सत्यमेव जयते

AESA BASED IPM Package

AESA based IPM – Citrus

रा व स्वा प्र सं
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Plant Health Management
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Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

Important Natural Enemies of Citrus Insect Pests

Parasitoids

Trichogramma spp.

Encarsia sp

Brachymeria sp

Leptomastix dactylopii

Telenomus sp

Tamarixia radiata

Predators

Coccinellid

Syrphid fly

Lacewing

Ground beetle

Rove beetle

Spider

The AESA based IPM - Citrus, 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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Front cover picture Model AESA chart for citrus

Back cover picture Citrus orchard

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FOREWORD

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

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

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

Date : 6.3.2014

(Avinash K. Srivastava)

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FOREWORD

IPM 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 (AESA) based IPM. Experience in different countries have sine show 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, through 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 CITRUS

Citrus plant description:

Citrus (*Citrus* spp. L.; Family: Rutaceae) plants are large shrubs or small trees, reaching 5–15 m tall, with spiny shoots and alternately arranged evergreen leaves with an entire margin. The flowers are solitary or in small corymbs, each flower 2–4 cm diameter, with five (rarely four) white petals and numerous stamens; they are often very strongly scented. The fruit is a hesperidium, a specialised berry, globose to elongated, 4–30 cm long and 4–20 cm diameter, with a leathery rind or "peel" called a pericarp. The outermost layer of the pericarp is an "exocarp" called the flavedo, commonly referred to as the zest. The middle layer of the pericarp is the mesocarp, which in citrus fruits consists of the white, spongy "albedo", or "pith". The innermost layer of the pericarp is the endocarp. The segments are also called "liths", and the space inside each lith is a locule filled with juice vesicles, or "pulp". From the endocarp, string-like "hairs" extend into the locules, which provide nourishment to the fruit as it develops.

Citrus fruits are notable for their fragrance, partly due to flavonoids and limonoids (which in turn are terpenes) contained in the rind, and most are juice-laden. The juice contains a high quantity of citric acid giving them their characteristic sharp flavour. The genus is commercially important as many species are cultivated for their fruit, which is eaten fresh, pressed for juice, or preserved in marmalades and pickles.

Many citrus fruits, such as oranges, tangerines, grapefruits, and clementines, are generally eaten fresh. They are typically peeled and can be easily split into segments. Grapefruit is more commonly halved and eaten out of the skin with a spoon. There are special spoons (grapefruit spoons) with serrated tips designed for this purpose. Orange and grapefruit juices are also very popular breakfast beverages. More acidic citrus, such as lemons and limes, are generally not eaten on their own. Meyer Lemons can be eaten 'out of hand' with the fragant skin; they are both sweet and sour. Lemonade or limeade are popular beverages prepared by diluting the juices of these fruits and adding sugar. Lemons and limes are also used as garnishes or in cooked dishes. Their juice is used as an ingredient in a variety of dishes; it can commonly be found in salad dressings and squeezed over cooked meat or vegetables.

I. PESTS

A. Pests of National Significance

1. Insect pests

1.1 Aphid: *Toxoptera aurantii* (Boyer de Fonscolombe) (Homoptera: Aphididae)

1.2 Citrus psylla: *Diaphorina citri* (Kuwayama) (Hemiptera: Psyllidae)

1.3 Citrus leaf miner: *Phyllocnistis citrella* (Stainton) (Lepidoptera: Gracillariidae)

1.4 Mealybug : *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae)

1.5 Fruit sucking moth: *Eudocima fullonica, E. materna* (Clerck) (Lepidoptera: Noctuidae)

1.6 Citrus/Lemon butterfly: *Papilio demoleus, P. polytes* (Linnaeus) (Lepidoptera: Papilionidae)

2. Diseases

2.1 Gummosis: *Phytophthora* spp.

2.2 Fruit rot: *Phytophthora palmivora* (Butler)

2.3 Anthracnose: *Colletotrichum gloeosporioides*

2.4 Scab: *Elsinoe fawcettii* (Bitanc & Jenkins)

2.5 Sooty mould: *Capnodium citri* (Berk and Desm), *Meliola butleri* (Briosi and Pass)

2.6 Citrus canker: *Xanthomonas axonopodis* pv. *citri* (Hasse)

2.7 Tristeza: *Citrus Tristeza Virus*

2.8 Greening: *Candidatus liberibacter* (Jagoueix)

3. Nematodes

3.1 Citrus nematode: *Tylenchulus semipenetrans* (Cobb) (Tylenchida: Tylenchulidae)

3.2 Lance nematode: *Hoplolaimus indicus* (Sher) (Tylenchida: Haplolaimidae)

3.3 Lesion nematode: *Pratylenchus coffee* (Goodey) (Tylenchida: Pratyleanchidae)

4. Weeds

Broad leaf weeds

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

4.2 Swine cress: *Coronopus didymus* (L.) Sm. (Brassicaceae)

4.3 Horse purslane: *Trianthema portulacastrum* L. (Aizoaceae)

4.4 Black nightshade: *Solanum nigrum* L. (Solanaceae)

4.5 False amaranth: *Digera arvensis* Forssk. (Amaranthaceae)

4.6 Puncture vine: *Tribulus terrestris* L. (Zygophyllaceae)

4.7 Field bindweed: *Convolvulus arvensis* L. (Convolvulaceae)

4.8 Common cocklebur: *Xanthium strumarium* L. (Asteraceae)

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

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

Grassy weeds

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

4.12 Annual brachiaria: ***Brachiaria deflexa*** (Schumach.) Robyns (Poaceae)

4.13 Viper grass: ***Dinebra retroflexa*** (Vahl.) Panzer. (Poaceae)

Sedges

4.14 Purple nut sedge: ***Cyperus rotundus*** L., (Cyperaceae)

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

B. Pests of Regional Significance

1. Insect and mite pests

1.1 Citrus blackfly : ***Aleurocanthus woglumi*** (Ashby) (Hemiptera: Aleurocanthus) (Punjab, Maharashtra, Karnataka, West Bengal and Madhya Pradesh)

1.2 Root grub: ***Holotrichia*** spp. (Coleoptera: Scarabaeidae)

1.3 Soft scale: ***Coccus hesperidium*** (Handlirsch) (Hemiptera: Coccoidea) (South India).

1.4 Armoured scale: ***Aonidiella aurantii*** (Maskell) (Hemiptera: Diaspididae) (Meghalaya, Punjab, Uttar Pradesh, Maharashtra,West Bengal and Karnataka)

1.5 Stem borer: ***Chloridolum alcmene*** (Guenee) (Lepidoptera: Noctuidae) (Tamil Nadu)

1.6 Mites: ***Eutetranychus orientalis*** (Klein) (Prostigmata: Tetranychidae) (Meghalaya, Punjab, Madhya Pradesh, Rajasthan, Haryana, Karnataka, Delhi, Jammu & Kashmir)

1.7. Thrips: ***Scirtothrips citri*** (Shull) (Thysanoptera: Thripidae) (Jammu & Kashmir)

2. Diseases

2.1. Powdery mildew: ***Oidium citri*** (Link) (Uttar Pradesh)

2.2 Sapling wilt: ***Fusarium solani*** (W.C. Snyder & H. N. Hansen)

2.3 Blue mould rot: ***Penicillium italicum*** (Wehmer)(Tamil Nadu, Haryana, Maharashtra and Uttar Pradesh)

2.4 Green mould rot: ***Penicillium digitatum*** (Pers & Sacc) (Maharashtra, Tamil Nadu and Uttar Pradesh)

2.5. Sour rot: ***Geotrichium candidum*** (Link) (Maharashtra, Himachal Pradesh and Madhya Pradesh)

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 sized white sheet (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 (insects, disease, weeds etc.), 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
- Treat the rootstocks/planting material with recommended pesticides especially biopesticides
- Select healthy rootstocks/planting material
- Follow proper spacing
- Follow soil health improvement practices (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

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 situations and P: D ratio
- Take direct action when needed (e.g. collect egg masses, remove infested plants etc.)

Plant compensation ability

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

Understand and conserve defenders

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

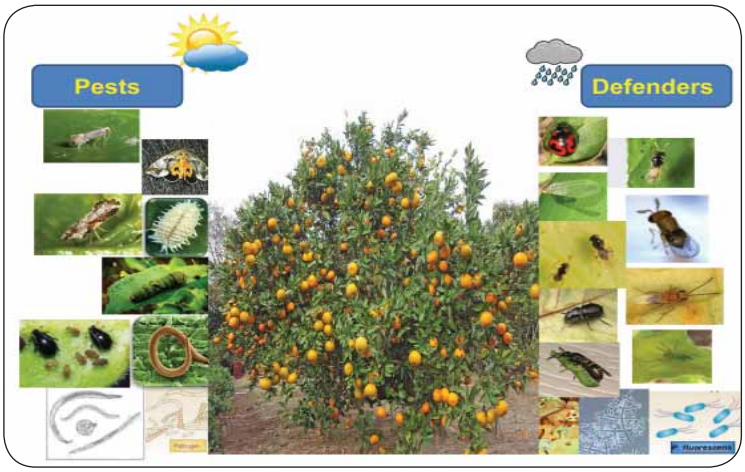
Insect zoo

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

Pest: Defender ratio (P: D ratio):

Model agro-ecosystem analysis chart

Date:
Village:
Farmer:



Decision taken based on the analysis of field situations

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

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 citrus pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens. The important natural enemies of citrus pests are given in ecological engineering table on page 14

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.

Feeding/egg laying potential of different parasitoids/predators

Predators/ Parasitoids	Feeding potential/ Egg laying capacity
 Ladybird beetle	Predatory rate of adult coccinellid on aphids is 50 aphids per day
 Hover fly	1st instar larva can consume 15-19 aphids/day, 2nd instar larva can consume 45-52 aphids/day. 3rd instar larva can consume 80-90 aphids/day. In total life cycle they can consume approx. 400 aphids.
 Green lacewing	Each larva can consume 100 aphids, 329 pupae of whitefly and 288 nymphs of jassids during entire larval period

Predators/ Parasitoids	Feeding potential/ Egg laying capacity
 Spider	5 larvae/adult per day
 *Bracon hebetor*	Egg laying capacity is 100-200 eggs/ female. 1-8 eggs/larva
 *Trichogramma* sp	Egg laying capacity is 20-200 eggs/ female.

Decision making

Farmers become experts in crop management

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

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

AESA methodology

- Go to the orchard in groups (about 5 farmers per group). Walk across the orchard and choose 10 trees/ acre randomly. Observe keenly each of these plants and record your observations:

- Collect 5-6 samples/tree (fruits/leaves/flowers/inflorescence/stem bark/roots/soil/insects) i.e. one sample from top, four samples from all the four sides (North, South, East, West) and one from bottom/soil. Observe keenly each of these samples and record your observations:
    - Pests: Observe and count pests at different places on the tree.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
    - Rats: Count number of plants affected by rats.
    - Weeds: Observe weeds in the orchard and their intensity.
    - Water: Observe the water situation in the orchard.
    - Weather: Observe the weather 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 tree 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 orchard management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on what orchard management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording

Farmers should record data in a notebook and drawing on a chart. Keeping records of what has happened help us making an analysis and draw conclusions.

Data to be recorded

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

Some questions that can be used during the discussion

- Summarize the present situation of the orchard?
- What crop management aspect is most important at this moment?
- Is there a big change in orchard 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 orchard is healthy?
- What management practices are needed at this moment?
- When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.
- Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest build-up?
- What problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.

Advantages of AESA over ETL

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

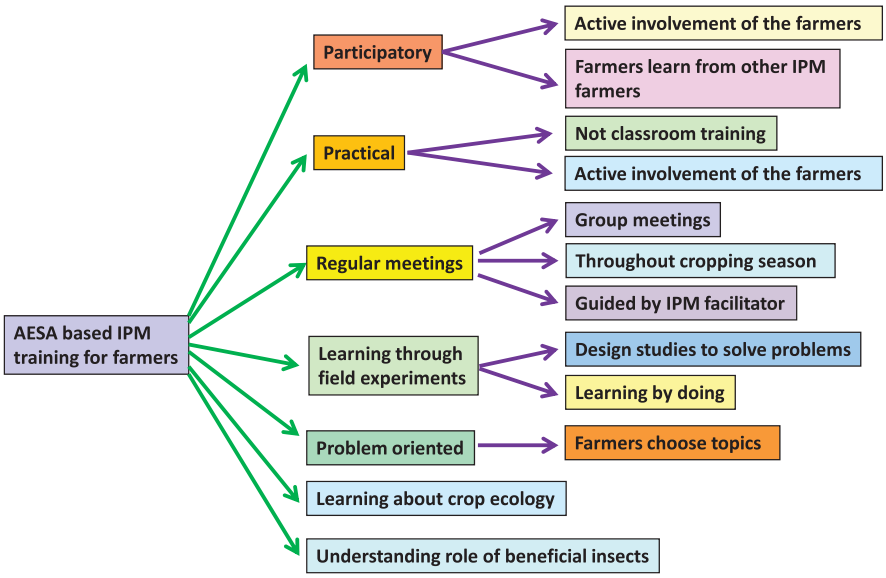
AESA and farmer field school (FFS)

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

Farmers can learn from AESA

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

FFS to teach AESA based IPM skills



B. Field scouting

AESA requires skill. So only the trained farmers can undertake this exercise. However, other farmers also can do field 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:

In orchard, select five trees such that four are from four corners and one from the centre of the orchard. Two rows of trees alongside of boundary of orchard in all directions should not be selected for observations. The tree selection for pest observations during each weekly visit should be random. In each of the selected trees, the observations are to be made from four directions viz., East, South, West and North (make it a habit to start at East direction of a tree and follow anticlockwise direction). Use either beat or tap method for taking observations on pests samples.

For insect pests:

Aphids and mites: 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).

Leaf miner: Only the number of live mines on five randomly selected leaves per plant 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/sheath 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 fruits infected due to disease and percent disease incidence should be recorded.

For weeds:

The goal of weed scouting is to assess the infestation level of known weeds as pests and detect new weeds that may be at very low levels so that action can be taken to control or prevent them from becoming an economic concern. In some cases, early detection of a weed can make eradication possible.

Begin scouting as soon as weeds appear in the field and continue until freeze-up. Record stages of growth of all the weeds and the number of each weed species/square metre.

Frequently, all scouting patterns must be used since weed habitat can be very species specific. Each field usually requires a pattern for a uniform sample and samples in low areas and field margins or ditches to assess immediate or future risk from problem weeds left uncontrolled. Detailed counts of the number of weeds per square metre provide the ideal record of a weed problem. If this is not possible, the following rating system may be useful:

Group I - Wild oats, stinkweed, wild buckwheat, lamb's-quarters, redroot pigweed, hemp-nettle, smartweed, rape, wild mustard, Russian thistle, tartary buckwheat, cow cockle, shepherd's-purse, kochia.

Light	Medium	Heavy
1-10 plants/m^2	10-30 plants/m^2	More than 30 plants/m^2

Group II - Chickweed, green foxtail, corn spurry.

Light	Medium	Heavy
1-20 plants/m^2	20-70 plants/m^2	70 or over plants/m^2

Group III - Canada thistle, sow-thistle, dandelion

Light	Medium	Heavy
1-2 plants/m^2	2-10 plants/m^2	10 or over plants/m^2

These definitions can be used to help standardize ratings. With experience, infestations can be visually estimated. These groupings are based on the competitive characteristics and life cycles of these weeds.

C. Surveillance through pheromone trap catches for fruit sucking moth and citrus butterfly

Pheromone traps for fruit sucking moth, leaf miner, citrus butterfly, stem borer @ 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 fixed field. Fix the traps to the supporting pole at a height of mid 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 water pan and sticky traps

Set up yellow water pan/sticky traps for monitoring aphid, black fly and blue water pan/sticky traps for thrips @ 4-5 traps/acre at the height of mid canopy. 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 traps @ 1 trap/acre at the height of mid 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).

F. Nematode extraction

Collect 100 to 300 cm^3 (200-300 g) representative soil sample. Mix soil sample and pass through a coarse sieve to remove rocks, roots, etc. Take a 600 cc subsample of soil, pack lightly into a beaker uniformly. Place soil in one of the buckets or pans half filled with water. Mix soil and water by stirring with paddle; allow to stand until water almost stops swirling. Pour all but heavy sediment through 20-mesh sieve into second bucket; discard residue in first bucket; discard material caught on sieve. Stir material in second bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 200-mesh sieve into first bucket; discard residue in second bucket. Backwash material caught on 200-mesh sieve (which includes large nematodes) into 250-ml beaker. Stir material in first bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 325-mesh sieve into second bucket; discard residue in first bucket. Backwash material caught on 325-mesh sieve (which includes small to mid-sized nematodes and silty material) into 250-ml beaker. More than 90% of the live nematodes are recovered in the first 5-8 mm of water drawn from the rubber tubing and the sample is placed in a shallow dish for examination.

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.* 2004).

Natural enemies may require

1. Food in the form of pollen and nectar for adult natural enemies.
2. Shelters 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 like *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:

- 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)
- Apply *Trichoderma* spp. and *Pseudomonas fluorescens* as seed/seedling/planting material, nursery treatment and soil 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).

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

Good insectary plants belonging to Compositae, Leguminaceae, Umbelliferae, Brassicaceae etc. families


Cluster bean


Cowpea


Carrot


Sunflower


Buckwheat


Alfalfa


Maize


Mustard


French bean


Marigold


Coriander


Chrysanthemum

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

Flowering plants that attract natural enemies/repel pests

Natural enemies	Attractant / Repellent / Trap Plants
Citrus aphid	
Predators: Lacewings, hover files, coccinellids, birds, earwigs, some ground beetles and rove beetles, and spiders	• **Attractant plant:** Carrot family, sunflower family, marigold, buckwheat, (syrphid, predatory mite, lacewing, minute pirate bug, samsel bug and ladybird beetle) • Nectar rich plants with small flowers i.e. dill and mustard (Aphid parasite and Braconid wasp) • Sunflower, buckwheat and cowpea (Braconid wasp)
Citrus black fly	
Parasitoids: *Encarsia formosa, Eretmocerus* spp. (Pupal) **Predators:** *Chrysoperla zastrowi sillemi,* coccinellids, spiders	• **Attractant plant:** French bean (Predatory thrips)
Citrus psylla	
Parasitoids: *Tamarixia radiata, Diaphorencyrtus aligarhensis* (nymphal and adult) **Predators:** *Chrysoperla zastrowi sillemi,* coccinellids, syrphids	• **Attractant plants:** Carrot family, sunflower family, buckwheat, alfalfa, (minute pirate bug, lacewing, syrphids)
Mealy bug	
Predators: Parasitic wasps, hover flies, ladybugs or mealy bug destroyers (*Cryptolaemus montrouzieri*)	• **Attractant plants:** Coriander attracts wasps.
Citrus butterfly	
Parasitoids:*Trichogramma evanescens, Telenomus* spp., (egg), *Brachymeria* sp (larval), *Pterolus* sp. (pupal)	• **Attractant plants:** Carrot family, sunflower family, buckwheat, alfalfa, shrubs (Lace wing) • Nectar rich plants with small flowers i.e. dill, mustard, sunflower, buckwheat and cowpea (Braconid wasp)

IV. CROP STAGE-WISE IPM

<table>
<tr><th>Management</th><th>Activity</th></tr>
<tr><td colspan="2">Pre planting*</td></tr>
<tr><td>Nutrients</td><td>• Pits of 1 meter cube are dug in square system during summer season and kept open for controlling soil borne pests.</td></tr>
<tr><td>Weeds</td><td>• Deep ploughing before establishment of orchards
• Remove the weeds mechanically.</td></tr>
<tr><td>Pests, nematode and soil borne pathogens</td><td>• Deep summer ploughing of fields to control nematodes and soil borne diseases
• Use of resistant / tolerant varieties</td></tr>
<tr><td colspan="2">Planting *</td></tr>
<tr><td>Nutrients</td><td>• Pits should be filled with a mixture of pond silt, red soil and FYM.
• Two- three Kg of bone meal or single super phosphate per pit should be applied.</td></tr>
<tr><td>Weeds</td><td>• Inter-cropping,
• Inter culture operation and hand weeding
• Where mechanical removal is not possible apply 2,4-D Sodium salt Technical (having 2,4-D acid 80 % w/w) (Earlier Registered as 80%WP) 0.5-1.28 Kg in 240 l of water/acre or apply Diuron 80% WP @ 1-2 Kg in 240 l of the water/acre (only for sweet orange) for control of weeds such as Cyperus iria, Tribulus terrestris, Digera arvensis, Commelina nudiflora.</td></tr>
<tr><td colspan="2">* Apply Trichoderma spp. and Pseudomonas fluorescens as seed/seedling/planting material, nursery treatment and soil 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).</td></tr>
<tr><td colspan="2">Vegetative growth stage * (1-5 years)</td></tr>
<tr><td>Nutrients</td><td>
<table>
<tr><th rowspan="2">Age of the plant (Year)</th><th colspan="3">Sathgudi & Pummelo</th><th colspan="3">Acid lime & Lemons</th></tr>
<tr><th>N (g)</th><th>P_2O_5 (g)</th><th>K_2O (g)</th><th>N (g)</th><th>P_2O_5 (g)</th><th>K_2O (g)</th></tr>
<tr><td>1</td><td>300</td><td>70</td><td>80</td><td>375</td><td>150</td><td>200</td></tr>
<tr><td>2</td><td>600</td><td>140</td><td>160</td><td>750</td><td>300</td><td>400</td></tr>
<tr><td>3</td><td>900</td><td>210</td><td>240</td><td>1125</td><td>450</td><td>600</td></tr>
<tr><td>4</td><td>1200</td><td>280</td><td>320</td><td>1500</td><td>600</td><td>600</td></tr>
<tr><td>5 & above</td><td>1500</td><td>350</td><td>400</td><td>1500</td><td>600</td><td>800</td></tr>
</table>
• Nitrogen is applied in the form of FYM and oil cakes each at 25% and the remaining 50% with chemical fertilizers, while, P_2O_5 in the form of super phosphate and K_2O in the form of muriate of potash.
• Manures are applied in 2 to 3 equal doses i.e. first dose in December-January, 2nd dose in June-July, 3rd dose in September. Potash application can be reduced if the soil is rich in this nutrient.
• Nitrogen containing fertilizers should be applied in three equal splits in January, July and November; phosphorus containing fertilizers in two splits in January and July and potassium containing fertilizers may be applied as single dose in January.
• Adopt ring method of fertilizer application.
• A mixture of zinc sulphate 0.5%, manganese sulphate 0.2%, boric acid 0.1%, urea 1% and lime 0.4% has to be sprayed two or three times in a year to control chlorosis in leaves.</td></tr>
</table>

	• **Intercrops** during pre bearing period short growing crops like groundnut, ragi, bajra wheat and vegetables (except solanaceous crops) can be profitably grown in the inter spaces. • In the bearing orchards, raise green manure crops like sunhemp, green gram, cowpea etc., and incorporate into the soil during the monsoon period.
Vegetative growth stage (1-5 years)	
Weeds	• Timely interculturing and hand weeding should be done. • **Mulching -** After weeding and manuring, apply dry-leaf mulch or paddy husk to a thickness of 8 cm in the basin. • **Inter-cultivation -** Shallow ploughing or light hand digging should be done during monsoon season. The soil in the basin is likely to become hard under continuous irrigation and therefore it should be given a light hand-digging with spade after every three irrigations so as to maintain porosity and tilth. Under no circumstances should weeds be allowed to grow rampant in the orchard.
Fruiting stage (5-20 years)	
Weeds	• Cultural operations same as in vegetative stage.
Citrus blackfly**	**Mechanical control:** • Collect and destroy the damaged plant parts along with nymphs, pupa and adults. • Use light trap (wavelength of 550 nm) • Yellow sticky traps or cards reduce the density of black flies **Biological control:** • Pupal parasitoids: *Encarsia formosa, Eretmocerus* spp • Predators: *Chrysoperla zastrowi sillemi*, coccinellids, spiders.
Citrus aphid	**Mechanical control:** • Use yellow sticky trap **Biological control:** • Conserve and enhance population of Predators: like Lacewings birds, earwigs, some ground beetles and rove beetles, spiders. **Chemical control:** • Foliar spray with dimethoate each at 30% EC @ 594-792ml in 600-800 l of water/ acre. • Foliar spray with chlorpyrifos 20% EC @ 600-800ml in 600-800 l of water/acre • Foliar spray with monocrotophos 36% SL @ 600-800ml in 200-800 l of water/acre • Foliar spray with oxydemeton-methyl 25% EC @ 480-640ml in 600-800 l of water/ acre
Citrus psylla	**Mechanical control:** • Collect and destroy the infested plant parts **Biological control:** • Conserve parasitoids such as *Tamarixia radiata, Diaphorencyrtus aligarhensis* • Conserve predators such as *Chrysoperla zastrowi sillemi*, coccinellids, syrphids.

	Chemical control: • Systemic insecticides like imidacloprid 17.8% SL @ 50 ml depending on size of tree & Protection equipment used are very effective at controlling both the nymphs and the adults. • Foliar spray thiamethoxam 25% WG @ 40 g in 400 l of water/acre. • Foliar spray with oxydemeton-methyl 25% EC @ 600-800 ml in 600-800 l of water/ acre
Fruit sucking moth	**Mechanical control:** • Destruction of larval hosts (alternate host) around orchards. • Collection and destruction of rotten and dropped fruits. • Collection and destruction of moths during night time using battery or flame torch in addition to installation of one fluorescent light trap/acre before one month of fruit maturation between 7.00 PM and 11.00 PM.
Mealybug	**Cultural control:** • Prune affected shoots during winter. • Destroy ant colonies. • Grow attractant plants to attract the defenders Bachelor's Buttons or cornflower (*Centaure acyanus*), coriander attract wasps. **Mechanical control:** • Collect and destroy the damaged leaves, twigs and stems • Use sticky barrier (5cm length) on trunk **Biological control:** • Field release of Australian ladybird beetle (*Cryptolaemus montrouzieri)* @10 beetles per tree. **Chemical control:** • Use fish oil rosin soap 25 g/lit • Spray with methyl demeton or dimethoate 2 ml /l or confidor 200 SL @ 4 ml/acre
Citrus leaf miner	**Mechanical control:** • Use pheromone trap @ 5/acre. • Pruning of affected parts during winter and burning **Chemical control:** • Carbofuran 3% CG @ 20000 g/acre • Foliar spray with imidacloprid 17.8% SL @ 50 ml and use spray volume depending on size of tree & protection equipment used • Foliar spray permethrin 25% EC @160-240 ml in 400 l of water/acre • Foliar spray with phorate 10% CG @ 6000 g/acre
Citrus/Lemon Butterfly	**Cultural control:** • Grow attractant plants: Carrot family, sunflower family, buckwheat, alfalfa, corn, shrubs (lacewing) • Nectar rich plants with small flowers i.e. anise, caraway, parsley, mustard, sun flower, buckwheat and cowpea (Braconid wasp)

	Mechanical control: • Hand pick the larvae and destroy. **Biological control:** • Conserve the parasitoids such as *Trichogramma evanescens*. • *Telenomus* spp on eggs *Brachymeria* spp, *Cotesia* on larvae and *Pterolus* sp. on pupae. **Chemical control:** • Spray Malathion @ 1 ml/ lit. • Foliar spray with quinalphos 25% EC @ 600-800 ml in 200-400 l of water/acre
Mite**	**Cultural control:** • Water stress often aggravates mite problem. Make sure that trees are well irrigated, particularly during the stress in late summer. **Biological control:** • The most important natural enemies of citrus mite are a predacious mite *Euseius hibisci* and the predators *Agistemus* sp. and *Amblylseisus hibisci*. **Chemical control:** • Foliar spray with monocrotophos 36% SL @ 374.8-500 ml in 200-800 l of water/acre
Scale**	**Cultural control:** • Pruning of the scale infested twigs. • Natural predators usually keep this insect in check. • Control ants and dust which can give the scale a competitive advantage. • Field release of *Vadalia* and Australian ladybugs. **Biological control:** • Spray dormant oil in late winter before spring. • Spray horticultural oil, if needed, year round. • Apply mixture of manure compost tea, molasses and citrus oil. • Garlic-pepper tea also helps. **Chemical control:** • Foliar spray with quinalphos 25% EC @1680-2240 ml in 200-400 l of water/acre.
Citrus scab	**Cultural control** • Collect and destroy the infested leaves, twigs and fruits. **Chemical Control** • Spray with 0.3 % COC or 1.0% Bordeaux mixture or 0.2% chlorothalonil at 15 day interval
Citrus canker	**Mechanical control:** • Select seedlings free from canker for planting in main field • Prune out and burn all canker infected twigs before monsoon. • Maintain proper aeration by training and pruning for reducing the leaf wetness period.

	Chemical control: • Captan 75% WP @ 666.8 g in 6-8 l of water/acre • Streptomycin Sulphate 9% + Tetracycline Hydrocloride 1%) SP Spray Streptocycline 50 to100 ppm solution repeatedly at an interval of 15 to20 days after the appearance of new growth. • Cover the foliage and young fruits fully.
Citrus tristeza disease	**Cultural control:** • Use certified budwood free of CTV • Remove all diseased trees as and when the disease is noticed. Fresh plantings to be taken with virus free materials on tolerant rootstocks. For sweet orange and mandarin avoid susceptible rootstocks. **Chemical control:** • For acid lime, use seedling immunised with mild strain of *Citrus Tristeza Virus* (Cross protection). • Periodic sprays of insecticides like Monochrotophos 0.05 % controls the population of citrus aphids that reduces secondary spread of the disease in the orchard. • Copper oxy chloride 50% WP @ 1 Kg in 300-400 l of water/acre
Gummosis	**Cultural control:** • Disease spread can be controlled by removing diseased bark and a buffer strip of healthy, light brown to greenish bark around the margins of the infection. • Preventive measures like selection of proper site with adequate drainage. • Use of resistant rootstocks and avoiding contact of water with the tree trunk by adopting ring method of irrigation are effective. **Chemical control:** • Aureofungin 46.15% w/v. SP @ 300 (1%) gm /ml/acre.
Powdery mildew**	**Cultural control:** • Nitrogen fertilizers encourage dense leafy growth, nitrogen should be applied at precise rates, less than 0.03175 metric per acre, to decrease severity. **Chemical control:** • Sulphur 80% WP @ 1252 g in 300-400 l of water/acre
Greasy spot	**Chemical control:** • Zineb 75% WP @ 600-800 g in 300-400 l of water/acre
Brown rot	**Chemical control:** • Captan 75% WP @ 500 g in 6-8 l of water/acre
Greening	**Cultural control:** • Selection of proper site with adequate drainage and high budding (30 to 46 cm or above).

	• Provision of an inner ring about 45 cm around the tree trunk to prevent moist soil. (Double ring method of irrigation) • Avoid irrigation water from coming in direct contact with the tree trunk. • Avoid injuries to crown roots or base of stem during cultural operations. • Use resistant sour orange rootstocks for propagating economic varieties • Use certified pathogen free bud wood for propagation. **Chemical control:** • Control psyllids with insecticides like dimethoate or imidacloprid • Applying Bordeaux paste or $ZnSO_4$, $CuSO_4$, lime (5:1:4) to a height of about 60 cm above the ground level at least once a year.

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

** 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

Nitrogen: Dull green, yellowish, smaller leaves. Die back of twigs, thin and bushy appearance of tops with sparse bloom. Deficiency is expressed by light green to yellow foliage over the entire tree. With mild deficiency, foliage will be light green progressing to yellow as conditions intensify. New growth usually emerges pale green in color, but darkens as foliage expands and hardens. With yellow vein chlorosis, the midribs and lateral veins turn yellow while the rest of the leaf remains a normal green color (Fig. 2).

Correction measure: Foliar sprays urea @ 2% at 15 days interval.

Potassium: Slower growth, shedding of leaves at blossom tine. New shoots poorly attached to twig. Smaller leaves, twigs die peak, scorching of leaf tips, small brown resinous spots on leaf. Small wrinkled spotted leaves. Small fruits, thin peel. In mandarin – yellowing and bronzing of leaves become twisted, wrinkled and spindy twigs.

Correction measure: Foliar spray of KNO_3 2% at fortnightly interval. Application of 200g N, 100g P_2O_5 and 200g K_2O / tree/year.

Boron: Premature wilting, water soaked spots on leaves. Premature shedding of leaves, bushing appearance curling of leaves, splitting and curling of veins. Fruits with gum spots and lumpings, hand abnormal shape and small.

Correction measure: Foliar spray of borax@0.5%

Copper: Reduced growth and dark green colour of leaves, twin led malformed leaves. New leaves shriveled, bushy growth.

Correction measure: Foliar spray of $CuSO_4$ each 0.5% at fortnightly interval.

Iron: Thin leaves with interregnal choruses in young leaves. Green tinge at the base of mid rib. Leaf size reduced. Later the leaves become pale or whitish and shed. Die back symptom older leaves remain green, fruits hand, coarse light coloured.

Correction measure: Foliar spray of $FeSO_4$ @ 0.5% twice at fortnight interval.

Manganese: Fine network of green veins as a light green background on young leaves. Leaf remains fairly green. Dark green irregular bands on mature leaves, along the midrib. White spots develop in interregnal area with die back symptom.

Correction measure: Foliar spray of 0.5% $MnSO_4$ at fortnightly interval.

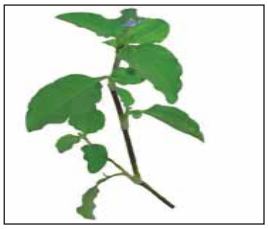
Zinc: Irregular and chlorite leaf spots, mottled leaf, small leaves, severe dieback of twigs. The area near midrib and lateral veins remain green. Terminal twigs with narrow small erect leaves. Small, thin skinned fruits.

Correction measure: Foliar spray 2% $ZnSO_4$ with 1% lime at fortnightly interval.

VII. DESCRIPTION OF COMMON WEEDS

Broad leaf weeds

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



A creeping or procumbent annual herb, 60-90 cm long. Dichotomously branched with diffuse branches, often rooting at nodes. Leaves 2.5-7.5 cm long and 1.3-3.8 cm wide, ovate or oblong, 1-3 together, funnel-shaped, and auricled on one side, pubescent or hirsute; flowers blue, borne in branched cymes. Fruits capsules 0.6 cm long, pyriform, membranous with oblong and closely pitted seeds.

2. Swine cress: *Coronopus didymus* (L.) Sm. (Brassicaceae)

An annual herb with, horizontal or ascending stem, multiple from the base, radiating from a central point; glabrous, green. Leaves are alternate, petiolate, pinnate, 4-5 cm long, 2 cm broad, glabrous. Divisions of the leaves opposite or lobed, linear-elliptic to linear oblong. Inflorescence is a small raceme, up to 4 cm long, opposite to one of the stem leaves, compact. Flowers minute, greenish. Fruits are glabrous, 3-4 mm broad, 2 mm long, slightly compressed, sub-globose, 2-seeded.

3. Horse purslane: *Trianthema portulacastrum* L. (Aizoaceae)

It is an annual herb with prostrate mat and stems up to a meter long. Stem is green to red in colour, hairless except for small lines of hairs near the leaves and fleshy. Leaves have small round or oval blades up to 4 cm long borne on short petioles. Flowers are solitary occur in leaf axils. The flower lacks petals but has purple, petal like sepals. Fruits are curved, cylindrical capsule emerging from the stem. Seeds are kidney-shaped, spiral, ended by a beak, 2 mm in diameter.

4. Black nightshade: *Solanum nigrum* L. (Solanaceae)

A variable annual herb up to 1 m tall with an erect, glabrous or sparsely pubescent stem and staggered branching pattern. Leaves are 2.5-9 cm long and 2-5 cm wide, ovate, glabrous, thin, margins toothed, tapering into the petiole, apex subacute. Flowers small, white, borne in drooping, umbellate 3-8 flowered cymes. Fruits berries globose, 5-8 mm in diameter, red, yellow or purplish-black. when ripened, fruits having numerous, disc-shaped, 1.5 mm in diameter, yellow, minutely pitted seeds.

5. False amaranth: *Digera arvensis* Forssk. (Amaranthaceae)

An annual herb, 30-60 cm heght with spreading branches. Leaves variable, 2-7.5 cm long and 1.3-4.5 cm wide, ovate or elliptic, acute or rounded at the apex, sometimes with reddish margins, glabrous. Flowers pink, borne in threes axillary, pedunculate spikes, 2.5-12.5 cm long. Fruits globose, approximately 0.3 cm in diameter having yellowish-brown.

6. Puncture vine: *Tribulus terrestris* L. (Zygophyllaceae)

A more or less pubescent annual herb Stem with prostrate or decumbent primary branches up to 1.5 m long radiating from the crown of the taproot. Opposite, paripinnate, up to 5.5 cm long, one of each pair usually smaller than the other; leaflets 3-6 pairs, 6-12 mm long, oblong to linear-oblong, with silky hairs on both surfaces, apex mucronate, base rounded oblique. Pale-yellow to yellow, 0.7-2 cm in diameter, leaf-opposite solitary. A schizocarp, globose, 1-1.5 cm across, consisting of 5 woody cocci, each with 2 pairs of hard, sharp, divaricate spines, one pair longer than the other. Seeds several in each coccus with transverse partitions between them; minute, oblong. A more or less pubescent annual herb.

7. Field bindweed: *Convolvulus arvensis* L. (Convolvulaceae)

A herbaceous perennial weed growing from a very deep root system. Shoots develop fromadventitious buds on the deep root system atalmost any depth down to 1 m. stem slender upto 1.5 m long, twining anticlockwise, glabrous or finely pubescent. Leaves alternate, variable in shape, ovate to narrow-oblong, 1.2-5.0 cm long, acute at the apex, pubescent with scattered crisped hairs. Flowers white or pink, axillary, solitary, peduncles, 2.5-5 cm long, slender with a pair of small linear bracts at the apex from which the pedicels arise; pedicels 3-25 mm long. Fruits capsules 6-8 mm in diameter, globose. Seeds are subtrigonous, dark reddish-brown and glabrous.

8. Common cocklebur: *Xanthium strumarium* L. (Asteraceae)

Annual herb Stout and hairy, much branched, up to 1.5 m tall. Leaves broadly triangular ovate or suborbicular, scarbid or hispid on both surfaces, apex acute, often 3-5 lobed, irregularly serrate, base some what cordate or shortly cuneate; petioles 2.5-7.5 cm long. Flower heads monoecious, numerous, white or green, in terminal and auxillary racemes; male heads in upper axils, globose; female heads in the lower axils, ovoid, covered with hooked bristles, ending in 2 strong hooked beaks. Achenes 1.3 cm long, obovoid, compressed, enclosed in a hardened, spinescent involucre.

9. Spurge herb: *Euphorbia hirta* L. (Euphorbiaceae)

An erect or procumbent annual herb, 15-50 cm height. Stem densely clothed with yellow hairs; branches often 4-angled.leaves opposite, 1.3-3.8 cm long and 0.6-1.6 cm wide, obliquely elliptic, apex acute, base usually unequal-sided, margins serrulate or dentate, hairy, dark green above and pale beneath. Flowers numerous, less than 1.3 mm long, crowded in small, globose, greenish-yellow auxillary cymes. Fruits capsules minute, 1.25 mm in diameter, trigonous, appressed hairy. Seeds angular, 0.8 mm long, light reddish-brown.

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

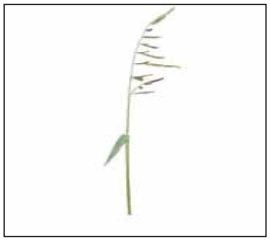
It is one of the worlds' worst weeds mostly found in uncultivated lands but now a -days it is seen invading cropped fields. It is a short-lived annual herb with an extensive root system and erect shoot upto 2 m height. Upper half of the main stem becomes highly-branched at flowering with strips due to longitudinal grooves or ribs and they become woody with age. Leaves are pale green, deeply lobed and covered with fine soft hairs. Flowers are creamy-white occurring at the tips of the stems. Clusters of male and female florets are grouped as five-lobed flowers on the terminal branches of the flower stem and measure 4–6 mm in diameter. Seeds are achene small (1–2 mm), flattened, triangular and dark brown–black with two thin, white, spoon-shaped appendages.

Grassy weeds

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

It is a perennial grass found on bunds and channels of cultivated fields. The rhizomes are mainly in the top 10 cm of the soil. They spread horizontally for several meters, with nodes at approximately 10 cm intervals. In dense stands, shoots developing from buds or rhizomes or runners tend to be erect and quite short, up to 25 cm height, but develop into prostrate runners under less dense conditions. Leaves are usually dull grey-green, flat, up to 15 cm long and finely parallel-ribbed on both surfaces, without a conspicuous midrib. Legule is very short but with white hairs.

12. Annual brachiaria: *Brachiaria deflexa* (Schumach.) Robyns (Poaceae)



Tufted annual, 15-125 cm height having weak, ascending, culms. Leaf-blades flat, 4-25 cm long and 4-22 mm wide, rounded to the base. Inflorescence is a false panicle of 4-24 often compound racemes on an axis, 5-18.5 cm long, racemes 2-10 cm in length with spikelets pedicelled, borne in pairs, one of a pair on a longer pedicel (up to 15 mm long) than the other; spikelets broadly elliptic, glabrous to pubescent 2.5-3.5 mm long with a short stipe up to 0.5 mm long.

13. Viper grass: *Dinebra retroflexa* (Vahl.) Panzer. (Poaceae)

An annual or perennial grass, up 50 cm or more tall. Stem culms usually straggling from a decumbent base, much branched, rooting at nodes, infrequently erect, green or purplish green. Leaves linear, 2-2.5 x 0.3-0.5 cm, glabrous or thinly pilose, apex acuminate. Inflorescence 6-20 cm long, narrowly elliptic oblong to pyramidal, open raceme 0.5-4 cm, stiff, ascending when young, reflexing and finally decumbent from the axis at maturity, rachis flattened, narrowly winged. Spikelets narrowly cuneate.

Sedge

14. Purple nut sedge: *Cyperus rotundus* L. (Cyperaceae)

A perennial sedge, hard, fragrant, globose-ovoid tubers 0.3-0.7 cm in diameter; culms solitary or few together, sparsely tufted, erect, 10-75 cm tall, 3-angled at top. Leaves narrowly linear, sometimes longer than stem, 0.4-0.8 cm wide, dark green above, pale beneath. Inflorescence is a simple or compound umbel, rays 2-8, each up to 7.5 cm long, bearing short spikes of 3-10 spreading, red-brown spikelets. Nuts oblong to ovate-oblong, 3-sided, 1.3-1.5 mm long and 0.5-0.7 mm wide, maturing brown.

VIII. DESCRIPTION OF INSECT AND NEMATODE PESTS

1) Citrus aphid:

Biology:

Egg: Eggs are not produced by this species. Females give birth to living young.

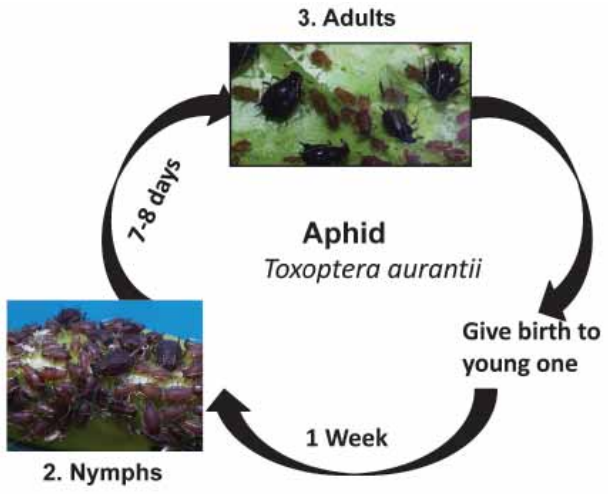
Nymph: There are four nymphal stages of this aphid. The first stage is approximately 1/36 inch in length and the last about 1/17 inch. They are without wings and brownish in color. Newly born nymphs are found grouped together since mothers do not move about while birthing.

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. This is the only aphid with an audible stridulation or high piercing sound caused by the aphid rubbing two parts of it body together much like crickets. Large colonies will produce this scrapping sound when they are disturbed. About thirty generations succeed each other and overlap throughout the year.

Favourable conditions:

- The development of this aphid is temperature dependent. The optimum temperature for this aphid is 20 to 25°C.
- Lower winter temperatures and particularly summer heat (above 30°C) slow down development.

Life cycle:



http://influentialpoints.com/Gallery/Polyphagous_aphids.htm
http://www.naturamalta.com/Toxoptera_aurantii.html

Damage symptoms:

- It feeds on tender foliage and flowers.
- It transmits Citrus Tristeza Virus disease.
- Nymphs and adults suck the sap of leaves which leads to wilting and flower dropping.
- Infested leaves become cup shaped and crinkled.
- Growth of the plants is hindered.

Aphids infested twig

http://www.infonet-biovision.org/default/ct/128/crops

Predators of citrus aphid:

1. Lacewing

2. Ground beetle

3. Rove beetle

4. Spider

2. http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/ Ground%20Beetle%20-%20Pterostichus%20madidus.html ; 3.http://www.naturephoto-cz.com/rove-beetle-photo-3703.html

*For the management refer page no 16

2) Citrus/Lemon-butterfly:

Biology:

Egg: Yellowish white, round, smooth eggs are laid singly on tender leaves and shoots by *P. demoleus*. Egg hatches in about 3 – 8 days.

Larva: Freshly hatched caterpillars are dark brown and soon develop irregular white markings on their body resembling bird's drop. The caterpillars feed voraciously on tender leaves right up to the mid ribs and defoliate the entire seedlings or the tree leaving behind only the midribs.

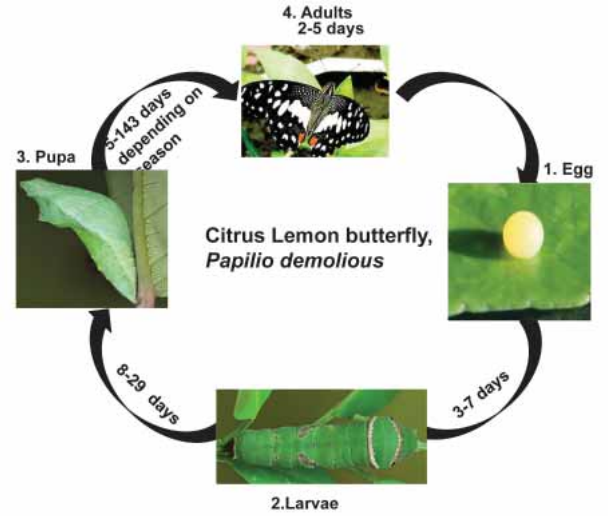
Pupa The caterpillars attach themselves to branches with silk, transforming into pupae. They remain in the pupal form for 2–3 weeks before emerging as adults.

Adult: *P. demoleus* is a big beautiful butterfly with yellow and black markings on all the four wings, having wing expanse of about 50-60 mm. Its hind wings have a brick red oval patch near the anal margin and there is no tail like extension behind though common in Papilionidae. *P. polytesmales* are black and females vary in form. *P. helenushas* black wings with three white distal spots.

Favourable conditions:

- The larval population density will be high during October to December months and July to December is the most favourable period of its activity in general.
- Citrus butterfly was able to survive during the winter even though temperatures dropped below 0°C.

Life cycle:



1,2,3,4:http://butterflycircle.blogspot.in/2011/11/life-history-of-lime-butterfly-v20.html

Damage symptoms

- Caterpillars prefers on light green tender leaves
- Feeding voraciously and leaving only the mid-ribs
- Severe infestation the entire tree gets defoliated.

Larvae feeding on leaves

http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insectpest%20_-Citrus.html#8a

Parasitoids of citrus butterfly :

Egg parasitoid:

1. *Telenomus*

Larval parasitoids:

2. *Distatrix papilionis*

3. *Brachymeria* sp.

2. http://www.nbaii.res.in/Featured_insects/images/distatrix-papilionis15.jpg
3. http://www.nbaii.res.in/Featured_insects/images/brachymeria-nephantidis4.jpg

*For the management refer page no. 17 & 18

3) Citrus psylla:

Biology:

Egg: Eggs are 0.2-0.3 mm pear shaped organe to yellow initially turn darker as they are ready to hatch**.**

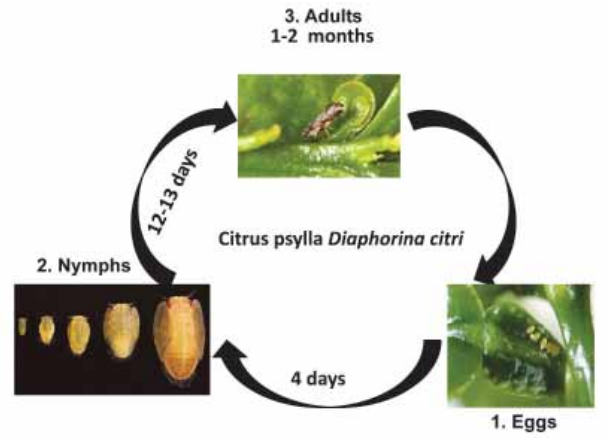
Nymph: Its nymphs are yellow, orange or brown with flattened bodies. They are hard to see, since they're only 1/100 to 1/14 inch long. The nymphs also secrete a sticky substance called honeydew that attracts sooty mold.

Adult: The Asian citrus psylla is a tiny, mottled-brown, winged insect that damages curry leaf plants when it sucks sap out of young leaves. This psyllid grows to be between 1/16 and 1/8 inch long with red eyes and short antennae.

Favourable conditions:

- Summer and rainy seasons.

Life cycle:



1&2http://entnemdept.ufl.edu/creatures/citrus/acpsyllid.htm

3. http://upload.wikimedia.org/wikipedia/commons/5/55/Asian_Citrus_Psyllid_adult.jpg

Damage symptoms:

- Asian citrus psyllids are mottled brown insects that feed directly on the leaf of the curry tree.
- This causes damage to the leaves and stems, and can also introduce bacteria to the tree.
- Psyllids, like other Homoptera, have piercing-sucking mouthparts used for feeding on plants.
- Feeding by psyllid adults and nymphs causes newly forming leaves to twist and curl similar to feeding damage from the green aphid.
- Psyllid feeding also results in reduction of shoot length giving a witches' broom effect
- If heavy feeding occurs early on the developing flush, the new flush will fail to develop or abort.
- In addition to direct feeding damage, honeydew inside the white waxy secretions produced by the nymphs promotes the growth of sooty mold which can reduce effective leaf area for photosynthesis.

1. Psylla damage symptoms

2. Damage to new leaves

3. Witches' broom effect

4. Accumulation of waxy secretions by nymphs

1. http://ucanr.edu/blogs/venturacountyucce/index.cfm?start=11&tagname=citrus
2. http://edis.ifas.ufl.edu/LyraEDISServlet?command=getImageDetail&imagesoid=FIGURE%207&document_soid=IN668&document_version=26977
3. http://edis.ifas.ufl.edu/LyraEDISServlet?command=getImageDetail&imagesoid=FIGURE%208&document_soid=IN668&document_version=26977
4. http://edis.ifas.ufl.edu/LyraEDISServlet?command=getImageDetail&image_soid=FIGUR
%2010&document_soid=IN668&document_version=26977

Parasitoids of citrus psylla:

Nymphal parasitoids:

1. *Tamarixia radiata*

2. *Diaphorencyrtus aligarhensis*

1. http://cisr.ucr.edu/blog/wp-content/uploads/2012/07/201_tamarixia_radiata_male_cisr_mike_lewis.jpg,
2. http://entnemdept.ufl.edu/creatures/beneficial/wasps/diaphorencyrtus_aligarhensis.htm

Predators of citrus psylla:

1. Coccinellid

2. Lacewing

*For the management refer page no. 16 & 17

4) Citrus leaf miner:

Biology:

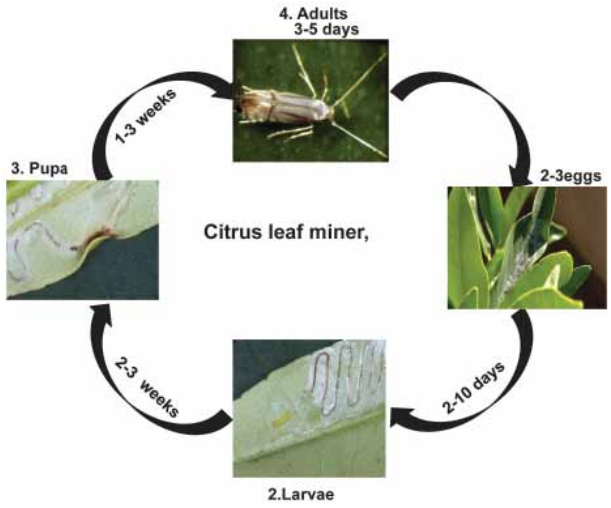
Egg: Eggs are very tiny (about 1.0 mm long and 0.2 mm wide), greyish or yellowish white and slightly translucent. They are laid inside the leaf tissue, just below the leaf surface. In some instances eggs are laid below the epidermis of fruits/pods (e.g. peas). Eggs hatch in about 3 days.

Larva: They are small yellow maggots (about 2 to 3 mm long when fully-grown). They are found feeding inside the leaf tissue, leaving a long, slender, winding, white tunnels (mines) through the leaf. They pass through 3 larval stages. After 5 to 7 days the maggots leave the mines and pupate either on the leaf surface or - more commonly - in the soil. In some cases, maggots pupate within the mines.

Pupa: Pupae are very small, about 2 mm long and 0.5 mm wide) oval, slightly flattened ventrally with variable colour varying from pale yellow-orange to golden-brown. They have a pair of cone-like appendages at the posterior end of the body. Adults emerge 4 to 5 days after pupation.

Adult: Adult flies are small, about 2 mm long. They are greyish to black with yellow markings. Female flies are slightly larger than males. The life cycle varies with host and temperature. The average life cycle is approximately 21 days in warm conditions, but can be as short as 15 days. Thus, populations can increase rapidly.

Life cycle:



. http://bugguide.net/node/view/705656
2. http://www.infonet-biovision.org/default/ct/83/pests
3. https://cisr.ucr.edu/citrus_leafminer.html

Favourable conditions:

- Citrus leaf miner develops best at temperatures between 70º to 85ºF and greater than 60% relative humidity, but will readily adapt to most California conditions.

Damage symptoms:

- Citrus leafminer larvae feed by creating shallow tunnels, referred to as mines, in young leaves.
- It is most commonly found on citrus (oranges, mandarins, lemons, limes, grapefruit and other varieties) and closely related plants (kumquat and calamondin).
- The larvae mine the lower or upper surface of the leaves causing them to curl and look distorted.
- Mature citrus trees (more than 4 years old) generally tolerate leaf damage without any effect on tree growth or fruit yield.
- Citrus leafminer is likely to cause damage in nurseries and new plantings because the growth of young trees is retarded by leafminer infestations. However, even when infestations of citrus leafminer are heavy on young trees, trees are unlikely to die.

Minings on leaves

http://www.iscatech.com/exec/news132.html

*For the management refer page no 17

5) Mealybug:

Biology:

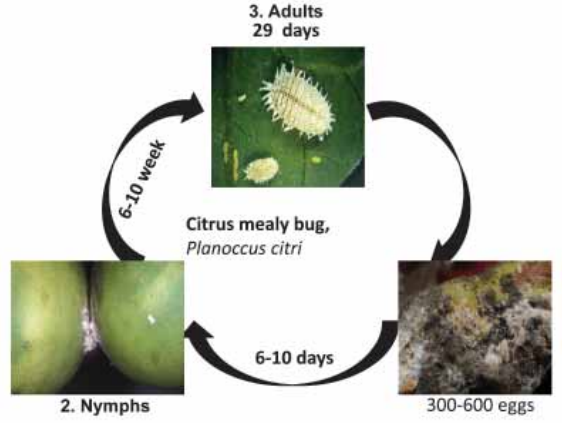
Egg: Eggs are deposited as white cottony masses called ovisacs on trunk and stems of citrus plants, giving the appearance of cotton spread on plants. The glossy, light yellow eggs are oval and approximately 0.3 mm long. A female can lay from 300 to 600 eggs in her life period, which are deposited in groups of 5 to 20. Depending on the season, egg hatch may occur after 6 - 10 days or several weeks. An average of 29 eggs per day is laid by females.

Nymphs: Nymphs emerge from the ovisacs and typically settle along midribs and veins on the underside of leaves, young twigs, and fruit buttons. Wax and honeydew secreted by crawlers are visible indicators of infestations. First instar female and male nymphs are called crawlers. The nymphs take 6 to 10 weeks to reach maturity. The nymphs

are yellow, oval-shaped with red eyes, and covered with white waxy particles The female nymphs resemble the adult female in appearance, while male nymphs are more elongated. Female nymphs have four instars. Males differ greatly; they have three instars and a pre-pupal stage.

Adult: Adult size ranges in length from 3 mm (females) to 4.5 mm (males). The females are wingless, white to light brown in color, with brown legs and antennae. The body of adult females is coated with white wax and bears a characteristic faint gray stripe along their dorsal side. Short waxy filaments can be seen around the margins of their oval body with a slightly longer pair of filaments present at the rear end of their body. Female mealybugs are wingless and, therefore, must be transported to subsequent host plants, although they are able to crawl for short distances. The immature can be blown by wind. Females can live for up to 29 days depending on the host plant. Males are similar in color to females and have two long backward-projecting white wax threads.

Life cycle:



1.http://www.alexanderwild.com/keyword/planococcus%20citri/
2.http://cals.arizona.edu/crops/citrus/pcaphotos.html#mealybug-
3.http://www.nbaii.res.in/insectpests/images/Planococcus-citri7.jpg

Damage symptoms:

- Citrus mealybug is a sporadic pest of citrus, occurring primarily in older, well-shaded groves planted on heavy soils.
- They will feed on the roots, bark, foliage, and fruit. The citrus mealybug injects toxic saliva while extracting plant sap resulting in defoliation, fruit discoloration, fruit splitting, and fruit drop.
- Mealy bugs usually gather in large numbers, causing premature leaf drop and twig dieback when they feed. Like psyllids, they secrete honeydew, which attracts black sooty mold.

1. Damage on fruits

1.http://cals.arizona.edu/crop/citrus/insects/citrusmealy.pdf

2. Damage on twigs

2.http://www.krishisewa.com/cms/disease-management/225-citrus_ip.html

Parasitoid of mealybug:

Nymphal and adult parasitoid:

1. *Leptomastix dactylopii*

1.http://www.nbaii.res.in/Introductions/images/leptomastix.jpg

Predators of mealybug:

1. *Cryptolaemus montrouzieri*

2. Lacewing

3. Ladybug beetle

1.http://www.nbaii.res.in/Featured_insects/images/cryptolaemus-montrouzieri5.jpg

*For the management refer page no 17

6) Fruit sucking moth:

Biology:

Egg: Eggs may be laid singly, or in egg masses containing 50-750 eggs. Placement may be on the underside of young leaves, or on any part of the host. Sometimes eggs may be placed on unsuitable hosts, particularly when the population density is high.

Larva: There are four molts and five instars. Total development time for larvae is about 21 days. Larvae can be found feeding anytime on the underside or edges of leaves, but typically feed between 5 PM and 10 AM. When in danger, young larvae tend to respond by dropping to the ground, while older larvae may exhibit a characteristic aggressive posture and swaying motion.

Pupa: Pupation occurs in an average of 12.5-17.8 days within a pupal cocoon that may remain in the tree or drop to the ground after drying.

Adult: The adult moth is large and robust. The eyes are large. The area behind the head of the moth, the thorax, is pale to purple-brown and the abdomen is pale brown at the base brightening to yellow-orange at the tip. The forewings resemble a leaf by being olive to purple-brown and may have white and green colored flecks (the colored flecks are more common on females). This leaf-like appearance of the forewings makes this moth difficult to see when it is at rest, especially, because the bright hindwings are not visible. The outer edges of the female's forewings are scalloped or toothed where those of the male's are evenly curved. The hindwings are bright orange, have a black comma-shaped mark and are fringed by a black border with white dots.

Damage symptoms:

- It is a serious pest of maturing mandarin fruits.
- The adults puncture the ripening fruits.
- Such fruits drop prematurely as a result of rotting due to fungal and bacterial infections introduced through punctures causing considerable fruit loss.

*For the management refer page no 17

1.Damage on fruit

2.Internal fruit damage

1&2.http://www.plantwise.org/default.aspx?site=234&page=4279&dsID=23012

7) Citrus blackfly:

Biology:

Egg: Eggs are laid in a spiral pattern on the underside of the leaf. Each female lays two to three egg-spirals during her 10 to 14 day life span. Eggs hatch within seven to 10 days.

Nymph: The first instar is elongate-oval, averaging 0.30 mm long x 0.15 mm wide and is brown in colour, with two glassy filaments curving over the body. The first instar lasts seven to 16 days. The second instar is more ovate and convex than the first instar, averaging 0.40 mm long x 0.20 mm wide, and is dark brown in colour with numerous spines covering the body. The second instar lasts seven to 30 days. The third instar is more convex and much longer than the second, averaging 0.87 mm long x 0.74 mm wide. The body is shiny black with spines stouter and more numerous than those in the second instar. The third instar lasts six to 20 days.

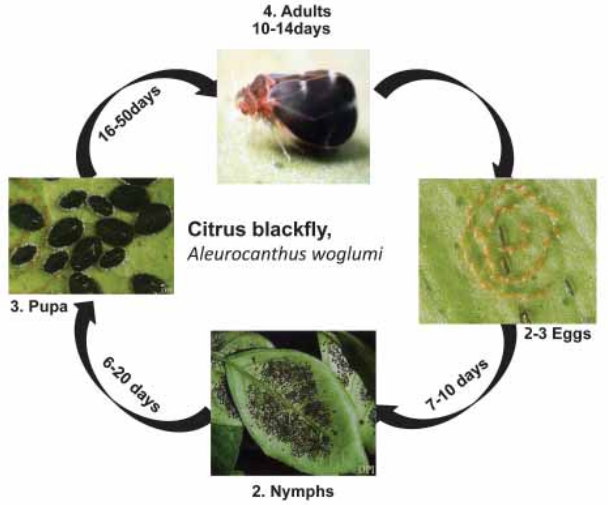
Pupa: The fourth instar, or so-called pupa case, is ovate and shiny black with a marginal fringe of white wax. The sex is readily distinguishable. Females average 1.24 mm long x 0.71 mm wide; males are 0.99 mm long x 0.61 mm wide. The pupal stage lasts 16 to 50 days.

Adult: The adult emerges from a T-shaped split appearing in the anterior end of the pupal case. At emergence, the head is pale yellow, legs are whitish, and eyes are reddish-brown. Within 24 hours after emergence, the insect is covered with a fine wax powder which gives it a slate blue appearance.

Favourable conditions:

- The development with high density citrus blackfly populations, especially during cool temperature and high humidity seasons.

Life cycle:



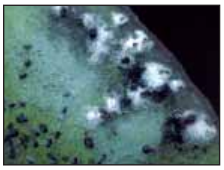
Damage symptoms:

- Citrus black fly is an endemic pest. The pest attack the crop during all the three flushing periods viz., Ambia (Jan.-Feb.), Mrig (Jun.- July) and Hasta (Oct.-Nov.) bahar and completes three generations in a year.
- Both nymphs and adults suck cell sap and secrete voluminous honeydew on which sooty mould grows wildly that leads to fungal manifestation (*Capnodium* sp.) locally called as 'Kolshi', covering entire plant due to which photosynthesis is affected.
- Plants are devitalized due to excessive desapping and in severe cases fruit bearing capacity of the tree is also affected. Fruits are rendered insipid in taste and blackened due to black sooty mould. Such fruits fetch low price in the market.

1. Nymphs on leaves

2. Adults and immatures secrete honeydew.

3. Sooty mould development on leaves



1&2 https://www.lsuagcenter.com/mcms/webtools/image.aspx?Watermark=ZABlAGYAYQB1AGwAdAA=&ResourcePath=/NR/rdonlyres/E8BCA637-D7DC-47AF-B345-D4EE47579AE1/45796/citrusblackflywithhoneydew.JPG3.https://www.lsuagcenter.com/mcms/webtools/image.aspx?Watermark=ZABlAGYAYQB1AGwAdAA=&ResourcePath=/NR/rdonlyres/E8BCA637-D7DC-47AF-B345-D4EE47579AE1/45792/blackflyandwoolywhitefly.JPG

Parasitoid of citrus blackfly:

1. *Amitus hesperidum*

1.http://www.forestryimages.org/browse/detail.cfm?imgnum=5194026

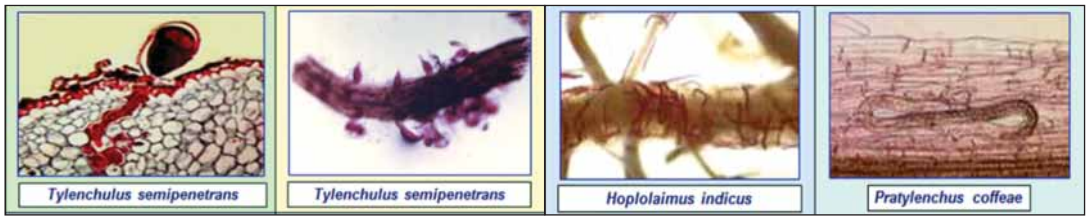
*For the management refer page no 16

8) Nematode:

Damage symptoms:

Symptoms are more prominent in established orchards as trees are stressed, either by suboptimal growing conditions, drought, or root stunting and decay induced by *T. semipenetrans* infection. Typically, reduced leaf and fruit size, canopy thinning, and exposure of bare crown limbs are the most conspicuous symptoms of slow decline and result in yield suppression

- Slow-decline, die-back, rootlets shortened, soil adhere to gelatinous matrix of eggmass
- Galls on roots, reduction in yield
- Heavily infested roots are darker in colour with branched rootlets
- Swollen and irregular in appearance than in normal ones



*For the management refer page no 15

IX. DESCRIPTION OF DISEASES

1) Citrus scab:

Disease symptoms:

- Initially small, semi-translucent dots like lesion develops on leaves which become sharply defined pustular elevations. The opposite surface corresponding to the warty growth shows a circular depression with a pink to red centre.
- On the fruit, lesions consist of corky projections which often break into scab affecting larger areas on the fruits

Survival and spread:

- Fungal survive in the infected leaves through overwintering lesions on the fruit or leaves and/or from any scab infections that have developed on the new spring flush.

Favourable conditions:

- Scab can be particularly severe on summer growth flushes. Summer wet periods associated with rain showers and dew is highly conducive for spore germination and infection.

*For the management refer page no 18

2) Citrus canker:

Disease symptoms:

- Initially, disease appears as minute water soaked round, yellow spots which enlarge slightly and turn brown, eruptive and corky.
- These pustules are surrounded by a characteristic yellow halo.
- Canker lesions on the fruit do not possess the yellow halo as on leaves. Several lesions on fruit may coalesce to form larger canker.
- Due to severe infections the there may be defoliation, and twig and stem may show die-back symptoms.

Survival and spread:

- In lesions on Citrus, and can also survive for long periods in diseased plant tissues
- Citrus leaf miners (*Phyllocnistis citrella*) helps in the dissemination of the pathogen.

Favourable conditions:

- Spring seasion is favourable for the development of disease

*For the management refer page no 18 & 19

3) Citrus tristeza disease:

Disease symptoms:

- Disease affected tree leaves becomes chlorotic in the early stages. Gradually the leaves drop and the defoliated twigs show die-back.
- Diseased trees usually blossom heavily.
- Under the tree bark stem pitting can be observed.
- Trees with stem pitting are stunted and set less fruits.
- The fruits are of smaller size and of poor quality (insipid fruits).

Transmission and favourable conditions:

- The disease is transmitted in semi persistent manner by aphid *Aphis gossypii*.
- Aphids are more active in warm summer conditions and increase their population as well as spread of the disease.

*For the management refer page no 19

4) Gummosis :

Disease symptoms:

- Disease starts as water soaked large patches on the basal portions of the stem near the ground level.
- Bark in such parts dries, shrinks and cracks and shreds in lengthwise vertical strips.
- Later profuse exudation of gum from the bark of the trunk occurs.
- Considerable amount of gum formation in sweet oranges may be observed, but relatively little in grapefruit.

Survival and spread:

- The fungus survives in the form of dormant mycelium and under moist conditions. The fungi produces large numbers of motile zoospores, which are splashed onto the tree trunks.
- Secondary infections often occur through lesions created by *Phytophthora*

Favourable conditions:

- The *Phytophthora* species causing gummosis develop rapidly under moist and cool conditions.

*For the management refer page no 19

5) Greening or Huanglongbing:

Disease symptoms:

- Affected leaves show small circular green islands within the chlorotic areas.
- Heavy leaf fall occurs with the onset of summer.
- Twig die-back may also occurs.
- Affected areas of the fruits remain green and gives bitter taste
- Affected fruits show reduction in size, loopsided growth and oblique columella.
- Seeds are poorly developed, dark coloured and aborted.

Transmission and favourable conditions:

- The bacterium is transmitted by the psyllids *Triozaerytreae* Del Guercio. The bacteria can be acquired by the insects in the nymphal stages and the bacteria may be transmitted throughout the life span of the psyllid.

*For the management refer page no 19 & 20

6) Anthracnose:

Disease symptoms:

- Leaf - common symptoms are a more or less circular, flat area, light tan in color with a prominent purple margin that at a later phase of infection will show the fruiting bodies of the fungus (tiny dispersed black flecks).
- Tissues injured by various environmental factors (such as mesophyll collapse or heavy infestations of spider mites) are more susceptible to anthracnose colonization.
- Fruit - anthracnose usually only occurs on fruit that have been injured by other agents, such as sunburn, chemical burn, pest damage, bruising, or extended storage periods. The lesions are brown to black spots of 1.5 mm or greater diameter. The decay is usually firm and dry but if deep enough can soften the fruit. If kept under humid conditions, the spore masses are pink to salmon, but if kept dry, the spores appear brown to black. On ethylene degreened fruit, lesions are flat and silver in color with a leathery texture. On degreened fruit, much of the rind is affected. The lesions will eventually become brown to grey black leading to soft rot.

Survival and spread

- Once the spores germinate, they form a resting structure that allows them to remain dormant until an injury occurs

Favourable conditions:

- Cool weather (temp 20°C) responsible for development of disease in plants
- Long period of high relative humidity >80% with mists

7) Sooty mould:

Disease symptoms:

- The dark, felty growth from sooty mold can be scraped off of plant surfaces, unlike fruit rots that extend into the rind and flesh.
- Where sooty mold occurs, look for aphids, citricola scale, cottony cushion scale, mealybugs, whiteflies, and other phloem-sucking insects that excrete honeydew on which sooty mold fungi grow.

8) Powdery mildew:

Disease symptoms:

Leaf

- White 'powdery' spores develop mostly on the upper leaf surface.
- Young leaves turn a pale whitish-grey-green.
- The ends of mildewed leaves can twist and curl upward.
- Young shoots can whither and die back.
- Sever infections cause defoliation.

Fruit

- White 'powdery' spores develop on the young fruits.
- Infected fruit fall prematurely.

Survival and spread:

- The fungi produce tiny, powdery spores that can survive on fallen leaves. It can be transported long distances by wind, on people (clothing, hands), equipment (e.g. pruning tools, mechanical harvesters or hedgers) or vehicles.

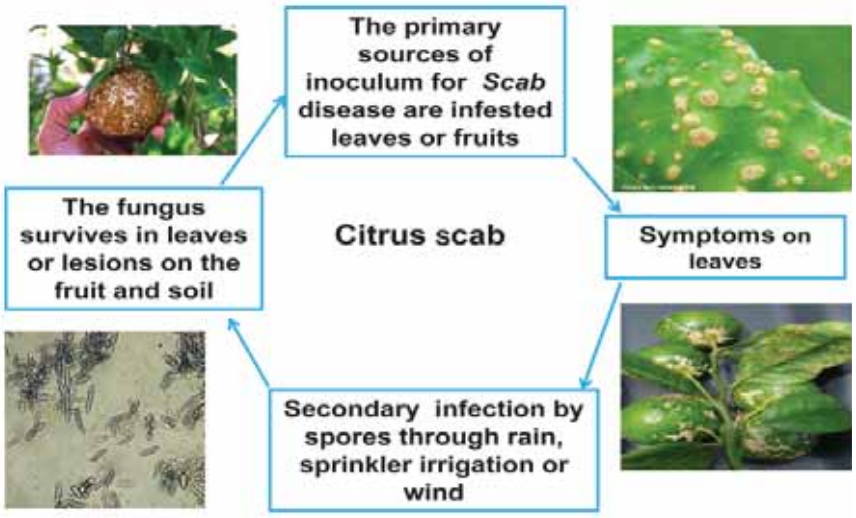
Favourable conditions:

- Cool and damp weather (temp 20°C) responsible for development of disease in plants
- Long period of high relative humidity >80% with mists and fog are especially conducive for the development of disease.

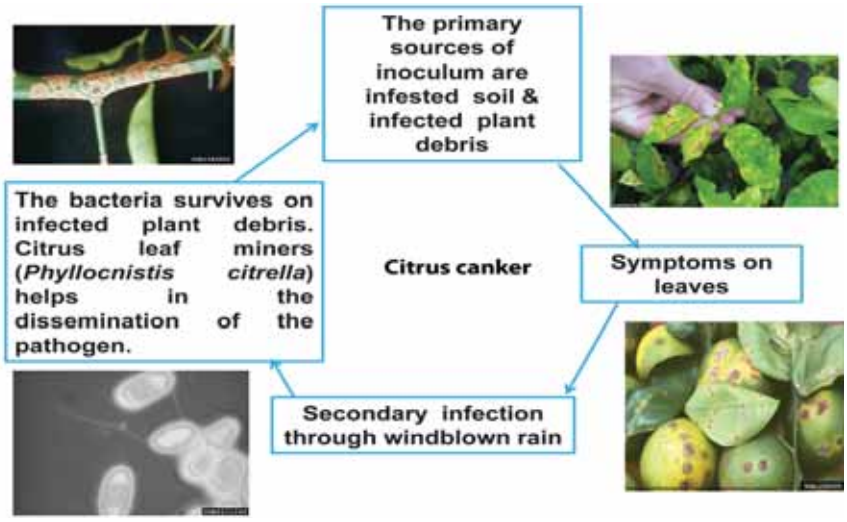
*For the management refer page no 19

Disease cycles:

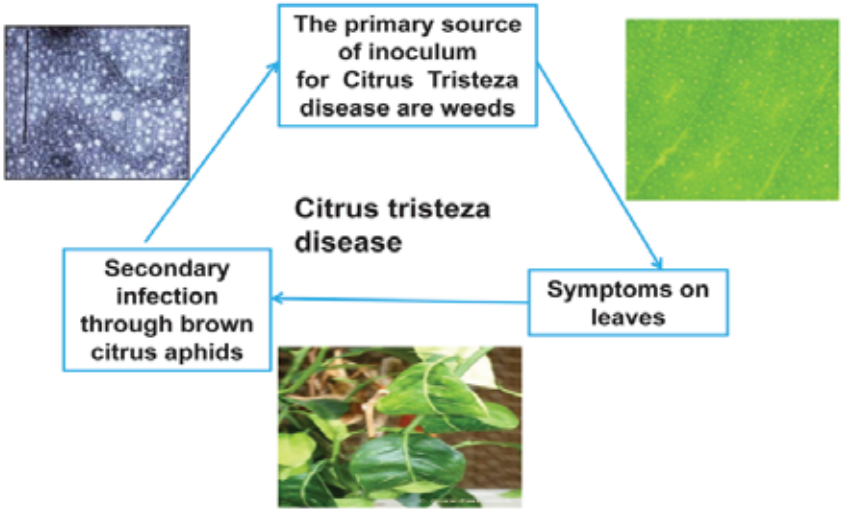
1. Citrus scab:



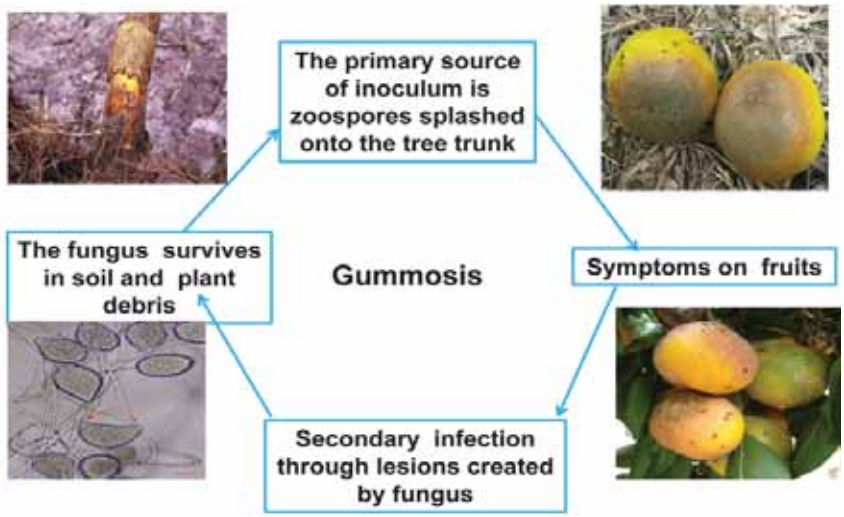
2. Citrus canker:



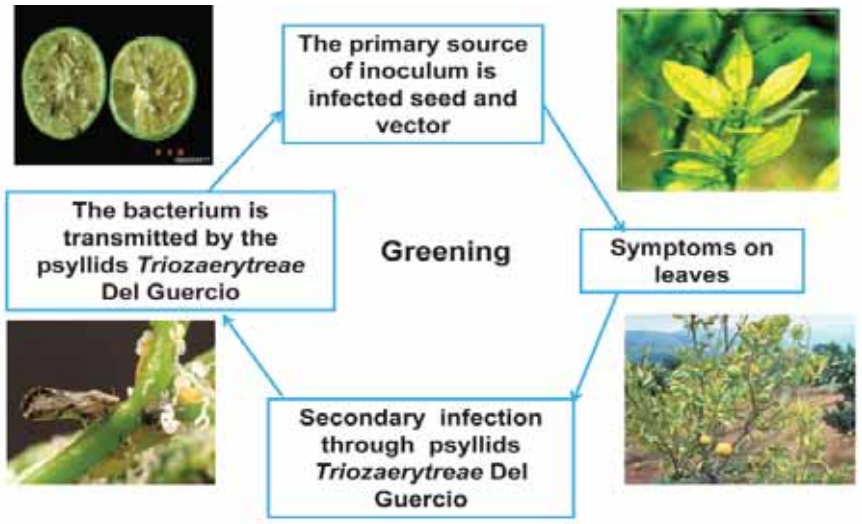
3. Citrus tristeza disease:



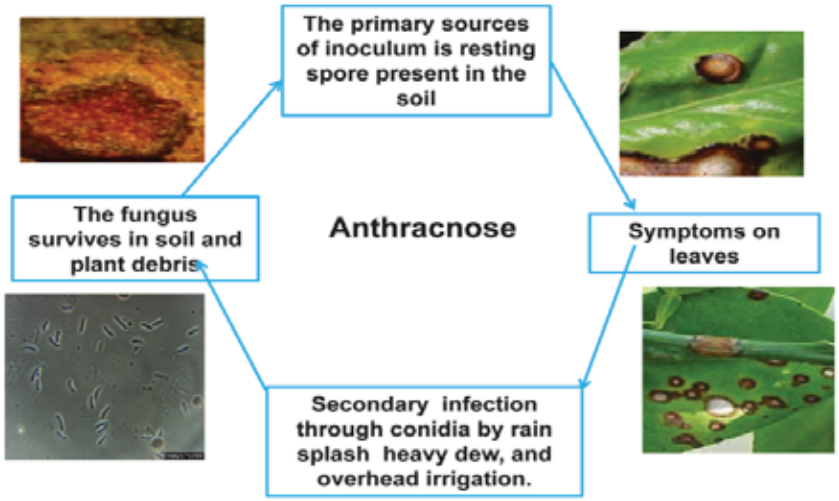
4. Gummosis:



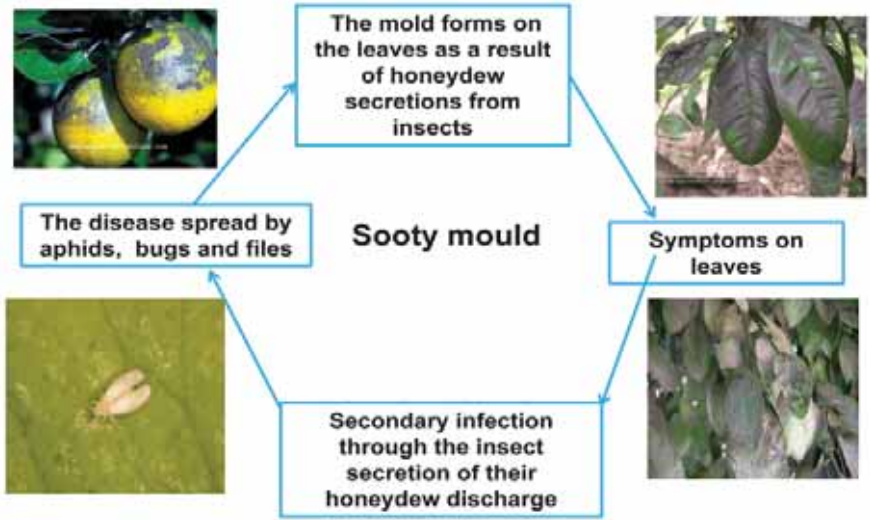
5. Greening or Huanglongbing:



6. Anthracnose:



7. Sooty mould:



X. SAFETY MEASURES

A. At the time of harvest:

Early and pre-harvest fruit drop is common in citrus fruits. To control this physiological disorder, it is a better to give three sprays of 2,4-D at 10 ppm (1g/100lit), one at the time of flowering, the second one month after fruit set and the third one month before harvest which is beneficial and increases the yield considerably minimizing the fruit drop. The harvest of contaminated fruit can increase the potential of food-borne illness to the consumer. Prior to harvest, an evaluation of the grove environment shall be performed and documented for changes that may be likely to result in contamination of citrus fruit. To the extent possible, action will be taken to prevent the harvest of fruit that is likely to be contaminated. The evaluation will be conducted no more than 7 days prior to harvest and will be recorded. Evidence of animal intrusion such as downed fences, presence of live or dead animals, animal tracks or feces. If animal intrusion is detected, measures shall be taken to remove or prevent from harvest any potentially contaminated product. Presence of potentially contaminating materials (e.g.non-composted manure, etc.) likely to pose a contamination risk to the grove to be harvested. Evidence that the irrigation water source and delivery system may potentially be compromised.

B. During post-harvest storage:

Citrus fruit that lose water at low relative humidities after harvest are prone to stem-end rind breakdown, a physiological injury that can predispose fruit to decay. Effective sanitation practices during postharvest handling can greatly reduce the incidence of decay. Harvested product is handled in such a manner that it is not likely to become contaminated. Harvested product is only handled with employees who have washed their hands. Gloves and sleeve guards will be used during harvest. They must be clean and replaced regularly or if contaminated. Product is only placed in clean harvesting containers (bins or harvest totes). Fruit will be removed from the orchard as soon after harvest as possible. Transportation from field to packinghouse will be arranged. Trailers will be clean, functional and free of objectionable odors before loading. Equipment used in the process shall be clean and well maintained and of suitable type to avoid contamination. All harvested fruit are delivered in open bins on flat-bed trucks. Truck beds and lift equipment do not contact fruit and therefore documented inspection of trucks is not necessary. Personnel responsible for the loading and unloading of product shall take steps to minimize the potential of physical damage.

XI. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The field should be kept exposed to sun light at least for 2-3 weeks.	Do not plant or irrigate the field after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/ or rhizomes of perennial weeds.
2.	Grow only recommended varieties.	Do not grow susceptible varieties
3.	Always treat the seedlings with approved chemicals/bio products for the control of seed borne diseases/pests. 	Do not use seeds without seedlings treatment with biopesticides/chemicals.
4.	Plant in rows at optimum depths under proper moisture conditions for better establishment.	Do not plant seedlings beyond 5-7 cm depth.
5.	Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
6.	Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition	Crops should not be exposed to moisture deficit stress at their critical growth stages.
7.	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
8.	Use micronutrient mixture after planting based test recommendations.	Do not apply any micronutrient mixture after planting without test recommendations.
9.	Conduct AESA weekly in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.	Do not take any management decision without considering AESA and P: D ratio
10.	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
11.	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per field observation 	Do not apply chemical pesticides within seven days of release of parasitoids.
12.	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites etc. 	Do not spray pesticides only on the upper surface of leaves.
13.	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
14.	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.

XII. SAFETY PARAMETERS IN PESTICIDE USAGE

S. No.	Pesticide	Classification as per insecticide rules	Colour of toxicity triangle	WHO classification of hazard	First Aid measures	Symptoms poisoning	Treatment of poisoning	Waiting period from last application to harvest (days)
Insecticides								
1	Dimethoate	Highly toxic		Class II Moderately 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.	
2	Imidacloprid	Highly toxic			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	Harmful if swallowed, absorbed through skin or inhaled. Avoid breathing vapor or spray mist. Causes moderate eye irritation.	No specific antidote. Treatment is essentially symptomatic.	3
3	Thiamethoxam				Have person sip a glass of water f able to		No specific antidote. Treatment is essentially symptomatic.	

					iswallow. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give anything by mouth to an unconscious			5
4	Cloropyrifos	Highly toxic		Class II - Moderately Hazardous	Atrophine sulphate	Severe – diarrhoea, pinpoint and non - reactive pupils, respiratory difficulty, pulmonary edema, cyanosis, loss of sphincter control, convulsions, coma and heart block.	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, aminophylln, barbiturates Phenothiaznines	7 days

5	Monocrotophos	Extremely toxic		Class I b Highly Hazardous	Atrophine sulphate	Severe – diarrhoea, pinpoint and non - reactive pupils, respiratory difficulty, pulmonary edema, cyanosis, loss of sphincter control, convulsions, coma and heart block.	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 r equired. Avoid morphine, theophylline, aminophylln, barbiturates Phenothiaznines	7 days
6	Oxydemeton-methyl	Highly toxic		Class Ib Moderately Hazardous	Atrophine sulphate	Severe – diarrhoea, pinpoint and non - reactive pupils, respiratory difficulty, pulmonary edema, cyanosis, loss of sphincter control, convulsions, coma and heart block.	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	7 days

							rate over a period of 5 minutes and administer again periodically as indicated. More than one injection may be required. Avoid morphine, theophylline, aminophylln, barbiturates Phenothiaznines	
7	Phorate	Extremely toxic		Class I a Extremely hazardous	Remove the person from the contaminated environment In case of (a) Skin contact Remove all contaminated clothings and immediately wash with lot of water and soap. (b) Eye contamination Wash the eyes with plenty of cool and clean water; (c) Inhalation – Carry the person to the open fresh air, loosen the clothings around neck and chest, and	Nausea, vomiting, restlessness, tremor, apprehension, convulsions, coma, respiratory failure and death Mild – anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity. Moderate- nausea, salivation, lacrimation, abdominal cramp, vomiting, sweating, slow pulse, muscular tremors, miosis. Severe – diarrhea, pinpoint and non-reactive pupils, respiratory difficulty, pulmonary edema,	- Gastric lavage with 2-4 L. tap water. Catharsis with 30 gm (10 oz) sodium sulphate in the cup of water - Barbiturates in appropriate dosages repeated as necessary for restlessness or convulsions. - Watch breathing closely, aspirate oxygen and/or artificial respiration, if needed. - Avoid oils, oil laxatives and epinephrine (Adrenalin) – do not give stimulants. - Give calcium gluconate (19% in 10 ml Ampules) intravenously every four hours.	-

					obstruction. Victim's head should be little lowered and face should be turned to one side in the lying down position. In case of breathing difficulty, give mouth to mouth or mouth to nose breathing. Medical aid: Take the patient to the doctor/ Primary Health Centre immediately along with the original container, leaflet and label	cyanosis, loss of sphincter control, convulsions, coma and heart block.	For extreme symptoms of O.P 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. Speed is imperative - Atropine injection – 1 to 4 mg. Repeat 2 mg, when toxic symptoms begin to recur (15-16 minute intervals), Excessive salivation good sign, more atropine needed. - Keep airways open, Aspirate, use oxygen, insert endotracheal tube. Do tracheotomy and give artificial respiration as needed. - For ingestion lavage stomach with 5% sodium bicarbonate if not vomiting. For skin contact, wash with soap and water (eye wash with isotonic saline). Wear rubber gloves while washing contact areas. In addition to atropine give 2-PAM (2- pyridine aldoximemethiodide)	

							1g and 0.25 g for infants intravenously at a 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, barbituaratesofrpheno-thiazines. Do not give atropine to a cyanotic patients. Give artificial respiration first then administer atropine.	
8	Quinalphos	Highly toxic		Class II Moderately Hazardous	Do	Do	Do	-
9	Dicofol	Moderately toxic		Class III slightly toxic		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin, allergic manifestations etc.	No specific antidote. Treatment is essentially symptomatic	15-20
10	Permethrin							
11	Metaldehyde	Highly toxic		Class II 'moderately hazardous		evere abdominal pain, nausea, vomiting, diarrhoea, fever, convulsions, and coma. Other symptoms of acute exposure include increased heart		

						rate, panting, asthma, depression, drowsiness, high blood pressure, inability to control release of urine and faeces, incoordination, muscle tremors, sweating, excessive salivation, tearing cyanosis, acidosis, stupor and unconsciousness In domesticated and wild mammals include inability to stand, blindness, change in respiratory rate, excessive sweating and salivation, sudden death and seizures. Autopsy results from metaldehyde poisoned dogs show congestion and haemorrhages in the liver, kidneys and heart.		
Fungicides								
1	Streptocy-cline	Slightly toxic		Unlikely to produce acute hazard	Headache, palpitation, nausea, vomiting, flushed face,		No specific antidote. Treatment is essentially symptomatic.	

					irritation of nose,throat, eyes and skin etc.			
2	Captan	Moderately toxic		Class III slightly hazardous		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose,throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic.	
3	Wettable sulphur	Slightly toxic		Unlikely to present acute hazard in normal use		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose,throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic.	
4	Copper oxychloride	Moderately toxic		Class III slightly hazardous		do	do	
5	Zined	Slightly to moderately toxic		Pale yellow		Early symptoms from exposure of humans to inhalation of zineb include tiredness, dizziness and weakness. More severe symptoms include headache, nausea, fatigue, slurred speech, convulsions and unconsciousness	-	

Herbicides								
1	2,4-D Sodium salt Technical	lesser extent, toxicity	White powder			Symptoms of acute oral exposure to 2,4-D include vomiting, diarrhea, headache, confusion, aggressive or bizarre behavior. A peculiar odor is sometimes noted on the breath. Skeletal muscle injury and renal failure may also occur.18 Systemic toxicity is mainly associated with suicide attempts. Dermal exposure may include irritation, and inhalation exposure may lead to coughing and burning sensations in the upper respiratory tract and chest.18 Prolonged exposure may result in dizziness.18 Chlorophenoxy	-	>6 months

						compounds such as 2,4-D are quickly absorbed when swallowed, but absorption from dermal or inhalation exposure is low.		
2	Diuron	Slightly toxic.		Class III		Diuron can enter the body either by inhalation of air containing diuron, accidental ingestion of diuron, or by dermal contact with diuron. Inhalation of diuron can irritate the nose and throat. Ingestion of diuron may lead to nausea, vomiting and diarrhoea. Dermal contact with diuron can cause skin irritation. Eye contact can cause irritation. It is unlikely that diuron will cause reproductive effects in humans at expected levels of exposure. The compound can cause eye and throat irritation. It is much less of an irritant to intact skin.	-	

XIII. BASIC PRECAUTIONS IN PESTICIDES USAGE

A. Purchase

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

B. Storage

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

C. Handling

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

D. Precautions for preparing spray solution

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

E. Equipment

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

F. Precautions for applying pesticides

1. Apply only at recommended dose and dilution
2. **Do not** apply on hot sunny day or strong windy condition ; **Do not** just before the rains and after the rains ; **Do not** 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 sprayer
7. Avoid tank mixing of different pesticides

G. Disposal

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

XIV. PESTICIDE APPLICATION TECHNIQUES

Equipment			
Category A: Stationary, crawling pest/disease			
Vegetative stage i) for crawling and soil borne pests	Insecticides and fungicides	• Lever operated knapsack sprayer (droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min *or* • Motorized knapsack sprayer or mist blower (droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle	 
ii) for small sucking leaf borne pests			
Reproductive stage	Insecticides and fungicides	• Lever operated knapsack sprayer (droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min	
Category B: Field flying pest/airborne pest			
Vegetative stage Reproductive stage *(Field Pests)*	Insecticides and fungicides	• Motorized knapsack sprayer or mist blower (droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle *Or* • Battery operated low volume sprayer (droplets of small size) • Spinning disc nozzle	 
Mosquito/ locust and spatial application *(migratory* Pests)	Insecticides and fungicides	• Fogging machine and ENV (exhaust nozzle vehicle) (droplets of very small size) • Hot tube nozzle	
Category C: Weeds			
Post-emergence application	Weedicide	• Lever operated knapsack sprayer (droplets of big size) • Flat fan or floodjet nozzle @ 15 to 20 psi • Lever operating speed = 7 to 10 strokes/min	 
Pre-emergence application	Weedicide	• Trolley mounted low volume sprayer (droplets of small size) • Battery operated low volume sprayer (droplets of small size)	

XV. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

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

XVI. REFERENCES

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Good insectary plants belonging to Compositae, Leguminaceae, Umbelliferae, Brassicaceae etc. families

Cluster bean

Cowpea

Carrot

Sunflower

Buckwheat

Alfalfa

Maize

Mustard

French bean

Marigold

Coriander

Chrysanthemum

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