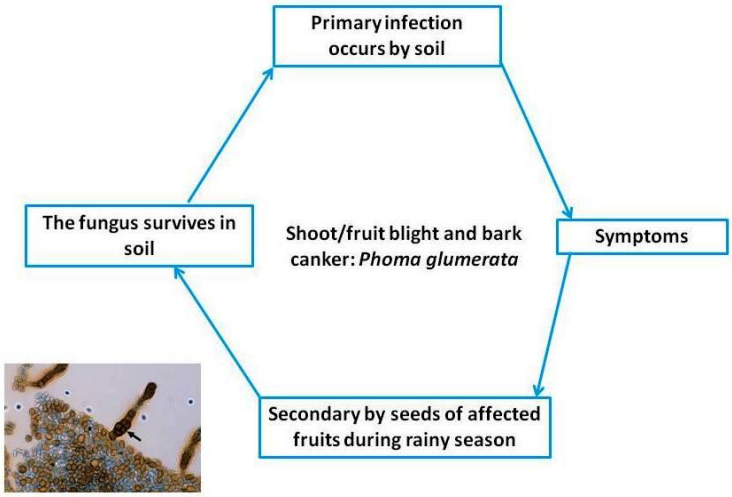
Favourable conditions:

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

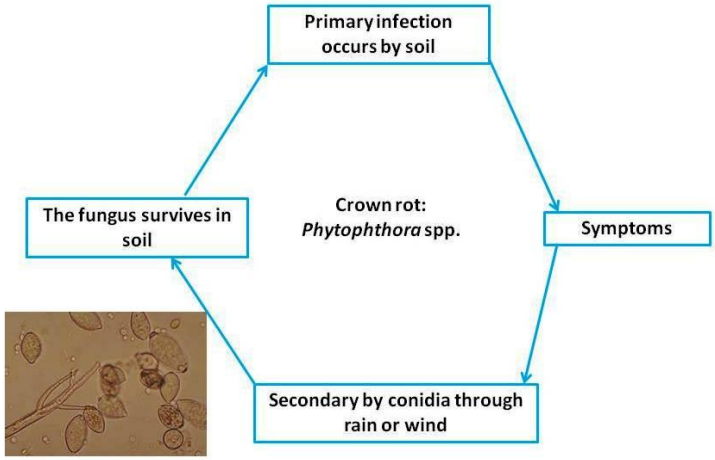
*For management refer to page number—23 & 25----------

Disease cycles:

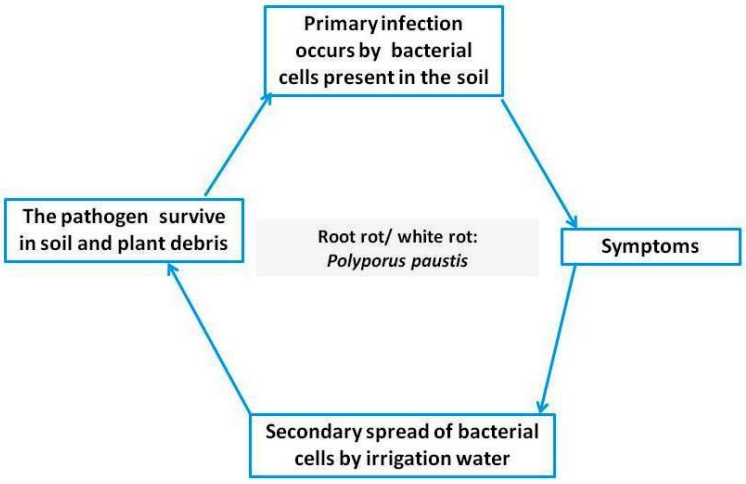
1. **Shoot/fruit blight and bark canker**



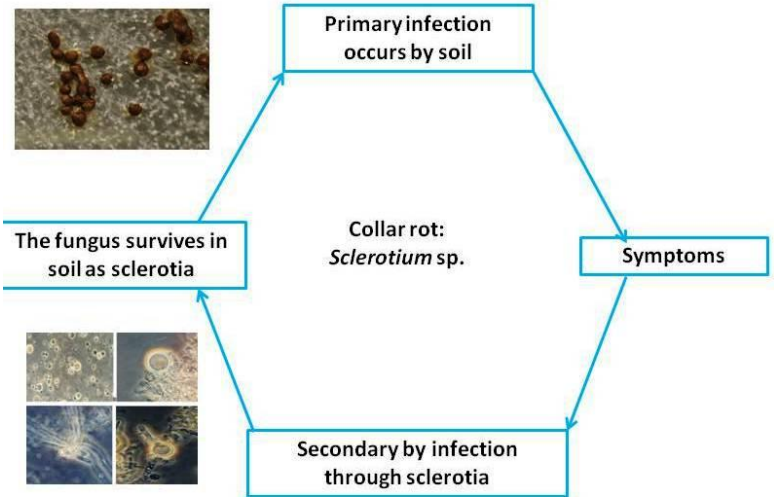
2. **Crown rot**



3. Root rot/ white rot:



4. Collar rot



X. DESCRIPTION OF RODENT PESTS

1) Lesser bandicoot:

- Distributed throughout India and infests almost all crops.
- Robust rodent (200 to 300 g body weight) with a rounded head and a broad muzzle. Dorsum covered with grey-brownish rough hairs. Tail is naked, shorter than head and body.
- Breeds throughout the season and litter size 6-8 in normal conditions.
- Nocturnal and fossorial. Burrows are characterized by the presence of scooped soil at the entrance and mostly burrow openings are closed with soil.
- It is a major pest in irrigated rice crop

2) Field mouse:

- Distributed in peninsular India to cutch in Punjab, Uttar Pradesh, Bihar, Odisha and in North east.
- Habitats especially irrigated crop orchards.
- Tiny mouse (10g) with slender, short, naked and bicolor tail
- Nocturnal and fossorial.
- Breeds throughout the year
- Individually it is a minor pest but, accumulated losses will be more.

3) Soft furred field rat:

- Distributed in Punjab, Uttar Pradesh southwards to western and southern India, also finds in foothills of eastern Himalayas. Found mostly in semi arid areas.
- Small rodent (40-60gm) with soft fur, dorsum light grey and bicolored tail equal to the head and body.
- It is associated with *T. indica* and *Musboodga* in northern part and with *Bandicota bengalensis* in southern part.
- Nocturnal and tonsorial with simple burrows.

XI. SAFETY MEASURES

A. At the time of harvest:

Maturity indices

- Minimum of 6.5% soluble solids content (SSC) at harvest
- Minimum flesh firmness of 14 lbf (penetration force with an 8-mm tip). Late harvested loquat fruits retain their firmness better than early harvested fruit and have higher SSC at harvest and when ripe

Quality Indices

- Freedom from growth cracks, insect injury, bruises, scars, sunscald, internal breakdown, and decay
- Minimum of 14% SSC when ripe (ready to eat); a loquat fruit at 2-3 lb flesh firmness is considered ripe

B. During post-harvest storage:

To ensure that fruits are a high quality, it is important to discard any damaged or diseased fruits prior to transport or storage so as to prevent them from having a negative effect on the healthy fruits. Loquat fruit must be firm and their skin and pulp must not be damaged either mechanically or by rot pathogens. To prevent injury to adjoining fruits, the stem-ends must be removed completely.

Temperature	Relative humidity	Maximum duration of storage
1.6°C	93%	6 months
0 - 0.5°C	90%	6 months
-0.5 - 0°C	90 - 95%	3 months

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 orchard should be kept exposed to sun light at least for 2-3 weeks	Do not plant or irrigate the orchard after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Adopt crop rotation with cover crops between the rows.	Avoid mono-cropping of the cover crops between the rows.
3.	Grow only recommended varieties.	Do not grow varieties that are not suitable for the season or the region.
4	Sow/plant early in the season	Avoid late sowing/planting as this may lead to reduced yields and incidence of insect pests and diseases.
5	Always treat the seeds with approved biopesticides/chemicals for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with biopesticides/chemicals.
6.	Sow/plant in rows at optimum depths Under proper moisture conditions for better establishment.	Do not sow/plant seeds beyond 5-7 cm depth.
7.	Apply only CIBRC recommended pesticides against a particular pest at the recommended dose, at the right time, with right methods with standard equipments e.g. Flat-fan or flood- jet nozzles for herbicides.	Non-recommended pesticides should not be applied in the Orchard field..
8.	Maintain optimum and healthy plant stand.	Orchard plants should not be exposed to moisture deficit stress at their critical stages.
9	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
10	Use micronutrient mixture after sowing based soil test recommendations.	Do not apply any micronutrient mixture after sowing without soil test recommendations.
11	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
12	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
13	Release parasitoids only after noticing adult moth catches in the pheromone trap or as per orchard observation	Do not apply chemical pesticides within seven days of release of parasitoids.

14	Apply NPV at recommended dose when a large number of egg masses and early instar larvae are noticed. Apply NPV only in the evening hours.	Do not apply NPV on late instar larva and during day time.
15	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
16	Follow the recommended procedure of trap crop technology.	Do not apply long persistent pesticides on trap crop, otherwise it may not attract the pests and natural enemies.

XVI. REFERENCES

- http://www.yourarticlelibrary.com/cultivation/loquat-cultivation-in-india-production-area-climate-harvesting-and-fruit-handling/24701/
- http://www.crfg.org/pubs/ff/loquat.html
- http://www.loquatworld.com/LoquatTrees.html
- http://i01.i.aliimg.com/wsphoto/v0/972387515/16-font-b-Loquat-b-font-SEEDS-Eriobotrya-japonica-font-b-Fruit-b-font-seeds-Lovely.jpg
- http://www7.inra.fr/hyppz/RAVAGEUR/6toxaur.htm#haut
- http://www.agritech.tnau.ac.in/expert_system/ragi/cropprotection.html
- http://www.slideshare.net/agp115/insect-pests-of-maize-wheat-ragi-1
- http://www.authorstream.com/Presentation/sakthi.sakthi-1341933-pests-of-brinjal/
- http://nhb.gov.in/fruits/mango/man002.pdf
- http://beta.krishiworld.com/html/horti_crops3d.html
- http://www.geocities.ws/phip2007proceedings/PHIP2007/38-151-156.pdf
- http://www.shouragroup.com/i_mango_e.htm
- http://nrcgrapes.nic.in/zipfiles/ExtFol22%20MgmtOfFleabeetle.pdf
- http://media.al.com/living-press-register/photo/loquatsjpg-e895918d7c94cd6a.jpg
- http://agroguide.weebly.com/uploads/5/0/3/1/5031454/tropical_and_sub_tropical_fruits.pdf
- http://www.scielo.org.ar/scielo.php?pid=S1851-56572011000200013&script=sci_arttext