सत्यमेव जयते

AESA BASED IPM PACKAGE
LITCHI

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

National Institute of Plant Health Management
Rajendranagar, Hyderabad, Telangana

Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

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

NIPHM Working Group:

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

Core Members :

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

Other members

5. Dr. N. Srinivasa, Assistant Director (RPM), Rodent Expertise.
6. Dr. B. S. Sunanda, Assistant Scientific Officer (PHM), Nematology Expertise.

Contributions by DPPQ&S Experts:

1. Shri. Ram Asre, Additional Plant Protection Advisor (IPM),
2. Dr. K. S. Kapoor, Deputy Director (Entomology),
3. Dr. Sanjay Arya, Deputy Director (Plant Pathology),
4. Dr. Subhash Kumar, Deputy Director (Weed Science)
5. Dr. C. S. Patni, Plant Protection Officer (Plant Pathology)

Contributions by External Experts:

1. Dr. Gundappa, Scientist (Entomology), Central Institute for Subtropical Horticulture, Rehmankhera, P.O Kakori,Lucknow-226101, U.P
2. Dr. Vishal Nath, Director, National Research Centre on Litchi, Mushahari, Muzaffarpur, Bihar-842002
3. Dr. V. K. Kalra, HOD (Entomology), CCS Haryana Agricultural University, Hisar- 125004, Haryana
4. Director of Research, CSK, Himachal Pradesh Krishi, Vishvavidyalaya, Palampur.
5. The Director, Indian Institute of Horticultural Research, Hessaraghatta lake Post,Banglore-560089
6. Director of Research, Navsari Agricultural University, Eru Char Rasta, Dandi Road, Navsari-396450 (Gujarat)
7. Director of Research, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli-415712,Dist-Ratnagiri.
8. Director of Research, Punjab Agriculture University, Ludhiana

9. Directorate of Experiment Station, G. B. Pant University of Agriculture & Technology Pantnagar-263145, Dist. Udham singh Nagar (Uttarakhand, India)
10. Dr. S. K. Panda, Professor & Head, Department of Entamology, College of Agriculture, Odhisha University of Agriculture & Technology, Bhubaneswar-751003
11. Dr. K. C. Sahu, Professor & Head, Department of Plant pathology, College of Agriculture, Odhisha University of Agriculture & Technology, Bhubaneswar-751003
12. Dr. S.N. Mohapatra, Professor & Head, Department of Nematology, College of Agriculture, Odhisha University of Agriculture & Technology, Bhubaneswar-751003
13. Dr. Jayalaxmi Ganguli, Asst. Professor (Entomology), IGKV, Raipur (CG) 492 012
14. Dr. Narendra Lakpale, Asst. Professor, (Plant Pathology) IGKV, Raipur (CG) 492 012.

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

सत्यमेव जयते

Avinash K Srivastava
Additional Secretary
Government of India
Ministry of Agriculture
(Department of Agriculture
& Cooperation)
Krishi Bhawan, New Delhi - 110001

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.

A K Srivastava

Date: 6.3.2014

(Avinash K. Srivastava)

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

सत्यमेव जयते

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

FOREWORD

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

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

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

(Utpal Kumar Singh)

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

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

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

PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

CONTENTS

Litchi -Plant description

I. Pests

A. Pests of National Significance

1. **Insect and mite pests**
2. **Diseases**
3. **Nematodes**
4. **Rodents**
5. **Weeds**

B. Pests of Regional Significance

1. Insect pests

2. Diseases

II. AESA based IPM

A. Agro-ecosystem analysis

B. Orchard scouting

C. Surveillance through pheromone trap catches for *Spodoptera*and *Helicoverpa*

D. Yellow pan water trap/sticky traps

E. Light traps

F. Nematode sampling

III. Ecological engineering for pest management

IV. Crop stage-wise IPM

VI. Description of common weeds

VII. Description of insect pests

VIII. Description of diseases

X Safety measures

A. At the time of harvest

B. Post-harvest storage

XIII. Do's and Don'ts in IPM

XIV. Safety parameters in pesticide usage

XV. Basic precautions in pesticides usage

XVI. Pesticide application techniques

XVII. References

AESA BASED IPM PACKAGE FOR LITCHI

Litchi- Plant description

The litchi (*Litchi chinensis* Sonn. *(Nephelium litchi* Cambess; Family: Sapindaceae) is the most renowned of a group of edible fruits. The litchi tree is, dense, round-topped, slow-growing, 30 to 100 ft (9-30 m) high and equally broad. Its evergreen leaves, 5 to 8 inch (12.5-20 cm) long, are pinnate, having 4 to 8 alternate, elliptic-oblong to lanceolate, abruptly pointed, leaflets, somewhat leathery, smooth, glossy, dark-green on the upper surface and grayish-green beneath, and 2 to 3 inch (5-7.5 cm) long. The tiny petalless, greenish-white to yellowish flowers are borne in terminal clusters to 30 inch (75 cm) long. Showy fruits, in loose, pendent clusters of 2 to 30 are usually strawberry-red, sometimes rose, pinkish or amber, and some types tinged with green. Most are aromatic, oval, heart-shaped or nearly round, about 1 in (2.5 cm) wide and 1 1/2 in (4 cm) long; have a thin, leathery, rough or minutely warty skin, flexible and easily peeled when fresh. Immediately beneath the skin of some varieties is a small amount of clear, delicious juice. The glossy, succulent, thick, translucent-white to grayish or pinkish fleshy aril which usually separates readily from the seed, suggests a large, luscious grape. The flavor of the flesh is subacid and distinctive. There is much variation in the size and form of the seed. Normally, it is oblong, up to 3/4 in (20 mm) long, hard, with a shiny, dark-brown coat and is white internally. Through faulty pollination, many fruits have shrunken, only partially developed seeds (called "chicken tongue") and such fruits are prized because of the greater proportion of flesh. In a few days, the fruit naturally dehydrates, the skin turns brown and brittle and the flesh becomes dry, shriveled, dark-brown and raisin-like, richer and somewhat musky in flavor. Because of the firmness of the shell of the dried fruits, they came to be nicknamed "lychee, or litchi, nuts" by the uninitiated and this erroneous name has led to much misunderstanding of the nature of this highly desirable fruit. It is definitely not a "nut", and the seed is inedible.

I. PESTS:

A. Pests of National Significance

1. Insect pests

1.1 Fruit borer: *Conopomorpha sinensis* (Hendel), (Lepidoptera: Gracillariidae)
1.2 Litchi mite: *Aceria litchi* (Acari: Eriophyidae)
1.3 Leaf roller: *Statherotis discana* (Felder & Rogenhofer) (Lepidoptera: Tortricidae)
1.4 Litchi bug: *Tessaratoma javanica* (Hemiptera: Tessaratomidae)
1.5 Mealy bug: *Planococcus litchi* Cox. (Hemiptera: Pseudococcidae)

2. Diseases

2.1 Fruit rot: *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc.
2.2 Powdery mildew: *Odium* spp.
2.3 Leaf rust: *Cephaleuros virescens* Kunze.
2.4 Postharvest diseases:
2.4.1 *Aspergillus* rot: *Aspergillus niger* van Teighem, *A. flavus* Link, *A. variecolor* (Vuillemin) Tiraboschi.
2.4.2 *Botryodiplodia rot: Botryodiplodia theobromae* Pat.
2.4.3 *Colletotrichum* rot: *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc.

3. Weeds

Broad leaf
3.1Tick weed: *Cleome viscosa L.* (Capparidaceae)
3.2 Coat buttons: *Tridax procumbens* L. (Fabaceae)
3.3 Congress grass: *Parthenium hysterophorus* L. (Asteraceae)
3.4 Horse Purslane: *Trainthema portulacastrum L.* (*Aizoaceae)*
3.5 Goat weed: *Ageratum conyzoides* L. (Asteraceae)
3.6 Joyweed*: Alternanthera sesilis* (Amranthaceae)

Grassy weeds
3.5 Crab grass *Digiteria sanguinalis* (L.) Scop. (Poaceae)
3.6 Yellow foxtail *Setaria glauca* (L.) P. Beauv. (Poaceae)
3.7 Bermuda grass *Cynodon dactylon* (L.) Pers. (Poaceae)
3.8 Torpedo grass *Panicum repens* L. (Poaceae)

Sedge
3.9 Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)

B. Pests of Regional Significance

1. Insect Pest

1.1 Bark eating caterpillar: *Indarbela quadrinotata* Walker (Lepidoptera: Metarbelidae)
1.2 Shoot borer: *Conopomorpha sinensis* Bradley (Lepidoptera ; Gracillariidae)
1.3 Litchi nut borer: *Blastobasis* sp (Lepidoptera: Blastobasidae)
1.4 Whitefly: *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae)
1.5 Leaf cutting weevil: *Myllocerus undatus* Marshall (Coleoptera: Curculionidae)
1.6 Leaf miner: *Acrocercops heirocosma* Meyrice (Lepidoptera: Gracillariidae)
1.7 Litchi semilooper: *Anisodes illepidaria* Guenée (Lepidoptera : Geometridae)

2. Diseases

2.1. Anthracnose: *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc.

2.2. Root rot: *Armillaria tabescens* (Scop.) Dennis, *Pythium* sp. *Fusarium* sp.

2.3. Dieback: *Phomopsis* sp.

2.4 Leaf spots: *Pestalotia pauciseta* Sacc., *Botryodiplodia theobromae* Pat.

II. AGRO-ECOSYSTEM ANALYSIS (AESA) BASED INTEGRATED PESTS 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 in the orchard. 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 of the orchard and how to make proper decisions for their crop management. This process is called the AESA. Participants of AESA will have to make a drawing on a large piece of paper (60 x 80 cm), to include all their observations. The advantage of using a drawing is that it requires the participants/farmers to observe closely and intensively. It is a focal point for the analysis and for the discussions that follow, and the drawing can be kept as a record.

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

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

Principles of AESA based IPM:

Grow a healthy crop

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

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

Farmers should

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

Plant compensation ability

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

Understand and conserve defenders

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

Insect zoo

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

Pest: Defender ratio (P: D ratio):

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

Model Agro-Ecosystem Analysis Chart

Date:
Village:
Farmer:

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

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

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

Decision making

Farmers become experts in crop management

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

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

AESA methodology

- Go to the orchard in groups (about 5 farmers per group). Walk across the orchard and choose 20 plants/acre randomly. Observe keenly each of these plants and record your observations:

    - Plant: Observe the plant height, crop stage, deficiency symptoms etc.
    - Insect pests: Observe and count insect pests at different places on the plant.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
    - Rats: Count number of plants affected by rats.
    - Weeds: Observe weeds in the orchard and their intensity.
    - Water: Observe the water situation of the orchard.
    - Weather: Observe the weather condition.
- While walking in the orchard, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the field situations of the orchard in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field situations of the orchard. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on what field management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording

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

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

Data to be recorded

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

Some questions that can be used during the discussion

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


Advantages of AESA over ETL

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

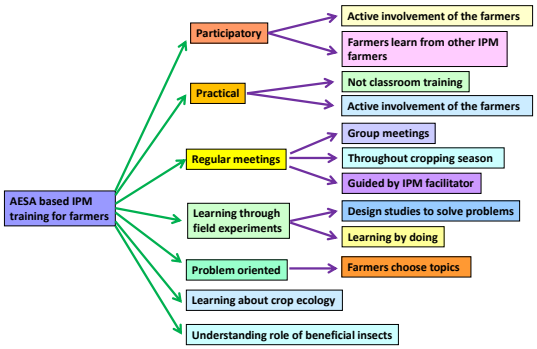
AESA and farmer field school (FFS)

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

Farmers can learn from AESA

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

FFS to teach AESA based IPM skills



B. Field scouting:

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

Surveillance on pest occurrence at the orchard should commence soon after crop establishment after sowing and at weekly intervals thereafter. In each of the orchard s, select five spots randomly as shown (four in the corners, at least 5 feet inside of the orchard borders, and one in the centre). Select five random plants at each spot for recording counts of insects as per procedure finalized for individual insects.

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

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

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

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

Sampling frequency:

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

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

C. For sucking pests:

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

For Diseases:

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

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

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

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

C. Yellow pan water trap:

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

D. Light traps:

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

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

Ecological Engineering for Pest Management – Below Ground:

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

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

Ecological Engineering for Pest Management – Above Ground:

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

Natural enemies may require:

1. Food in the form of pollen and nectar.
2. Shelter, overwintering sites and moderate microclimate etc.

3. Alternate hosts when primary hosts are not present.

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

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

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

Plants Suitable for Ecological Engineering for the Pest Management

French bean

Marigold

Carrot

Sunflower

Mustard

Caraway

Alfalfa

Dill

Cowpea

***Desmodium*sp**

Chrysanthemum

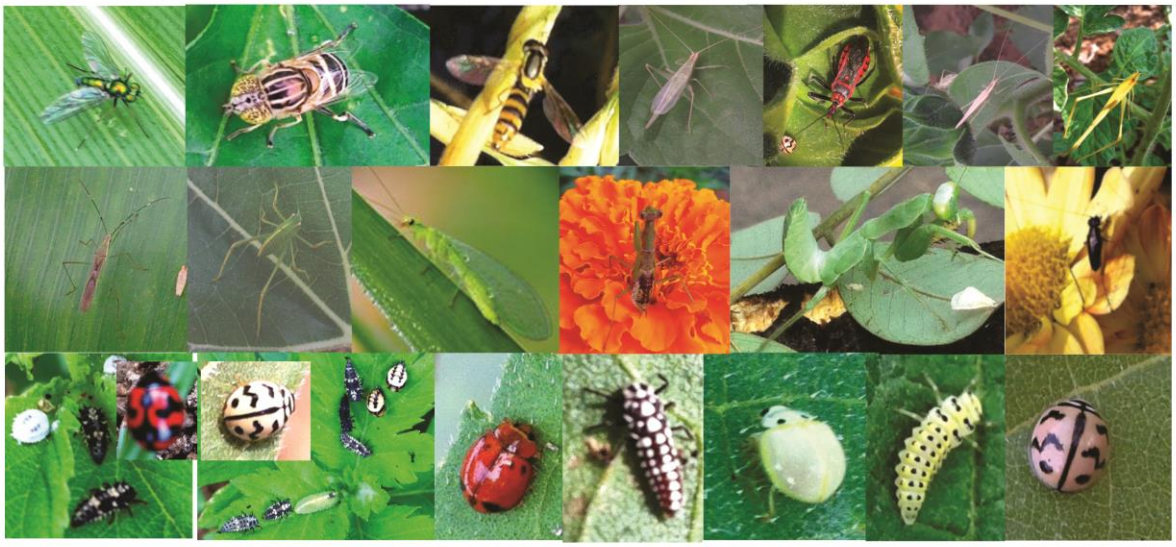
Buckwheat

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

Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders

IV. CROP STAGE-WISE IPM

Management	Activity
Pre-planting	
	Common cultural practices: • Timely planting should be done. • Orchard sanitation • Destroy the alternate host plants • Apply manures and fertilizers as per soil test recommendations • Sow the ecological engineering plants • Sow the intercrops as per the season.
Nutrients	• Nutrient should be applied on the basis of soil test report and recommendation for the particular agro-climatic zone. • Prepare land by ploughing and harrowing. • The pits are dug in summer about a fortnight before planting and left undisturbed. • Pits of about 1m x 1m x 1m at a distance of 8 to 10 meter in square system of planting. • Pits are filled with top soil mixed with manures and fertilizers @ 20-25 kg FYM, 2 kg bonemeal and 300 g muriate of potash per pit.
Weeds	• Plough the orchard before first planting to destroy the existing weed in the orchard. • Remove existing weeds in and around the pits at the time of planting.
Resting stages of soil borne pathogens (root rot), pests	**Cultural control:** • Deep summer ploughing of orchard s to control soil borne pathogens and subsequently reduces their initial population build up.
Planting*	
	Common cultural practices: • Use resistant/tolerant planting material/seedlings • Follow proper plant spacing • Use healthy, certified and weed seed free planting material. **Common mechanical practices:** • Remove new sprouts emerging from root stock at frequent intervals. • Shift the grafts frequently from one place to another to prevent them from striking roots into the ground.
Nutrients	• Planting is done in pits already filled with top soil and farm yard manure during the months of August-September. • A basket of soil taken from old litchi orchard is added to each pit to ensure mycorrhizal association with litchi roots. • Pits are then watered so that the soil settles down
Weeds	• Use fibrous mulch of wheat or barley straw and pea nut shells to reduce the weed problems and conserve the soil moisture. • Adopt the intercropping of recommended crops between the rows of litchi depending upon the stage of orchard

Pests, soil-borne pathogens	**<u>Cultural Control:</u>** • Well decomposed farm yard manure coupled with *Trichoderma viride/harzianum* should be used. • Nursery beds should be raised. • Nursery beds should be fumigated with 4% formalin
Termites	**<u>Cultural control</u>** • Copious irrigation and drenching nurseries or basin of transplanted seedlings. • Apply well rotten FYM only to discourage the termite infestation. • Avoid late planting. • Destroy the residue which is the source of infestation. • Digging the termitaria and destruction of the queen is mostimportant in termite management. • Light irrigation at weekly intervals may be done. • Termite kills small and young litchi plants. **<u>Biological control</u>** • Spray Neem oil 5% (50 ml/l) once on the base and upto 2 m height of the trunk for effective control
***** Apply *Trichoderma viride/harzianum* and *Pseudomonas fluorescens* for seed, 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).	
Vegetative (1-5 year onward)	
	<u>Common cultural practices:</u> • Collect and destroy crop debris • Provide irrigation at the critical stages of the crop • Avoid water logging • Avoid water stress during flowering stage • Follow judicious use of fertilizers • Enhance parasitic activity by avoiding chemical pesticide spray, when 1-2 larval parasitoids are observed in the crops orchard. **<u>Common mechanical practices:</u>** • Collect and destroy disease infected and insect infested plant parts. • Collect and destroy eggs and early stage larvae • Handpick the older larvae during early stages of plants • Hand pick the gregarious caterpillars and cocoons which are found on stem/branches and destroy them in kerosene mixed water. • Use yellow sticky trap for monitoring whitefly@4-5 traps/acre • Use light trap @ 1/acre and operate between 6 pm and 10 pm • Set up bonfire during evening hours at 7-8 pm. **<u>Common biological practices:</u>** • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies
Weeds	• Deep hoeing is recommended during the first year to check weed growth. Weeding should be done on regular basis

<table>
<tr><td></td><td>especially around the plants.
• Earthing up is done before or after the onset of monsoon to avoid water-logging and also to help the plants to stand erect.
• To suppress the weeds between rows, leguminous crops and vegetables can be grown as intercrops in the first 6 to 7 years.
• Use straw or plastic mulch to avoid weed growth and to maintain soil moisture for longer period.</td></tr>
<tr><td>Nutrients</td><td>• Apply fertilizers according to the age of plant as mentioned below;
Table-3: Manure/Fertilizer application for Litchi
<table>
<tr><th rowspan="2">Age of the plant (in years)</th><th colspan="4">Manure/Fertilizer applied (per plant/year in kg)</th></tr>
<tr><th>FYM</th><th>Calcium Ammonium Nitrate</th><th>Super phosphate</th><th>Muriate of potash</th></tr>
<tr><td>1-3</td><td>10 - 20</td><td>0.3-1.00</td><td>0.2-0.6</td><td>0.05-0.15</td></tr>
<tr><td>4-6</td><td>25 - 40</td><td>1.0-2.0</td><td>0.75-1.25</td><td>0.20-0.30</td></tr>
<tr><td>7-10</td><td>40 – 50</td><td>2.0-3.0</td><td>1.50-2.0</td><td>0.35-0.45</td></tr>
<tr><td>Above 10</td><td>60</td><td>3.5</td><td>2.25</td><td>0.60</td></tr>
</table>
• The fertilizers should be applied in 20-30 cm deep and 30cms wide trench along the drip line of the tree.</td></tr>
<tr><td>Litchi mite</td><td><u>Cultural control</u>
• Deep ploughing of the field and exposing the soil to sun (May-June and Sept-October) helps to minimize the incidence.
• Layers should be prepared only from non-infested plants.
• The leaves should be checked regularly for symptoms over summer and autumn.
• All trees in an orchard are not to be flushed or infested at the same time. Therefore, branches infested with the mite should be cut off and burnt.
• After harvesting in June, infested branches must be removed.
• Infested leaves should be gathered and burnt or buried deeply into the ground.
• In December-January, just before flush/flower buds, the affected shoots must be removed
<u>Chemical control:</u>
• Dicofol 18.5% EC@ 2700-4050 ml in 1000-5000 l of water/ha and observe waiting period of 15-20 days
<u>Biological control:</u>
• Follow common biological practices.</td></tr>
<tr><td>Leaf roller</td><td><u>Cultural control:</u>
• The damage caused by leaf rollers is tolerated as long as it is restricted to the foliage and unlikely to affect flower initiation.
• The rolled leaves that contain larvae may be removed manually</td></tr>
</table>

	during light infestations
Litchi bug	• Follow common mechanical practices.
Bark Eating caterpillar**	**Cultural control:** • The caterpillars can be killed by inserting an iron spoke into the tunnels made on the stem. • This insect has also been successfully controlled by injecting kerosene oil into the tunnel by means of a syringe and then sealing the opening of the tunnel with mud. • Remove the webs from tree trunks
Shoot borer **	**Cultural control:** • The attacked shoots may be clipped off and destroyed.
Nut borer**	• Follow common mechanical practices.
Mealy bug	• Follow common cultural, mechanical and biological practices **Cultural control:** • Deep ploughing of orchard in the month of June kill the eggs. • Ploughing of orchard in November. • Raking of soil around tree trunk to expose the eggs to natural enemies and sun, removal of weeds • Fastening of alkathene sheet (400 gauge)/grease band of 25 cm wide afterwards mud plastering of trunk at 30 cm above the ground in the middle of December. • In July –August destruction of infested fallen leaves with scales **Biological control:** • Raking of soil around tree trunk to expose the eggs to natural enemies and sun, removal of weeds and releasing 10-15 grubs • Releasing 10-15 grubs of cocinellid predator, *C. montrozieri* per tree.
Whitefly**	**Cultural control:** • Field sanitation and rogueing of alternate hosts. • A regularly maintained program of hedging and topping can help avoid whitefly problems • For others see common practices. **Biological control:** • See common biological practices.
Leaf cutting weevil	• The grubs of these weevils feed on organic matter in the soil below the canopy, hence, ploughing and exposing these grubs reduces the problem. • Hand picking of the adult weevils reduces their problem to some extent.
Leaf miner	• Ploughing of the orchard and timely application of nutrients and water so that new leaves emerge before September. • After emergence of flush spray 5% NSKE at interval of 7 days.
Litchi semilooper	• Follow common cultural and biological practices. • Spray 5% NSKE
Powdery mildew	**Cultural control:** • Follow proper spacing during planting. • Spraying at full bloom needs to be avoided. **Mechanical control:**

	• Prune diseased leaves and malformed panicles harbouring the pathogen to reduce primary inoculum load.
Anthracnose**	• Follow common cultural, mechanical and biological practices **Cultural control:** • Diseased leaves, twigs, gall midge infected leaves and fruits, should be collected and burnt. • Avoidance of overcrowding of trees and branches in orchard. • Pruning of affected plants and burning has been suggested to minimize the chances of fresh infections. • The rates of latent infection of the fruits could be evidently controlled by integrated management of the disease in the growing season, and the post-harvest decay and browning of the fruits are effectively reduced. • The effect of storage can be improved when the measure is applied to control the latent infection of anthracnose on litchi fruit before harvest.
Dieback**	**Cultural Control:** • Scion wood selected for propagation should be free from infection • Every care should be taken to prevent introduction of disease in newly planted orchards. **Mechanical control:** • Any infected portion should immediately be pruned, followed by spraying/ pasting of copper oxy-chloride or pasting with cow dung at the cut ends. • Pruning should be done in such a way that some healthy portion is also removed, to ensure complete eradication of pathogen (3 “below the infection site).
Leaf rust	• Follow common cultural, mechanical and biological practices. • If vigour of plant is maintained by balanced nutrients, the disease is less.
***Armillaria* rot**	• As water stress predisposes litchi plants to *Armillaria rot,* excess of water should be avoided in the plantations. • Infected part should be removed and soil drenching with a good fungicide should be given.
Flowering and Fruiting/maturity stage:	
Nutrients	• Apply recommended micronutrients, if symptoms are observed. Litchi fruits are deformed under boron deficiency. • To avoid boron deficiency, apply H_2BO_3 (0.1%) as foliar spray.
Weeds	• Remove weeds around the plants. • Use straw or plastic Mulch to avoid weed growth and to maintain soil moisture for longer period.
Fruit/shoot borer	**Cultural control:** • Attacked shoots should be clipped off and destroyed. • Clean hole and pour kerosene/petrol/crude oil or formalin into the stem borer hole and subsequently close entrance of the tunnel by plugging with cotton wool and paste the mud. **Biological control:** • **To minimize the population of fruit borer, use**

	***Trichogramma* @ 20,000 eggs/acre**
Anthracnose fruit rot	• Covering the fruits on tree, 15 days prior to harvest with news or brown paper bags.
Other insect pests and diseases	• Same as vegetative stage.
Posthravest	
Fruit rot	**Physical control:** • Hot water treatment at 52^0C for 4-5min. • Fruits should be sprayed with the mixture of bio-inoculants. **Botanical control:** • Postharvest dip treatment of fruits with botanical fungicides could also control the diseases during storage.

Note: The pesticide dosage is based on high volume sprayer.
**Pest of regional significance

V. INSECTICIDE RESISTANCDE AND ITS MANAGEMENT

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

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

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

1) **Monitor pests:** Monitor insect population development in orchard s 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 orchard s, adjacent "refuge" orchard s, or habitat attractions within a treated orchard that facilitate immigration. These susceptible individuals may outcompete and interbreed with resistant individuals, diluting the resistant genes and therefore the impact of resistance.

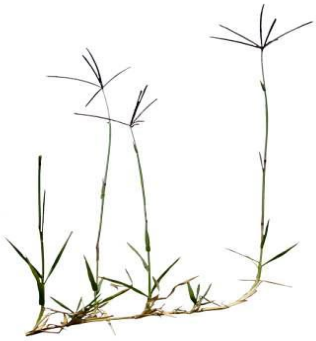
VI. NUTRIENT DEFICIENCY / PHYSIOLOGICAL DISORDER IN LITCHI

Fruit cracking: it is a major problem in litchi resulting in deterioration of fruit quality. Early varieties (e.g. Shahi) are more susceptible to cracking than late ripening one (e.g. China). Presence of optimum moisture level in the soil during fruit development is crucial for reducing fruit cracking and quality litchi production.

Application of two foliar sprays of 20 ppm NAA, first at pea stage of fruit development and second ten days after the first spray and scheduling of irrigation at 20% DASM (at 3 days interval during May-June) should be given to control the disorder. Foliar application of boric acid (0.4 %) and 2,4- D (10 ppm.) is also effective in minimizing the disorder.

http://agropedia.iitk.ac.in/sites/default/files/litchi.jpg

VII. COMMON WEEDS

		
1.Tick weed: *Cleome viscosa L.* (Capparidaceae)	**2. Coatbuttons: *Tridax procumbens* L. (Fabaceae)**	**3. Congress grass: *Parthenium hysterophorus* L. (Asteraceae)**
		
4. Horse Purslane: *Trainthema monogynae L.* (Aizoaceae)	**5. Yellow foxtail: *Setaria glauca* (L.) P. Beauv. (Poaceae)**	**6. Bermuda grass: *Cynodon dactylon* (L.) Pers. (Poaceae)**
		
7. Crab grass: *Digiteria sanguinalis* (L.) Scop. (Poaceae)	**8. Torpedo grass: Panicum repens L. (Poaceae)**	**9. Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)**

VIII. DESCRIPTION OF INSECT PESTS

1. Lithi mite:

Biology

- The adults start multiplying from the end of March and the peak activity is noticed around July.
- The female adults lay eggs singly at the base of the hair on the lower surface of the leaves.
- The eggs hatch within 2-3 days and newly emerged nymphs feed on soft leaves.
- Both nymphs and adults damage the leaves, inflorescence and young developing fruits

Damage symptoms:

- The mites puncture and lacerate the tissues of the leaf and suck the cell sap
- They attack the young leaves causing hairy blister like gall on the upper side of the leaves
- The leaves become thickened wrinkled and distorted
- The leaves may ultimately fall off
- The mite also attack and cause malformation of inflorescence

Damage symptoms

1. http://agropedia.iitk.ac.in/content/litchi-mite
2. http://tmnehs.gov.in/writereaddata/Chap-14.pdf

Natural enemies of mite:

Predators: *Chrysoperla zastrowii sillemi*, anthocorid bug, predatory mite (*Amblyseius fallacis*), coccinellid (*Stethorus punctum*) etc.

2. Litchi fruit borer:

Biology

Egg: Female lays eggs singly on the under surface of the leaf or near the calyx of litchi fruits.
Larvae: milky white, slender with distinct light brown head. The newly emerged larvae start boring into the fruits and feed on its pulp.

Damage Symptoms

- The young larvae make mine in the lamina and bore into mid-rib of young leaves and tunnel through it, as a result branches wither and drop

Affected fruits

1. http://tmnehs.gov.in/writereaddata/Chap-14.pdf

Natural enemies of litchi fruit borer

Parasitoids: *Trichogramma chilonis*

Predators: Mirid bug (C*ampyloneura* sp), lady bird beetles (*Cheilomenes sexmaculata*, *Coccinella septempunctata*-seven spotted, *Brumoides suturalis*-three striped), lacewing (*Chrysoperla carnea*), King crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants, big eyed bugs (*Geocoris* sp), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc.

3. Bark eating caterpillar:

Biology

Egg: Female moths deposit eggs below loose bark, in forks in the older wood, or where twigs have broken off or been badly pruned. Egg hatch 8-10 days after being laid

Larvae: 50-60 mm and have pale brown bodies with dark brown heads. Caterpillars eat the bark and bore inside the tree, feeding for 9-11 months.

Adults: Adults are active at the beginning of the wet season in May-June. They are 35-40 mm in size, pale brown or grey in colour

1. **Larva**

2. Adult

1. http://agropedia.iitk.ac.in/content/pomegranate-bark-eating-caterpillar
2. http://www.waiwiki.o rg/index.php?title=File:Indarbela_quadrinotata_2.jpg

Damage symptoms

- Several caterpillars may attack the same tree at different locations with serious injury to the bark and the death of small branches.
- The holes left on the trunk may lead to infestation by other insects or plant pathogens. Affected trees also break at the points of attack.
- A severe infestation may arrest the growth of the tree and the fruiting capacity.

1. Bark eating caterpillar damage

4. Mealy bug:

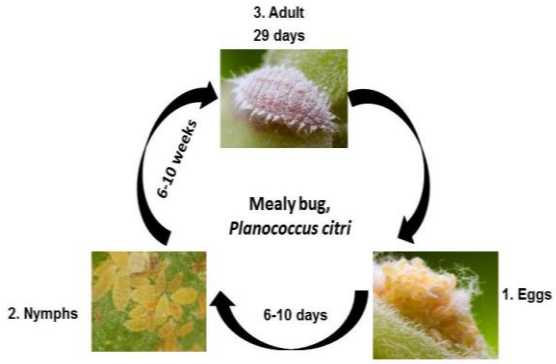
Biology:

Egg: Eggs are deposited as white cottony masses called ovisacs. The glossy, light yellow eggs are oval and approximately 0.3 mm long. A female lay 300 to 600 eggs in a life period, which are deposited in groups of 5 to 20.

Nymph: Nymphs emerge from the ovisacs and typically settle along midribs and veins on the underside of leaves and young twigs. Wax and honeydew secreted by crawlers are visible indicators of infestations. 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.

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.

Life cycle:



1.http://www.alexanderwild.com/keyword/planococcus%20citri/
2. http://cals.arizona.edu/crops/citrus/photos/figure21.jpg\

Damage symptoms:

- Young plants – susceptible for heavy infestation.
- Infest tender branches, nodes, leaves, spikes, berries and roots
- Both nymphs and adults suck the sap from the leaves.
- Severe infestation - Chlorotic leaves, aborted flower buds and small berries

- Honey dew excrete – development of sooty mould fungus (affects photosynthesis)

http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insectpest%20Coffee.html#7

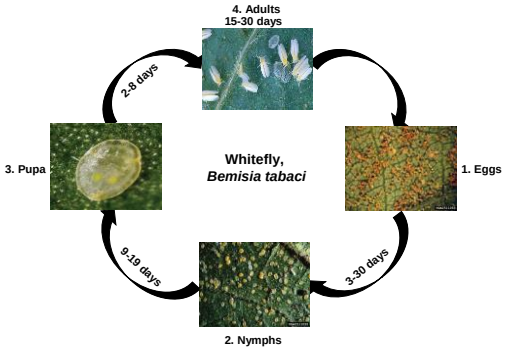
Natural enemies of mealybugs:
Parasitoid: *Leptomastix dactylopii* etc.
Predators: Ladybird beetle, *Cryptolaemus montrouzieri*, spider, reduviid etc.
*For the management refer page no….

5. Whitefly:

Biology:

Egg: The females mostly lay eggs near the veins on the underside of leaves. They prefer hairy leaf surfaces to lay more eggs. Each female can lay about 300 eggs in its lifetime. Eggs are small (about 0.25 mm), pear-shaped, and vertically attached to the leaf surface through a pedicel. Newly laid eggs are white and later turn brown. The eggs are not visible to the naked eye, and must be observed under a magnifying lens or microscope. Egg period is about three to five days during summer and 5 to 33 days in winter.
Nymph: Upon hatching, the first instar larva (nymph) moves on the leaf surface to locate a suitable feeding site. Hence, it is commonly known as a "crawler." It then inserts its piercing and sucking mouthpart and begins sucking the plant sap from the phloem. The first instar nymph has antennae, eyes, and three pairs of well developed legs. The nymphs are flattened, oval-shaped, and greenish-yellow in color. The legs and antennae are atrophied during the next three instars and they are immobile during the remaining nymphal stages. The last nymphal stage has red eyes. This stage is sometimes referred to puparium, although insects of this order (Hemiptera) do not have a perfect pupal stage (incomplete metamorphosis). Nymphal period is about 9 to 14 days during summer and 17 to 73 days in winter (David 2001). Adults emerge from puparia through a T-shaped slit, leaving behind empty pupal cases or exuviae.
Adult: The whitefly adult is a soft-bodied, moth-like fly. The wings are covered with powdery wax and the body is light yellow in color. The wings are held over the body like a tent. The adult males are slightly smaller in size than the females. Adults live from one to three weeks.

Life cycle:



1.http://m.animal.memozee.com/m.view.php?q=%EB%8B%B4%EB%B0%B0%EA% B0%80%EB%A3%A8%EC%9D%B4&p=3
2. http://www.forestryimages.org/browse/detail.cfm?imgnum=2511050
3. http://agspsrv34.agric.wa.gov.au/ento/pestweb/Query1_1.idc?ID=955595135
4. http://www.entomology.umn.edu/cues/inter/inmine/Whitefg.html

Damage symptoms:

Both the adults and nymphs suck the plant sap and reduce the vigor of the plant. In severe infestations, the leaves turn yellow and drop off. When the populations are high they secrete large quantities of honeydew, which favors the growth of sooty mould on leaf surfaces and reduces the photosynthetic efficiency of the plants.

Natural enemies of whitefly:
Parasitoids: *Encarsia* sp, *Eretmocerus* sp, *Chrysocharis pentheus*
Predators: Mirid bug (*Dicyphus hesperus*), dragonfly, hover fly, spider, robber fly, praying mantis, fire ants, coccinellids, lace wings, big eyed bugs (*Geocoris* sp) etc.

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

Natural Enemies of Litchi Insect Pests

Parasitoids
Egg parasitoids

1. *Trichogramma* sp

Nymphal/larval and adult parasitoids

2. *Chrysocharis* sp

3. *Encarsia formosa*

4. *Eretmocerus* spp.

2. http://baba-insects.blogspot.in/2012/05/blog-post_21.html
3. http://www.buglogical.com/whitefly-control/encarsia-formosa/
4. http://www.dongbufarmceres.com/main/mboard.asp?strBoardID=c_product01_en

Predators

1. Lacewing

2. Ladybird beetle

3. Reduviid bug

4. Spider

5. Robber fly

6. Red ant

7. Black drongo

8. Common mynah

9. Big-eyed bug

10. Earwig

11. Ground beetle

12. Pentatomid bug

13. Preying mantis

15. Predatory mite

16. Predatory thrips

17. *Oligota* spp.

18. *Orius* spp.

19. Hover fly

20. Mirid bug

5. http://www.warpedphotosblog.com/robber-fly-and-prey

6.http://www.couriermail.com.au/news/queensland/queensland-launched-a-war-against-the-fire-ant-invasion-but-12-years-later-they8217re-still-on-the-march/story-fnihsrf2-1226686256021
7. http://nagpurbirds.org/blackdrongo/picture/1639
8. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
9. http://bugguide.net/node/view/598529
10. http://www.flickr.com/photos/johnhallmen/2901162091/
11.http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/ Ground%20Beetle%20-%20Pterostichus%20madidus.html
12. http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asopinae/ Eocanthecona.htm
13. http://spirit-animals.com/praying-mantis/
14. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
15. http://biocontrol.ucr.edu/hoddle/persea_mite.html
16. http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33
17. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
18. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html

IX. DESCRIPTION OF DISEASES

1. Anthracnose:

Disease symptoms:

- Attacks both the leaves and the fruit, which are sensitive from flowering to the mid-growth stage.
- Most of the rot found in mature fruit comes from the infection of young fruit.
- The small spots develop into large, brown spots indicative of fruit rot.
- Finally, a white mycelium appears on the fruit during storage.
-

Anthracnose affected fruits of litchi

http://tmnehs.gov.in/writereaddata/Chap-15.pdf

2. Fruit rot:

Disease symptoms

- Fruit rot of litchi has been a serious problem. Litchi is host to a range of post-harvest pathogens, often with quite different modes of infection.
- Several fungi have been found to be associated with diseases
- Usually large water soaked lesions appear on the surface of fruits.
- Initially the disease symptoms are perceptible on injured portion of the fruits.
- With the advance of the disease the decayed areas get depressed.
- The rot gradually penetrates deep into the pulp.
- Ultimately rind of infected fruits cracks off exposing the pulp which subsequently is covered with thick cottony mycelium.
- Such affected fruits emit an odour of fermentation.

3. Root rot:

Disease symptoms

- A slow decline and a sudden death of plant have been recorded in litchi. It can affect the whole tree or just one or two branches.

- The symptoms include a sudden branch wilt that is followed by the decline of new growth on the affected branch over a period. In other situations, the tips die without wilting.
- The tree or branch may recover temporarily, but subsequently dies. Parts of the tree flush and grow, while other sections die.
- In some parts of litchi belt, trees are killed by the root rot.
- One side of the tree's crown may be perfectly sound and the other totally necrosis.
- Leaf shed never occurs (it does in the case of a nematode attack) and the internal parts of the roots are characteristically red in colour
- No method has been found to save the tree once it has become infected.

Disease symptoms

X. SAFETY MEASURES

A. At the time of pre-harvest:

- Irrigate orchard properly up to fruit ripening. Start harvesting of fruit in 3rd week of May.
- Harvesting to be done in morning hours (4-8 am) and keep fruit in orchard at cooler place, where grading and packing should be done after pre cooling of fruits.
- If package house facility is available, transport the fruit avoiding scorching sun light, so that proper grading and packing can be done in pack house.
- Make arrangement to transport the fruit in card board boxes in refrigerated van maintaining cool chain for marketing or processing.
- Prune the tress just after harvesting.
- The stage of maturity at which fruit is harvested is one of the most important factors that determine the ultimate quality at the point of sale. Litchis do not develop further after picking.
- The fruit must therefore remain on the tree until quite ripe. Litchis harvested too early have an unattractive colour and have a sour taste. Ripe fruit has an average mass of between 21 and 25 g.
- Fruit with a mass of at least 21 g is therefore ready for harvesting during a normal season.

Harvesting methods

- Litchis for fresh consumption are harvested by hand, leaving the pedicels intact. They are harvested at firm-mature stage to reduce bruising.

b. During postharvest:

Sorting

Product quality is maintained by removing damaged and inferior fruit during sorting. Close attention to detail and good lighting are required at this stage. Sorting can be carried out on a table, or preferably as the fruit moves along a series of rollers. The entire surface of each fruit must be observed to ensure that damaged specimens are not packed. Damage extending to the aril rapidly leads to rots, which may spread to sound fruit within the package. For this reason, fruit with pulled stems, splits, cracks and insect damage should be rejected at this stage.

Fruit damaged by piercing moths the night before harvest show little damage initially, but will show signs of weeping and tissue darkening within 24 hours. For this reason, some growers store fruit overnight in high humidity cold stores to ensure that all stung fruit is detected. If cold stores are not available or a quick turnaround is preferred, recently stung fruit can often be identified by leakage of aril juice when the fruit is squeezed. Immature fruit and fruit

showing any signs of rot are also removed during sorting. Some markets have a low tolerance for cosmetic defects, such as scale infestation, small fruit, severe pepper spot (anthracnose) infection or superficial browning. Fruit showing these defects is generally downgraded and not sent to the central markets, but can be processed or sold at roadside stalls.

Post-harvest handling

Once litchis are picked, they start to dry out and brown. The mechanisms of pericarp browning, colour retention and pulp quality maintenance have been the worldwide focus of litchis post-harvest biology research. Progress has been made in litchi pericarp browning and colour maintenance. The fruit should be kept in high humidity and cooled to 5 °C as quickly as possible. Hydro-coolers or cold stores are frequently used for this purpose. Sulphur fumigation has so far been the main post-harvest handling technology in prevention of litchi browning and maintenance of fruit quality. However, it has recently been questioned by both scientists and customers owing to the chemical S residue and off-putting taste.

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 orchard should be kept exposed to sun light at least for 2-3 weeks.	Do not plant or irrigate the orchard after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Plant only recommended varieties.	Do not plant varieties not suitable for the season or the region.
3.	Always treat the seeds with approved chemicals/biopesticides for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with biopesticides/chemicals.
4.	Plant in rows at optimum depths under proper moisture conditions for better establishment.	Do not plant seeds/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 sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
9.	Conduct AESA weekly in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.	Do not take any management decision without considering AESA and P: D ratio
10.	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
11.	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per orchard observation	Do not apply chemical pesticides within seven days of release of parasitoids
12.	In case of pests which are active during night spray recommended biocides/ chemicals at the time of their appearance in the night.	Do not spray pesticides at midday since, most of the insects are not active during this period.
13.	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, scales, thrips, etc.	Do not spray pesticides only on the upper surface of leaves.
14.	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
15	Follow the recommended procedure of trap or border crops technology.	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.

XII. BASIC PRECAUTIONS IN PESTICIDES USAGE

A. Purchase

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

B. Storage

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

C. Handling

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

D. Precautions for preparing spray solution

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

E. Equipments

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

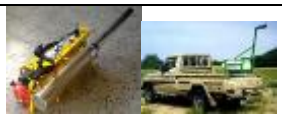
F. Precautions for applying pesticides

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

G. Disposal

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

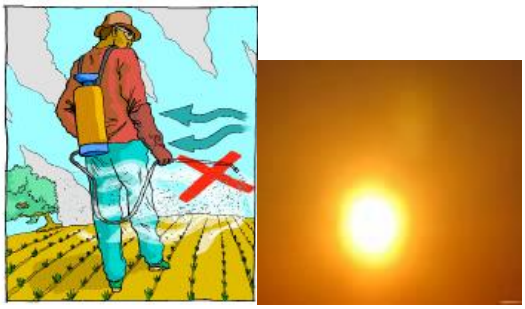
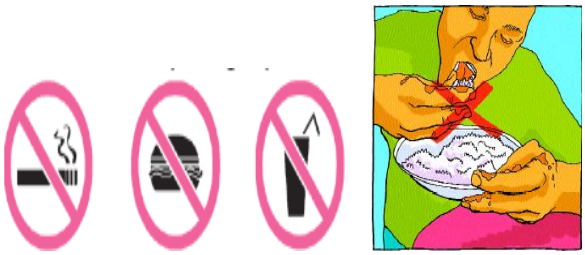
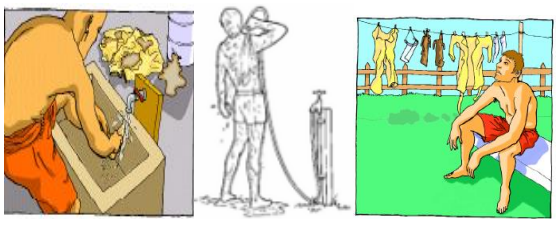
XIII. PESTICIDE APPLICATION TECHNIQUES

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

Pests)			
Category C: Weeds			
Post-emergence application	Weedicide	• Lever operated knapsack sprayer (Droplets of big size) • Flat fan or floodjet nozzle @ 15 to 20 psi • Lever operating speed = 7 to 10 strokes/min	 
Pre-emergence application	Weedicide	• Trolley mounted low volume sprayer (Droplets of small size) • Battery operated low volume sprayer (Droplets of small size)	 

XIV. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

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

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

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

XV. REFERENCES

1. http://agropedia.iitk.ac.in/content/litchi-mite
2. http://tmnehs.gov.in/writereaddata/Chap-14.pdf
3. http://www.alexanderwild.com/keyword/planococcus%20citri/
4. http://cals.arizona.edu/crops/citrus/photos/figure21.jpg\
5. http://tmnehs.gov.in/writereaddata/Chap-14.pdf
6. http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insectpest%20Coffee.html#7
7. http://m.animal.memozee.com/m.view.php?q=%EB%8B%B4%EB%B0%B0%EA% B0%80%EB%A3%A8%EC%9D%B4&p=3
8. http://www.forestryimages.org/browse/detail.cfm?imgnum=2511050
9. http://agspsrv34.agric.wa.gov.au/ento/pestweb/Query1_1.idc?ID=955595135
10. http://www.entomology.umn.edu/cues/inter/inmine/Whitefg.html
11. http://baba-insects.blogspot.in/2012/05/blog-post_21.html
12. http://www.buglogical.com/whitefly-control/encarsia-formosa/
13. http://www.dongbufarmceres.com/main/mboard.asp?strBoardID=c_product01_en
14. http://www.warpedphotosblog.com/robber-fly-and-prey
15. http://www.couriermail.com.au/news/queensland/queensland-launched-a-war-against-the-fire-ant-invasion-but-12-years-later-they8217re-still-on-the-march/story-fnihsrf2-1226686256021
16. http://nagpurbirds.org/blackdrongo/picture/1639
17. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
18. http://bugguide.net/node/view/598529
19. http://www.flickr.com/photos/johnhallmen/2901162091/
20. http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/Ground%20Beetle%20-%20Pterostichus%20madidus.html
21. http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asopinae/ Eocanthecona.htm
22. http://spirit-animals.com/praying-mantis/
23. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
24. http://biocontrol.ucr.edu/hoddle/persea_mite.html
25. http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33
26. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
27. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.htm
28. http://tmnehs.gov.in/writereaddata/Chap-15.pdf
29. http://tmnehs.gov.in/writereaddata/Chap-15.pdf