



सत्यमेव जयते

AESA BASED IPM PACKAGE

Guava



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Protection, Quarantine and
Storage**
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Department of Agriculture and Cooperation
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The AESA based IPM –Guava (*Psidium guajava* L.) 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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FOREWORD

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

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

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

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AK Srivastava
(Avinash K. Srivastava)

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FOREWORD

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

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

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


(Utpal Kumar Singh)



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PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

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AESA BASED IPM PACKAGE FOR GUAVA

Guava - Plant description:

Guava (*Psidium guajava* L. Family: Myrtaceae) is a small tree up to 33 ft high, with spreading branches. The guava plant is easy to recognize because of its smooth, thin, copper-colored bark that flakes off, showing the greenish layer beneath; and also because of the attractive, "bony" aspect of its trunk which may in time attain a diameter of 10 inch. Young twigs are quadrangular and downy. The leaves are aromatic when crushed, evergreen, opposite, short-petioled, oval or oblong-elliptic, somewhat irregular in outline; upto 6 inch, up 2 inch wide, leathery, with conspicuous parallel veins, and more or less downy on the underside. Faintly fragrant, the white flowers, borne singly or in small clusters in the leaf axils, are 1 inch wide, with 4 or 5 white petals which are quickly shed, and a prominent tuft of perhaps 250 white stamens tipped with pale-yellow anthers. The fruit, exuding a strong, sweet, musky odor when ripe, may be round, ovoid, or pear-shaped, 2 to 4 inch long, with 4 or 5 protruding floral remnants (sepals) at the apex; and thin, light-yellow skin, frequently blushed with pink. Next to the skin is a layer of somewhat granular flesh, 1/8 to 1/2 inch thick, white, yellowish, light- or dark-pink, or near-red, juicy, acid, subacid, or sweet and flavorful. The central pulp, concolorous or slightly darker in tone, is juicy and normally filled with very hard, yellowish seeds, 1/8 inch long, though some rare types have soft, chewable seeds. Actual seed counts have ranged from 112 to 535 but some guavas are seedless or nearly so. When immature and until a very short time before ripening, the fruit is green, hard, gummy within and very astringent.



I. PESTS:

A. Pests of National Significance:

1. Insect pests:

1.1 Fruit fly: *Bactrocera correcta* (Bezzi) and *B. spp* (Diptera: Tephritidae)

1.2. Fruit borer complex:

1.2.1 Castor capsule borer: *Congethes (Dichocrocis) punctiferalis* Guenée
(Lepidoptera: Crambidae)

1.2.2 Pomegranate butterfly: *Deudorix (Virachola) isocrates* Fabricius
(Lepidoptera: Lycaenidae)

1.2.3 Fruit borer: *Rapala varuna* Hewitson (Lepidoptera: Lycaenidae)

1.3 Bark eating caterpillar: *Indarbela tetraonis* (Moore) (Lepidoptera : Cossidae)

2. Diseases

2.1 Guava wilt: *Fusarium oxysporum* f.sp. *psidii* and *F. solani* (Mart.) Sacc.

2.2 Fruit rot: *Phytophthora nicotianae* Dastur, *P. nicotianae* Breda de Haan var. *parasitica*, *P. citricola* Sawada and *Rhizopus stolonifer* (Ehrenb.) Vuill.

2.3. Stem canker and dry fruit rot. *Physalopara psidii* Stevens & Pierce and *Diplodia netalensis* Evans.]

2.4 Dieback and fruit rot: *Colletotrichum psidii* Curzi./*Colletotrichum gloeosporioides* (Penz.) Penz. and Sacc.

3. Weeds

Grasses

3. 1 Bermuda grass: *Cynodon dactylon* L. Poaceae

3. 2 Hairy crabgrass: *Digitaria sanguinalis* (L.) Scop. Poaceae

3. 3 Egyptian crowfoot grass: *Dactyloctenium aegyptium* (L.) Willd Poaceae

3. 4 Buffalo grass: *Paspalum conjugatum* P. J. Bergius Poaceae

3. 5 Cogongrass: *Imperata cylindrica* (L.) P. Beauv. Poaceae

Broad leaf

3. 6 Coat buttons: *Tridax procumbens* L. Fabaceae

3. 7 Beggar-ticks: *Bidens pilosa* L. Asteraceae

3. 8 Silk Leaf: *Lagascea mollis* Cavanilles Asteraceae

3. 9 Canoe weed: *Phyllanthus maderaspatensis* L. Euphorbiaceae

3. 10 Mohanavallee: *Loranthus longiflorus* Desr. (Loranthaceae) (Semi- parasitic weed)

3. 11 Amaranth: *Amaranthus viridis* L. Amaranthaceae

3. 12 False amaranth: *Digera arvense* Forssk. Amaranthaceae

3. 13 Asthma herb: *Euphorbia hirta* L. Euphorbiaceae

3. 14 Milkweed: *Euphorbia geniculata* L. Euphorbiaceae

3. 15 Whitetop Weed: *Parthenium hysterophorus* L. Asteraceae

3. 16 Horse purslane: *Trianthema portulacastrum* L. Aizoaceae

Sedges

3. 17 Purple nut sedge: *Cyperus rotundus* L. Cypraceae

3. 18 Flat sedge: *Cyperus iria* L. Cypraceae

B. Pests of Regional Significance:

1. Insect pests:

- 1.1 Tea mosquito bug: *Helopeltis antonii* Signoret (Hemiptera: Miridae)
- 1.2 Mealy bug: *Ferrisia virgata* (Cockerell), *Maconellicoccus hirsutus* Green (Hemiptera: Pseudococcidae:)
- 1.3 Coccids: *Hemaspido proctus cinereus* Green. (Hemiptera: Margarodidae)
- 1.4 Guava aphid: *Aphis punicae* Passerini (Hemiptera: Aphididae)

2. Diseases

- 2.1 Fruit canker: *Pestalotia psidii* Pat. (Mumbai, Mysore, Thane, Dharwar, Pune, Ponta Vally, Himachal Pradesh and Lucknow)
- 2.2 Algal leaf and fruit spot: *Cephaleuros virescens* Kuntze (Mysore, Patna, Lucknow and Sitapur)
- 2.3 Styler end rot: *Phomopsis psidii* de Camara (Lucknow and Bangalore)

3. Weeds

Grasses

- 3. 1 Quackgrass: *Agropyron repens* (L.) P.Beauv. Poaceae
- 3. 2 Indian goosegrass: *Eleusine indica* (L.) Gaertn. Poaceae
- 3. 3 Lovegrass: *Eragrostis tanella* (L.) P.Beauv. Poaceae
- 3. 4 Johnson grass: *Sorghum helepense* (L.) Pers. Poaceae

Broad leaf

- 3. 5 Pig weed: *Boerhavia hirsuta* Willd Nyctaginaceae
- 3. 6 Shaggy Button Weed: *Borreria hispida* (Linn.) K. Schum. Rubiaceae
- 3. 7 Swine Cress: *Cronopus didymus* L. Sm. Brassicaceae
- 3. 8 Common Purslane: *Portulaca oleracea* L. Portulacaceae
- 3. 9 Launaea: *Launea nudicaulis* (L.) Hook. f. Asteraceae
- 3. 10 Sticky spider-flower: *Cleome viscosa* L. Capparaceae

Sedges

- 3. 11 Yellow nutsedge: *Cyperus esculentus* L. Cyperaceae
- 3. 12 Small-floweed umbrella sedge: *Cyperus difformis* L. Cyperaceae

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

A. AESA

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

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

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

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

Principles of AESA based IPM:

Grow a healthy crop

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

- Proper irrigation
- Crop rotation

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

Farmers should

- Monitor the orchard situation at least once a week (soil, water, plants, pests, natural enemies, weather factors etc.)
- Make decisions based on the field situation 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 field various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in crop field. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial and harmful insects. In this method, unfamiliar/unknown

predators are collected in plastic containers with brush from the field and brought to a place for study. Each predator is placed inside a plastic bottle together with parts of the plant and some known insect pests. Insects in the bottle are observed for certain time and determined whether the test insect is a pest (feeds on plant) or a predator (feeds on other insects).

Pest: Defender ratio (P: D ratio):

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

Model agro-ecosystem analysis chart

Date:
Village:
Farmer:

The chart is a model agro-ecosystem analysis chart for a guava tree. It consists of a central photograph of a guava tree in a garden. Above the tree are two weather icons: a sun behind a blue cloud and a blue rain cloud with raindrops. To the left of the tree is a vertical column of small images labeled 'Pests', showing various insects and larvae. To the right is a vertical column of small images labeled 'Defenders', showing various beneficial insects like ladybugs, ants, and beetles. The entire chart is set against a blue textured background at the bottom.

Decision taken based on the analysis of orchard situations

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

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

Decision making

Farmers become experts in crop management

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

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

AESA methodology

- Go to the field in groups (about 5 farmers per group). Walk across the field and choose 20 plants/acre randomly across the diagonal of the field. Observe keenly each of these plants in each bed and record your observations:
 - Plant: Observe number of branches, crop stage, deficiency symptoms etc.
 - Pests: Observe and count pests at different places on the plant.
 - Defenders (natural enemies): Observe and count parasitoids and predators.
 - Diseases: Observe leaves, branches and stem and identify any visible disease symptoms and severity.
 - Weeds: Observe weeds in the field and their intensity.
 - Water: Observe the water situation of the field.
 - Weather: Observe the weather conditions.

- While walking in the field, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the field situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant/hill representing the field situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on what 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

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

Some questions that can be used during the discussion

- Summarize the present situation of the field?
- What crop management aspect is most important at this moment?
- Is there a big change in crop situation compared to last visit? What kind of change?
- Is there any serious pest or disease outbreak?
- What is the situation of the beneficial insects?
- Is there a balance in the field between pests and defenders?
- Were you able to identify all pests and diseases?
- Do you think the crop is healthy?
- What management practices are needed at this moment?

- When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.
- Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest buildup?
- What problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.



Advantages of AESA over ETL

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

AESA and farmer field school (FFS)

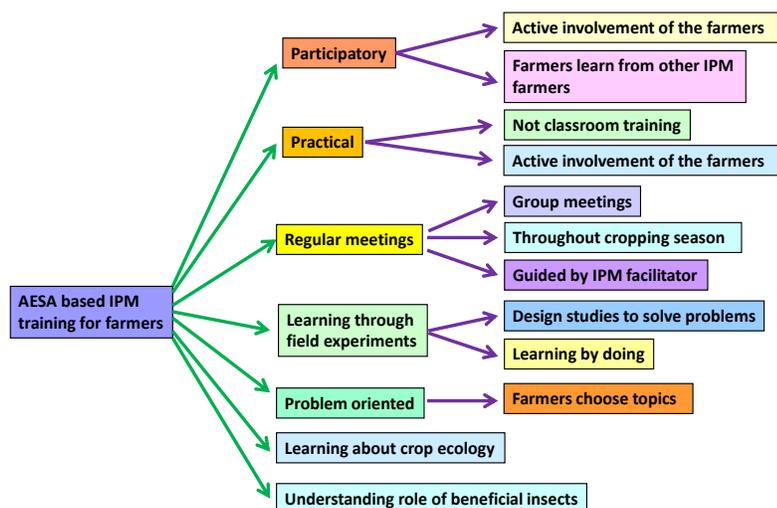
AESA is a season-long training activity that takes place in the farmer field. It is season-long so that it covers all the different developmental stages of the crop and their related management practices. The process is always learner-centered, participatory and relying on an experiential learning approach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

Farmers can learn from AESA

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



FFS to teach AESA based IPM skills



B. Field scouting

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

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

For insect pests:

Aphids, whitefly: 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).

Fruit fly: Hanging of bottle traps containing 100 ml water emulsion of methyl euginol (0.1%) + malathion (0.1%) during fruiting season (April - July) is very effective for control of fruitfly. Ten traps per hectare of orchards gives satisfactory control.

For diseases:

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

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

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

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

C. Yellow/blue pan water/sticky traps

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

D. Light traps

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

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

Ecological Engineering for Pest Management – Below Ground:

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

- Crop rotations with leguminous plants which enhance nitrogen content.
- Keep soils covered year-round with living vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance below ground biodiversity of beneficial microbes and insects.
- Application of balanced dose of nutrients using biofertilizers based on soil test report.

- Application of biofertilizers with special focus on mycorrhiza and plant growth promoting rhizobia (PGPR)
- Application of *Trichoderma harzianum/ viride* and *Pseudomonas fluorescens* for treatment of seed/seedling/planting materials in the nurseries and field application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

Ecological Engineering for Pest Management – Above Ground:

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

Natural enemies may require

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

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

- Raise the flowering plants / compatible cash crops along the field border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population
- Grow flowering plants on the internal bunds inside the field
- Not to uproot weed plants those are growing naturally such as *Tridax procumbens*, *Ageratum* sp, *Alternanthera* sp etc. which act as nectar source for natural enemies,
- Not to apply broad spectrum chemical pesticides, when the P: D ratio is 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, *Chrysoperla*, earwigs, etc.

Plants suitable for Ecological Engineering for Pest Management

Attractant plants



Cowpea



Carrot



Sunflower



Buckwheat



Alfalfa



Mustard



Cosmos



Anise



Caraway



Dill



Parsely

Repellent plants



Ocimum sp



Peppermint

Border plants



Sorghum



Maize



Pearl Millet

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

Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

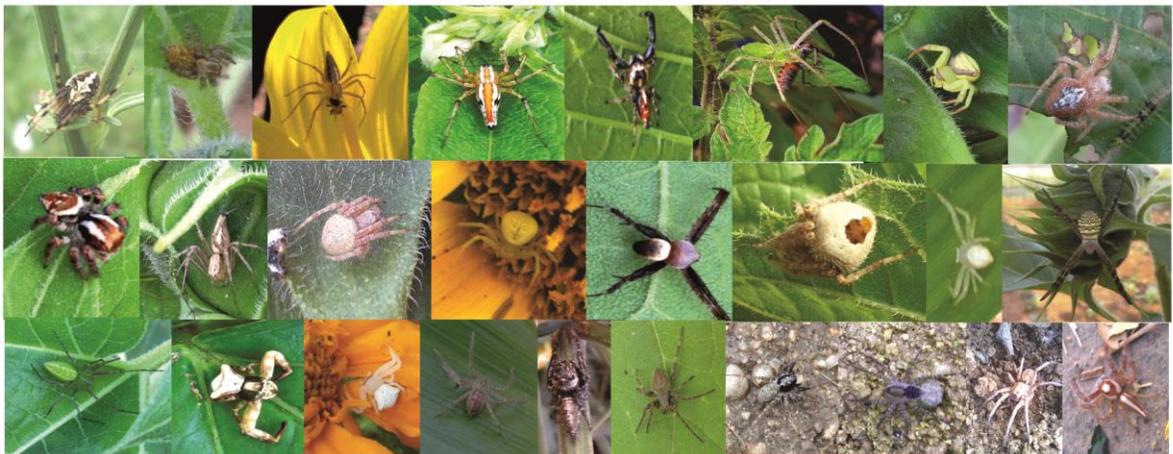
Biodiversity of natural enemies: Parasitoids



Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



IV. CROP STAGE-WISE IPM

Management	Activity
Pre planting*	
	<p><u>Common cultural practices:</u></p> <ul style="list-style-type: none"> • Timely sowing should be done. • Field sanitation, rogueing • Destroy the alternate host plants • Apply manures and fertilizers as per soil test recommendations
Nutrients	<ul style="list-style-type: none"> • Square system of planting is generally adopted with a spacing of 6m x 6m and pits of 1x1x1m size are dug during summer season and kept open for controlling soil born pests. • Pit should be filled with mixture of top soil and FYM in the ratio of 1:1. • 15-20kg of well rotten FYM + 1.5kg single super phosphate per pit
Weeds	<ul style="list-style-type: none"> • Plough the field before planting to destroy existing weeds in the field. • Summer ploughing is helpful in destroying weed seeds and rhizomes in the soil. • Adopt stale seed bed technique
Pest & Diseases	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Ploughing the field before digging the pits.
Planting*	
	<p><u>Common cultural practices:</u></p> <ul style="list-style-type: none"> • Use healthy, certified and weed free seeds.
Nutrients	<ul style="list-style-type: none"> • Application and thorough mixing of 500g SSP, and 1 kg Neem cake per pit.
Weeds	<ul style="list-style-type: none"> • Remove existing weeds in and around the pits at the time of planting. • Mulching with organic or biodegradable material. •
Pest & Diseases	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Clean cultivation: Keep basin clean .Soil health: Maintain proper moisture and aeration in soil. Avoid water logging. • Moderate to heavy pruning to remove disease affected, broken, crisscross branches, water sprouts, suckers and opening canopy to improve light penetration. <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Infested/infected young plants should be uprooted, burnt and replaced with healthy saplings
<p>* Apply <i>Trichoderma viride/ harzianum</i> and <i>Pseudomonas fluorescens</i> for treatment of seed/seedling/planting materials in the nurseries and field application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).</p>	

Vegetative stages	
	<p><u>Common cultural practices:</u></p> <ul style="list-style-type: none"> • Destroy crop debris • Avoid water logging • Avoid water stress • Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed <p><u>Common mechanical practices:</u></p> <ul style="list-style-type: none"> • Use light trap @ 1/acre and operate between 6 pm and 10 pm • Erecting of bird perches @ 20/acre for encouraging predatory birds such as King crow, common mynah etc. <p><u>Common biological practices:</u></p> <ul style="list-style-type: none"> • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies
Nutrients	<ul style="list-style-type: none"> • Green manuring during rainy season. • Grow leguminous crops or vegetables as intercrops during the first three years of planting, provided irrigation facility is available. • Fertilizers should be applied based on soil test values and recommendation for the agro-ecological regions. • Apply fertilizers after first pre-monsoon shower (June) for rainy season crop and in first week of September for winter season crop. For one year old plants apply 100g nitrogen, 40g phosphorus 100g potash in two splits (June and September) except phosphorus. . . • Increase the dose by 100g nitrogen, 100g potash and 40g phosphorus every year until the plants are 5 years old and there after a dose of 500g nitrogen, 200g phosphorus and 500g potash should be applied yearly. Half of the nitrogen should be given in the form of organic manures.
Weeds	<ul style="list-style-type: none"> • Remove weeds by using tools before flowering. and Timely inter-culture should be done. • Mulching can be done either with black polyethylene sheet or with organic materials like dry leaves, paddy straw, etc. Mulching helps in conserving moisture, controlling weeds and improving the fruit quality. • In the initial years of planting regional recommended intercrops should be grown. •
Mealy bugs**	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Collect and destroy the infested plant parts. • Remove other hosts. • Deep ploughing of the field. • Overlapping and overcrowding branches should be pruned <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Conserve parasitoids such as <i>Aenasius advena</i>, <i>Blepyrus suturalis</i>,

	<p><i>Spalgis epius</i> etc.,</p> <ul style="list-style-type: none"> • Release <i>Cryptolaemus montrouzieri</i> beetles @ 10/tree.
Aphid**	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Collect and destroy the infested plant parts • Maintain adequate aeration by proper training and pruning <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Conserve predators such as ladybird beetles i.e. <i>Scymnus</i>, <i>Chilomenus sexmaculatus</i>, preying mantids, green lacewings, etc., • Release first instar larva of <i>Chrysoperla carnea</i> @ 15 / flowering branch (four times) at 10 days interval from the time of flower initiation.
Flowering and Fruiting	
Nutrients	<ul style="list-style-type: none"> • In the bearing orchards green manure crops like sunnhemp, green gram, cowpea etc., are raised and incorporated into the soil during the monsoon period. • Avoid fertilizer application during flowering time. • For bearing trees apply 500g nitrogen, 200g phosphorus and 500g potash every year. 600 g N, 300g P and 400 g K • If required, apply micronutrients in case any deficiency is observed. Spraying of 4g Zinc Sulphate + 2g Boric acid per liter of water and urea 2% during fruit develop..
Weeds	<ul style="list-style-type: none"> • Remove weeds from basins around the trees by hand weeding before manure and fertilizer application followed by mulching with organic materials. • Control weeds between rows by shallow cultivation and grow the regional recommended intercrop/cover crop. • Inter row space should kept weed free by light cultivation and using green manuring or inter cropping with leguminous crops.
Fruit fly	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Collect and destroy fallen and infested fruits. • Tillage of tree basin helps in checking the pest population as the pupae and hibernating larvae are destroyed by natural enemies. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Conserve parasitoids such as <i>Opius compensates</i>, <i>Spalangia philippinensis</i>, <i>Diachasmimorpha kraussi</i> etc.,

<p>Bark- eating caterpillar</p>	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Detect early infestation by periodic monitoring. • Keep the orchard clean and healthy to prevent the infestation.. • Remove and destroy alternate host, silk cotton, other hosts and severely affected branches of the tree, <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Scraping the loose bark to prevent oviposition by adult beetles. • Hook out the caterpillar from the bore hole and kill them. • Insert cotton plug soaked in kerosene or petrol into the holes and close them with mud.
<p>Castor capsule borer</p>	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Detect early infestation by periodic monitoring. • Keeping basin clean. • Maintain adequate aeration by proper training and pruning • Pomegranate should not be cultivated close to guava as this is the most preferred host of this pest. • Collect and destroy the infested fruits regularly. <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Prune the affected parts of the plant and destroy. • Use light trap @ 1/acre and operate between 6 pm and 10 pm <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Conserve parasitoids such as <i>Trichogramma chilonis</i> (egg), <i>Tetrastichus</i> spp. (egg), <i>Telenomus</i> spp. (egg), <i>Chelonus blackburni</i> (egg-larval), <i>Carcelia</i> spp. (larval-pupal), <i>Campoletis chloridae</i> (larval), <i>Goniophthalmus halli</i> (larval), <i>Bracon</i> spp. (larval) etc. • Conserve predators such as <i>Chrysoperlazastrowii</i> sellimi, coccinellids, King crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, preying mantid, fire ants, big eyed bugs (<i>Geocoris</i> sp), pentatomid bug (<i>Eocanthecona furcellata</i>), earwigs, ground beetles, rove beetles etc.
<p>Pomegranate / Guava butterfly</p>	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Cover fruits with paper bags. • Remove and destroy the affected fruits. <p>Pomegranate should not be cultivated close to guava as this is the most preferred host of this pest Collect and destroy the infested fruits regularly.</p> <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Remove weeds of compositae family • Prune the affected parts of the plant and destroy them. • Detect early infestation by periodic monitoring Install light trap @ 1/ acre to monitor and mechanical collection of insects <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Same as <u>castor capsule borer</u>

Tea mosquito bug**	<p><u>Cultural methods:</u></p> <ul style="list-style-type: none"> • Maintain proper sunlight in the plant canopy by adequate pruning. • Collect and destroy the damaged plant parts. • Do not interplant guava with crops that are host for <i>Helopeltis</i> bugs, such as cotton, tea, sweet potato, cashew and mango. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Conserve predators such as <i>Mallada</i> sp., <i>Oxyopes</i> sp., Reduviid bug.
Diseases	
Guava wilt	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Follow clean cultivation and strict sanitation in orchard • Wilted trees should be uprooted, burnt and trench should be dug around the tree trunk. • Roots of plants should not be damaged while transplanting. • Maintain proper tree vigour by timely and adequately manuring, inter-culture and irrigation enable them to withstand infection. • The pits may be treated with formalin and kept covered for about 3 days and transplanting should be done after two weeks. • Apply organic manures, oil cakes and lime Use rootstocks resistant to wilt <i>i.e.</i> Cross of <i>Psidium molle</i> x <i>P. guajava</i>. • Eco-friendly approach of guava wilt control is suggested where biological control (<i>Trichoderma</i> spp., <i>Aspergillus niger</i> AN27), soil amendment (lime, neem cakes, gypsum) and intercropping (marigold, turmeric) are effective.
Fruit rot/ fruit canker**/ algal leaf** and fruit spot**	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Prune and destroy the dead twigs and fruits. • Plant spacing and fertilizer régimes should be managed to avoid unnecessarily dense plant canopy. • Prune old and non-productive branch which may serve as potential source of infection • For managing fruit rot disease good field sanitation (maintain field free of infected dry or semi-dry twigs and mummified fruits of previous harvest which may serve as primary inoculum. • Algal leaf spot can be reduced by maintaining tree vigour with cultural techniques such as proper fertilization and irrigation, proper pruning to enhance air circulation within the canopy and sunlight penetration, managing weeds and wider tree spacing. • Managing insect, mite and other foliar diseases increases tree vigour and lessens susceptibility to algal disease <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Apply Zineb 75% WP @600 -800 g in 300-400 l of water/ acre or Mancozeb 75% WP 20g in 10 l of water/tree.
Dieback/ anthracnose/ Stem canker and dry fruit rot	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Maintain orchard hygienic • Monitor disease and use of micro irrigation systems • Follow clean cultivation and strict sanitation in orchard

	<ul style="list-style-type: none"> • Use disease free planting material • Implement a good weed control to reduce humidity • Adhere to recommended plant density to reduce competition for sunlight, water and nutrient
Post-harvest	
Pest & diseases	<u>Mechanical control:</u> <ul style="list-style-type: none"> • Keeping of good quality of fruits and bagging fruits, Remove and destroy all the affected fruits to reduce, the incidence of Anar butterfly. Cover the fruit with polythene bags when the fruits are up to 5 cm.

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

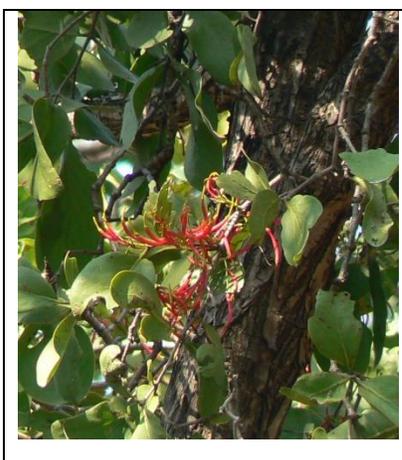
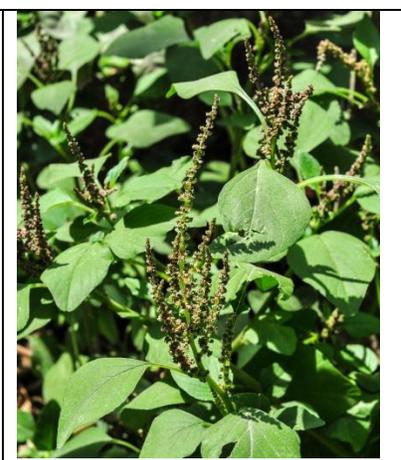
VI. NUTRITIONAL DEFICIENCIES/ DISORDERS

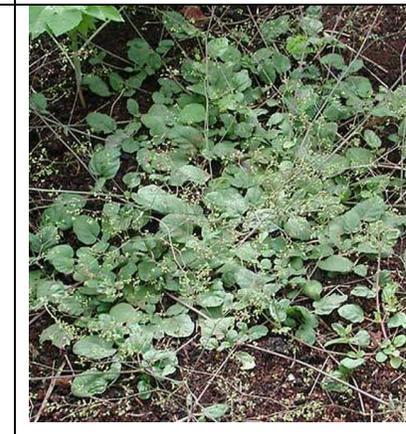
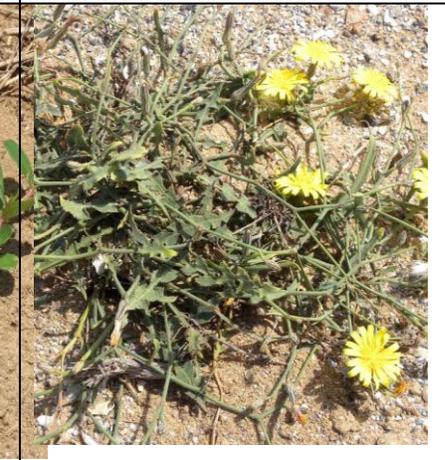
Nutrients	Fig.
<p>Nitrogen: Stunted growth. Pale green to light yellow colour (chlorosis) appearing first on older leaves, usually starting at the tips. Depending on the severity of deficiency, the chloroses could result in the death and / or dropping of the older leaves.</p> <p>Correction Measure: Foliar spray of Urea @ 1-2 % at fortnightly intervals</p>	
<p>Phosphorus: Slow, weak and stunted growth with dark to blue-green coloration to appear on older leaves of some plants. Under severe deficiency, purpling in leaves and stems may appear. Delayed maturity and poor seed and fruit development.</p> <p>Correction Measure: Foliar spray of DAP 2% at fortnightly interval.</p>	
<p>Potassium: Chlorosis along the edges of leaves (leaf margin scorching) occurs first in older leaves. Plants lacking K will have slow and stunted growth. Stems are weak. The size of seeds and fruits and the quantity of their production is reduced.</p> <p>Correction Measure: Foliar spray of K₂SO₄ @ 2% at fortnightly interval.</p>	

<p>Calcium: Symptoms first appear on the younger leaves and leaf tips. The growing tips of roots and leaves turn brown and die. Newly emerging leaves may stick together at the margins, which causes tearing as the leaves expand and unfurl. Younger leaves may be cupped and crinkled, with the terminal bud deteriorating.</p> <p>Correction Measure: Soil application of gypsum @ 100 kg acre.</p>	
<p>Magnesium : The deficiency symptom of interveinal chlorosis first appears in older leaves. Leaf tissue between the veins may be yellowish, bronze or reddish, while the leaf veins remain green. In severe cases, symptoms may appear on younger leaves and cause premature leaf drop. Symptoms occur most frequently in acid soils and soils receiving high amounts of K fertilizer or Ca.</p> <p>Correction Measure: Foliar spray of MgSO₄ @ 2% at fortnightly interval.</p>	
<p>Sulphur: Younger leaves are chlorotic with evenly, lightly colored veins. Growth rate is retarded and maturity is delayed. Plant stems are stiff, thin and woody. Symptoms may be similar to N deficiency and are most often found in sandy soils that are low in organic matter and receive moderate to heavy rainfall.</p> <p>Correction Measure: Soil application of gypsum @ 100 kg acre.</p>	
<p>Boron: Stunted growth, first showing symptoms on the growing point and younger leaves. The leaves tend to be thickened and may curl and become brittle.</p> <p>Correction Measure: Foliar spray of Borax @ 0.5% at fortnightly interval.</p>	

VII. DESCRIPTION OF COMMON WEEDS

		
<p>1. Bermuda grass: <i>Cynodon dactylon</i> L. Poaceae</p>	<p>2. Hairy crabgrass: <i>Digitaria sanguinalis</i> (L.) Scop. Poaceae</p>	<p>3. Egyptian crowfoot grass: <i>Dactyloctenium aegyptium</i> (L.) Willd Poaceae</p>
		
<p>4. Buffalo grass: <i>Paspalum conjugatum</i> P. J. Bergius Poaceae</p>	<p>5. Cogongrass: <i>Imperata cylindrica</i> (L.) P. Beauv. Poaceae</p>	<p>6. Coat buttons: <i>Tridax procumbens</i> L. Fabaceae</p>
		
<p>7. Spanish needles: <i>Bidens Pilosa</i> L. Asteraceae</p>	<p>8. Silk leaf: <i>Lagascea mollis</i> Cavanilles Asteraceae</p>	<p>9. Canoe weed: <i>Phyllanthus</i> <i>maderaspatensis</i> L. Euphorbiaceae</p>

		
<p>10. Mohanavallee: <i>Loranthus longiflorus</i> Des r Loranthaceae</p>	<p>11. Amaranth: <i>Amaranthus viridis</i> L. Amaranthaceae</p>	<p>12. False amaranth: <i>Digera arvensis</i> Forssk. Amaranthaceae</p>
		
<p>13. Asthma herb: <i>Euphorbia hirta</i> L. Euphorbiaceae</p>	<p>14. Milkweed: <i>Euphorbia geniculata</i> L. Euphorbiaceae</p>	<p>15. Whitetop Weed <i>Parthenium hysterophorus</i> L. Asteraceae</p>
		
<p>16. Horse purslane: <i>Trianthema portulacastrum</i> L. Aizoaceae</p>	<p>17. Purple nut sedge: <i>Cyperus rotundus</i> L. Cypraceae</p>	<p>18. Flat sedge: <i>Cyperus iria</i> L. Cypraceae</p>

		
<p>19. Quackgrass: <i>Agropyron repens</i> (L.) P. Beauv. Poaceae</p>	<p>20. Indian goosegrass: <i>Eleusine indica</i> (L.) Gaertn. Poaceae</p>	<p>21. Lovegrass: <i>Eragrostis tanella</i> (L.) P. Beauv. Poaceae</p>
		
<p>22. Johnson grass: <i>Sorghum helepense</i> (L.) Pers. Poaceae</p>	<p>23. Pig weed: <i>Boerhavia hirsuta</i> Willd Nyctaginaceae</p>	<p>24. Shaggy Button Weed: <i>Borreria hispida</i> (Linn.) K. Schum. Rubiaceae</p>
		
<p>25. Swine Cress: <i>Cronopus didymus</i> L. Sm. Brassicaceae</p>	<p>26. Common Purslane: <i>Portulaca oleracea</i> L. Portulacaceae</p>	<p>27. Launaea: <i>Launea nudicaulis</i> (L.) Hook.f Asteraceae</p>

		
<p>28. Sticky spider-flower: <i>Cleome viscosa</i> L. Capparaceae</p>	<p>29. Yellow nutsedge: <i>Cyperus esculentus</i> L. Cyperaceae</p>	<p>30. Small-flowered umbrella sedge: <i>Cyperus difformis</i> L. Cyperaceae</p>

2. http://upload.wikimedia.org/wikipedia/commons/f/fa/Harig_vingergras_plant_%28Digitaria_sanguinalis%29.jpg
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28. http://www.oswaldasia.org/species/c/clevi/clevi_01.jpg
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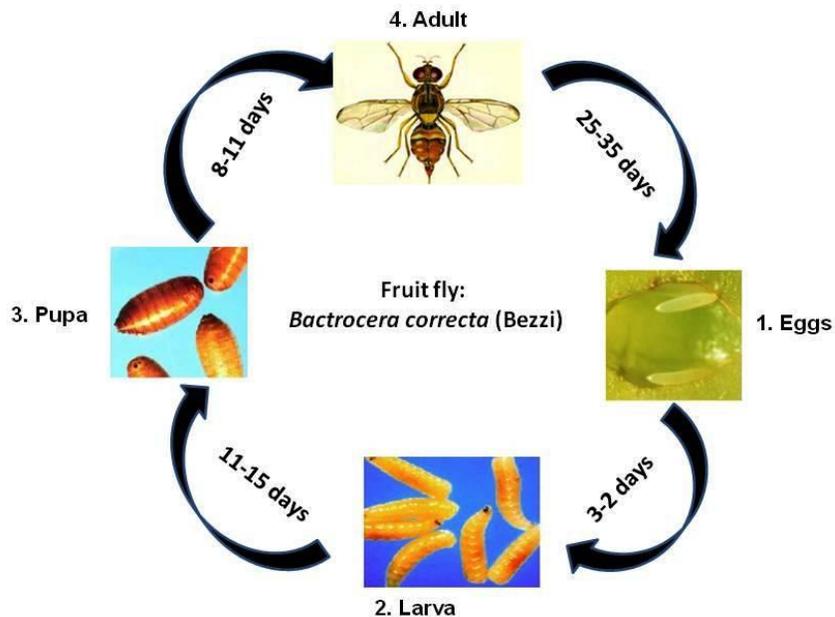
VIII. DESCRIPTION OF INSECT PESTS

1. Fruit fly:

Biology:

- **Egg:** Under optimum conditions, a female can lay more than 3,000 eggs during her lifetime, but under field conditions from 1,200 to 1,500 eggs per female is considered to be the usual production. Development from egg to adult under summer conditions requires about 16 days.
- **Larva:** The mature larva emerges from the fruit, drops to the ground, and forms a tan to dark brown puparium.
- **Pupa:** Pupation occurs in the soil. About nine days are required for attainment of sexual maturity after the adult fly emerges.
- **Adult:** Brown or dark brown with hyaline wings and yellow legs.

Life cycle:



2. http://www.cdfa.ca.gov/plant/pdep/target_pest_disease_profiles/guava_fruit_fly_profile.html

3. <http://www.fightthefruitfly.org/information.html>

Damage symptoms:

- Adults and maggots attack semi – ripe fruits
- Oviposition punctures on fruits
- Maggots destroy and convert pulp into a bad smelling
- Discoloured semi liquid mass



Fruit fly damage due to ovipositional

1. Horticulture Year, 2012, National Horticulture Mission, IPM SCHEDULE FOR GUAVA PESTS

2-3. <http://www.taiwanembassy.org/public/Data/11294252171.pdf>

Natural enemies of fruit fly:

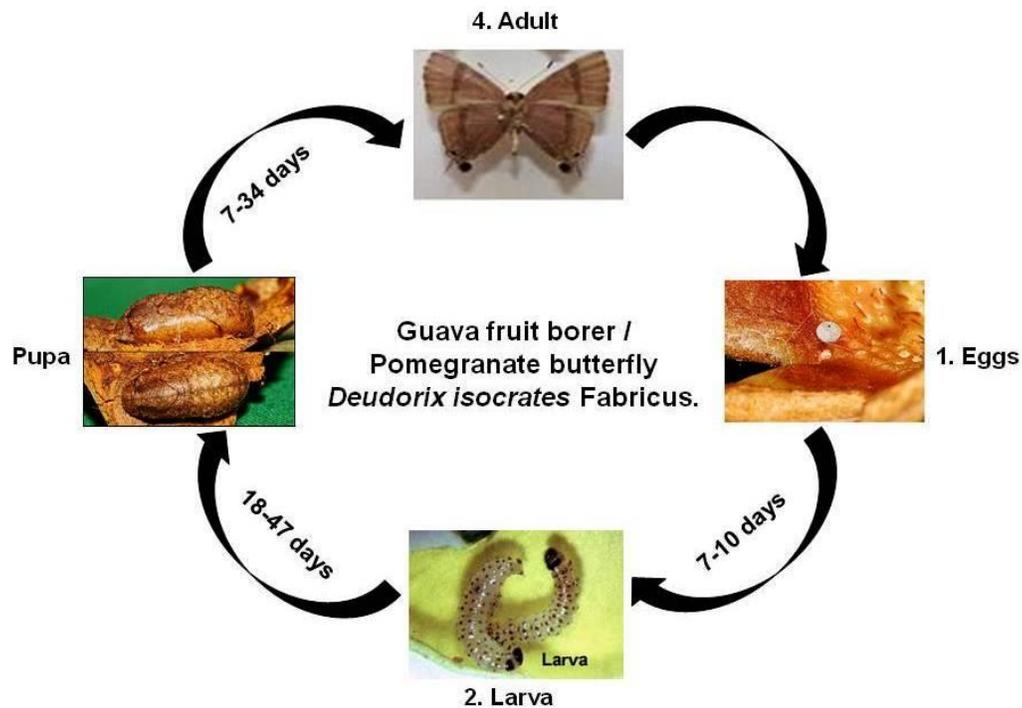
Parasitoids : *Opius compensates*, *Spalangia philippinensis*, and *Diachasmimorpha kraussi*

2. Guava fruit borers/ pomegranate butterfly:

Biology:

- **Eggs:** Eggs are laid singly on tender leaves, stalks and flower buds.
- **Larvae** - Dark brown, short and stout, covered with short hairs, larval period lasts for 18-47 days.
- **Pupa:** Development occurs either inside the damaged fruits or on the stalk holding it. Pupal period lasts for 7-34 days. Total life cycle is completed in 1 to 2 months.
- **Adult** - bluish brown butterfly, Female – V shaped patch on forewing

Life cycle:



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

Damage symptoms:

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



1. Fruits damaged by *D. Isocrates*, 2. Larvae inside the damaged fruits

Horticulture Year, 2012, National Horticulture Mission, IPM SCHEDULE FOR GUAVA PESTS.

Natural enemies of fruit borers:

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

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

Management:

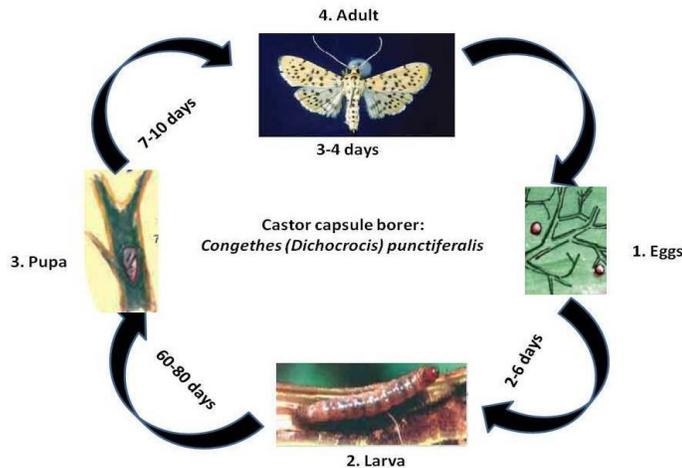
*For management refer to page number-----

3.. Castor capsule borer:

Biology:

- **Egg:** Pink colored eggs laid singly on flower buds, or young capsules.
- **Larva:** Pale reddish brown with black blotches and tubercles on body.
- **Pupal:** Pupates on plants in stem or capsule.
- **Adult:** Yellow colored moth with black dots.

Life cycle:



http://takingroots.in/ipm_cscb

Damage symptoms:

- Stem dries up as larva bores in to it and then damages capsules.
- Caterpillar bores into young fruits but they may also bore buds and tender shoots.
- Feeds on internal contents (pulp and seeds)
- Infected fruits dry up and fall off without ripening
- The affected fruits are generally deformed at the point of entry of larvae.
- Larvae faeces may be seen exuding out of the borer hole. Such fruits weaken, rot and drop down.



Fruits damaged by *D. punctiferalis*

Horticulture Year, 2012, National Horticulture Mission, IPM SCHEDULE FOR GUAVA PESTS.

Natural enemies of castor capsule borer:

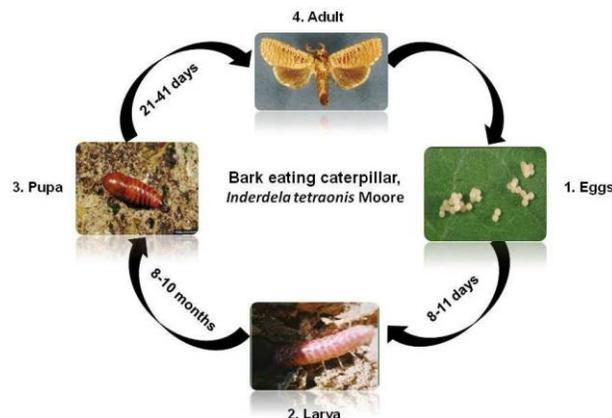
Parasitoids and predators: Same as mentioned in pomegranate butterfly.

4. Bark eating caterpillar:

Biology:

- **Eggs:** Eggs are laid under loose bark or in cracks and crevices in clusters of 15-25 from April to June. Eggs hatch in 8-11 days. Eggs are oval in shape and reddish in colour.
- **Larval:** Caterpillars are pinkish white with brown spots and are about 40mm long. Larval duration is of 8-10 months.
- **Pupal:** Pupae are chestnut-brown in colour and 22 to 28 mm long, Pupal period is 21- 41 days. Total life cycle lasts 4-5 months in south India and more than a year in north India. One generation per year.
- **Adult:** Moths are white with pairs of small black dots on thorax, numerous small black spots and streaks on fore wings and few black spots on posterior edges of hind wings.

Life cycle:



Damage symptoms:

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



Damage of bark eating caterpillar Infestation of bark eating caterpillar on twigs.

Horticulture Year, 2012, National Horticulture Mission, IPM SCHEDULE FOR GUAVA PESTS.

B. Pests of Regional Significance:

1. Tea mosquito bug :

Biology:

- **Eggs:** Eggs are elongate and slightly curved with a pair of filaments, egg period 7-8 days.
- **Nymph:** Nymphal period 14-16 days. Life cycle completed in 22-25 days.
- **Adult:** Reddish brown bug with black head, red thorax, black and white abdomen, and a knob like process on mid-dorsal thorax.

Damage symptoms:

- Nymphs and adults make punctures on petiole, tender shoots and fruits
- Brownish – black necrotic patches develop on the foliage
- Elongate streaks and patches develop on shoots
- Corky scab formation on fruits.



http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insectpest%20guava.html#6

Natural enemies of tea mosquito bug:

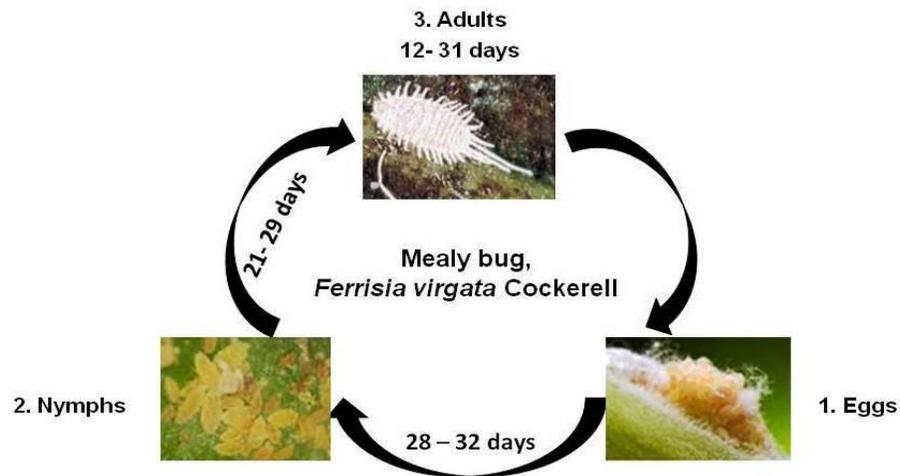
Predators: Reduviid bug, *Oxyopes* sp. and Green lacewing

2 Mealy bug:

Biology:

- **Egg:** The egg period was 28-32 days. Female and male adults live for 23 to 28 days, respectively. Pre-oviposition, oviposition and post-oviposition periods is 6-7, 8.-9 and 1-2 days, respectively. The total life span of female and male 46 -49 and 23 -29 days. The reproduction took place both sexually as well as parthenogenetically and female laid an average of 155 eggs during its life period.
- **Nymph:** Yellow to pale white in colour. Three to four nymphal instars and that the total nymphal period is 21 to 29 days.
- **Adult:** Females apterous, long, slender covered with white waxy secretions, The life-span of the adult female is 12-31 days.

Life cycle:



Symptoms of Damage:

- The tiny small bugs usually suck sap from twigs, leaves and flowers. Infested fruits will have uneven shapes, poor quality, and are susceptible to secondary infections by pathogens.



Fruit and leaves infested with mealy bug

<http://www.taiwanembassy.org/public/Data/11294252171.pdf>

Favourable condition:

- The maximum temperature had significant positive correlation with the build-up of population of mealy bugs while high humidity had significant negative correlation. The other meteorological parameters, i.e. minimum temperature, relative morning humidity and rain, had no significant influence on the incidence of the pests.
- A major pest of several vegetables, ornamental plants, tropical orchard trees and was observed feeding on 76 species of plants belonging to 33 families.

Natural enemies of mealy bug:

Predators: *Chrysoperla carnea*, *Cryptolaemus montrouzieri*, and *Spalgis epius*

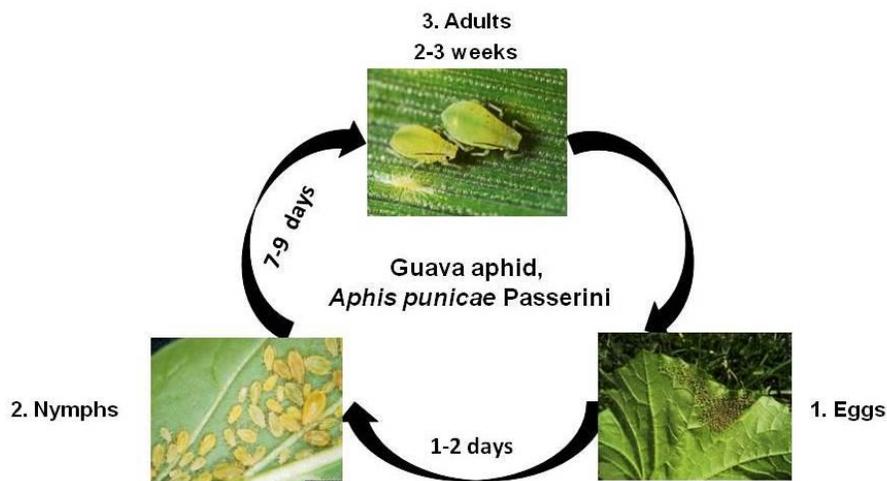
Parasitoids: *Aenasius advena*

3. Aphid:

Biology:

- **Eggs:** Eggs are very small white to dull white in cloured layered on Both winged and wingless forms breed parthenogenetically.
- **Nymph:** The nymphal period lasts for 7-9 days.
- **Adult:** Adults live for 2-3 weeks and produce 8-22 nymphs per day. Entire life cycle takes 22-25 days. It has 12-14 generations per year.

Life cycle:



Damage symptoms:

- Nymphs and adults suck the sap from leaves, shoots and fruits
- Yellowing of leaves

- Wilting of terminal shoots

Favourable conditions:

- Damage is severe because the green citrus aphid colonizes young shoots, buds, grafts and young plants, the development of which is inhibited. Spring-time attacks are the most deleterious.

Natural enemies of mealy bug:

Predators: *Scymnus*, *Chilomenes sexmaculatus*, *Chrysoperla carnea*, Predatory mantids, parasitic wasps, ladybird beetle, predatory mite

4. Whitefly:

Biology:

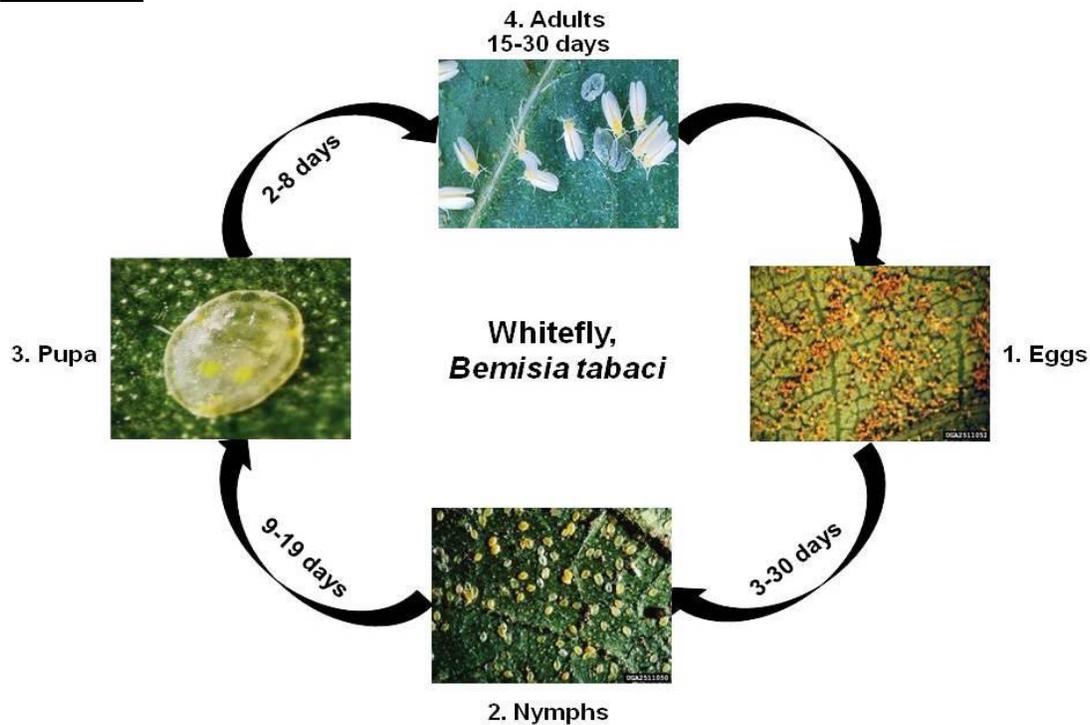
Egg: The female white flies lay eggs singly on the underside of the leaves. Eggs are smooth, sub elliptical, stalked at broader basal end. Its colour is light yellow, when freshly laid, turn dark brown later on. The eggs hatch in 5-17 days.

Stalked Nymph: It is louse like, sluggish creature having pale-yellow body. The nymphal stage lasts 14 to 81 days.

Pupa: Convex in shape and possesses deep yellow patches on the abdomen.

Adult: In 2-8 days, the pupae change into white flies. Adult fly is small winged insect having light yellow body of 1.0-1.5mm length dusted with a white waxy powder. Wings are pure white and have prominent long legs. The life cycle is completed in 14-122 days. Eleven generations of this pest are completed in a year.

Life cycle:



Favorable conditions:

The temperature of 28-36° C and 62-92% relative humidity and scanty rainfall during August to January are quite favorable for this pest.

Damage symptoms:

- Chlorotic spots
- Yellowing
- Downward curling and drying of leaves.
- Vector of potato leaf curl disease

Natural enemies of Guava insect-pests

Parasitoids:

Egg parasitoids



1. *Trichogramma chilonis* 2. *Telenomus* sp.

Egg-larval parasitoids



3. *Chelonus blackburni*

Larval parasitoids



4. *Opius compensatēs*



5. *Spalangia philippinensis*,



6. *Carcelia* spp.



7. *Campoletis chloridea*



8. *Bracon* spp.



9. *Aenasius advena*

Larval-pupal parasitoids



10. *Diachasmimorpha kraussi*

Pupal Parasitoid



11. *Tetrastichus* spp.

Predators:



12. Rove beetles



13. Earwigs



14. Ground beetles



15. Fire ants



16. Big eyed bugs



17. Pentatomid bug



18. Reduviid bug



19. Praying mantis



20. *Chrysoperla*



21. Spiders



22. Predatory mite



23. Coccinellids



23. Robber fly



24. Dragonfly



25. *Cryptolaemus montrouzieri*,



26. King crow



27. Common mynah

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IX. DESCRIPTION OF DISEASES

1. Guava wilt:

Disease symptoms:

- First symptoms start with the onset of monsoon. Appearance of light yellow foliage with loss of turgidity and epinasty.
- Plants, at a later stage, show unthriftiness. Subsequently, premature shedding and defoliation.
- Some of the twigs become bare and fail to bring forth new leaves or flowers and eventually dry up. Fruits of all the affected branches remain underdeveloped, hard and stony. Later, the entire plant is defoliated and eventually dies.
- The roots also show rotting at the basal region and the bark is easily detachable from the cortex. Light brown discoloration is also noticed in vascular tissues.
- The pathogen attacks young as well as old fruit bearing trees but older trees are more prone to the disease.



<http://www.midh.gov.in/technology/IPM-GUAVA-Revised-Sept2011.pdf>

Wilted plants

Horticulture Year, 2012, National Horticulture Mission, IPM SCHEDULE FOR GUAVA PESTS.

Survival and spread:

- Through movement of plants containing sick soil in virgin areas.
- Short distance spread is by water.
- Root injury predisposes wilt disease.

Favourable conditions:

- High rainfall during August/ September.
- Stagnation of water in guava field for long duration.
- Maximum and minimum temperature ranges 23-32 C with 76% RH are conducive.
- Lack of timely application of suitable control measures.

2. Fruit rot:

Disease symptoms:

- The symptom starts at calyx disc of the fruit during rainy season.
- Affected area is covered with whitish cotton like growth which develops very fast as the fruit matures and pathogen is able to cover almost the entire surface within a period of 3-4 days during humid weather.
- Under high relative humidity, the fruits near the soil level covered with dense foliage are most severely affected. The fallen fruits are badly affected.
- The skin of the fruit below the whitish cottony growth becomes a little soft, turns light brown to dark

brown and emits a characteristics unpleasant smell. Ultimately such fruits drop off from the tree.



Phytophthora fruits rot on green fruit and foliage

Horticulture Year, 2012, National Horticulture Mission, IPM SCHEDULE FOR GUAVA PESTS.

Survival and spread:

- Rain and the wind are conducive for spread.
- The pathogen produces a great number of sporangia and spores on the surface of diseased tissues principally when the temperature is near 25°C and this is an important sources of inoculum in the development of epidemics.
- Spores spread from the infected plant material or soil by rain splashes.

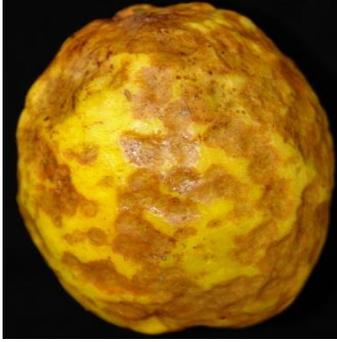
Favourable conditions:

- Cool, wet environmental conditions with high soil moisture favour disease development.
- High humidity, temperature from 28-32°C (25 °C), poorly drained soils and injuries are favourable for initiation of disease.
- Close plantation.

3. Dieback and Anthracnose (fruit rot):

Disease symptoms:

- **Die back phase:** The plant begins to die backwards form the top of a branch.
- Young shoots, leaves and fruits are readily attached, while they are still tender. The greenish colour of the growing tip is changed to dark brown and later to black necrotic areas extending backwards.
- The fungus develops from the infected twigs and then petiole and young leaves which may drop down or fall leaving the dried twigs without leaves.
- **Fruit and leaf infection phase:** Fruit and leaf infection is generally seen during rainy season crop. Pin-head spots are first seen on unripe fruits, which gradually enlarge.
- Spots are dark brown in colour, sunken, circular and have minute black stromata in the center of the lesion, which produce creamy spore masses in moist weather.
- Several spots coalesce to form bigger lesions .
- The infected area on unripe fruits become corky and hardy, and often develops cracks in case of severe infection.
- Unopened buds and flowers are also affected which cause their shedding.
- On leaves, the fungus causes necrotic lesions usually ashy grey and bear fruiting bodies at the tip or on the margin. .



Disease symptoms on unripe and mature fruits

Horticulture Year, 2012, National Horticulture Mission, IPM SCHEDULE FOR GUAVA PESTS.

http://s3.amazonaws.com/plantvillage/images/pics/000/001/078/large/Anthracnose_1.jpg?1375806757

Survival and spread:

- Infection spreads by wind borne spores develop on dead leaves, twigs and mummified fruits in the orchard.
- Dense canopy is congenial for germination of spores due to high moisture condition.
- Movement of planting material through infected foliage.
- Transportation of fruits from high disease prone area.

Favourable conditions:

- Closer planting without canopy management
- Dew or rains encourages spore production and its dispersal around canopy.
- Temperature between 10 to 35 °C with best 24 to 28 °C/

4. Stem canker and dry fruit rot. *Physalopara psidii* Stevens & Pierce and *Diplodia natalensis* Evans.]

Disease symptoms:

- *Physalopara psidii* causes stem canker and the imperfect stage *Diplodia natalensis* dry fruit rot.
- Pathogen attack main branches and stem on which it causes cracking of lesion.
- Affected branches wilt as the stem tissues are killed. Fungal perithecia small brown to black structures may develop on the infected stem.
- On fruit disease symptoms appears as light brown spots generally at the stalk or calyx end .
- With four days the entire fruit become dark brown to black and mummified.
- Twing bearing infected fruits show die back.

Survival and spread:

- Pathogen survives beneath the bark which becomes active during favorable condition.
- It may spread from plant to plant through air.

Favourable conditions:

- Rainy season is the favorable for disease development.

5. Fruit canker (*Pestalotia psidii* Pat.)

Disease symptoms:

- Symptoms occur generally on green fruits and rarely on leaves.
- Initially minute, brown or rust coloured, unbroken, circular, necrotic areas appears on fruits, which in advanced stage of infection; tears open the epidermis in a circinate manner.
- The margin of lesion is elevated and a depressed area is noticeable inside. The crater like

appearance is more noticeable on fruits than on leaves. In older cankers, white myceliums consisting of numerous spores are noticeable.

- In severe cases, raised, cankerous spots develop in great numbers and the fruits break open to expose seeds
- Infected fruits remain underdeveloped, become hard, malformed and mummified and drop. Sometimes, small rusty brown angular spots appear on the leaves.



Canker on the fruit

http://agritech.tnau.ac.in/crop_protection/crop_prot_crop%20diseases_postharvest_guava_clip_image004.jpg

<http://www.taiwanembassy.org/public/Data/11294252171.pdf>

Horticulture Year, 2012, National Horticulture Mission, IPM SCHEDULE FOR GUAVA PESTS.

Survival and spread:

- The pathogen is primarily a wound parasite and avoid injury to fruits.

Favourable conditions:

- Germination of spores is maximum at 30°C & do not germinate below 15°C or above 40°C with RH above 96%.

6. Algal leaf and fruit spot (*Cephaleuros virescens* Kuntze)

Disease symptoms:

- Alga infects immature guava leaves during early spring flush.
- Minute, shallow brown velvety lesions appear on leaves specially on leaf tips, margins or areas near the mid vein and as the disease progresses, the lesions enlarge to 2-3 mm in diameter.
- On leaves the spots may vary from specks to big patches which may be crowded or scattered.
- On immature fruits the lesions are nearly black. As fruits enlarge, lesions get sunken and get cracked frequently on older blemishes as a result of enlargement of fruits, lesions are usually smaller than leaf spots. They are darkish green to brown or black to colour.



Algal spots on leaves

http://agritech.tnau.ac.in/crop_protection/crop_prot_crop%20diseases_fruits_guava.html
http://s3.amazonaws.com/plantvillage/images/pics/000/001/083/large/Algal_leaf_spot_2.jpg?1375812222

Survival and spread:

- Pathogen survives on infected plant debris.
- Disease is air borne and spreads by air and rain splashes.

Favourable conditions:

- Wet, humid conditions promote spread of the disease; zoospores spread by splashing water.

7. Styler end rot (*Phomopsis psidii* de Camara)

Disease symptoms:

- The visible disease symptom appears as discoloration in the region lying just below and adjoining the persistent calyx. Such area gradually increases in size and turn dark brown.
- Later the affected area becomes soft. Along with the discoloration of epicarp, the mesocarp tissue also shows discoloration and the diseased area is marked by being pulpy and light brown in colour in contrast to the bright white colour of the healthy area of the mesocarp



Styler end rot (infected and healthy fruits)

Horticulture Year, 2012, National Horticulture Mission, IPM SCHEDULE FOR GUAVA PESTS.

Survival and spread:

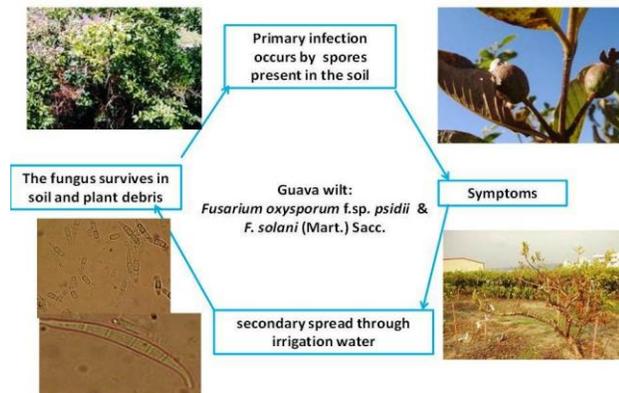
- Pathogen survives in infected fruits and plant debris.
- Pathogen spread through wind.

Favourable conditions:

- Temperature 10 to 35 °C (25 °C optimum) is favourable for disease development.

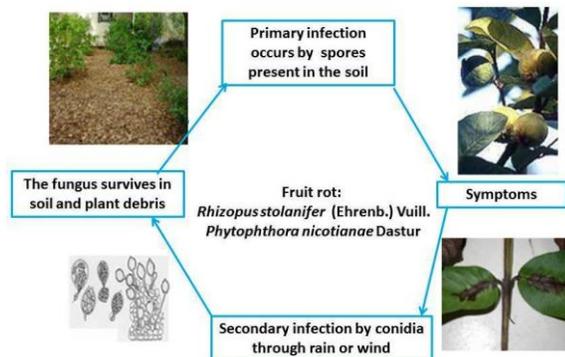
Disease cycles:

1. Guava wilt:



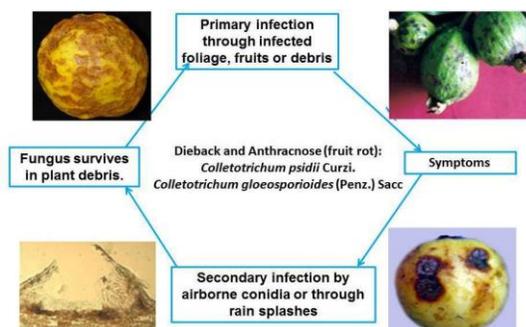
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2. Phytophthora fruit rot:

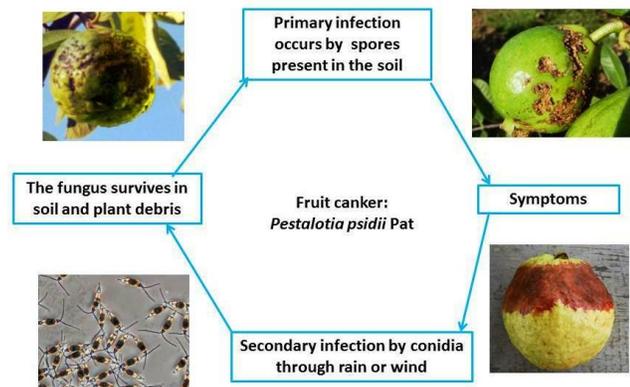


2. <http://forums.gardenweb.com/forums/load/flgard/msg021837397945.html>
3. Ipm Schedule For Guava Pests , National Horticulture Mission Ministry of Agriculture, New Delhi.

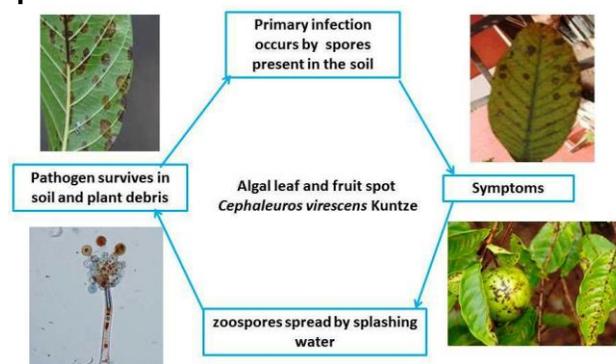
3. Anthracnose and dieback:



4. Fruit canker:



5. Algal leaf and fruit spot



X. Safety measures

A. At the time of harvest: Guava fruits are most commonly harvested by hand. Firm yellow to half-yellow mature fruits should be harvested. Over ripe fruits are easily damaged during transport and handling. Fruits that are immature when harvested do not develop into quality ripe fruits. Guava fruits can be kept in ventilated polyethylene bags for 10 days at ambient temperature 18-20°C.

B. Post-harvest storage: Guava is very popular as a fresh fruit because of its excellent taste, high vitamin content and 100% edibility. This fruit is equally important for the processing industry. A large number of processed products are manufactured from guava. Because of presence of rich amount of pectin, a high quality natural jelly is obtained from guava. Processed guava pulp is an excellent raw material for preparation of various other guava products such as nectars, beverages, jams, toffee, cheese, ice cream topping etc. Guava pulp can be preserved successfully in bulk either by application of heat (aseptic packaging) or addition of chemical preservation (SO₂). Cannel guavas with sugar syrup (40°Brix), dehydrated guavas, and guava powder are the other important products

Grading: The fruits are mostly graded as per the size and colour. Fully ripened fruits, which are yellow in colour are immediately sent to the market.

Packaging: For local markets the fruits are packed in bamboo baskets. As a padding material neem leaves or dried grass is used.

Storage: Mature-green and partially-ripe guavas are stored at 8-10°C for 2-3 weeks while fully-ripe guavas are stored at 5-8°C for 1 week at 90-95% optimum relative humidity

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 varieties not suitable for the season or the region.
3.	Sow/plant early in the season	Avoid late sowing as this may lead to reduced yields and incidence of pests
4.	Always treat the seeds/seedlings/planting material with approved chemicals/bio products for the control of seed borne diseases/pests.	Do not use seeds/seedlings/planting without treated with biocides/chemicals.
5.	Plant in rows at optimum depths under proper moisture conditions for better establishment.	Do not plant seeds beyond 5-7 cm depth.
6.	Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
7.	Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition	Crops should not be exposed to moisture deficit stress at their critical growth stages.
8.	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.

9.	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
10.	Conduct 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
11.	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
12.	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per field observation	Do not apply chemical pesticides within seven days of release of parasitoids.
13.	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.
14.	Spray pesticides thoroughly to treat the undersurface of the leaves.	Do not spray pesticides only on the upper surface of leaves.
15.	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
16.	Follow the recommended procedure of trap crop technology.	Do not apply long persistent 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 1971 Colour of toxicity triangle	WHO classification of hazard	Symptoms of poisoning	First aid measures and treatment of poisoning	Safety interval (days)
1.	Mancozeb Slightly toxic	Unlikely produce acute hazard	Headache, palpitation, nausea, vomiting, flushed face, irritation of	No specific antidote. Treatment is essentially	

			nose,throat, eyes and skin etc.	symptomatic	
2.	Zineb Slightly toxic 	Unlikely produce acute hazard	Headache, palpitation, nausea, vomiting, flushed face, irritation of nose,throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic	

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** apply just before the rains and after the rains; **Do not** apply against the windy direction
3. Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer
4. Wash the sprayer and buckets etc. with soap water after spraying
5. Containers buckets etc. used for mixing pesticides should not be used for domestic purpose
6. Avoid entry of animals and workers in the field immediately after spraying
7. Avoid tank mixing of different pesticides

G. Disposal

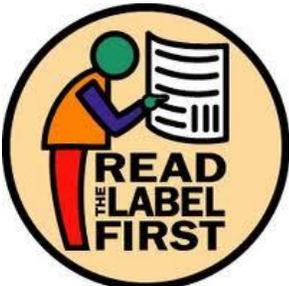
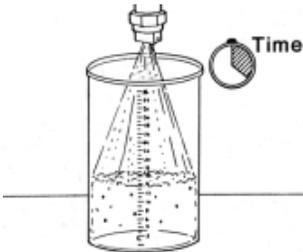
1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

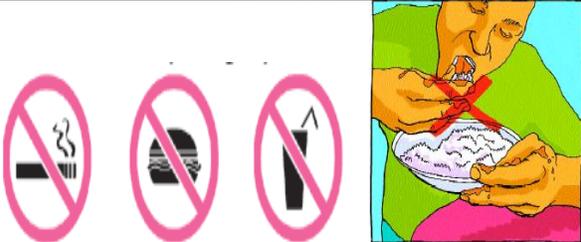
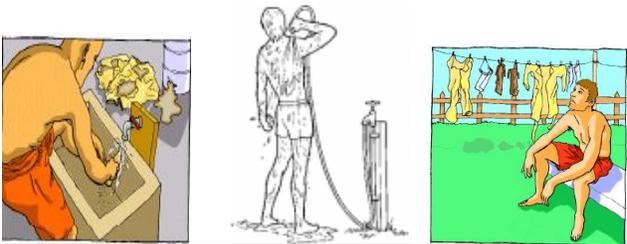
XIV. PESTICIDE APPLICATION TECHNIQUES

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	<ul style="list-style-type: none"> • Lever operated knapsack sprayer (droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min or <ul style="list-style-type: none"> • Motorized knapsack sprayer or mist blower (droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle 	
			

Reproductive stage	Insecticides and fungicides	<ul style="list-style-type: none"> Lever operated knapsack sprayer (droplets of big size) Hollow cone nozzle @ 35 to 40 psi Lever operating speed = 15 to 20 strokes/min 	
Category B: Field flying pest/airborne pest			
Vegetative stage	Insecticides and fungicides	<ul style="list-style-type: none"> 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 	
Reproductive stage (Field Pests)			
Mosquito/ locust and spatial application (migratory Pests)	Insecticides and fungicides	<ul style="list-style-type: none"> Fogging machine and ENV (exhaust nozzle vehicle) (droplets of very small size) Hot tube nozzle 	
Category C: Weeds			
Post-emergence application	Weedicide	<ul style="list-style-type: none"> Lever operated knapsack sprayer (droplets of big size) Flat fan or floodjet nozzle @ 15 to 20 psi Lever operating speed = 7 to 10 strokes/min 	 
Pre-emergence application	Weedicide	<ul style="list-style-type: none"> Trolley mounted low volume sprayer (droplets of small size) Battery operated low volume sprayer (droplets of small size) 	

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.	<p>It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides.</p> <p>Do not apply pesticides without protective clothing and wash clothes immediately after spray application.</p>	 
5.	Do not apply in hot or windy conditions.	 

6.	Operator should maintain normal walking speed while undertaking application.	
7.	Do not smoke, chew or eat while undertaking the spraying operation	
8.	Operator should take proper bath with soap after completing spraying	
9.	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

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