सत्यमेव जयते

AESA BASED IPM PACKAGE

Custard Apple

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

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Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

The AESA based IPM – Custard apple (*Annona squamosa* 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 (AESA) based IPM strategies. The AESA based IPM focuses on the relationship among various components of an agro-ecosystem with special focus on pest-defender dynamics, innate abilities of plant to compensate for the damages caused by the pests and the influence of abiotic factors on pest buildup. In addition, Ecological Engineering for pest management - a new paradigm to enhance the natural enemies of pests in an agro-ecosystem is being considered as an important strategy.The ecological approach stresses the need for relying on bio intensive strategies prior to use of chemical pesticides.

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

A 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)

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AESA BASED IPM PACKAGE FOR CUSTARD

APPLE Custard apple plant description:

Custard apple (*Annona squamosa* L.) can be called as a delicacy of dry region due to its very sweet delicate flesh. It is a deciduous or semi deciduous tall woody shrub of about 5-6 meters height having irregularly spreading branches. The fruits are rich in carbohydrate mainly in the form of sugar (23.5%), protein (1.6%), calcium (17mg/100g), phosphorus (47mg/100g) and iron (1.5mg/100g). The custard apple of India the sitaphal or sugar apple of sweet sop has many relatives. It is one of the finest fruits introduced in India from tropical America and found in wild form in many parts of the country. It is common in China, Phillippines, Egypt and Central Africa.

Fruits are dark greening brown in colour and marked with depressions giving it a quilted appearance; its pulp is reddish yellow, sweetish, and very soft (hence the common name); the kernels of the seeds are said to be poisonous.

Custard apple growing regions in India include Assam, Bihar, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, and Uttar Pradesh, Andhra Pradesh, Telangana and Tamil Nadu. Approximately 55,000 hectares are dedicated to custard apple cultivation. Along with Maharashtra, Gujarat is another large custard apple growing state. The fruit tolerates a variety of conditions, from saline soils to droughts. In fact, farmers usually cultivate the fruits on hills in barren lands. Erratic rains will, however, impede fruit quality.

Annona fruits grow well throughout the plains of India at elevations not exceeding 4,000 ft. It prefers a tropical climate, but with cool winters. The fruit tolerates a variety of conditions, from saline soils to droughts. Farmers usually cultivate the fruits on hills in barren lands. Erratic rains will, however, impede fruit quality. The tree displays yellow trumpet shaped flowers that emit a pleasant sweet smell, with only a small number of flowers setting fruit. The fruits are variable in shape with the outer being covered in rounded knobs, with the inside containing a custard like flesh.

I. PESTS

A. Pests of National Significance:

1. Insect pests

- **1.1 Mealy bug: *Ferrisia virgata* Cockerell (Hemiptera: Pseudococcidae)**
- **1.2 Fruit fly: *Bactrocera* spp*, B. zonata* Saunders (Diptera: Tephritidae)**
- **1.3 Scales: *Ceroplastes floridensis* Comstock (Hemiptera: Coccidae)**
- ***1.4* Fruit boring caterpillar: *Heterographis bengalella* Ragonot (Syn: *Anonaepestis bengalella)* (Lepidoptera: *Pyralidae)***

2. Diseases

- **2.1 Fruit rot & Anthracnose: *Colletotrichum gloeosporioides* (Penz.) Penz. and Sacc. (Perfect stage *Glomerella cingulata* (Stoneman) Spauld. & H. Schrenk**
- **2.2 *Alternaria* leaf spot: *Alternaria* spp.**
- **2.3 *Cylindrocladium* leaf spot: *Cylindrocladium colhounii* and *Cylindrocladium scoparium***
- **3.4 *Diplodia* rot: *Botryodiplodia theobromae* Patouillard**
- **3.5 Black canker: *Phomopsis annonacearum* (Bond) Mont.**

3. Nematodes

- **3.1 Spiral nematode: *Helicotylenchus* spp.**
- **3.2 Stint nematode: *Tylenchorhynchus* spp.**

4. Weeds

Grasses

- **4.1 Bermuda grass: *Cynodon dactylon* (L.) Pers. Poaceae**
- **4.2 Annual brachiaria: *Brachiaria deflexa* (Schumach.) Robyns Poaceae**
- **4.3 Viper grass: *Dinebra retroflexa* (Vahl.) Panzer. Poaceae**
- **4.4 Dropseed: *Sporobolus diandrus* (Retz.) P. Beauv., Poaceae**

Broadleaf

- **4.5 Horse purslane: *Trianthema portulacastrum* L. Aizoaceae**
- **4.6 Black nightshade: *Solanum nigrum* L. Solanaceae**
- **4.7 False amaranth: *Digera arvensis* Forssk. Amaranthaceae**
- **4.8 Puncture vine: *Tribulus terrestris* L. Zygophyllaceae**
- **4.9 Common cocklebur: *Xanthium strumarium* L. Asteraceae**
- **4.10 Asthma herb/Spurge: *Euphorbia hirta/geniculate* L. Euphorbiaceae**
- **4.11 Carrot grass: *Parthenium hysterophorus* L. Asteraceae**
- **4.12 Stone breaker: *Phyllanthus niruri* L. Euphorbiaceae**
- **4.13 Sensitive plant: *Mimosa pudica* L. Fabaceae**
- **4.14 Broadleaf woodsorrel: *Oxalis latifolia* Kunth Oxalidaceae**
- **4.15 Common Purslane: *Portulaca oleracea* Portulacaceae**

Sedges

- **4.16 Purple nut sedge: *Cyperus rotundus* L. Cypraceae**

5. Rodents

- **5.1 Soft furred field rat: *Millardia meltada* Gray**
- **5.2 Indian mole rats/Smaller: *Bandicoota bengalensis* Gray**
- **5.3 Common house rat: *Rattus rattus* Linn**
- **5.4. Bats**

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 field regularly (climatic factors, soil and biotic factors)

Farmers should

- Monitor the field situation of the orchrad 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

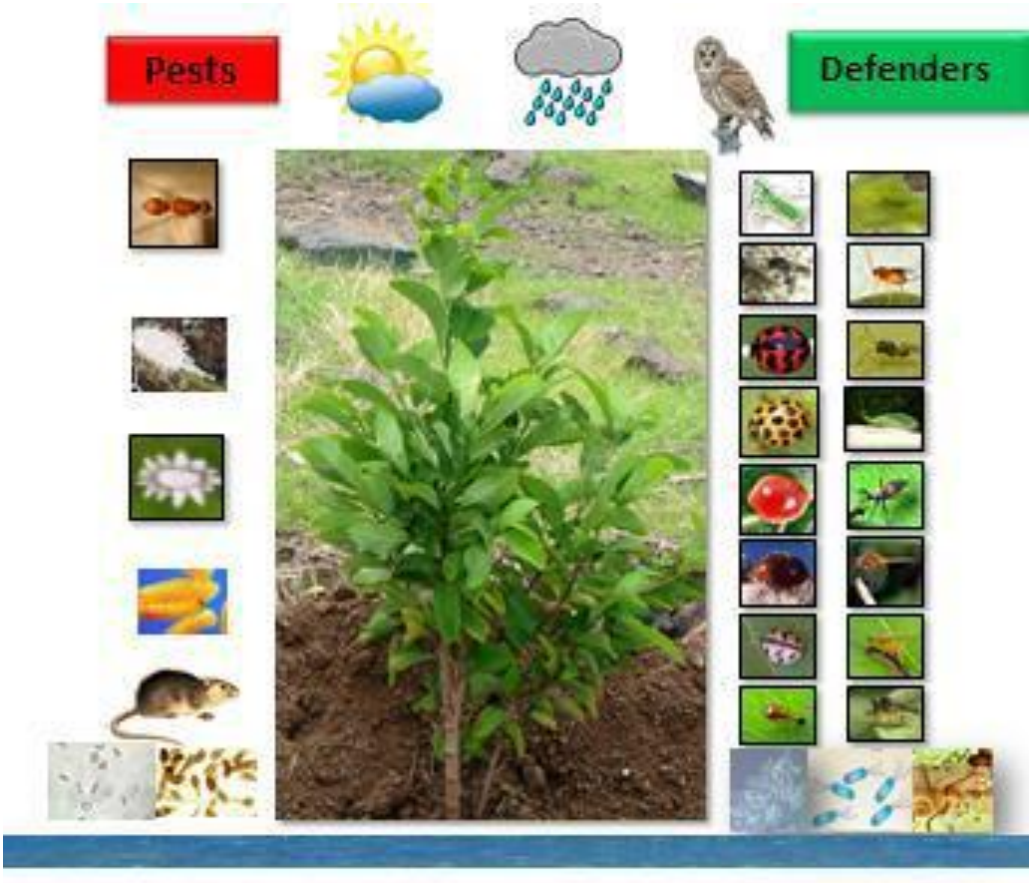
In field various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in crop field. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial 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 custard apple pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens. The important natural enemies of custard apple insect pests are given in ecological engineering table on page …..

Model Agro-Ecosystem Analysis Chart

Date:
Village:
Farmer:



Decision taken based on the analysis of field situations

Soil conditions :

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

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. 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 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 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

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

Data to be recorded

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

Some questions that can be used during the discussion

- Summarize the present situation of the 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 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.

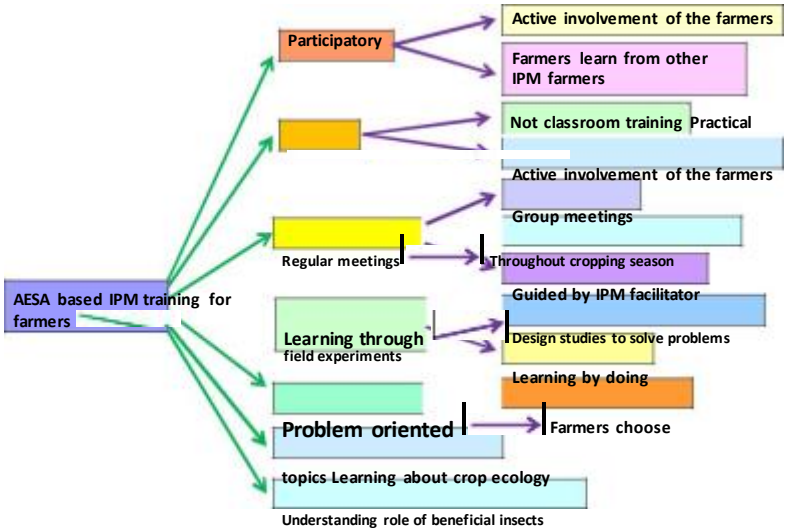
AESA and farmer field school (FFS)

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 build up
- 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:

Fruit borer, scale and mealy bug: population should be counted on three leaves (top and middle portion) of new shoot at 5 sites randomly in each tree. During Fruiting stage population can be counted on fruits on the three top and three middle branches.

Fruit fly: select five apical twigs per tree, each from top, middle and bottom portion randomly and record number of larvae per twig. During Fruiting stage population can be counted on fruits on the three top and three middle branches.

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 capsule should be split or taken apart and examined for discoloration caused by fungi and bacteria. Count the number of stems, flowers and fruit infected due to disease and percent disease incidence should be recorded.

C. Surveillance through pheromone trap catches for fruit boring caterpillar:

Pheromone traps for insect viz., fruit boring caterpillar @ 4-5/acre have to be installed, if available. Install the traps for each species separated by a distance of >75 feet in the vicinity of the selected field. Fix the traps to the supporting pole at a height of one foot above the plant canopy. Change of lures should be made at 2-3 week interval (regular interval). During each week of surveillance, the number of moths/trap/week should be counted and recorded year round. The trapped moths should be removed and destroyed after each recording.

Procedure for observation: Total number of moths of fruit boring caterpillar / trap/week should be recorded. The trapped moths should be destroyed and removed after each recording.

D. Light traps:

Set up light traps 1 trap/acre 15 cm above the crop canopy for monitoring and mass trapping insects (fruit fly). 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).

E. Nematode sampling

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

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

Ecological engineering for pest management has recently emerged as a paradigm for considering pest management approaches that rely on the use of cultural techniques to effect habitat manipulation and to enhance biological control. 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

Cluster bean

Cowpea

Carrot

Sunflower

Buckwheat

French bean

Alfalfa

Maize

Mustard

Casor bean

Cosmos

Dandelion

Repellent plants

Marigold

Asparagus

Dahelia

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

Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators

Biodiversity of natural enemies: Spiders

IV. CROP STAGE-WISE IPM

Management	Activity
Pre planting*	
	Common cultural practices: • Timely sowing should be done. • Field sanitation, rogueing • Destroy the alternate host plants • Apply manures and fertilizers as per soil test recommendations
Nutrients	• Pits (50 x 50 x 50cm) are to be dug during summer season and kept open for controlling soil borne pests. • Pits should be filled with a mixture of top soil and farmyard manure in 1:1 ratio a fortnight before planting.
Weeds	• Cultivate the field before planting to destroy existing weeds in the field. • Summer ploughing is helpful in destroying weeds seeds and rhizomes in the soil. • Adopt stale seed bed technique
Resting stages of diseases & pests and nematodes	**Cultural control:** • Dig the planting pit during summer season and keep it open for at least one month. • Soil solarization: Cover the pits with polythene sheet of 45 gauge (0.45 mm) thickness for three weeks before sowing for soil solarization which will help in reducing the soil borne pests. • Apply neem cake @ 2 kg/pit.
Planting*	
	Common cultural practices: • Use healthy, certified and weed free seeds.
Nutrient	• Planting is done in rainy season at a distance of 4m x 4m. • Add *Trichoderma* and Mycorrhiza mixture @ 50 g per pit at the time of planting. • Apply 300 g of fertilizers mixture of Urea, Single super phosphate and muriate of potash in equal proportion are added in each pit.
Weed	• Remove existing weeds in and around the pits at the time of planting. • Mulching with organic or biodegradable material.
Soil borne diseases and nematodes	**Cultural control:** • Make a trench keeping the distance from the main stem as per the plant canopy width and apply neem cake @ 2 kg/ plant/pit.

***** Apply *Trichoderma viride/harzianum* and *Pseudomonas fluorescens* as seed/seedling/planting material, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

Vegetative stages (1-5 years)

<table>
<tr><td></td><td><u>Common cultural practices:</u>
• Destroy crop debris
• Avoid water logging
• Avoid water stress
• Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed
• Custard apple bears flowers on current season growth and very rarely on older branches. The early completion of season is essential for the initiation of new growth. Therefore manual defoliation during the mid-summer is recommended.
<u>Common mechanical practices:</u>
• Use light trap @ 1/acre and operate between 6 pm and 10 pm
• Install pheromone traps @ 4-5/acre for monitoring adult moths activity (replace the lures with fresh lures after every 2-3 weeks)
• Erecting of bird perches @ 20/acre for encouraging predatory birds such as King crow, common mynah etc.
<u>Common biological practices:</u>
• Conserve natural enemies through ecological engineering
• Augmentative release of natural enemies</td></tr>
<tr><td>Nutrient</td><td>Application of manures & fertilizers: (per plant)
The bearing trees of Custard apple should be fertilized as follows
<table><tr><th>2nd to 5th year</th></tr><tr><td>FYM</td><td>20 kg</td></tr><tr><td>N</td><td>400 g</td></tr><tr><td>P</td><td>250 g</td></tr><tr><td>K</td><td>800 g</td></tr></table>• Nitrogen should be applied in the form of FYM and oil cakes each at 25% and the remaining 50% with chemical fertilizers. While P_2O_5 in the form of super phosphate and K_2O in the form of sulphate of potash.
• Manures are applied in 2 to 3 equal doses i.e. first dose in December-January, 2nd done in June-July, 3rd dose in September, Potash application can be reduced if the soil is rich in this nutrient.
• Nitrogen containing fertilizers should be applied in three equal splits in January, July and November months; phosphorus containing fertilizers in two splits in January and July months and Potassium containing fertilizers may be applied as singly dose in January.
• Adopt ring method of fertilizer application.
• A mixture of zinc sulphate 0.5%, manganese sulphate 0.2%, boric acid 0.1%, urea 1% and lime 0.4% has to be sprayed two or three times in a year to control chlorosis in leaves.
• Intercrops: During pre bearing period short growing crops like groundnut, ragi, bajra wheat, pulses and vegetables (except solanaceous crops) can be profitably grown in the inter spaces.
• In the bearing orchards green manure crops like sunhemp, green gram, cowpea etc., are raised and incorporated into the soil during the monsoon period.</td></tr>
</table>

Weeds	• Timely Interculture and hand weeding should be done with hand tools for initial 5 years. • **Mulching:** After weeding and manuring, application of dry-leaf mulch or paddy husk to a thickness of 8 cm in the basin keeps down the weed growth and decreases the number of irrigations, and improves the fruit quality. • In the initial years of planting, intercrops like groundnut, minor millets, linseed and gram should be grown.
Mealy bug	**Cultural control:** • Collect and destroy the mealy bug infested leaves, twigs and fruits. • Flooding of orchard with water in the month of October kill the eggs. • Ploughing of orchard in November. • Avoid plant stresses - healthy plants are much less susceptible to attack **Biological control:** • Release *Cryptolaemous montrouzieri* beetles @ 10/tree or @ 30 larvae/plant twice at 15 days interval. • The Coccinellid *Menochilus (Chilomenes*) sex maculatus (F) is a predator of the nymphs and adults, and the Hymenopterous parasite *Anaysis alcocki* (Ashm.) *Anagyrus dactylopii* and *Aenasius advena* are three parasitoids on mealy bugs. • Release of coccinellid *Scymnus coccivora* @ 10 beetles /tree or @ 30 larvae/plant is a good predator of both nymphs and adults.
Scale insect	**Cultural control:** • Collect and destroy damaged leaves • Apply well rotten sheep manure @ 4 t/ acre in two splits or poultry manure in 2 splits • Control ants and dust which can give the scale a competitive advantage. **Biological control:** • Field release of ladybird beetle. • Spray dormant oil in late winter before spring. • Spray horticultural oil, if needed, year round.
Anthracnose	**Cultural Control:** • Prune dead twigs before flowering, and remove infected fruit and dead leaves regularly. • Leaf and soil analysis should be done to maintain adequate nutrient concentration in plants particularly calcium and nitrogen • Avoid planting susceptible varieties.
Leaf spot(S)	**Cultural control:** • Collect and burn the infected plant parts to minimize the spread of the disease. • Increase air circulation by proper training and pruning.

<table>
<tr><td colspan="2">Flowering and fruiting</td></tr>
<tr><td>Nutrient</td><td>• The bearing trees of Custard apple should be given 250 g N, 125 g P_2O_5, and 125 gK_2O per plant before the commencement of rainy season.
<table>
<tr><td colspan="2">6th year onwards (per plant)</td></tr>
<tr><td>FYM</td><td>30 kg</td></tr>
<tr><td>N</td><td>600 g</td></tr>
<tr><td>P</td><td>500 g</td></tr>
<tr><td>K</td><td>1200 g</td></tr>
</table></td></tr>
<tr><td>Weeds</td><td>• Remove weeds from basins around the trees by hand weeding followed by mulching with organic materials.
• Control weeds between rows by shallow cultivation and grow the cover crops as mentioned in vegetative stage.</td></tr>
<tr><td>Mealy bug</td><td><u>Cultural control:</u>
• Collect and destroy the mealy bug infested leaves, twigs and fruits.
• Flooding of orchard with water in the month of October kill the eggs.
• Ploughing of orchard in November.
• Avoid plant stresses - healthy plants are much less susceptible to attack

<u>Biological control:</u>
• Release Cryptolaemous montrouzieri beetles @ 10/tree or @ 30 larvae/plant twice at 15 days interval.
• The Coccinellid Menochilus (Chilomenes) sex maculatus (F) is a predator of the nymphs and adults, and the Hymenopterous parasite Anaysis alcocki (Ashm.) Anagyrus dactylopii and Aenasius advena are three parasitoids on mealy bugs.
• Release of coccinellid Scymnus coccivora @ 10 beetles /tree or @ 30 larvae/plant is a good predator of both nymphs and adults.</td></tr>
<tr><td>Fruit borer/ Fruit boring caterpillar</td><td><u>Cultural control:</u>
• Collect and destroy affected fruits.
Physical Control:
• Adopt bagging of fruits.
<u>Biological control:</u>
• Use of braconid parasitoids (Apanteles spp.) to parasitize larvae;</td></tr>
<tr><td>Fruit fly</td><td><u>Cultural Control:</u>
• Collect fallen infested fruits and destroy them.
• Provide summer ploughing to expose the pupae.
<u>Physical control:</u>
• Immersion of fruits in hot water (45 to 47°C) for 60 minutes to kill eggs and maggots
• Use 10 traps per acre of methyl eugenol.
<u>Biological control:</u>
• Field release of natural enemies Opius compensates and Spalangia philippines.</td></tr>
<tr><td>Scale insect</td><td><u>Cultural control:</u></td></tr>
</table>

	• Collect infeseted plant parts and destroy them. • Apply well rotten sheep manure @ 10 t/ ha in two splits or poultry manure in 2 splits • Control ants and dust which can give the scale a competitive advantage. **Biological control:** • Field release of *Vadalia* and Australian ladybugs. • Spray dormant oil in late winter before spring.
Anthracnose	**Cultural Control:** • Prune dead twigs before flowering, and regularly remove infected fruit and dead leaves. • Leaf and soil analysis should be done to maintain adequate nutrient concentration in plants particularly calcium and nitrogen • Avoid planting susceptible varieties.
Leaf spot (s)	**Cultural control:** • Collect and burn the infected plant parts to minimize the spread of the disease. • Increase air circulation by proper training and pruning.
	Cultural control: • Mulch under trees to reduce soil splash. • Remove dead twigs and mummified fruit each season. • Prune tree skirts to 50 cm above the ground. • Regularly monitor fruit for infection during the season so that spraying can start before fruit diseases get too severe.
Diplodia rot	**Cultural control:** • Use mulching under trees to reduce soil splash. • Remove dead twigs and mummified fruits. • Maintain proper plant canopy to reduce the high humidity by appropriate pruting and training. Pruin trees 50 cm above the ground.
Black canker	**Cultural control:** • Use mulching under trees to reduce soil splash. • Regularly monitor the diseases and remove dead twigs and mummified fruits. • Follow proper plant canopy by appropriate prunning and training. • Prune trees 50 cm above the ground.
Spiral nematode (*Helicotylenchus* sp.) **Stunt nematode (*Tylenchorhynchus* sp.)**	**Cultural control:** • Fallow, flooding and deep summer ploughing, • Timely planting, manuring and irrigation, • Use cover crops, antagonistic crops, trap crops, • Follow crop rotation • Grow resistant/tolerant varieties **Physical control:** • Practice soil solarization • Phytosanitary measures: Follow International/ Domestic regulatory measures.

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

V. RODENT PEST MANAGEMENT

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

Bats management:

Cultural control:

- Ripening fruits are protected by placing them between empty coconut shells.
- Cloth bags are used to cover and protect ripening fruit.
- Old fishing nets are placed over fruit trees keeping fruit bats from getting access to fruit.

Mechanical control:

- Fishing nets are strung up between trees to trap bats in flight.
- Fishing lines with numerous dangling hooks are strung up around home gardens in order to snare bats.
- Long poles, with fishing lines and hooks, are hung in fruit trees so that the hooks dangle at the periphery of the tree.
- Human effigies are placed in fruit trees scaring off bats.
- Scaring devices, made from tin cans, are hung in trees and are pulled at regular intervals during the night.
- Oil lamps are sometimes burnt in trees to ward off fruit bats.

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/ DISORDERS

Sr. no.	Nutrients	Symptoms

1.	**Iron deficiency** **Cause:** Insufficient iron available to the tree**.** Generally caused by poor root health or over-liming. **Identification notes:** Causes an overall yellowing or whitening of leaves with the veins remaining green. **Treatment:** Apply a foliar spray of iron chelate or soluble ferrous sulphate. **Prevention:** Do annual leaf and soil analyses to monitor nutrient levels. To avoid over-liming, calculate lime or dolomite rates carefully in accordance with soil analysis results. Mulch trees to improve root health.	
2.	**Sulphur deficiency** **Cause:** Insufficient sulphur available to the tree**.** **Identification notes:** Healthy leaf (bottom) for comparison**.** Causes a uniform yellowing of the leaves but the veins do not remain green. Rarely seen in well-managed orchards. **Treatment:** Not serious enough to warrant treatment. **Prevention:** Do annual leaf and soil analyses to monitor nutrient levels. Where deficient, use fertilisers with a higher sulphur content.	
3.	**Manganese deficiency** **Cause:** Insufficient manganese available to the tree**.** Generally caused by high soil pH or high levels of soil phosphorus or zinc. **Identification notes:** Affected leaves are a mottled pale-green, with green veins. Yellowing is more pronounced towards the leaf tips. Rarely seen in well-managed orchards. **Treatment:** Apply foliar spray of manganese sulphate and urea. **Prevention:** Do annual leaf and soil analyses to monitor nutrient levels. Apply manganese to the soil when indicated by leaf and soil analysis results.	
4.	**Magnesium deficiency** **Cause:** Insufficient magnesium available to the tree. Generally results from excessive use of potassium. **Identification notes:** Yellowing occurs in bands on either side of the midrib while the margin of the leaf remains green. A reddish-brown discolouration sometimes develops in the yellow areas. Most common in acid sandy soils. **Treatment:** Do leaf and soil analyses to check soil pH and magnesium levels. Apply dolomite or magnesium oxide (choice depends on pH level). A short-term response can be achieved with a foliar spray of Epsom salts and urea. **Prevention:** Do annual leaf and soil analyses to monitor soil pH and nutrient levels. Apply magnesium to the ground under the trees according to leaf and soil analysis results. Do not apply excessive amounts of	

	potassium fertiliser.	
5.	**Nitrogen deficiency** **Cause:** Insufficient nitrogen available to the tree**.** **Identification notes:** Left: mild symptom showing the pale green leaves. Right: severe symptom where the oldest leaves turn bright yellow and fall prematurely. **Treatment:** Do a leaf analysis to confirm the diagnosis. Adjust the fertiliser program according to the leaf analysis results. **Prevention:** Do annual leaf and soil analyses to monitor nutrient levels. Apply appropriate amounts of nitrogen fertiliser throughout the growing season.	
6.	**Boron deficiency** **Cause:** High uptake of boron from the soil. Generally caused by applying boron unevenly or at high rates. **Identification notes:** Leaves near growing point yellowed, growth bud appear white or brownish dead tissue. **Treatment:** Apply boron at 2.0 g/m2 and broadcast over the ground area under the canopy. Boron and calcium sprays during flowering and early fruit set are beneficial in reducing internal fruit browning. **Prevention:** Do annual leaf and soil analyses to monitor boron levels. Take particular care to apply boron at the correct rates.	
7.	**Potassium deficiency** **Cause:** Insufficient potassium available to the tree**.** Generally caused by an imbalance of potassium, calcium and magnesium in the soil. More common in light soils where heavy leaching occurs and in trees with heavy crop loads. **Identification notes:** Yellowing begins at the margin of the leaf and spreads towards the veins. Small black spots develop within affected areas. **Treatment:** Do a leaf analysis to confirm the diagnosis. Adjust the fertiliser program according to the results. **Prevention:** Do annual leaf and soil analyses to monitor nutrient levels. Apply appropriate amounts of potassium fertiliser throughout the growing season.	
8.	**Boron toxicity** **Cause:** High uptake of boron from the soil. Generally caused by applying boron unevenly or at high rates. **Identification notes:** Note the small brown spots developing inside the burnt margin. **Treatment:** No applicable **Prevention:** Do annual leaf and soil analyses to monitor boron levels. Take particular care to apply boron at the correct rates. Apply boron evenly when spraying it on the ground or applying it by fertigation.	 
9.	**Manganese toxicity**	

	Cause: High uptake of manganese from the soil. Occurs in soils with high manganese levels when pH falls below 5.5 (1:5 water test). **Identification notes:** Affected leaves have an irregular yellow or whitish margin. **Treatment:** Do a leaf analysis to confirm the diagnosis. Apply lime or dolomite to raise soil pH to 6.5 (1:5 water test). **Prevention:** Do annual leaf and soil analyses to monitor nutrient levels. In high manganese soils, maintain soil pH at 6.5 or above (1:5 water test).
	
10.	**Zinc deficiency** **Cause:** Insufficient zinc available to the tree**.** Generally caused by high soil pH or high levels of soil phosphorus. **Identification notes:** Affected leaves are yellow-green with green veins, smaller than usual, narrow and slightly distorted. **Treatment:** Apply zinc to the ground under the tree. In severe cases, also spray chelated zinc onto the spring flush. **Prevention:** Do annual leaf and soil analyses to monitor nutrient levels. Apply zinc to the ground under the trees annually according to leaf and soil analysis results.
	

1. Stone Fruits: **Disorders**
Some fruits instead of attaining full size remain very small and become brown and dry up. These are known as stone fruits which are retained on tree for a long period. Competition among the developing fruits and high temperature are supposed to cause stone fruit formation.
2. Fruit Cracking: Disorders
This usually happens from a heavy rainfall or irrigation after a prolonged dry spell. Evenly distributed irrigation schedule and constant and uniform moisture level in the soil will reduce this

problem.

VIII. COMMON WEEDS

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

2. Purple nut sedge: ***Cyperus rotundus*** **L. Cypraceae**

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

4. Horse purslane: ***Trianthema portulacastrum*** **L. Aizoaceae**

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

6.Black nightshade: ***Solanum nigrum*** **L. Solanaceae**

7.Common cocklebur: *Xanthium strumarium* L. Asteraceae

8. False amaranth: *Digera arvense* Forssk. Amaranthaceae

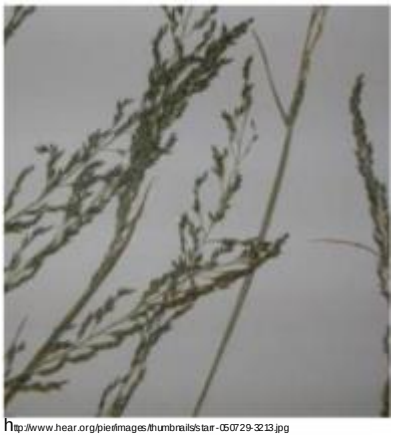
9. Puncture vine: *Tribulus terrestris* L. Zygophyllaceae

10. Asthma herb *Euphorbia: hirta* L. Euphorbiaceae

11. Carrot grass: *Parthenium hysterophorus* L. Asteraceae

12. Stone breaker: *Phyllanthus niruri* L. Euphorbiaceae

13. Sensitive plant: *Mimosa pudica* L. Fabaceae



http://www.hear.org/pier/images/thumbnails/stur-050729-3213.jpg

14. Dropseed: *Sporobolus diandrus* (Retz.) P. Beauv., Poaceae)

https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcTPQkeED3qIARbkc0jNHoSv-0HIK7SDzlFih31TnwiUv-5G5PzF

15. Broadleaf woodsorrel: *Oxalis latifolia* Kunth Oxalidaceae

http://jimbotany.com/Monastery_Plants/Portulaca%20oleracea%20%202012-07-30.jpg

16. Common Purslane:
Portulaca oleracea
Portulacaceae

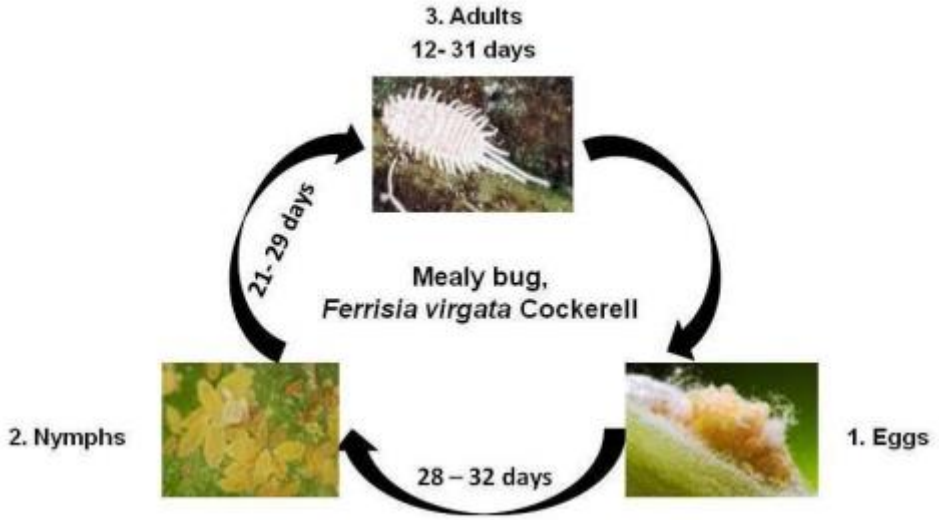
IX. DESCRIPTION OF INSECT PESTS

1. Mealy bug:

Biology:

- **Egg:** The egg period is 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 is 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. It has three to four nymphal instars and 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 12-31days**.**

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.

Infestation of mealy bug on custard apple fruit
http://era.deedi.qld.gov.au/1653/6/5probcus.pdf

Natural enemies of mealybug:

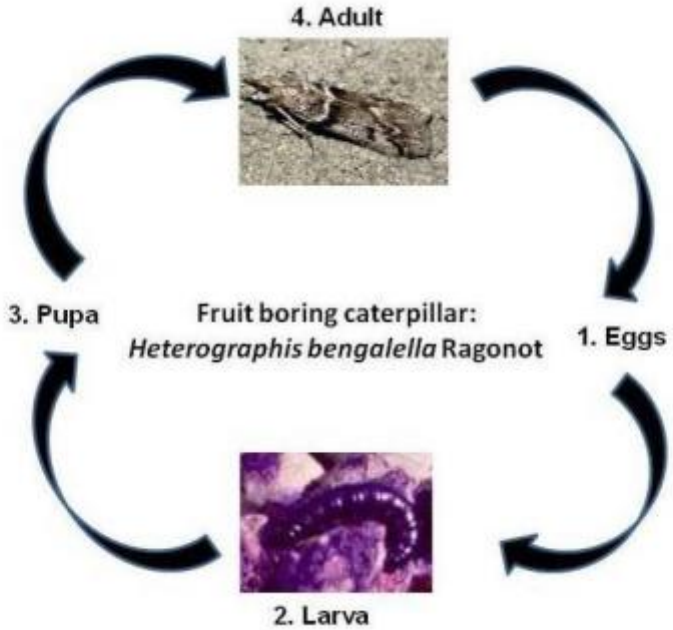
Predators: Ladybird beetle namely *Menochilus sexmaculatus, Rodolia fumida, Cryptolaemus montrouzieri.*

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

2. **Fruit borer/ Fruit boring caterpillar :**

Biology:

- **Eggs** are laid singly on immature fruit. Upon hatching, the caterpillar bore into the fruits where they pupate.
- **Larva:** Fully developed gray to black coloured caterpillars are about 20 mm long.
- **Adult:** Light brown with transparent wing



Damage symptoms:

- Caterpillar makes irregular tunnels and damages the mesocarp by feeding the internal content of the fruits.
- The presence of excreta of the caterpillars near the entry holes on the affected fruits
- The growth of affected fruits are arrested and later fall down.

Larvae feeding on fruits

Natural enemies of fruit boring caterpillar:

Predators: *Chrysoperla zastrowii* Sellimi, coccinellids, king crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, preying mantid, fire ants, big eyed bugs (*Geocoris* sp), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc.

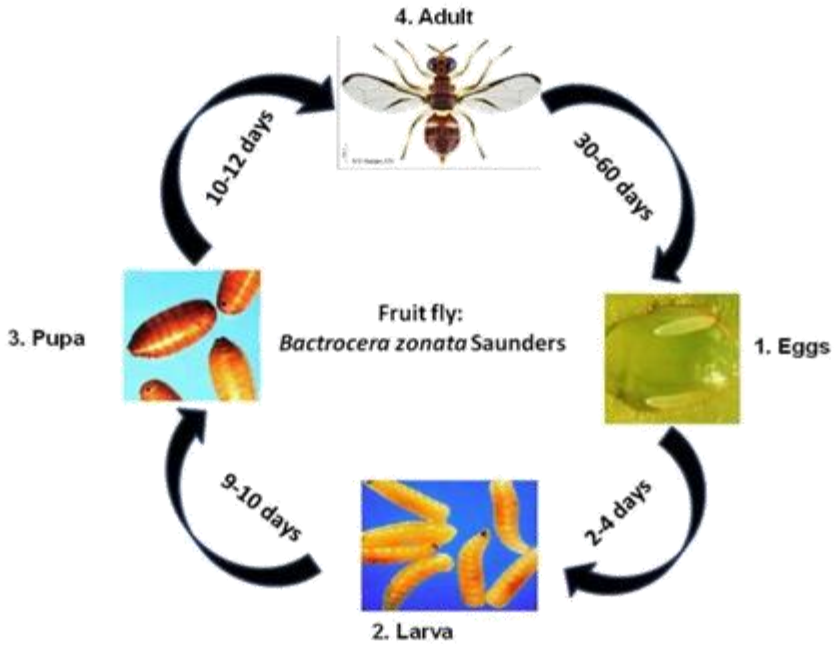
*****For management refer to page number----------

3. Fruit fly*:*

Biology:

- **Egg**: Under optimum conditions, a female can lay more than 3,000 eggs during its 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:

- Maggots bore into the semi ripened fruits and feed on the pulp.
- Affected fruits become shrivelled, deformed, rot and drop.

Natural enemies of fruit flies:

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

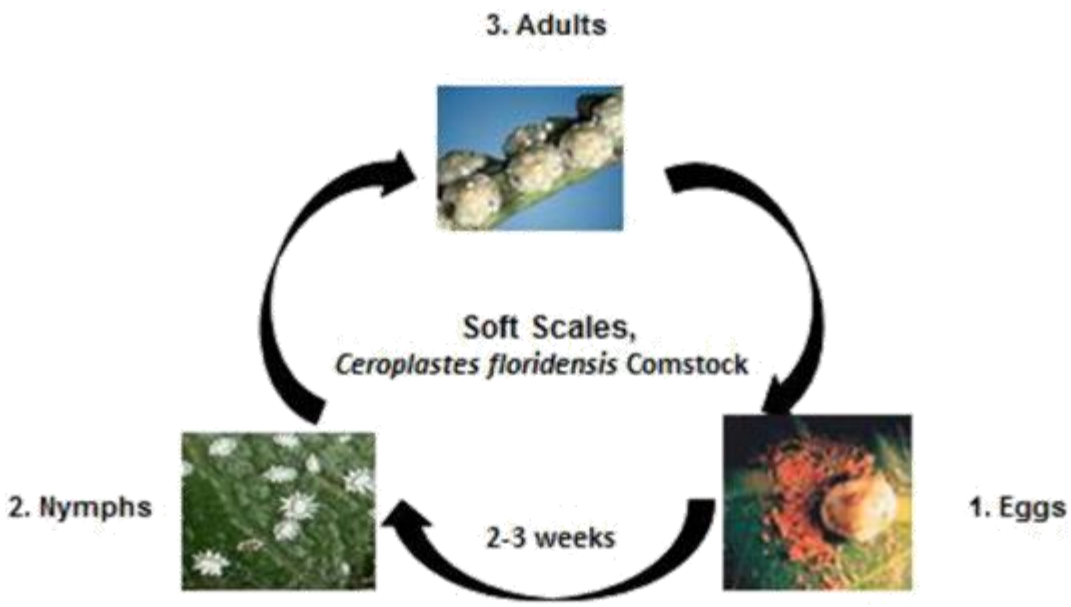
4. Scales:

Biology:

Egg: The eggs are pink to dark red and are laid under the scale's wax covering of adult females. Females lay about 2000 eggs.

Nymph: First stage (instar) nymphs, called crawlers hatch from eggs over a period of 2 to 3 weeks. Immediately after hatching the first instar crawlers come out which are pink in colour. They disperse on the leaves and twigs and find a suitable feeding place to settle. The crawlers undergo three moults and develop into adults. The wax-covering secreted around their body gives them a star-like appearance. Soft scales have 3 or 4 instars in the female and 5 in the male

Adult: The adults are elliptical, reddish brown with short anal process. The adult female is reddish which is coated with a thick layer of pinkish-white wax. Adults are mostly found on twigs and branches. The size of the female is about 2 to 4 mm in length and 1 to 3.5 mm in width. Males are not known in this species. Females have 2 to 3 immature stages without any pupa-like instars while males have 4 immature stages with the two pupa-like instars.



ttp://entnemdept.ufl.edu/creatures/orn/scales/florida_wax_scale.htm

http://edis.ifas.ufl.edu/pdffiles/IN/IN91300.pdf

Damage symptoms:

- The direct damage is caused by insertion of stylets during feeding by the nymphs, which causes premature leaf drop and drying of twigs.
- Sooty mould develops on honeydew excreted by these scale insects and incase of severe infestations shoots or branches die and host's death may also occur.

Natural enemies:

Parasitoids: *Coccophagus lycimnia*, *Metaphycus eruptor* and *Scutellista cynea*

Natural Enemies of Custard apple Insect Pests

Parasitoids

Larval parasitoids

1. *Diachasmimorpha longicaudata*

2. Fopius arisanus

Nymphal and adult parasitoids

3. *Coccophagus lycimnia*

4. Scutellista cynea

1. http://entnemdept.ifas.ufl.edu/creatures/beneficial/d_longicaudata.htm
2. http://www.tephritid.com/digital.php?act=page&pid=28&id=25
3. http://www.entocare.nl/english/products_pulvinaria.htm
4. http://www.nbaii.res.in/Featured_insects/Scutellista-caerulea.php

Predators

1. *Chrysoperla*

2. Coccinellid

3. Reduviid bug

4. Spider

5. Robber fly

6. Fire ant

7. Mirid bug

8. *Scynimus coccivora*

9. Big-eyed bug

10. Earwig

11. Ground beetle

12. Pentatomid bug


13. Preying mantis


14. *Geocoris* spp.


15. *Oligota* spp.


16. *Orius* spp.


17. Hover fly


18.Cryptolaemus


19. Black drongo


20. Common mynah

5. http://www.warpedphotosblog.com/robber-fly-and-prey 6.http://www.couriermail.com.au/news/queensland/queensland-launched-a-war-against-the-fire-ant-invasion-but-12-years-later-they8217re-still-on-the-march/story-fnihsrf2-1226686256021

7. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html
8. http://www.nbaii.res.in/Featured_insects/images/scymnus-coccivora2.jpg
9. http://bugguide.net/node/view/598529
10. http://www.flickr.com/photos/johnhallmen/2901162091/
11.http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/ Ground%20Beetle%20-%20Pterostichus%20madidus.html
12. http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asopinae/ Eocanthecona.htm
13. http://spirit-animals.com/praying-mantis/
14. http://nathistoc.bio.uci.edu/hemipt/Dicyphus.htm
15. http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33
16. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
17. http://nagpurbirds.org/blackdrongo/picture/1639
18. http://biobee.in/wp-content/uploads/2013/01/cryptolimus-400-266.jpg
19 http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
20. http://www.arkive.org/common-myna/acridotheres-tristis/

X. DESCRIPTION OF DISEASES

1. Anthracnose:

Disease symptoms:

- Infection begins at blossom-end of the fruit and later spreads on entire fruit surface, affected fruits shrivel and they may cling to the tree or fall down.
- Necrotic spots of 2-10 mm in diameter appear on unripe fruits which turn into dark brown to black spots. These spots coalesce later and cover entire fruit.

Favourable condition:

- Wet and windy conditions favour the disease

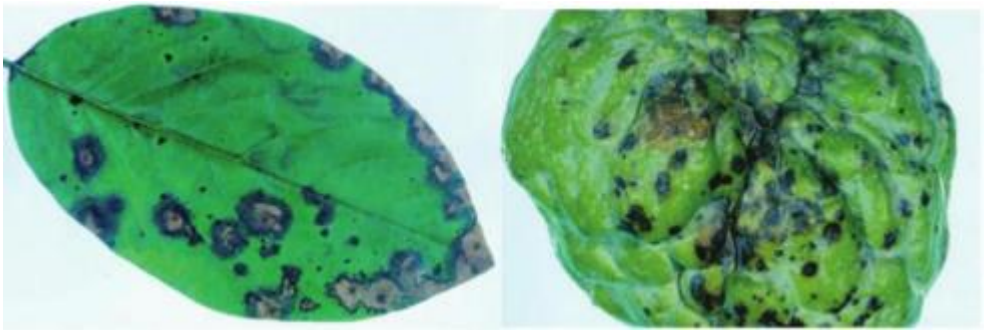
Survival and spread:

- Older fruits left on the trees provide inoculum for disease spread.

2. Leaf spot

Disease symptoms:

- ***Alternaria* leaf spot:** Small yellowish spots first appear along the leaf margins, which gradually enlarge and turn into brownish patches with concentric rings. Severe infection leads to drying and defoliation. Dark brown-purplish patches appear on the infected fruits andrachis just below its attachment with the shoots.
- ***Cylindrocladium* leaf spot:** Upper: dark purple spots about 1 to 2 mm in diameter develop first on the shoulders of the fruit and then spread down the sides. Spots enlarge and then later dry out and crack. Similar in appearance to spotting bug damage, but spots are irregular in shape whereas spotting bug lesions are round, and damage does not extend very far into the fruit



***Cylindrocladium* leaf spot symptoms on leaf and fruit**

Survival and spread:

- The pathogen survives through spores (conidia) or mycelium in diseased plant debris or other hosts. .

Favourable conditions:

- Relative humidity above 70% coupled with warm weather (12-25 ºC temp.) and intermittent rains favours disease.

3. *Diplodia* rot

Disease symptoms:

- Diseased fruits show symptoms of purplish to black spots or blotches confined to the surface of the fruit and eventually covered with white mycelia and black pycnidia.
- *Diplodia* rot is distinguished by its dark internal discolouration and the extensive corky rotting produces.
- The penetrated flesh eventually softens or hardens and cracks, depending on the presence of secondary microbes.

Favourable condition:

- Optimum temperature is 25.9°C to 31.5°C and relative humidity is 80%

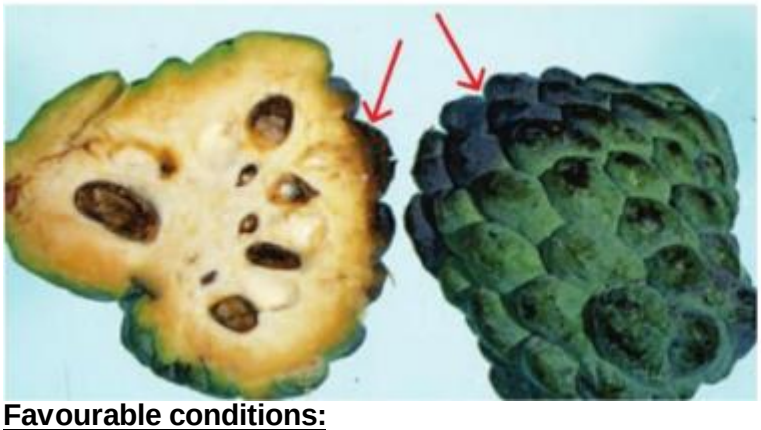
Survival and spread

- The pathogen persists in infected plant parts which serve as source of inoculums.

4. Black canker

Disease symptoms:

- Irregularly shaped spots ranging from small specks to large blotches.
- Spots have an indistinct 'feathered' edge.
- Tissue damage under the spots is no more than 10 mm deep.



Favourable conditions:

- The disease is favored by extremely wet weather and cool-to-moderate temperatures (15ºC to 20ºC). When prolonged rainy periods exist in the spring and provide at least six hours of continuous wetness

Survival and spread

The pathogen persists in infected plant parts which serve as source of inoculums.

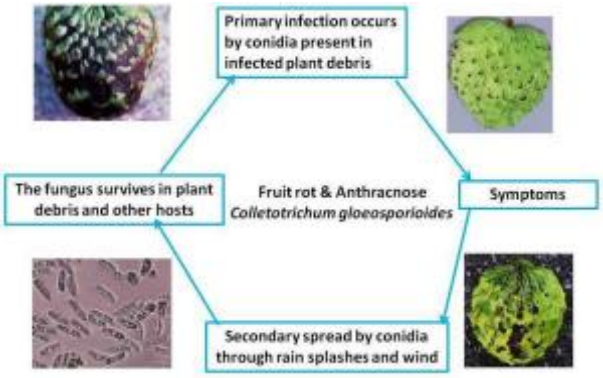
5. Spiral nematode and Stunt nematode:

Life cycle:

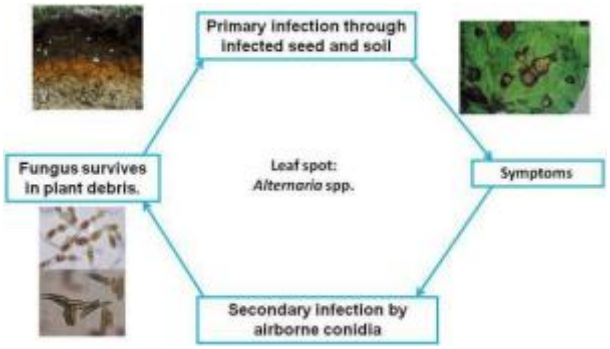
- Nematodes molt four times during each life cycle with a molt occurring at the end of each larval stage.
- Therefore, molts separate the first and second larval stages, the second and third larval stages, the third and fourth larval stages, and also the fourth larval stages and immature adults.
- The 5^{th} stage larva grows to the limit of its new cuticle, at the same time developing into a sexually mature adult male or female.

Disease cycles:

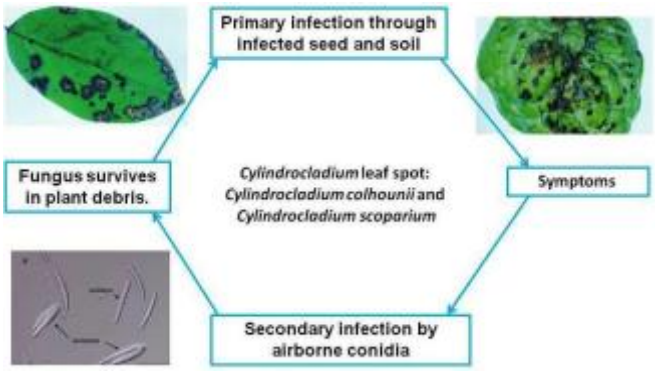
1. Anthracnose:



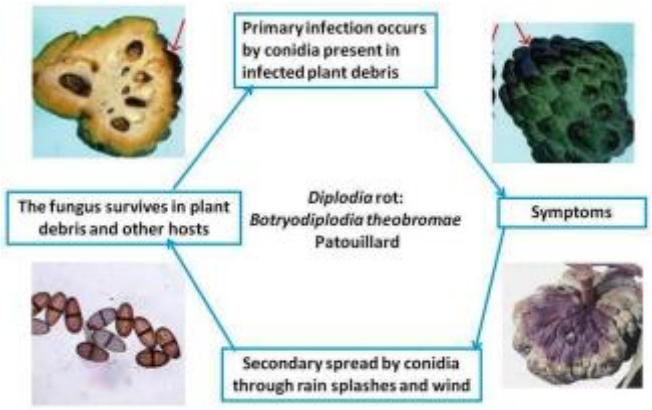
2. Leaf spot:



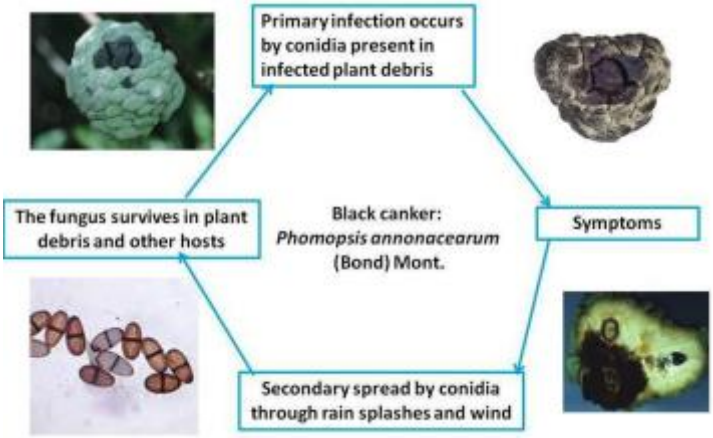
3. *Cylindrocladium* leaf spot:



4. *Diplodia* rot:



5. Black canker:



XI. DESCRIPTION OF RODENT PESTS

1) Lesser bandicoot: *Bandicota bengalensis*

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

2) Field mouse: *Mus booduga*

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

3). Soft furred field rat: *Millardia meltada*

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

5. Indian gerbil:*Tateraindica*

- Distributed throughout the India. Inhabits rain-fed crop fields/ fallow/wastelands
- Medium sized (100-250 g.) with light brownish dorsum and longer tail than head and body
- Earmarked enlarged eyes, rounded ears and bicolour tail with terminal black tuft.
- Nocturnal and fossorial, with semi circular openings in burrows with zigzag shape and 2 to 4 openings and emergency exits.
- Inhabits dry land crop fields, fallow and wastelands in ruderal, sandy, gravel plains habitats.
- Minor pest in rice fields.

XII. SAFETY MEASURES

A. At the time of harvest

Harvest fruits when they have developed full bright color for the variety, but while they are still firm to touch. At this stage, the seeds will be young, white, and tender and the flesh firm and white. As the fruit passes the prime stage for eating and becomes over-mature, the fruit surface becomes dull, the seeds harden and darken, and the flesh becomes spongy. Prompt picking stimulates fruit set and increases yields.

Fruits can be snapped from the plant, but less damage usually occurs if they are clipped with a sharp knife or scissors. A short piece of stem should be left attached to the fruit. Handle the

fruit carefully to avoid damage, wipe it to give a clean, bright appearance. Staking of plants may be necessary to prevent branches touching the ground later in the season as the number and size of the fruits increase. Rain, wind and irrigation can cause the branches to break or droop. Avoid fruit touching the ground as it may spoil the fruit.

B. Post-harvest storage

Brinjal fruits loose water and quality quickly at warm temperature after harvest. Ideal would be to store fruits in a cool space (7 to 13 °C and a relative humidity of 90-95%). In some countries, eggplant fruits are wrapped in plastic shrink film to reduce weight loss and maintain firmness, due to the high relative humidity. However, wrapped fruits decay rapidly if the film is not perforated. It is obvious that this practice is very expensive and is only worth it if high prices are fetched in the market.

XIII. 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.

XIV. 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

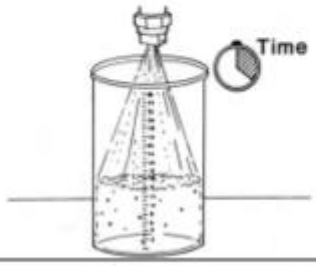
1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

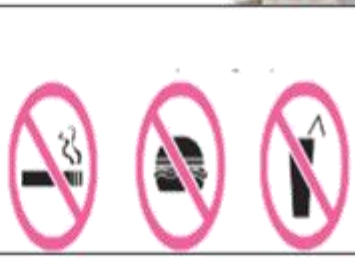
XV. PESTICIDE APPLICATION TECHNIQUES

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

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

XVI. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

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

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

XVII. REFERENCES:

- http://1.bp.blogspot.com/-GN506DZJMd0/UBiAdTmZF8I/AAAAAAAAAUA/x7ZJrmMWf18/s1600/custard.JPG
- http://www.agritech.tnau.ac.in/horticulture/horti_fruits_custardapple.html
- http://www.crec.ifas.ufl.edu/extension/greening/ndccg.shtml#Calcium
- http://nhb.gov.in/report_files/orange/ORANGE.htm
- http://aphorticulture.nic.in/
- https://edis.ifas.ufl.edu/LyraEDISServlet?command=getScreenImage&oid=13466353
- https://www.inaturalist.org/taxa/169291-Sporobolus-diander
- http://www.hear.org/pier/images/thumbnails/starr-050729-3213.jpg
- http://www.uoguelph.ca/~gbarron/MISCELLANEOUS/altern3.jpg
- http://www.caes.uga.edu/applications/publications/files/html/B1336/images/image04.jpg
- http://www.cropsforthefuture.org/publication/Manuals/Annona%20extension%20manual.pdf
- http://www.daff.qld.gov.au/plants/fruit-and-vegetables/a-z-list-of-horticultural-diseases-and-disorders/anthracnose
- http://www.hear.org/pier/images/thumbnails/starr-050729-3213.jpg
- http://ucce.ucdavis.edu/files/repository/calag/img6204p167b.jpg
- http://era.deedi.qld.gov.au/1653/6/5probcus.pdf
- http://www.organicgardeninfo.com/images/mealybug-destroyer.jpg

- http://www.nbaii.res.in/Featured_insects/images/rodolia-fumida2.jpg
- http://m4.i.pbase.com/g5/98/670198/2/67511694.sm3rvt0l.jpg
- http://baba-insects.blogspot.in/2012/02/telenomus.html
- http://www.nbaii.res.in/Featured%20insects/chelonus.htm
- http://spirit-animals.com/praying-mantis/
- http://en.wikipedia.org/wiki/Dragonfly
- http://www.warpedphotosblog.com/robber-fly-and-prey http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
- http://somethingscrawlinginmyhair.com/2011/09/17/yellowjacket-with-prey/
- http://books.google.co.in/books?id=pXRVKymuLqEC&pg=PA124&lpg=PA124&dq=life+cycle+of+Heterographis+bengalella&source=bl&ots=zRk7I2wrVY&sig=WCweUeF-oBgEKjHQg3IISabGUMc&hl=en&sa=X&ei=Q2NGU7nCEsGzrgfNkIAw&ved=0CCcQ6AEwAA#v=onepage&q=life%20cycle%20of%20Heterographis%20bengalella&f=false
- http://agritech.tnau.ac.in/crop_protection/custard%20apple%20images
- http://pikul.lib.ku.ac.th/insect/007-013%20INSECTS%20of%20Thailand/012%20Thai%20Insect%20Families/Pyralidae/Annodiella%20bengalella%20L.jpg
- http://pikul.lib.ku.ac.th/insect/007-013%20INSECTS%20of%20Thailand/012%20Thai%20Insect%20Families/Pyralidae/Anonaepestis%20bengalella%20S.jpg
- http://pikul.lib.ku.ac.th/insect/007-013%20INSECTS%20of%20Thailand/012%20Thai%20Insect%20Families/Pyralidae/
- http://m.russellipm-agriculture.com/insects/bactrocera-zonata-biology
- http://www.acgov.org/cda/awm/agprograms/images/pfflarge.jpg
- http://www.alexanderwild.com/Ants/Natural-History/Soldier-Ants/i-fRW7mWk/1/L/megacephala1-L.jpg
- http://1.bp.blogspot.com/-uxgBrHLvE20/Uy27N4ymqII/AAAAAAAAA7o/d1fvDIBid4U/s1600/D_longicaudatus_side_FB_IMG_1412.tif
- http://ucce.ucdavis.edu/files/repository/calag/img6501p21.jpg
- http://edis.ifas.ufl.edu/pdffiles/IN/IN91300.pdf
- http://www.ento.csiro.au/biology/ladybirds/layout_images/frontCover.jpg
- http://tnau.ac.in/eagri/eagri50/HORT181/lec18.pdf
- http://books.google.co.in/books?id=GepY5GLJjHIC&pg=PA125&lpg=PA125&dq=anthracnose+of+custard+apple&source=bl&ots=Mj8sKm9qRI&sig=5wfXA8XF_n4_Ax0Tojc8jtMBNN0&hl=en&sa=X&ei=lzRGU4C9BseHrQevtYG4Cw&ved=0CGwQ6AEwDQ#v=onepage&q=anthracnose%20of%20custard%20apple&f=false
- http://www.diark.org/img/species_pict/large/Glomerella_cingulata/
- http://www.britannica.com/EBchecked/topic/147387/custard-apple
- http://www.indiaagronet.com/indiaagronet/horticulture/CONTENTS/custard_apple.htm
- http://www.dinofert.com.au/technical-information/plant-nutrition-guide/item/13-custard-apple
- http://www.cropsforthefuture.org/publication/Manuals/Annona%20extension%20manual.pdf
- http://www.agriculturesnetwork.org/magazines/global/rejuvenate-local-knowledge/rats-bats-and-traps-indigenous-methods-of
- http://era.deedi.qld.gov.au/1653/6/5probcus.pdf
- http://www.daff.qld.gov.au/plants/fruit-and-vegetables/a-z-list-of-horticultural-diseases-and-disorders/anthracnose
- http://www.cropsforthefuture.org/publication/books-and-reports/Control%20of%20Post%20Harves%20Disease%20(Botryodiplodia%20sp.)%20of%20Rambutan%20and%20Annona%20Species.pdf
- http://books.google.co.in/books?id=GepY5GLJjHIC&pg=PA125&lpg=PA125&dq=black+canker+of+custard+apple&source=bl&ots=Mk0IQs4hWN&sig=R5u1Ic1HCVm3-o6SMMlcz1kxILM&hl=en&sa=X&ei=IY0WVPqwM4-OuAS91YCgDw&ved=0CC4Q6AEwAw#v=onepage&q&f=true