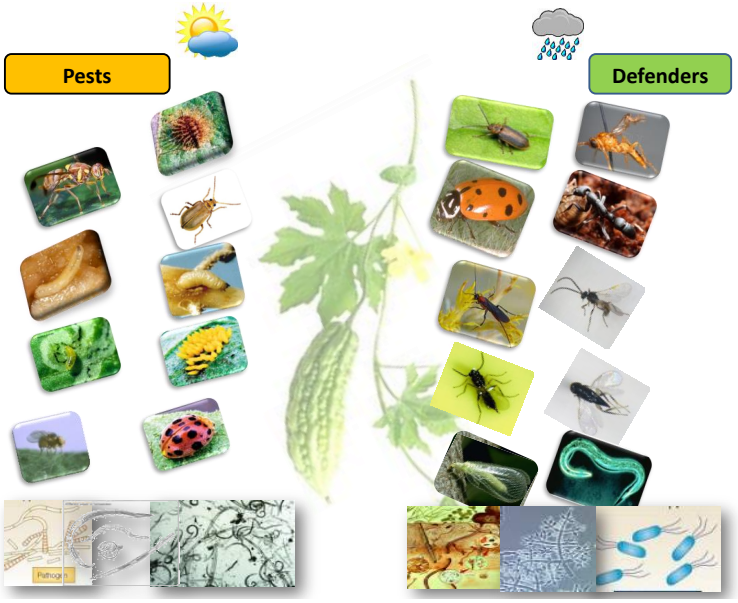
सत्यमेव जयते

AESA BASED IPM Package No. 21

AESA based IPM – Cucurbitaceous Vegetable Crops

(Cucumber, Bottle Gourd, Bitter Gourd, Sponge Gourd, Snake Gourd, Ash Gourd, Pumpkin, Squash)



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FOREWORD

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

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

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

A K Srivastava

Date: 6.3.2014

(Avinash K. Srivastava)

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FOREWORD

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

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

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

(Utpal Kumar Singh)

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PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

Contents

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IPM Package for Cucurbitaceous Vegetable Crops

I. PESTS

A. Pests of National Significance

1. Insect and mite pests

1.1 Cucurbit fruit fly: *Bactrocera cucurbitae* (big size), *B. tau*, *B. dorsalis* (medium size) (Coquillett) (Tephritidae: Diptera) (Assam, Andaman and Nicobar, Delhi, Kerala, Maharashtra, Rajasthan, Tamil Nadu)

1.2 Pumpkin beetles: *Raphidopalpa foveicollis, Aulacophora intermedia, A. cincta* (Lucas) (Chrysomelidae: Coleoptera) (Assam, Madhya Pradesh, Uttar Pradesh)

1.3 *Epilachna* beetles: *Epilachna vigintioctopunctata*, *E. dodecastigma* (Fabricius) (Epilachninae: Coccinellida: Coleoptera)

1.4 Serpentine leaf miner: *Liriomyza trifolii* (Burgess) (Agromyzidae: Diptera) (Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Madhya Pradesh, Tamil Nadu, Uttar Pradesh)

1.5 Aphids: *Aphis gossypii (Glover)* (Aphididae: Hemiptera) (Himachal Pradesh, Kerala, Manipur, Tamil Nadu, Uttar Pradesh)

1.6 Pumpkin leaf caterpillar: *Diaphania indica* (Saunders) (Pyralidae: Lepidoptera) (Gujarat, Karnataka, Punjab, Tamil Nadu)

2. Diseases

2.1 Downy mildew: *Pseudoperonospora cubensis* (Berkeley & M. A. Curtis) Rostovzev (Karnataka, Maharashtra, Punjab)

2.2 Powdery mildew: *Erysiphe cichoracearum* DC, *Sphaerotheca fuligenia* (Schltdl.) Pollacci (Haryana, Karnataka, Tamil Nadu, Uttar Pradesh)

2.3 Cucumber mosaic: *Cucumber Mosaic Virus* (Delhi, Haryana, Kerala, Punjab, Uttar Pradesh)

2.4 Fusarium wilt: *Fusarium oxysporum* Schlecht (Delhi, Karnataka, Maharashtra, Orissa, Punjab, Rajasthan, Uttar Pradesh)

3. Weeds

3.1 Major Kharif weeds

Broadleaf weeds

3.1.1 Pigweed: *Amaranthus viridis* Hook. F.

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

3.1.3 Black nightshade: *Solanum nigrum* L.

3.1.4 Common purselane: *Portulaca oleracea* L.

3.1.5 False amaranth: *Digera arvensis* Forssk.

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3.1.7 Witch weed: *Striga* sp

Grassy weeds

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

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

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

Sedges

3.1.11 Purple nutsedge: *Cyperus rotundus* L.

3.1.12 Flat sedge: *Cyperus iria* L.

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Broadleaf weeds

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

3.2.2 Scarlet Pimpernel: *Anagallis arvensis* L.

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

3.2.4 Fine leaf fumitory: *Fumaria parviflora* Lam.

3.2.5 Corn spurry: *Spergula arvensis* L.

Grassy weeds

3.2.6 Blue grass: *Poa annua* L.

3.2.7 Canary grass: *Phalaris minor* Retz.

II AESA based IPM

A. Agro-ecosystem analysis

The integrated pest management (IPM) has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment ultimately affecting the interests of the farmers. The economic threshold level (ETL) was the basis for several

decades but in modern IPM (FAO 2002) emphasis is given to AESA where farmers take decisions based on larger range of field observations. The health of a plant is determined by its environment which includes physical factors (i.e. soil, wind, rain sunshine hours 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 **<u>at least</u>** 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

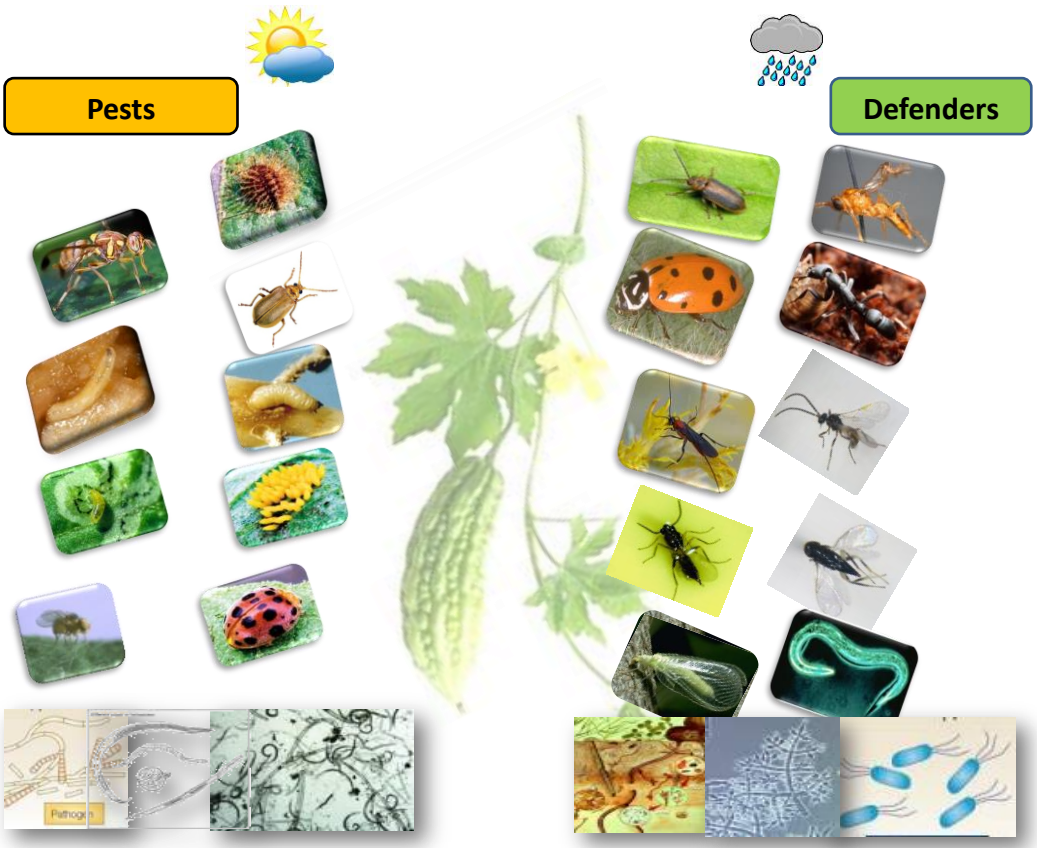
pests are not easy to observe in crop field. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial and harmful insects. In this method, unfamiliar/unknown predators are collected in plastic containers with brush from the field and brought to a place for study. Each predator 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 cucurbit crops pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens. The important natural enemies in cucurbit crops are given in ecological engineering on page……

Model agro-ecosystem analysis chart

Date:
Village:
Farmer:



Decision taken based on the analysis of field situation

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

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

Feeding/egg laying potential of different parasitoids/predators

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

 Predatory mite http://www.eduwebs.org/bugs/predatory_mites.htm	Predatory rate of adult is 20-35 phytophagous mites/female/day
 *Bracon hebetor*	Egg laying capacity is 100-200 eggs/female. 1-8 eggs/larva
 *Trichogramma* sp	Egg laying capacity is 20-200 eggs/female.

Decision making

Farmers become experts in crop management

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

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

AESA methodology

- Go to the field in groups (about 5 farmers per group). Walk across the field and choose 20 plants/acre randomly. Observe keenly each of these plants and record your observations:
    - Plant: Observe the plant height, number of branches, crop stage, deficiency symptoms etc.
    - Pests: Observe and count pests at different places on the plant.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
    - Rats: Count number of plants affected by rats.
    - Weeds: Observe weeds in the field and their intensity.
    - Water: Observe the water situation of the field.
    - Weather: Observe the weather condition.

- While walking in the field, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the field situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on what field management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording

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

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

Data to be recorded

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

- Price of produce (Rs./kg)

Some questions that can be used during the discussion

- Summarize the present situation of the field?
- What crop management aspect is most important at this moment?
- Is there a big change in crop situation compared to last visit? What kind of change?
- Is there any serious pest or disease outbreak?
- What is the situation of the beneficial insects?
- Is there a balance in the field between pests and defenders?
- Were you able to identify all pests and diseases?
- Do you think the crop is healthy?
- What management practices are needed at this moment?
- When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.
- Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest buildup?
- What problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.

Advantages of AESA over ETL

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

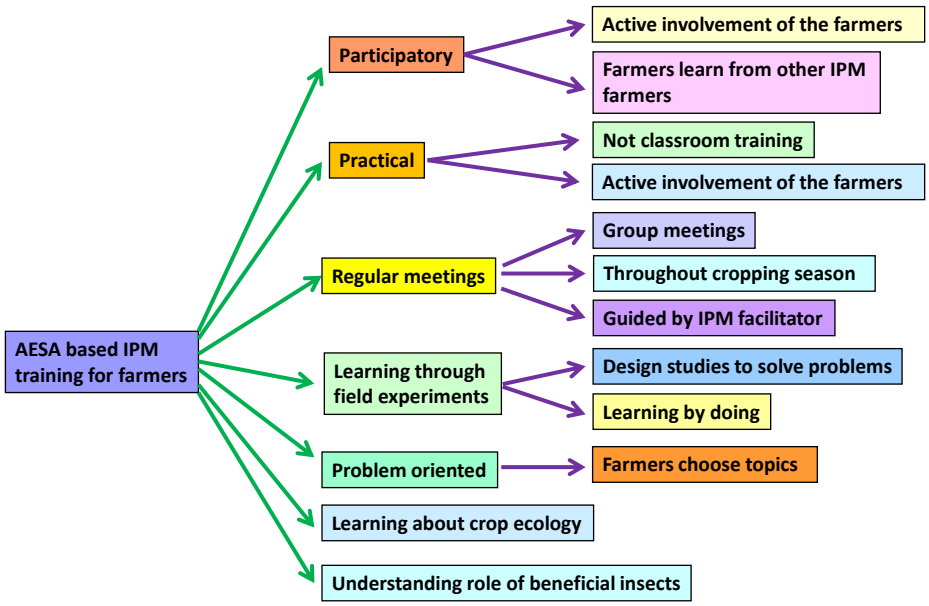
AESA and farmer field school (FFS)

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

Farmers can learn from AESA

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

FFS to teach AESA based IPM skills



B. Field Scouting

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

Surveillance on pest occurrence at the main field should commence soon after crop establishment 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 per plant.
For thrips: Count and record the number of nymphs and adults of thrips present on five terminal leaves per plant (tapping method also can be used to count thrips).
For leaf miner: Only the number of live mines on five randomly selected leaves per plant should be counted and recorded.

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

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

III. Ecological engineering for pest management

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

Natural enemies may require

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

Ecological Engineering for Pest Management – Above Ground :

- Raising the flowering plants / compatible cash crops along the field border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population
- Growing flowering plants on the internal bunds inside the field
- Not to uproot weed plants those are growing naturally like *Tidax 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.
- 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

Mustard

Dill

Anise

Caraway

Cowpea

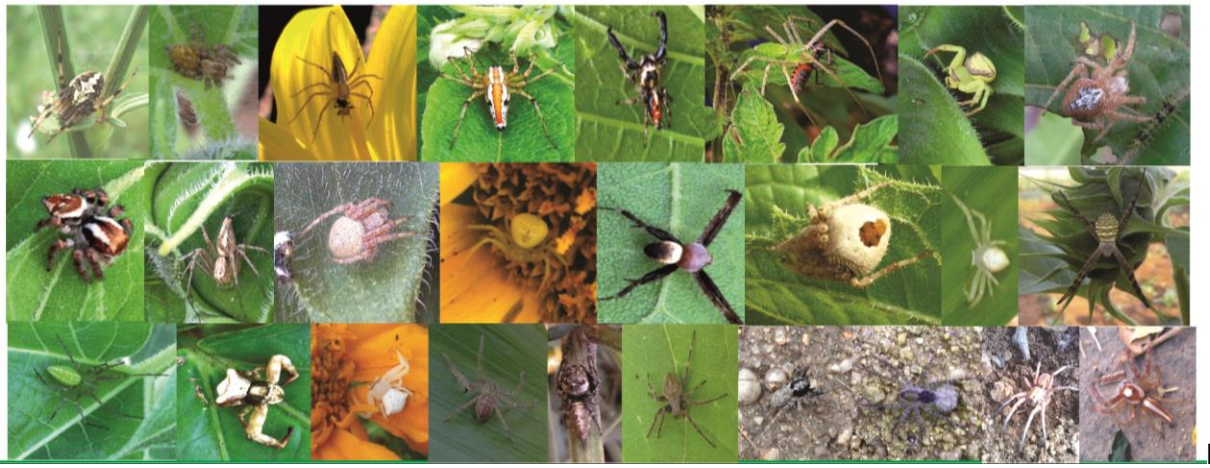
White Clover

Parsley

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators

Biodiversity of natural enemies: Spiders



Flowering plants that attract natural enemies/repel pests

S. No.	Pest	Natural enemies	Flowering plants that attract natural enemies/repel pests
1	Cucurbit fruit fly	**Parasitoids:** *Opius fletcheri* (pupal) etc.	Attractant plants: • Permanent plantings for shelter (hedge rows): (assassin bug) • Strips of rye, grains, cover crops and bio mulch beds (rove beetle) • Nectar-pollen rich plants with small flowers i.e. anise, caraway, dill, parsely, mustard, sunflower, buckwheat and cowpea (braconid wasp).
2	Pumpkin beetle	**Parasitoids:** *Celatoria setosa* (grub) etc. **Predators:** Pennsylvania leather wing beetle (*Chauliognathus pensylvanicus*) **Nematodes:** *Steinernema riobravis*	Attractant plants: • Nectar-pollen rich plants with small flowers (caraway, dill, parsley, Queen Anne's lace, fennel, mustard, white clover, tansy, and yarrow), sunflower, buckwheat, cowpea, crocuses, spearmint (braconid wasp)
3	Serpentine leaf miner	**Parasitoids:** *Gronotoma micromorpha* (larva and pupa), *Diglyphus sp.* (larva), *Opius sp.* (pupal) *Chrysocharis* sp., *Neochrysocharis formosa* (Larval) etc. **Predators:** Lacewings, lady beetle, spiders, fire ants, dragonfly, robber fly, praying mantis etc.	• Attractant plants: Carrot family, sunflower family, buckwheat (lacewings) • French bean (predatory thrips)

4	Aphids	**Parasitoid:** *Aphidius colemani, Diaeretiella* spp. *Aphelinus* spp. etc **Predators:** Anthocorid bugs/pirate bugs (*Orius* spp.), mirid bugs, syrphid/hover flies, green lacewings (*Mallada basalis* and *Chrysoperla carnea*), predatory coccinellids (*Stethorus punctillum*), staphylinid beetle (*Oligota* spp.), predatory cecidomyiid fly (*Aphidoletis aphidimyza*) and predatory gall midge, (*Feltiella minuta*), earwigs, ground beetles, rove beetles, spiders, wasps etc.	• Carrot family, sunflower family, marigold, buckwheat, spear mint (syrphid fly, lacewing, minute pirate 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, *Aphidoletes aphidimyza*) • Nectar rich plants with small flowers i.e. anise, caraway, dill, parsely, mustard (aphid parasite and braconid wasp) • Sunflower, buckwheat and cowpea (braconid wasp)

Resistant/Tolerant varieties of Cucurbitaceous vegetables

Pest	Resistant/ Tolerant variety*
Pumpkin	
Fruit fly	Arka Suryamukhi
Cucumber	
Powdery mildew	Phule Shubangi
Bottle gourd	
blossom end rot.	Arka Bahar
Anthracnose	N. Shishir (NDBG-202)
Powdery mildew	N. Shishir (NDBG-202)
Downy mildew	N. Shishir (NDBG-202)
Viral disease	N. Shishir (NDBG-202)
Bitter gourd	
Downy mildew	Phle Green Gold

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

IV. Crop stage-wise IPM

Stage	Management	Activity
Pre-sowing*	**Nutrients**	• Apply farm yard manure (FYM) @ 8-10 t/acre and incorporate in the soil 2 to 3 weeks before sowing.
	Weeds	• Field is kept weed free before sowing by ploughing.
	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/pongamia cake @ 100 kg/acre in soil at the time of last plouging or reducing nematodes, and soil dwelling pests. • Apply *Trichoderma* spp. @ 2.5 kg/acre along with FYM
Seedling stage*	**Red pumpkin beetle**	**Cultural control:** • Deep summer ploughing exposes the grubs and pupae. **Biological control:** • Conserve predators such as Pennsylvania leather wing beetle (*Chauliognathus pensylvanicus*); larvae of which feed on pumpkin beetle larva. • Conserve parasitoids such as *Celatoria setosa* (grub) • Spray NSKE 5% **Chemical control:** • Apply trichlorfon 5% GR @ 200 g/acr or trichlorfon 5% DUST @ 200 g/acre

***** Applying *Trichoderma* as seed and nursery treatment and *Pseudomonas fluorescens* as seed, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own

consumption in their fields, registration is not required).		
Vegetative stage	**Nutrients**	• Generally cucurbit crops require 40: 32: 24 kg N: P: K/acre • Apply N in two splits first one (50%) at 25 days after sowing. • Apply entire P and K at the time of sowing. • Micro nutrient deficiency should be corrected by foliar spray of particular nutrient. • To maintain the sex ratio (more number of female flowers), spray borax @ 1 g/l at 2-4 leaf stage
	Weed management	• Regular hoeing and weeding should be done to keep the field weed free up to 30 days crop stage.
	Fusarium wilt	**Cultural control:** • Use pathogen free seeds • Remove and destroy the infected plants and plant debris • Adopt crop rotation • Avoid water stagnation and maintain proper drainage • Use resistant varieties
	Serpentine leaf miner	**Cultural control:** • Change in dates of sowing • Growing castor, tomato or marigold as a trap crop. **Biological control:** **Cultural and mechanical control:** • Use yellow sticky traps or cards @ 10/acre **Biological control:** • Conserve parasitoids such as *Tetrastichus ovularum* (egg), *Gronotoma micromorpha* (larval and pupal), *Diglyphus* sp (larval), *Opius phaseoli* (pupal), *Chrysocharis* sp, *Neochrysocharis formosa* (larval) etc. • Conserve predators such as lacewings, lady beetles, spiders, fire ants etc. • Foliar spray with NSKE 5%
	Aphids	**Cultural control:** • Lablab and seed mixture including

		self-sowing annual and perennial herbaceous flower species are viable options to grow within cucurbits or as field boundary crops to attract and increase beneficial insects and spiders for the control of sap-sucking insect pests. **<u>Biological control:</u>** • Conserve parasitoids such as *Aphidius colemani*, *Diaeretiella* spp., *Aphelinus* spp. • Release 1st instar larvae of green lacewing bug (*Chrysoperla carnea*) @ 10,000/acre ○ Conserve predators such as anthocorid bugs/pirate bugs (*Orius* spp.), mirid bugs, syrphid/hover flies, green lacewings (*Mallada basalis* and *Chrysoperla carnea*), predatory coccinellids (*Stethorus punctillum*, *Coccinella septumpunctata* and *Menochilus sexmaculata*, *Hippodamia convergens*), staphylinid beetle (*Oligota* spp.), predatory cecidomyiid fly (*Aphidoletis aphidimyza*) and predatory gall midge, (*Feltiella minuta*), earwigs, ground beetles, rove beetles, spiders, wasps etc. **<u>Chemical control:</u>** ○ Spray imidacloprid 70% WG @ 14 g in 200 l of water/acre
	***Cercospora* leaf spot**	**<u>Cultural Control:</u>** • Field sanitation • Maintain good soil drainage and good aeration between vines. **<u>Chemical control:</u>** • Spray zineb 75% WP @ 600-800 g in 300-400 l of water/acre

	Cucumber mosaic virus	**Cultural control:** • Raise 4 rows of barrier crops such as main or sorghum • Avoid planting tomatoes next to cucurbits, spinach, or other vegetables and flowers susceptible to these diseases. • Control of aphids (*A. gossypii*) will help reduce the likelihood of cucumber mosaic. **Chemical control:** o Vector control by spraying imidacloprid 70% WG @ 14 g in 200 l of water/acre
	Powdery mildew	**Cultural control:** • Plant resistant varieties • Increasing air movement inside the canopy **Chemical control:** • Spray carbendazim 50% WP @ 120 g in 240 l of water or benomyl 50% WP @ 80 g in 200 l of water/acre or thiophanate methyl 70% WP @ 572 g in 00-400 l of water/acre
	Downy mildew	**Cultural control:** • Trellising cucumbers • Avoiding overhead irrigation or irrigating only in the late morning hours will limit the amount of time that leaves are wet. • Control alternate weed hosts (wild cucumber, golden creeper and volunteer cucumbers) in neighbouring fence rows and field edges **Chemical control:** • Spray zineb 75% WP @ 600-800 g in 300-400 l of water/acre or cymoxanil 8% + mancozeb 64% WP @ 600 g in 200-240 l of water/acre
Reproductive stage	**Nutrients**	• Apply the second dose (50%) at 45 days after sowing • 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.
	Fruit fly	**<u>Cultural control:</u>** • Early maturing varieties are less affected than later ones. • Changing of sowing dates. • Collection and destruction of infested fruits • Slight raking of soil during fruiting time and after the harvest to expose pupae from the soil. • Use methyl eugenol (0.1%) based trap **<u>Biological control:</u>** • Conserve parasitoids such as *Opius fletcheri* (pupal) • Spray NSKE 5%

V. Insecticide resistance and its management

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

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

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

1) **Monitor pests:** Monitor insect population development in fields to determine if and when control measures are warranted. Monitor and consider natural enemies when making control decisions. After treatment, continue monitoring to assess pest populations and their control.
2) **Focus on AESA.** Insecticides should be used only as a last resort when all other non-chemical management options are exhausted and P: D ratio is above 2: 1.
3) **Take an integrated approach to managing pests.** Use as many different control measures as possible. Select insecticides with care and consider the impact on future pest populations and the environment. Avoid broad-spectrum insecticides when a narrow-spectrum or more specific insecticide will work.

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

VI. Nutritional deficiencies:

S. No	Nutrients and their deficiency symptoms	
1.	**Nitrogen** **Deficiency symptoms:** Both vegetative growth and fruit production are severely restricted plants appear pale and spindly. New leaves are small but remain green, whereas the oldest leaves turn yellow and die. The yellowing spreads up the shoot to younger leaves. Yield is reduced and fruit are pale, short and thick. **Correction measure:** Side-dress deficient in-ground crops with 20-50 kg N/ac, or apply fortnightly foliar sprays of 2% urea at high volume.	
2	**Potassium** **Deficiency symptoms:** Potassium deficiency causes yellowing and scorching or older leaves. These symptoms begin at the margins of the leaf and spread between the veins towards its centre. Large areas of tissue around the major veins remain green until the disorder is well advanced. A brown scorch develops in the yellow areas and spreads until the leaf is dry and papery. Potassium from a fertilizer side-dressing will move from the soil surface to the roots only if the soil is very sandy. Potassium fertilizers are therefore best incorporated in the soil before	

	planting. Fertigation or drip feeding can also be used to treat a deficient crop. **Correction measure:** Foliar spray of KCl 1% at weekly interval.	
3	**Calcium** **Deficiency symptoms:** Emerging leaves appear scorched and distorted and may cup downwards because the leaf margins have failed to expand fully. Mature and older leaves are generally unaffected. With a severe deficiency, flowers can abort, and the growing point may die. Fruits from calcium-deficient plants are smaller and tasteless, and may fail to develop normally at the blossom end. **Correction measure:** Soil application of gypsum as per gypsum requirement based on soil test report or by foliar spray of CaSO4@ 2% solution in water.	
4	**Magnesium** **Deficiency symptoms:** Magnesium deficiency causes yellowing of older leaves. The symptom begins between the major veins, which retain a narrow green border. A light tan burn will develop in the yellow regions if the deficiency is severe. Fruit yields are reduced. **Correction measure:** Incorporate magnetite (300 kg/ac) or dolomite (800 kg/ac) into deficient soils before planting. Fortnightly foliar sprays of MgSO4 (2 kg/100 L) at high volume (500-1000 L/ac).	
5	**Boron** **Deficiency symptoms:** Distortion of newer leaves (in severe cases the growing point dies) and the appearance of a broad yellow border at the margins of the oldest leaves. Young fruit can die or abort; abortion rates are high. Stunted development and mottled yellow longitudinal streaks, which develop into corky marking (scurfing) along the skin. **Correction measure:** Foliar spray of 0.2% Borax at forthrightly interval. Application of 10 kg borax per hectare to deficient soil before will prevent boron deficiency.	

6.	**Iron** **Deficiency symptoms:** Iron deficiency causes a uniform pale green chlorosis of the newest leaves; all other leaves remain dark green. Initially, the veins remain green, which gives a net-like pattern. If the deficiency is severe, the minor veins also fade, and the leaves may eventually burn, especially if exposed to strong sunlight. Good drainage and soil aeration favour iron availability. Foliar sprays of iron sulphate (150 g/100 L) can be used to treat symptoms **Correction measure:** Foliar spray of 0.5% FeSO4.	
7	**Manganese** **Deficiency symptoms:** The veins of middle to upper leaves of manganese-deficient plants appear green against the mottled pale green to yellow of the blade. **Correction measure:** Spray the foliage with MnSO4 @ 0.1% (100 g/100 L water). http://www.haifa-group.com/knowledge_center/deficiencies/crops/vegetables/cucumber/	

Physiological and nutritional disorders:

1. **Blossom end rot:** It is a physiological disorder observed in many cucurbits as well other crops. It typically appears as a general rot at the blossom end of developing fruit .Blossom end rot is usually the result of inadequate or uneven irrigation high humidity , or their factor that slow the movement of water movement can often lead to temporary calcium deficiencies, resulting in blossom end rot.

   Management: provide adequate calcicum fertility and proper irrigation .Do not use high levels of ammonia fertilizer, which can aggravate this problem. Avoid toot injury

2. **Drought stress:** cucurbits are particularly sensitive to drought .Fruit are typically 85% to 90% water and can suffer under drought condition. Pumpkins often produce long vines with many leaves and can transpire large quantities of water during hot summer days. Severe drought stress affects fruit development , resulting in unmarketable produce ,or tapered at the blossom end ; pumpkins became soft and wrinkled .In addition , drought – stressed pumpkins fail to gain appropriate size, which affects yields. A loss of foliage during drought will also results in sunburn of the fruit.

   Management: Irrigate when necessary

3. **Flood damage:** Symptoms often appears as nutrients deficiencies or a generalized yellowing. Prolonged exposure to flooded soils will result in anaerobic conditions for plant roots eventually causing death. When large number of roots die, the plant is often unable to take up sufficient nutrients , resulting in nutrient deficiencies

   Management: while damage from flooding is often unavoidable, planting in raised beds will improve drainage.

4. **Hollow heart:** It is the formation of a hollow cavity inside some cucurbit fruit. This disorder can result from a number of factors , including low boron levels, genetics and uneven visible hollow heart makes fruit unmarketable

   Management: Avoid varieties with a tendency to exhibits hollow heart. Ensure that boron levels in the soil are adequate; however, be careful not to over fertilize. Follow recommended plant spacing, and avoid erratic irrigation

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**

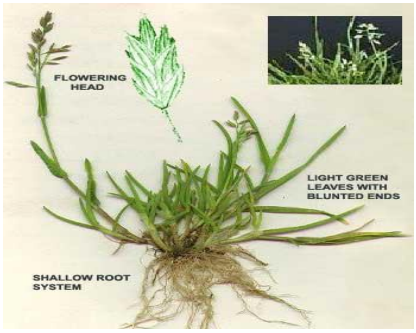
Annual herb, up to 60 cm tall. Stem Slender, much branched and succulent. Leaves 2-3 pinnatisect, 2-5 cm long, segments linear oblanceolate, apiculate. Flowers Purplish-red, spurred, in terminal or leaf opposed bracteate racemes. Fruits are rounded nuts, 2-3 mm in diameter, wrinkled when dry.

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. Cucurbit fruit fly:

It is one of the important pests on gourds like bittergourd, snakegourd, melons, coccinia etc., throughout the country

Biology:

Egg: The female fly oviposits on soft fruits. Cavity is made by sharp ovipositor and 12 cylindrical eggs are laid in the evening time and exuding gummy substance covers, cements and makes it water proof. Female lays 58-95 eggs in 14-54 days. Egg period is 1-9 days.

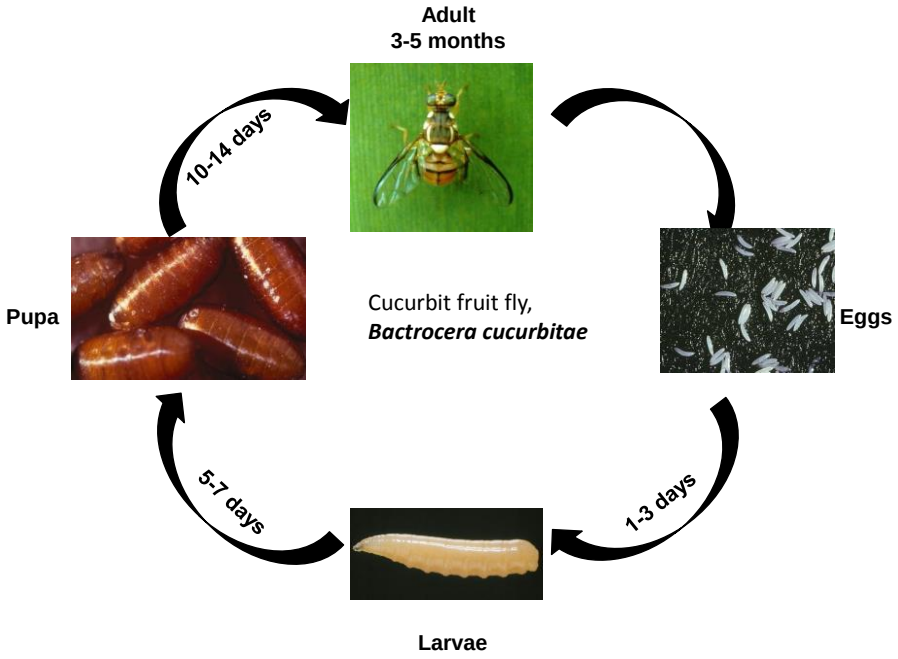
Maggot: The maggots are apodus, acephalous, dirty white, wriggling creatures, thicker at posterior end and tapering at the other to a point. Larval period is 13 days in summer and about

three weeks in winter. Mature maggots come out and jump to ground and select suitable place, enter soil and pupate.

Pupa: Pupa is barrel shaped. Pupal period is 69 days

Adult: Adult flies emerge from pupa during morning hours and mate at dusk. Adults are reddish brown with lemon yellow markings on thorax with spotted wings. It is active throughout the year. Adults hibernate during winter and they become active in hot weather. Longevity is 14 days.

Life cycle:



Symptoms of damage:

Only maggots cause damage by feeding near ripe fruits, riddling them and polluting pulp.
Maggots bore into the fruit and feed on pulp forming lesions.
Fruits decay due to secondary bacterial infection.
Damage is more serious in melons. Fruits at early stage also are attacked. Such fruits do not develop. Infestation results in premature drop of fruits.
Decay of fruits due to secondary bacterial infection
The damage is more in monsoon season.

For management refer to page number----------.

Parasitoids:
1. *Opius fletcheri*

1 http://mx.speciesfile.org/projects/8/public/public_content/show/ 13297

Predators:

Ants:

1.http://www.alexanderwild.com/keyword/predatory%20ants/1377309969_TMKBZkg

2) Red pumpkin beetles:

These insects infest bittergourd, snakegourd, melons, pumpkin, coccinia etc.

Biology:

Egg: Brownish elongate eggs are laid in the soil and each female may lay about 150 to 300 eggs singly or in groups of 8-9 near the base of plants. Egg period is 5-8 days.

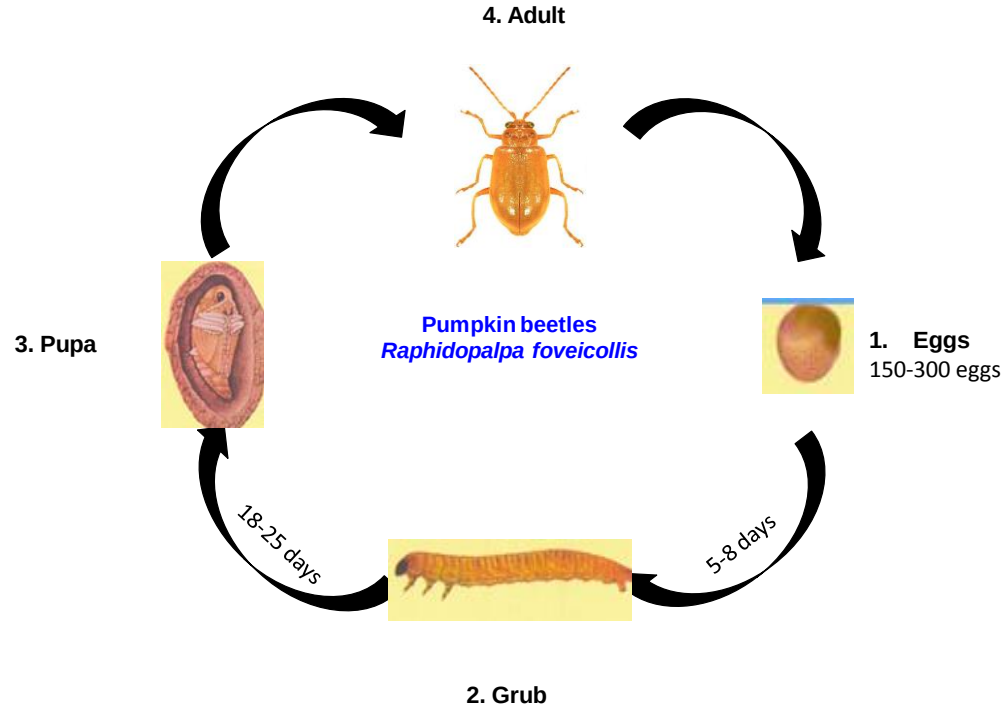
Grub: Grubs are creamy white with darker oval shield at back. Grub period is 13-25 days.

Pupa: Pupation takes place in an earthen cocoon. Pupal period is 7-17 days.

Adult: *Raphidopalpa foveicollis* has reddish brown elytra; *A. intermedia* has blue black elytra; and *A. cincta* has grey elytra with black border.

Total life cycle takes 26-27 days. There are 5 to 8 generations/year.

Life cycle:



Nature and symptoms of damage:

Beetles are more destructive.
They bite holes on leaves and also feed on flowers.
Beetles injure the foliage, flowers and cotyledons by biting holes into them.
Early sown cucurbits are severely damaged necessitating resowing.
Beetle damage results in
Numrous of holes on leaves.
Grubs after hatching, feed on roots of plants below soil surface.
Grubs bore into vines, feed on fruits that come in contact with the soil.

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

1. Entomopathogenic nematodes

1. http://www.biocontrol.entomology.cornell.edu/pathogens/nematodes.html

Predators:

1. Pennsylvania leather wing beetle

1. http://bugguide.net/node/view/6246

Parasitoids:

1 Braconid wasp

2. *Celatoria cetosa* (tachinid fly)

1. http://nathistoc.bio.uci.edu/hymenopt/Braconid2.htm
2.http://www.hr-na.com/RNA/Other%20insect%20pages/Eastern% 20Tachinids.htm

3) *Epilachna* beetle/Hadda beetle:

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

Biology:

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

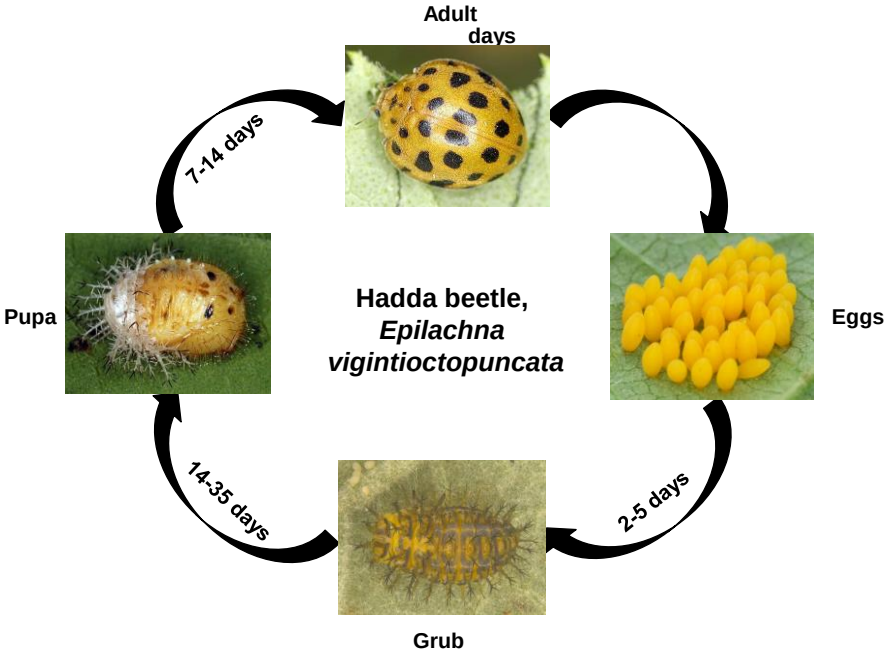
Grub: The grub is creamy white or yellowish in color with black spiny hairs on the body. The grub period is two to five weeks depending on the temperature. Grubs pupate on the leaves and stem.

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

Adult: The subfamily Epilachninae contains plant-feeding ladybird beetles because most other ladybird beetles are predators, not plant pests. These brownish or orange- colored, hemispherical beetles are larger than other ladybird species. *E. vigintioctopunctata* (in Latin,

viginti means 20 and octo means 8) has 28 black spots on the forewing (elytra). *E. dodecastigma* (dodecam means 12 in Greek) has 12 black spots on the elytra. However, beetles with 14, 16, 18, 20, 22, 24 or 26 spots have been observed under field conditions, due to mating between females of *E. dodecastigma* and males of *E. vigintioctopunctata*.

Life cycle:



Damage symptoms:

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

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

Parasitoids*:*

1. *Celatoria setosa*

2. Braconid wasp (tachinid fly)

1.http://www.hrrna.com/RNA/Other%20insect%20pages/Eastern%20Tachinids.htm
2.http://www.waspweb.org/Ichneumonoidea/Ichneumonidae/ Classification/

Nematodes:

http://www.biocontrol.entomology.cornell.edu/pathogens/nematodes.html

4) Serpentine leaf miner:

Biology:

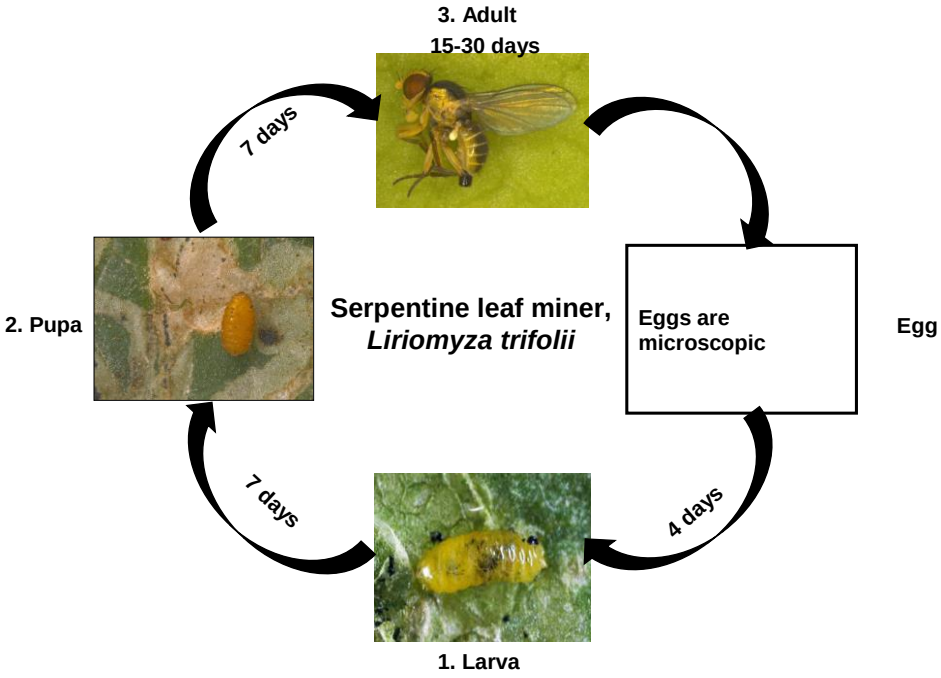
Egg: Eggs are minute in size and orange yellow in colour. The egg hatches in 4 days.

Larva: Apodous maggot feeds on chlorophyll mining in between epidermal layers. Full grown maggot measures 3 mm. Larval duration is about 7 days.

Pupa: Pupation is in soil. Some pupae are found in leaves.
Pupation takes place inside a thin loose mesh of silken cocoon. Pupal period is about 7 days.

Adult: It is a pale yellowish fly, measuring 1.5 mm in length. The female fly punctures upper surface of leaf to lay eggs singly
.
Total life cycle takes 3 weeks.

Life cycle:



1. http://entnemdept.ufl.edu/creatures/veg/leaf/aserpentine_leafminer.htm
2. http://www.nbaii.res.in/insectpests/images/Liriomyza-trifolii3.jpg
3. http://www.nbaii.res.in/insectpests/images/Liriomyza-trifolii8.jpg6

Damage symptoms:

Leaves with serpentine mines
Drying dropping of leaves in severe cases

Favourable conditions:

Warm weather conditions are favourable for multiplication.

*For management refer to page number----

Mining on leaves

1 2


1. http://www.nbaii.res.in/insectpests/Liriomyza-trifolii.php
2. http://www.hort.purdue.edu/rhodcv/hort410../ho09000.htm

Parasitoids:

1. *Chrysocharis pentheus* 2. *Diglyphus isaea* 3. *Gronotoma micromopha*



1. http://baba-insects.blogspot.in/2012/05/blog-post_21.html
2. http://www.evergreengrowers.com/diglyphus-isaea-114.html
3.http://www.ento.csiro.au/science/Liriomyza_ver3/key/Eucoilidae_Key/Media/Html/gronotoma_sp.html

Predators:

1. Lacewing

2. Lady beetle

3. Spider

4. Fire ant

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) Pumpkin leaf caterpillar:

Biology:

Adult: Moth is medium with whitish wings, transparent with brown marginal patches.

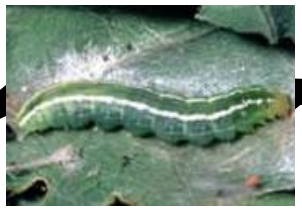
Larva: Elongate bright green caterpillar is seen with two narrow longitudinal white stripes dorsally.

Life cycle:

4. Adult

3. Pupae

1. Eggs



2. Larva

Symptoms of damage:

It folds the leaves and scrapes the green matter. As a result the leaves get dried up. It can also feed on ovaries of flower, sometimes bore into young developing fruits.

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

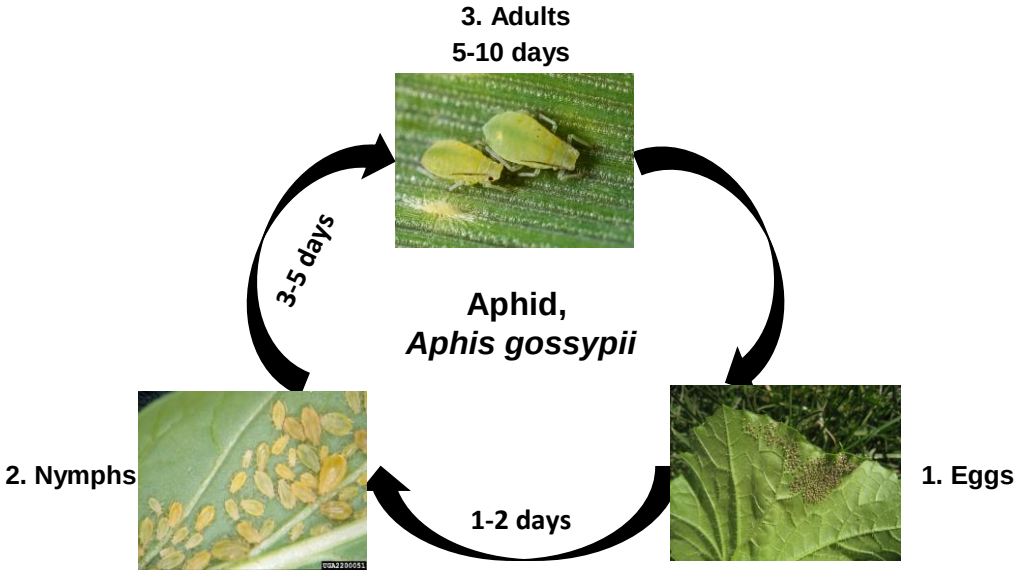
6) Aphids:

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

Biology:

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

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:

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

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

Parasitoids:

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


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

Predators:

1. Lacewing

2. Lady beetle

3. Spider

4. Syrphid larva

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

IX. Description of diseases

1) Downy mildew:

Host range:

- Musk melon, Sponge gourd and Bitter gourd etc.

Symptoms:

- Yellow, angular spots restricted by veins resembling mosaic mottling appear on upper surface of leaves
- The corresponding lower surface of these spots shows a purplish downy growth in moist weather
- The spots turn necrotic with age
- The diseased leaves become yellow and fall down
- Diseased plants get stunted and die
- Fruits produced may not mature and have a poor taste

Survival and spread:

Primary: Oospores in soil and sporangia from perennial collateral weed hosts in the vicinity
Secondary: Wind borne and rain splashed conidia (sporangia) or autonomous zoospores

Favourable conditions:

- Relative humidity > 90%
- High soil moisture
- Frequent rains


Symptom on leaf of bottle gourd and cucumber;
Photos by : SK Sain

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

2) Powdery mildew:

Host range:

- Pumpkins, bottle gourd, coccinia, cucumber, ridge gourd, Bitter gourd is less affected.

Symptoms:

- Whitish or dirty grey, powdery growth on foliage, stems and young growing parts
- The superficial growth ultimately covers the entire leaf area
- The diseased areas turn brown and dry leading to premature defoliation and death
- Fruits remain underdeveloped and are deformed

Survival and spread:

Primary: Dormant mycelium or cleistothecia in infected plant debris or conidia from collateral

hosts
Secondary: Wind borne conidia

Favourable conditions:

- Morning relative humidity > 90%
- Cool and dry weather


Symptom on leaf; Photos by: SK Sain

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

3) Cucumber mosaic:

Wide host range:

- Cucumber, Pumpkin, gourds, Cowpea, tomato, chilli, etc. Cucumovirus with spherical particles having ssRNA

Symptoms:

- Symptoms appear on the youngest and still expanding leaves when infection occurs at 6 – 8 leaves stage
- Typical mosaic pattern develops on young leaves
- Leaves curl downwards and become mottled, distorted, wrinkled and reduced in size
- Veins appear bunchy because of shortening of internodes
- When infection occurs at midseason previous growth remains normal and produces normal fruit
- Fruit set is very less if infection occurs early in crop growth
- Fruits are often misshapen, mottled, warty and reduced in size

Survival and spread:

Primary: Virus particles on collateral and other weeds, ornamentals or crops
Hosts: Banana, clover, corn, passion fruit, safflower, spinach, sugarbeet, wild cucumber, *Commelina communis, C. diffusa, C. nudiflora, Solanum elaegnifolium, Phytolacca sp., periwinkle, Gladiolus sp., Impatiens sp.* and Phlox
Secondary: Virus particles transmitted by aphids (*Aphis craccivora*, *Myzus persicae*) and spotted and striped cucumber beetles


Symptom on leaves; Photos by SK Sain

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

4. Cercospora leaf spot:

Host range:

- Common on watermelon, muskmelon and cucumber

Symptoms:

- Minute water soaked spots or yellow specks develop initially on leaves
- Spots enlarge rapidly and becomes circular to irregular with pale brown, tan or white centers and purple to almost black margins
- Spots coalesce to form large blotches
- The leaf may dry and die presenting the leaf a scorched appearance
- Fruits are also occasionally attacked

Survival and spread:

Primary: Dormant mycelium or conidia on infected plant debris or collateral hosts

Secondary: Wind borne conidia

Symptom on leaves: Photo by SK Sain

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

5) Fusarium wilt:

Damage symptoms:

- The first symptom of the disease is clearing of the veinlets and chlorosis of the leaves.
- The younger leaves may die in succession and the entire may wilt and die in a course of few days.
- Soon the petiole and the leaves droop and wilt.

- In young trailing plant, symptom consists of clearing of veinlet and dropping of petioles. In field, yellowing of the lower leaves first and affected leaflets wilt and die.
- The symptoms continue in subsequent leaves. At later stage, browning of vascular system occurs. Plants become stunted and die.

Survival and spread:

- Soil and implements

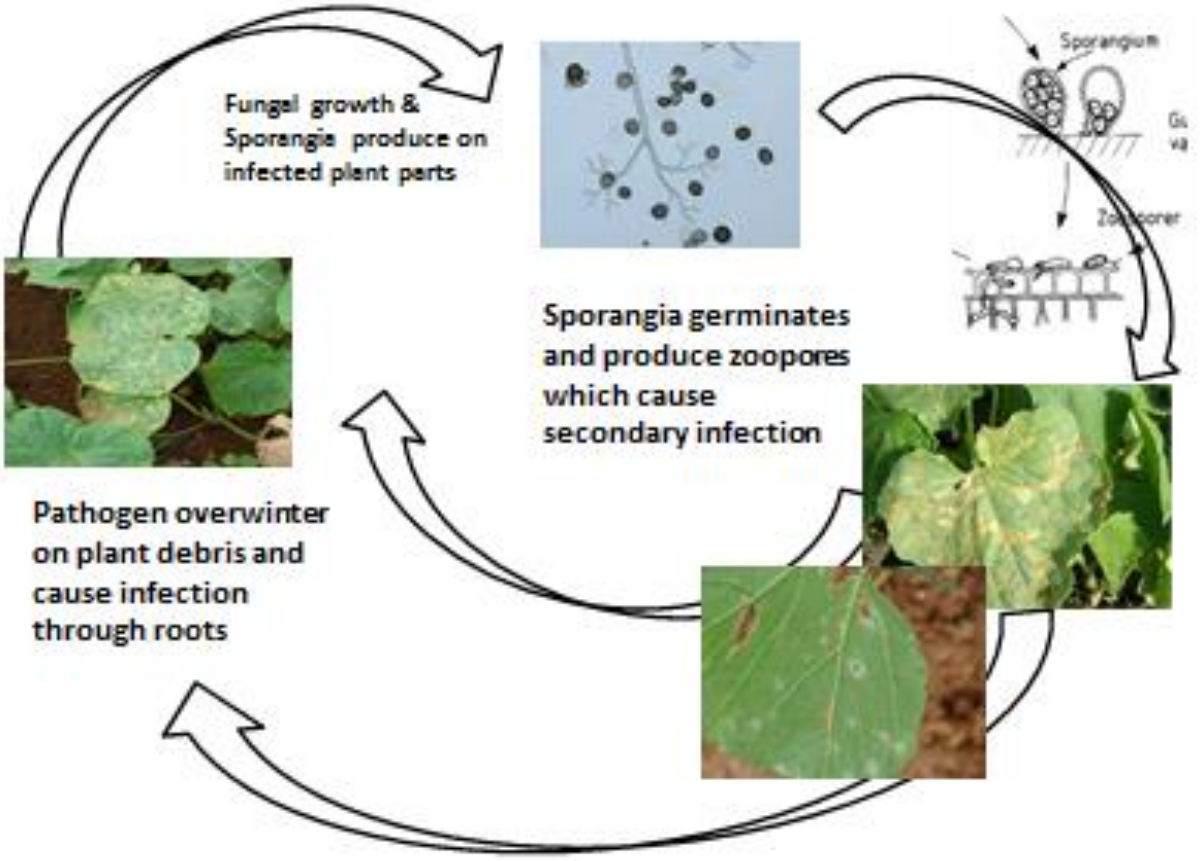
Favourable conditions:

- Relatively high soil moisture and soil temperature

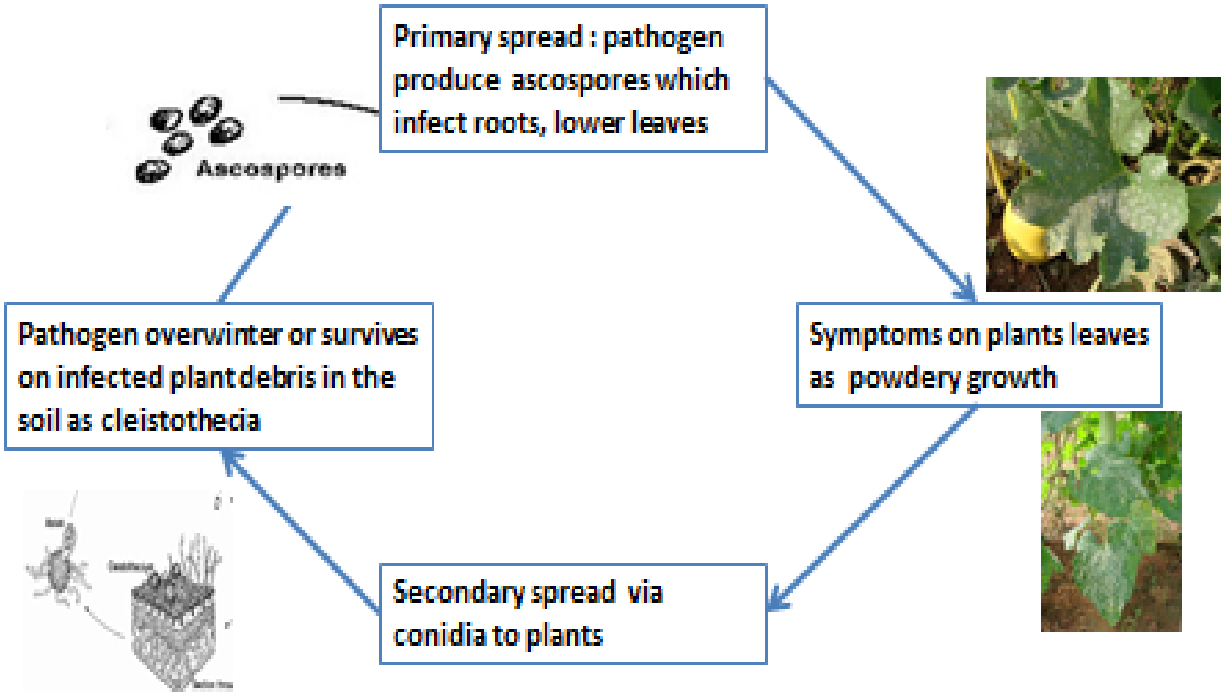
*For management refer to page number-----

Diseases cycles

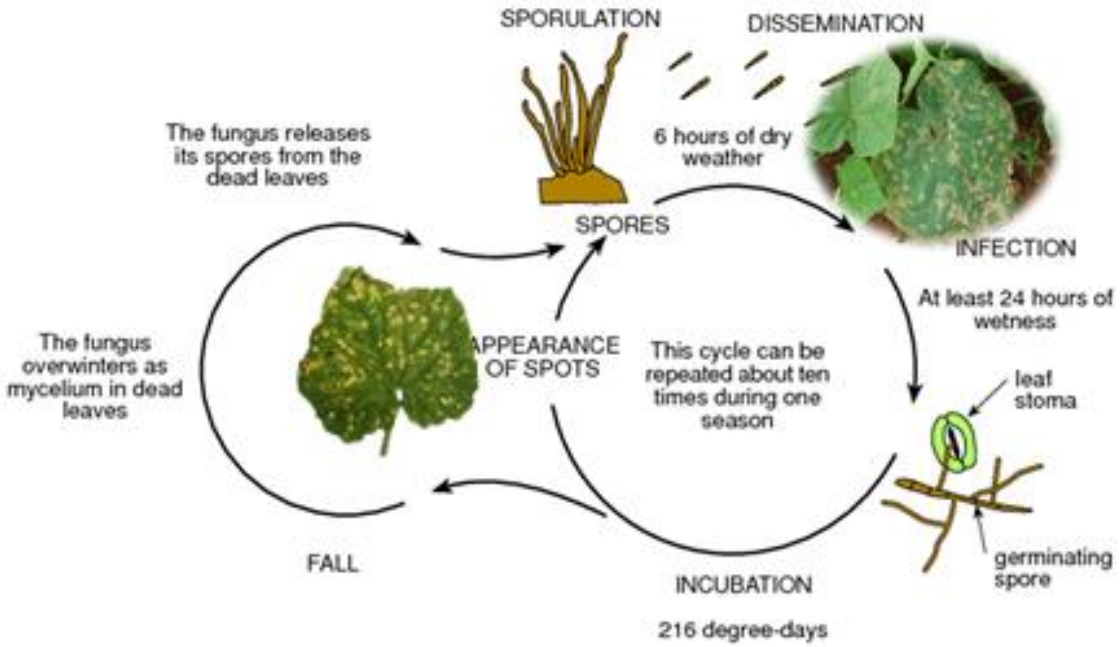
1. Downy mildew: *Pseudoperonospora cubensis*



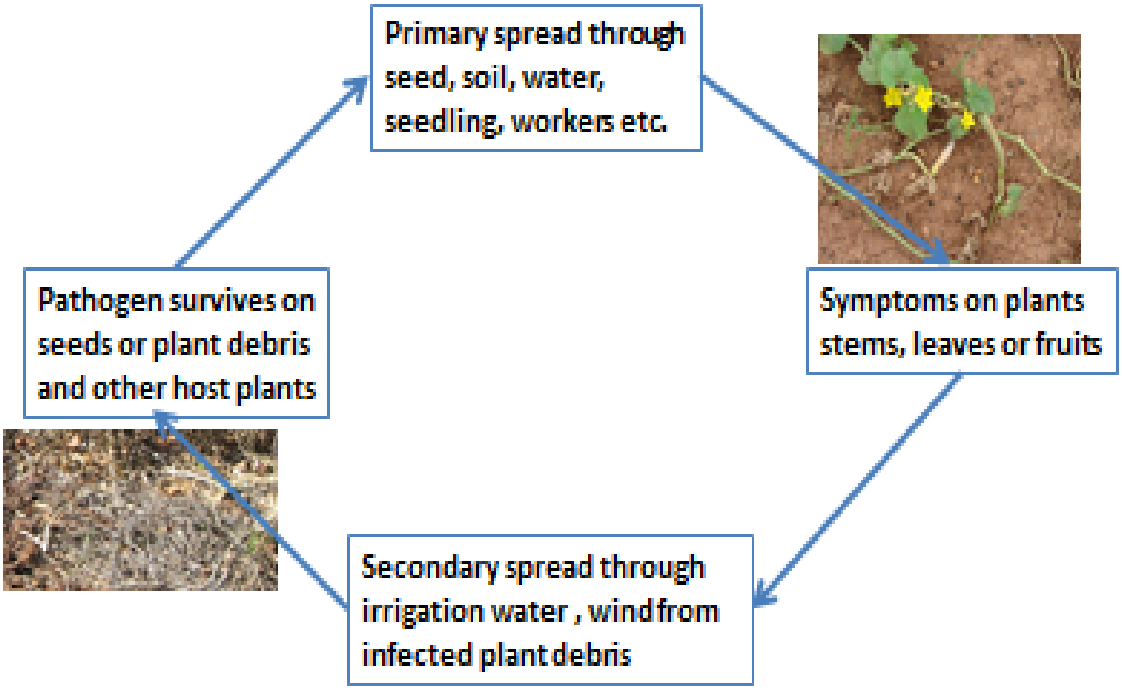
2. Powdery mildew: *Erysiphe cichoracearum* DC, *Sphaerotheca fuligena* (Schltdl.) Pollacci



3. Cercospora leaf spot:Cercospora leaf spot *C. citrullina, C. melonis, C. lagenarium*



4. Fusarium wilt: *Fusarium oxysporum* Schlecht



X. Safety measures

A. At the time of the harvest

The cucumber crop is ready for harvest about 45-60 days after sowing, depending on cultivars and growing conditions. The fruits take about 7–10 days from setting to reach marketable stage. Fruit size during harvesting depends on the purpose of use or market requirement. Fruits for salad or slicing are picked when they are 15-25 cm long; for pickles they are harvested when they are 5-15 cm long. The fruits should be picked at 2-day intervals

B. Safety measures for post-harvest storage

Cucumbers are harvested at a range of developmental stages. Depending on cultivar and temperature, the time from flowering to harvest may be 55 to 60 days. Generally fruit are harvested at a slightly immature stage, near full size but before seeds fully enlarge and harden. Firmness and external glossiness are also indicators of a pre-maturity condition. At proper harvest maturity, a jellylike material has begun to form in the seed cavity.

Storage of cucumber is generally less than 14 days as visual and sensory quality deteriorate rapidly. Shriveling, yellowing, and decay are likely to increase following storage beyond two weeks, especially after removal to typical retail conditions. Short term storage or transit temperatures below this range (such as 7.2°C (45°F)) are commonly used but will result in chilling injury after 2-3 days.

Cucumbers are chilling sensitive at temperatures below 10°C (50°F) if held for more than a day to 3 days depending on temperature and cultivar. Consequences of chilling injury are water-soaked areas, pitting and accelerated decay. Chilling injury is cumulative and may be initiated in the field prior to harvest. Cucumber varieties vary considerably in their susceptibility to chilling injury.

XI. Do's and Don'ts in IPM

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The field should be kept exposed to sun light at least for 2-3 weeks 	Do not plant or irrigate the field after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	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	Do not apply chemical pesticides within seven days of release of parasitoids.

	trap or as per field observation 	
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 for pesticides usage

S. No.	Pesticide	Classification as per insecticide rules 1971	Colour of toxicity triangle	WHO classification of hazard	First Aid measures	Symptoms poisoning	Treatment of poisoning	Waiting period (days)
Carbamate insecticides								
1	Carbofuran	Extremely toxic	Red 	Class I b highly haardous		Constriction of pupils, salivation, profuse sweating, muscle incordination, nausea, vomiting,diarrhea, epigastric pain, tightness in chest	Atropine injection-1-4 mg. repeat 2 mg when symptoms begin to recur (15-16 min interval) excessive salivation- good sign, more atropine needed	
Neonicotinoids								
2	Imidacloprid				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	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.	5

					by mouth to an unconscious person			
Fungicides								
3	Carbendazim	Slightly toxic	Green 	Unlikely to present acute hazard in normal use		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose,throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic	

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.

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

F. Precautions for applying pesticides
   1. Apply only at recommended dose and dilution
   2. Do not apply on hot sunny day or strong windy condition

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

G. Disposal

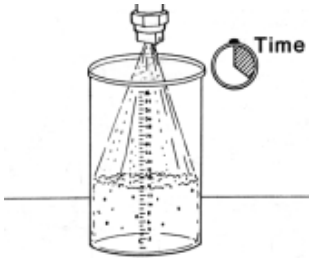
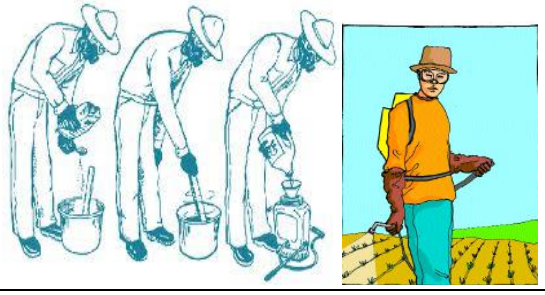
1. Left over spray solution should be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

XIV. Pesticide application techniques

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

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

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

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
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