सत्यमेव जयते

AESA BASED IPM Package No. 23

AESA based IPM – Okra

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The AESA based IPM - Okra, 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.

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(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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***E. insulana* (Boisduval) (Lepidoptera Noctuidae)**

1.2 Gram pod borer: *Helicoverpa armigera* (Hübner) (Lepidoptera Noctuidae)

1.3 Jassids: *Amrasca biguttula biguttula* Ishida (Hemiptera Cicadellidae)

1.4 Aphids: *Aphis gossypii* Glover (Hemiptera Aphididae)

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Broadleaf weeds

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Grassy weeds

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Sedges

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Broadleaf weeds

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Grassy weeds

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1. Insect pests

1.1 Red cotton bug: *Dysdercus cingulatus* (Fabricius) (Hemiptera: Pyrrhocoridae)

1.2 Ash/gray weevils: *Myllocerus subfaciatus* Guerin (Coleoptera: Curculionidae)

1.3 Stem fly: *Melanagromyza hibisci* Spencer (Diptera: Agromyzidae)

2. Diseases

2.1 Wilt: *Fusarium oxysporum* f. sp. *Vasinfectum* Schlecht

2.2 Pod spot:

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3.1 Root-knot nematode: *Meloidogyne* spp.

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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.)

Plant Compensation ability

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

Understand and conserve defenders

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

Insect zoo

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

Pest: Defender ratio (P: D ratio):

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

Model agro-ecosystem analysis chart

Date:
Village:
Farmer:

Decision taken based on the analysis of field situation

Soil condition :
Weather condition :
Diseases types and severity :
Weeds types and intensity :
Rodent damage (if any) :

No. of insect pests :
No. of natural enemies :
P: D ratio :

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

Feeding/egg laying potential of different parasitoids/predators

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

 *Trichogramma* sp	Egg laying capacity is 20-200 eggs/female.

Decision making

Farmers become experts in crop management

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

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

AESA methodology

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

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

- While walking in the field, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the field situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.

- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on what field management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording

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

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

Data to be recorded

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

Some questions that can be used during the discussion

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

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

Advantages of AESA over ETL

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

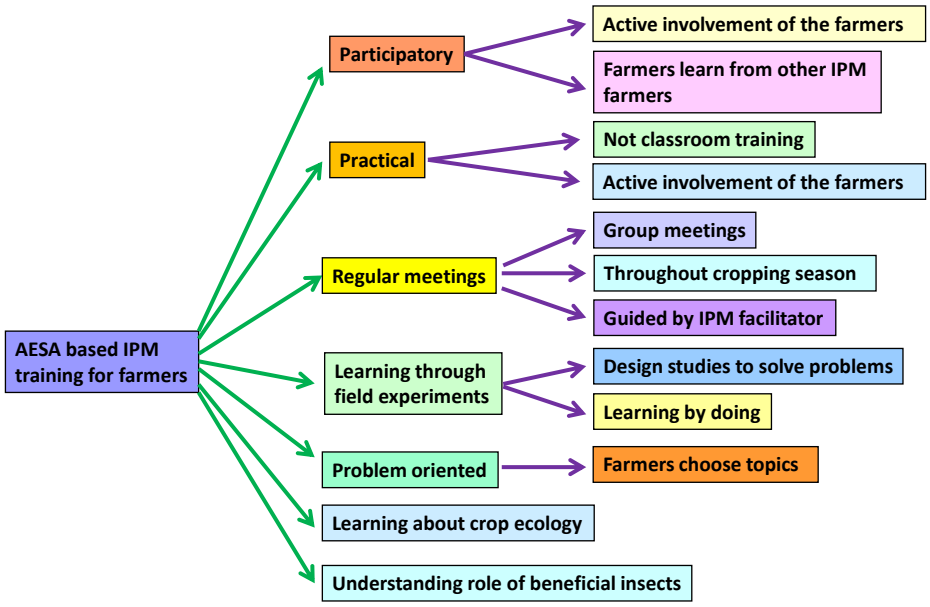
AESA and farmer field school (FFS)

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

Farmers can learn from AESA

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

FFS to teach AESA based IPM skills



B. Field Scouting

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

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

For Sucking pests:

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

For leaf miner: Only the number of live mines on five randomly selected leaves/plant should be counted and recorded.

For *Helicoverpa* and *Earias*: Total number of fruits, damaged fruits due to *Helicoverpa armigera* and *Earias* spp. and number of larvae on individual plants should be counted and recorded.

C. Surveillance through pheromone trap catches for *Earias* and *Helicoverpa*:

Pheromone traps for two insects viz., *Helicoverpa armigera* and *Earias* @ 4-5/acre have to be installed. Install the traps for each species separated by a distance of >75 feet in the vicinity of the selected fixed field. Fix the traps to the supporting pole at a height of one foot above the plant canopy. Change of lures should be made at 2-3 weeks interval (regular interval). During each week of surveillance, the number of moths/trap should be counted and entered.
Procedure for observation: Total number of moths of *Helicoverpa armigera* and *Earias*/trap/week should be recorded year round. The trapped moths should be destroyed and removed after each recording.

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

E. Light traps
Set up light traps 1-2 traps/acre 15 cm above the crop canopy for monitoring and mass trapping insects. Light traps with exit option for natural enemies of smaller size should be installed and operate between 6 pm and 11 pm. Light trap catches should be counted and kill the pests and release the natural enemies.

F. Nematode sampling
Collect 100 to 300 cm^3 (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 hand or 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 mychorrhiza 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, Leguminaceae, Umbelliferae, Brassicaceae etc. families

French bean

Marigold

Carrot

Sunflower

Buckwheat

***Desmodium* sp**

Mustard

Castor

Maize

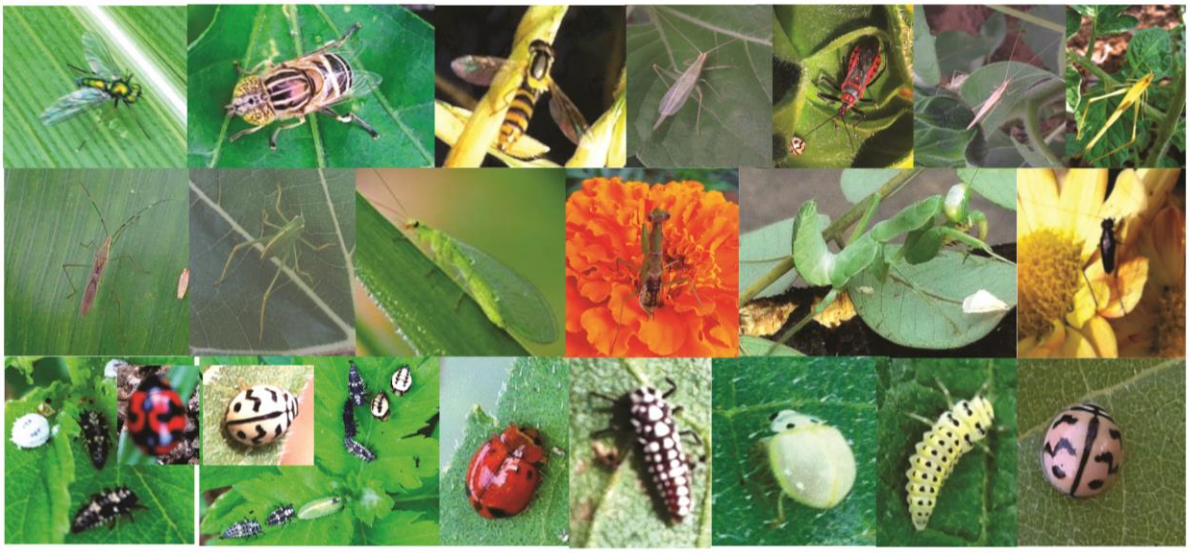
Alfalfa

Chrysanthemum

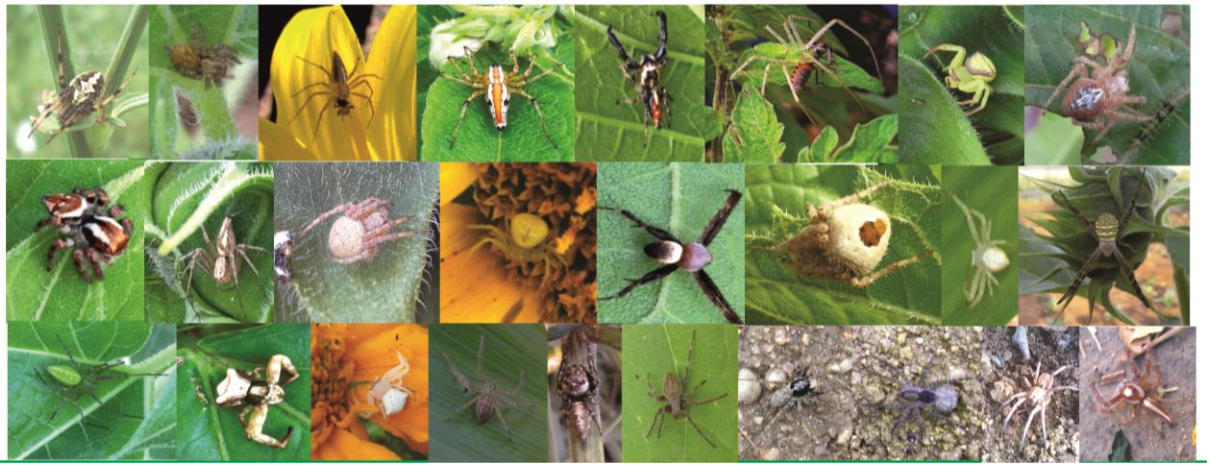
Dill

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



Flowering plants that attract natural enemies/repel pests

	Insect pest	Natural enemies	Attractant Plants
1	Shoot and fruit borer	**Parasitoids:** *Trichogramma achaeae* (egg), *T. chilonis* (egg), *Trichogrammatoidea* sp. nr. *guamensis* (egg), *Telenomus remus* (egg), *Aphelinus* sp, *Erythmelus empoascae* (egg), *Gonatocerus* (egg), *Chelonus heliopae* (egg-larval), *C. rufus* (egg-larval), *Strobliomyia nana* (larval), *Actia aegyptia* (larval), *Centrochalcis* sp. (larval), *Phanerotoma hendecasisella* (larval), *Bracon greeni* (larval), *B. brevicornis* (larval), *Rogas aligarhensis* (larval), *R. testaceus* (larval, *R. kampurensis* (larval) *Elasmus johnstoni* (larval), *Brachymeria tachardiae* (pupal), *B. responsator* (pupal), *B. nephantidis* (pupal), *Goryphus nursei* (pupal) etc. **Predators:** *Chrysoperla carnea*, coccinellids, King crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants, earwings, ground beetle, big-eyed bugs (*Geocoris* sp), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc. **Nematode:** *Ovomermis albicans* **Pathogens:** *Fusarium moniliformae* var. *subglutinams*, *Serratia marcescens*, *Bacillus cereus* etc.	• Attractant plants: Carrot family, sunflower family, buckwheat (lacewings)
2	*Helicoverpa armigera*	**Parasitoids:** *Trichogramma chilonis* (egg), *Tetrastichus* spp. (egg), *Telenomus* spp. (egg), *Chelonus blackburni* (egg-larval), *Carcelia* spp. (larval-pupal), *Campoletis chlorideae* (larval), *Goniophthalmus halli* (larval), *Bracon* spp. (larval) etc. **Predators:** *Chrysoperla carnea*, coccinellids, King crow, common mynah, wasp, dragonfly, spider,	• Attractant plants: Carrot family, sunflower family, buckwheat, alfalfa, corn, and shrubs (minute pirate bug and lacewing) • Nectar rich plants with small flowers i.e. anise, caraway, dill, parsely, mustard, sunflower, buckwheat and cowpea (braconid wasp)

		robber fly, reduviid bug, praying mantis, fire ants, big eyed bugs (*Geocoris* sp), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc. *Ovomermis albicans,* a nematode	
3.	Leafhoppers	**Parasitoids:** *Lymaenon empoascae* (egg), *Anagrus flaveolus*, *Stethynium triclavatum* **Predators:** Lady beetle, ants *Distina albino*, *Chrysoperla* spp., mired bug (*Dicyphus hesperus*), big-eyed bug, (*Geocoris* sp) etc.	• Sunflower family, alfalfa (damsel bug and minute pirate bug) • Carrot family, buckwheat, alfalfa, corn, and shrubs (minute pirate bug)
4.	Aphids	**Parasitoid:** *Aphidius colemani* **Predators:** Anthocorid bugs/pirate bugs (*Orius* spp.), mirid bugs, syrphid/hover flies, green lacewings (*Mallada basalis* and *Chrysoperla carnea*), predatory coccinellids (*Stethorus punctillum*), staphylinid beetle (*Oligota* spp.), cecidomyiid fly (*Aphidoletis aphidimyza*), gall midge (*Feltiella minuta*), earwigs, ground beetles, rove beetles, spiders, wasps etc.	• Carrot family, sunflower family, marigold, buckwheat, spearmint (syrphid fly, lacewing, minute pirate bug, damsel bug and lady beetle) • French bean (predatory thrips) • Strips of rye, grains, cover crops and mulch beds (rove beetle) • Mustard, sweet clove, dill (aphid midge, *Aphiodoletes aphidimyza*) • Nectar rich plants with small flowers i.e. anise, caraway, dill, parsely, mustard (aphid parasitoid and braconid wasp) • Sunflower, buckwheat and cowpea (braconid wasp)
5	Whitefly	**Parasitoids:** *Encarsia* sp, *Eretmocerus* sp, *Chrysocharis pentheus* **Predators:** Mirid bug (*Dicyphus hesperus*), dragonfly, spider, robber fly, praying mantis, fire ants, coccinellids, lace wings, big eyed bugs (*Geocoris* sp) etc.	• Carrot family, sunflower family, marigold, buckwheat, spearmint (syrphid fly, lacewing, minute pirate bug, damsel bug and lady beetle)
5	Spider mites	**Predators:** Anthocorid bugs (*Orius* spp.), mirid bugs, syrphid/hover flies, green lacewings (*Mallada basalis* and *Chrysoperla carnea*), predatory mites	• Carrot family, bishop's weed (spider mite destroyer) • Sunflower family, marigold, buckwheat, spearmint (lady beetle)

		(*Amblyseius alstoniae*, *A. womersleyi, A. fallacies* and *Phytoseiulus persimilis*), predatory coccinellids (*Stethorus punctillum*), staphylinid beetle (*Oligota* spp.), cecidomyiid fly (*Anthrocnodax occidentalis*), gall midge (*Feltiella minuta*) etc. *Beauveria bassiana* (entomo pathogen)	• Carrot family, sunflower family, buckwheat, alfalfa, corn, and shrubs (minute pirate bug) • Mustard, sweet clove, and dill (aphid midge) • French bean (predatory mites) • Berseem clover, sub-terranean clovers (big–eyed bugs)
6	Root-knot nematode	Use of biocontrol agents like *Paecilomyces lilacinus* (egg parasite)	• Intercropping of marigold with okra reduces nematode population • Repellant plants: Marigold • Crop rotation: Marigold, *Chrysanthemum* spp., *Sesbania* spp., *Crotalaria* spp., *Gaillardia* spp., castor bean and *Desmodium* spp. (parasitic nematodes)

Resistant/tolerant varieties

Pest/disease	Tolerant/Resistant Variety*
Yellow vein mosaic virus	Pusa Sawani, Pusa A 4, Arka Abhay, Arka Anamika, Varsha Uphar, Hisar Unnat, Hisar Naveen, HBH-142 (F1 hybrid), Gujarat Anand Okra-5, CO 1, CO 3, COBhH 1, Azad Bhindi -1, Azad Bhindi-3
Aphid	Pusa A 4, Gujarat Anand Okra-5

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

IV. Crop stage–wise IPM

Stage	Management	Activity
Pre-sowing*	**Nutrients**	• Add well decomposed farm yard manure (FYM) @ 8-10 t/acre or vermicompost @ 5 t/acre treated with *Trichoderma* spp. and/or *Pseudomonas* sp @ 2 kg/acre. Incorporate at the time of field preparation at 1 week (vermicompost) or 2 to 3 weeks (FYM) before transplanting
	Weeds	• At the time of field preparation, adopt stale seed bed technique to minimize the weeds menace in field. • Black plastic mulch prevents entry of light, which restricts germination of weed seeds and growth
	Soil borne fungus, nematodes, resting stages of insects and weeds	**Cultural control:** • Deep ploughing of fields during summer. • **Soil solarization:** Cover the beds with polythene sheet of 45 gauge (0.45 mm) thickness for three weeks before sowing for soil solarization which will help in reducing the soil-borne pests. **Biological control:** • Apply neem cake @ 100 kg/acre at the time of transplanting for reducing nematodes and borer damage.
Seed Sowing/ Transplanting stage*	**Nutrients**	• Before sowing, soil testing should be done to find out the soil fertility status. Nutrient should be provided as per soil test recommendations. Generally, okra needs 48: 20: 20 kg N: P: K/acre for varieties and 72: 30: 30 Kg N: P: K/acre for hybrids. • Apply 33.3 % of N fertilizer dose as a basal dose at the time of sowing. • Entire dose of phosphatic fertilizers is applied at the time of last ploughing. • Biofertilizers: Seed treatment with Azotobacter and phosphorous solubilizing bacteria (PSB) cultures @ 10 g/kg seed each
	Weeds	• At seedling stage keep the field weed free by following good cultural practices
***** 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 state	**Nutrients**	• Apply the second dose of N (33.3%) at 30 days after transplanting. • Micronutrient deficiency should be corrected by foliar spray of particular micronutrient.

	Weeds	• Weeding and earthing up in rows should be done at 25-30 days after sowing especially during rainy season. • 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 between the rows by burying both the ends into the soil to a depth of 10 cm will avoid weed growth.
	Okra shoot and fruit borer	**<u>Cultural control:</u>** • Collect and destroy affected fruits. • Avoid growing Malvaceous crops in sequence. • Remove and destroy affected shoots, fruits by clipping/nipping off the shoots below the entrance hole. • Set up pheromone traps @ 4-5/acre for monitoring purpose. **<u>Biological control:</u>** • Spray azadirachtin 0.03% (300 ppm) neem oil based WSP @ 1000-2000 ml in 200-400 l of water/acre or azadirachtin 5% W/W neem extract concentrate @ 80 ml in 160 l of water/acre • Spray *B. t*. var gallariae @ 400-600 g in 200 l of water/acre • Release egg parasitoid, *Trichogramma chilonis* @ 40,000/acre. • Release first instar larvae of predator, *Chrysoperla carnea* @ 4,000/acre. • Conserve parasitoids such as *Trichogramma achaeae* (egg), *T. chilonis* (egg), *Trichogrammatoidea* sp. nr. *guamensis* (egg), *Telenomus remus* (egg), *Aphelinus* sp, *Erythmelus empoascae* (egg), *Gonatocerus* (egg), *Chelonus heliopae* (egg-larval), *C. rufus* (egg-larval), *Strobliomyia nana* (larval), *Actia aegyptia* (larval), *Centrochalcis* sp. (larval), *Phanerotoma hendecasisella* (larval), *Bracon greeni* (larval), *B. brevicornis* (larval), *Rogas aligarhensis* (larval), *R. testaceus* (larval, *R. kampurensis* (larval) *Elasmus johnstoni* (larval), *Brachymeria tachardiae* (pupal), *B. responsator* (pupal), *B. nephantidis* (pupal), *Goryphus nursei* (pupal) etc. • Conserve predators such as *Chrysoperla carnea*, coccinellids, King crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants, earwings, ground beetle, big-eyed bugs (*Geocoris* sp), pentatomid bug

		(*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc. • Spray *Beauveria bassiana* 1% WP @ 1500-2000 g in 160-200 l of water/acre • Apply entomopathogenic nematodes (EPNs) @ 250 crore infective juveniles of *Steinernema feltiae*/acre **<u>Chemical control:</u>** • Foliar spray with chloranthraniliprole 18.5% SC @ 50 ml in 200 l of water/acre or cypermethrin 10% EC @ 220-304 ml in 60-160 l of water/acre or cypermethrin 25% EC @ 60-80 ml in 200 l of water/acre or fenpropathrin 30% EC @ 100-136 ml in 300-400 l of warer/acre or deltamethrin 2.8% EC @ 160-240 ml in 160-240 l of water/acre or emamectin benzoate 5% SG @ 54-68 g in 200 l of water/acre or fenvalerate 20% EC @ 120-150 ml in 240-300 l of water/acre or lambda cyhalothrin 4.9% CS @ 120 ml in 200 l of water/acre or permethrin 25% EC @ 160-200 ml in 300-400 l of water/acre or pyridalyl 10% EC @ 200-300 ml in 200-300 l of water/acre or quinalphos 20% AF @ 500-600 ml in 300-400 l of water/acre or pyriproxyfen 5% EC + fenpropathrin 15% EC @ 200-300 ml in 200-300 l of water/acre or carbaryl 50% WP @ 800 g in 200-400 l of water/acre or carbaryl 10% D.P @ 10000 g/acre or lambda-cyhalothrin 5% EC @ 120 ml in 120-160 l of water/acre or malathion 50% EC @ 600 ml in 200-400 l of water/acre or phosalone 35% EC @ 500 ml in 200-400 l of water/acre or quinalphos 25% EC @ 320 ml in 200-400 l of water
	Whitefly/Yellow vein mosaic virus	**<u>Cultural control:</u>** • Field sanitation, roguing • Plant tall border crops like maize, sorghum or pearl millet to reduce whitefly infestations (4 rows). • Install yellow sticky traps @ 2/acre for monitoring purpose • Peppermint plants act as repellent for whitefly. • French bean acts as an attractant plant for predatory thrips. • Grow tolerant varieties • Rain bird type of irrigation **<u>Biological control:</u>** • Conserve predators such as coccinellids, lacewings, spiders, predatory bugs (*Dicyphus hesperus*), wasps etc. • Conserve parasitoids such as *Encarsia* sp*, Eretmocerus* spp. (nymphal and pupal)*,*

		Chrysocharis pentheus (nymphal) etc. • Release *Chrysoperla carnea* @ 8,000 larvae/acre • Spray NSKE 5% or azadirachtin 0.03% (300 ppm) neem oil based WSP @ 1000-2000 ml in 200-400 l of water/acre or azadirachtin 5% W/W neem extract concentrate @ 80 ml in 160 l of water/acre **Chemical control** • Spray oxydemeton-methyl 25% EC @ 400 ml in 200-400 l of water/acre or fenpropathrin 30% EC @ 100-136 ml in 300-400 l of warer/acre or thiamethoxam 25% WG @ 40 g in 200-400 l of water/acre or pyriproxyfen 5% EC + fenpropathrin 15% EC @ 200-300 ml in 200-300 l of water/acre
	Leafhoppers	**Cultural control:** • Destroy the alternate host plants. • Use resistant varieties • Okra intercropped with baby corn brought some significant reduction in pre-spray population of leaf hoppers. **Biological control:** • Conserve predators such as *Distina albina* and *Chrysoperla* spp. • Conserve parasitoids such as *Lymaenon empoascae* (egg) • Spray NSKE 5% or azadirachtin 0.03% (300 ppm) neem oil based WSP @ 1000-2000 ml in 200-400 l of water/acre or azadirachtin 5% W/W neem extract concentrate @ 80 ml in 160 l of water/acre **Chemical control:** • Seed treatment with imidacloprid 48% FS @ 500-900 ml/100 kg seed or imidacloprid 70% WS @ 500-1000 ml/100 kg seed • Spray thiamethoxam 25% WG @ 40 g in 200-400 l of water/acre or cypermethrin 25% EC @ 60-80 ml in 200 l of water/acre or fenvalerate 20% EC @ 120-150 ml in 240-300 l of water/acre or imidacloprid 70% WG @ 12-14 g in 150-200 l of water/acre or imidacloprid 17.8% SL @ 40 ml in 200 l of water/acre or permethrin 25% EC @ 160-200 ml in 300-400 l of water/acre or carbaryl 5% D.P @ 8000 g/acre or carbaryl 10% D.P @ 10000 g/acre or carbofuran 3% CG @ 13320 g/acre or deltamethrin 2.8% EC @ 160-240 ml in 160-240 l of water/acre or dimethoate 30% EC @ 792 ml in 200-400 l of water/acre or or lambda-cyhalothrin 5% EC @ 120 ml in 120-160 l of water/acre or malathion 50% EC

		@ 500 ml in 200-400 l of water/acre or oxydemeton-methyl 25% EC @ 640 ml in 200-400 l of water/acre or quinalphos 25% EC @ 400 ml in 200-400 l of water
	Aphids	**<u>Biological control:</u>** • Conserve predators such as wasps, green lacewings, earwigs, ground beetles, rove beetles, spiders coccinellids, syrphids etc. • Spray azadirachtin 5% W/W neem extract concentrate @ 80 ml in 160 l of water/acre **<u>Chemical control:</u>** • Seed treatment with imidacloprid 48% FS @ 500-900 ml/100 kg seed or imidacloprid 70% WS @ 500-1000 ml/100 kg seed • Spray acetamiprid 20% SP @ 30 g in 200-240 l of water/acre or imidacloprid 70% WG @ 12-14 g in 150-200 l of water/acre or imidacloprid 17.8% SL @ 40 ml in 200 l of water/acre or permethrin 25% EC @ 160-200 ml in 300-400 l of water/acre or malathion 50% EC @ 400 ml in 200-400 l of water/acre or thiamethoxam 70% WS @ 286 ml in 200-400 l of water/acre or thiamethoxam 25% WG @ 40 g in 200-400 l of water/acre or dimethoate 30% EC @ 924 ml in 200-400 l of water/acre
	Mites	**<u>Cultural control:</u>** • Grow nurseries away from infested crops and avoid planting next to infested fields • 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 **<u>Biological control:</u>** • Conserve predators such as anthocorid bugs/minute pirate bugs (*Orius* spp.), mirid bugs, syrphid/hover flies, green lacewings (*Mallada basalis* and *Chrysoperla carnea*), predatory mites (*Amblyseius alstoniae*, *A. womersleyi, A. fallacies* and *Phytoseiulus persimilis*), predatory coccinellid

		beetle (*Stethorus punctillum*), staphylinid beetles (*Oligota* spp.), cecidomyiid (*Anthrocnodax occidentalis*), gall midge (*Feltiella minuta*) etc. **Chemical control:** • Spray dicofol 18.5% EC @ 540-1080 ml in 200-400 l of water/acre or fenazaquin 10% EC @ 500 ml in 200 l of water/acre or fenpropathrin 30% EC @ 100-136 ml in 300-400 l of warer/acre or spiromesifen 22.9% SC @ 160-200 ml in 200 l of water/acre or quinalphos 25% EC @ 400 ml in 200-400 l of water
	Nematodes	**Cultural control:** • Crop rotation with cereal crops • **Intercropping** of marigold with okra reduces nematode population • Nursery should be raised in nematode free sites or fumigated or solarized beds.
	***Cercospora* leaf spots**	**Cultural control:** • Removal and proper disposal and burning the infected leaves
	Powdery mildew	**Cultural control:** • Monitor the adjacent field for infection • Maintain proper plant spacing for reducing the relative humidity **Biological control:** • Spray azadirachtin 0.03% (300 ppm) neem oil based EC @ 800-1000 ml in 200 l of water/acre **Chemical control:** • Spray sulphur 80% WP @ 1252 g in 300-400 l of water/acre or dinocap 48% EC @ 90 ml in 300 l of water/acre
Reproductive stage	**Nutrients**	• The third dose (33.3%) of N to be applied at 45 days after transplanting. • Micronutrient deficiency should be corrected by foliar spray of particular micronutrient.
	Weeds	• Left over weeds should be removed from the field to avoid further spread of weed seeds.
	Gram pod borer	**Cultural control:** • Field sanitation and rogueing • Ocimum/Basil acts as repellent plants • Setting up light traps @ 1/acre for adults • Erecting of bird perches @ 40/acre for encouraging predatory birds such as king crow, mynah, drongo etc. • Use of ovipositional trap crops such as marigold @ 100 plants/acre and collection of larvae from flowers • Installing pheromone traps @ 4-5/acre (ETL 10

		moths/trap/day) **<u>Biological control:</u>** • Spraying NSKE 5 % against eggs and first instar larva or azadirachtin 0.03% (300 ppm) neem oil based WSP @ 1000-2000 ml in 200-400 l of water/acre or azadirachtin 5% W/W neem extract concentrate @ 80 ml in 160 l of water/acre • Spraying NPV @ 250 LE/acre in combination with jaggery 1 kg, sandovit 100 ml or Robin Blue 50 g thrice at 10-15 days interval on observing the eggs or first instar larvae in the evening hours. • Conserve parasitoids such as *Trichogramma chilonis* (egg), *Tetrastichus* spp. (egg), *Chelonus* spp. (egg-larval), and *Telenomus* spp. (egg), *Netelia product* (larval), *Carcelia* spp. (larval-pupal), *Chaetopthalmus* (larval), *Campoletis chlorideae* (larval), and *Bracon* spp. (larval) etc. • Conserve predators such as *Chrysoperla carnea,* coccinellids, king crow, wasp, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants etc. • Spray *Beauveria bassiana* 1% WP @ 1500-2000 g in 160-200 l of water/acre • Spray *B. t*. var gallariae @ 400-600 g in 200 l of water/acre • Conserve parasitic nematode, *Ovomermis albicans* **<u>Chemical control:</u>** • Foliar spray with chloranthraniliprole 18.5% SC @ 50 ml in 200 l of water/acre or cypermethrin 10% EC @ 220-304 ml in 60-160 l of water/acre or cypermethrin 25% EC @ 60-80 ml in 200 l of water/acre or emamectin benzoate 5% SG @ 54-68 g in 200 l of water/acre or fenpropathrin 30% EC @ 100-136 ml in 300-400 l of warer/acre or fenvalerate 20% EC @ 120-150 ml in 240-300 l of water/acre or lambda cyhalothrin 4.9% CS @ 120 ml in 200 l of water/acre or permethrin 25% EC @ 160-200 ml in 400 l of water/acre or pyridalyl 10% EC @ 200-300 ml in 200-300 l of water/acre or or quinalphos 20% AF @ 500-600 ml in 300-400 l of water/acre or pyriproxyfen 5% EC + fenpropathrin 15% EC @ 200-300 ml in 200-300 l of water/acre or carbaryl 50% WP @ 800 g in 200-400 l of water/acre or carbaryl 10% D.P @ 10000 g/acre or deltamethrin 2.8% EC @ 160-240 ml in 160-240 l of water/acre or phosalone 35% EC @ 500 ml in 200-400 l of water/acre or quinalphos 25% EC @ 320 ml in 200-400 l of water

	Okra shoot and fruit borer	Same as in vegetative stage
	White fly	Same as in vegetative stage

V. Insecticide resistance and its management

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

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

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

1) **Monitor pests:** Monitor insect population development in fields to determine if and when control measures are warranted. Monitor and consider natural enemies when making control decisions. After treatment, continue monitoring to assess pest populations and their control.
2) **Focus on AESA.** Insecticides should be used only as a last resort when all other non-chemical management options are exhausted and P: D ratio is above 2: 1. Apply biopesticides/chemical insecticides judiciously after observing unfavourable P: D ratio and when the pests are in most vulnerable life stage. Use application rates and intervals as per label claim.
3) **Ecological engineering for pest management:** Flowering plants that attract natural enemies as well as plants that repel pests can be grown as border/intercrop.
4) **Take an integrated approach to managing pests.** Use as many different control measures as possible viz., cultural, mechanical, physical, biological etc. Select insecticides with care and consider the impact on future pest populations and the environment. Avoid broad-spectrum insecticides when a narrow-spectrum or more specific insecticide will work. More preference should be given to green labeled insecticides.
5) **Mix and apply carefully.** While applying insecticides care should be taken for proper application of insecticides in terms of dose, volume, timing, coverage, application techniques as per label claim.
6) **Alternate different insecticide classes.** Avoid the repeated use of the same insecticide, insecticides in the same chemical class, or insecticides in different classes with same mode of action and rotate/alternate insecticide classes and modes of action.

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

VI. Nutritional deficiencies

S. No.	Nutrients and their deficiency symptoms	
1	**Nitrogen:** Plants are stunted. Leaves are smaller than normal. Leaves are yellow. Shoots are thin. Pods are tough. **Correction measures:** Application of nitrogen fertilizer at optimum dose. The dose may be determined by soil test. In absence of soil testing. 40 - 150 kg N/ac may be applied. Three or four consecutive foliar sprays with 1% urea solution at an interval of 10 days. Six foliar sprays with 2% urea solution at an interval of 7 days starting from 20 days after sowing.	
2	**Phosphorous:** Plants are stunted. Leaves are dark green. Application of phosphorus fertilizer at optimum dose. The dose may be determined by soil test in absence of soil testing. **Correction measures:** 8-75 kg P2O5/ac may be applied.	
3	**Potassium:** Number of leaves are low. Leaf margins are brown yellow, brown or scorched. Abscission of scorched leaves. **Correction measures:** Application of potassium fertilizer at optimum dose. The dose may be determined by soil test. In absence of soil testing, 20 - 75 kg potash /ac may be applied.	
4	**Magnesium:** Lower leaves show yellow spots. Veins are green. **Correction measures:** Foliar spray with 1 – 2 % magnesium sulphate (MgSO4.7 H2O) may be tried.	

5	**Manganese:** Leaves show chlorosis. Foliar spray with 0.6% manganese sulphate + 0.3% lime may be tried. **Correction measure:** Foliar spray of MnSO4 @0.5%.	
6	**Zinc:** Number of leaves are low. Leaves are smaller. Leaves are mottled. Stem is thin. **Correction measures:** Broadcasting of zinc sulphate @ 4.5 - 9.0 kg/ac along with NPK fertilizers. band placement of zinc sulphate @ 2.2 - 4.5 kg/ac along with NPK fertilizers. Foliar spray with zinc sulphate @ 0.7 kg Zn/ac. Foliar spray with Zn-EDTA @ 0.17 kg Zn / ha. Foliar spray with zinc sulphate @ 0.56 - 1.1 kg Zn/ ha. Foliar spray with zinc sulphate @ 1.4 Zn /ac.	
7	**Boron:** Leaves become brittle; stunted plant growth, young leaves become smaller in size; malformed fruits **Correction measure:** Foliar spray of borax@0.5%	 
8	**Iron:** Stunted plant growth; chlorosis occur in young leaves **Correction measure:** Foliar spray of FeSO4 @ 05.%	

VII. Description of common weeds

Major kharif weeds

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

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

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

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

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

A variable annual herb upto 1 m tall with an erect, glabrous or sparsely pubescent stem and staggered branching pattern. Leaves are 2.5-9 cm long and 2-5 cm wide, ovate, glabrous, thin, margins toothed, tapering into the petiole, apex subacute. Flowers small, white, borne in

drooping, umbellate 3-8 flowered cymes. Fruits berries globose, 5-8 mm in diameter, red, yellow or purplish-black. when ripened, fruits having numerous, disc-shaped, 1.5 mm in diameter, yellow, minutely pitted seeds.


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

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

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

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

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

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

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

A prostrate or ascending annual grass with spreading, branched stem having rooting at nodes. Leaves are 3-20 cm long, 3-10 mm wide, with hairs on both the surfaces. Stem sheaths hairy and closed. Leaves and sheaths may turn dark red or maroon with age. Seed head composed of 4-6 branches (spikes) at the top of the stems, each approximately 3-15 cm long. Fruit caryopsis shiny, yellowish-brown, 2-3 mm long.

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

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

Sedges

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

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

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

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

Major rabi weeds

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

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



2. Scarlet pimpernel: *Anagallis arvensis* Primulaceae L

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

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

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

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

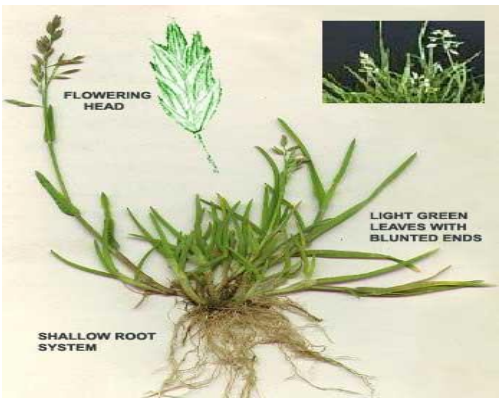
Annual herb, up to 60 cm tall. Stem Slender, much branched and succulent. Leaves 2-3 pinnatisect, 2-5 cm long, segments linear oblanceolate, apiculate. Flowers Purplish-red, spurred, in terminal or leaf opposed bracteate racemes. Fruits are rounded nuts, 2-3 mm in diameter, wrinkled when dry.

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

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

6. Bluegrass: *Poa annua* L. Poaceae

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



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

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

VIII. Description of insect pests

1) Shoot and fruit borers:

It is one of the important pests of bhendi throughout the country. It also infests cotton, mesta etc.

Biology: ***E. insulana***

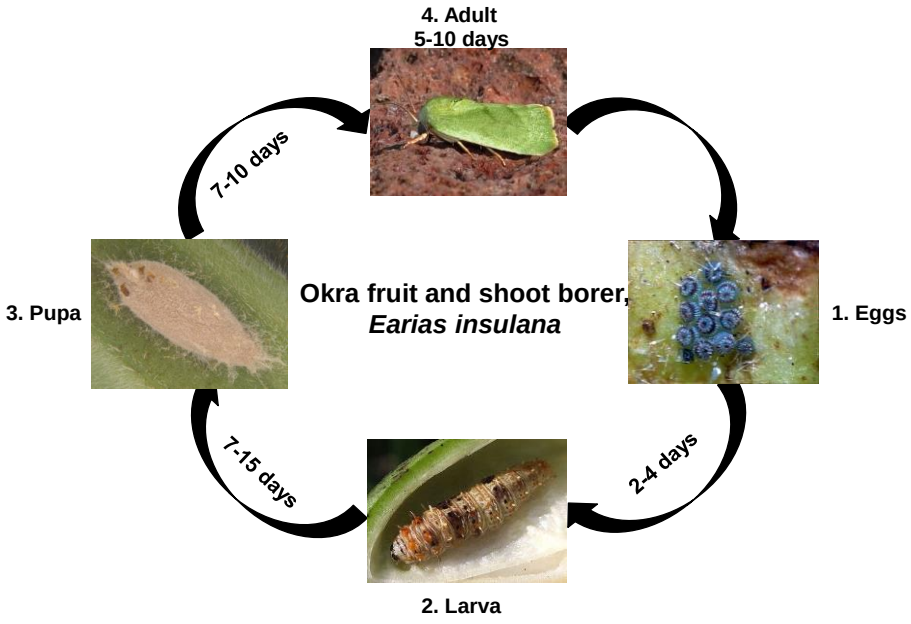
Egg: Sculptured egg and sky blue in colour.

Larva: Brown with dorsum showing a white median longitudinal streak.

Pupa: Brown and boat shaped.

Adult: Forewing – uniformly silvery green.

Life cycle:



1. http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insect-veg_bhendi.html
2. http://ww.w.lepidoptera.pl/show.php?ID=3640&country=CY
3. http://www.nbaii.res.in/insectpests/Earias-vittella.php
4. http://www.chemtica.com/site/wp-content/uploads/2012/11/ Earias-insulana-4-e1353432997300.jpg

Biology: ***E. vitella***

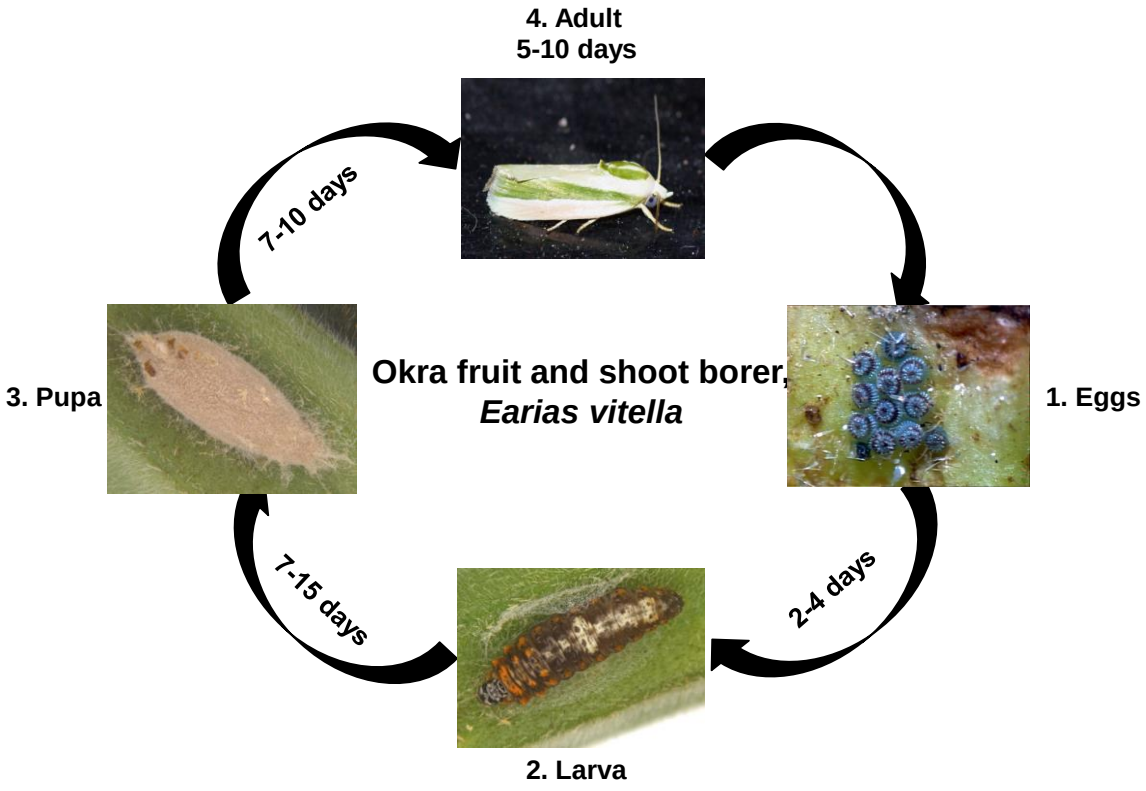
Egg: Sculptured egg and sky blue in Colour.

Larva: Brownish with white streaks dorsally and pale yellow ventrally.

Pupa: Brown and boat shaped.

Adult: Forewing – pale with a wedge shaped green band in the middle.

Life cycle:



1. http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insect-veg_bhendi.html
2, 3, and 4. http://www.nbaii.res.in/insectpests/Earias-vittella.php

Damage symptoms:
Terminal shoots wither and droop
Shedding of buds and flowers
Bore hole in fruits and feed

Deformed fruits

1. 2.


1. http://www.nbaii.res.in/insectpests/Earias-vittella.php
2. http://www.infonet-biovision.org/print/ct/115/crops

Parasitoids:

1. *Trichogramma* spp.

2. *Bracon* spp.

3. *Elasmus* sp

4. *Brachymeria* spp.

5. *Goryphus* sp

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 (*Eocanthecona furcellata*)**



1. http://www.macro-world.cz/image.php?id_foto=514&gal=29
2. http://llladybug.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_Asopinae/ Eocanthecona.htm

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

2) Gram pod borer:

It is a polyphagous, infesting gram, lablab, safflower, chillies, groundnut, tobacco, cotton etc.

Biology:

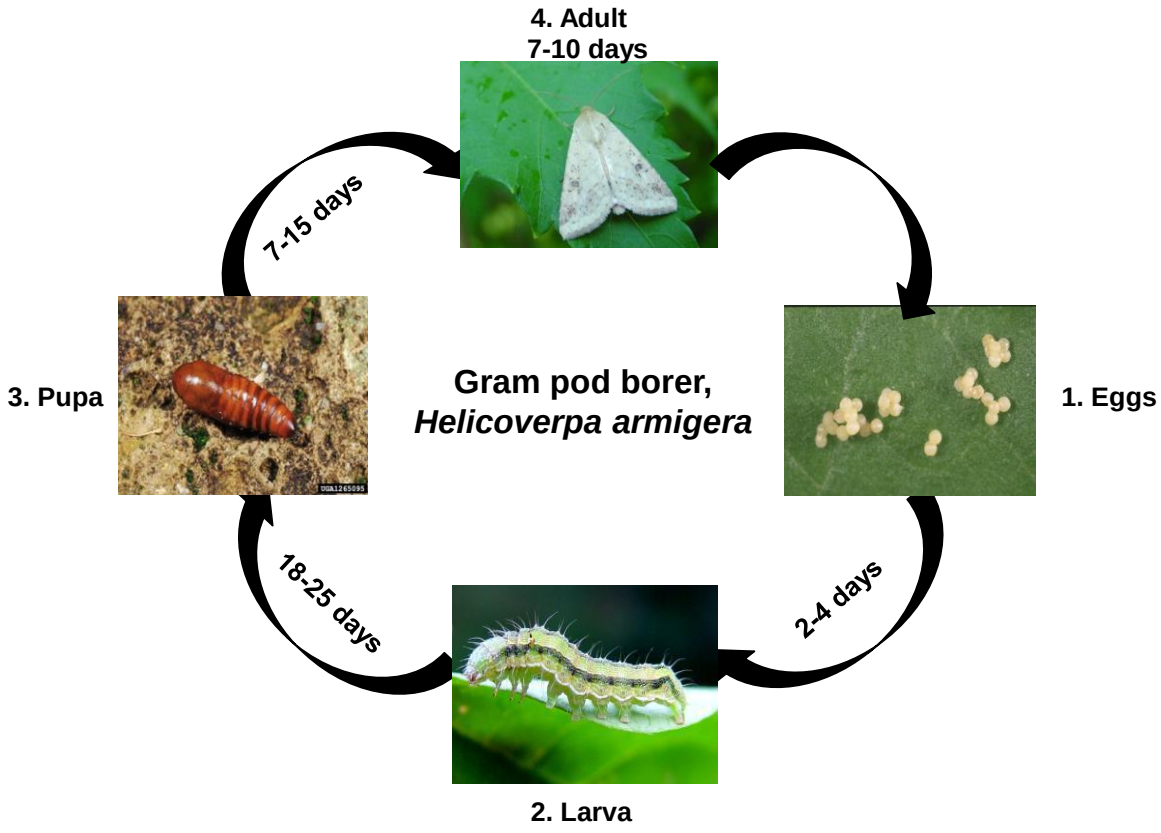
Egg: The spherical, yellowish eggs are laid singly on tender parts and buds of plants. The egg period lasts for 2-4 days.

Larva: Caterpillars are of varying colour, initially brown and later turn greenish with darker broken lines along the side of the body.
The larval period lasts for 18-25 days. Body covered with radiating hairs. When full grown, they measure 3.7 to 5 cm in length. The full grown caterpillar pupates in the soil in an earthen cell and emerges in 16-21 days.

Pupa: Pupation takes place inside the soil. Pupal stage lasts 7-15 days.

Adult: Moth is stout, medium sized with brownish/greyish forewings with a dark cross band near outer margin and dark spots near costal margins, with a wing expanse of 3.7cm.

Life cycle:



http://www7.inra.fr/hyppz/RAVAGEUR/6helarm.htm
http://www.infonet-biovision.org/default/ct/120/crops

http://www.invasive.org/browse/subinfo.cfm?sub=9408
http://en.wikipedia.org/wiki/Helicoverpa_armigera

Damage symptoms:

In early stages, the caterpillars are gregarious and scrape the chlorophyll content of leaf lamina giving it a papery white appearance. Later they become voracious feeders making irregular holes on the leaves.

Irregular holes on leaves initially and later skeletonisation leaving only veins and petioles

Heavy defoliation.

Bored fruits with irregular holes

Fed leaves, shoots and buds.

The activity of *Helicoverpa* starts on green gram, summer vegetables and maize and continues their generation by Aug-Sept months synchronizing with main crop.

Parasitoids:

1. *Trichogramma* spp.

2. *Tetrastichus* spp.

3. *Chelonus* spp.

4. *Telenomus* spp.

5. *Bracon* spp.

6. *Ichneumon* spp.

7. *Carcelia* spp.

8. *Campoletis* spp.

http://gsquaredbugs.com/?page_id=318
http://www.pbase.com/image/135529248
http://www.nbaii.res.in/Featured%20insects/chelonus.htm
http://baba-insects.blogspot.in/2012/02/telenomus.html
http://www.nbaii.res.in/Featured%20insects/Bracon%20brevicornis.htm
http://www.organicgardeninfo.com/ichneumon-wasp.html
http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398
http://www.nbaii.res.in/Featured%20insects/Campoletis.htm

Predators:

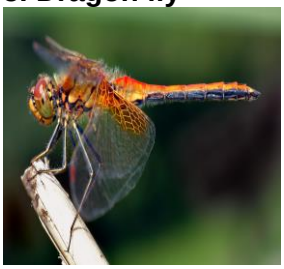
1. Lacewing

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)

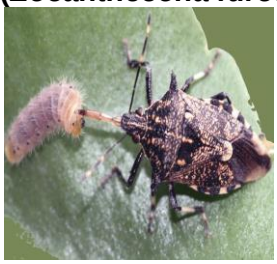
10. Wasp

11. Common mynah

12. Big-eyed bug (*Geocoris* sp)

13. Earwig **14. Ground beetle** **15. Pentatomid bug (*Eocanthecona furcellata*)**





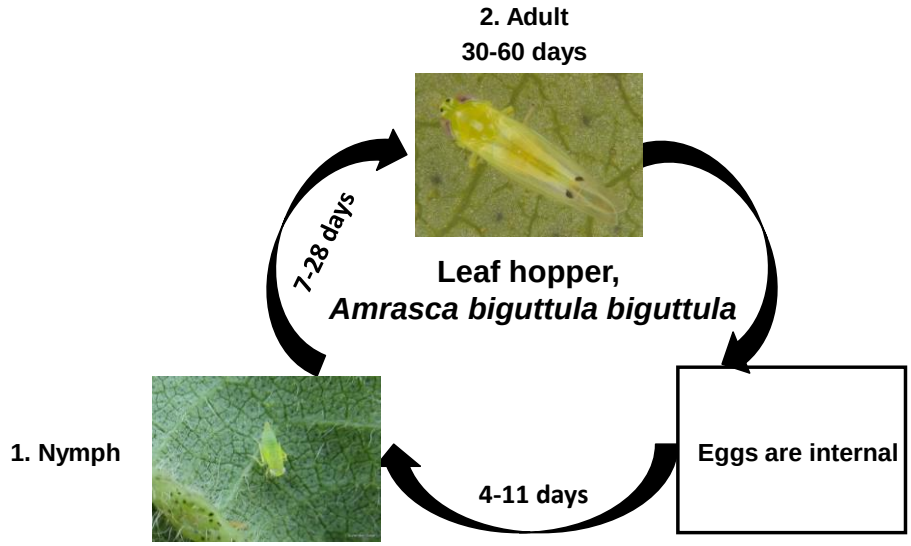
1. http://www.macro-world.cz/image.php?id_foto=514&gal=29
2. http://llladybug.blogspot.in/
3. http://en.wikipedia.org/wiki/Wolf_spider
4.http://www.couriermail.com.au/news/queensland/queensland-launched-a-war-against-the-fire-ant-invasion-but-12-years-later-they8217re-still-on-the-march/story-fnihsrf2-1226686256021
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_Asopinae/Eocanthecona.htm

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

3**) Leaf hoppers:**

It is distributed throughout the country. Both nymphs and adults suck the sap from underside of leaves injecting toxic saliva

Life cycle:



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

Damage symptoms:

Characteristic hopper burn symptom.
Infested leaves crinkle and show characteristic browning
Attacked plants stunted, fail to bear fruits.

1. **2.**

1&2. http://www.ikisan.com/Crop%20Specific/Eng/links/ap_bhendiInsect%20Management.shtml

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

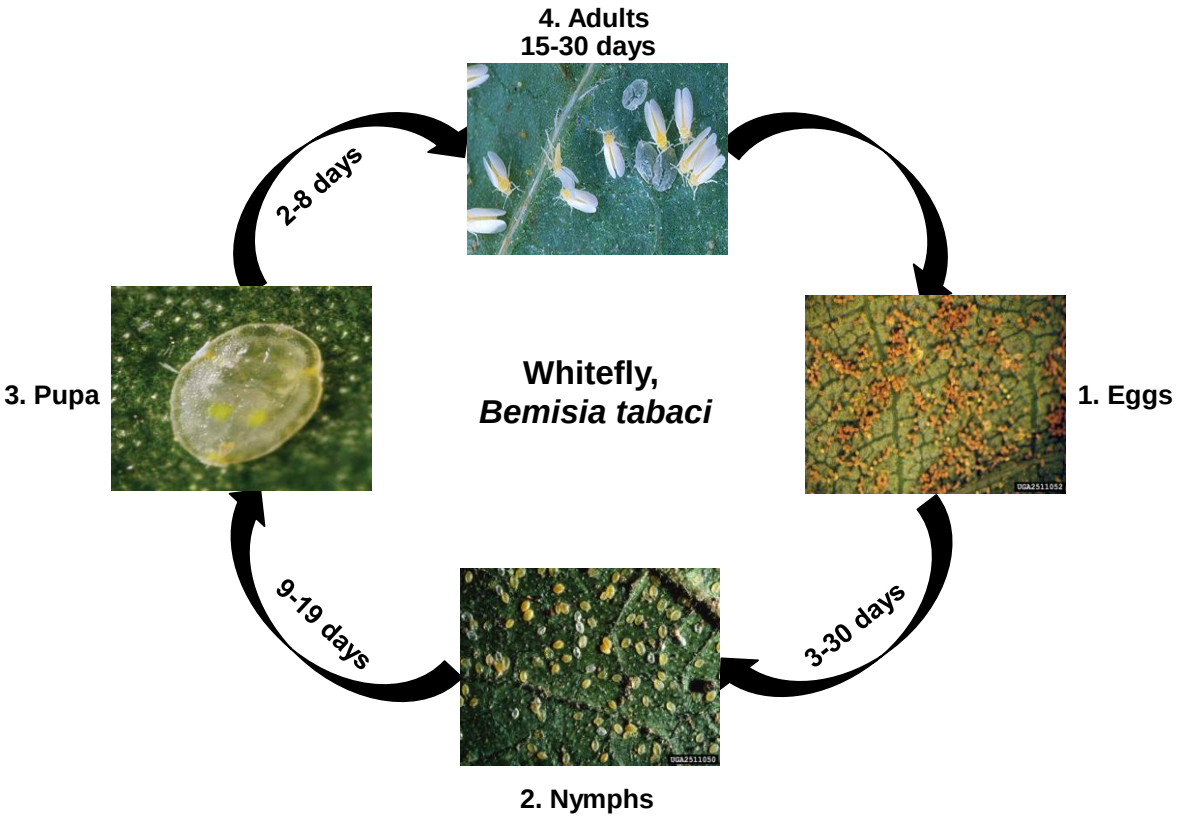
*For management refer to page number----------

4) Whitefly:

Biology:

Nymph: Greenish yellow, oval in outline,
Pupa: Puparia oval in shape, present on the under surface of the leaves.
Adult: Minute insects with yellow body covered with a white waxy bloom.

Life cycle:



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://www.fera.defra.gov.uk/plants/publications/documents/factsheets/bemisia.pdf
4. http://www.entomology.umn.edu/cues/inter/inmine/Whitefg.html

Damage symptoms:

Chlorotic spots on the leaves which latter coalesce forming irregular yellowing of leaf tissue which extends from veins to the outer edges of the leaves
Severe infestation results in premature defoliation
Development of sooty mould
Shedding of buds and bolls and poor boll opening
It also transmits the leaf curl virus diseases of cotton.

http://www.flickr.com/photos/greenery/3807115533/

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)**



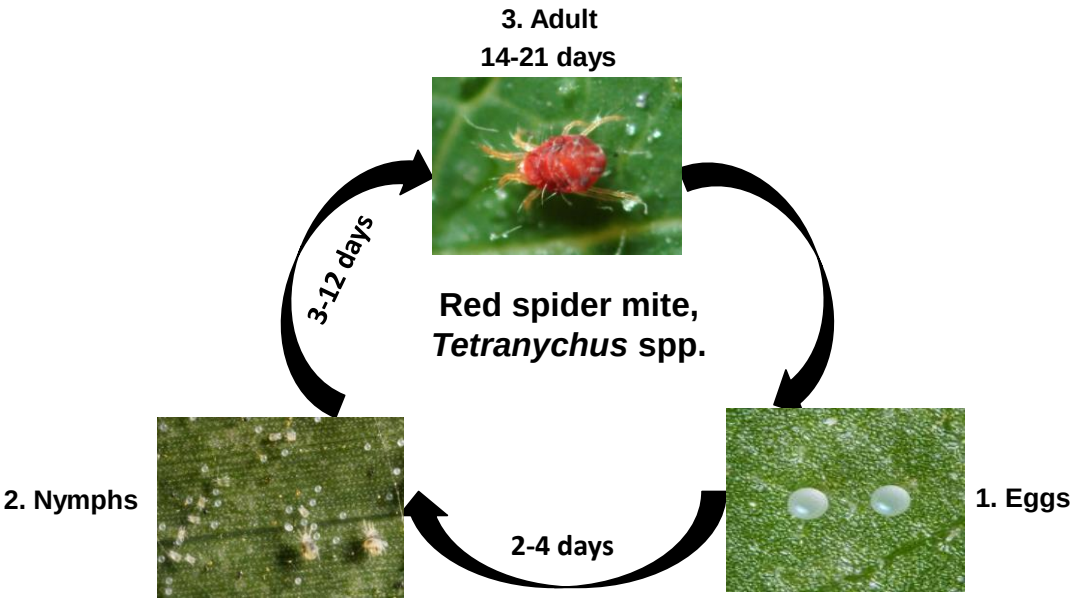

1. http://nathistoc.bio.uci.edu/hemipt/Dicyphus.htm
2. http://www.macro-world.cz/image.php?id_foto=514&gal=29
3. http://llladybug.blogspot.in/
4. http://commons.wikimedia.org/wiki/File:Geocoris_punctipes.jpg

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

5) Red spider mite:

Biology:
Egg: Hyaline, globular laid in mass
Nymphs: Yellowish in colour
Adult: Red coloured small size

Life cycle:



1. http://www.simplepestcontrol.com/spider-mite-control.htm

2. http://entomology.k-state.edu/extension/insect-photo-gallery/Corn-Insects.html
3. http://www.al.gov.bc.ca/cropprot/grapeipm/spidermites.htm

Damage symptoms:

Affected leaves become reddish brown and bronzy
Severe infestation larvae silken webbing on the leaves
Leaves wither and dry
Flower and fruit formation affected

Predators:

1. Predatory mite

2. Predatory thrips

3. *Oligota* spp.

4. Spider

5. *Orius* spp. (pirate/anthocorid bug)

6. Hover fly

7. 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/Wolf_spider
5. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
6. http://freepages.misc.rootsweb.ancestry.com/~larsonmorgan/flies/flies.html

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

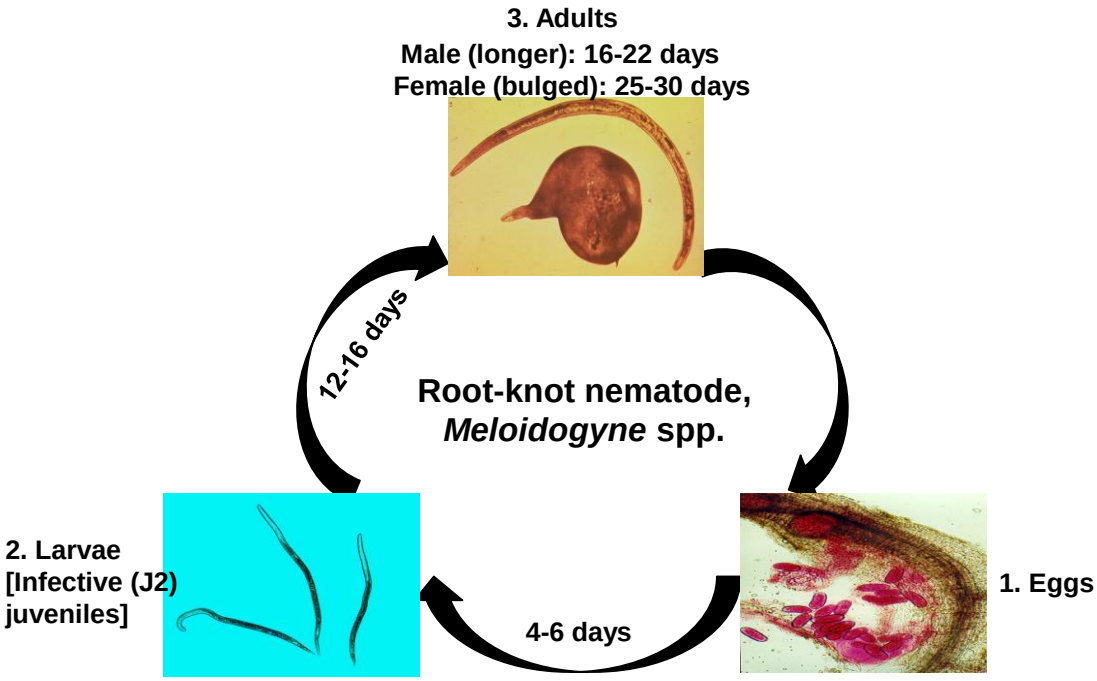
*For management refer to page number----------

6) Root-knot nematode:

Most species of plant parasitic nematodes have a relatively simple life cycle consisting of the egg, four larval stages and the adult male and female.
Development of the first stage larvae occurs within the egg where the first molt occurs. Second stage larvae hatch from eggs to find and infect plant roots or in some cases foliar tissues.
Under suitable environmental conditions, the eggs hatch and new larvae emerge to complete the life cycle within 4 to 8 weeks depending on temperature.
Nematode development is generally most rapid within an optimal soil temperature range of 70 to 80°F.

Life cycle:

Life stages are microscopic in size



1.http://keys.lucidcentral.org/keys/sweetpotato/key/Sweetpotato%20Diagnotes/Media/Html/The Problems/Nematodes/RootKnotNematode/Root-knot.htm
2. http://nematology.umd.edu/rootknot.html
3. http://www.cals.ncsu.edu/pgg/dan_webpage/Introduction/Images/pyroform.htm

Damage symptoms:

Infected plants in patches in the field
Formation of galls on host root system is the primary symptom
Roots branch profusely starting from the gall tissue causing a '**beard root**' symptom
Infected roots become knobby and knotty
In severely infected plants the root system is reduced and the rootlets are almost completely absent. The roots are seriously hampered in their function of uptake and transport of water and nutrients
Plants wilt during the hot part of day, especially under dry conditions and are often stunted
Seedlings infected in nursery do not normally survive transplanting and those surviving have reduced flowering and fruit production
Nematode infection predisposes plants to fungal and bacterial root pathogens

1.

2.

1. http://utahpests.usu.edu/htm/utah-pests-news/up-summer12-newsletter/root-knot-nematodes/
2. http://extension.entm.purdue.edu/nematology/melonnems.html

Survival and spread:
Primary: Cysts and egg masses in infected plant debris and soil or collateral and other hosts like Solonaceous, Malvaceous and Leguminaceous plants act as sources of inoculum
Secondary: Autonomous second stage juveniles that may also be water dispersed

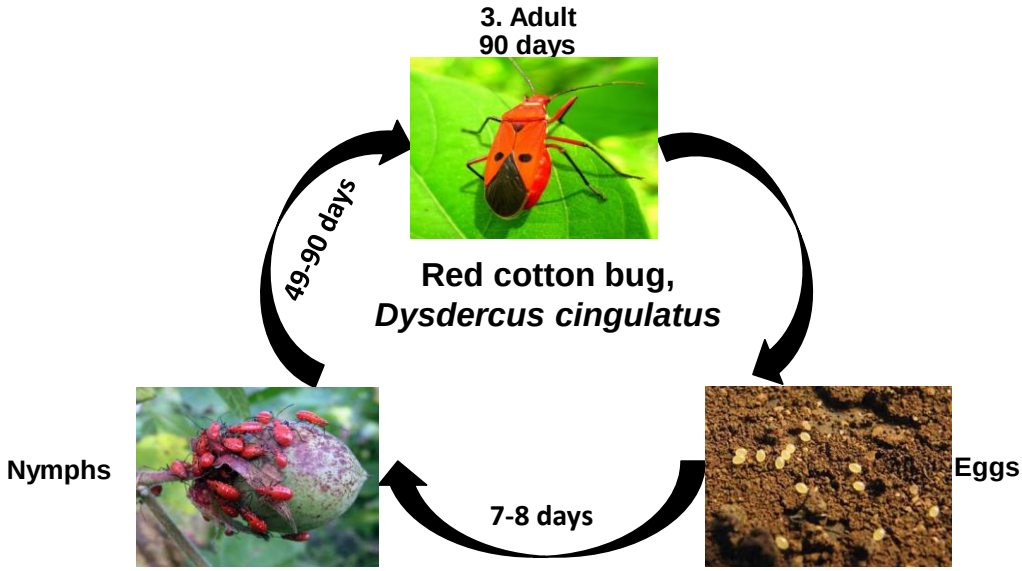
Favourable conditions:
Loamy light soils

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

7) Red cotton bug:

Biology:
Nymphs and Adults: Reddish bugs with white bands on the abdomen and black markings on the wings.

Life cycle:



1.http://www.cottoncrc.org.au/industry/Publications/Pests_and_Beneficials/Cotton_Insect_Pest_and_Beneficial_Guide/Pests_by_common_name/Cotton_stainers
2. http://tnaucottondatabase.wordpress.com/category/cotton-pest/
3. http://www.flickriver.com/photos/tags/dysdercuscingulatus/interesting/

Symptoms of damage: Adults and nymphs suck sap from leaves, fruits, and seeds. Vitality of the plant is lowered, in genera. Affected fruits stained with insects excreta. Fruit rotting occurs due to infection of secondary bacteria.

Predators:

1. Spider

2. Fire ant

3. Earwig

4. Ground beetle

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)

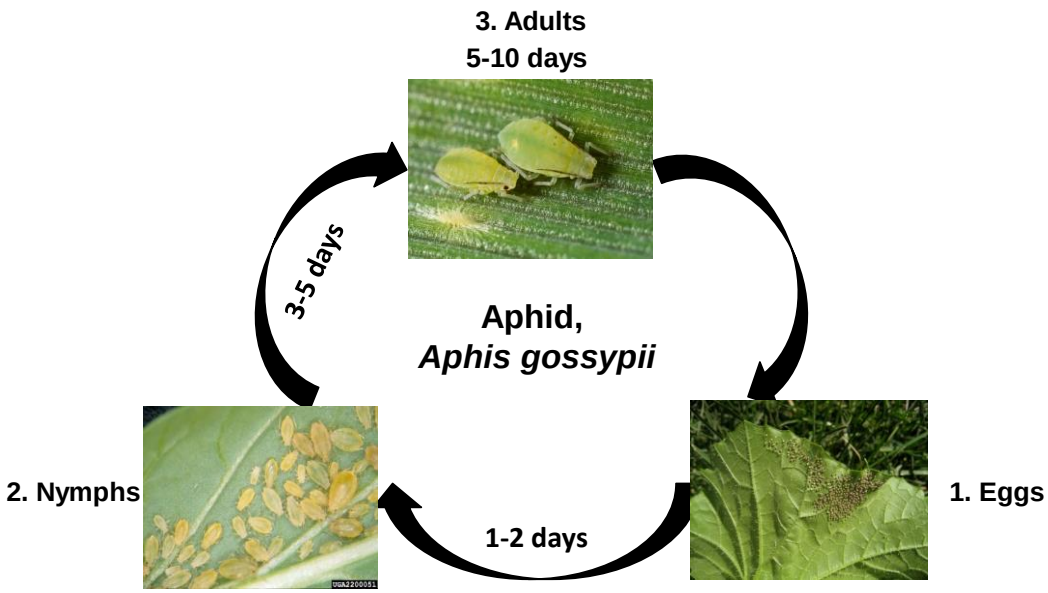
1. http://en.wikipedia.org/wiki/Wolf_spider
2.http://www.couriermail.com.au/news/queensland/queensland-launched-a-war-against-the-fire-ant-invasion-but-12-years-later-they8217re-still-on-the-march/story-fnihsrf2-1226686256021
3. http://www.flickr.com/photos/johnhallmen/2901162091/
4.http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/Ground%20Beetle%20-%20Pterostichus%20madidus.html
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

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

8) Aphids:

Nymphs: Yellowish or greenish brown found on the undersurface of leaves.
Adults: Greenish brown, soft bodied and small insects

Life cycle:



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:

Infesting tender shoots and under surface of the leaves.
Curling and crinkling of leaves
Stunted growth
Development of black sooty mould due to the excretion of honeydew

1.

2.

1 and 2. http://www.missouribotanicalgarden.org/gardens-gardening/your-garden/help-for-the-home-gardener/advice-tips-resources/pests-and-problems/insects/aphids/aphids-outdoors.aspx

Parasitoid:

1. *Aphidius colemani*

1. http://biobee.in/products-and-services/solutions/bio-aphidius/

Predators:

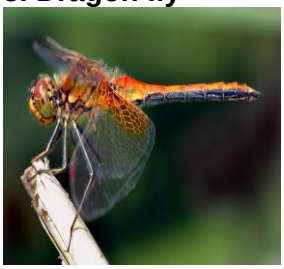
1. Lacewing

2. Lady beetle

3. Spider

4. Fire ant

5. Dragon fly



6. Robber fly

7. Reduviid bug

8. Praying mantis

9. Big-eyed bug (*Geocoris* sp)

10. Earwig

11. Ground beetle

12. Cecidomyiid fly (*Aphidoletis aphidimyza*)

1. http://www.macro-world.cz/image.php?id_foto=514&gal=29
2. http://llladybug.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://bugguide.net/node/view/598529
10. http://www.flickr.com/photos/johnhallmen/2901162091/
11.http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/Ground%20Beetle%20-%20Pterostichus%20madidus.html
12. http://jenny.tfrec.wsu.edu/opm/displaySpecies.php?pn=740
*For management refer to page number----------

IX. Description of diseases:

1) Yellow vein mosaic virus:

Very serious constraint in bhindi production throughout the country

Gemini virus having spherical bipartite particles with ss DNA as genome

Damage symptoms:

- **Yellowing of the entire network of veins** in the leaf blade (**vein clearing**) is the characteristic symptom.
- In severe infections the **younger leaves turn yellow**, become reduced in size and the plant is highly stunted
- In a field, most of the plants may be diseased and the infection may start at any stage of plant growth
- Infection restricts flowering and fruits are not formed, if formed, turn smaller, harder and rough.
- Loss in fruit yield ranges from 50-100% based on disease incidence

Yellow vein mosaic visus symptoms; Photo by: SK Sain

Survival and spread:

Primary: Virus particles in infected plants and collateral hosts like ***Hibiscus tetraphyllus*****,** ***Croton sparsiflora*** **and** ***Ageratum*** **spp**

Secondary: Virus particles transmitted by **whitefly** ***Bemisia tabaci***

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

2) Cercospora leaf spot: ***Cercospora malayensis*** **F. Stevens & Solheim**

Damage symptoms:

- *C. malayensis* causes brown, irregular spots and *C. abelmoschi* causes sooty black,
- angular spots on lower surface of leaves
- Both the leaf spots cause severe defoliation and are common during humid season

Disease symptom on leaf; Photo by : SKSain

Survival and spread:

Primary: The fungi survive through conidia and stromata on crop refuse in soil

Secondary: Wind dispersed **conidia**

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

3) Powdery mildew: ***Erysiphe cichoracearum*** **DC.**

Damage symptoms:

- Grayish powdery growth occurs on the under as well as on the upper surface of the leaf
- Affected leaves turn yellow and drop off leading to severe yield loss

Powdery mildew symptoms of okra foliage: Photo by: SK Sain

Survival and spread:

Primary : Dormant mycelium and cleistothecia in crop residue

Secondary: Wind dispersed conidia

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

4 Damping off: *Pythium aphanidermatum*

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://www.infonet-biovision.org/res/res/files/1528.400x300.jpeg

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.

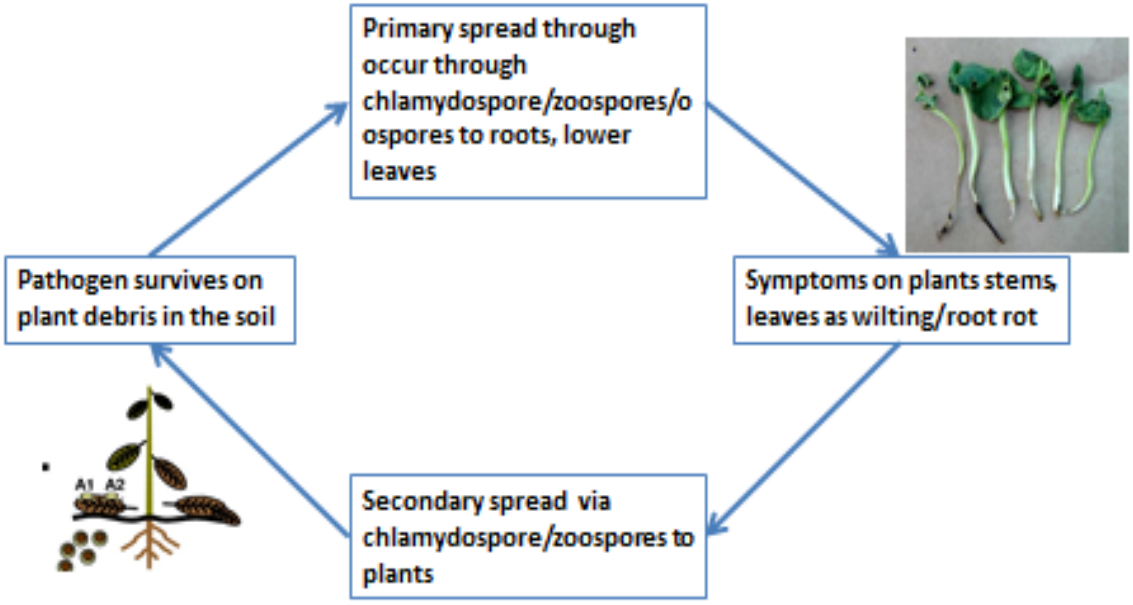
Survival and spread:

Primary: Soil, Seed, Water
Secondary: Conidia through rain splash or wind

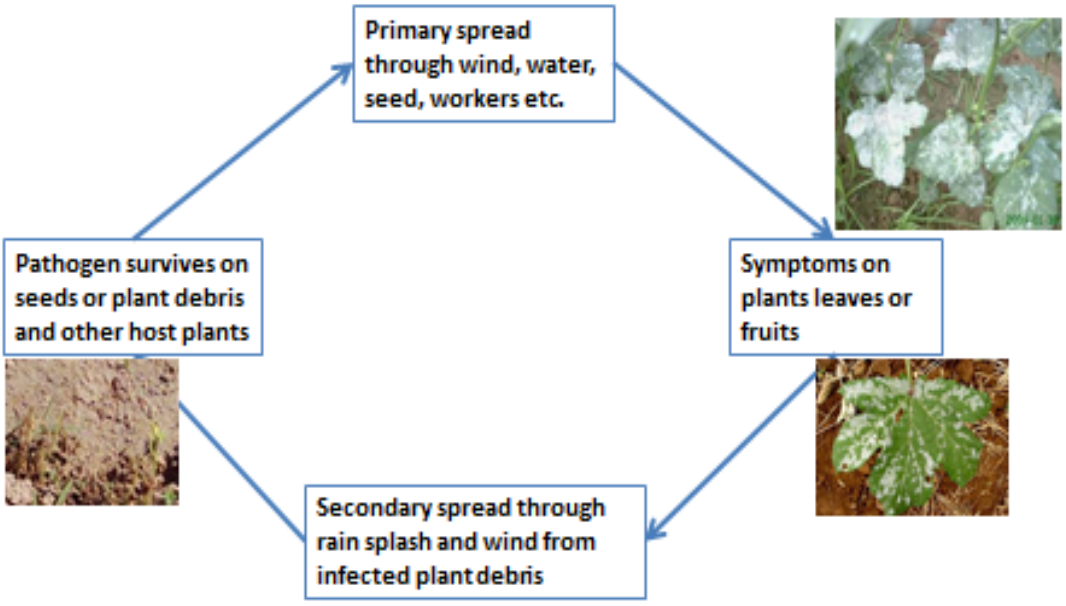
*For management refer to page number----------

Diseases life cycle

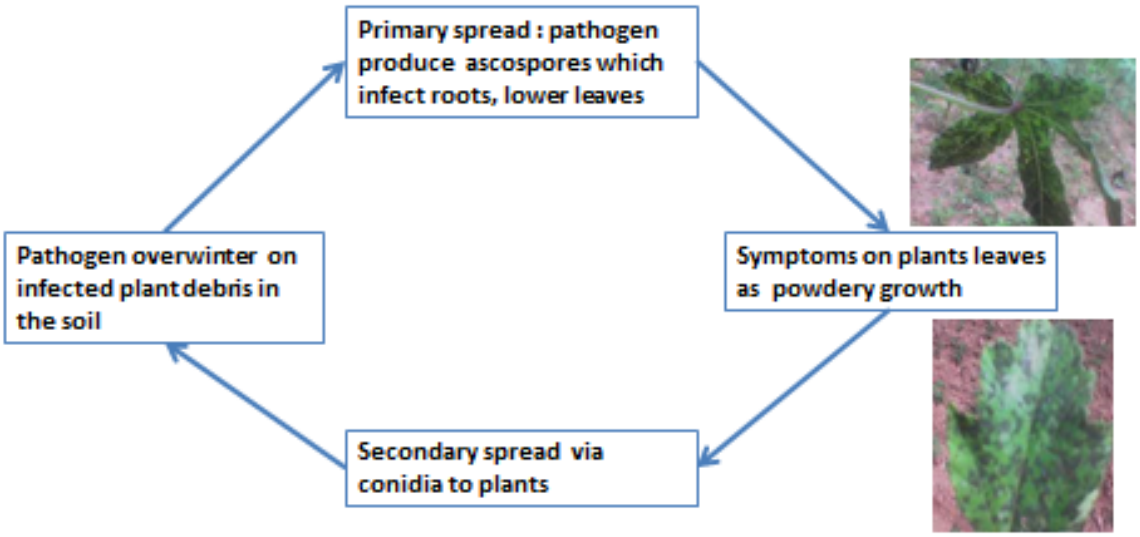
1. Damping off: *Pythium debaryanum* R. Hesse



2. Powdery mildew: *Erysiphe cichoracearum* DC.



3. Cercospora leaf spot: *Cercospora malayensis* F. Stevens & Solheim



X. Safety measures

A) at the time of the harvest

For vegetable use, the fruits should be picked about one week after anthesis. In the vegetable crop, the picking of young fruits permits sustained vegetative growth prolonging the harvest. Okra pods are ready for harvest when they are about 2-4 inches or 4-9 cm long or while the pod is soft and tip snaps. The pods are bright green, fleshy and seeds are small. The pods should be gathered everyday. They are usually handpicked and sharp knives are used to cut them from the stalks to avoid fruit damage such as bruises and discoloration. About 1 cm of stem should remain attached to the pod.

B) post-harvest storage

Okra should not be stored more than 36 hours after packing (deterioration already starts at this time). Do not put ice on top of the packages because it causes water spots on the pods and decay. Optimum transport/storage temperature is 10-12°C if temperature is below 10-12 °C, chilling injury develops, pitting, discoloration and excessive decay also will result. Okra can be stored together with snap beans, cucumber, eggplant, pepper, potato, squash, sweet potato, and watermelons (because these commodities have the same temperature requirements as that of okra). Okra is not compatible for storage with tomatoes and muskmelons. These crops are ethylene producers while okra is ethylene sensitive. Exposure of okra to ethylene causes toughening and yellowing of pods and browning of skin.

XI. Do's and Don'ts

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The field should be kept exposed to sun light at least for 2-3 weeks 	Do not plant or irrigate the field after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Adopt crop rotation.	Avoid growing monocrop.
3.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
4	Sow early in the season	Avoid late sowing as this may lead to reduced yields and incidence of white grubs and diseases.
5	Always treat the seeds with approved chemicals/bio products for the control of seed borne diseases/pests. 	Do not use seeds without seed treatment with biocides/chemicals.
6.	Sow in rows at optimum depths under proper moisture conditions for better establishment. 	Do not sow seeds beyond 5-7 cm depth.
7.	Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
8.	Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition	Crops should not be exposed to moisture deficit stress at their critical growth stages.

	 .	
9	Use NPK fertilizers as per the soil test recommendation. 	Avoid imbalanced use of fertilizers.
10	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
11	Conduct AESA weekly in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only. 	Do not take any management decision without considering AESA and P: D ratio
12	Install pheromone traps at appropriate period. 	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
13	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per field observation 	Do not apply chemical pesticides within seven days of release of parasitoids.

14	Apply HaNPV or SINPV at recommended dose when a large number of egg masses and early instar larvae are noticed. Apply NPV only in the evening hours after 5 pm. 	Do not apply NPV on late instar larva and during day time.
15	In case of pests which are active during night like *Spodoptera* spray recommended biocides/ chemicals at the time of their appearance in the night.	Do not spray pesticides at midday since, most of the insects are not active during this period.
16	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, whiteflies, *Spodoptera* etc. 	Do not spray pesticides only on the upper surface of leaves.
17	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
18	Follow the recommended procedure of trap crop technology. 	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.

XII. Safety parameters in pesticides usage

S. No	Pesticide	Classification as per insecticide rules	Colour of toxicity triangle	WHO classification of hazard	First Aid measures	Symptoms poisoning	Treatment of poisoning	Waiting period from last application to harvest
Organophosphates								
1.	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 occur.	--
Carbamates								
2.	Carbofuran	Extremely toxic		Class I b highly haardous		Constriction of pupils, salivation, profuse sweating, muscle incordination, nausea, vomiting,diarrhea, epigastric pain, tightness in t	Atropine injection-1-4 mg. repeat 2 mg when symptoms begin to recur (15-16 min interval) excessive salivation- good sign, more atropine needed chest	--
Synthetic pyrathroids								

3	Cypermethrin	Highly toxic		Class II Moderately hazardous		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose,throat, eyes and skin, allergic manifestation etc.	No specific antidote. Treatment is essentially symptomatic.	3
4	Fenvalerate				Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious person	Ingestion may cause nonspecific discomfort, such as nausea, vomiting, headache, or weakness; temporary nervous system effects such as muscular weakness, tremors and incoordination.	If on skin, after drying apply vitamin E cream or oil if available. If not available, apply vegetable oil liberally over painful areas. The oil or cream may be used repeatedly until relief is achieved	7
5	Lambda-cyhalothrin				Do not induce vomiting unless told to do so by a doctor, do not give anything	Toxic if swallowed or inhaled. Irritating to eyes and skin. Vapors	There is no specific antidote. Treatment is essentially symptomatic.	5

					by mouth to an unconscious person	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		
Neonicotinoids								
6	Thiamethoxam				Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give anything by mouth to an unconscious		No specific antidote. Treatment is essentially symptomatic.	5

7	Imidacloprid	Highly toxic			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	Harmful if swallowed, absorbed through skin or inhaled. Avoid breathing vapor or spray mist. Causes moderate eye irritation.	No specific antidote. Treatment is essentially symptomatic.	3
Avermectins								
8	Emamectin benzoate				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	Pupil dilation, muscular incooridnation , muscular tremors	Administer repeatedly medical charcoal in large quantity of water or ipecac	5
Insect growth regulators								
9	Pyriproxyfen				Do not induce vomiting unless told to do so by a doctor, do not give anything	May cause irritation of the eyes, nose, respiratory tract and skin. Prolonged	No specific antidote. Treatment is essentially symptomatic	

					by mouth to an unconscious person	and repeated exposure may cause headache and dizziness		
Anthranilic diamides								
10	Chloranthraniliprole				When used as directed this product does not present a hazard to humans or domestic animals			5
Fungicides								
11	Wettable sulphur	Slightly toxic				Headache, palpitation, nausea, vomiting, flushed face, irritation of nose,throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic	--
12	Dinocap	Moderately toxic		Class III slightly hazardous		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic.	--

XIII. Basic precautions in pesticides usage

A. Purchase
   1. Purchase only just required quantity e.g. 100, 250, 500, 1000 g/ml for single application in specified area.
   2. Do not purchase leaking containers, loose, unsealed or torn bags.
   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

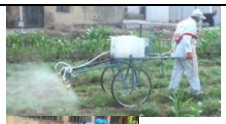
G. Disposal

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.

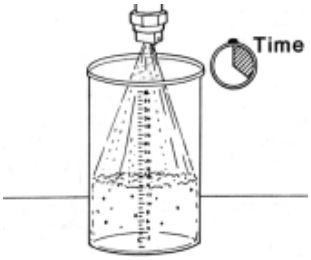
XIV. Pesticide application techniques

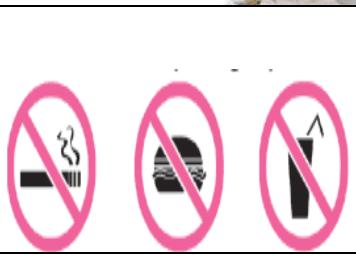
<table>
<tr><th></th><th></th><th>Equipment</th><th></th></tr>
<tr><td colspan="4">Category A: Stationary, crawling pest/ disease</td></tr>
<tr><td>Vegetative stage
i) for crawling and soil borne pests

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

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

XV. Operational, calibration and maintenance guidelines in brief

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

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

XVI. References:

Parasitoids and predators of *Earias* spp. http://www.faculty.ucr.edu/~legneref/biotact/ch-100.htm
Parasitoids of *Earias* sp.:
http://www.cicr.org.in/research_notes/Cotton%20pests%20dynamics.pdf
http://www.cicr.org.in/research_notes/BIOCONTROL%20BASED.pdf
http://www.avonpestcontrol.ca/pestcontrolnews/pest-control-delta/red-cotton-bug
http://www.cabi.org
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
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