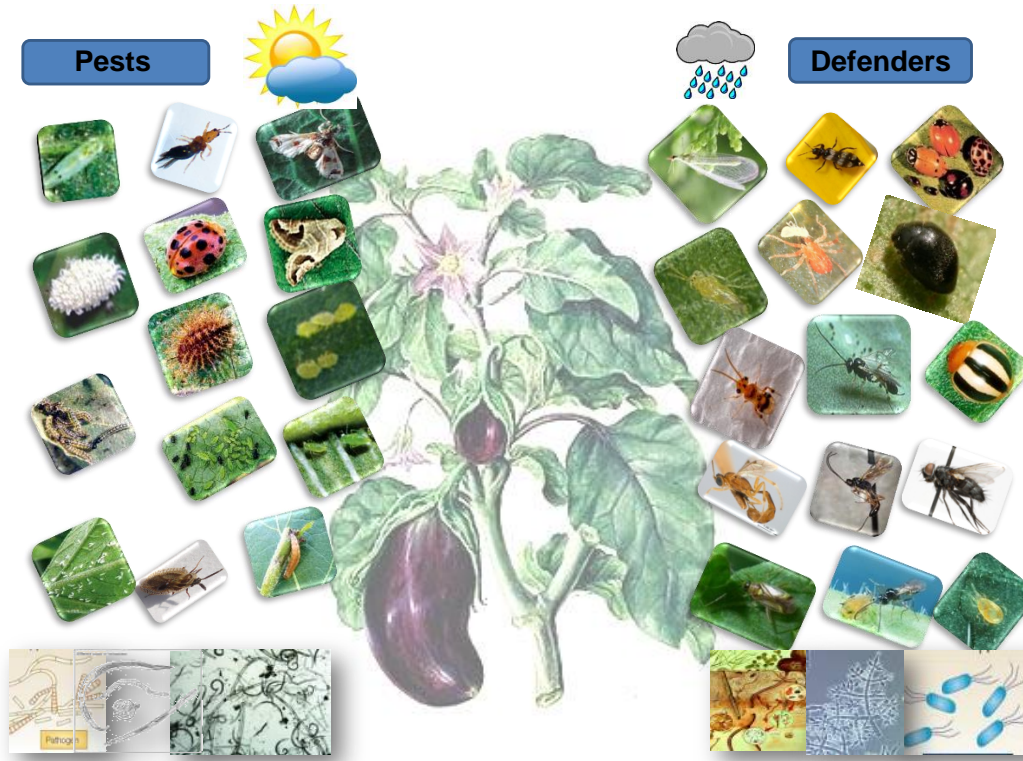




AESA BASED IPM Package No.22

AESA based IPM – Brinjal



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The AESA based IPM - Brinjal, 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

Ak Srivastava
(Avinash K. Srivastava)

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FOREWORD

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

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

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


(Utpal Kumar Singh)



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PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

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IPM Package for Brinjal

I. PESTS

A. Pests of National Significance

1. Insect and mite pests

- 1.1 Fruit and shoot borer: *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae)
- 1.2 Jassids: *Amrasca biguttula biguttula* Ishida (Homoptera: Cicadellidae)
- 1.3 *Epilachna* (Hadda) beetle: *Epilachna vigintioctopunctata* Fabricius (Coleoptera: Coccinellidae)
- 1.4 Whitefly: *Bemisia tabaci* (Gennadius) (Hemiptera : Aleyrodidae)
- 1.5 Aphids: *Myzus persicae* Sulzar (Hemiptera: Aphididae)
- 1.6 Spider mites: *Tetranychus* spp.

2. Diseases

- 2.1 Damping off: *Pythium aphanidermatum* (Edson) Fitzp
- 2.2 Phomopsis blight: *Phomopsis vexans* (Sacc. & Syd.) Harter
- 2.3 Little leaf of brinjal: Phytoplasmas
- 2.4. Bacterial wilt: *Ralstonia solanacearum* (Smith) Yabuuchi *et al*

3. Nematodes

- 3.1 Root-knot nematode: *Meloidogyne incognita* and *M. javanica*

4. Rodent pests

- 4.1 Lesser bandicoot: *Bandicota bengalensis* (Gray) (throughout India)
- 4.2 Palm rat/house rat: *Rattus rattus* (Linnaeus) (throughout India)
- 4.3 Indian gerbil: *Tatera indica* (throughout India)

5. Major weeds

5.1 Major Kharif weeds Broadleaf weeds

5.1.1 Pigweed: *Amaranthus viridis* Hook. F.

5.1.2 Swine cress: *Coronopus didymus* (L.) Sm.

5.1.3 Black nightshade: *Solanum nigrum* L.

5.1.4 Common purselane: *Portulaca oleracea* L.

5.1.5 False amaranth: *Digera arvensis* Forssk.

Grassy weeds

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

5.1.7 Crabgrass: *Digitaria sanguinalis* (L.) Willd.

5.1.8 Barnyard grass: *Echinochloa crusgalli* (L.) Scop.

Sedges

5.1.9 Purple nutsedge: *Cyperus rotundus* L.

5.1.10 Flat sedge: *Cyperus iria* L.

5.2 Major Rabi weeds

Broadleaf weeds

5.2.1 Lamb's quarter: *Chenopodium album* L.

5.2.2 Scarlet Pimpernel: *Anagallis arvensis* L.

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

5.2.4 Fine leaf fumitory: *Fumaria parviflora* Lam.

5.2.5 Corn spurry: *Spergula arvensis* L.

Grassy weeds

5.2.6 Blue grass: *Poa annua* L.

5.2.7 Canary grass: *Phalaris minor* Retz.

B. Pests of Regional Significance

1. Insect pests

1.1 Bud worm: *Scrobipalpa blapsigona* Meyrick (Lepidoptera: Gelechiidae)

1.2 Mealybug: *Phenacoccus solenopsis* Tinsley (Hemiptera: pseudococcidae)

1.3 Leaf roller: *Eublemma olivacea* Walker (Lepidoptera: Noctuidae)

1.4 Leaf webber: *Psara bipunctalis* Fabricius (Lepidoptera: Pyralidae)

1.5 Termites:

1.5.1 *Microtermes obesi* (Termitidae: Isoptera) (throughout India)

1.5.2 *M. anandi* (Termitidae: Isoptera) (throughout India)

1.5.3 *Odontotermes obesus* (Termitidae: Isoptera) (throughout India)

1.5.4 *O. assumthi* (Termitidae: Isoptera) (throughout India)

1.5.5 *O. taprobenes* (Termitidae: Isoptera) (throughout India)

1.5.6 *Eremotermes nerapololis* (Termitidae: Isoptera) (throughout India)

1.5.7 *Trinervitermes biformis* (Termitidae: Isoptera) (throughout India)

1.6 Grey weevils: *Myloccerus subfasciatus* Guerin (Coleoptera: Curculionidae)

1.7 Tobacco cut worm: *Spodoptera litura* Fabricius (Noctuidae: Lepidoptera)

1.8 Stem borer: *Euzophera perticella* Ragonot (Lepidoptera: Pyralidae)

1.9 Thrips: *Thrips palmi* Karny (Thysanoptera: Thripidae)

1.10 Brinjal lacewing bug: *Urentius hystericellus* Richter (Hemiptera: Tingidae)

2. Diseases

2.1 Blight: *Alternaria melongenae*, Rangaswami & Samb *Alternaria* spp.

2.2 Cercospora leaf spot: *Cercospora solani* f.sp.–*melongenae* Feuilleaub
Cercospora melongena

2.3 Root and collar rots: *Rhizoctonia solani* J.G. Kühn

2.4 Spotted wilt virus: *Peanut Bud Necrosis Virus* (PbNV)

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, 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 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.)



Compensation ability

Compensation is defined as the replacement of plant biomass lost to herbivores 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). Plant tolerance to herbivory can arise from the interaction of a variety of plant traits and external environmental factors. Several studies have documented compensatory regrowth via side braches, through increased growth and photosynthetic rates.

When eggplant shoots are lost, for example due to feeding damage of fruit and shoot borer larvae (FSB) the plant can also compensate for this loss by producing more shoots. Eggplant is able to compensate for feeding because more leaves and roots are produced than are actually needed for fruit formation, and new shoots are regularly formed. Even when the plant is almost completely cut back to about 15 cm above soil level, the plant will produce new shoots and form a new plant. This regrowth is often very strong because the roots are already there and can provide the nutrition and water from the soil to feed the new shoots.

Understand and conserve defenders

- Know defenders/natural enemies to understand their role through regular observations of the agro-ecosystem
- Avoid the use of poisonous chemicals that kill the natural enemies of pests

Insect zoo

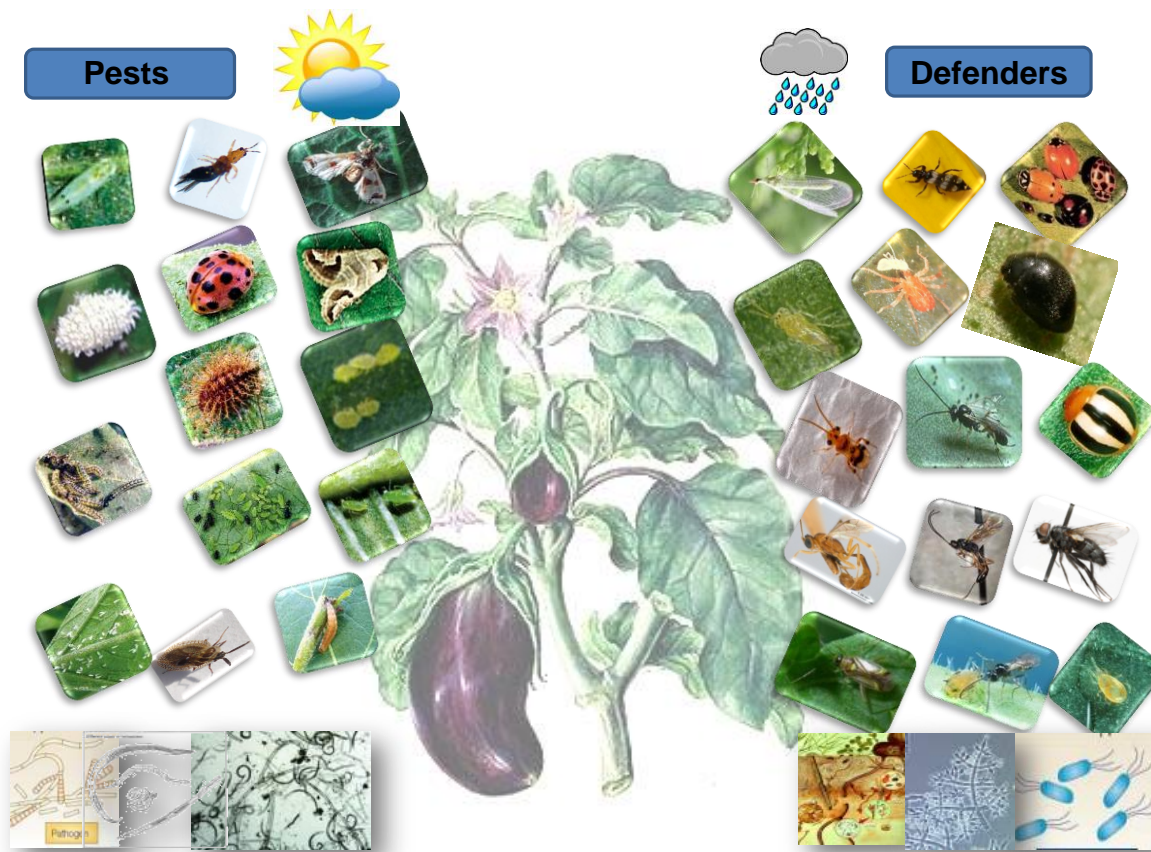
In field various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in crop field. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial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

Model Agro-Ecosystem Analysis chart

Date:
Village:
Farmer:










- Soil condition :
- Weather condition :
- Diseases types and severity :
- Weeds types and intensity :
- Rodent damage (if any) :
- No. of insect pests :

Decision taken based on the analysis of field situation

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	1 st instar larva can consume 15-19 aphids/day 2 nd instar larva can consume 45-52 aphids/day 3 rd 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	1 st & 2 nd nymphal instars can consume 1 small larva/day 3 rd & 4 th nymphal instars can consume 2 to 3 medium larvae/day 5 th 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
 <i>Bracon hebetor</i>	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)

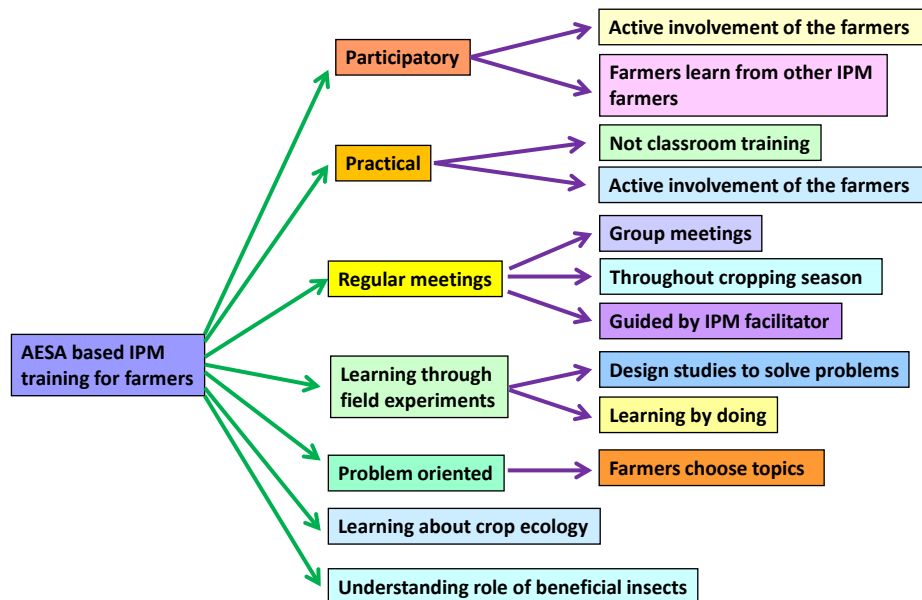
AESA is a season-long training activity that takes place in the farmer field. It is season-long so that it covers all the different developmental stages of the crop and their related management practices. The process is always learner-centered, participatory and relying on an experiential learning approach 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 after transplanting and at weekly intervals thereafter.

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 whitefly etc. @ 10-12 traps/ha. Locally available empty tins can be painted yellow/coated with grease/ Vaseline/castor oil on outer surface may also be used as yellow sticky trap. For thrips use blue sticky traps.

D. Surveillance through pheromone trap catches for brinjal fruit and shoot borer:

Pheromone traps for brinjal fruit and shoot borer

Procedure for observation: Total number of moths of brinjal fruit and shoot borer /trap/week should be recorded year round. The trapped moths should be destroyed and removed after each recording.

E. Light traps

Set up light traps 1 trap/acre 15 cm above the crop canopy for monitoring and mass trapping of brinjal stem borer. 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).

F. Nematode sampling

Collect 100 to 300 cm³ (200-300 g) 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. 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. 2004).**

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 nutrients using biofertilizers.
- Apply mycorrhiza and PGPR
- 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, Leguminosae, Umbelliferae, Brassicaceae etc. families



French bean



Marigold



Carrot



Sunflower



Buckwheat



***Desmodium* sp**



Mustard



Castor



Maize



Alfalfa



Chrysanthemum



Dill

Biodiversity of natural enemies: Parasitoids



Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



Flowering plants that attract natural enemies/repel pests

S. No.	Insect	Natural enemies	Attractant Plants
	Brinjal shoot and fruit borer	<p>Parasitoids: <i>Trichogramma chilonis</i> (egg), <i>Pseudoperichaeta</i> sp (larval), <i>Phanerotoma</i> sp (larval), <i>Itamoplex</i> sp (larval), <i>Eriborus argenteopilosus</i> (larval), <i>Diadegma apostata</i>, <i>Pristomerous testaceus</i>, <i>Trathala flavo-orbitalis</i> (larval and pupal), <i>Cremastus</i> sp (larval), <i>Bracon greeni</i> (larval), <i>Iphiaulax</i> sp (larval), <i>Goryphus nursei</i> (pupal) etc.</p> <p>Predators: Mirid bug (<i>Campyloneura</i> sp), lady bird beetles (<i>Cheilomenes sexmaculata</i>, <i>Coccinella septempunctata</i>-seven spotted, <i>Brumoides suturalis</i>-three striped), lacewing (<i>Chrysoperla carnea</i>), King crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants, big eyed bugs (<i>Geocoris</i> sp), pentatomid bug (<i>Eocanthecona furcellata</i>), earwigs, ground beetles, rove beetles etc.</p>	<ul style="list-style-type: none"> • Attractant plants : Carrot family, sunflower family, buckwheat, (lacewings and lady beetle)
	Aphids	<p>Parasitoids: <i>Aphidius colemani</i> (adults and nymphs), <i>Diaeretiella</i> spp. (adults and nymphs), <i>Aphelinus</i> spp. (adults and nymphs) etc.</p> <p>Predators: Anthocorid bugs/pirate bugs (<i>Orius</i> spp.), mirid bugs, syrphid/hover flies, green lacewings (<i>Mallada basalis</i> and <i>Chrysoperla carnea</i>), predatory coccinellids (<i>Stethorus punctillum</i>), staphylinid beetle (<i>Oligota</i> spp.), predatory cecidomyiid fly</p>	<p>Attractant plants:</p> <ul style="list-style-type: none"> • Carrot family, sunflower family, marigold, buckwheat, spearmint (syrphid fly, lacewing, minute pirate bug, damsel bug and lady beetle) • Cosmos (praying mantis). • Strips of rye, grains, cover crops and mulch beds (rove beetle) • Mustard, sweet clove, dill (aphid midge, <i>Aphidoletes aphidimyza</i>) • Nectar rich plants with small flowers i.e. anise, caraway,

		(<i>Aphidoletis aphidimyza</i>) and predatory gall midge, (<i>Feltiella minuta</i>), earwigs, ground beetles, rove beetles, spiders, wasps etc.	dill, parsley, mustard (aphid parasitoid and braconid wasp). • Sunflower, buckwheat and cowpea (braconid wasp)
	Leafhoppers	Parasitoids: <i>Lymaenon empoasca</i> (egg), <i>Anagrus flaveolus</i> , <i>Stethynium triclavatum</i> Predators: Lady beetle, ants <i>Distina albino</i> , <i>Chrysoperla</i> spp., mired bug (<i>Dicyphus hesperus</i>), big-eyed bug, (<i>Geocoris</i> sp) etc.	• Attractant plants: • Sunflower family, alfalfa (damselfly) carrot family, buckwheat, alfalfa, corn, shrubs (minute pirate bug).
	Mites	Predators: Anthocorid bugs (<i>Orius</i> spp.), mirid bugs, syrphid/hover flies, green lacewings (<i>Mallada basalis</i> and <i>Chrysoperla carnea</i>), predatory mites (<i>Amblyseius alstoniae</i> , <i>A. womersleyi</i> , <i>A. fallacies</i> and <i>Phytoseiulus persimilis</i>), predatory coccinellids (<i>Stethorus punctillum</i>), staphylinid beetle (<i>Oligota</i> spp.), predatory cecidomyiid fly (<i>Anthrocnodax occidentalis</i>), predatory gall midge (<i>Feltiella minuta</i>) etc.	• Citrus, avocados, bananas, papaya, palms, tea, cassava, maize, strawberries, vegetables, and cotton, as well as ornamental plantings, grasslands attract <i>Stethorus punctillum</i> . • <i>Daucus carota</i> (Queen Anne's lace) attracts lady bugs. • Crop rotation : Marigold, Chrysanthemum spp., <i>Sesbania</i> spp., <i>Crotalaria</i> spp., <i>Gaillardia</i> spp., castor bean and <i>Desmodium</i> spp., (parasitic nematodes) • Border crops: Strips of rye, grains, cover crops and mulch beds (rove beetle).
	Whitefly	Parasitoids: <i>Encarsia</i> sp, <i>Eretmocerus</i> sp, <i>Chrysocharis pentheus</i> (nymphal) Predators: Mirid bug (<i>Dicyphus hesperus</i>), dragonfly, spider, robber fly, praying mantis, fire ants, coccinellids, lace wings, big eyed bugs (<i>Geocoris</i> sp) etc.	• Border crops: maize, sorghum or pearl millet. • Attractant plants: • Cowpea (<i>Eretmocerus hayati</i>) • French bean (Predatory thrips)

A. Resistant/tolerant varieties:

Pest	Resistant/Tolerant Varieties
Bacterial wilt	Pusa Purple Cluster, Pusa Anupama, Arka Anand, Arka Keshav, Arka Nidhi, Arka Neelkanths, JC-1, JC-2, Pant Samrat, Pant Brinjal Hybrid1
Fruit and shoot borer	HLB-12, JC-1, GBH-1,JC-2, Pant Brinjal Hybrid1, PPI 1
Phomopsis blight	JC-1, JC-2, Pant Samrat, Pant Brinjal Hybrid1, Azad B-2
Little leaf virus	JC-1, JC-2

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

IV. Crop stage-wise IPM:

Crop Stage	Management	Activity
Pre-sowing*	Nutrients	<ul style="list-style-type: none"> • Add well rotten farm yard manure (FYM) @ 8-10 t/acre or vermicompost @ 5 t/acre. Incorporate at the time of field preparation at 1 week (vermicompost) or 2 to 3 weeks (FYM) before transplanting.
	Weeds	<ul style="list-style-type: none"> • At the time of field preparation, adopt stale seed bed technique to minimize the weeds menace in field. • Raising seedlings in raised nursery beds (15 cm) or pro-trays • Keep the nursery weed free by hand weeding. • Black plastic mulch prevents entry of light, which restricts germination of weed seeds and growth.
	Soil borne fungus, nematodes, resting stage of insects	<p>Cultural control:</p> <ul style="list-style-type: none"> • Deep summer ploughing of fields to control juveniles and adults of nematodes, and resting stages of insect pests. • Soil solarization: Cover the beds with polythene sheet of 45 gauge (0.45 mm) thickness for three weeks before sowing for soil solarisation which will help in reducing the soil borne pests. <p>Biological control:</p> <ul style="list-style-type: none"> • Apply neem cake @ 100 kg/acre at the time of transplanting for reducing nematodes and borer damage. <p>Chemical control:</p> <ul style="list-style-type: none"> • Apply carbofuran 3% CG @ 26,640 g/acre
Pre-sowing*	Damping off, root rot, wilt	<p>Cultural control:</p> <ul style="list-style-type: none"> • Avoid excessive watering and poorly drained areas in field • Use raised beds: more than 15 cm height is better for water drainage • Use of plug tray method and sterilized potting mixture • Nursery treatment: Mix 250 gm of <i>Trichoderma viride</i> 1.0% WP in 50 litre of water and drench the soil in 400 sq. mt. area
Seed Sowing/	Nutrient	<ul style="list-style-type: none"> • Before sowing, soil testing should be

Transplanting stage*	Management	<p>done to find out the soil fertility status. Nutrient should be provided as per soil test recommendations. Generally, brinjal needs 40: 24: 24 Kg N: P: K/acre for varieties and 60: 36: 36 kg N: P: K/acre for hybrids.</p> <ul style="list-style-type: none"> • Apply 50 % of N fertilizer dose as a basal before transplanting. • Apply entire dose of phosphatic fertilizers at the time of last ploughing/transplanting. • Biofertilizers: For seed treatment with <i>Azotobacter</i> and phosphorous solubilizing bacteria (PSB) cultures @ 8-10 g/kg seed • For seedling root dip treatment with <i>Azotobacter</i> and phosphorous solubilizing bacteria (PSB) cultures @ 250 g/acre seedlings
	Weed management	<ul style="list-style-type: none"> • Keep the nursery weed free by hand weeding. • Avoid carrying weed seedlings along with brinjal seedlings
	Damping off, wilt, root rot	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Raised nursery bed. • Avoid excess dose of nitrogenous and phosphorous fertilizers. • Use of plug tray method and sterilized potting mixture <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Seed treatment with <i>Trichoderma viride</i> 1% WP @ 5 g/kg of seed. Make a thin paste of required quantity of <i>Trichoderma viride</i> 1% WP with minimum volume of water and coat the seeds uniformly, shade dry the seeds just before sowing. • <u>Seedling root dip treatment:</u> Mix 10 g of <i>Trichoderma viride</i> 1% WP in one l of water and dip the brinjal seedling root for 15 minutes • <u>Soil treatment (main field):</u> Mix 1.0 kg of <i>Trichoderma viride</i> 1% WP with 25 kg FYM and broadcast uniformly over an acre of land and irrigate the field immediately <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Soil drench with captan 75% WP @ 1000 g in 400 l of water/acre (nursery)

* 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	<ul style="list-style-type: none"> • Apply the second dose (25%) of N at 45 days after transplanting. • Micronutrient deficiency should be corrected by foliar spray of particular micronutrient.
	Weeds	<ul style="list-style-type: none"> • Field should be weed free before 30 days crop stage. Use one or two hand weeding at 15 and 30 days after planting. • Mulching with black Low Density Polyethylene (LDPE) sheets of 30 micron thickness by burying both the ends into the soil to a depth of 10 cm will avoid weed growth.
	Hadda Beetle	<p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • All life stages are exposed on leaf surfaces, and the grub, pupae and adults can easily be found on skeletonized leaves. Pick off the insects by hand and destroy. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Conserve parasitoids such as <i>Pediobius foveolatus</i> (eulophid wasp parasitizing nymph), <i>Chrysocharis johnsoni</i> (nymphal), <i>Tetrastichus ovularum</i> (egg), <i>Uga menoni</i> (larval) etc. which suppress the population during March – July. • Conserve predators such as <i>Eocanthecona furcellata</i>, <i>Rhinocoris fuscipes</i> etc. • Spray NSKE 5% <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Spray cypermethrin 25 % EC @ 60-80 ml in 200 l of water/ acre or quinalphos @ 20% AF @ 600-700 ml in 300-400 l of water or triazophos 40% EC @ 500 ml in 200 l of water/acre or deltamethrin 1% + triazophos 35% EC @ 400-500 ml in 200 l of water/acre
	Aphids	<p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Release 1st instar larvae of green lacewing (<i>Chrysoperla carnea</i>) @ 4,000/acre

		<ul style="list-style-type: none"> • Conserve parasitoids such as <i>Aphidius colemani</i>, <i>Diaeretiella</i> spp., <i>Aphelinus</i> spp. etc. • Conserve predators such as ladybird beetles (<i>Coccinella septumpunctata</i> and <i>Menochilus sexmaculata</i>) etc. <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Spray betacyfluthrin 8.49% + imidacloprid 19.81% OD @ 70-80 ml in 200 l of water/acre or fenvalerate 20 % EC @ 150-200 ml in 240-320 l of water/acre or phorate 10% CG @ 6000 g/acre or phosphamidon 40% SL @ 250-300 ml in 300 l of water/acre or thiometon 25% EC @ 400 ml in 300-400 l of water/acre or deltamethrin 1% + triazophos 35% EC @ 400-500 ml in 200 l of water/acre
	<p>Leafhoppers</p>	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Grow okra as a trap crop. • Removal of affected parts. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Conserve parasitoids such as <i>Lymaenon empoascae</i> (egg), <i>Anagrus flaveolus</i> (egg), <i>Stethynium triclavatum</i> etc. • Conserve predators such as ladybird beetles, green lacewings etc. • Spray NSKE 5%. <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Apply phorate 10 % CG @ 6000 g/acre or spray phosphamidon 40% SL @ 250-300 ml in 200 l water/acre or quinalphos 25% EC @ 400 ml in 200-400 l of water/acre or quinalphos @ 20% AF @ 600-700 ml in 300-400 l of water or thiometon 25% EC @ 400 ml in 300-400 l of water/acre or spray betacyfluthrin 8.49% + imidacloprid 19.81% OD @ 70-80 ml in 200 l of water/acre or carbaryl 50% WP @ 800 g in 200-400 l of water/acre or cypermethrin 25 % EC @ 60-80 ml in 200 l of water/ acre or deltamethrin 1% + triazophos 35% EC @ 400-500 ml in 200 l of water/acre
	<p>Mites</p>	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Grow nurseries away from infested

		<p>crops and avoid planting next to infested fields</p> <ul style="list-style-type: none"> • Grow healthy crops; avoid water and nutrient stress • Apply mulch and incorporate organic matter into the soil to improve the water holding capacity and reduce evaporation • Keep perennial hedges such as pigeon peas, they are said to encourage predatory mites • Uproot and burn infested plants. This can be successful during the early stages of infestation when the mites concentrate on a few plants • Keep the field free of weeds • Remove and burn infested crop residues immediately after harvest <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Conserve predators such as green lacewings (<i>Mallada basalis</i> and <i>Chrysoperla carnea</i>), predatory mites (<i>Amblyseius alstoniae</i>, <i>A. womersleyi</i>, <i>A. fallacies</i> and <i>Phytoseiulus persimilis</i>), coccinellid beetles (<i>Stethorus punctillum</i>, staphylinid beetles (<i>Oligota</i> spp.), cecidomyiid fly (<i>Anthrocnodax occidentalis</i>), gall midge (<i>Feltiella minuta</i> etc. • Spray NSKE (5%) <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Spray fenazaquine 10% EC @ 500 ml in 200 l of water/acre or fenprothrin 30% EC @ 100-136 ml in 300-400 l of water/acre or dicofol 18.5% EC @ 540-1080 ml in 200-400 l of water/acre or malathion 50% EC @ 600 ml in 200-400 l of water/acre or flumite/flufenzinine 20% SC @ 160-200 ml in 200-400 l of water/acre or propargite 57% EC @ 400 ml in 160 l of water/ acre or spiromesifen 22.9% SC @ 160 ml in 200 l of water/acre or phorate 10% CG @ 6000 g/acre
	<p>Shoot and fruit borer</p>	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Continuous cropping of brinjal and potato in the same area encourages

		<p>the pest activity and hence proper rotation should be followed.</p> <ul style="list-style-type: none"> • Use resistant varieties • Intercropping of brinjal (2 rows) with coriander (one row) or fennel (1 row). • Install pheromone traps @ 4-5/acre for monitoring and 10/acre for mass trapping at 10 m distance from 20 DAT, the pheromone septa should be changed at regular interval. Place the traps either at canopy level or at slightly above the canopy level for effective attraction • Promptly remove and destroy infested shoots and fruit at regular intervals until final harvest. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Release <i>Trichogramma chilonis</i> at 20,000/acre/week commencing from 21 days after transplanting (based on adult activity) till end of the crop. Trichocards should be tied to sticks placed at 4-5 m apart in the field in the evening prior to 1 day of parasitoid adult emergence • Conserve predators such as <i>Campyloneura</i> sp (a bug), <i>Cheilomenes sexmaculata</i> (a ladybird beetle), <i>Coccinella septempunctata</i> (seven spotted ladybird beetle), <i>Brumoides suturalis</i> (three striped ladybird), <i>C. carnea</i> (lacewing) • Conserve parasitoids such as <i>Pseudoperichaeta</i> sp (tachinid fly) <i>Phanerotoma</i> sp, <i>Itamoplex</i> sp, <i>Eriborus argenteopilosus</i>, <i>Diadegma apostate</i>, <i>Pristomerus testaceus</i>, <i>Trathala flavor-orbitalis</i>, <i>Bracon greeni</i> • Spray azadirachtin 1% EC (10000 ppm) nee based EC @ 400-600 ml in 400 l of water/acre or azadirachtin 0.03% (300 ppm) nee oil based WSP @ 1000-2000 ml in 200-400 l of water/acre • Spray NSKE 5% • Apply entomopathogenic nematodes (EPNs) @ 1.0 crore infective juveniles of <i>Steinernema glaceri</i>/acre
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	<p>Stem borer</p>	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Avoiding ratooning of the brinjal crop • Uproot and burn the infested plants before planting the new crop to avoid carryover of the pest to the next crop <p><u>Mechanical control:</u></p> <ul style="list-style-type: none"> • Install light trap with exit option for

		<p>natural enemies of smaller size @ one/acre and operate around the dusk time (6 pm-10pm) to attract moths</p> <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Conserve parasitoids such as <i>Pristomerus euzopherae</i> etc.
	Root-knot nematode	<p><u>Biological control:</u> In the main field, apply 2 tons of FYM enriched with 100-200 kg of neem or pongamia cake</p> <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Apply carbofuran 3% CG @ 26,640 g/acre
	Bacterial wilt	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Growing resistant varieties • Crop rotation with non-solanaceous hosts. Since pathogen is soil born, a rotation with inclusion of maize, soybean, wheat, rice, gingelly and green manuring has been found effective in reducing the disease in infested soil. • Green manuring with <i>Brassica</i> sp (biofumigation) • Soil solarization with a transparent polyethylene sheet (125 µm thick) for 8-10 weeks during March-June in nurseries <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Use neem cake. • Mix 1 kg of <i>Trichoderma viride</i> 1% WP with 25 kg FYM and broadcast uniformly over an acre of land and irrigate the field immediately.
	Phomopsis blight	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Procuring seeds from healthy fruits followed by hot water treatment of seed at 50°C for 30 minutes. • Avoid continuous cultivation of brinjal. • Rotation with non-solanaceous crops such as paddy - gingelly will helps to check the disease development. • Summer deep ploughing helps in reducing initial inoculums. • Removal and destruction of diseased crop debris. • Use resistant varieties.

		<p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Spray zineb 75% WP @ 600-800 g in 300-400 l of water/acre or carbendazim 50% WP @ 120 g in 240 l of water/acre.
	<p>Little leaf of brinjal (vector jassid/leaf hopper)</p>	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Destruction of affected plants in the early stages. • Eradication of Solanaceous weed hosts • Plant tolerant varieties <p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Vector (jassid/leaf hopper) control by spraying insecticides (see jassid/leafhopper)
	<p><i>Alternaria</i> and <i>Cercospora</i> leaf spot</p>	<p><u>Chemical control:</u></p> <ul style="list-style-type: none"> • Spray carbendazim 50% WP @ 120 g in 240 l of water/acre
Reproductive stage	Nutrients	<ul style="list-style-type: none"> • The third dose (25%) of N to be applied at 60 days after transplanting. • Micronutrient deficiency should be corrected by foliar spray of particular micronutrient.
	Weeds	<ul style="list-style-type: none"> • Left over weeds should be removed from the field to avoid further spread of weed seeds.
	Fruit and shoot borer	<ul style="list-style-type: none"> • Remove damaged shoots • Release <i>T. chilonis</i> @ 20,000/acre at weekly intervals. • Other practices same as in vegetative stage.
	Hadda beetle	<ul style="list-style-type: none"> • Same as in seedling
	Leafhoppers, mites, and aphids	<ul style="list-style-type: none"> • Same as in seedling
	Bacterial blight	<ul style="list-style-type: none"> • Same as in seedling

Management of regional pests:

Termites:

Termites are the most important pests of cereal, vegetable, fruit, plantation and cash crops such as wheat, coconut, sugarcane, mango and tomato in India. Termites cause destruction of the germinating grains, nursery seedlings, transplanted seedlings and grown up plants. Termites could be both mound builders and subterranean forms. Termites are polyphagous, widely distributed throughout India. Loamy soils or sandy loams are more suitable. Their attack is severe in red soils and where irrigation facilities are inadequate.

Soon after first monsoon showers winged forms (reproductive castes) leave colony for flight to select mates. Majority perish due to predations by birds and other natural enemies. Survivors alight again on the soil, shed wings and enter soil in royal pairs. They are confined to royal chamber at enormous depth, copulate several times and start a colony. These are primary reproductives. In case one or both royal members die, supplementary reproductives develop to run the colony. Queen, after fertilization enlarges in size to a length of 11 cm. Eggs are laid @ 30,000/day and the longevity of the queen is 5-15 years, even up to 50 years. Males undergo little morphological changes but become more flattened. Egg period lasts for 30-90 days and nymphal period 6-12 months. Members that develop first in the colony are workers (sterile caste) which constitute 75-80% of colony. Workers take care of eggs, young ones till they live independently. They feed and tend the queen. They forage for food and cultivate fungal gardens. Workers are whitish yellow, soft bodied, flat and wingless. They only are injurious to crops. They feed on roots, stem of growing plants, even dead tissues of plants feeding on cellulose. As a result of damage, there will be wilting and drying at all stages of crop plants and plants may succumb (die). Soldiers (sterile caste) can be readily identified with powerful mandibles and are found at damaging site.

Management: Locating termitarium, digging out queen and destroying is the only permanent remedy. Fumigation of ant hill with carbon disulphide or chloroform mixture. Destruction of crop residues which form sources of infestation.

Mealy bug:

- All crop residues in previously infested fields should be removed and burnt. Crop residues and grass left in the field may harbor mealybug populations which may invade the new crop.
- The coccinellid beetles such as *Cryptolaemus montrouzieri*, *Cheilomenes sexmaculata*, *Rodolia fumida*, *Scymnus coccivora* and *Nephus regularis* are important predators of mealybug nymphs.
- Use of soap oil or fish oil resin soap twice at an interval of 15–20 days.

Brinjal lace bug:

- Crop rotation.
- Brinjal lace bugs are preyed upon by lady beetle larvae and adults, spiders, and shield-shaped soldier bugs.
- Apply phorate 10% CG @ 6000 g/acre.

Brinjal leaf roller and leaf webber:

- Monitor the crop for symptoms of damage.
- Remove and destroy the rolled leaves and caterpillars by hand when the infestation is light.

Thrips:

- Grow eggplant seedlings in insect-proof (50–64 mesh) net houses, net tunnels, greenhouses, or plastic houses to avoid early infestation, especially in the dry season.
- Use blue sticky traps to monitor thrips at regular intervals.
- Conserve predators such as green lacewings, predatory mites, and predatory thrips.
- Use mulch and reflective materials in the field to reduce the incidence of *T. palmi*.
- Apply phorate 10% CG @ 4000 g/acre.

Bud worm:

- Spray neem oil 2 ml/l.

V. Rodent pest management

Common/Scientific name	Damage symptoms	Management
Lesser bandicoot, <i>Bandicota bengalensis</i> Palm rat/House rat, <i>Rattus rattus</i>	<ul style="list-style-type: none"> • Active burrow in the field • Presence of damaged fruits in dug out rodent burrows and in premises 	<p>Cultural control:</p> <ul style="list-style-type: none"> • Practice clean cultivation/maintain weed free fields which reduces the harboring/hiding points for rodents. • Practice trapping with locally available traps using lure @ 20-25 traps/ac. In areas, where <i>Rattus rattus</i> is a problem, wonder traps/multi-catch traps work better and enable to trap more animals int a single trap. • Identify live rodent burrows and smoke the burrows with burrow smoker for 2-3 minutes • Erect owl perches @ 12-15/ac to promote natural control of rodents <p>Chemical control:</p> <ul style="list-style-type: none"> • In cases of high level of infestation (>50 live burrows/ac) practice poison baiting with zinc phosphide @ 2.0% on community approach.

		<p>PRACTICE PRE-BAITING TO AVOID BAIT SHYNESS</p> <p>Day 1: Close all the burrows in the fields, field bunds, canal bunds and surrounding barren lands etc.</p> <p>Day 2: Count the re-opened burrows and practice pre-baiting @ 20 g/burrow (98 parts of broken rice + 2 parts of edible oil)</p> <p>Day 4: Observe the re-opened burrows and treat the burrow with zinc phosphide poison bait (96 parts of broken rice + 2 parts of edible oil + 2 parts of zinc phosphide) @ 10g/ burrow. Collect the dead rats, if found any outside and bury them.</p>
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VI. Insecticide resistance and its management

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

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

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

- 1) **Monitor pests:** Monitor insect population development in fields to determine if and when control measures are warranted. Monitor and consider natural enemies when making control decisions. After treatment, continue monitoring to assess pest populations and their control.
- 2) **Focus on AESA.** Insecticides should be used only as a last resort when all other non-chemical management options are exhausted and P: D ratio is above 2: 1. Apply biopesticides/chemical insecticides judiciously after observing unfavourable P: D ratio and when

the pests are in most vulnerable life stage. Use application rates and intervals as per label claim.

3) **Ecological engineering for pest management:** Flowering plants that attract natural enemies as well as plants that repel pests can be grown as border/intercrop.




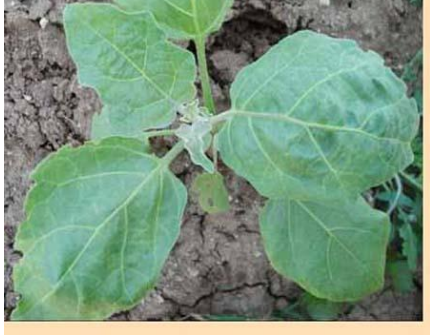


4) **Take an integrated approach to managing pests.** Use as many different control measures as possible viz., cultural, mechanical, physical, biological etc. Select insecticides with care and consider the impact on future pest populations and the environment. Avoid broad-spectrum insecticides when a narrow-spectrum or more specific insecticide will work. More preference should be given to green labeled insecticides.

5) **Mix and apply carefully.** While applying insecticides care should be taken for proper application of insecticides in terms of dose, volume, timing, coverage, application techniques as per label claim.




6) **Alternate different insecticide classes.** Avoid the repeated use of the same insecticide, insecticides in the same chemical class, or insecticides in different classes with same mode of action and rotate/alternate insecticide classes and modes of action.






7) **Preserve susceptible genes.** Preserve susceptible individuals within the target population by providing unsprayed areas within treated fields, adjacent "refuge" fields, or habitat attractions within a treated field that facilitate immigration. These susceptible individuals may outcompete and interbreed with resistant individuals, diluting the resistant genes and therefore the impact of resistance.




VII. Nutrients and their deficiency symptoms/disorders




		
<p>Nitrogen Deficiency Symptoms</p>	<p>Potassium Deficiency Symptoms</p>	<p>Magnesium Deficiency Symptoms</p>
<p>Light green to a yellowing symptom first occurs in older leaves progressing to the newer leaves. Firing of the older leaves. Plants stunted with hard, fibrous and slender stems. Older leaves become stiff.</p>	<p>Older leaves affected first. Leaf tips and margins turn yellow and then become scorched continuing inward to the leaf center. Leaf margin cup downward interveinal leaf necrosis restricted growth. Poorly developed roots and fruit.</p>	<p>Interveinal chlorosis of older larger leaves veins remain green necrotic areas with time and die. Leaf margins curl upward purple tinting on older leaves smaller fruit.</p>
<p>Correction Measure Foliar spray of Urea 2% twice at weekly interval.</p>	<p>Correction Measure Foliar application of K₂SO₄ @1%.</p>	<p>Correction Measure Foliar spray of MgSO₄ @2%.</p>
		
<p>Calcium Deficiency Symptoms</p>	<p>Sulphur Deficiency Symptoms</p>	<p>Boron Deficiency Symptoms</p>
<p>Necrosis at tip and margins of newer immature leaves nearest the terminal growth with a distorted appearance stems thick fibrous retarded growth terminal buds die. Brown to Black leathery spots on the underside of fruits.</p>	<p>Newer leaves light green to yellowish leaf veins appear lighter in color leaf tips cupping downward stems hard fibrous and spindly.</p>	<p>Leaves chlorotic small thick brittle and misshapened the base of the new leaves wrinkled or deformed internodes short with a resetting appearance terminal bud dies.</p>
<p>Correction Measure</p>	<p>Correction Measure</p>	<p>Correction Measure</p>
<p>Foliar spray of 2% Calcium sulphate twice at weekly intervals.</p>	<p>Foliar spray of K₂SO₄ @1%.</p>	<p>Soil application of borax @ 5Kg/ha or foliar spray of borax @ 0.2%.</p>





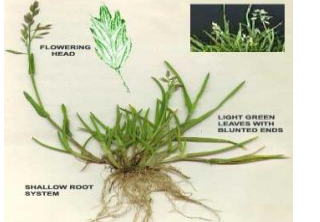


VIII. Description of common weeds

Common name	Description	Fig.
Major kharif weeds		
1. Pigweed <i>Amaranthus viridis</i> 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 <i>Coronopus didymus</i> (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 <i>Solanum nigrum</i> 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 <i>Portulaca oleracea</i> L. Portulacaceae	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 smooth, granular, or stellate, with rounded tubercles.	
5. False amaranth <i>Digera arvensis</i> 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 <i>Dactyloctenium aegyptium</i> (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 <i>Digitaria sanguinalis</i> (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.	

<p>8. Barnyard grass <i>Echinochloa crusgalli</i> (L.) Beauv. Poaceae</p>	<p>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.</p>	
<p>Sedges</p>		
<p>9. Purple nutsedge <i>Cyperus rotundus</i> L. Cyperaceae</p>	<p>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.</p>	
<p>10. Flat sedge <i>Cyperus iria</i> L. Cyperaceae</p>	<p>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</p>	

	wide, obovate, triangular in cross section, dark-brown to almost black; the surface is almost smooth.	
Major rabi weeds		
1. Lambs quarter <i>Chenopodium album</i> L. Chenopodiaceae	<p>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 paniced axillary spike. Fruits utricle, seeds round, compressed, black and shining.</p>	
2. Scarlet pimpernel <i>Anagallis arvensis</i> Primulaceae L	<p>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, seeds 1.3 mm long, trigonous, brown.</p>	
3. Sweet clover <i>Melilotus indica</i> (L.) All. Fabaceae	<p>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.</p>	

<p>4. Fine leaf fumitory <i>Fumaria parviflora</i> Lam. Fumariaceae</p>	<p>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.</p>	 
<p>5. Corn spurry <i>Spergula arvensis</i> L. Caryophyllaceae</p>	<p>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.</p>	 
<p>6. Bluegrass <i>Poa annua</i> L. Poaceae</p>	<p>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 <i>Poa</i> boat-shaped leaf tips- a key characteristic of annual bluegrass. Inflorescence is branched with three to eight flattened florets in each spikelet.</p>	 
<p>7. Canary grass <i>Phalaris minor</i> Retz. Poaceae</p>	<p>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.</p>	

IX. Description of insect pests

1. Fruit and shoot borer:

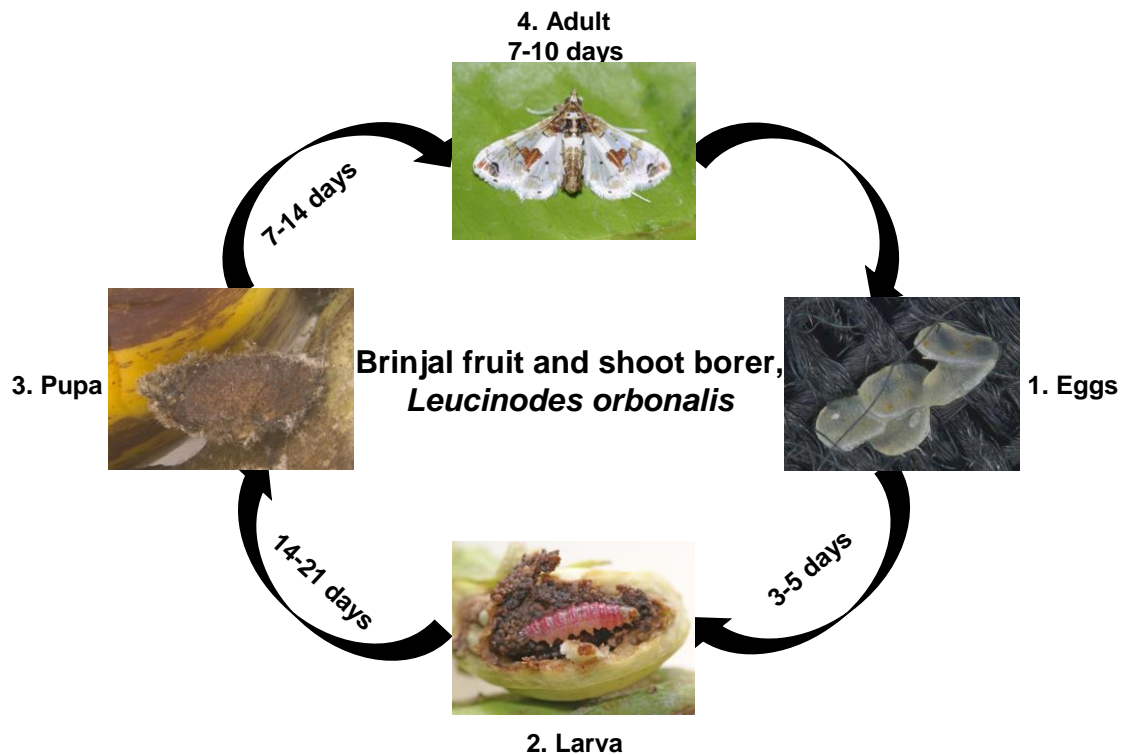
Biology:

Egg: The adult females lay eggs singly or in groups of two to five on the under surfaces of leaves, tender shoots, flower buds, or the base of developing fruits. Each female lays about 250 eggs, which are creamy white soon after laying, but turn red before hatching. The egg period is three to five days.

Larva: The larva is creamy white to pink in color in the early stages. The grown-up larva is pink with sparse hairs on the warts on the body and a dark brown or blackish head. The full-grown larva measures about 16-23 mm in length. The larva usually has five instars, sometimes six. The larval period is about two weeks in summer and three weeks in winter.

Pupa: The larva pupates on the plant parts or plant debris on the soil surface, or rarely, under the soil. The pupation occurs in tough silken cocoons, and the pupa is dark brown in color. The pupa measures about 13 mm. The pupal period varies from one to two weeks.

Adult: The moth is white or dirty white with pale brown or black spots on the dorsum of thorax and abdomen. Wings are white with a pink or blue tinge, and have pink or brown and red spots on the forewings. The female is bigger than male, with a bulged abdomen. The female moth tends to curl its abdomen upwards. The adult life span is about a week; the females live longer than males.



1, 2, 3, 4. <http://www.nbaii.res.in/insectpests/Leucinodes-orbonalis.php>

Damage symptoms:

It is mostly monophagous, sometimes also feeds on potato, *Solanum indicum* L., *S. xanthocarpum*, *S. torvum*, and *S. nigrum*. Upon hatching, the larva starts boring near the growing point or into the flower buds or fruits. During the early vegetative phase of the crop growth, it feeds on the tender shoots. Soon after boring into the shoots and fruits, the larva seals the entry hole with excreta. The larva tunnels inside the shoot and feeds on the inner contents. It also fills the feeding tunnels with excreta. This results in wilting of young shoots, followed by drying and drop off, which slows plant growth. In addition, it produces new shoots, delaying crop maturity.

During the early reproductive phase, the larva occasionally may feed on flower buds and flowers. However, it prefers to feed on the fruit rather than other plant parts during the fruiting stage of the crop. Damaged fruit exhibits boreholes on the surface, which often are sealed with excreta. The larva feeding inside the fruit creates tunnels filled with frass and fecal pellets. Hence, the fruit becomes unfit for marketing and consumption. Under heavy infestation, more than one larva will feed inside the same fruit.

1. Shoot damage



2. Fruit damage



1, http://203.64.245.61/fulltext_pdf/EB/2001-2010/eb0122.pdf

2. Photo by: SK Sain

Parasitoids:

1. *Pseudoperichaeta* sp



2. *Phanerotoma* sp



3. *Itamoplex* sp



4. *Eriborus argenteopilosus* 5. *Trathala flavor-orbitalis* 6. *Trichogramma* sp



1. <http://www.fugleognatur.dk/artintro.asp?ID=14759>
2. http://arthropoda.pavouci-cz.eu/CZ%20INSECTA/CZ%20HYMENOPTERA/Str_Braconidae.htm
3. <http://cedarcreek.umn.edu/insects/album/025016166ap.html>
4. <http://www.nbaii.res.in/Featured%20insects/Eriborusargent.htm>
5. <http://www.agr.kyushu-u.ac.jp/lab/ine/suiden/suiden2.html>
6. http://gsquaredbugs.com/?page_id=318

Predators:

1. Lacewing



2. Lady beetle



3. Spider



4. Fire ant



5. Dragon fly



6. Robber fly



7. Reduviid bug



8. Praying mantis



9. Black drongo (King crow)



10. Wasp



11. Common mynah



12. Big-eyed bug (Geocoris sp)



13. Earwig**14. Ground beetle****15. Pentatomid bug
(*E. furcellata*)****16. Mirid bug
(*Campyloneura* sp)**

1. http://www.macro-world.cz/image.php?id_foto=514&gal=29
2. <http://ladybug.blogspot.in/>
3. http://en.wikipedia.org/wiki/Wolf_spider
4. <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>
5. <http://en.wikipedia.org/wiki/Dragonfly>
6. <http://www.warpedphotosblog.com/robber-fly-and-prey>
7. <http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-of-predators,-parasites-and-pathogens/assassin-bugs>
8. <http://spirit-animals.com/praying-mantis/>
9. <http://nagpurbirds.org/blackdrongo/picture/1639>
10. <http://somethingscrawlinginmyhair.com/2011/09/17/yellowjacket-with-prey/>
11. <http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/>
12. <http://bugguide.net/node/view/598529>
13. <http://www.flickr.com/photos/johnhallmen/2901162091/>
14. <http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/Ground%20Beetle%20-%20Pterostichus%20madidus.html>
15. http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asoptinae/Eocanthecona.htm
16. <http://christophe.quintin.pagesperso-orange.fr/Heteropteres.html>

2. *Epilachna* beetle/Hadda beetle/Spotted leaf beetle:

Spotted beetles are distributed from East Asia to South Asia and Australia. They are polyphagous, and feed predominantly on cucurbits, brinjal, potato, and kidney bean as well as eggplant. These beetles are considered to be one of the most serious groups of pests damaging eggplant. In addition, they also feed on other solanaceous plants such as *S. nigrum*, *S. xanthocarpum*, *S. torvum*, *Datura* sp., *Physalis* sp. and *Withania somnifera* (L.).

Biology:

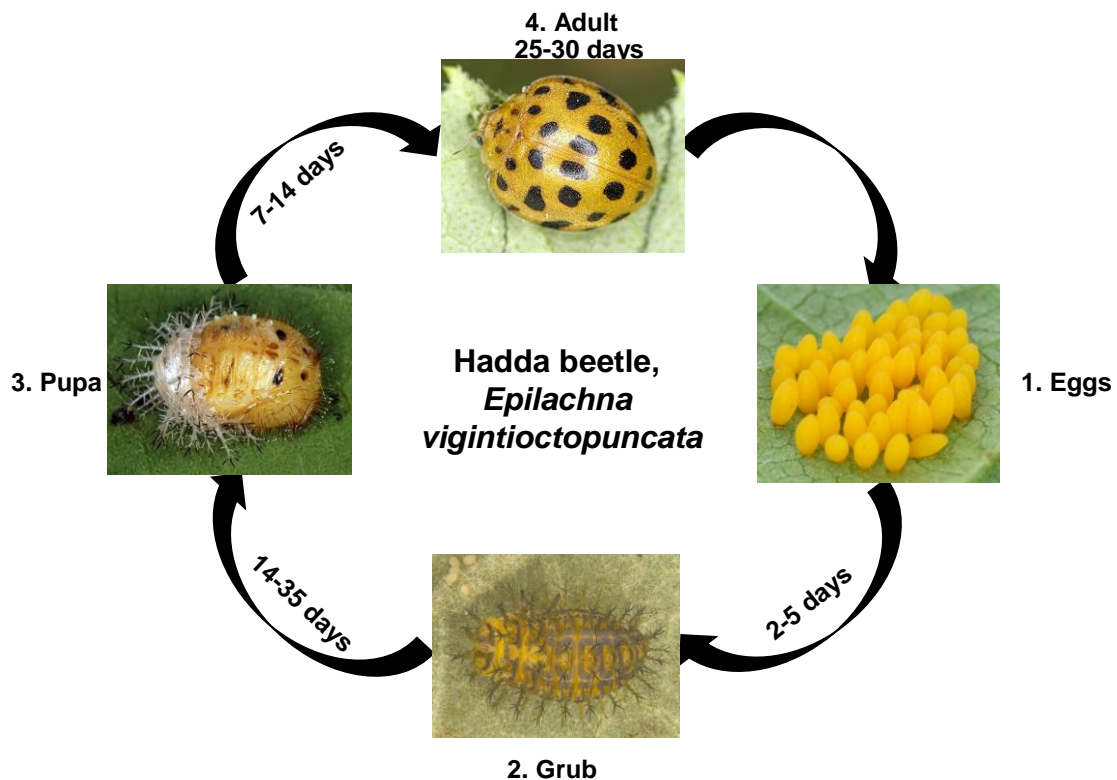
Egg: The females lay eggs mostly on the lower leaf surfaces. Each female lays about 100-400 eggs. The egg is spindle-shaped and yellowish in color. Eggs are laid in clusters of 10-40. The egg period varies from two to five days.

Grub: The grub is creamy white or yellowish in color with black spiny hairs on the body. The grub period is two to five weeks depending on the temperature. Grubs pupate on the leaves and stem.

Pupa: The pupa resembles the grub but is mostly darker in color, although it sometimes is yellowish in color. The pupa bears spiny hairs on the posterior, but not the anterior, part of the

body. The pupal period is one to two weeks.

Adult: The subfamily Epilachninae contains plant-feeding ladybird beetles because most other ladybird beetles are predators, not plant pests. These brownish or orange-colored, hemispherical beetles are larger than other ladybird species. *E. vigintioctopunctata* (in Latin, viginti means 20 and octo means 8) has 28 black spots on the forewing (elytra). *E. dodecastigma* (dodecam means 12 in Greek) has 12 black spots on the elytra. However, beetles with 14, 16, 18, 20, 22, 24 or 26 spots have been observed under field conditions, due to mating between females of *E. dodecastigma* and males of *E. vigintioctopunctata* (Lall and Mandal 1958).



1. <http://bugguide.net/node/view/573366/bgimage>
2. <http://www.nbaii.res.in/insectpests/Epilachna-vigintioctopunctata.php>
3. <http://www.pestnet.org/SummariesofMessages/Pests/PestsEntities/Insects/Beetles/Henosepilachnasp,Guam.aspx>
4. <http://lepidoptera.butterflyhouse.com.au/lynf/lynf.html>

Damage symptoms:

The grub and adult have chewing mouthparts. Hence, they scrape the chlorophyll from the epidermal layers of the leaves. The feeding results in a typical ladder-like window. The windows will dry and drop off, leaving holes in the leaves. In severe infestations, several windows coalesce together and lead to skeletonization—the formation of a papery structure on the leaf.

Damage symptoms:

Ladder-like windows:



Parasitoid:

1. *Pediobius foveolatus*



1. http://www.nbaii.res.in/Featured%20insects/Pediobius_foveolatus.htm

Predators:

1. Reduviid bug/assassin bug (*Rhynocoris fuscipes*)
2. Pentatomid bug, (*Eocanthecona furcellata*)



1. <http://www.corzonneveld.nl/selected/2007/tessin/malvaglia.php>
2. <http://www.bvtvhcm.gov.vn/document.php?id=130&cid=22>

3. Brinjal stem borer:

This insect is limited in distribution. It is found mostly on the Indian subcontinent. This oligophagous insect feeds mainly on eggplant, and sometimes on other solanaceous Plants such as brinjal, potato, and chilies. Although it is not a serious pest, infestations occasionally can be severe. Monitor the crop for symptoms of damage.

Biology:

Egg: The cream-colored eggs are laid either singly or in groups on the tender leaves, shoots, and petioles. The eggs are elongate and flat. The egg period varies from three to ten days.

Larva: The larva is white or yellowish white in color with several bristly hairs and an orange-brown or red head. The full-grown larva is 1.5 to 2 cm long. The larval period is about four to eight weeks depending on the temperature.

Pupa: Larvae pupate within silken cocoons inside the feeding tunnel in the stem or in the soil. The pupal period is about one to two weeks.

Adult: The medium-sized moth is pale in color. The forewing is pale yellow or grayish-brown in color, with black lines in the middle. The hind wings are white.

Damage symptoms:

Soon after hatching, the larva starts boring into the stem near ground level. Mostly they bore in the branching area or in leaf axils, and seal the entry holes with excretory materials. Larvae feed downward along the length of the main stem, which results in stunted growth or wilting and withering of the whole plant. The later stages of plant growth are most vulnerable to this insect.

- 1.
2. **Larval tunnels**



1. <http://www.ikisan.com/Crop%20Specific/Andhra%20Pradesh/Brinjal/Insect%20%20Management.htm>

2. http://www.moef.nic.in/divisions/csurv/geac/presentation_brinjal.pdf

4. Leaf hoppers:

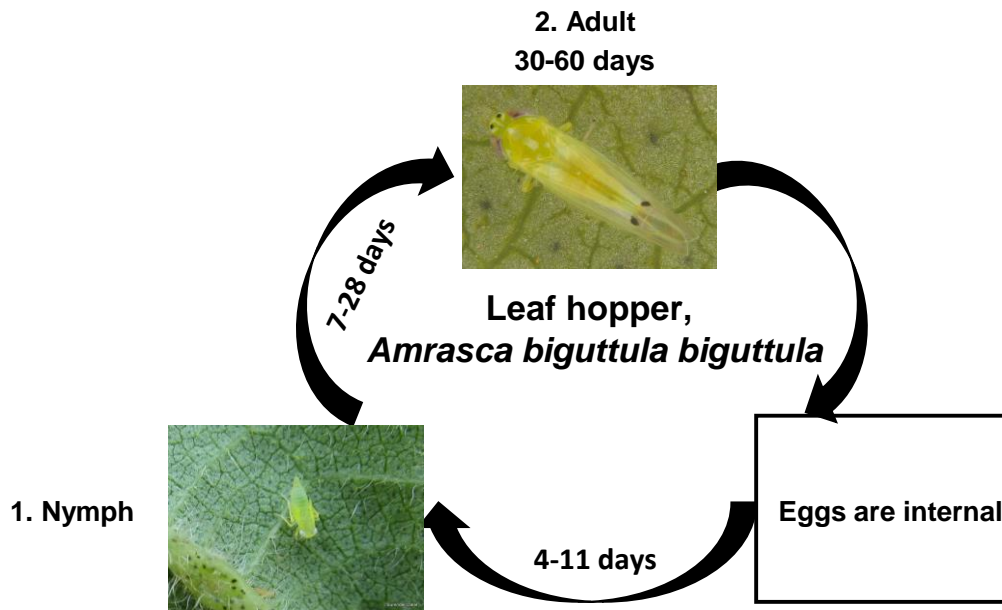
It occurs in several countries including India, Bangladesh, China, Myanmar, North Africa, Pakistan, Philippines, Sri Lanka, and Taiwan. Relatively dry (mean temperature around 32°C) and humid (RH around 70%) weather favors population build-up.

Biology:

Egg: Adult females lay eggs along the midrib and lateral veins of the leaves. The egg period is 4 to 11 days.

Nymph: The nymphs resemble the adults, but lack wings. Instead, they have slightly extended wing pads. They are pale green in color. They tend to move sideways when disturbed. The nymphal period varies from one to four weeks depending on the temperature.

Adult: The adults are wedge-shaped, pale green insects. They have fully developed wings with a prominent black spot on each forewing. The adults may live for one to two months.



1. <http://www.flickr.com/photos/dalalsure/3726494086/>
2. <http://www.nbaii.res.in/insectpests/Amrasca-biguttula.php>

Damage symptoms:

Both nymphs and adults suck the sap from the lower leaf surfaces through their piercing and sucking mouthparts. While sucking the plant sap, they also inject toxic saliva into the plant tissues, which leads to yellowing. When several insects suck the sap from the same leaf, yellow spots appear on the leaves, followed by crinkling, curling, bronzing, and drying, or “hopper burn”. Leafhoppers also damage in okra, cotton, and potato.

Damage symptoms:



http://203.64.245.61/fulltext_pdf/EB/2001-2010/eb0122.pdf

Parasitoids:

1. *Anagrus flaveolus*



2. *Stethynium triclavatum*



1. <http://www.plantwise.org/default.aspx?site=234&page=4279&dsID=5090>

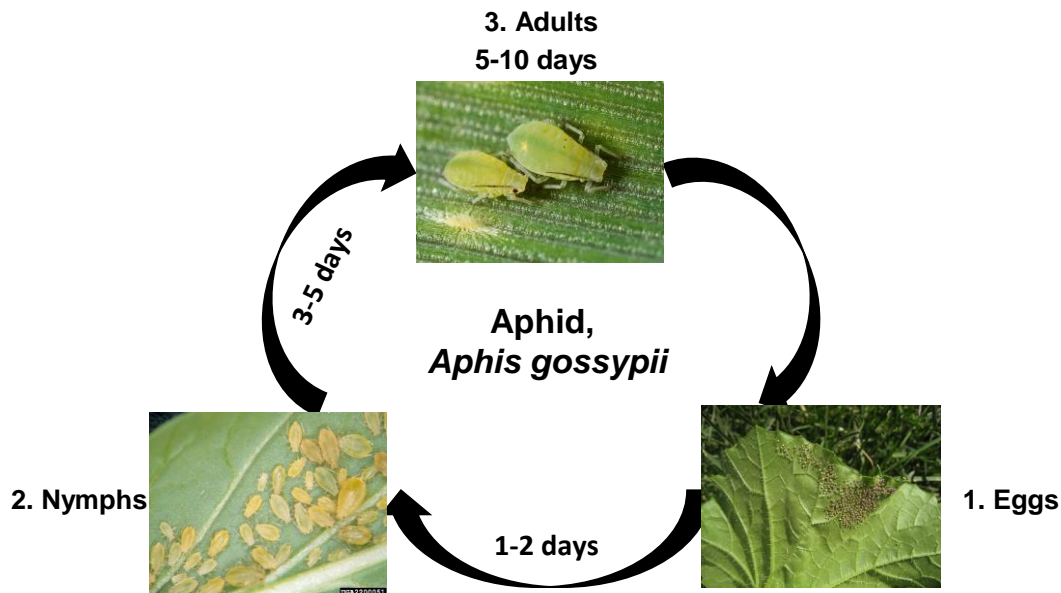
2. http://www.nbaii.res.in/IndianMymaridae/Mymaridae/html/Mymaridae/Stethynium_Enock.htm

5. Aphids:

This is a cosmopolitan pest and highly polyphagous. It prefers to feed on cotton, cucurbits, eggplant, and okra. Aphids occur during the cool dry season.

Biology:

Adult: Unlike many insects, most aphids do not lay eggs. They usually reproduce through parthenogenesis (development of embryo without mating with males) and are viviparous (give birth to nymphs directly rather than eggs). The adult color is highly variable and it varies from light green to greenish brown. Both wingless and winged forms occur. Winged forms are produced predominantly under high population density conditions, inferior host plant quality, etc. The wingless forms are more common. They possess a pair of black-colored cornicles on the dorsal side of the abdomen. Aphids mostly are found in groups. Each female produces about 20 nymphs a day, which become adults in a week.



1. <http://www.flickr.com/photos/23293858@N04/2672985270/>
2. <http://pubs.ext.vt.edu/2902/2902-1081/2902-1081.html>
3. <http://www.flickr.com/photos/25848431@N02/7479982150/>

Damage symptoms:

Although *A. gossypii* is polyphagous, it prefers to feed on cotton and cucurbit vegetables; it is commonly known as “cotton aphid” or “melon aphid.” Both the nymphs and adults possess piercing and sucking mouthparts. They occur in large numbers on the tender shoots and lower leaf surfaces, and suck the plant sap. Slightly infested leaves exhibit yellowing. Severe aphid infestations cause young leaves to curl and become deformed. Like whitefly, aphids also produce honeydew, which leads to the development of sooty mould.



Damage on the plant and honeydew Deposit on the mulch surface

http://203.64.245.61/fulltext_pdf/EB/2001-2010/eb0122.pdf

Parasitoid:

- 1. *Aphidius colemani* 2. *Aphelinus* spp.**



1. <http://biobee.in/products-and-services/solutions/bio-aphidius/>
 2. <http://australianmuseum.net.au/image/Aphelinus-wasp-stings-aphid-Denis-Crawford/>

koilPredators:

- 1. Lacewing**



- 2. Lady beetle**



- 3. Spider**



- 4. Syrphid larva**



1. http://www.macro-world.cz/image.php?id_foto=514&gal=29
 2. <http://ladybug.blogspot.in/>
 3. http://en.wikipedia.org/wiki/Wolf_spider
 4. <http://en.wikipedia.org/wiki/Aphid>

6. Whitefly:

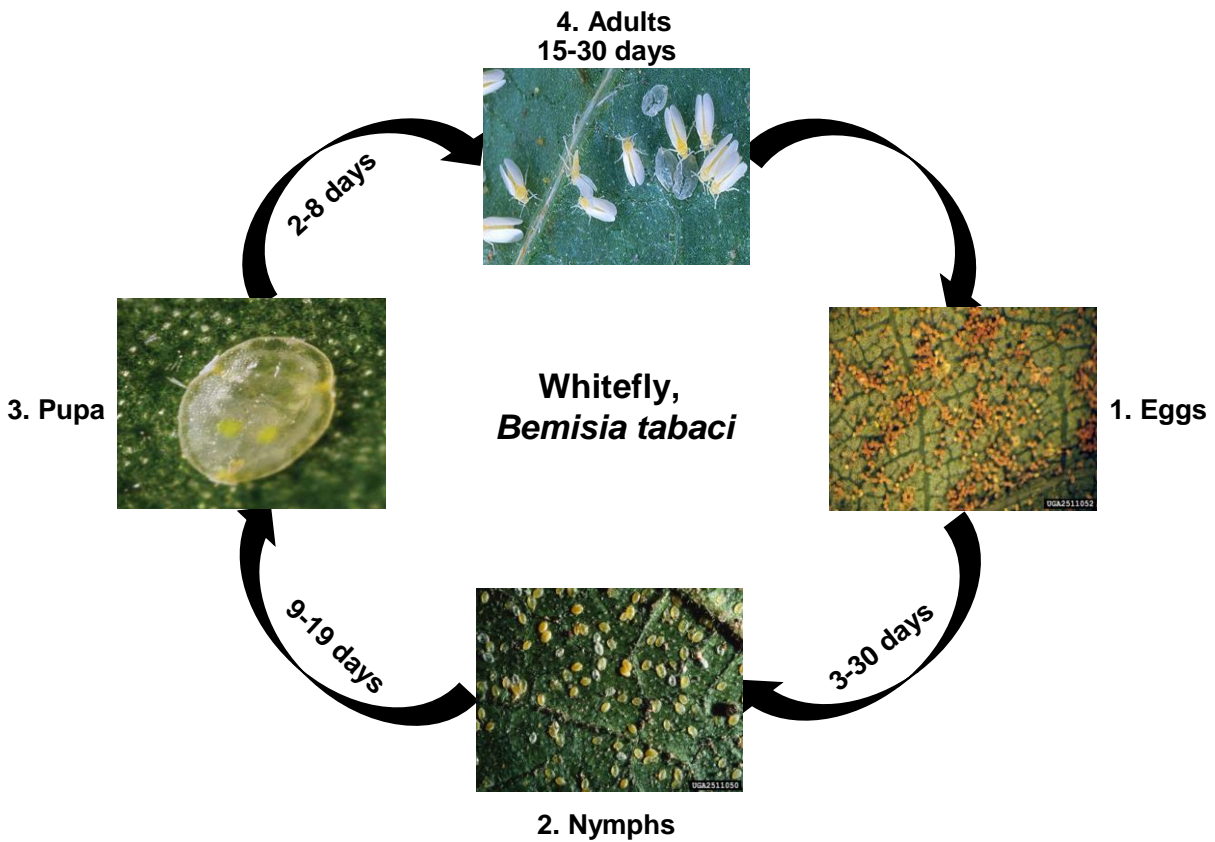
The whitefly is widely distributed in tropical and subtropical regions, and in greenhouses in temperate regions. *B. tabaci* is highly polyphagous and is known to feed on several vegetables including tomato, eggplant and okra, and on field crops and weeds. Hot and dry conditions favor the whitefly, while heavy rain showers drastically reduce its population build-up. This insect is active during the day and settles on lower leaf surfaces at night.

Biology:

Egg: The females mostly lay eggs near the veins on the underside of leaves. They prefer hairy leaf surfaces to lay more eggs. Each female can lay about 300 eggs in its lifetime. Eggs are small (about 0.25 mm), pear-shaped, and vertically attached to the leaf surface through a pedicel. Newly laid eggs are white and later turn brown. The eggs are not visible to the naked eye, and must be observed under a magnifying lens or microscope. Egg period is about three to five days during summer and 5 to 33 days in winter.

Nymph: Upon hatching, the first instar larva (nymph) moves on the leaf surface to locate a suitable feeding site. Hence, it is commonly known as a “crawler.” It then inserts its piercing and sucking mouthpart and begins sucking the plant sap from the phloem. The first instar nymph has antennae, eyes, and three pairs of well developed legs. The nymphs are flattened, oval-shaped, and greenish-yellow in color. The legs and antennae are atrophied during the next three instars and they are immobile during the remaining nymphal stages. The last nymphal stage has red eyes. This stage is sometimes referred to puparium, although insects of this order (Hemiptera) do not have a perfect pupal stage (incomplete metamorphosis). Nymphal period is about 9 to 14 days during summer and 17 to 73 days in winter (David 2001). Adults emerge from puparia through a T-shaped slit, leaving behind empty pupal cases or exuviae.

Adult: The whitefly adult is a soft-bodied, moth-like fly. The wings are covered with powdery wax and the body is light yellow in color. The wings are held over the body like a tent. The adult males are slightly smaller in size than the females. Adults live from one to three weeks.



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

Damage symptoms:

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



Crowding on lower surface of leaf

http://203.64.245.61/fulltext_pdf/EB/2001-2010/eb0122.pdf

Parasitoids:

1. *Encarsia formosa*



2. *Eretmocerus* spp.



3. *Chrysocharis pentheus*



1. <http://www.buglogical.com/whitefly-control/encarsia-formosa/>

2. http://www.dongbufarmceres.com/main/mboard.asp?strBoardID=c_product01_en

3. http://baba-insects.blogspot.in/2012/05/blog-post_21.html

Predators:

1. *Dicyphus hesperus* (mirid bug)



2. Lacewing



3. Lady beetle



4. Big-eyed bugs (*Geocoris* sp)



1. <http://nathistoc.bio.uci.edu/hemipt/Dicyphus.htm>

2. http://www.macro-world.cz/image.php?id_foto=514&gal=29

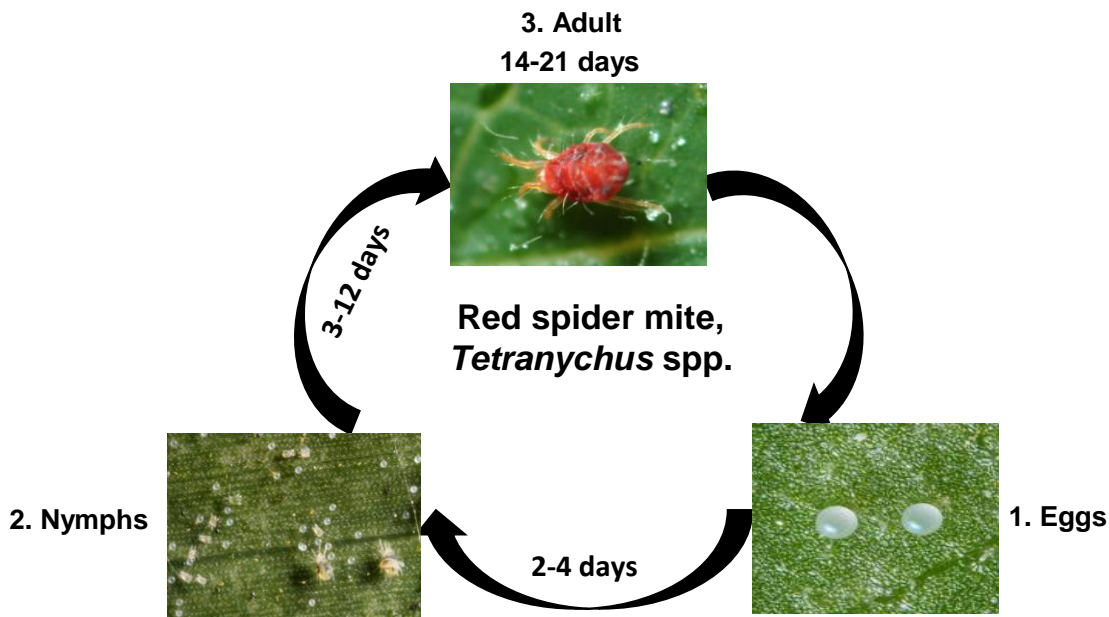
3. <http://ladybug.blogspot.in/>

4. http://commons.wikimedia.org/wiki/File:Geocoris_punctipes.jpg

7. Mites:

Biology:

Tetranychus urticae is commonly known as red spider mite or two spotted spider mite. They are minute in size, and vary in color (green, greenish yellow, brown, or orange red) with two dark spots on the body. Eggs are round, white, or cream-colored; egg period is two to four days. Upon hatching, it will pass through a larval stage and two nymphal stages (protonymph and deutonymph) before becoming adult. The lifecycle is completed in one to two weeks. There are several overlapping generations in a year. The adult lives up to three or four weeks.



1. <http://bugguide.net/node/view/348888>

2. <http://entomology.k-state.edu/extension/insect-photo-gallery/Corn-Insects.html>

3. <http://nathistoc.bio.uci.edu/Other%20Arachnids/Acari4.htm>

Damage symptoms:

Spider mites usually extract the cell contents from the leaves using their long, needle-like mouthparts. This results in reduced chlorophyll content in the leaves, leading to the formation of white or yellow speckles on the leaves. In severe infestations, leaves will completely desiccate and drop off. The mites also produce webbing on the leaf surfaces in severe conditions. Under high population densities, the mites move to using strands of silk to form a ball-like mass, which will be blown by winds to new leaves or plants, in a process known as "ballooning."

1. White and yellow speckles



2. Webbing of leaves



http://203.64.245.61/fulltext_pdf/EB/2001-2010/eb0122.pdf

Predators:

1. Predatory mites



2. Predatory thrips



3. *Oligota* spp.



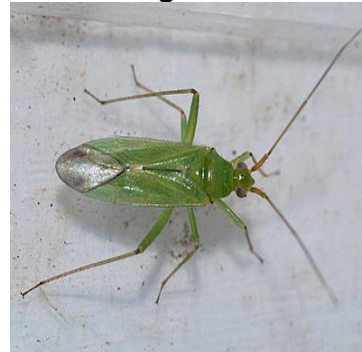
4. *Orius* sp (pirate bug)



5. Hover flies



6. Mirid bug



1. <http://www.dragonfli.co.uk/natural-pest-control/natural-enemies>

2. http://biocontrol.ucr.edu/hoddle/persea_mite.html

3. http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33

4. [http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_\(cropped\).jpg](http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg)

5. <http://freepages.misc.rootsweb.ancestry.com/~larsonmorgan/flies/flies.html>

6. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html

X. Description of plant diseases

1. Little leaf:

Damage symptoms:

- Infection is initially observed in one branch and later the entire plant shows symptoms
- Reduction in size of newly formed leaves
- Reduction in petiole length making the leaves appear to be sticking to the stem
- Affected plants have narrow, soft, smooth and yellow shorter leaves
- Internodes of the stem are also shortened
- Axillary buds get enlarged but their petioles and leaves also remain shortened giving the plant a bushy appearance
- Mostly there is no flowering but if flowers are formed they remain green
- Fruiting is rare, if any fruit is formed, it becomes hard, tough and fails to mature. Young fruit turns necrotic, get mummified and cling to the plant

Little leaf disease caused by phytoplasma, and vectored by *Hishimonus phycitis*



Diseased plant; Photo by: SK Sain

Survival and spread:

Primary: The pathogen survives in collateral weed hosts like *Datura fastuosa*, *D. stramonium*, *Catheranthus roseus*, *Argemone mexicana* and transmitted to egg plant by jassids.

Secondary: Jassid - *Hishimonas phycitis*

*For management refer to page number---

2. Bacterial wilt:

Damage symptoms:

- Sudden wilting and death of infected plants is the characteristic symptom. The petioles of older leaves droop down and the leaves show epinasty symptoms accompanied by yellowing and stunting of whole plant.
- Typical browning of vascular tissues of roots and stems can be seen
- From cross sections of infected plants whitish bacterial ooze comes out

Bacterial wilt



http://2.bp.blogspot.com/-E7jzgH4paXM/TdZF5xZ_WYI/AAAAAAAAAMU/pGjIcm0zac0/s1600/2BACTERIAL+WILT.jpg

Survival and spread:

Primary: The bacterium (cells) is both seed and soil borne in nature and overwinters in infected plant parts in soil, in wild host plants and weeds

Secondary: Bacterial cells spread through irrigation water or infested soil and agricultural implements

Favourable conditions:

- Relatively high soil moisture and soil moderate temperature favour the disease development
- Continuous cultivation of Solanaceous crops in the same field.

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

3. Phomopsis fruit rot or blight:

The disease is severe in tropical and sub-tropical areas of the world. In India, it was reported in 1935 in Gujarat. The pathogen attacks foliage and fruits, but the latter phase is more destructive.

Damage symptoms:

- The plants are attacked at all stages of growth, producing damping-off symptoms in nurseries

and collar rot on young plants

- On leaves, circular to irregular, clearly defined grayish brown spots having light centers appear. The diseased leaves become yellowish in colour and may drop off. Several black pycnidia can be seen on older spots
- The lesions on stem are dark brown, round to oval and have grayish centers where pycnidia develop. At the base of the stem, the fungus causes characteristic constrictions leading to canker development and toppling of plants
- On fruits, small pale sunken spots showing concentric rings appear which on enlargement cover entire fruit surface. These spots become watery leading to soft rot phase of the disease. A large number of dot like pycnidia also develop on such spots
- The infection of fruit through calyx leads to development of dry rot and fruits appear black and mummified.



Disease symptoms on fruit, stem and plant

Photos by : SK Sain

Survival and spread:

Primary: Pathogen is seed borne and also survives in plant debris as mycelium and pycnidia

Secondary: Conidia dispersed through rain splashes, irrigation water, agricultural tools and insects

Favourable conditions:

- High relative humidity coupled with higher temperatures favour disease development. Maximum disease development takes place at about 26°C under wet weather conditions

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

4. Damping off:

Damage symptoms:

- Damping off occurs in two stages, i.e. the pre-emergence and the post-emergence phase.
- In the pre-emergence the phase the seedlings are killed just before they reach the soil surface.
- The young radical and the plumule are killed and there is complete rotting of the seedlings.
- The post-emergence phase is characterized by the infection of the young, juvenile tissues of the collar at the ground level.

- The infected tissues become soft and water soaked. The seedlings topple over or collapse.



<http://geekgardener.in/wp-content/uploads/mygarden672.jpg>

Favourable conditions:

- High humidity, high soil moisture, cloudiness and low temperatures below 24° C for few days are ideal for infection and development of disease.
- Crowded seedlings, dampness due to high rainfall, poor drainage and excess of soil solutes hamper plant growth and increase the pathogenic damping-off.

Survival and spread:

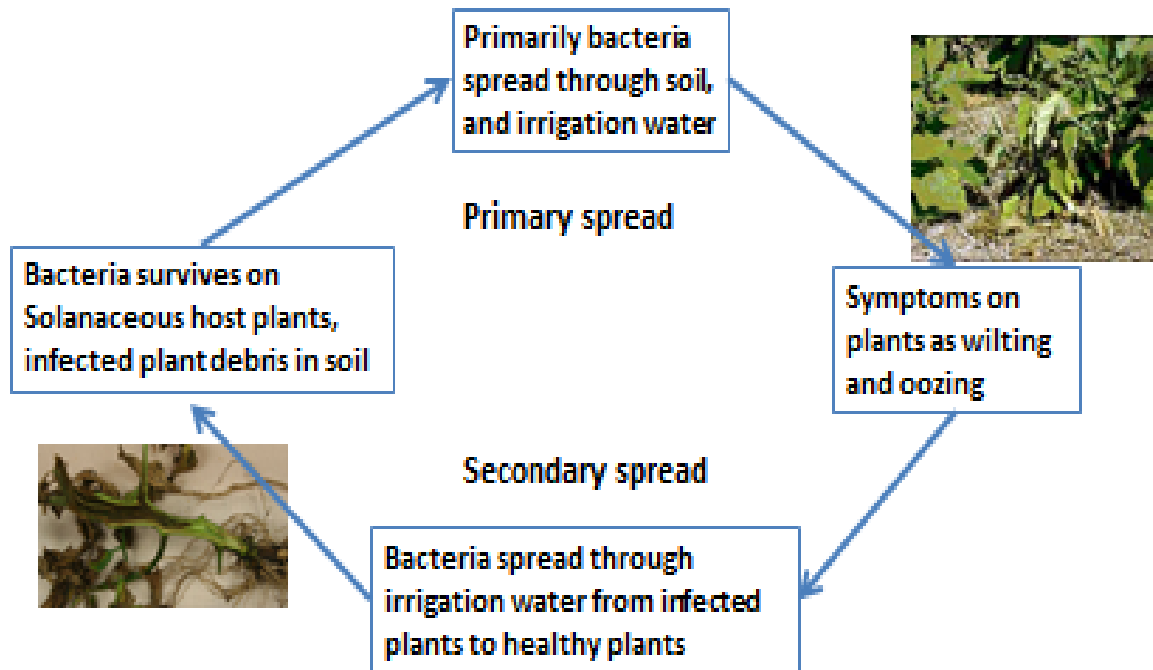
Primary: Soil, Seed, Water

Secondary: Conidia through rain splash or wind

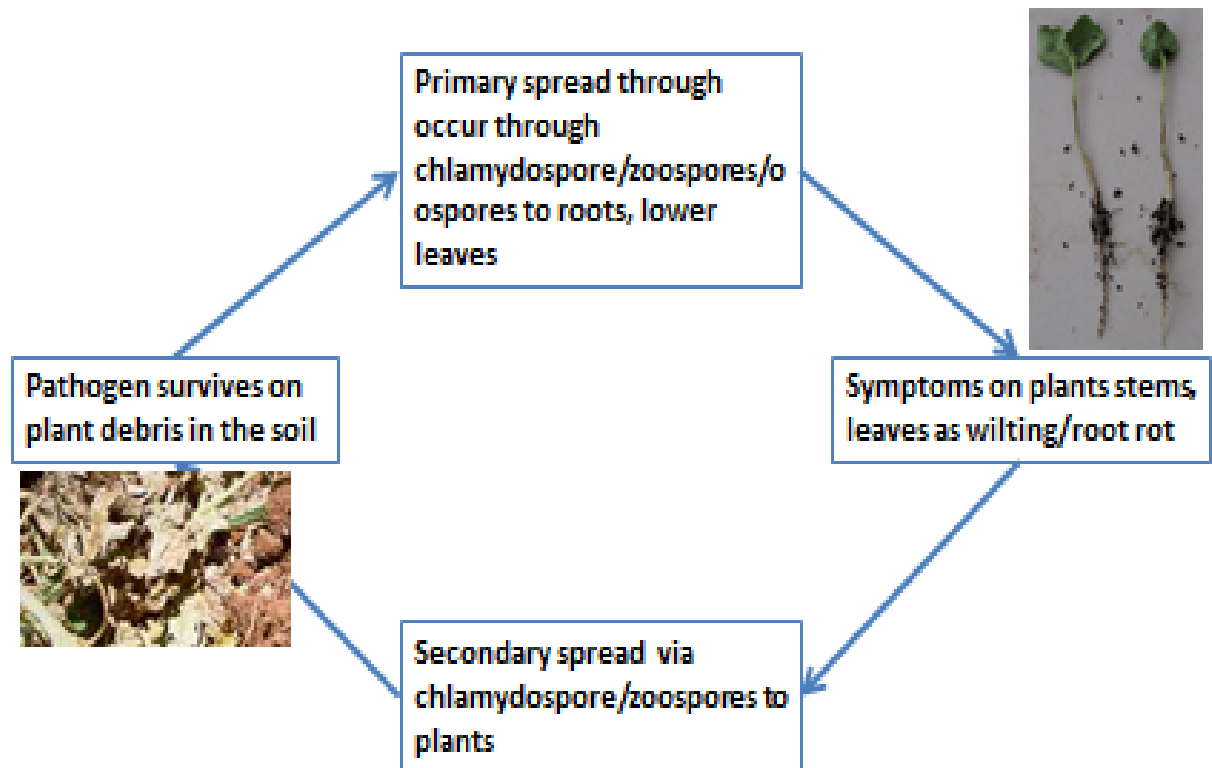
*For management refer to page number-----

Disease cycle:

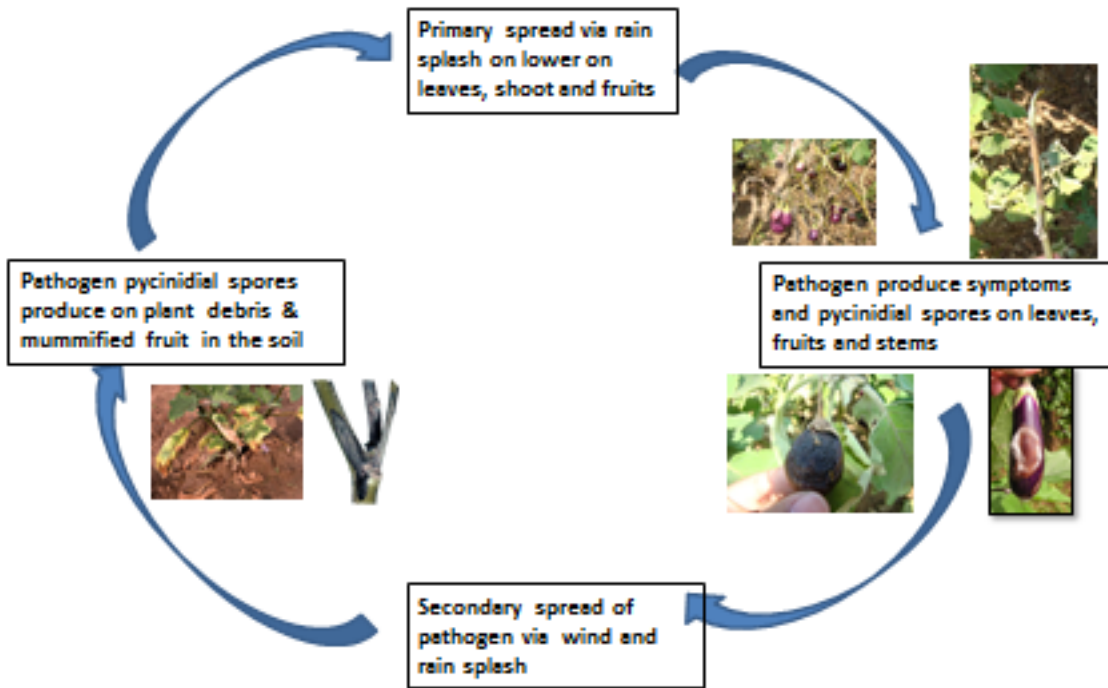
1. Bacterial wilt:



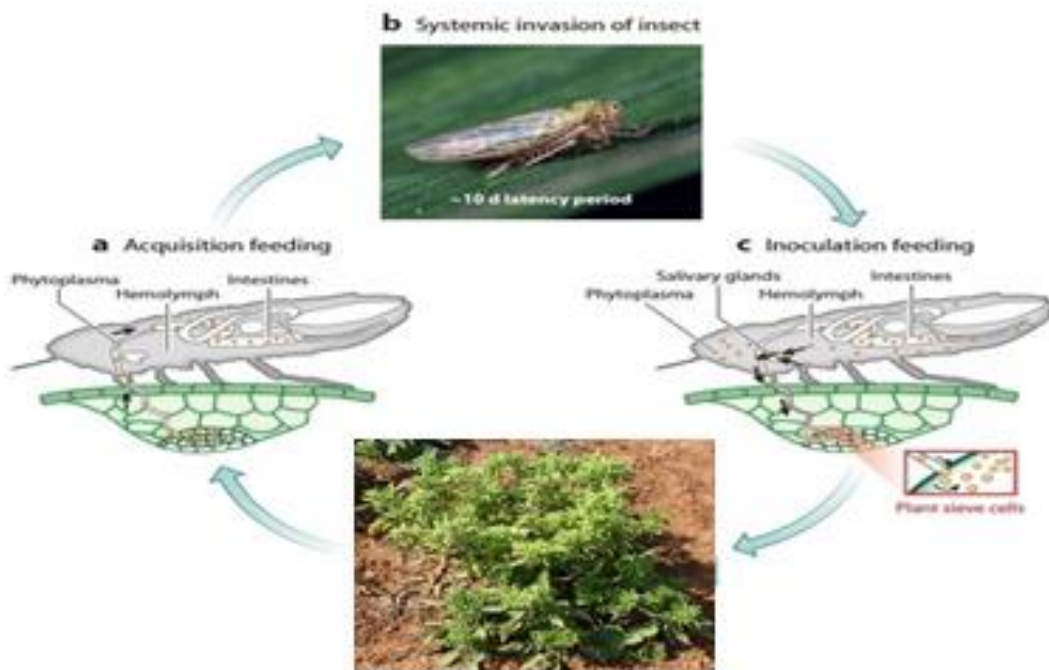
2.Damping off:



3. Phomopsis blight: *Phomopsis vexenus*



4. Little leaf of brinjal: Phytoplasma



http://img.scoop.it/73xDeKFw6MHa15uPFE1mejl72eJkfbmt4t8yenImKBVaiQDB_Rd1H6kmuBWtceBJ

VII. Description of rodent pests

1) Lesser bandicoot:

Distribution and Identification:

Distributed throughout India and infests almost all crops. It is a 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.

Burrows are characterized by the presence of scooped soil at the entrance and mostly burrow openings are closed with soil.

Damage symptoms:

Mostly damage occurs at fruiting stage. Bandicoots cut the raw and ripened fruits and hoard them in their burrows.



2. House rat:

Distributed throughout India. Medium sized (80-120g) slender rodent. Commonly found in houses and on plantation crops. Very good climber with longer tail than head and body. Occasionally causes damage to tomato in certain pockets. Inhabitation on trees and other places and won't make any burrows in fields



3. Indian gerbil:

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. The eyes are large, rounded

ears and bicolour tail with terminal black tuft. The burrows have semi-circular openings with zigzag shape and 2 to 4 openings and emergency exits.



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. Safety measures for post-harvest storage

Brinjal fruits lose 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.	<p>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</p> 	<p>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.</p>
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.	<p>Always treat the seeds with approved chemicals/bio products for the control of seed borne diseases/pests.</p> 	Do not use seeds without seed treatment with biocides/chemicals.
6.	<p>Sow in rows at optimum depths under proper moisture conditions for better establishment.</p> 	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	<p>Use NPK fertilizers as per the soil test recommendation.</p> 	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	<p>Conduct AESA weekly in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.</p> 	Do not take any management decision without considering AESA and P: D ratio
12	<p>Install pheromone traps at appropriate period.</p> 	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
13	<p>Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per field observation</p> 	Do not apply chemical pesticides within seven days of release of parasitoids.

14	<p>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.</p> 	Do not apply NPV on late instar larva and during day time.
15	<p>In case of pests which are active during night like <i>Spodoptera</i> spray recommended biocides/chemicals at the time of their appearance in the night.</p>	Do not spray pesticides at midday since, most of the insects are not active during this period.
16	<p>Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, whiteflies, <i>Spodoptera</i> etc.</p> 	Do not spray pesticides only on the upper surface of leaves.
17	<p>Apply short persistent pesticides to avoid pesticide residue in the soil and produce.</p>	Do not apply pesticides during preceding 7 days before harvest.
18	<p>Follow the recommended procedure of trap crop technology.</p> 	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.



XIV. Safety parameters in pesticide usage

S. No.	Pesticide	Classification as per insecticide rules 1971	Colour of toxicity triangle	WHO classification of hazard	First Aid measures	Symptoms poisoning	Treatment of poisoning	Waiting period (No. of days)
Organophosphate insecticides								
1.	Dimethoate	Highly toxic		Class II Moderately hazardous		Mild-anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity	For extreme symptoms of OP poisoning, injection of atropine (2-4 mg for adults, 0.5-1.0 mg for children) is recommended. Repeated at 5-10 minute intervals until signs of atropinization occur.	7
2.	Malathion	Moderately toxic		Class III slightly hazardous		Mild-anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity	For extreme symptoms of OP poisoning, injection of atropine (2-4 mg for adults, 0.5-1.0 mg for children) is recommended. Repeated at 5-10 minute intervals until signs of atropinization	3

							occur.	
3.	Dichlorvos	Extremely toxic		Class I b highly hazardous		Moderate nausea, salivation, lacrimation, abdominal cramp, vomiting, sweating, slow pulse, muscular tremors, miosis	Speed is imperative. Atropine injection-1-4 mg. repeat 2 mg when symptoms begin to recur (15-16 min interval) excessive salivation-good sign, more atropine needed	
4	Phorate	Extremely toxic		Class I b highly hazardous	Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious person	Weakness, headache, tightness in chest, blurred vision, nonreactive pinpoint pupils, salivation, nausea, vomiting, diarrhea, and abdominal cramps.	Give atropine intramuscularly or intravenously, depending on severity of poisoning, 2 to 4 milligrams every 10 minutes until fully atropinized as shown by dilated pupils, dry	

							flushed skin and tachycardia. Twenty to thirty milligrams, or more, may be required during the first 24 hours. Never give opiates or phenothiazine tranquilizers.	
5	Quinalphos	Highly toxic		Class II Moderately hazardous		Excessive salivation, sweating, rhinorrhea and tearing. Muscle twitching, weakness, tremor, incoordination. Hedache, dizziness, nausea, vomiting, abdominal cramps, diarrhea. - Respiratory depression, tightness in chest, wheezing, productive cough, fluid in	For extreme symptoms of OP poisoning, injection of atropine (2-4 mg for adults, 0.5-1.0 mg for children) is recommended. Repeated at 5-10 minute intervals until signs of atropinization occur.	7

						<p>lungs.</p> <ul style="list-style-type: none"> - Pin-point pupils, sometimes with blurred or dark vision. - Severe cases: seizures, incontinence, respiratory depression, loss of consciousness. 		
7	Triazophos				<p>Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious Person.</p>	<p>Symptoms of cholinesterase inhibition (gastrointestinal disturbances, dyspnoea, narrowing of the respiratory passages, bradycardia, miosis, clonic spasms),, somnolence.</p>	<p>Endotracheal intubation and gastric lavage, followed by administration of charcoal. Antidotes to be given atropin and pralidoxim/obidoxim. Treatment for adults: for all cases a high dose of atropine (2 to 4 mg) repeated every 10 to 15 minutes as needed.</p>	5
Carbamate insecticides								

9	Carbofuran	Extremely toxic		Class I b highly hazardous		Constriction of pupils, salivation, profuse sweating, muscle incoordination, nausea, vomiting, diarrhea, epigastric pain, tightness in chest	Atropine injection-1-4 mg. repeat 2 mg when symptoms begin to recur (15-16 min interval) excessive salivation-good sign, more atropine needed	
Synthetic pyrethroids								
10	Cypermethrin	Highly toxic		Class II Moderately hazardous	Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious person	Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin, allergic manifestation etc.	No specific antidote. Treatment is essentially symptomatic.	3
11	Fenvalerate				Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious	Ingestion may cause nonspecific discomfort, such as nausea, vomiting, headache, or weakness; temporary nervous	If on skin, after drying apply vitamin E cream or oil if available. If not available, apply vegetable oil liberally over painful areas.	5

					person	system effects such as muscular weakness, tremors and incoordination.	The oil or cream may be used repeatedly until relief is achieved	
12	Lambda-cyhalothrin				Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious person	Toxic if swallowed or inhaled. Irritating to eyes and skin. Vapors may cause drowsiness and dizziness. May be harmful if swallowed and enters airway. May cause temporary itching, tingling, burning or numbness of exposed skin, called paresthesia	There is no specific antidote. Treatment is essentially symptomatic.	4
13	Fenpropathrin				Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious	Salivation, weakness, ataxia, tremors, convulsions, gastrointestinal irritation, nausea, vomiting and diarrhea.	Possible mucosal damage may contraindicate the use of gastric lavage. Treatment is supportive and symptomatic. Diazepam has	10

					person		been recommended to reduce the central nervous system effects	
14	Chloranthranili prole				When used as directed this product does not present a hazard to humans or domestic animals			22
Other classes insecticides								
15	Propargite				Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious person	Corrosive. Causes irreversible eye damage. Causes skin burns. Harmful if swallowed. Harmful if absorbed through skin. Harmful if inhaled.	No specific antidote. Treatment is essentially symptomatic.	6
16	Thiodicarb				Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious	Salivation, muscle tremors, nausea, watery eyes, difficult breathing, vomiting, pinpoint eye pupils, excessive sweating,	Atropine sulfate is highly effective as an antidote	6

					person	diarrhea, blurred vision, abdominal cramps, weakness, headache		
17	Dicofol	Moderately toxic		Class III slightly toxic		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin, allergic manifestations etc.	No specific antidote. Treatment is essentially symptomatic	15-20
Fungicides								
18	Carbendazim	Slightly toxic		Unlikely to present acute hazard in normal use		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic	
19	Wettable sulphur	Slightly toxic		-do-----		-----do----- -	-----do----- --	

XV. 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.

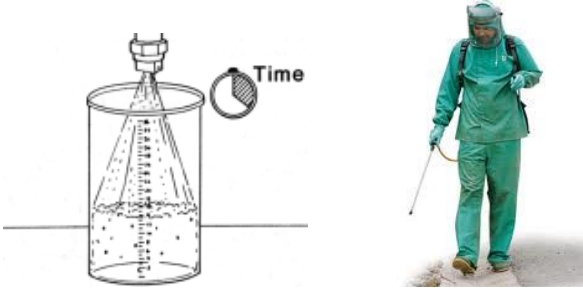
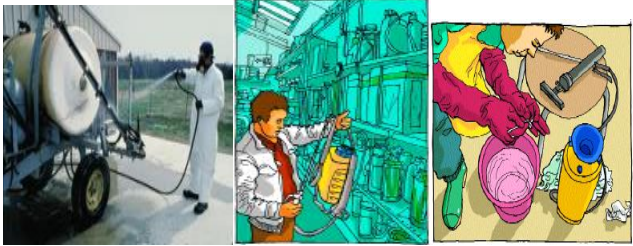
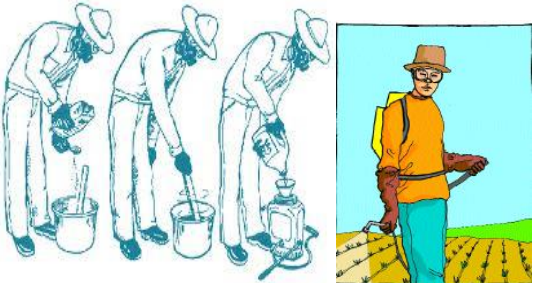
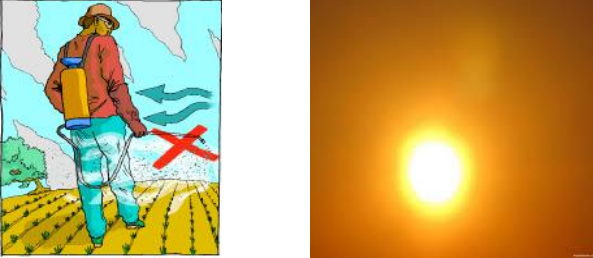

XVI. Pesticide application techniques

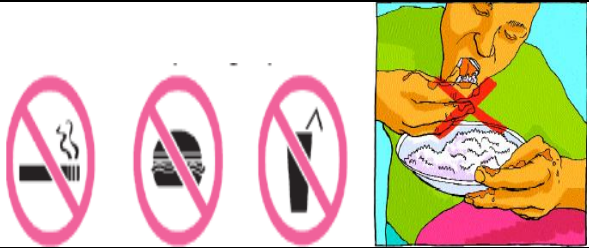
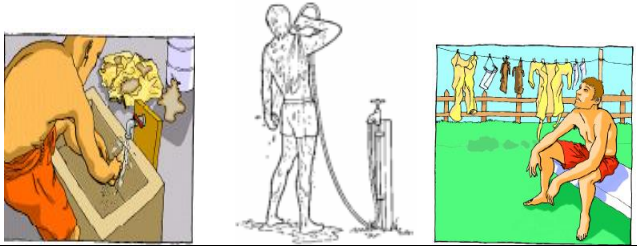

		Equipment	
Category A: Stationary, crawling pest/ disease			
Vegetative stage i) for crawling and soil borne pests	Insecticides and fungicides	<ul style="list-style-type: none"> • Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min 	
ii) for small sucking leaf borne pests		<ul style="list-style-type: none"> • Motorized knapsack sprayer or mist blower (Droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle 	
Reproductive stage	Insecticides and fungicides	<ul style="list-style-type: none"> • Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min 	
Category B: Field Flying pest/ airborne pest			

Vegetative stage	Insecticides and fungicides	<ul style="list-style-type: none"> Motorized knapsack sprayer or mist blower (Droplets of small size) Airblast nozzle Operating speed: 2/3rd throttle Or <ul style="list-style-type: none"> Battery operated low volume sprayer (Droplets of small size) Spinning disc nozzle 	 
Reproductive stage (Field Pests)			 
Mosquito/ locust and spatial application (migratory Pests)	Insecticides and fungicides	<ul style="list-style-type: none"> Fogging machine and ENV (Exhaust nozzle vehicle) (Droplets of very small size) Hot tube nozzle 	 
Category C: Weeds			
Post-emergence application	Weedicide	<ul style="list-style-type: none"> Lever operated knapsack sprayer (Droplets of big size) Flat fan or floodjet nozzle @ 15 to 20 psi Lever operating speed = 7 to 10 strokes/min 	   
Pre-emergence application	Weedicide	<ul style="list-style-type: none"> Trolley mounted low volume sprayer (Droplets of small size) Battery operated low volume sprayer (Droplets of small size) 	  

XVI. Operational, calibration and maintenance guidelines in brief

1.	For application rate and dosage see the label and leaflet of the particular pesticide.	 
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2.	<p>It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.</p>	 <p>The diagram shows a sprayer nozzle on the left, with a circular arrow labeled 'Time' indicating the duration of the spray. On the right, a person in a full green protective suit is shown using a sprayer wand.</p>
3.	<p>Clean and wash the machines and nozzles and store in dry place after use.</p>	 <p>The images show a person cleaning a large sprayer tank, a person cleaning a nozzle, and a person washing a sprayer component in a bucket.</p>
4.	<p>It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides.</p> <p>Do not apply pesticides without protective clothing and wash clothes immediately after spray application.</p>	 <p>The illustrations show three people in protective suits and hats preparing pesticides, and a person in a hat and sunglasses applying pesticides in a field.</p>
5.	<p>Do not apply in hot or windy conditions.</p>	 <p>The images show a person spraying in windy conditions with a red 'X' over the spray, and a bright sun in a clear sky.</p>
6.	<p>Operator should maintain normal walking speed while undertaking application.</p>	 <p>The image shows a person in a green protective suit walking while spraying.</p>

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.	

XVIII. References

http://www.postharvest.com.au/Produce_Information.htm
<http://postharvest.ucdavis.edu/pfvegetable/Eggplant/>
<http://nhb.gov.in/vegetable/brinjal/bri0v08.pdf>
http://www.ikisan.com/Crop%20Specific/Eng/links/ap_chilliHarvestingandStorage.shtml
<http://postharvest.ucdavis.edu/pfvegetable/ChilePeppers/>
<http://www.icar.org.in/files/reports/icar-dare-annual-reports/2009-10/Post-harvest-Management.pdf>
http://www.farmerfred.com/plants_that_attract_benefi.html
<http://www.agritech.tnau.ac.in>
 NHM manual for post harvest management and integrated pest management:
<http://www.nhm.nic.in>
 AVRDC the world vegetable center: <http://www.avrdc.org>
 FAO Regional Vegetable IPM Programme in South & Southeast Asia:
<http://www.vegetableipmasia.org/CropsSites.html>
 Indian Institute of Horticultural Research: <http://www.iihr.ernet.in>
 Fiedler, A., Tuell, J., Isaacs, R. and Doug Landis . Attracting beneficial insects with native flowering plants. January 2007. Extension bulletin. E-2973.
 Acharya N. G. Agricultural University, Hyderabad: <http://www.angrau.ac.in>
 University of Agricultural Sciences, Dharwad: <http://www.uasd.edu>
 Jawarharlal Nehru Krishi Viswa Vidyalaya, Jabalpur: <http://www.jnkvv.nic.in>
 Punjab Agricultural University, Ludhiana: <http://www.pau.edu>
<http://agropedia.iitk.ac.in/content/brinjal-fruit-and-shoot-borer-leucinodes-orbonalis-pyraustidae-lepidoptera>

http://r4d.dfid.gov.uk/PDF/Outputs/CGIAR_Funds/bang_topic14.pdf
http://books.google.co.in/books?id=q7Nqhe_T_6EC&pg=PA371&lpg=PA371&dq=Eriborus+sinicus+and++brinjal+fruit+and+shoot+borer&source=bl&ots=4FpeRF1ZwM&sig=G8EYXBRxOzFqKoiVOTUJFVQm3u8&hl=en&sa=X&ei=X_ZkUq-OloWxrgeBnYAo&ved=0CC0Q6AEwAQ#v=onepage&q=Eriborus%20sinicus%20and%20%20brinjal%20fruit%20and%20shoot%20borer&f=false
<http://www.cabdirect.org/abstracts/19891106771.html;jsessionid=C16383CF0325533B1D738B045B037077>
http://books.google.co.in/books?id=kY_pr8kIPXgC&pg=PA32&lpg=PA32&dq=Itamoplex+sp,+in+india&source=bl&ots=Q8YBNUGZC_&sig=5DrjrePXQ0z_pCrcfEgpDm-ykBI&hl=en&sa=X&ei=kPpkUqmlBorprQfE9YG4Dw&ved=0CDQQ6AEwAg#v=onepage&q=Itamoplex%20sp%2C%20in%20india&f=false
http://takingroots.in/ipm_bsfb
http://www.nbaii.res.in/Featured%20insects/Henosepilachna_vigintioctopunctata.htm
<http://www.cabdirect.org/abstracts/19931178576.html;jsessionid=75422544D06F177181B90F2E4D11035F?freeview=true>
[http://www.ncipm.org.in/mealybugs/BulletinMealybugs%20\(English\).pdf](http://www.ncipm.org.in/mealybugs/BulletinMealybugs%20(English).pdf)
http://www.ikisan.com/Crop%20Specific/Eng/links/ap_brinjalInsect%20Management.shtml
http://203.64.245.61/fulltext_pdf/EB/2001-2010/eb0122.pdf
http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insect-veg_brinjal.html#3
<http://www.cabi.org>
Biocontrol Potential and Its Exploitation in Sustainable Agriculture: Volume ... edited by R. K. Upadhyay, K. G. Mukerji, B. P. Chamola, Springer publication.