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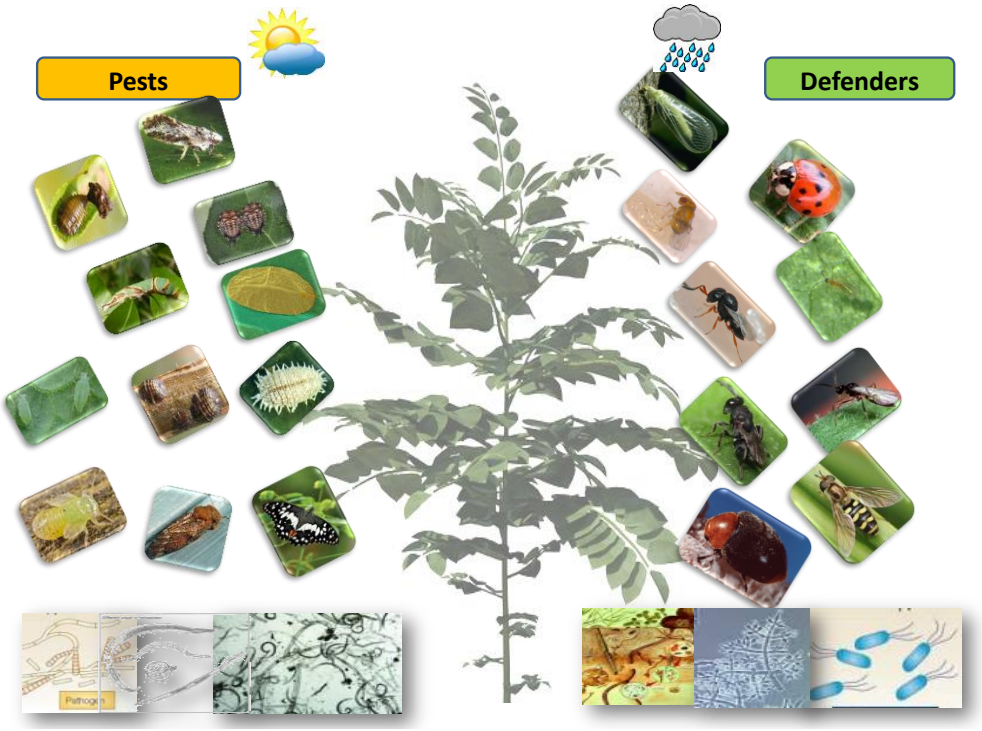
AESA BASED IPM Package No.78

AESA based IPM – Curry Leaf



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The AESA based IPM – Curry Leaf, was compiled by the NIPHM working group under the Chairmanship of Dr. K. Satyagopal DG, NIPHM, and guidance of Shri. Utpal Kumar Singh 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.

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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IPM Package for Curry Leaf

I. Pests

A. Pests of National Significance

1. Insect pests

1.1 Citrus butterfly: *Papilio demoleus,* (Esper, 1798) *P. polytes polytes,* (Linnaeus, 1758) (Lepidoptera: Papilionidae)

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

1.3 Scales: *Unaspis citri* (Comstock) (Hemiptera: Coccoidea: Diaspididae)

1.4 Mealy bugs: *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae)

1.5 Aphids: *Toxoptera aurantii* (Boyer de Fonscolombe) (Hemiptera: Aphididae)

1.6 Tortoise beetle: *Silana farinose* (Boheman) (Coleoptera: Chrysomelidae: Cassidinae)

1.7 Two spotted mites: *Tetranychus* spp. Koch (Acarina: Tetranychidae)

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

2. Diseases

2.1 Leaf spot (*Phyllosticta* leaf spot)

3. Major weeds

Broadleaf weeds

3.1.1 Pigweed: *Amaranthus viridis* Hook. F.

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3.1.3 Black nightshade: *Solanum nigrum* L.

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3.1.5 False amaranth: *Digera arvensis* Forssk.

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3.1.7 Scarlet Pimpernel: *Anagallis arvensis* L.

3.1.8 Sweet clover: *Melilotus indica* (L.) All.

3.1.9 Fine leaf fumitory: *Fumaria parviflora* Lam.

3.1.10 Corn spurry: *Spergula arvensis* L.

Grassy weeds

3.1.11 Rabbit/Crow foot grass: *Dactyloctenium aegyptium* (L.) Beauv.

3.1.12 Crabgrass: *Digiteria sanguinalis* (L.) Willd.

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3.1.14 Blue grass: *Poa annua* L.

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Sedges

3.1.16 Purple nutsedge: *Cyperus rotundus* L.

3.1.17 Flat sedge: *Cyperus iria* L.

II AESA based IPM

A. Agro-ecosystem analysis

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, wind, rain, and sunshine hours) 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 paper (60 x 80 cm), to include all their observations. The advantage of using a drawing is that it forces 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 Integrated Pest Management (IPM):

Grow a healthy crop

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

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

Farmers should

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

Plant compensation ability

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

Understand and conserve defenders

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

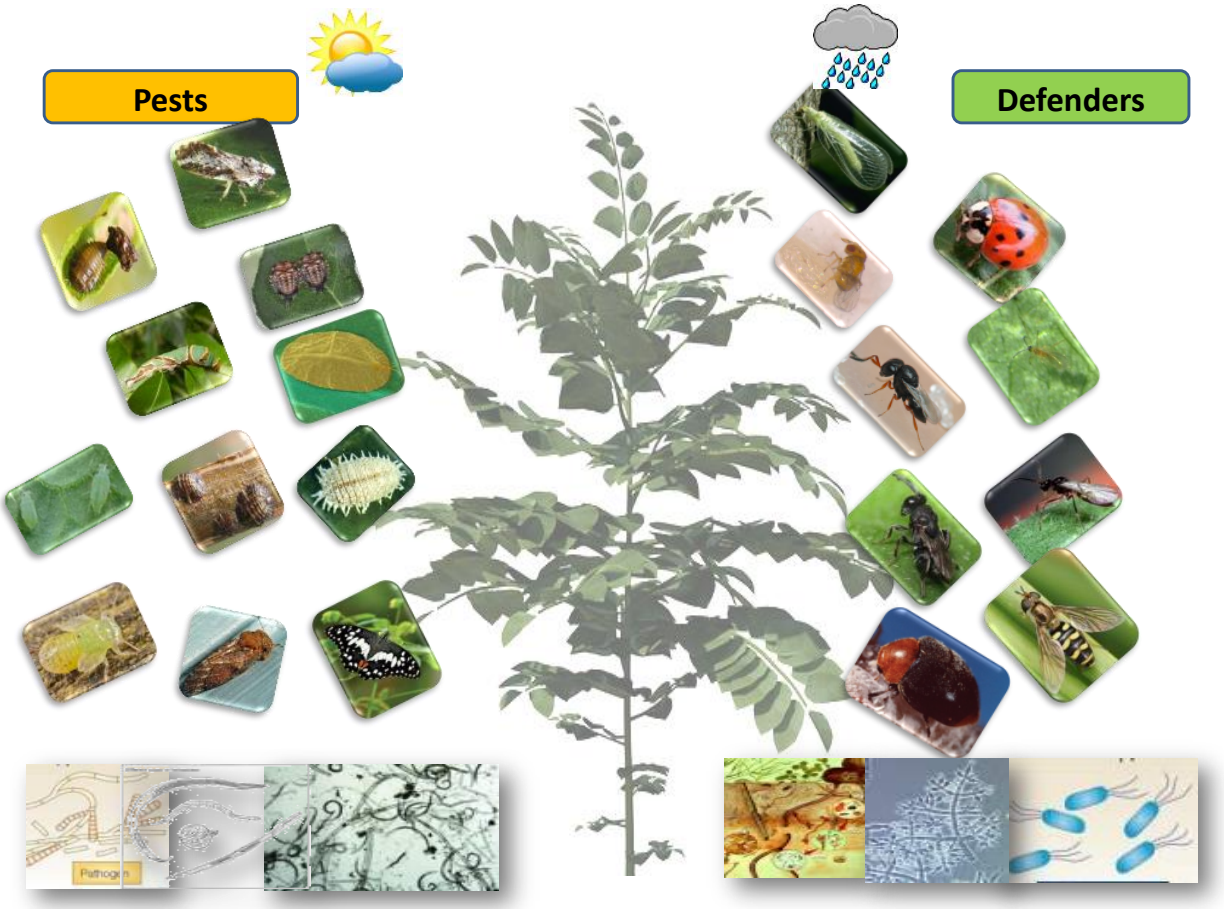
Insect zoo

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

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

Model agro-ecosystem analysis chart

Date:
Village:
Farmer:



Decision taken based on the analysis of field situation

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.

Feeding/egg laying potential of different parasitoids/predators

Predators/ Parasitoids	Feeding potential/ Egg laying capacity
 Lady bird beetle	Predatory rate of adult coccinellid on aphids is 50 aphids per day
 Hover fly	1st instar larva can consume 15-19 aphids/day 2nd instar larva can consume 45-52 aphids/day 3rd instar larva can consume 80-90 aphids/day In total life cycle they can consume approx. 400 aphids.
 Green Lace wing	Each larva can consume 100 aphids, 329 pupa of whitefly and 288 nymphs of jassids
 Reduviid bug	1st & 2nd nymphal instars can consume 1 small larva/day 3rd & 4th nymphal instars can consume 2 to 3 medium larvae/day 5th nymphal instar & adult can consume 3 to 4 big larvae/day In total life cycle they can consume approx. 250 to 300 larvae
 Spider	5 big larvae/day
 Predatory mite http://www.eduwebs.org/bugs/predatory_mites.htm	Predatory rate of adult is 20-35 phytophagous mites/female/day
 *Bracon hebetor*	Egg laying capacity is 100-200 eggs/female. 1-8 eggs/larva
 *Trichogramma* sp	Egg laying capacity is 20-200 eggs/female.

Decision making

Farmers become experts in crop management

Farmers have to make timely decisions about the management of their crops. AESA farmers have learned to make these decisions based on observations and analysis viz. abiotic and biotic

factors of the crop ecosystem. The past experience of the farmers should also be considered for decision making. However, as field conditions continue to change and new technologies become available, farmers need to continue improving their skills and knowledge.

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

AESA methodology

- Go to the 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

- 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 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 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.

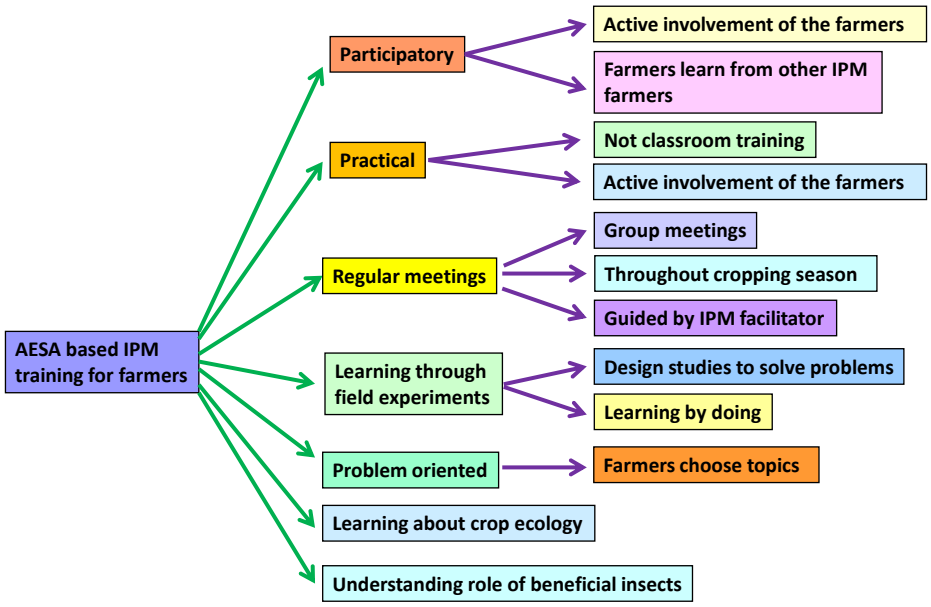
AESA and farmer field school (FFS)

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 field scouting in their own fields at regular intervals to monitor the major pest situation.
Surveillance on pest occurrence at the main field should commence soon after crop establishment and at weekly intervals thereafter. In each of the fields, select five spots randomly. Select four random plants at each spot for recording counts of insects as per procedure finalized for individual insects.

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

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

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

III. Ecological engineering for pest management

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

Natural enemies may require

1. Food in the form of pollen and nectar for adult natural enemies.
2. Shelters such as overwintering sites, moderate microclimate, etc are needed.
3. Natural enemies may also require alternate host when primary host are not present.

Ecological Engineering for Pest Management – Above ground:

- Raising 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
- Growing flowering plants on the internal bunds inside the field
- Not to uproot weed plants those are growing naturally like *Tridax procumbens, Ageratum* sp. *Alternanthera* sp., which act as nectar source for natural enemies,
- Not to apply broad spectrum chemical pesticides, when the P: D is favourable. The plant compensation ability should also be considered before applying chemical pesticides.

Ecological Engineering for Pest Management – Below ground:

- Crop rotations with leguminous plants which enhance nitrogen content.
- Keeping soils covered year-round with living vegetation and/or crop residue.
- Adding organic matter in the form of FYM, Vermicompost, crop residue which enhance below ground biodiversity.
- Reducing tillage intensity so that hibernating natural enemies can be saved.
- Applying balanced dose of fertilizers and nutrients.
- Applying *Trichoderma* as seed and nursery treatment and *Pseudomonas fluorescens* as seed, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

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

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

French bean

Marigold

Carrot

Sunflower

Mustard

Caraway

Dill

Cowpea

Buckwheat

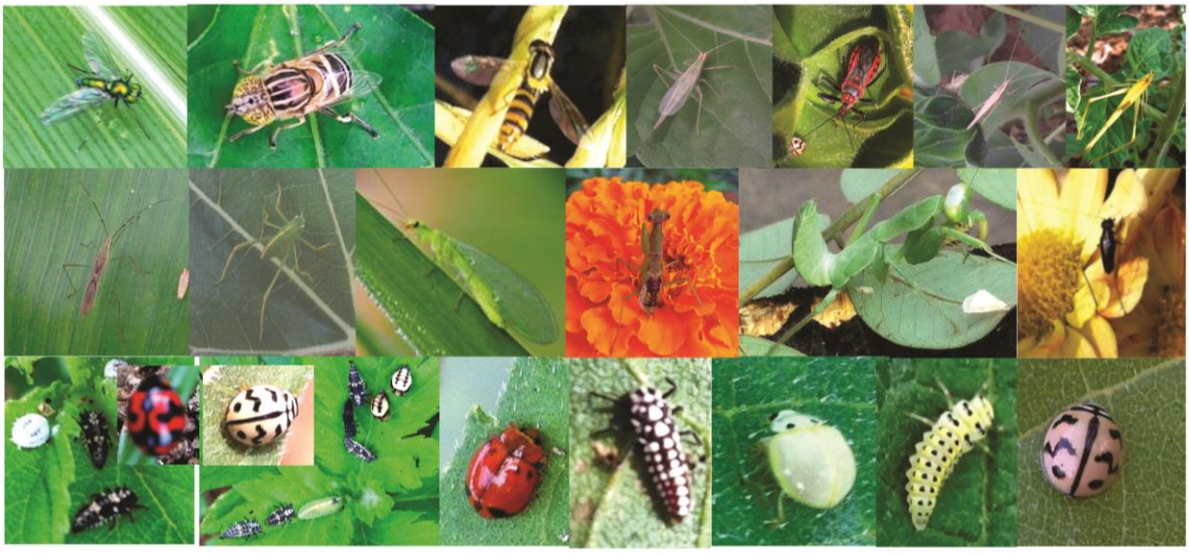
Maize

Coriander

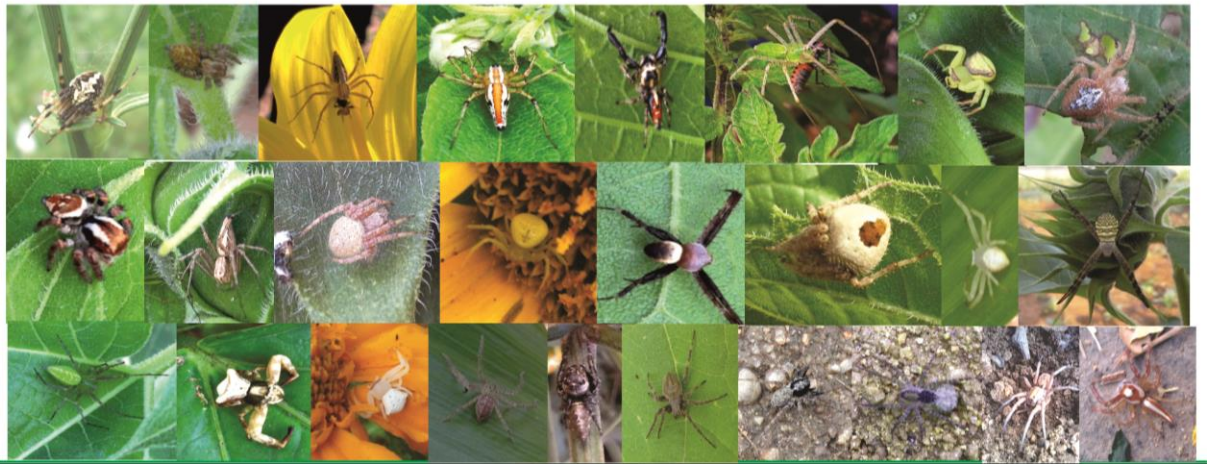
Cosmos

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



Flowering plants that attract natural enemies/repel pests

	Insect	Natural enemies	Attractant Plants
1	Leaf eating caterpillar (Citrus butterfly)	**Parasitoids:** *Trichogramma* spp. (egg), *Telenomus* sp (egg), *Distatrix papilionis* (larval), *Brachymeria* spp. (larval), *Pteromalus* spp. (pupal) etc. **Predators:** *Chrysoperla carnea*, coccinellids, King crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants, big eyed bugs (*Geocoris* sp), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc.	Attractant plants: • Dill, anise, caraway, spearmint, buckwheat, yarrow, white clover, tansy, cowpea, fennel, and cosmos (chalcid wasps)
2	Citrus psylla or psyllid	**Parasitoids:** *Tamarixia radiata* (nymphal), *Diaphorencyrtus aligarhensis* (nymhal) etc. **Predators:** Predatory wasps, lady beetles, lacewings, syrphid fly larvae etc.	Attractant plants: • Bachelor's buttons or cornflower *(Centaurea cyanus),* coriander, prairie sunflower, cosmos (lacewings). • Cosmos, sunflower (syrphids) • Golden rod, buckwheat, coriander, sunflower (lady beetles)
3	Scale insect	**Predators:** Predatory wasps, lacewings, ladybugs, ants and mites etc.	• Nectar rich plants with small flowers i.e. anise, caraway, dill, parsely, mustard, sun flower, buckwheat and cowpea attract parasitic wasps (braconid wasp) • Bachelor's button or cornflower *(Centaurea cyanus),* coriander, prairie sunflower, and cosmos (lacewings). • French bean (predatory mites)
4	Aphids	**Parasitoids:** *Aphidius colemani, Diaeretiella* spp., *Aphelinus* spp. etc. **Predators:** Anthocorid bugs/pirate bugs (*Orius* spp.), mirid bugs, syrphid/hover flies, green lacewings (*Mallada basalis* and *Chrysoperla carnea*), predatory coccinellids (*Stethorus punctillum*), staphylinid beetle (*Oligota* spp.), predatory cecidomyiid fly (*Aphidoletis*	• Carrot family, sunflower family, marigold, buckwheat, spearmint (syrphid fly, lacewing, minute pirate bug, damsel bug and lady beetle) • Nectar rich plants with small flowers i.e. anise, caraway, dill, parsely, mustard (aphid parasitoid and braconid wasp) • Sunflower, buckwheat and cowpea (braconid wasp)

		aphidimyza) and predatory gall midge, (*Feltiella minuta*), earwigs, ground beetles, rove beetles, spiders, wasps etc.	
5	Mealybug	**Predators:** Predatory wasps, syrphid/hover flies, ladybugs or mealybug destroyers (coccinellid, *Cryptolaemus montrouzieri*) etc.	**Attractant plants:** • Bachelor's buttons or cornflower (*Centaurea cyanus*) and coriander attract wasps.
6	Citrus leaf miner	**Parasitoids:** *Closterocerus* spp., *Cirrospilius* spp., *Pnigalio* spp., *Chrysocharis* spp., *Sympieses* spp. etc.	**Attractant plants:** • Dill, anise, caraway, spearmint, buckwheat, yarrow, white clover, tansy, cowpea, fennel, and cosmos
7	Two spotted mites	**Predators:** Anthocorid bugs (*Orius* spp.), mirid bugs, syrphid/hover flies, green lacewings (*Mallada basalis* and *Chrysoperla carnea*), predatory mites (*Amblyseius alstoniae*, *A. womersleyi, A. fallacies* and *Phytoseiulus persimilis*), predatory coccinellids (*Stethorus punctillum*), staphylinid beetle (*Oligota* spp.), predatory cecidomyiid fly (*Anthrocnodax occidentalis*), predatory gall midge (*Feltiella minuta*) etc. *Beauveria bassiana* (entomo pathogen)	• Citrus, avocadoes, bananas, papaya, palms, tea, cassava, maize, strawberries, vegetables, and cotton, as well as ornamental plantings, grasslands attract *Stethorus punctillum.* • *Daucus carota* (Queen Anne's lace) attract lady bugs. Border crops: Strips of rye, grass, cover crops and mulch beds (rove beetle).

IV. Crop stage-wise IPM

Stage	Management	Activity
Pre-sowing*	**Nutrients**	• The field is ploughed 3-4 times to get a fine tilth. Before last ploughing well decomposed farm yard manure (FYM) is applied @ 8 t/acre. • Pit size of 30 x30x30 cm is dug one to two months before planting at a spacing of 1.2 x 1.5 m (in case of sole crop) or 1.5 x 3 m or 1.5 x 2m • Apply 26: 9: 8 kg N: P: K/acre acre at the time of planting
	Weeds	• Remove or incorporate previous crop residues before planting. • Plan to grow suitable intercrops like legumes, ginger, tapioca etc. •
	Resting stages of pests, soil-borne fungus	• Deep summer ploughing • **Soil solarization:** Cover the beds 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.
***** Applying *Trichoderma* as seed and nursery treatment and *Pseudomonas fluorescens* as seed, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).		
Vegetative stage	**Nutrients**	• Apply 4 kg of FYM, 5: 10: 10 g N: P: K/plant and mix with soil after every harvest.
	Weeds & **Inter cultivation**	• Periodical hoeing/ hand weeding from pits should be done after every irrigation. • In the first year intercropping with pulses can be grown. • After attaining 1 m height, the terminal bud is cut off to encourage basal branching. In total 5-6 branches are maintained per bush.
	Leaf spot	**<u>Cultural control:</u>** • Disease-free seed and seedlings should always be used **<u>Biological control:</u>** • Preventive spray of tobacco decoction could be sprayed (dose). • Citrus oil at 1360 ppm inhibited the maximum growth of the fungus followed by lemongrass oil at 1720 ppm and peppermint at 2260 ppm, respectively.

		• Spray NSKE 5%
	Tortoise beetle	**<u>Mechanical control:</u>** • Hand picking of larva **<u>Biological control:</u>** • Conserve parasitoids such as *Trichogramma evanescens* (egg), *Telenomus* sp (egg), *Distatrix papilionis* (larval), *Brachymeria* sp (larval), *Pteromalus* sp (pupal), • Spray NSKE 5% or neem oil @ 1-2 %
	Leaf eating caterpillar (Citrus butterfly)	**<u>Cultural control:</u>** • Yellow sticky traps @4-5 /acre for monitoring **<u>Biological control:</u>** • Conserve predators such as predatory wasps, lady beetles, lacewing, syrphid fly larvae. • Horticultural mineral oils @ 0.5 -1% • Dusting of cow dung ash. • Spray NSKE 5% or 0.03 % azadirachtin • Application of fish oil rosin soap at one part in 25 parts of water is highly effective against this sucking pest.
	Citrus psylla or psyllid	**<u>Cultural control:</u>** • Close monitoring and pruning of the infested plant parts **<u>Biological control:</u>** • Conserve natural predators such as predatory wasps, lacewings, ladybugs (*Chilocoris nigritus*), predatory ants, predatory mites etc. • Horticultural mineral oils @ 0.5-1%
	Scale insects	**<u>Biological control:</u>** • Predatory wasps, syrphid/hover flies, ladybugs or mealybug destroyers (a conccinellid, *Cryptolaemus montrouzieri*) etc.
	Mealybug	**<u>Biological control:</u>** • Predatory midges, green lacewings, lady bird beetles, hover flies, wasps etc.
	Citrus leafminer	**Biological control:** • Conserve parasitoids such as *Closterocerus* spp., *Cirrospilius* spp., *Pnigalio* spp., *Chrysocharis* spp., and *Sympieses* spp. • Spray NSKE 5%

	Aphid	**<u>Biological control:</u>** • Conserve parasitoids such as *Aphidius colemani, Diaeretiella* spp*. Aphelinus* spp*.* etc. • Conserve predators such as anthocorid bugs/pirate bugs (*Orius* spp.), mirid bugs, syrphid/hover flies, green lacewings (*Mallada basalis* and *Chrysoperla carnea*), predatory coccinellids (*Stethorus punctillum*), staphylinid beetle (*Oligota* spp.), predatory cecidomyiid fly (*Aphidoletis aphidimyza*) and predatory gall midge, (*Feltiella minuta*), earwigs, <u>ground beetles</u>, rove beetles, spiders, wasps etc.
Reproductive stage (in subsequent seasons)	**Nutrient management**	Apply 4 kg of FYM, 5: 10:10 g N: P: K/plant and mix with soil after every harvest.
	Weed management	Need based hoeing and weeding should be done around the plant to keep it weed free.
	Citrus psylla or psyllid	Same as in vegetative stage
	Mealybug **Aphid**	Same as in vegetative stage Same as in vegetative stage
	Scale	Same as in vegetative stage
	Citrus leaf miner	Same as in vegetative stage

V. Insecticide resistance and its management

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

Causes of resistance development: The causes and rate at which insecticide resistance develops depend on several factors, including 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.

3) **Take an integrated approach to managing pests.** Use as many different control measures as possible. 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.
4) **Time applications correctly.** Apply insecticides when the pests are most vulnerable. Use application rates and intervals recommended by the manufacturer, university insect management specialist, county Extension agent, or crop consultant.
5) **Mix and apply carefully.** While applying insecticides care should be taken for proper application of insecticides in terms of dose, volume, timing, coverage, using techniques recommended by the manufacturer etc.
6) **Alternate different insecticide classes.** Avoid the repeated use of the same insecticide, insecticides in the same chemical class, or insecticides in different classes with same mode of action and rotate/alternate insecticide classes and modes of action.
7) **Preserve susceptible genes.** Preserve susceptible individuals within the target population by providing unsprayed areas within treated fields, adjacent "refuge" fields, or habitat attractions within a treated field that facilitate immigration. These susceptible individuals may outcompete and interbreed with resistant individuals, diluting the resistant genes and therefore the impact of resistance.

VI. Description of common weeds:

Major kharif weeds

1. Pigweed: *Amaranthus viridis* Hook. F. Amaranthaceae

It is an erect 6 to 100 cm tall annual herb with especially upwards glabrous to pubescent stem. Leaves are also glabrous or pubescent on the veins of the lower surface; petioles long (up to 10 cm), occasionally longer than the blade; blade ovate to rhombic-oblong, base tapered to blunt, tip rounded. Flowers green, unisexual, male and female intermixed, in slender axillary to terminal paniculate spikes 2-12 cm long and 2-5 mm wide, or in dense axillary clusters in the lower part of the stem. Fruits are capsule almost round shaped 1.25-1.75 mm long with rough surface. Seeds 1-1.25 mm, round, slightly compressed, dark brown to black with a paler thick border.

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

An annual herb with , horizontal or ascending stem, multiple from the base, radiating from a

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


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

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


4. Common purselane: ***Portulaca oleracea*** **L. Portualacaceae**

An annual glabrous herb with prostrate and succulent stem. Leaves spatulate, flattened, apex round nearly truncate. Flowers 3-10 mm diameter and yellow. Fruits capsules ovoid, 4-9 mm diameter. Seeds black or dark brown, orbiculate or elongate, flattened, 0.6-1.1 mm; surface cells sooth, granular, or stellate, with rounded tubercles.

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

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

6. Rabbit/crow foot grass: ***Dactyloctenium aegyptium*** **(L.) Willd Poaceae**

Annual, very variable, grass, 10-44 cm high. Stem erect or creeping culms, rooting from the profusely branched nodes. Leaves are linear, tapering to a fine point, 2-10 cm long and 0.2-0.4 cm wide, flat, glaucous, glabrous or hispid; leaf sheaths striate, the lower whitish; ligules membranous, very short. Inflorescence comprised of 2-6 digitate spikes, 0.5-4 cm long, olive-grey; spikelets 2-5 flowered, spreading at right angles, pendulous, strongly striate. Grain 0.5-1 mm long, subglobose, reddish, very rugose.

7. Crabgrass: ***Digiteria sanguinalis*** **(L.) Scop. Poaceae**

A prostrate or ascending annual grass with spreading, branched stem having rooting at nodes. Leaves are 3-20 cm long, 3-10 mm wide, with hairs on both the surfaces. Stem sheaths hairy

and closed. Leaves and sheaths may turn dark red or maroon with age. Seed head composed of 4-6 branches (spikes) at the top of the stems, each approximately 3-15 cm long. Fruit caryopsis shiny, yellowish-brown, 2-3 mm long.

8. Barnyard grass: *Echinochloa crusgalli* (L.) Beauv. Poaceae

Robust, tufted annual grass, erect or at the base decumbent and rooting at the nodes, 20-150 cm tall. Culms cylindrical, glabrous, filled with white spongy pith. Leaf sheaths glabrous and 9-13 cm long. Leaf blades merging into the sheath, linear, with a broad, rounded base and acute top; rough margined, glabrous or at the base with a few long hairs, smooth or the upper surface minutely bristly. Inflorescence is an apical panicle of 5-40 spikes like racemes. Fruit are caryopsis ovoid to obovoid, compressed, 1.5-2 mm long.

Sedges

9. Purple nutsedge: *Cyperus rotundus* L. Cypraceae

A perennial sedge, hard, fragrant, globose-ovoid tubers, up to 1.2 cm long and 0.3-0.7 cm in diameter; culms solitary or few together, sparsely tufted, erect, 10-75 cm tall, 3-angled at top. Leaves narrowly linear, sometimes longer than stem, 0.4-0.8 cm wide, dark green above, pale beneath. Inflorescence is a simple or compound umbel, rays 2-8, each up to 7.5 cm long, bearing short spikes of 3-10 spreading, red-brown spikelets. Nuts oblong to ovate-oblong, 3-sided, 1.3-1.5 mm long and 0.5-0.7 mm wide, maturing brown.


10. Flat sedge: ***Cyperus iria* L. Cypraceae**

Annual sedge, sometimes behaving as a perennial with 8 to 60 cm high. The culms are tufted, triangular, smooth, green and 0.6-3.0 mm thick. The roots are numerous, short and yellowish-red. Leaves are linear-lanceolate, usually all shorter than the culm, 1-8 mm wide, flat, and rough on the margin and major ribs; leaf sheaths are green to reddish-brown, membraneous and envelope the culm at the base. Inflorescence is simple or compound, usually open, 1-20 cm long and 1-20 cm wide, with groups of spikes which are either attached directly to stem or on 0.5-15.0 cm long peduncles (rays). Spikelets are erect-spreading, crowded, 6-24-flowered, 2-13 mm long, 1.5-2.0 mm wide, golden to yellowish green. Nutlet, 1.0-1.5 mm long, 0.6-0.7 mm wide, obovate, triangular in cross section, dark-brown to almost black; the surface is almost smooth.

11. Lambs quarter: *Chenopodium album* L. Chenopodiaceae

It is an annual weed found in agricultural fields. It is a polymorphous, non-aromatic, erect herb**,** 0.3-3 m tall with angled stems that are often striped green, red or purple. Leaves are variable in size and shape, lower leaves are toothed or irregularly lobes, 10-15 cm long, with petioles often as long as leaf blades. Flowers are green, borne in clusters forming a compact or loosely panicled axillary spike. Fruits utricle, seeds round, compressed, black and shining.



12. Scarlet pimpernel: *Anagallis arvensis* Primulaceae L

A low-growing annual, up to 30 cm tall with branched or erect herbaceous, 4-angled, glabrous to pubescent stem. Sometimes rooting observed at the nodes. Leaves are opposite, entire, sessile, ovate variously pubescent, margins somewhat tuberculate. Flowers are bright blue, solitary arising from the area between the stem and leaves (leaf axils) and occur on relatively long stalks (pedicels). Fruits capsule, globose, seeds1.3 mm long, trigonous, brown.

13. Sweet clover: *Melilotus indica* (L.) All. Fabaceae

It is a sweet-smelling erect herb, up to 10-60 cm high with hairless, spreading or erect stem. Leaves odd-1-pinnate; leaflets 1-2.5 cm, inverted, lance-shaped to wedge-shaped, generally sharply toothed on the broader part. Flowers yellow; appear in slender, compact racemes that are 1-2 inches in length. Plant bear papery, small, round, 2-3 mm long, yellow or grey, reticulately wrinkled and slightly hairy pods. Seeds 2 mm long; 1.5 mm wide; broadly oval, one side plane, the other side rounded; yellowish green; roughened by minute tubercles.

14. Fine leaf fumitory: ***Fumaria parviflora*** **Lam. Fumariaceae**

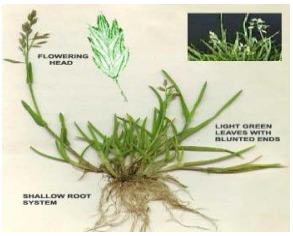
Annual herb, up to 60 cm tall. Stem Slender, much branched and succulent. Leaves 2-3 pinnatisect, 2-5 cm long, segments linear oblanceolate, apiculate. Flowers Purplish-red, spurred, in terminal or leaf opposed bracteate racemes. Fruits are rounded nuts, 2-3 mm in diameter, wrinkled when dry.

15. Corn spurry: ***Spergula arvensis*** **L. Caryophyllaceae**

A diffuse annual herb. Stem branched from the root, grooved. Leaves are in pseudo whorls, fleshy, linear-subulate, spreading. Flowers small, white. Fruits capsule rounded, five valved. Seeds are circular, thick lens shaped in cross section; margins winged with one small notch. Seeds are greyish black to black with margins usually light brown.

16. Bluegrass: ***Poa annua*** **L. Poaceae**

Annual cool-season grass grows 6 to 8 inches high when left unmowed. It has light green flattened stems that are bent at the base and often rooted at the lower stem joint. Leaf blades are often crinkled part way down and vary from 1 to 3 inches long with typical *Poa* boat-shaped leaf tips- a key characteristic of annual bluegrass. Inflorescence is branched with three to eight flattened florets in each spikelet.



17. Canary grass: *Phalaris minor* Retz. Poaceae

A tufted annual bunchgrass, up to 1.8 meters in height. Stem is erect or horizontal with long, linear leaves. Ligule is an oblong hyaline membrane, about 2-5 mm long, often truncate and/or fringed; auricles absent, sheath smooth. Panicle more or less protruding or entirely protruding from the uppermost swollen leaf sheath, ovate to oblong, 5-8 cm long, green. Spikelets green, broadly lanceolate on short pedicels, shining, 4 -6 mm long, strongly laterally compressed.

VII. Description of insect pest:

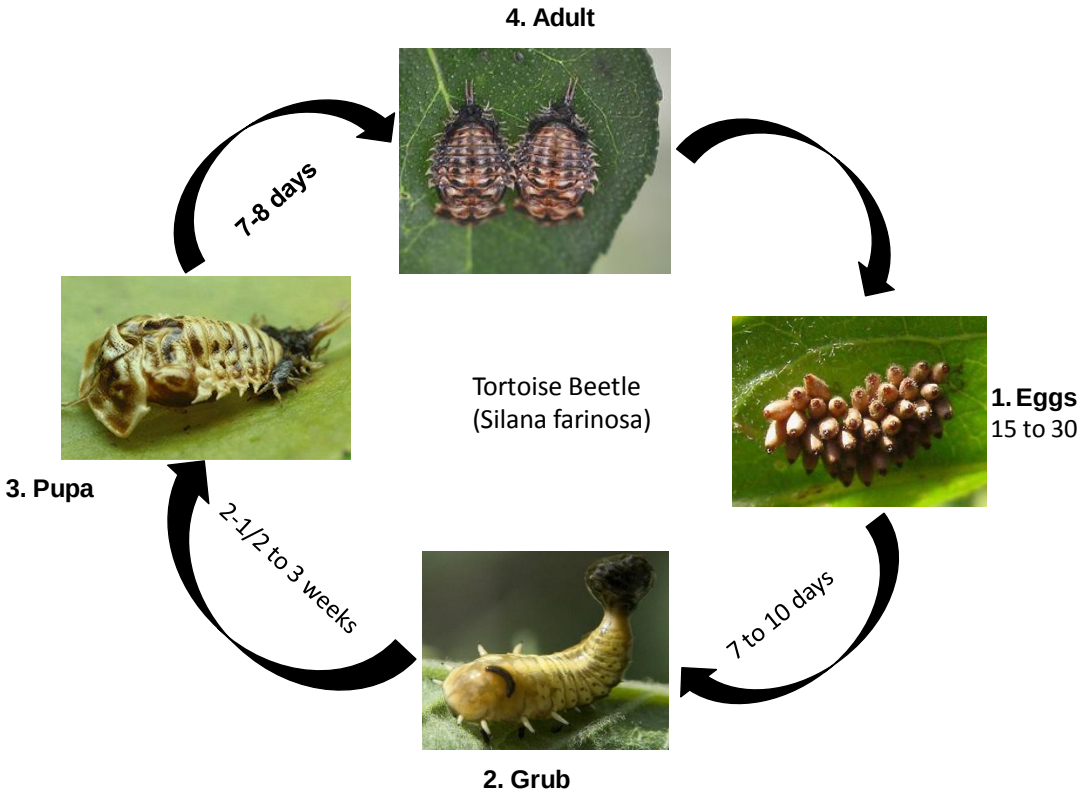
1) Tortoise beetle:

Biology:

Grub: Black with a forked posterior and a flattened body.

Adults: Reddish-brown beetles.

Life cycle:



Damage Symptoms:

Cause heavy defoliation of commercial crops.
Both the adult beetle and the grub feed on the leaves, boring holes into them.

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

2) Citrus butterfly:

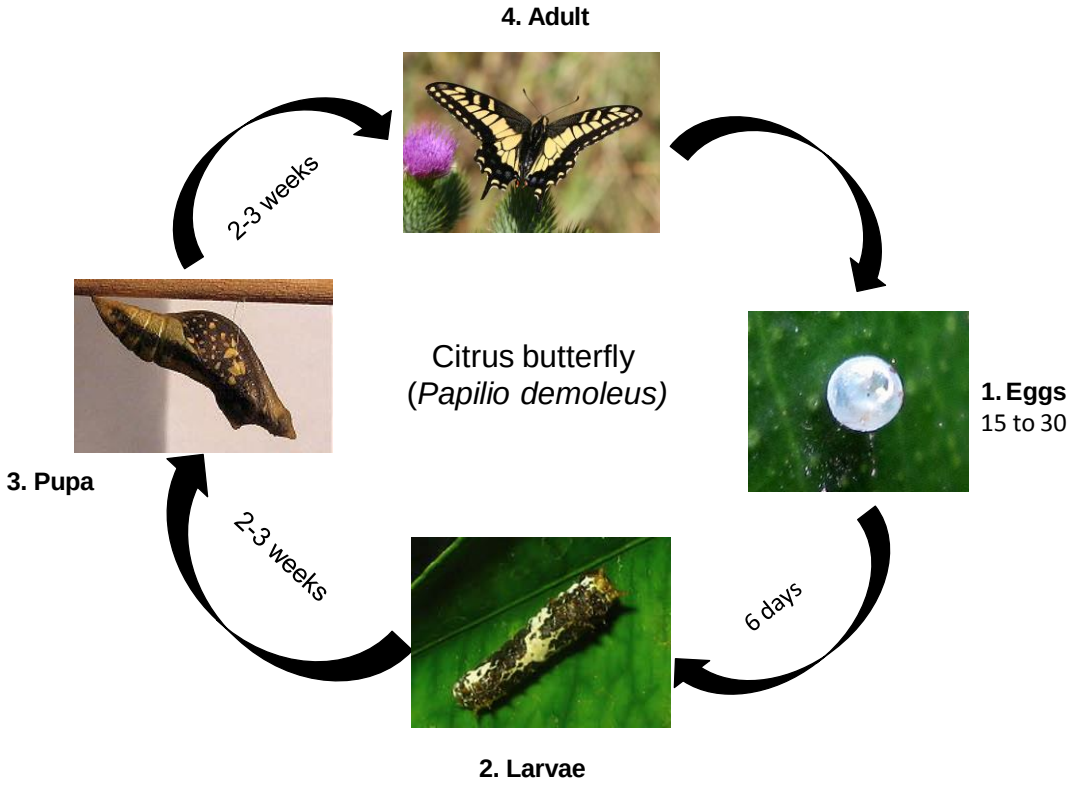
Biology:

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

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

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

Life cycle:



Parasitoids:

**1*. Trichogramma evanescens* (egg) 2*. Telenomus sp* (egg)

1. http://gsquaredbugs.com/?page_id=318 .
2.http://www.plantwise.org/default.aspx?site=234&page=4279&dsID=52991

3. *Brachymeria* sp (larval) **4*. Pteromalus* spp. (pupal)**

3..http://insectsgalore.blogspot.in/2010_07_01_archive.html
4. http://nathistoc.bio.uci.edu/hymenopt/Pteromalus.htm

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

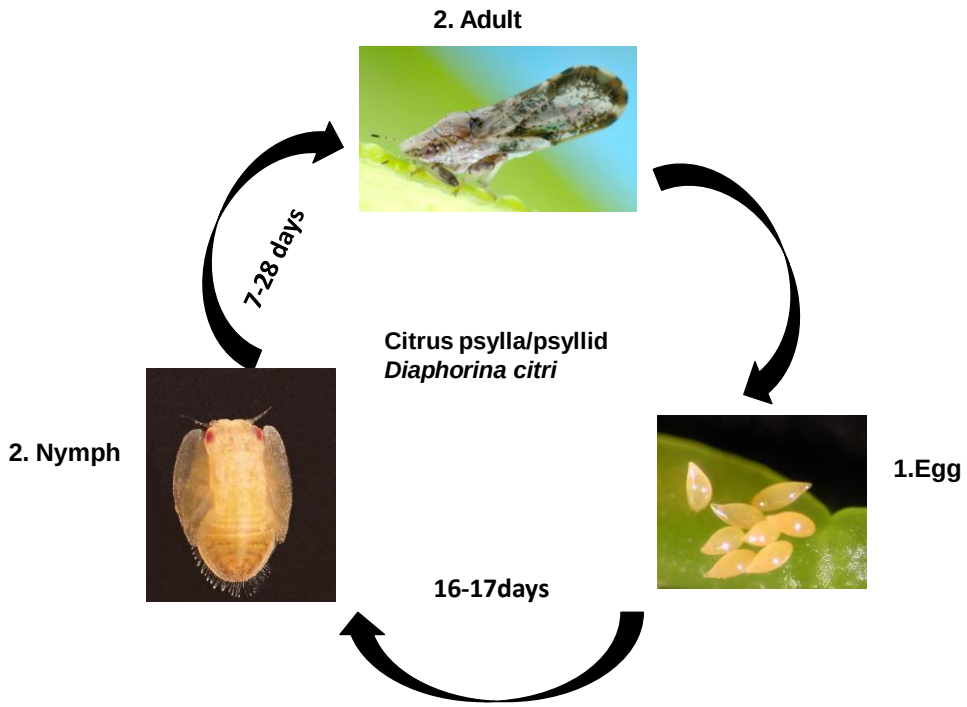
3) Citrus psylla/psyllid:

Biology:

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

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

Life cycle:



Damage symptoms:

Citrus psyllids are mottled brown insects that feed directly on the leaf of the curry leaf tree. This causes damage to the leaves and stems, and can also introduce bacteria to the tree. Symptoms include twisted and curling leaves, and dieback of shoots.

Parasitoids:

1. Parasitic wasp

http://bugguide.net/node/view/175277

Predators:

1. Ladybird beetle **2. Lacewing** **3. Syrphid fly larva**



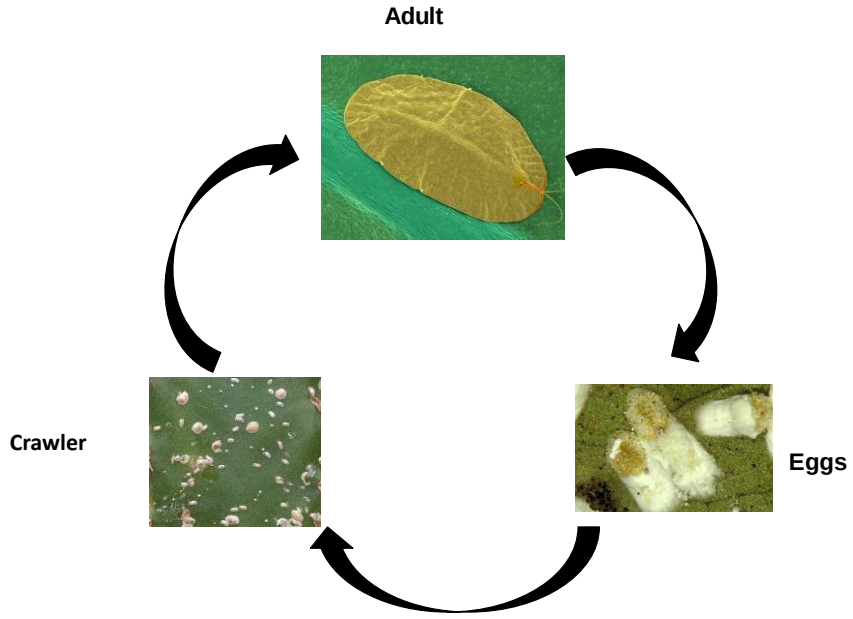
1. http://en.wikipedia.org/wiki/Coccinella_septempunctata
2. http://uconnladybug.wordpress.com/2013/04/30/the-green-lacewing-delicate-fierce/
3. http://ippc2.orst.edu/potato/syrphidfly.html

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

4) Scales:

Scales are tiny insects that appear as small, flat bumps on the surface of a leaf.

Life cycle:



Nature and symptoms of damage:

Scales damage plants by sucking out plant sap as a result leaves to yellow and wilt. While a few scales will not damage a curry tree, this insect reproduces rapidly and a small population can quickly become an infestation. Close monitoring of your curry tree can also help to catch scale problems before they become infestations.

Parasitoids:

1. Aphytis melinus

1. http://ucanr.org/repository/cao/landingpage.cfm?article=ca.v047n01p16&fulltext= yes

Predators:

1*. Rhyzobius lophanthae* 2. Lacewing 3. Predatory mite 4. Ants




1 http://bugguide.net/node/view/589307
2.http://uconnladybug.wordpress.com/2013/04/30/the-green-lacewing-delicate-fierce/
3. http://www.planetnatural.com/product/predatory-mites-spidex/
4. http://jonlieffmd.com/blog/ants-individual-and-colony-superorganism- leadership-and-fire-ants

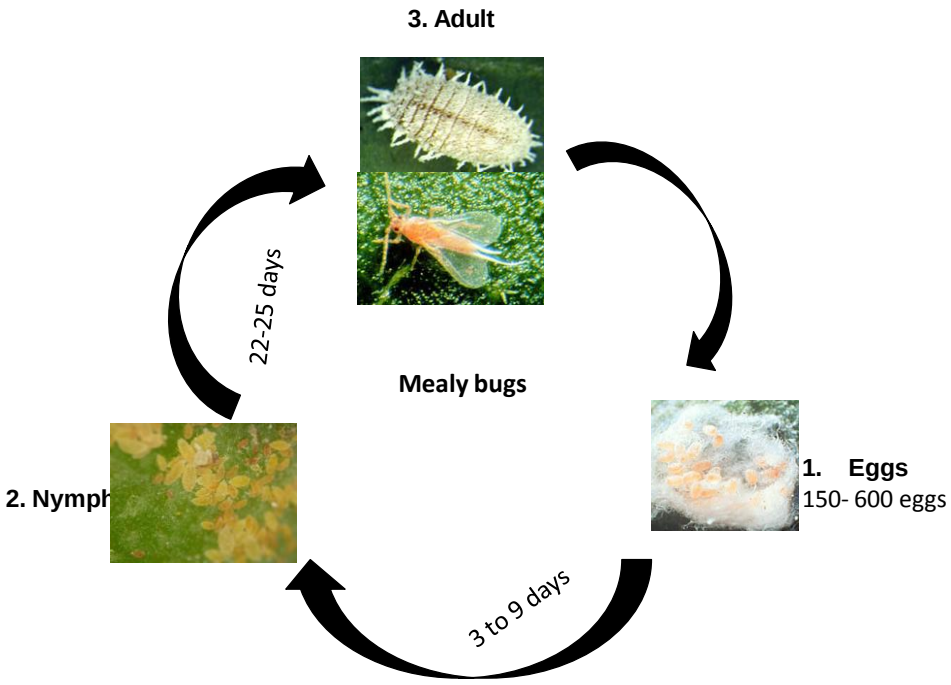
*For management refer to page number----------

5) Mealybugs:

Biology:

Citrus mealy bugs are soft pinkish-white insects with a waxy appearance. Mealy bugs 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.

Life cycle:



Damage symptoms:

In addition to causing leaves to shrivel, large infestations of citrus mealybugs can cause a tree's fruit to drop prematurely. Mealybugs usually gather in large numbers, causing premature leaf drop and twig dieback when they feed. Like psyllids, they secrete honeydew, which attracts black sooty mold.

Parasitoids:

1. Parasitic wasp

http://bugguide.net/node/view/175277

Predators:

1. Hover flies **2. Ladybird bettle** **3. Cryptolaemus montrouzieri**



http://ucanr.edu/blogs/bugsquad/index.cfm?tagname=hover%20flies
http://en.wikipedia.org/wiki/Coccinella_septempunctata
http://chem-gro.com/cart/product_info.php?products_id=191

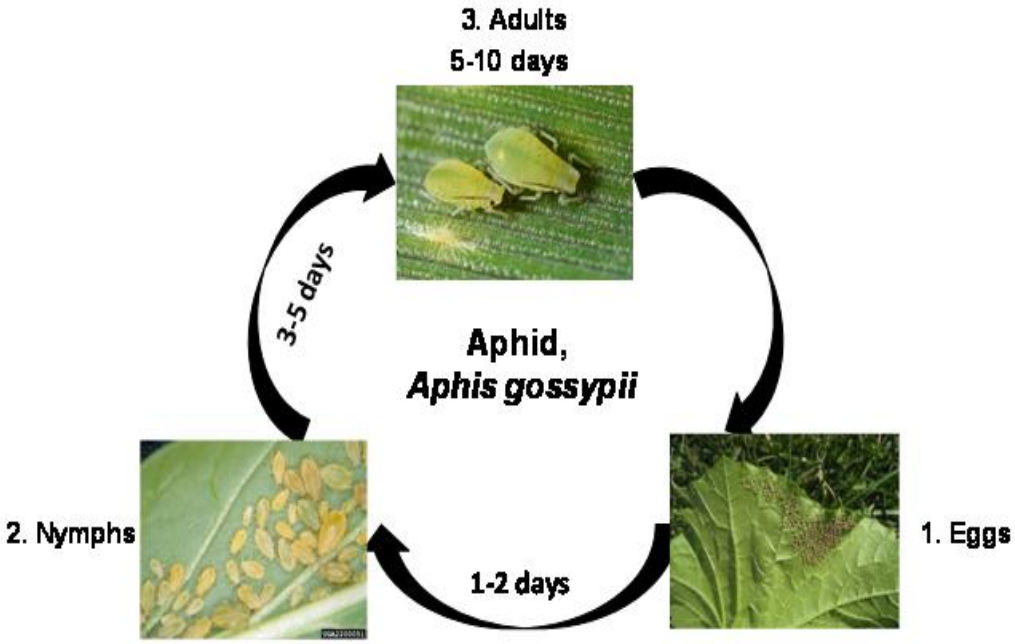
*For management refer to page number----------

6) Aphids:

Biology:

Aphids are small pear-shaped insects that may appear in a range of colors, including yellow, green, brown or white.

Life cycle:



Damage symptoms:

Aphids suck the juices from a plant, causing the leaves to mottle and curl, and can also introduce mold fungus. Aphids tend to feed in dense clusters and are slow to react when disturbed.

Predators:

1. **Lady beetle** **2. Lacewing** **3. Syrphid fly**



1.http://lladybug.blogspot.in/
2.http://www.macro-world.cz/image.php?id_foto=514&gal=29
3.http://freepages.misc.rootsweb.ancestry.com/~larsonmorgan/flies/flies.html

Parasitoids:

1. *Aphidius colemani* **2. *Aphidius* sp** **3. *Aphelinus* sp**



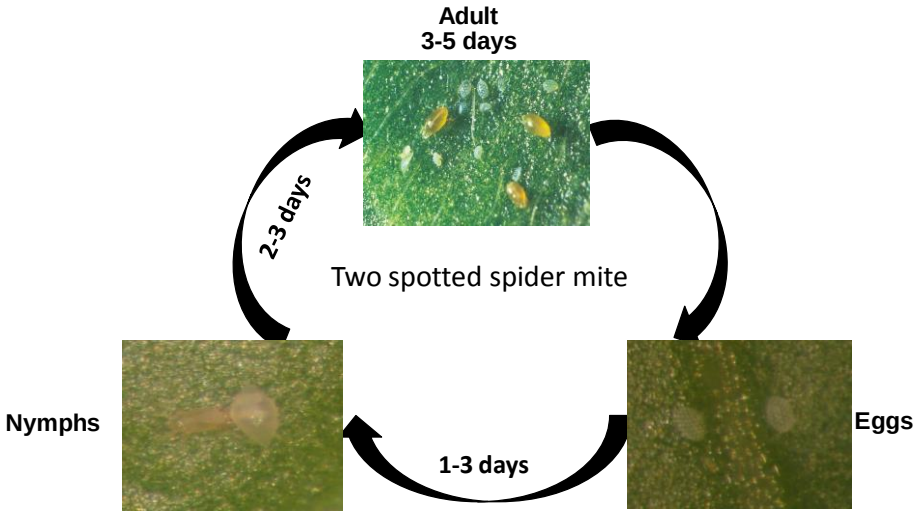
1. http://www.pbase.com/image/103498236
2. http://www.evergreengrowers.com/aphidius-colemani-133.html
3. http://australianmuseum.net.au/image/Aphelinus-wasp- stings-aphid- Denis-Crawford/

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

7) Two spotted spider mite:

Two-spotted mites reproduce sexually, and the females lay eggs on buds, leaves, twigs, stems and trunks. The eggs, which are laid in vast numbers, hatch to produce nymphs which grow through a succession of moults. The first stage nymphs are six-legged; the subsequent stage produces nymphs with a full complement of eight legs. Two-spotted mites overwinter in the soil. Generation time will vary according to temperature, but in warm conditions this time can be as short as four days.

Life cycle:



Damage symptoms:

Two spotted spider mite and carmine spider mite damage to strawberries appears as stippling, scarring, and bronzing of the leaves and calyx.

damaging during the first 2 to 5 months following transplanting in late summer or fall, and yield loss is detectable at all mite infestation levels exceeding one mite per leaflet

Predator mites:

1. *Phytoseiulus persimilis* **2. *Galendromus occidentalis*** **3. minute pirate bug** **4. Black lady beetle**




5. Damsel bug **6. Lacewing** **7. Six-spotted thrips**



1.http://www.nhm.ac.uk/nature-online/species-of-the-day/scientific-advances/bio-control/phytoseiulus-persimilis/index.html
2.http://chem-gro.com/cart/product_info.php?products_id=169
3.http://www.bloomingarden.com/Newsletters2012/032212/4ohiosbeneficialbugs032212.html
4.http://bugguide.net/node/view/286215
5.http://mint.ippc.orst.edu/damselid.htm
6.http://www.macro-world.cz/image.php?id_foto=514&gal=29
7.http://www.ipm.ucdavis.edu/PMG/NE/sixspotted_thrips.html

VIII. Description of disease:

1) Leaf spot

Phyllosticta leaf spot symptoms range from a few round spots or lesions. It may cause early loss of leaves in case of severe infestation and can debilitate the tree. The irregular, round, yellowish brown lesions are produced on leaves. Under the favourable conditions, tiny black fruiting bodies of the pathogen are produced, usually they form a circle. The center of these spots is dead tissue that easily breaks away leaving a hole

- **Primary infection:** Through soil and rain splash
- **Secondary infection :** through air and rain splash during wed condition

IX. Do's and Don'ts

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.	Adopt crop rotation.	Avoid growing monocrop.
3.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
4	Sow early in the season	Avoid late sowing as this may lead to reduced yields and incidence of white grubs and diseases.
5	Always treat the seeds with approved chemicals/bio products for the control of seed borne diseases/pests. 	Do not use seeds without seed treatment with biocides/chemicals.
6.	Sow in rows at optimum depths under proper moisture conditions for better establishment. 	Do not sow seeds beyond 5-7 cm depth.
7.	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.
8.	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.

	 .	
9	Use NPK fertilizers as per the soil test recommendation. 	Avoid imbalanced use of fertilizers.
10	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
11	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
12	Install pheromone traps at appropriate period. 	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
13	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.

14	Apply HaNPV or SINPV at recommended dose when a large number of egg masses and early instar larvae are noticed. Apply NPV only in the evening hours after 5 pm. 	Do not apply NPV on late instar larva and during day time.
15	In case of pests which are active during night like *Spodoptera* 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.
16	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, whiteflies, *Spodoptera* etc. 	Do not spray pesticides only on the upper surface of leaves.
17	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
18	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.

X. 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.
   3. Do not purchase pesticides without proper/approved labels.
   4. 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.
   4. Never keep them together with food or feed/fodder.
   5. Keep away from reach of children and livestock.
   6. Do not expose to sunlight or rain water.
   7. Do not store weedicides along with other pesticides.

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. Read the label on the container before preparing spray solution.
   7. Prepare the spray solution as per requirement
   8. Do not mix granules with water
   9. Concentrated pesticides must not fall on hands etc. while opening sealed container. Do not smell pesticides.
   10. Avoid spilling of pesticides while filling the sprayer tank.
   11. Do not eat, drink, smoke or chew while preparing solution
   12. 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. 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
3. Do not apply just before the rains and after the rains.
4. Do not apply against the windy direction
5. Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer
6. Wash the sprayer and buckets etc. with soap water after spraying
7. Containers buckets etc. used for mixing pesticides should not be used for domestic purpose
8. Avoid entry of animals and workers in the field immediately after spraying
9. Avoid tank mixing of different pesticides

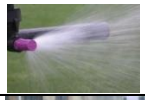
G. Disposal

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.

XI. Pesticide application techniques

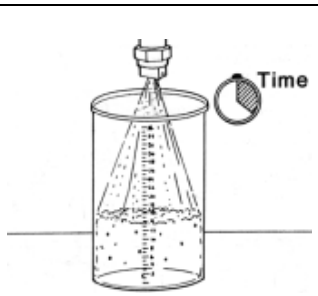
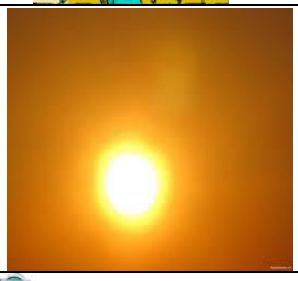
<table>
<tr><td colspan="4">Equipment</td></tr>
<tr><td colspan="4">Category A: Stationary, crawling pest/disease</td></tr>
<tr><td rowspan="2">Vegetative stage
i) for crawling and soil borne pests

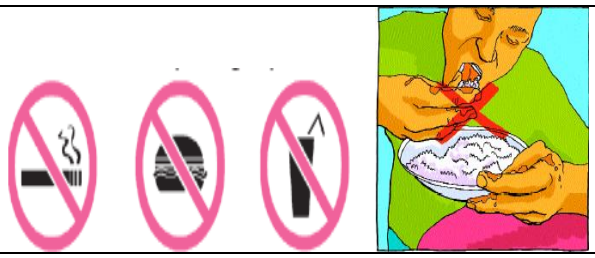
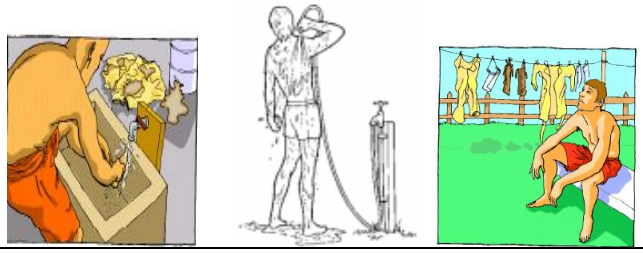
ii) for small sucking leaf borne pests</td><td rowspan="2">Insecticides and fungicides</td><td rowspan="2">• Lever operated knapsack sprayer (Droplets of big size)
• Hollow cone nozzle @ 35 to 40 psi
• Lever operating speed = 15 to 20 strokes/min
or
• Motorized knapsack sprayer or mist blower (Droplets of small size)
• Airblast nozzle
• Operating speed: 2/3rd throttle</td><td>  </td></tr>
<tr><td>  </td></tr>
<tr><td>Reproductive stage</td><td>Insecticides and fungicides</td><td>• Lever operated knapsack sprayer (Droplets of big size)
• Hollow cone nozzle @ 35 to 40 psi
• Lever operating speed = 15 to 20 strokes/min</td><td>  </td></tr>
</table>

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)	  

XII. 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.	

XIII. References

http://www.ipm.ucdavis.edu/PMG/r734400111.html
http://bugguide.net/node/view/286215
http://agritech.tnau.ac.in/
http://www.cabi.org