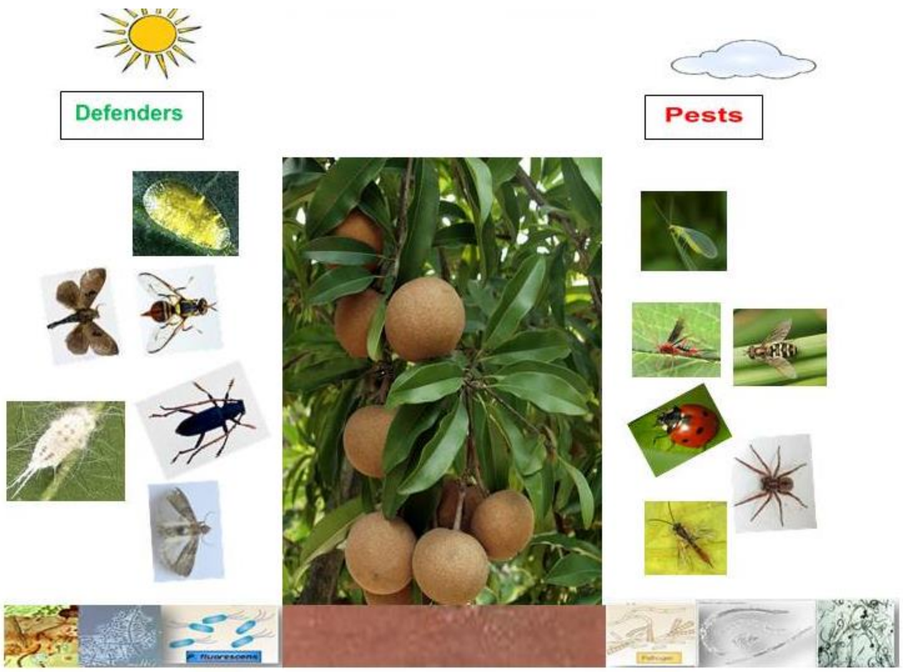
AESA BASED IPM PACKAGE

SAPOTA



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FOREWORD

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

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

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

AK Srivastava

Date: 6.3.2014

(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)

Contents

AESA BASED IPM PACKAGE FOR SAPOTA

Sapota-Plant description:

Sapota (*Manilkara zapota* (L.) P.Royen; Family: Sapotaceae) commonly known as the sapodilla, is a long-lived, evergreen tree native to southern Mexico, Central America and the Caribbean. Sapodilla can grow to more than 30 m (98 ft) tall with an average trunk diameter of 1.5 m (4.9 ft). The average height of cultivated specimens, however, is usually between 9 and 15 m (30 and 49 ft) with a trunk diameter not exceeding 50 cm (20 in). It is wind-resistant and the bark is rich in a white, gummy latex called chicle. The ornamental leaves are medium green and glossy. They are alternate, elliptic to ovate, 7–15 cm long, with an entire margin. The white flowers are inconspicuous and bell-like, with a six-lobed corolla. An unripe fruit has a firm outer skin and when picked, releases white chicle from its stem. A fully ripened fruit has saggy skin and does not release chicle when picked. The fruit is a large ellipsoid berry, normally 4–8 but up to 15 cm in diameter, containing two to five seeds. Inside, its flesh ranges from a pale yellow to an earthy brown color with a grainy texture akin to that of a well-ripened pear. The seeds are black and resemble beans, with a hook at one end that can catch in the throat if swallowed.

I. PESTS

A. Pests of National significance:

1. Insect Pests

- **1.1 Leaf webber: *Nephopteryx eugraphella* Ragonot (Lepidoptera : Pyralidae)**
- **1.2 Green scale: *Coccus viridis* Green (Hemiptera: Coccidae)**
- **1.3. Fruit fly: *Bactrocera (Dacus) dorsalis (*Diptera: Tephritidae)**
- **1.4. Bud borer: *Anarsia achrasella,* Latreille (Lepidoptera: Gelechidae)**
- **1.5 Sapota Seed Borer: *Trymalitis margarias* Meyrick (Lepidoptera: Tortricidae*)***

2. Diseases

2.1 leaf spot: *Phaeophleospora indica* Chinnappa

2.2 Leaf blight: *Fusicoccum sapoticola* Chinnappa & V.G. Rao

2.3 Sooty mould: *Capnodium* sp.

2.4 Postharvest diseases

2.4.1 Soft rot: *Pestalotiopsis mangiferae* (Henn.) Steyaert

2.4.2 Fruit rot:

3. Weeds

Broad leaf
3.1 Tick weed: *Cleome viscosa* L. (Capparidaceae)
3.2 Coat buttons: *Tridax procumbens* L. (Fabaceae)
3.3 Congress grass: *Parthenium hysterophorus* L. (Asteraceae)
3.4 Horse Purslane: *Trainthema portulacastrum* L. (Aizoaceae)
3.5 Crofton weed: *Eupatorium odoratum* L. (Asteraceae)
3.6 Siam weed: *Chromolaena odorata* L. R.M. king & H. Rob (Asteraceae)
3.7 False amaranth: *Digera arvensis* L. (Amaranthaceae)
3.8 Spurge: *Euphorbia hirta* L. (Euphorbiaceae)

Grasses
3.5 Crab grass *Digiteria sanguinalis* (L.) Scop. Poaceae
3.6 Yellow foxtail *Setaria glauca* (L.) P. Beauv. Poaceae
3.7 Bermuda grass *Cynodon dactylon* (L.) Pers. Poaceae
3.8 Torpedo grass *Panicum repens* L. Poaceae
Sedges
3.9 Purple nutsedge *Cyperus rotundus* L. (Cyperaceae)

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

B. Pests of Regional significance

1. Insect Pests

1.1 Mealybug: *Ferrisia virgata* Ckll (Homoptera: Pseudococcidae)

2. Diseases

2.1 Faciation: *Botrydiplodia theobromae* Pat.

2.2 Phanerogamic parasites

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

A. AESA:

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

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

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

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

Principles of AESA based Integrated Pest Management (IPM):

Grow a healthy crop:

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

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

Farmers should:

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

Understand and conserve defenders

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

Insect zoo:

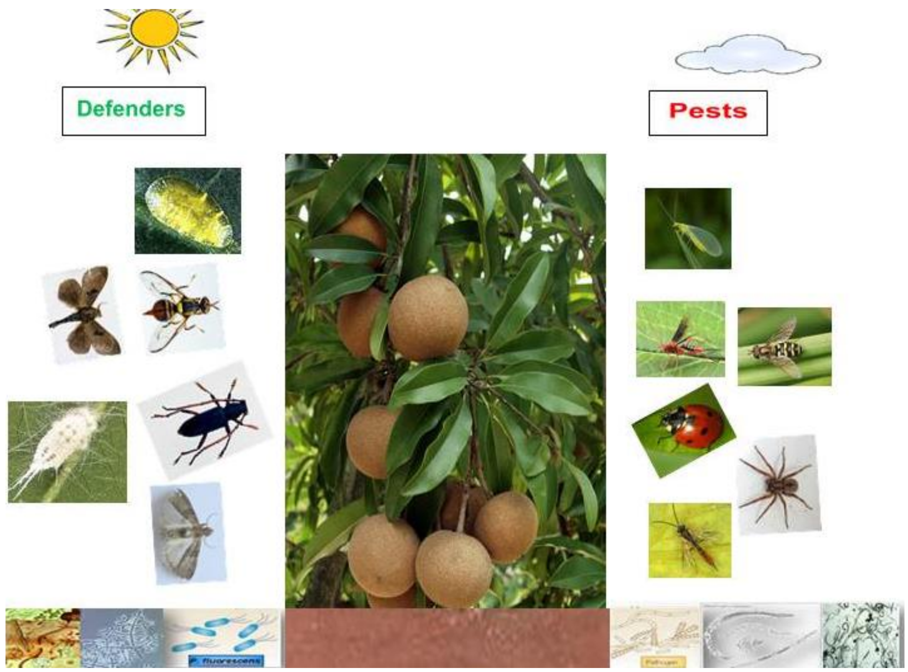
In orchard various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in orchard. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial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

Pest: Defender ratio (P: D ratio):

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

Model Agro-Ecosystem Analysis Chart

Date:
Village:
Farmer:



Decision taken based on the analysis of field situations

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

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

Decision making:

Farmers become experts in crop management:

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

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

AESA methodology:

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

    - Plant: Observe the plant height, number of branches, crop stage, deficiency symptoms etc.
    - Pests: Observe and count pests at different places on the plant.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
    - Rats: Count number of plants affected by rats.
    - Weeds: Observe weeds in the field and their intensity.
    - Water: Observe the water situation of the field.
    - Weather: Observe the weather condition.

- While walking in the orchard, manually collect insects in plastic bags. Collect additional insets and plant parts with disease symptoms in a plastic bag for further examination in the laboratory. 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 representing the field situations. The weather conditions, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.

- Formulate a common conclusion. The whole group should support the decision on what field management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording:

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

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

Data to be recorded:

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

Some questions that can be used during the discussion:

- Summarize the present situation of the 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 build-up?
- What are the problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.

Advantages of AESA over ETL

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

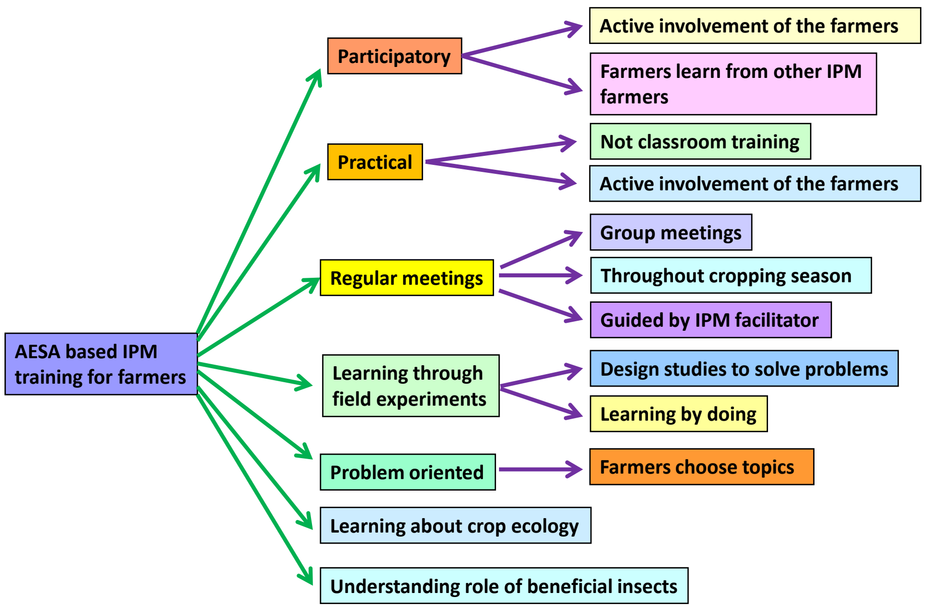
AESA and farmer field school (FFS)

AESA is a season-long training activity that takes place in the farmer 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 their exercise. However, other farmers also can do orchard scouting in their own orchards at regular intervals to monitor the major pest situation.

Undertake roving surveys at every 10 km distance 7-10 days intervals (depending upon the pest population). Record the incidence of major pests and diseases on citrus tree and other host plants of that locality. Observe at each spot 20 trees at random and 5 samples in each tree all around. Record the population of all insect-pests on 3 leaves of new shoots of these plants. Record the other insect-pests and disease occurring on the other parts of tree-plant. Record the population potential of different bio-control fauna.

For sucking pests:

Fruit fly: Population should be counted on three leaves (top and middle portion) of new shoot at 5 sites randomly in each tree.

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

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

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

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

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

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

For Diseases:

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

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

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

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

D. Light traps

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

III. Ecological engineering for pest management

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

Ecological Engineering for Pest Management – Below Ground:

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

- Keep soils covered year-round with living vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance below ground biodiversity of beneficial microbes and insects.
- Application of balanced dose of nutrients using biofertilizers based on soil test report.
- Application of biofertilizers with special focus on mycorrhiza and plant growth promoting rhizobia (PGPR)
- Application of *Trichoderma harzianum/ viride* and *Pseudomonas fluorescens* for treatment of seed/seedling/planting materials in the nurseries and field application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their 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.

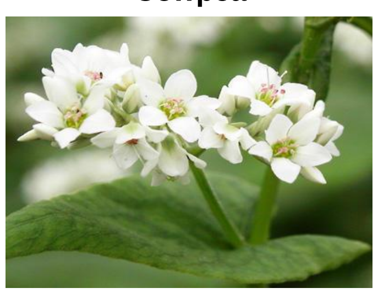
In order to attract natural enemies following activities should be practiced:

- 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, lacewing, earwigs, etc.

Plants Suitable for Ecological Engineering for Pest Management

Cluster bean **Cowpea** **Carrot**



Sunflower **Buckwheat** **Alfalfa**

Maize **Mustard** **French bean**

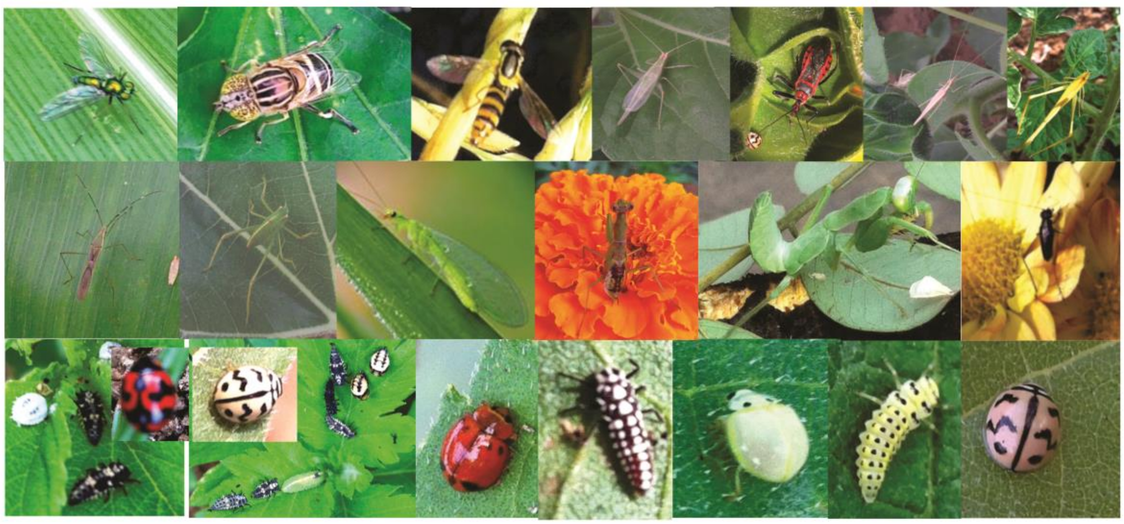
Marigold **Coriander** ***Chrysanthemum***

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

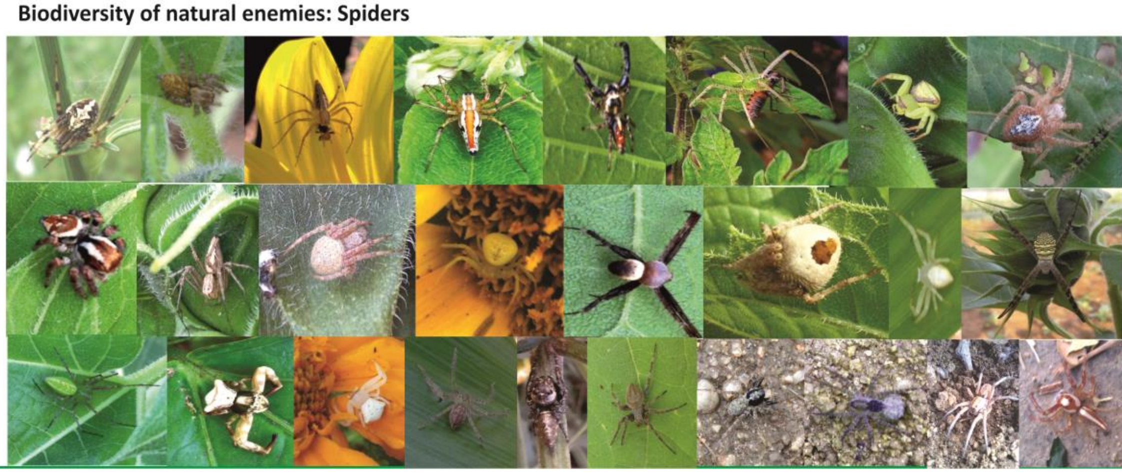
Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



IV. RESISTANT/TOLERANT VARIETIES

Pest	Tolerant/ Resistant variety*
Tolerant to leaf spot and leaf webber	PKM.3 (1994)

***For detailed information and further updates nearest KVK, SAU / ICAR Institute may be contacted**

V. CROP STAGE-WISE IPM

Management	Activity
Pre-planting	
	Common cultural practices: • Harrowing, levelling and application of FYM to the soil help in achieving to conserve soil moisture, and ensure excellent bearing of fruits and resist to insect invasion later • Field sanitation, rogueing • Destroy the alternate host plants • Apply manures and fertilizers as per soil test recommendations
Nutrients	• Nutrient should be applied on the basis of soil test report and recommendation for the particular agro-climatic zone. • Prepare land by ploughing and harrowing. • The pits are dug in summer about a fortnight before planting. • Dig pits of about 1 m x 1 m x 1 m at a distance of 10 m x 10 m apart (high density planting of 5 X 5 m up to the age of 13 years may be adopted). Fill the pits with top soil mixed with 25 kg FYM treated with *Trichoderma* cultures.
Weeds	• Plough the field before planting to destroy existing weeds in the field. • Remove existing weeds in and around the pits at the time of planting.
Soil borne pathogens, resting stages of insects	**Cultural control:** • Grow resistant/tolerant varieties, if any. • Deep summer ploughing of field to control resting stages of insect pests. • Avoid excessive watering and provide proper drainage in the field.
Planting	
Nutrients	• Planting is done in pits already filled with top soil and farm yard manure. • Apply 20 g each of *Azospirillum* and mycorrhizae per

<table>
<tr><td></td><td>plant during planting.</td></tr>
<tr><td>Weeds</td><td>Remove weeds from the pit, if any at the time of plant
Use fibrous biological mulch to reduce the weed problems and conserve the soil moisture.
Adopt the intercropping of recommended crops between the rows of sapota depending upon the stage of orchard e.g. banana, papaya, pine apple, cocoa, French bean, peas, tomato, brinjal, cabbage, cauliflower and cucurbits.</td></tr>
<tr><td>Insect & Diseases</td><td><u>Mechanical Practices</u>
Neem cake must be incorporated @ 40kg/acre, to protect from pest attack.
Growing of forage crops as a mixed crop, helps in "maintaining ecological balance".</td></tr>
<tr><td colspan="2">Vegetative stage (2nd to 4th years)</td></tr>
<tr><td></td><td><u>Common cultural practices:</u>
Collect and destroy diseased and insect infected plant parts.
Provide irrigation at critical stages of the crop
Avoid water stagnation.
Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed
<u>Common mechanical practices:</u>
Collection and destruction of eggs and early stage larvae
Handpick the older larvae during early stages
The infested curd and seed capsules may be collected and destroyed
Handpick the gregarious caterpillars and the pupae which are found on leaves and destroy them in kerosene mixed water.
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.
Set up bonfire during evening hours at 7-8 pm
<u>Common biological practices:</u>
Conserve natural enemies through ecological engineering
Augmentative release of natural enemies</td></tr>
<tr><td>Nutrients</td><td>Apply fertilizers according to the age of plant as mentioned below;
<table><tr><th>Age of</th><th>Nitroge</th><th>Phosp</th><th>Potash</th></tr></table></td></tr>
</table>

the tree	n	horus	
	(grams /tree)		
1-3 Years	50	25	75
4-6 Years	100	40	150
7-10 years	200	80	300
11 years and onward	400	160	450

Weeds	**<u>Cultural control:</u>** • Use black polythene mulch for suppressing the weeds growth. • Remove the existing weeds around the pits by using hand tools as and when required. • Inter-cultivation by suitable plough or cultivator between the rows of sapota plants immediately after onset of the monsoon and may be repeated after suitable interval.
Leaf webber	**<u>Cultural control:</u>** • Follow common cultural, mechanical and biological practices. **<u>Biological control:</u>** • Neem seed kernel extract (NSKE) 5 %
Scale insects and mealy bug	• Follow common cultural, mechanical and biological practices. **<u>Biological control:</u>** • After two weeks release 20 predator beetles viz., *Cryptolaemus. montrouzieri* beetle per tree
Flowering stage	
Nutrients	• Apply recommended micronutrients, if symptoms are observed. • Micro-nutrients viz. $ZnSO_4$ (0.5%) and H_2BO_3 (0.1%) are sprayed in order to increase growth and yield characters
Weeds	• Remove weeds around the plants. • Use straw or plastic Mulch to avoid weed growth and to maintain soil moisture for longer period
Bud borer	• Follow common cultural, mechanical and biological practices.
Fruit laden phase	

Leaf webber	• Same as in vegetative stage.
Sapota caterpillar	• Follow common cultural, mechanical and biological practices. **<u>Cultural control:</u>** • Field sanitation • Free from weeds and debris **<u>Mechanical control:</u>** • Collect and destroy the egg mass • Burning the groups of larvae found on tree trunks with torches
Harvesting stage	
	• Fruits should be harvested in the month of January
Fruit fly	• Follow common cultural, mechanical and biological practices. **<u>Mechanical control:</u>** • Collect fallen infested fruits and dispose them by dumping in a pit and covering with soil. • Raking the soil around the tree to expose the pupa • Monitor and mass trap the fruit flies with methyl eugenol traps. • Use bait spray combining any one of the insecticides and molasses
Seed Borer	• Follow common cultural, mechanical and biological practices. **<u>Mechanical control</u>** • **Sanitation:** Sanitation is to be maintained for eliminating the sources of seed borer infestation. • Collection and destruction of the off season stray mature sapota fruits after main harvest till November will bring down the pest incidence.

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

VI. INSECTICIDE RESISTANCDE AND ITS MANAGEMENT

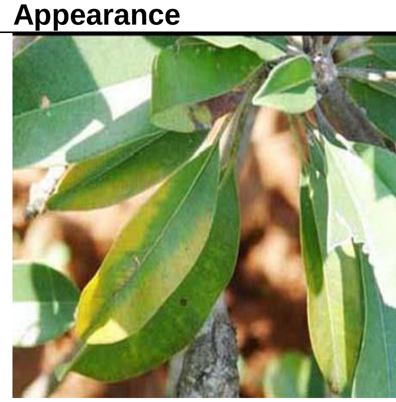
Insecticide resistance: Resistance to insecticides may be defined as ‘a heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species’ (IRAC).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

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

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

1) **Monitor pests:** Monitor insect population development in 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.

VII. NUTRITIONAL DEFICIENCIES

Nutrients	Appearance
Nitrogen: Stunted growth. The bark of the shoots turned reddish-brown in colour. On elongating shoots, the immature leaves become amber to bright red while the mature leaves remained small and yellow-green in colour. Early abscission of leaves, smaller and fewer fruits. **Correction Measure:** Foliar sprays of urea @ 2% with 250 g N per tree from both sources increase the fruit weight and yield.	

Phosphorus: Pigmentation seen in older leaves; leaf size become small. **Correction Measure:** Foliar spray of DAP 2% at fortnightly intervals.	
Potassium: Light brown specks scattered all over the leaves which appeared later merged forming necrotic patches between the large veins. Browning on the under side of the leaves and chlorotic areas between veins due to K deficiency. **Correction Measure:** Application of KCl on soil test basis.	
Calcium: Tip of the twig and flower bud affected and growth retarded. **Correction Measure:** Apply gypsum of lime based on soil test recommendation.	
Magnesium: Leaves become lighter green which gradually turned greenish yellow, remaining deeper green along the mid rib and larger veins. Leaves turned yellow with scattered brown lesion on the leaf blade. Interveinial chlorosis on older leaves followed by necrosis of distal leaf edge. **Correction Measure:** Application of dolomite or spraying magnesium nitrate @ 1% can avoid the deficiency.	
Sulphur: Yellowing of young leaves; growth of the leaf is affected. **Correction Measure:** Foliar spray of CaSO4@1%.	

Boron: Leaves turn yellowish-green in colour the older leaves show signs of burning at the tips and along the margins which abscised prematurely. The tip burning of young leaves and splits or crack on the midrib and large veins on the underside of the leaf is observed. **Correction Measure:** Soil application of borax at 2 kg/acre.	
Copper: The leaf veins developed a reddish-brown colour, premature defoliation and die back of twigs also occurred. The tip of the twigs developed multiple buds which died soon. **Correction Measure:** Application $CuSO_4$ @ 2 to 4 Kg/acre. Cu-fungicide sprays will be helpful in correcting the deficiency.	
Iron: yellowing of young leaves; occurrence of interveinal chlorosis is commonly observed and severe iron deficiency. **Correction Measure:** Foliar spray of $FeSO_4$@0.5 % at fortnightly intervals.	
Manganese: Light colored spots on the leaves and sometimes necrotic spots also appear. Green bands of varying width appear along the midrib and veins with yellow areas between the veins. Interveinal chlorosis, premature dropping of the leaves and dye back of terminals due to Mn deficiency can also be observed. **Correction Measure:** Spraying of $MnSO_4$ @ 0.3% at fortnightly intervals.	
Zinc: Symptoms seen in young leaves; size of the leaf become small. **Correction Measure:** Foliar spray of $ZnSO_4$@0.5%.	

VIII. COMMON WEEDS

1. Tick weed: *Cleome viscosa* L. (Capparidaceae)

2. Coat buttons: (*Tridax procumbens*) L. Fabaceae

3. Congress grass: *Parthenium hysterophorus* L. (Asteraceae)

4. Horse purslane: *Trainthema portulacastrum* L. (Aizoaceae)

5. Crofton weed: *Eupatorium odoratum* L. (Asteraceae)

6. Siam weed: *Chromolaena odorata* L. R.M. king & H. Rob (Asteraceae)

7. False amaranth: *Digera arvensis* L. (Amaranthaceae)

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

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

1

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

11

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

12

. Torpedo grass: *Panicum repens* L. (Poaceae)

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

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

IX. DESCRIPTION OF INSECT PESTS

1. Leaf webber:

Biology

Egg: Freshly laid eggs were soft, pale yellow but semi-transparent and fertile eggs turned pink within 24 hrs. Eggs are laid usually in small batches of 4 to 30 along the mid rib of the underside of leaf or tender branches.

Larva: neonate larvae measured 1.35 mm in length. Initially it is pink and become yellow within 24 h and later turns into greenish in colour. Head is pale yellow. Dorsal side of body is pink in colour while ventral side is green. First and third pair of strips are pink in colour blended with black spots on each segment while second pair is purple.

Pupa: Pupation takes place in plant debris or in soil.

Adult: Adult is grayish in colour with compound black eyes with setaceous antennae. Fore wings are grayish with four black transverse wavy lines. Hind wings are membranous white. Both the wings are fringed at the outer margins. A brownish line is present near the outer margins of the wings.

Damage symptoms:

Caterpillar webs and feed on leaves by scrapping chlorophyll content Caterpillar also bores into flower buds and tender fruits leading to withering and shedding.

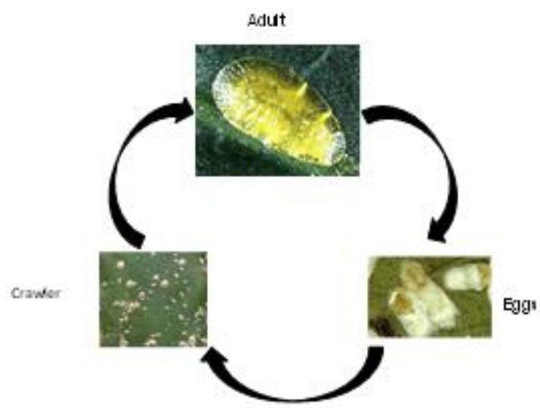
2. Green scale:

Egg: Eggs are whitish green and elongate-oval and are laid singly and hatch beneath the female where they are protected. Eggs hatch from a few minutes to several hours after being laid

Nymphs (Crawlers): Nymphs, or immature green scales are oval, flat and yellowish green in color, and have six short legs. There are three nymphal stages before becoming an adult, each stage being larger and more convex than the previous stage

Adults: The adult female is shiny pale green with a conspicuous black, irregular U-shaped internal marking that is dorsally visible to the naked eye. Two sub-marginal black eye spots are also present and can be seen with a hand lens. The outline shape may be described as elongate- oval and moderately convex. Adult scales are 2.5-3.25 mm. Dead scales are light brown or buff color and the black internal marking is lost.

Life cycle:



Nature and symptoms of damage:

Scales damage plants by sucking out plant sap as a result leaves to yellow and wilt.

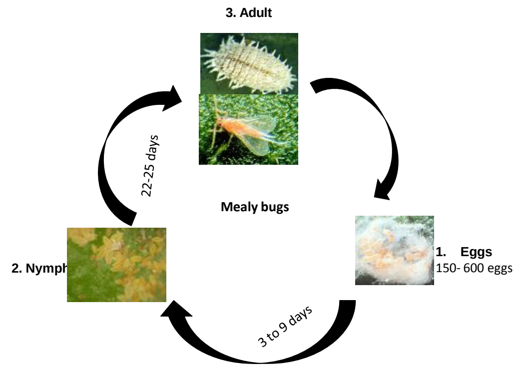
Natural enemies of scale insects:

Parasitoids: *Coccophgagus cowperi*

Predators: *C. montrouzieri*

3.Striped mealy bug:

Biology: Mealy bugs are soft pinkish-white insects with a waxy appearance. Adult females are soft-bodied, wingless insects that grow between 1/20 and 1/5 inch long. Mealy bugs lay large clusters of several hundred eggs on the surface of a leaf, which then hatch into yellow nymphs, which feed on plant sap.



Natural enemies of mealy bug:
Parasitoids: Parasitic wasp
Predators: Hover flies, ladybird beetle, *Cryptolaemus montrouzieri*

5.Fruit fly:

Biology

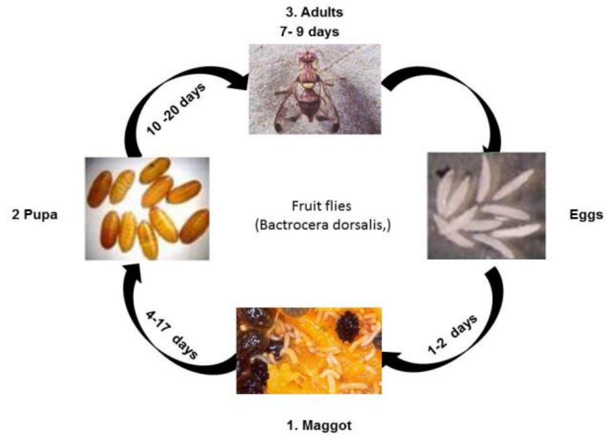
Egg: The eggs of *Bactrocera* species are very similar. Size, 0.8 mm long, 0.2 mm wide, with the micropyle protruding slightly at the anterior end. The chorion is reticulate (requires scanning electron microscope examination). White to yellow-white in colour.

Maggot: The third-instar, which has a typical maggot appearance, is about 10 mm in length and creamy white. The only band of spinules encircling the body is found on the first segment. The external part of the anterior respiratory organs, the spiracles, located one on each side of the pointed or head end of the larva, has an exaggerated and deflexed lobe at each side and bears many small tubercles. The caudal segment is very smooth. The posterior spiracles are located in the dorsal third of the segment as viewed from the rear of the larva. The mature larva emerges from the fruit, drops to the ground, and forms a tan to dark brown puparium about 4.9 mm in length. The entire larval stage lasts for 11-15 days.

Pupa: When mature, larvae drop to the ground and pupate in the soil. The puparium is yellowish-brown and seed-like. Adults emerge in about 10 days.

Adult: Generally, the abdomen has two horizontal black stripes and a longitudinal median stripe extending from the base of the third segment to the apex of the abdomen. These markings may form a "T" shaped pattern, but the pattern varies considerably. Females begin to lay eggs about 8 days after emergence from the puparium. Under optimum conditions, a female can lay more than 3,000 eggs during her lifetime, but under field conditions approximately 1,200 to 1,500 eggs per female is considered to be the usual production.Ripe fruit are preferred for egg laying, but immature ones may be also attacked.

Life cycle:



Symptoms of damage:

- Maggot bore into semi-ripen fruits with decayed spots and dropping of fruits.
- Oozing of fluid
- Brownish rotten patches on fruits

Natural enemies of fruit fly:

Parasitoids: *Fopius arisanus*, *Diachasmimorpha kraussi*

6. Bud borer

Biology:

Eggs: The eggs of A. achrasella were smooth, oval and white in colour at the time of oviposition and turned to light brown before hatching. The length of eggs ranged from 0.37 to 0.49 mm with an average of 0.46 ± 0.04 mm, while the breadth varied from 0.20 to 0.29 mm with an average of 0.25 ± 0.03 mm. The incubation period varied from 4 to 6 days with an average of 4.64 ± 0.70 days.

Larva -. The larva is small, slender, pinkish brown with black head and passed through four instars on sapota buds. The newly hatched caterpillar was light yellow in colour, shiny with black head. It was tiny and delicate with slender body.

Pupa: This pre-pupal condition lasted for about one day during which the larva did not exhibit any movement unless it was disturbed. The prepupal period lasted for 1 to 2 days with an average of 1.52 ± 0.51 days. The length of pre-pupa varied from 6.10 to 7.20 mm with an average of 6.62 ± 0.34 mm, while breadth ranged from 1.61 to 2.10 with an average of 1.41 ± 0.05 mm. A newly formed pupa was obtect type, brick-red in colour and changed into dark brown prior to the emergence as adult. The pupation took place either inside or out side of the flower buds.

Adult: Grey moth with black patch on wings. The adults development was completed and legs and the wings are clearly visible through the pupal skin under microscope.

Damage

- The bud borer webs together flower buds and flowers and reported to cause huge damage ranged from 2-15%.
- The bud borer feeds by making holes into the petals and ovary resulting in significant crop loss.
- Larvae damages inflorescences of the trees

7. Seed Borer:

Bioolgy

Eggs:

- A female moth lays eggs on medium sized immature fruits of sapota with the fecundity of 29 to 255 eggs/female.

Larva: The larvae are very minute, white in colour with pinkish tinge.

- The larvae feed only on endosperm of the seed and complete its larval period inside the seed.
- For pupation, the mature larva comes out by tunneling out the fruit which usually coincides with the fruit harvest.
-

Damage symptoms

The seed borer is a monophagous pest attacking immature fruits of sapota. A neonate larva bore into the fruit and finally enters the seed. The larvae feed only on endosperm of the seed . Full grown larvae prepare a tunnel to come out for pupation. Due to the infestation of the pest quality of the fruit deteriorates and hence the market price goes down.

Natural Enemies of Sapota Insect Pests

Parasitoids




1. *Coccophagus cowperi* 2.Parasitic wasp 3. *F. arisanus* 4. *Diachasmimorpha kraussi*

1. http://www2.hawaii.edu/~messing/projects.htm
2. https://www.spc.int/pacifly/Control/Biocontrol.htm
3. https://uribotanicalgardens.wordpress.com/tag/biocontrol/

Predators




1. *Cryptolaemus montrouzieri* 2. Hover flies 3. Ladybird bettle 4. *Geocoris* sp

5. Lacewing (mirid bug) **6. Lady beetle** **7. Big-eyed bugs**

1. http://www.macro-world.cz/image.php?id_foto=514&gal=29
2. http://ucanr.edu/blogs/bugsquad/index.cfm?tagname=hover%20flies
3. http://llladybug.blogspot.in/
4. http://commons.wikimedia.org/wiki/File:Geocoris_punctipes.jpg
5. http://www.nbaii.res.in/Featured_insects/Coccophagus-cowperi.php
6. http://bugguide.net/node/view/175277

VIII. DESCRIPTION OF DISEASES

1.Leaf spot:

Disease symptom:

- Numerous, small, circular, pinkish to reddish brown, conspicuous spots with whitish center on mature leaves
- Spots coalesce and leaves drop prematurely

http://www.agritech.tnau.ac.in/crop_protection/crop_prot_crop%20diseases_fruits_sapota.html

2. Sooty mould :

Disease symptom:

1. It is a fungal disease developed on honeydew-like excretion secreted by aphids and scale insects.
2. The fungus slowly covers the entire leaf area severely affecting the process of photosynthesis.
3. This results in reduced translocation of food to the fruits, which leads to reduction in their size.

http://www.agritech.tnau.ac.in/crop_protection/crop_prot_crop%20diseases_fruits_sapota.html

3. Fasiation:

Disease symptom:

- Branches of affected trees become flat and twisted
- Leaves become thin, small and yellow
- Cluster of leaves and flowers on affected twigs
- Flowers remain infertile
- If fruits are set, they are undersized, hard and fail to ripen

4. Postharvest Diseases:

1. Soft rot –*Pestalotiopsis mangiferae*

Disease symptoms:

- The diseases appear as water-soaked spots covering the entire fruit within 3 to 4 days.
- Rotted fruits become soft and dark brown and later numerous acervuli are seen in rotted zones.
- The fungal colonies are yellowish white.
- Mycelium is branched & septate.
- Acervuli are black, globose to sub-globose
- Conidiophores are short and simple
- Conidia are fusiform, 4-septata.
- Middle three cells are dark brown.
- End cells are hyaline and pointed.
- Apical cell is with 1 to 3 hyaline setulae.

2. Fruit rots:

Disease symptoms:

- Diseased fruits exhibited water-soaked lesions which become brown within 2 to 3 days. Subsequently the whole fruit is covered with tufts of mycelium

IX. SAFETY MEASURES

A. At the time of pre-harvest:

Harvest when:

- The brown scaly external material from the fruit sheds off.
- Fruit becomes corky brown in color.
- Latex does not flow when the fruit is scratched with the finger nail.

Harvesting:

- Harvest with the use of appropriate harvesting tools.
- Detached fruits must not be allowed to fall to the ground.

B. During postharvest storage:

- Fruit must be carefully handled in order to prevent bruising and wounding.
- Harvested fruit must not be exposed to direct sunlight, but should be kept under shade.

- Harvested fruit must be collected in clean and dry plastic crates.
- Defective fruits, i.e., those that are diseased, mechanically damaged and not marketable must be separated out.
- Fruits must be cleaned by wiping or brushing. They must not be immersed in water as the corky fruit peel can retain moisture.
- Fruits must be transported during the cooler part of the day, in well ventilated plastic crates under clean and dry conditions.
- Wetting of fruit during transportation must be avoided.
- Fruit must be transported as quickly as possible to the final destination, to prevent spoilage.
- Fruit destined for export must be packed in cardboard cartons lined with shredded paper to protect against injury.

Storage

- Ambient conditions. For temporary storage under ambient conditions, fruit must be stored in a cool, dry place with adequate ventilation.
- Cool storage. The naseberry/sapodilla can be transported and stored at 13–15 °C and a relative humidity 85–90%

http://www.fao.org/fileadmin/user_upload/ags/publications/exotic_fruit_book_web.pdf

X. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The orchard should be kept exposed to sun light at least for 2-3 weeks.	Do not plant or irrigate the orchard after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Plant only recommended varieties.	Do not plant varieties not suitable for the season or the region.
3.	Always treat the seeds with approved chemicals/biopesticides for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with biopesticides/chemicals.
4.	Plant in rows at optimum depths under proper moisture conditions for better establishment.	Do not plant seeds/seedlings beyond 5-7 cm depth.
5.	Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
6.	Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition	Crops should not be exposed to moisture deficit stress at their critical growth stages.
7.	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.

8.	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
9.	Conduct AESA weekly in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.	Do not take any management decision without considering AESA and P: D ratio
10.	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.
11.	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, scales, thrips, etc.	Do not spray pesticides only on the upper surface of leaves.
12.	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
13	Follow the recommended procedure of trap or border crops technology.	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.

XI. BASIC PRECAUTIONS IN PESTICIDES USAGE

A. Purchase

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

B. Storage

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

C. Handling

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

D. Precautions for preparing spray solution

1. Use clean water.
2. Always protect your nose, eyes, mouth, ears and hands.
3. Use hand gloves, face mask and cover your head with cap.
4. Use polythene bags as hand gloves, handkerchiefs or piece of clean cloth as mask and a cap or towel to cover the head (Do not use polythene bag contaminated with pesticides).
5. Read the label on the container before preparing spray solution.
6. Prepare the spray solution as per requirement

7. **Do not** mix granules with water; **Do not** eat, drink, smoke or chew while preparing solution.
8. Concentrated pesticides must not fall on hands etc while opening sealed container. Do not smell pesticides.
9. Avoid spilling of pesticides while filling the sprayer tank.
10. The operator should protect his bare feet and hands with polythene bags

E. Equipments

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

F. Precautions for applying pesticides

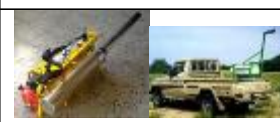
1. Apply only at recommended dose and dilution
2. **Do not** apply on hot sunny day or strong windy condition; **Do not** apply just before the rains and after the rains; **Do not** apply against the windy direction.
3. Emulsifiable concentrate formulations should not be used for spraying with battery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

G. Disposal

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

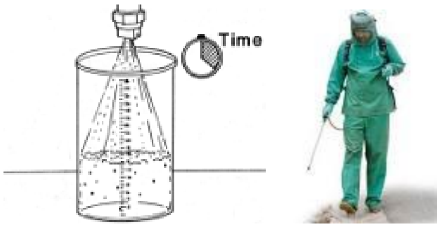
XII. PESTICIDE APPLICATION TECHNIQUES

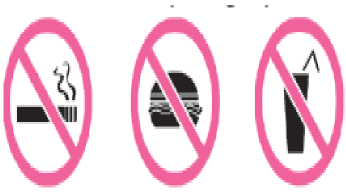
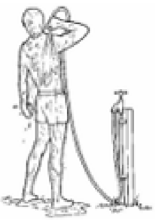
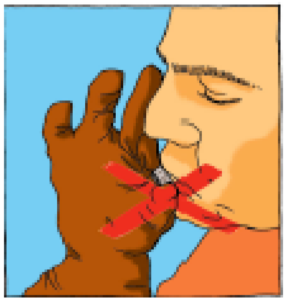
		Equipment	
Category A: Stationary, crawling pest/ disease			
Vegetative stage i) for crawling and soil borne pests ii) for small	Insecticides and fungicides	• Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min ***or*** • Motorized knapsack sprayer or mist blower (Droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle	 

sucking leaf borne pests			
Reproductive stage	Insecticides and fungicides	• Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min	
Category B: Orchard Flying pest/ airborne pest			
Vegetative stage Reproductive stage *(Orchard Pests)*	Insecticides and fungicides	• Motorized knapsack sprayer or mist blower (Droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle ***Or*** • Battery operated low volume sprayer (Droplets of small size) Spinning disc nozzle	 
Mosquito/ locust and spatial application *(migratory* Pests)	Insecticides and fungicides	• Fogging machine and ENV (Exhaust nozzle vehicle) (Droplets of very small size) • Hot tube nozzle	
Category C: Weeds			
Post-emergence application	Weedicide	• Lever operated knapsack sprayer (Droplets of big size) • Flat fan or floodjet nozzle @ 15 to 20 psi • Lever operating speed = 7 to 10 strokes/min	 

Pre-emergence application	Weedicide	• Trolley mounted low volume sprayer (Droplets of small size) • Battery operated low volume sprayer (Droplets of small size)	  

XIII. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

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

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

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