सत्यमेव जयते

AESA BASED IPM Package No.24

AESA based IPM – Chillies/ Capsicum

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The AESA based IPM – Chillies/ Capsicum was compiled by the NIPHM working group under the Chairmanship of Dr. K. Satyagopal DG, NIPHM, and guidance of Shri. Utpal Kumar Singh JS (PP). The package was developed taking into account the advice of experts listed below on various occasions before finalization.

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FOREWORD

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

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

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

Date: 6.3.2014

(Avinash K. Srivastava)

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FOREWORD

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

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

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

(Utpal Kumar Singh)

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PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

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Grassy weeds

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1. Insect pests

1.1 Whitefly: *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae)

I AESA based IPM

A. Agro-ecosystem Analysis

The integrated pest management (IPM) has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment ultimately affecting the interests of the farmers. The economic threshold level (ETL) was the basis for several decades but in modern IPM (FAO 2002) emphasis is given to AESA where farmers take decisions based on larger range of field observations. The health of a plant is determined by its environment which includes physical factors (i.e. soil, rain, sunshine hours, wind etc.) and biological factors (i.e. pests, diseases and weeds). All these factors can play a role in the balance which exists between herbivore insects and their natural enemies. Understanding the intricate interactions in an ecosystem can play a critical role in pest management.

Decision making in pest management requires a thorough analysis of the agro-ecosystem. Farmer has to learn how to observe the crop, how to analyze the field situation and how to make proper decisions for their crop management. This process is called the AESA. Participants of AESA will have to make a drawing on a large piece of paper (60 x 80 cm), to include all their observations. The advantage of using a drawing is that it forces the participants/farmers to observe closely and intensively. It is a focal point for the analysis and for the discussions that follow, and the drawing can be kept as a record.

AESA is an approach, which can be gainfully employed by extension functionaries and farmers to analyze the field situations with regards to pests, defenders, soil conditions, plant health and the influence of climatic factors and their relationship for growing a healthy crop.

- The basic components of AESA are
- Plant health at different stages
- Built-in compensation abilities of plants
- Pest and defender population dynamics
- Soil conditions
- Climatic factors
- Farmers past experience

Principles of AESA based Integrated Pest Management (IPM):

Grow a healthy crop

- Select a variety resistant/tolerant to major pests
- Treat the seed with recommended pesticides especially biopesticides

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

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

Farmers should

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

Compensation ability

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

Understand and conserve defenders

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

Insect zoo

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

Pest: Defender ratio (P: D ratio):

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

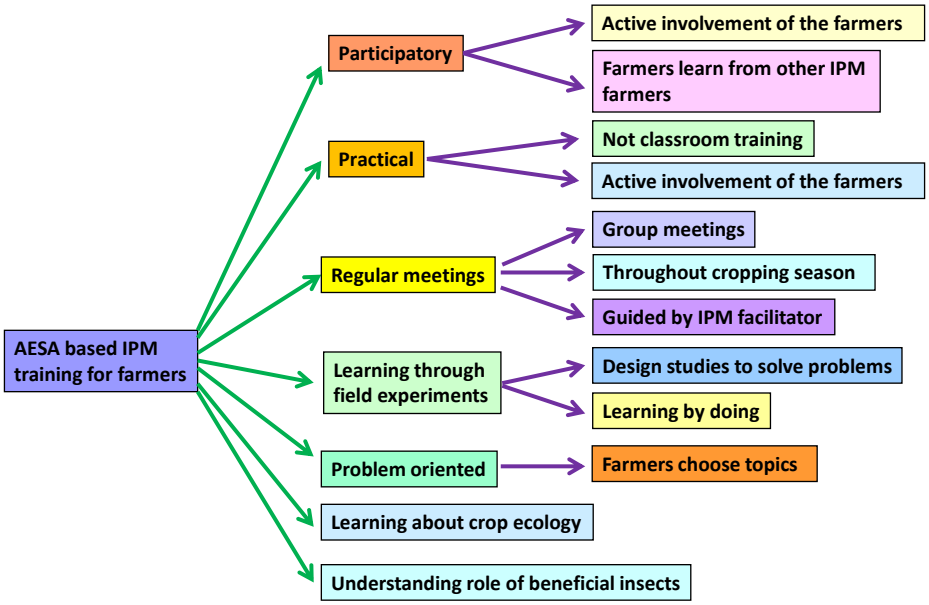
AESA and farmer field school (FFS)

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.

For sucking pests:

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

C. Surveillance through pheromone trap catches for *Spodoptera* and *Helicoverpa*:
Pheromone traps for two insects viz., *Helicoverpa armigera* and *Spodoptera litura* @ 2/fixed field 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 week 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 *Spodoptera litura*/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 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.

E. 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).

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 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).
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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

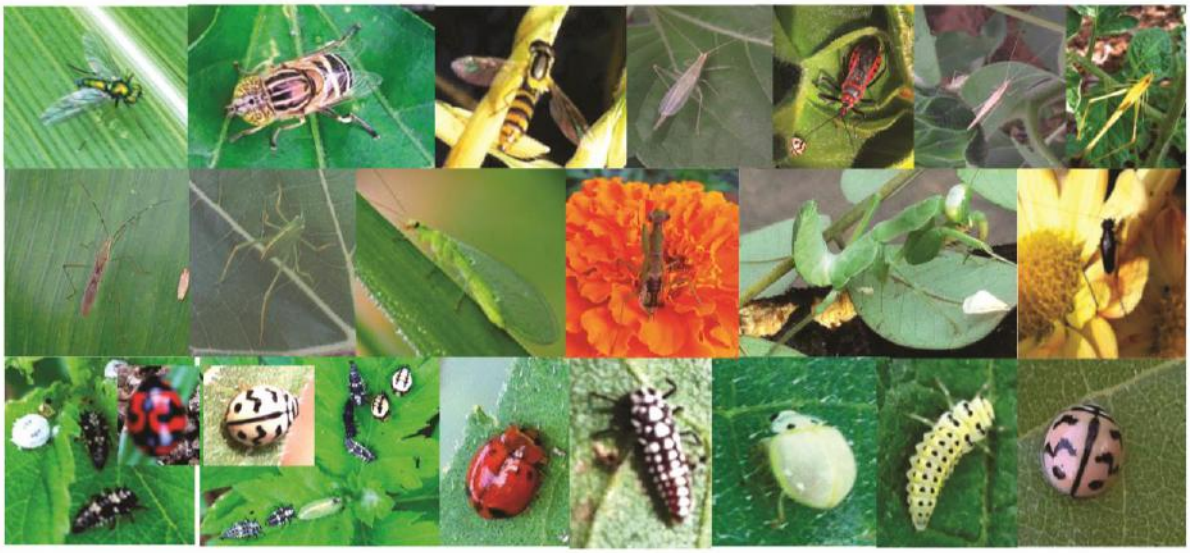
Alfalfa

Chrysanthemum

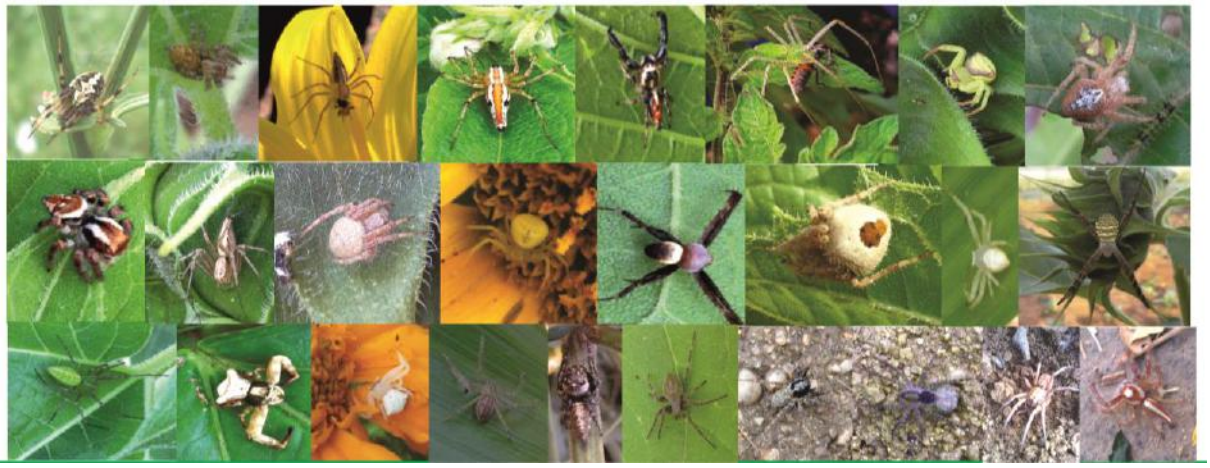
Dill

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	Gram pod borer	**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, 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,	• Repellant plants: Ocimum/Basil • Attractant plants: Carrot family, sunflower family, buck wheat, alfalfa, corn, shrubs (minute pirate bug and lacewing) • Nectar rich plants with small flowers i.e. anise, caraway, dill, parsely, mustard, sunflower, buck wheat and cowpea (wasp)
2.	Tobacco caterpillar	**Parasitoids:** *Trichogramma chilonis* (egg)*, Tetrastichus* spp. (egg)*, Telenomus* spp. (egg), *Chelonus blackburni* (egg-larval), *Carcelia* spp. (larval-pupal), *Campoletis chlorideae* (larval), *Eriborus argentiopilosus* (larval), *Microplitis* sp (larval) etc. **Predators:** *Chrysoperla carnea*, coccinellids, King crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants, big eyed bugs (*Geocoris* sp), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc. *Ovomermis albicans*, a nematode,	• Repellant plants: Osimum/Basil • Attractant plants: Carrot family, sunflower family, buck wheat, alfalfa, corn, shrubs (minute pirate bug and lacewing) • Nectar rich plants with small flowers i.e anise, caraway, dill, parsely, mustard, sunflower, buck wheat and cowpea (wasp)
3.	Leafhoppers	**Parasitoids:** *Lymaenon empoascae* (egg), *Anagrus flaveolus*, *Stethynium triclavatum* **Predators:** Lady beetle, ants *Distina albino*, *Chrysoperla* spp., mirid bug (*Dicyphus hesperus*), big-eyed bug, (*Geocoris* sp) etc.	• Sunflower family, alfalfa (damsel bug & minute pirate bug) • Carrot family, buck wheat, alfalfa, corn, shrubs (minute pirate bug)

4.	Aphids	**Parasitoids:** *Aphidius colemani, Diaeretiella* spp.*, Aphelinus* spp. etc. **Predators:** Anthocorid bugs/pirate bugs (*Orius* spp.), mirid bugs, syrphid/hover flies, green lacewings (*Mallada basalis* and *Chrysoperla carnea*), predatory coccinellids (*Stethorus punctillum*), staphylinid beetle (*Oligota* spp.), predatory cecidomyiid fly (*Aphidoletis 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, lace wing, minute pirate bug, damsel fly 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, coriander (aphid parasite and braconid wasp) • Sunflower, buckwheat and cowpea (braconid wasp)
5	Spider mites and yellow mites	**Predators:** Anthocorid bugs (*Orius* spp.), mirid bugs, syrphid/hover flies, green lacewings (*Mallada basalis* and *Chrysoperla carnea*), predatory mites (*Amblyseius alstoniae*, *A. womersleyi, A. fallacies* and *Phytoseiulus persimilis*), predatory coccinellids (*Stethorus punctillum*), staphylinid beetle (*Oligota* spp.), predatory cecidomyiid fly (*Anthrocnodax occidentalis*) , predatory gall midge (*Feltiella minuta*) etc. **Fungal pathogen:** *Beauveria bassiana* (entomo pathogen)	• Attractant plants: Carrot family, bishop's weed (spider mite destroyer) • Sunflower family, marigold, buck wheat, spear mint (lady beetle) • Carrot family, sunflower family, buck wheat, alfalfa, corn, shrubs (minute pirate bug) • Mustard, sweet clove, dill (aphid midge) • French bean (predatory mites) • Berseem clover,(big eyed bugs)
6	Root knot nematode	Use of biocontrol agents like *Paecilomyces lilacinus* (egg parasite)	• Intercropping of marigold with tomato reduces nematode population • Repellant plants: Marigold • Crop rotation : Marigold, *Chrysanthemum* spp., *Sesbania* spp., *Crotalaria* spp., *Gaillardia* sp, castor bean and *Desmodium* spp., (parasitic nematodes) • Boarder crops: Strips of Rye, grains, cover crops and mulch beds (rove beetle)

A. Resistant/tolerant varieties:

Pest	Resistant/Tolerant variety
Thrips	Pusa Jwala, Phule Jyoti
Mites	Pusa Jwala, Phule Jyoti
Viral diseases and leaf curl complex	Pusa Sadabahar, Arka Harita, Arka Meghana, Arka Sweta, Hisar Shakti, Hisar Vijay, Pant C-1
Powdery mildew	Arka Suphal, Arka Harita, Arka Meghana, Hisar Shakti, Hisar Vijay, Phule Mukta
Fruit rot	Hisar Shakti, Hisar Vijay, TNAU Chilli Hybrid Co 1
Fusarium Wilt	Phule Jyoti, Phule Mukta

***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 rotten farm yard manure (FYM) @ 25 t/acre or vermicompost @ 4 t/acre. Incorporate at the time of field preparation 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 • Keep the nursery weed free by hand weeding
	Soil borne fungus, nematodes, and resting stages of insects	**Cultural control:** • Deep summer ploughing of fields to control nematodes, *Helicoverpa*, and *Spodoptera*. • **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. **Chemical control:** • In nematode severe area apply carbofuran 3% CG granules @ 26,640 g/acre
	Damping off	**Cultural control:** • Excessive watering and poorly drained areas of field should be avoided • **Use raised beds:** more than 15 cm height is better for water drainage. • Raise seedlings in pro-trays/plug trays. **Chemical control:** • Seed treatment with captan 75 WS @ 25-30 g/kg seed • Soil drenching with captan 75% WP @ 1000 g in 400 l of water/acre or
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, for rainfed chilli: 60: 30: 50: Kg N: P: Kg/ha should be applied as basal dose. For irrigated chilli: 60: 60: 30 Kg N: P: K/ha should be applied

		as a basal dose. • Based on soil test for micronutrient, the deficient micronutrient should be applied in soil at sowing / transplanting. In Zn deficient areas, zinc sulphate @ 25 kg/acre should be applied at last ploughing. Biofertilizers: For seed treatment with *Azotobacter* and phosphorous solubilizing bacteria (PSB) cultures @ 8-10 g/kg seed • For seedling root dip treatment with *Azotobacter* and phosphorous solubilizing bacteria (PSB) cultures @ 250 g/acre seedlings
	Weeds	• Keep the nursery weed free by hand weeding.
***** 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**	• In rainfed chilli, apply 25 kg N/acre as top dressing with rains. • In irrigated chilli, first top dressing of 20 kg N + 10 kg K/acre should be done at 45 days after planting. • Second top dressing of 20 kg N + 10 kg K/acre should be done at 60 days after planting. • Third top dressing of 20 kg N + 10 kg K/acre should be done at 75 days after planting. • Micronutrient deficiency should be corrected by foliar spray of particular micronutrient. • Apply NAA @ 50 ppm (1 ml in 4.5 lit of water) 2-3 times at 15 days interval to minimize flower drop.
	Weeds	• Field should be weed free up to 30 days to enable the crop to cover up. • After transplanting 2 hand weedings are required. • 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 as well as drip irrigation will avoid weed growth.
	Thrips	**<u>Cultural control:</u>** • Inter crop with *Sesbania grandiflora*, to

		provide barrier which regulate the thrips population. • Do not follow chilli and onion mixed crop – both the crops attacked by thrips • Sprinkle water over the seedlings to check the multiplication of thrips **<u>Biological control:</u>** • Conserve predators such as predatory mite (*Amblyseius swirskii*), insidious flower bugs (*Orius insidiosus*) etc. • Apply neem cake to the beds @ 100 kg/acre in two split doses at the time of planting and 30 days after transplanting **<u>Chemical control:</u>** • Seed treatment with imidacloprid 70% WS @ 400-600 g/100 kg seed. • Apply fipronil 5% SC @ 320-400 ml in 200 l of water/acre or lambda-cyhalothrin 4.9% CS @ 200 ml in 200 l of water/acre or lambda-cyhalothrin 5% EC @ 120 ml in 160-240 l of water/acre or spinosad 45% SC @ 64 ml in 200 l of water/acre or thiacloprid 21.7% SC @ 90-120 ml in 200 l of water/acre or acetamiprid 20% SP @ 20-40 g in 200-240 l of water/acre or emamectin benzoate 5% SG @ 80 g in 200 l of water/acre or carbaryl 50% WP @ 800 g in 200-400 l of water/acre or carbofuran 3% CG @ 13320 g/acre or ethion 50% EC @ 600-800 ml in 200-400 l of water/acre or fenpropathrin 30% EC @ 100-136 ml in 300-400 l of water/acre or methomyl 40% SP @ 300-450 ml in 200-400 l of water/acre or oxydemeton-methy 25% EC @ 400 ml in 200-400 l of water/acre or phorate 10% CG @ 4000 g/acre or phosalone 35% EC @ 800 ml in 200-400 l of water/acre or indoxacarb 14.5% + acetamiprid 7.7% W/W SC @ 160-200 ml in 200 l of water/acre
	Aphids	**<u>Biological control:</u>** • Conserve parasitoids such as *Aphidius colemani, Diaeretiella* spp*. Aphelinus* spp*.* etc. • Conserve predators such as anthocorid bugs/pirate bugs (*Orius* spp.), mirid bugs, syrphid/hover flies, green lacewings (*Mallada basalis* and *Chrysoperla*

		carnea), predatory coccinellids (*Stethorus punctillum*), staphylinid beetle (*Oligota* spp.), predatory cecidomyiid fly (*Aphidoletis aphidimyza*) and predatory gall midge, (*Feltiella minuta*), earwigs, ground beetles, rove beetles, spiders, wasps etc. **<u>Chemical control:</u>** • Seed treatment with imidacloprid 70% WS @ 400-600 g/100 kg seed. • Apply fipronil 5% SC @ 320-400 ml in 200 l of water/acre or oxydemeton methyl 25% EC @ 640 ml in 200-400 l of water/acre or carbofuran 3% CG @ 13320 g/acre or carbosulfan 25% EC @ 320-400 ml in 200-400 l of water/acre or phorate 10% CG @ 4000 g/acre or phosalone 35% EC @ 800 ml in 200-400 l of water/acre or quinalphos 25% GEL @ 400 g in 200-400 l of water/acre or quinalphos 25% EC @ 400 ml in 200-400 l of water/acre or quinalphos 1.5% DP @ 8000 g/acre • Alternate chemicals at 10 days interval till the end of aphid population
	Yellow mite/other mites	**<u>Cultural control:</u>** • **Chilli** crop bordered by two rows of maize at every 0.5 acre area (31.2 x 60 sqm). **<u>Biological control:</u>** • Conserve the predators such as predatory mite (*Amblyseius ovalis*), predatory bug (*Orius* spp.), spiders etc. • If the incidence of mites is low, spray neem seed powder extract 4% at 10 days interval **<u>Chemical control:</u>** • Spray dimethoate 30% EC @ 396 ml in 200-400 l of water/acre or emamectin benzoate 5% SG @ 80 g in 200 l of water/acre or fenazaquin 10% EC @ 500 ml in 160-240 l of water/acre or fenpropathrin 30% EC @ 100-136 ml in 300-400 l of water/acre or fenpyroximate 5% EC @ 120-240 ml in 120-200 l of water/acre or milbemectin 1% EC @ 130 ml in 200 l of water/acre or propargite 57% EC @ 600 ml in 200-250 l of water/acre or spiromesifen 22.9% SC@ 160 ml in 200-300 l of water/acre or chlorfenapyr 10% SC

		@ 300-400 ml in 200 l of water/acre or diafenthiuron 50% WP @ 240 g in 200-300 l of water/acre or ethion 50% EC @ 600-800 ml in 200-400 l of water/acre or hexythiazox 5.45% W/W EC @ 120-200 ml in 250 l of water/acre or lambda-cyhalothrin 5% EC @ 120 ml in 160-240 l of water/acre or or oxydemeton-methy 25% EC @ 800 ml in 200-400 l of water/acre or phorate 10% CG @ 4000 g/acre or phosalone 35% EC @ 514 ml in 200-400 l of water/acre or quinalphos 25% EC @ 600 ml in 200-400 l of water/acre
	Tobacco caterpillar	**Cultural control:** • Field sanitation and roguing • Castor can be grown as a trap crop along the field border to attract the egg laying female adult moths (collect and destroy the laid egg masses and gregarious neonates) • Pest repellant plants: Ocimum/Basil • Setting up light traps for collecting adults @ 1/acre • Erecting of bird perches for encouraging predatory birds such as king crow, mynah etc. • Install pheromone traps @ 4-5/acre for monitoring adult moth activity. Replace the lures with fresh lures after every 2-3 weeks **Biological control:** • Spray NSKE 5 % against eggs and first instar larva. • Spray *B. t.* var *gallariae* @ 600-800 g in 400 l of water/acre • Conserve parasitoids such as *Trichogramma chilonis* (egg), *Tetrastichus* spp. (egg), *Telenomus* spp. (egg), *Chelonus blackburni* (egg-larval), *Carcelia* spp. (larval-pupal), *Campoletis chlorideae* (larval), *Eriborus argentiopilosus* (larval), *Microplitis* sp etc. • Conserve predators such as *Chrysoperla carnea*, coccinellids, King crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants, big eyed bugs (*Geocoris* sp), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc. **Chemical control**

		• Apply emamectin benzoate 5% SG @ 80 g in 200 l of water/acre or fipronil 5% SC @ 320-400 ml in 200 l of water/acre or flubendiamide 39.35% M/M SC @ 40-50 ml in 200 l of water/acre or indoxacarb 14.5% SC @ 133-160 ml in 120-240 l of water/acre or lufenuron 5.4% EC @ 240 ml in 200 l of water/acre or spinosad 45% SC @ 64 ml in 200 l of water/acre or novaluron 10 % EC @ 150 ml in 200 l of water/acre or chlorantraniliprole 18.5% SC @ 60 ml in 200 l of water/acre or deltamethrin 2.8% EC @ 160-200 ml in 160-240 l of water/acre or lambda-cyhalothrin 4.9% CS @ 200 ml in 200 l of water/acre or lambda-cyhalothrin 5% EC @ 120 ml in 160-240 l of water/acre or methomyl 40% SP @ 300-450 ml in 200-400 l of water/acre or thiodicarb 75% WP @ 250.4-400 g in 200 l of water/acre or indoxacarb 14.5% + acetamiprid 7.7% W/W SC @ 160-200 ml in 200 l of water/acre or pyriproxyfen 5% + fenpropathrin 15% EC @ 200-300 ml in 200-300 l of water/acre
	Gram pod borer	**<u>Cultural control:</u>** • Field sanitation and roguing • Erecting suitable physical barriers such as nylon nets • Growing intercrops such as cowpea, onion, maize, coriander, urdbean in 5 or 4:1 ratio • Guard crop sorghum or maize in 4 rows all around cotton crop as guard crop. • Rotate the chilli crop with a non-host cereal crop, cucurbit, or cruciferous vegetable. • Repellant plants: Ocimum/Basil • Erecting of bird perches for encouraging predatory birds such as king crow, mynah, and drongo etc. • Install pheromone traps @ 4-5/acre for monitoring adult moths activity. Replace the lures with fresh lures after every 2-3 weeks • Use of ovipositional trap crops such as marigold @ 100 plants/acre 1 row of marigold for every 18 rows of chilli and collection of larvae from flowers (marigold seedling of 45 days should be planted along with chilli transplanting)

		Biological control: • Release of egg parasitoid *Trichogramma pretiosum* @ 50,000 adults (in the form of parasitized card)/acre/week commenced right from the start of flower initiation to till end of the crop, tie the egg cards on the stick placed through out the field at 4-5 m apart, in the evening, a day prior to the emergence of adult. • Conserve parasitoids such as *Tetrastichus* spp. (egg), *Telenomus* spp. (egg), *Campoletis chlorideae* (larval) etc. • Conserve predators such as *Chrysoperla carnea*, coccinellids, King crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants, big eyed bugs (*Geocoris* sp), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc. **Chemical control:** • Seed treatment with thiamethoxam 30% FS @ 7 g/kg seed • Apply emamectin benzoate 5% SG @ 80 g in 200 l of water/acre or fipronil 5% SC @ 320-400 ml in 200 l of water/acre or flubendiamide 39.35% M/M SC @ 40-50 ml in 200 l of water/acre or indoxacarb 14.5% SC @ 133-160 ml in 120-240 l of water/acre or lufenuron 5.4% EC @ 240 ml in 200 l of water/acre or spinosad 45% SC @ 64 ml in 200 l of water/acre or novaluron 10 % EC @ 150 ml in 200 l of water/acre or chlorantraniliprole 18.5% SC @ 60 ml in 200 l of water/acre or deltamethrin 2.8% EC @ 160-200 ml in 160-240 l of water/acre or lambda-cyhalothrin 4.9% CS @ 200 ml in 200 l of water/acre or lambda-cyhalothrin 5% EC @ 120 ml in 160-240 l of water/acre or methomyl 40% SP @ 300-450 ml in 200-400 l of water/acre or thiodicarb 75% WP @ 250.4-400 g in 200 l of water/acre or indoxacarb 14.5% + acetamiprid 7.7% W/W SC @ 160-200 ml in 200 l of water/acre or pyriproxyfen 5% + fenpropathrin 15% EC @ 200-300 ml in 200-300 l of water/acre
	Choeanephora blight	**Cultural control:** • Adopt recommended spacing to maintain adequate air circulation. • Grow resistant varieties.

		Chemical control: • Spray captan 75% WP @ 800 g in 400 l of water/acre
	Die back and fruit rot	**Cultural control:** • Production of pathogen-free planting materials is the key control measure used to manage the disease. • Use healthy pathogen-free chilli seed • Early removal of affected plants will control the spread of the diseases. • Transplants should be kept clean by controlling weeds and solanaceous volunteers in the vicinity of the transplant houses • Stagnation of water should not be allowed in nursery beds and fields in order to avoid fungal infection. The field should have good drainage and be free from infected plant debris. **Chemical control:** • For die back and fruit rot spray benomyl 50% WP @ 80 g in 240 l of water/acre or captan 75% WP @ 800 g in 400 l of water/acre or copper oxy chloride 50% WP @ 1000 g in 300-400 l of water/acre or difenoconazole 25% EC @ 50 ml in 200 l of water/acre or hexaconazole 2% SC @ 1200 ml in 200 l of water/acre or propineb 70% WP @ 200 g in 200-300 l of water/acre or tebuconazole 25% WG @ 200-300 g in 200 l of water/acre or zineb 75 % WP @ 600-800 g in 300-400 l of water/acre or azoxystrobin 23% SC @ 200 ml in 200-300 l of water/acre or chlorothalonil @ 75% WP @ 320 g in 300 l of water/acre or kitazine 48% EC @ 80 ml in 200-300 l of water/acre or mancozeb 75% WP @ 600-800 g in 300 l of water • For anthracnose and fruit rot apply captan 50% WG @ 600 g in 200 l of water/acre or captan 70% + hexaconazole 5% WP @ 200-400 g in 200 l of water/acre or copper sulphate 2.62% SC @ 400 ml in 200 l of water/acre or copper hydroxide 77% WP @ 500 ml in 200 l of water/acre
	Mosaic	**Cultural control:** • Select healthy seed for planting. • Crop rotation with non-hosts.

		• Control perennial weed hosts. • Rogue out and destroy infected plants in early stages of infection. • Grow disease tolerant varieties. • Raise 4 rows of maize or sorghum as border crop to restrict the spread of aphid vectors. • Cover the seed bed with nylon net or paddy straw. **<u>Chemical control:</u>** • **For vector control** • Seed treatment with imidacloprid 70% WS @ 10 g/kg of seed. • Apply fipronil 5% SC @ 320-400 ml in 200 l of water/acre.
	Powdery mildew	**<u>Chemical control:</u>** • Spray dinocap 48% EC @ 90 ml in 300 l of water/acre or fenarimol 12% EC @ 40 ml in 200-300 l of water/acre or flusilazole 40% EC @ 40-60 ml in 200 l of water/acre or sulphur 52% SC @ 800 ml in 160 l of water/acre or sulphur 80% WP @ 1252 g in 300-400 l of water/acre or azoxystrobin 23% SC @ 200 ml in 200-300 l of water/acre or benomyl 50% WP @ 80 g in 240 l of water/acre or hexaconazole 2% SC @ 1200 ml in 200 l of water/acre or tebuconazole 25% WG @ 200-300 g in 200 l of water/acre
	***Cercospora* leaf spot**	**<u>Chemical control:</u>** • Spray mancozeb 75% WP @ 600-800 g in 300 l of water or zineb 75% WP @ 600-800 g in 300-400 l of water/acre or copper oxy chloride 50% WP @ 1000 g in 300-400 l of water/acre or benomyl 50% WP @ 80 g in 240 l of water/acre or copper hydroxide 77% WP @ 500 ml in 200 l of water/acre
	Bacterial leaf spot	**<u>Cultural control:</u>** • Field sanitation is important. Also seeds must be obtained from disease free plants. • Seeds should be collected from healthy fruits **<u>Chemical control:</u>** • Spray streptomycin sulfate 9% + tetracycline hydrochloride 1% SP solution (streptocycline) 40-100 ppm in fields after the appearance of first true leaves. Two sprays of streptocycline, one before

		transplanting (nursery) and another after transplanting (main field)
Reproductive stage	**Nutrients**	• 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 and Tobacco caterpillar	• Same as in vegetative stage
	Thrips	• Same as in vegetative stage
	Mites	• Same as in vegetative stage
	Die back & fruit rot	• Same as in vegetative stage
	Choeanephora blight	• Same as in vegetative stage
	Bacterial blight	• 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.

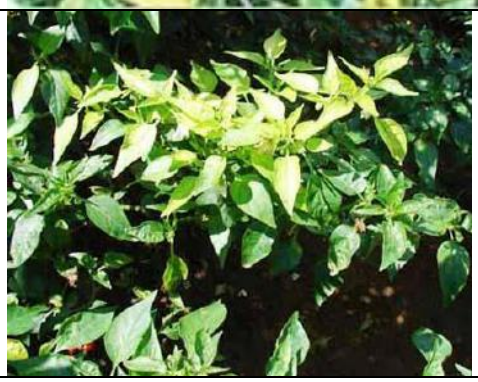
6) **Alternate different insecticide classes.** Avoid the repeated use of the same insecticide, insecticides in the same chemical class, or insecticides in different classes with same mode of action and rotate/alternate insecticide classes and modes of action.

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 and disorders

Poor fruit setting and development, limited growth, defective flower formation and yellowing of leaves are some of the symptoms caused by nutrients deficiencies in chilli plants. The deficiency symptoms shown below help advice to identify the cause of symptoms and physiological disorders in chilli plant.

Nutrient and their deficiency symptoms	Appearance
Nitrogen: Plant development gradually slows down. Gradual drying, beginning at leaf margins, of the area between the lower leaf veins. The petioles bend and hang downwards, parallel to the stem. The plant develops few flowers and fruit setting is poor. The fruit receptacle is thin, and the ovary is small. Sometimes there is no fruit development on the plant at all, and on those plants that bear fruits, the fruit is deformed.	

Phosphorus: The plants display limited growth. The leaves are hard and brittle to the touch. Flower formation is defective. Few flowers develop, and in those that do develop, only one in every four or five develops a fruit. The fruit is underdeveloped, with a thin receptacle, and very few seeds. The root system is undeveloped.	
Potassium: Yellow chlorosis spots appear between leaf veins, firstly in the lower leaves. The veins and the areas adjacent to these spots do not change their color. Later, the chlorotic spots become lighter. (This can be seen mainly in the upper parts of the plant). There is little fruit setting, and not much fruit, which is smaller than usual.	
Magnesium: Common in pepper plants. Yellowing of the leaves is apparent in the interveinal areas and veins remain green. The oldest leaves are affected first. Sometimes magnesium deficiency occurs when excessive applications of potassium have been made. It may also show up under extremely hot dry weather.	
Sulphur: Chlorosis occur in young leaves; leaves become small.	

Calcium: The most common reason for Blossom End Rot of the fruit. This may be corrected by foliar spray of calcium chloride or calcium nitrate. Further information following downwards.

Blossom end rot (BER): occurs mainly during hot weather conditions. Fruits are affected in their early stages of development (10-15 days after fruit set); the cause is related to the rate of calcium supply to the fruit, which is lower than the rate of the fruit growth. This results in the collapse of certain tissues in the fruit, demonstrated as BER. Factors that favor BER are directly related to limited calcium uptake and transport to the fruit, like high salinity, high temperatures and high growing intensity and water shortage.

Pepper spots: Black spot or strip is shown in the fruit as grey/black spots, which develop under the skin in the fruit wall about the time the fruit attains a diameter of 8 centimeters or more. As the fruits ripen, the spots slightly enlarge and turn green or yellow. Strip is a calcium disorder, caused by excessive N-NH_4 and K rates. Susceptibility greatly varies by variety.

Boron: The deficiency manifests itself very quickly. The lower leaves curl upwards. Growth is stunted. The plant develops a thick, short stem. The apex withers and the leaves become yellow from bottom to top of the plant. There is a reduced production of flowers, and fruit setting is poor. In case of severe deficiency the growing points die and decay, and the leaves are misshapen:

Iron: Symptoms show at the later stages of growth. The young leaves fade and then become yellow in the areas between the veins. The veins remain green.
Chloride: Wilted leaves, which then become chlorotic bronze, and necrotic. Roots become stunted and thickened near tips.
Manganese: Chlorotic spots between the upper leaf veins.
Zinc: The leaves become narrow and small in chili.
Copper: Appear late in the vegetative stage. The leaf margins curl and dry up. The leaves and the fruit become narrow and rectangular.
Molybdenum: The foliage turns yellow-green and growth is somewhat restricted. The deficiency occurs most commonly on acidic substrates.

Source: http://www.haifa-group.com
http://agritech.tnau.ac.in/agriculture/agri_min_fldcrops_vegetables.html

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.

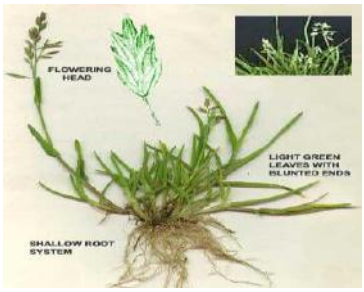
5. Corn spurry: *Spergula arvensis* L. Caryophyllaceae

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. 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.

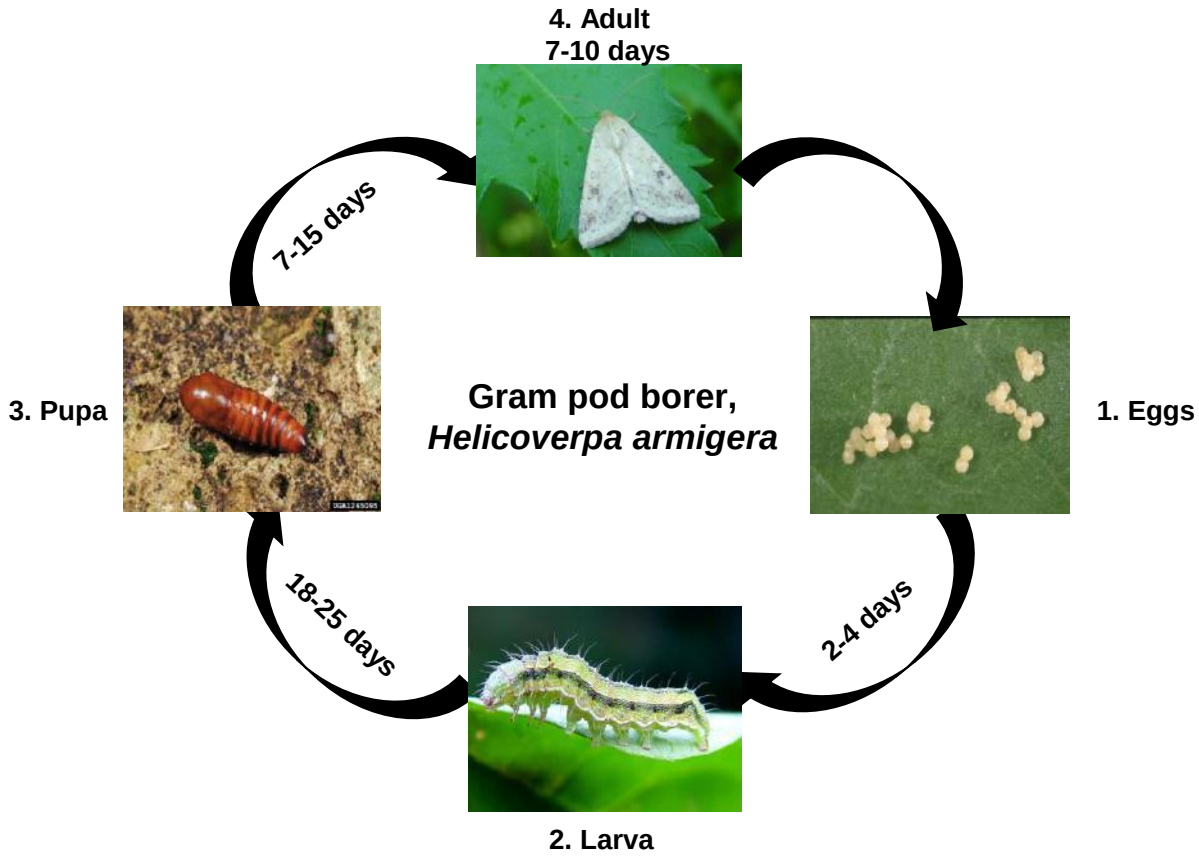
Larva: Caterpillars vary in colour, initially brown and later turn greenish with darker broken lines along the side of the body.

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:



1. http://www7.inra.fr/hyppz/RAVAGEUR/6helarm.htm
2. http://www.infonet-biovision.org/default/ct/120/crops
3. http://www.invasive.org/browse/subinfo.cfm?sub=9408
4. http://en.wikipedia.org/wiki/Helicoverpa_armigera

Damage symptoms:

- Young larva feeds on the leaves for some time and then attacks fruits. Internal tissues are eaten severely and completely hollowed out. While feeding the caterpillar thrust its head inside leaving the rest of the body outside.
- Bored fruits with round holes.
- Fed leaves, shoots and buds.
- The activity of *Helicoverpa* starts on greengram, summer vegetables and maize and continues their generation by Aug-Sept months synchronizing with main crop.

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

http://agropedia.iitk.ac.in/content/chilli-fruit-borer

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.** **9. *Senometopia illota***



1. http://gsquaredbugs.com/?page_id=318
2. http://www.pbase.com/image/135529248
3. http://www.nbaii.res.in/Featured%20insects/chelonus.htm
4. http://baba-insects.blogspot.in/2012/02/telenomus.html
5. http://www.nbaii.res.in/Featured%20insects/Bracon%20brevicornis.htm
6. http://www.organicgardeninfo.com/ichneumon-wasp.html
7. http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398
8. http://www.nbaii.res.in/Featured%20insects/Campoletis.htm
9. http://eol.org/pages/28099/details

Predators:

1. Lacewing

2. Lady beetle

3. Spider

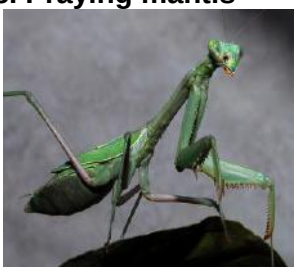
4. Fire ant

5. Dragon fly

6. Robber fly

7. Reduviid bug

8. Praying mantis



9. Black drongo (King crow)

10. Wasp

11. Common mynah

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/

2. Tobacco caterpillar:

It is found throughout the tropical and sub tropical parts of the world, wide spread in India. Besides tobacco, it feeds on cotton, castor, groundnut, CHILLI, cabbage and various other cruciferous crops.

Biology:

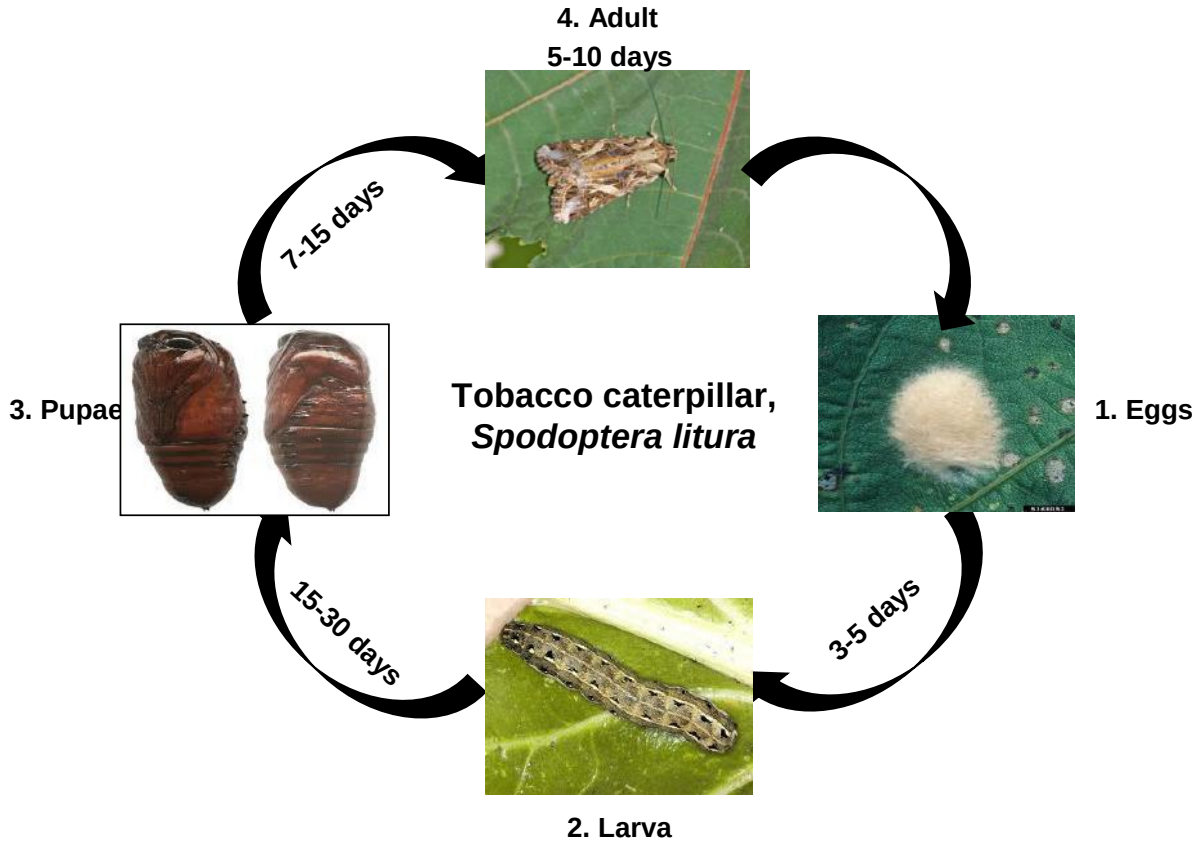
Eggs: Female lays about 300 eggs in clusters. The eggs are covered over by brown hairs and they hatch in about 3-5 days.

Larva: Caterpillar measures 35-40 mm in length, when full grown. It is velvety, black with yellowish – green dorsal stripes and lateral white bands with incomplete ring – like dark band on anterior and posterior end of the body. It passes through 6 instars. Larval stage lasts 15-30 days.

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

Adult: Moth is medium sized and stout bodied with forewings pale grey to dark brown in colour having wavy white crisscross markings. Hind wings are whitish with brown patches along the margin of wing.

Life cycle:



1. http://commons.wikimedia.org/wiki/File:Spodoptera_litura_egg_mass.jpg
2. http://lepidoptera.butterflyhouse.com.au/lynf/lynf.html
3. http://www.ccs-hk.org/DM/butterfly/Noctuid/Spodoptera-litura.html
4. http://www.nbaii.res.in/insectpests/images/Spodoptera-litura11.jpg

Damage symptoms:

- Pest breeds throughout the year.
- Moths are active at night.
- Adults live for 7-10 days. Total life cycle takes 32-60 days.
- There are eight generations in a year.

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

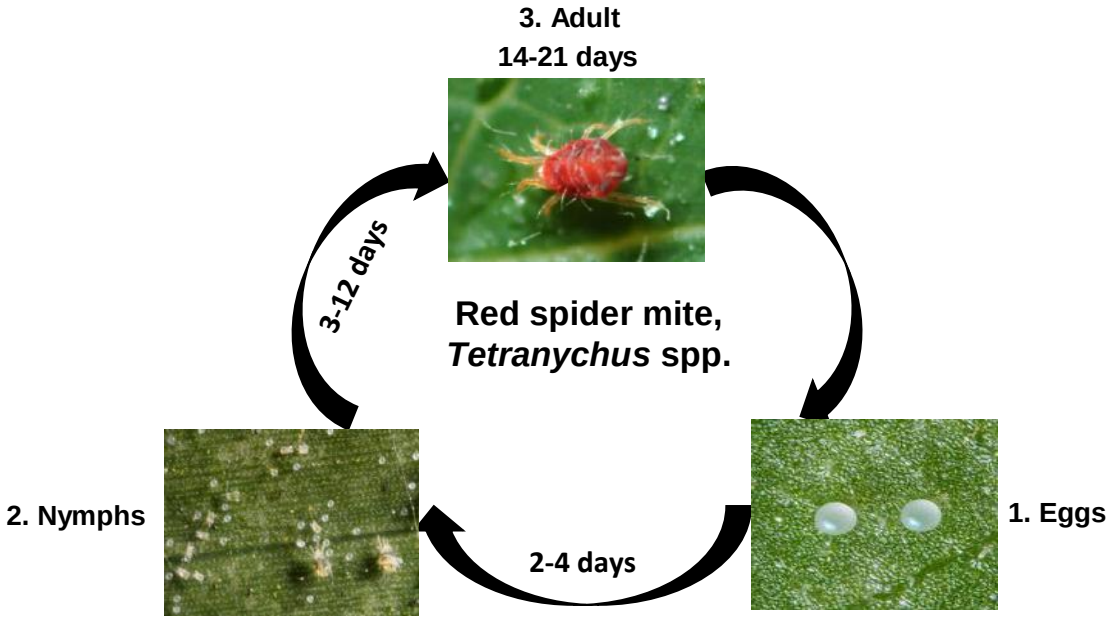
1. Affected pods develop white 2. Holes on leaves color and drop off on drying

http://agropedia.iitk.ac.in/content/chilli-tobacco-caterpillar

For parasitoids and predators see *Helicoverpa armigera* on page……..

3. Spider mites:

Life cycle (*Tetranychus* spp.):



1.http://bugguide.net/node/view/348888
2. http://entomology.k-state.edu/extension/insect-photo-gallery/Corn-Insects.html
3. http://nathistoc.bio.uci.edu/Other%20Arachnids/Acari4.htm

Damage symptoms:

- The infested leaves develop crinkles and curl downwards
- Elongated petiole
- Buds become brittle and drop down.
- Early stage, infestation leads to stunted growth and flower production, fruit set are arrested

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

Downward curling

http://agropedia.iitk.ac.in/content/chilli-mite

Predators:

1. Predatory mites

2. Predatory thrips

3. *Oligota* spp.

4. *Orius* spp. (pirate bug)

5. Hover flies

6. Mirid bug



1. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
2. http://biocontrol.ucr.edu/hoddle/persea_mite.html
3. http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33
4. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
5. http://freepages.misc.rootsweb.ancestry.com/~larsonmorgan/flies/flies.html
6. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html

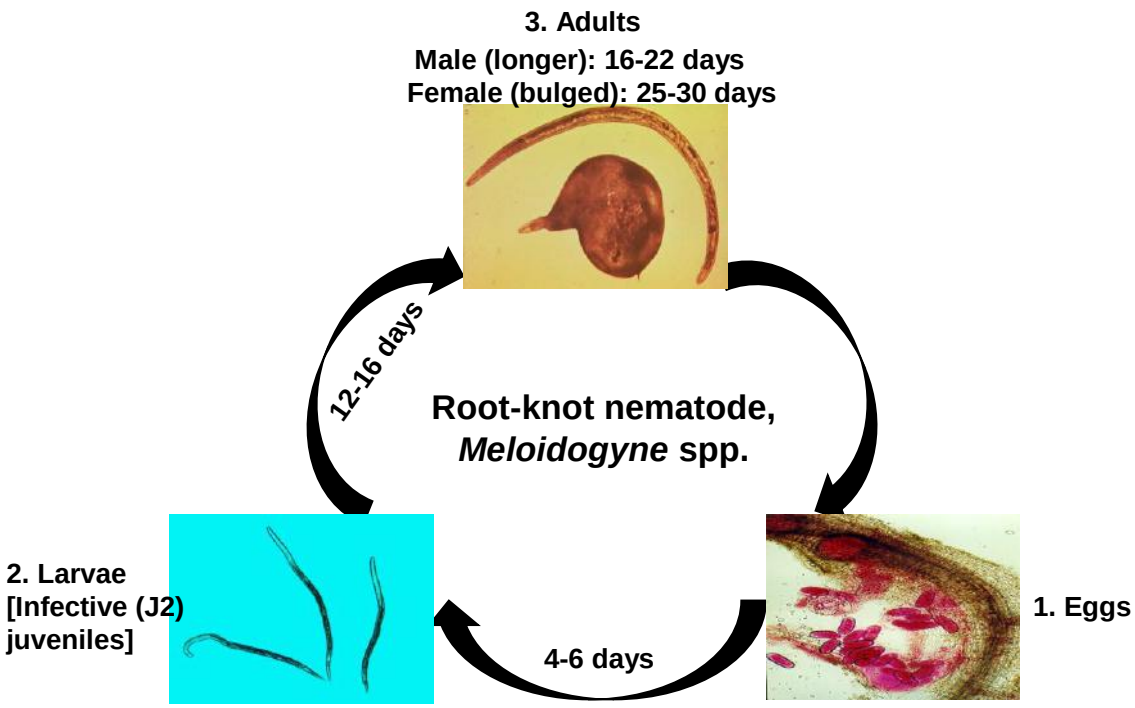
4. Root-knot nematodes:

Biology:

- 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. They are microscopic in size.
- Development of the first stage larvae occurs within the egg where the first moult 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/
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

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----------

5. Thrips:

Biology:

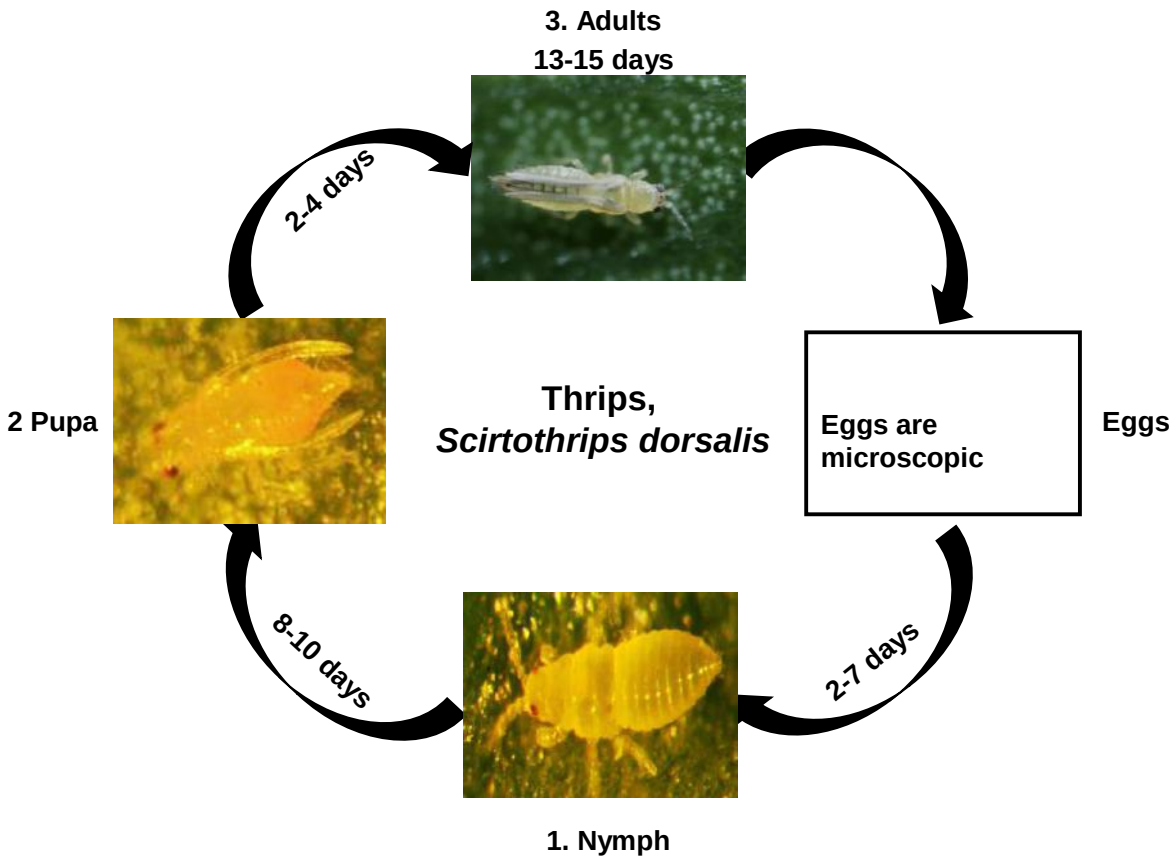
Egg: Hyaline, globular laid in mass.

Nymphs: Nymphs tiny, slender, fragile and straw yellow in colour.

Adult: Adults with heavily fringed wings

Life cycle:

1. Eggs are microscopic



2,3,4: http://entnemdept.ufl.edu/creatures/orn/thrips/chilli_thrips.htm

Damage symptoms:

- The infested leaves curl upward, crumble and shed
- Infested buds become brittle and drop down.
- Affected fruits show light brown scars
- Early stage, infestation leads to stunted growth and flower production, fruit set are arrested

Host-range and favourable conditions:

- *S. dorsalis* is found in almost all chilly growing areas. It is a polyphagus pest. Besides chilli, it also infests brinjal, cotton, groundnut, castor, bottlegourd, guava, tea and grapevine. It is more common on un-irrigated chilli crop than irrigated one.

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

1. Upward curling

2. Plant shows stunted growth and elongation of petiole

1, 2. http://agropedia.iitk.ac.in/content/chilli-thrip

Predators:

1. Predatory mite **2. Predatory thrips** **3. *Oligota* spp.** ***Orius* spp. (pirate bug)**




5. Hover flies **6. Mirid bug**


1. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
2. http://biocontrol.ucr.edu/hoddle/persea_mite.html
3. http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33
4. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
5. http://freepages.misc.rootsweb.ancestry.com/~larsonmorgan/flies/flies.html
6. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html

6. Spider mites/Yellow mites:

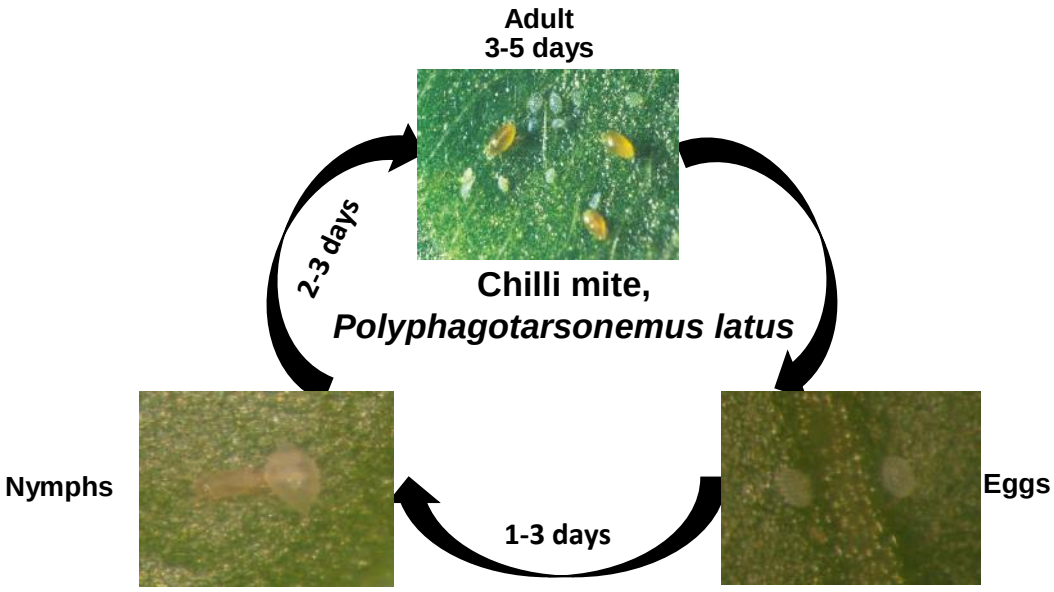
Biology:

Egg: Eggs are oval shaped eggs and white in colour. Eggs are glued firmly on the leaf surface.

Nymph: Nymphs white in colour.

Adult: Adults large, oval and broad and yellowish in colour.

Life cycle (*Polyphagotarsonemus latus*):



Damage symptoms:

- Both nymphs and adults suck sap and devitalize the plant causing 'Murda' disease of chillies.
- Infestation results in downward curling of leaves,
- The affected leaves becoming inverted boat shaped,
- The leaves rolling down along the margin with elongation of petioles.
- Affected leaves turning dark green in certain cases.
- Younger leaves at the tip of branch clustering.

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

Downward curling


http://agropedia.iitk.ac.in/content/chilli-mite

Predators:

Please see the predators of thrips (same as in thrips).

7. Aphids:

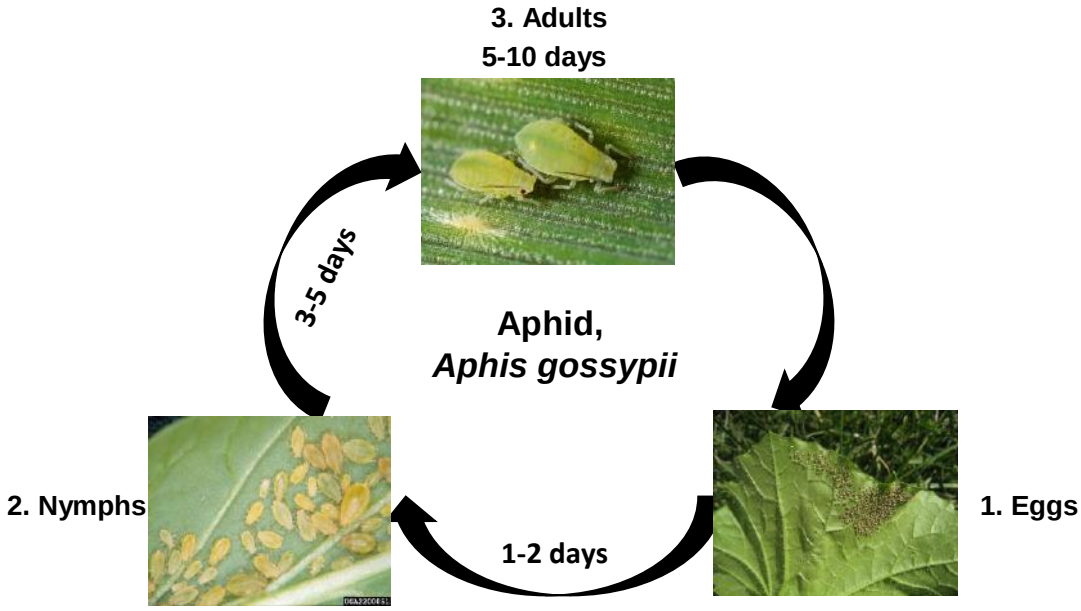
Biology:

Eggs are very tiny, shiny-black, and are found in the crevices of bud, stems, and barks of the plant. Aphids usually do not lay eggs in warm parts of the world.

Nymphs (immature stages) are young aphids, they look like the wingless adults but are smaller. They become adults within 7 to 10 days.

Adults are small, 1 to 4 mm long, soft-bodied insects with two long antennae that resemble horns. Most aphids have two short cornicles (horns) towards the rear of the body

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:

- Appear on the tender shoots, leaves and on the lower surface of the leaves.
- The honeydew is very sweet which attracts sooty mould growth, making the leaves turn black.
- Suck the sap and reduce the vigour of the plant.
- Secrete sweet substances which attracts ants and develops sooty mould.
- The pods that develop black colour due to sooty mould lose quality and fetch low price.
- The yields are also reduced by aphids directly and more through the spread of virus diseases acting as vectors indirectly

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

1. Aphids on chilli leaf **2. Aphid damage on chilli**


1. http://www.thechilliking.com/aphids-on-chilli-pepper-plants-how-i-solved-the-problem/
2. http://chillininja.wordpress.com/tag/aphids/page/2/

Parasitoid:

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


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

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 plant Diseases:

1) Damping off: *Pythium aphanidermatum* (Edson) Fitzp

Damage symptoms:

Disease of nursery beds and young seedlings resulting in reduced seed germination and poor stand of seedlings.

Very high seedling mortality 25-75%

- **Pre-emergence** damping off: Seedlings disintegrate before they come out of soil surface leading to poor seed germination
- **Post-emergence** damping off is characterised by development of disease after seedlings have emerged out of soil but before the stems are lignified
- **Water soaked lesion** formation at collar region
- Infected areas turn **brown and rot**
- Plants shrivel and **collapse** as a result of softening of tissues
- In *Rhizoctonia solani* attack infected stems become hard, thin (**wire stem** symptoms) and infected seedlings topple Disease appear in patches both in nursery and field beds.

http://www.omafra.gov.on.ca/IPM/images/peppers/diseases/damping_off/peppers_damping_off2_zoom.jpg

Survival and spread:

Primary: Oospores in soil in case of *Pythium*
Sclerotia in soil in case of *Rhizoctonia*

Secondary: Zoospores through irrigation water in case of *Pythium.* Mycelial growth in soil and sclerotia through irrigation water in case of *Rhizoctonia.*

Favourable conditions:

For *Pythium*:

Heavy rainfall, excessive and frequent irrigation, poorly drained soil and close spacing, high soil moisture with temp around 25-30 °C

For *Rhizoctonia*:
High soil moisture with temp around 30 – 35 °C.

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

2) Die-back and Anthracnose (fruit rot): *Colletotrichum* spp

Damage symptoms:

Dieback Symptoms:

- Disease is more in December - October in transplanted crop
- Small, circular to irregular, brownish black scattered spots appear on leaves
- Severely infected leaves defoliate
- Infection of growing tips leads to necrosis of branches from tip backwards
- Necrotic tissues appear grayish white with black dot like acervuli in the center
- Shedding of flowers due to the infection at pedicel and tips of branches
- *Fruit symptoms*
- Ripe fruits are more vulnerable to attack than green ones
- Small, circular, yellowish to pinkish sunken spots appear on fruits
- Spots increase along fruit length attaining elliptical shape
- Severe infection result in the shrivelling and drying of fruits.
- Tissues around lesions will be bleached and turn white or greyish in colour and lose their pungency
- On the surface of the lesions minute black dot like fruiting bodies called ‘acervuli’ develop in concentric rings and fruits appear straw coloured
- The affected fruits may fall off subsequently. The seeds produced in severely infected fruits are discoloured and covered with mycelial mat.



Photos by: SK Sain

Survival and spread:

Primary: Mycelium and conidia in acervuli in infected seeds and diseased crop debris.

Secondary: Conidia dispersed by rain splash and wind.
Favourable conditions:

Temp, 28 °C with RH more than 97%, humid weather with rainfall at frequent intervals, intercropping with turmeric which is another host of the fungus

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

3. Choeanephora blight/ wet rot: *Coeanephora cucurbitarum* (Berk. & Ravenel) Thaxt

Damage symptoms:

- Plants from seedling to early flowering stage are susceptible
- Being a weak parasite the fungus colonises dead or dying tissues before it actively
- invades living tissues
- Fruit infection is observed predominantly around calyx
- The pathogen attacks flowers through the senescing petals and overgrows on flowers resulting in brown or black mass of rotten tissue
- Flower stalks, buds and leaves will be attacked subsequently
- On infected tissues stiff silvery mass of whisker-like or hairy strands of the fungal growth develops on which black mass of spores is produced which is the chief diagnostic feature
- Infected young fruits may abort
- Individual branches of plants may be attacked which show dieback
- Stems of infected plants appear wet and green and the bark peels of in to shreds

http://4.bp.blogspot.com/-GUs2E-CWAj0/TdZMVhqlAuI/AAAAAAAAANI/-gUzJ9qfZ7Q/s1600/7CHOANEPHORA+BLIGHT.jpg

Survival and spread:

Primary: Zygospores on seeds and diseased crop debris in soil.

Secondary: Conidia (sporangiospores) dispersed by rain splash and wind.

Favourable conditions:

- Warm, Rainy and wet weather Temp, 280 C with RH more than 97%
- Extended periods of high rainfall followed by warm weather.

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

4. Mosaic complex:

Damage symptoms:

- Symptoms vary with the virus **TMV**
- Raised blisters and mottled areas of light and dark green areas on the foliage
- Leaves point towards ground
- Necrotic spots on stem
- Fruit ripens unevenly and is reduced in size **CMV**
- Reduction in leaf size and narrowing of lamina Chlorosis leading to mosaic symptoms
- Downward curling along with midrib
- Fruit may be small and distorted, on volunteer CHILLI plants and on infected plant debris.

Disease symptoms on plant foliage; Photos by: SK Sain

Survival and spread:

TMV:

Primary: Externally seed borne virus particles

Secondary: Mechanically transmitted virus particles.

CMV:

Primary: Externally seed borne virus particles to some extent and vector transmitted from other and collateral hosts

Secondary: Virus particles transmitted by aphid vectors, *Myzus persicae, Aphis gossypii, A. craccivora*

Favourable conditions:

- Moist weather and splattering rains
- High humidity or persistent dew

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

5. Powdery mildew: *Leveillula taurica* (Lév.) G. Arnaud

Damage symptoms:

- White powdery coating appears mostly on the lower surface and occasionally on upper surface
- Correspondingly on the upper surface yellow patches are seen
- Severe infection results in the drying and shedding of affected leaves
- Powdery growth can also be seen on branches and young fruits
- Diseased fruits do not grow further and may drop down prematurely

http://www.chileplanet.eu/img/Leveillula%20taurica.jpg

Survival and spread:

Primary: Dormant mycelium in the infected crop debris
Secondary: Wind dispersed conidia

Favourable conditions

- Cool dry weather favours conidial germination
- High RH favours disease development

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

6. *Cercospora* leaf spot: *Cercospora capsici* Heald & F.A. Wolf

Damage symptoms:

- Circular spots with brown margins and grey centre appear on leaves
- The spots enlarge and coalesce with others
- The central portion of the spot becomes white and the leaves turn yellow and defoliate
- Sometimes central portion of spot drops off
- Spots also appear on stems and twigs as dark brown, irregular lesions with whitish centers
- In severe cases die-back of twigs occur


Photos by: SK Sain

Survival and spread:

Primary: Dormant mycelium in the infected crop debris, seeds and volunteer plants
Secondary: Wind dispersed conidia

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

7. Bacterial leaf spot: *Xanthomonas campestris pv. vesicatoria* (Pammel) Dowson

Damage symptoms:

- Leaves, fruits and stems are affected
- Lesions on leaf begin as circular, water soaked spots
- Spots become necrotic with brown center with chlorotic borders
- Enlarged spots may develop straw coloured centres
- Lesions are slightly raised on lower leaf surface
- Severely spotted leaves turn yellow and drop
- Raised brown lesions appear on fruits
- Narrow elongated lesions or streaks may develop on stems

http://www.chileplanet.eu/diseases.html#

Survival and spread:
Primary: **Seed borne** bacterial **cells**
Secondary: Bacterial **cells** spread by **rain splash**
Favourable conditions:

- Moderate temperature
- High relative humidity
- Intermittent rains
-

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

8. Alternaria leaf spot: *Alternaria solani* Ell. Mart

Damage symptoms:

- This is a common disease of chilli occurring on the foliage at any stage of the growth.
- The fungus attacks the foliage causing characteristic leaf spots and blight. Early blight is first observed on the plants as small, black lesions mostly on the older foliage.
- Spots enlarge, and by the time they are one-fourth inch in diameter or larger, concentric rings in a bull's eye pattern can be seen in the center of the diseased area.
- Tissue surrounding the spots may turn yellow. If high temperature and humidity occur at this time, much of the foliage is killed.
- Lesions on the stems are similar to those on leaves, sometimes girdling the plant if they occur near the soil line.
- Transplants showing infection by the late blight fungus often die when set in the field. The fungus also infects the fruit, generally through the calyx or stem attachment.
- Lesions attain considerable size, usually involving nearly the entire fruit; concentric rings are also present on the fruit.


Disease symproms on leaf and fruit; <u>Photo by: SK Sain</u>

<u>Survival and spread:</u>

Primary : The fungus spends the winter in infected plant debris in or on the soil where it can survive at least one and perhaps several years. It can also be seed borne.
Secondary:The spores are transported by water, wind, insects, other animals including man, and machinery. Once the initial infections have occurred, they become the most important source of new spore production and are responsible for rapid disease spread.

Favourable conditions:

- Warm, rainy and wet weather

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

9. Fusarium wilt: *Fusarium solani* (Mart.) Sacc

<u>Damage symptoms:</u>

- 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 plants, 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.


http://www.infonet-biovision.org/res/res/files/1658.400x400.jpeg
http://www.apsnet.org/publications/apsnetfeatures/Article%20Images/Chile_Fig09.jpg

Survival and spread:

- Soil and implements

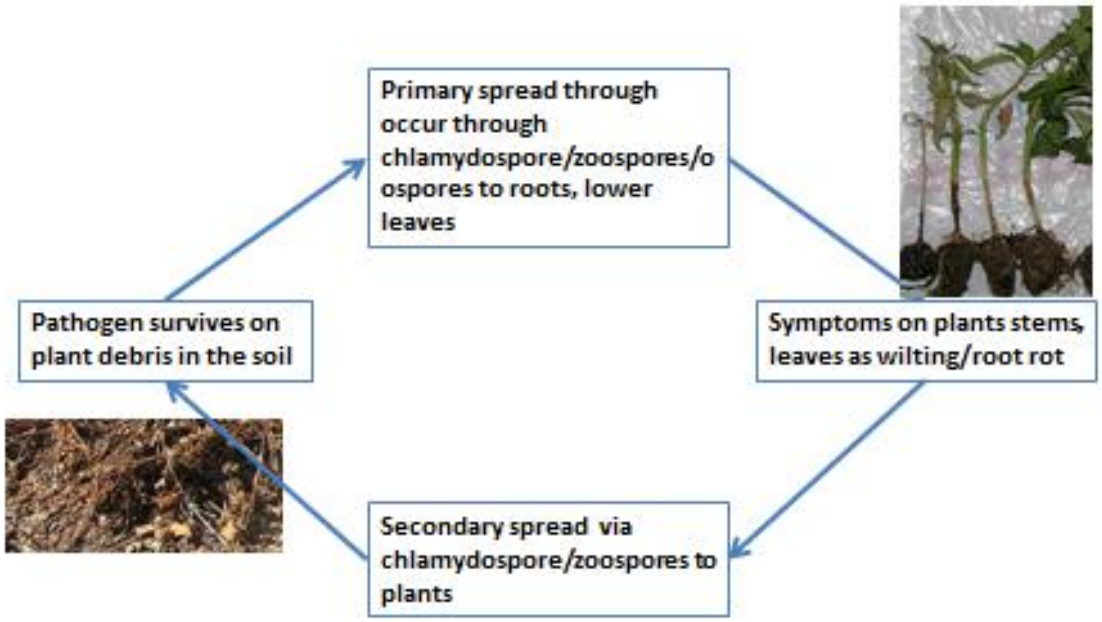
Favourable conditions:

- Relatively high soil moisture and soil temperature

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

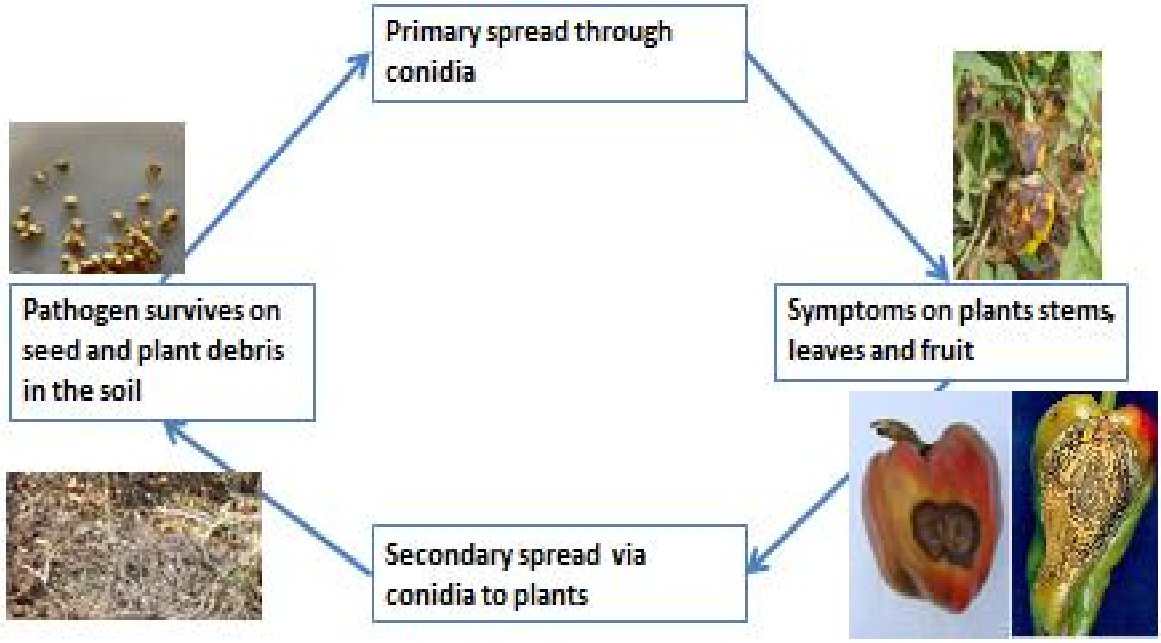
Disease cycles:

1. Damping off: : *Pythium aphanidermatum* (Edson) Fitzp



http://www.omafra.gov.on.ca/IPM/images/peppers/diseases/damping_off/peppers_damping_off2_zoom.jpg

2. Die-back, Anthracnose & fruit rot: *Colletotrichum capsici* (Syd.)



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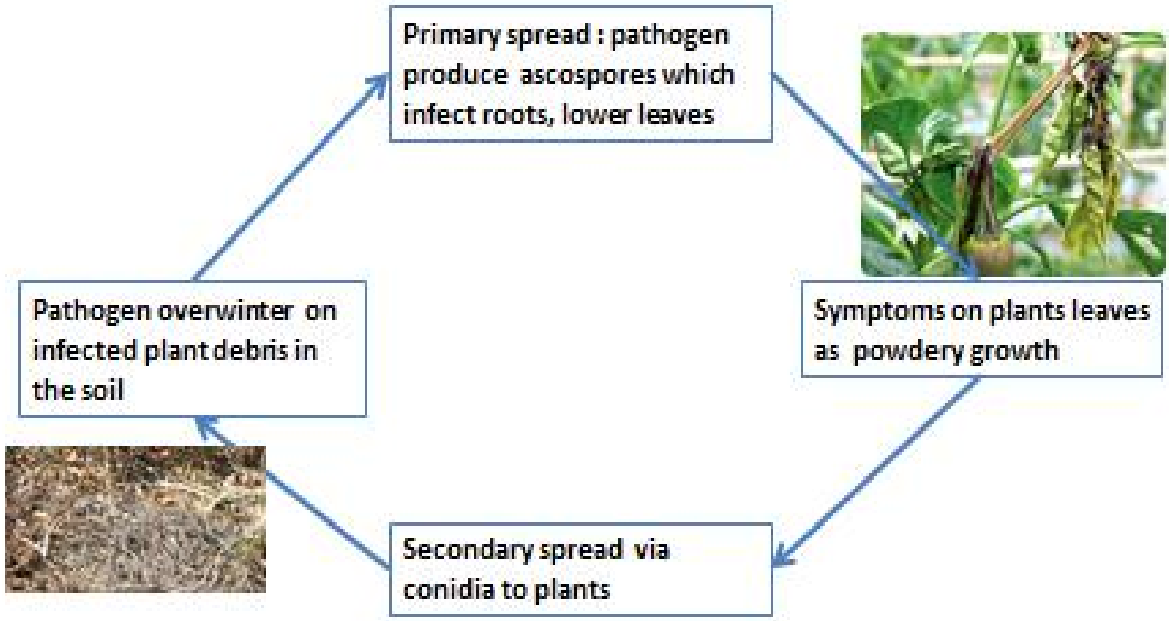

http://4.bp.blogspot.com/-GUs2E-CWAj0/TdZMVhqlAuI/AAAAAAAAANI/-gUzJ9qfZ7Q/s1600/7CHOANEPHORA+BLIGHT.jpg

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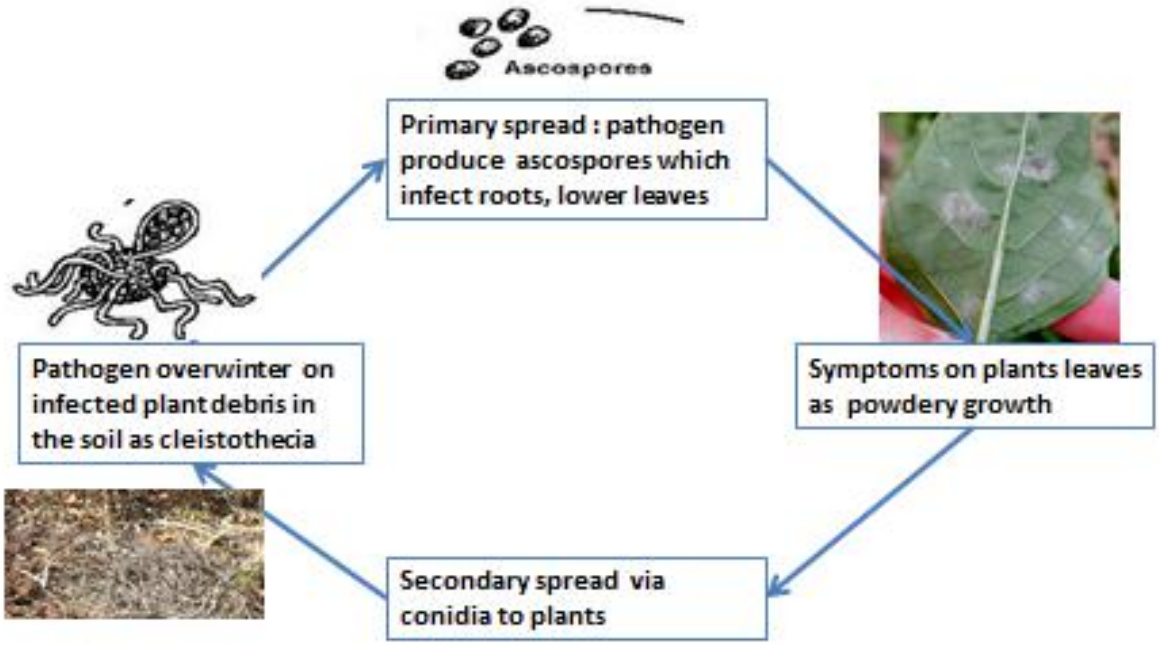
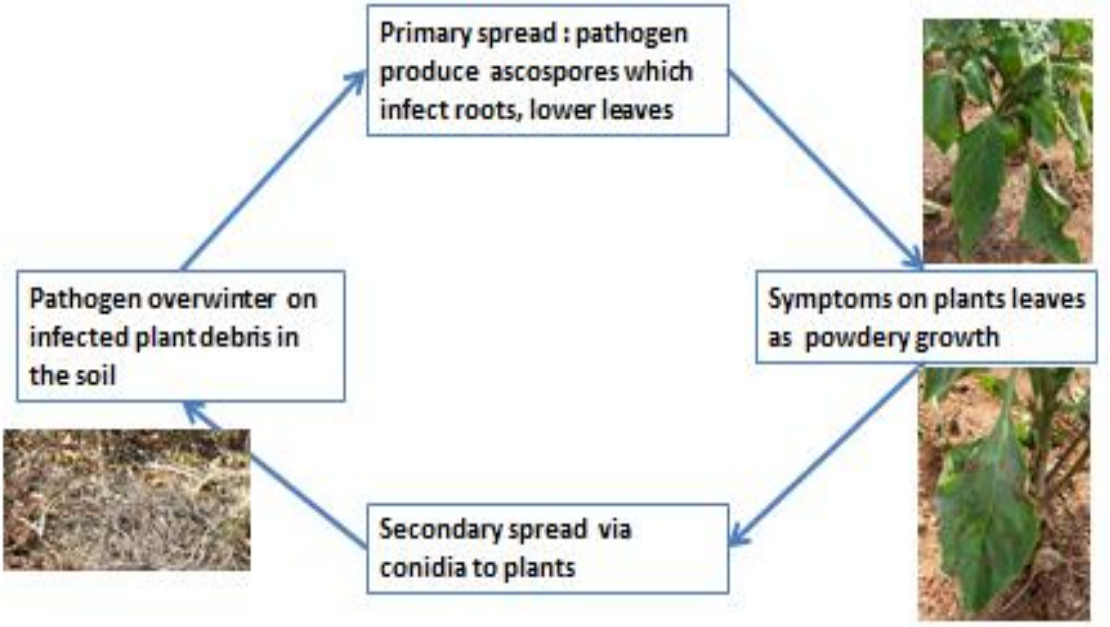


http://www.chileplanet.eu/img/Leveillula%20taurica.jpg

5. Cercospora leaf spot: *Cercospora capsici* Heald & F.A. Wolf



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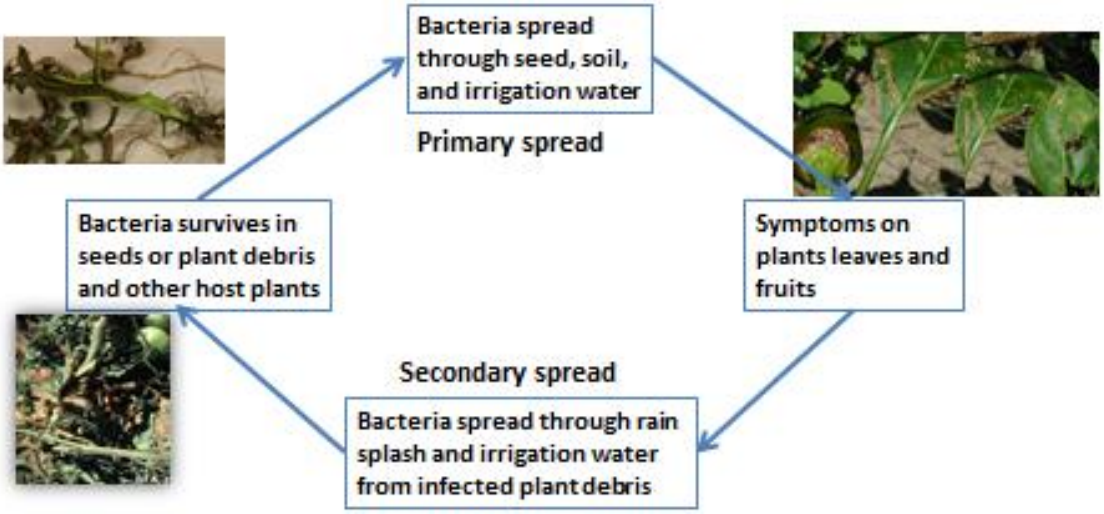

http://www.chileplanet.eu/diseases.html#

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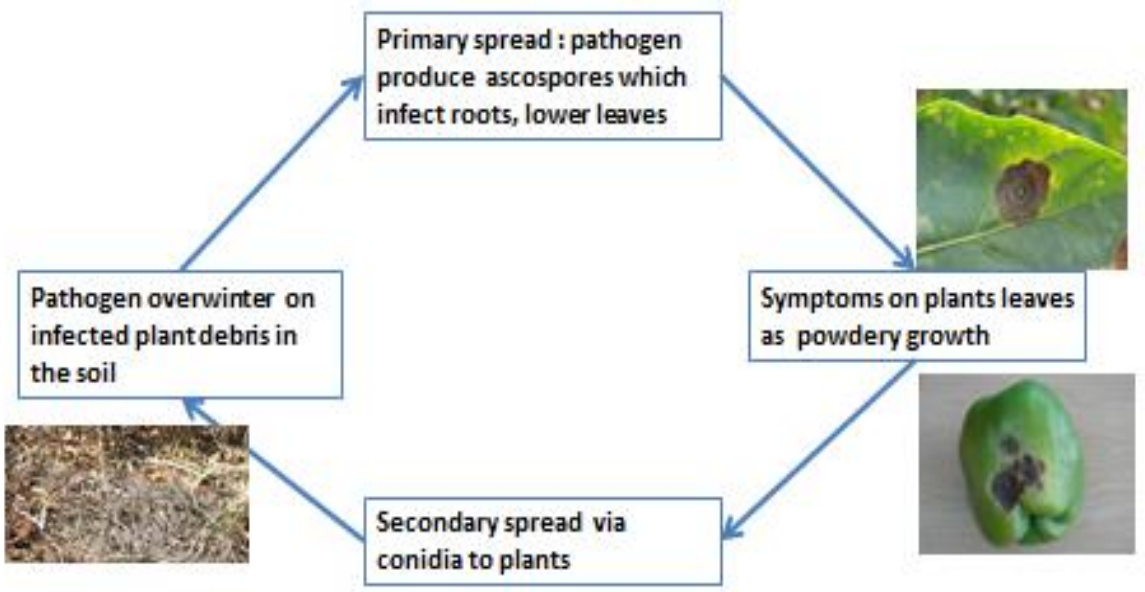

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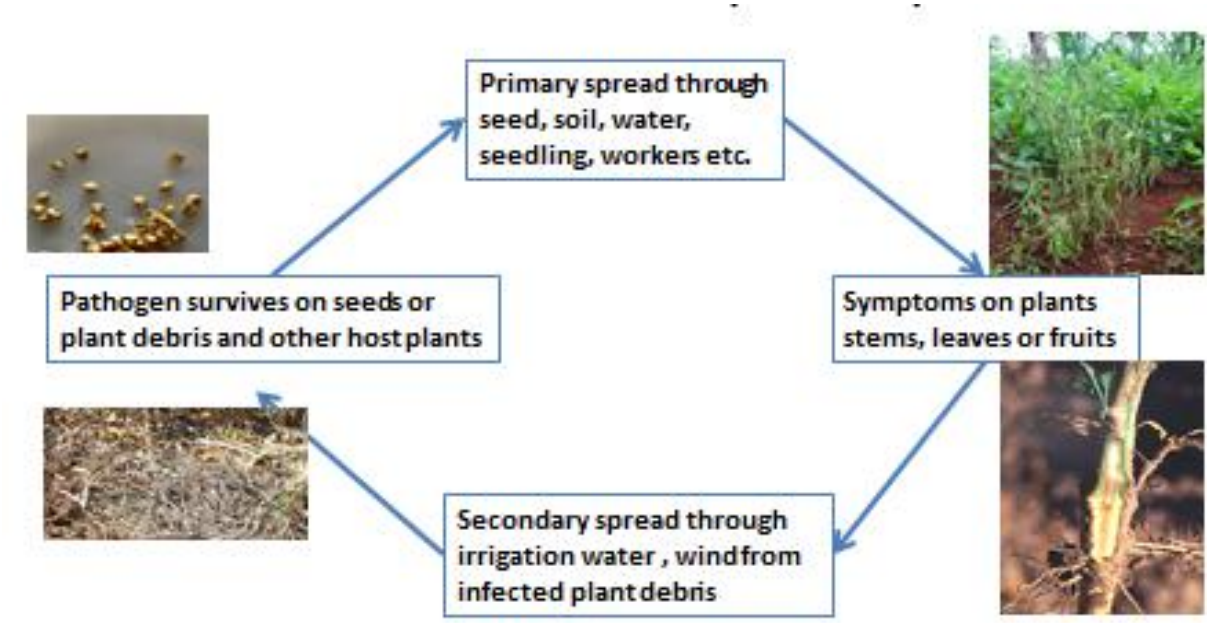


http://www.infonet-biovision.org/res/res/files/1658.400x400.jpeg
http://www.apsnet.org/publications/apsnetfeatures/Article%20Images/Chile_Fig09.jpg

X. Safety measures

A. At the time of harvest:

Chillies are picked by hand. The fruit is harvested by removing it from the branch and ensuring that the stem remains intact and attached to the fruit. Only fruit with the required color and size should be harvested. If possible, overripe soft fruit is removed from the plant and graded out to be used for other purposes. During harvesting, pickers should wear gloves to protect their hands because the oils (capsaicin) in the fruit can cause severe burns; pickers should take care not to touch their face or eyes. Harvested fruits can be placed directly into plastic field crates or into smaller plastic buckets, which are then transferred to crates at the side of the field. Cotton waist bags also can be used to collect the peppers and carry them to field crates. Mechanical harvesting is not advisable for chillies destined for the fresh market because the machinery may injure the fruit. However, mechanically harvested fruit can be used for processing.

B. Post-harvest storage

If cold storage facilities are available, peppers can be stored at 10 °C with 85-90% RH. The fruit can last for 2-3 weeks. Chillies can be damaged when stored below 10 °C; symptoms include surface pitting, water soaked areas, decay (especially *Alternaria*) and discoloration of the seed cavity. Symptoms can appear after a few days at 0°C or a few weeks at 5 °C. Sensitivity to cold varies with the cultivar; ripe fruit is less sensitive than green fruit. When stored above 13 °C, chillies is subject to accelerated ripening and bacterial soft rot infection. Because peppers are sensitive to ethylene, chillies should be stored away from ethylene-producing fruit such as bananas, avocados, melons, etc. and ripening rooms. Chillies in storage should be inspected periodically and decayed fruit culled. Where no cold storage facilities are available, fruit should be sorted, packed, and marketed within 24 hours of harvest. This is particularly important for varieties that exhibit short shelf life. Simple methods to maintain freshness and extend shelf life can be employed, such as modified atmosphere (MA) storage or packaging made from polymeric films, particularly commercially available products such as polyethylene and polypropylene bags.

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 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 1971	Colour of toxicity triangle	WHO classification of hazard	First Aid measures	Symptoms poisoning	Treatment of poisoning	Waiting period(days)
Organophosphate insecticides								
1	Dimethoate	Highly toxic		Class II Moderately hazardous		Mild-anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity	For extreme symptoms of OP poisoning, injection of atropine (2-4 mg for adults, 0.5-1.0 mg for children) is recommended. Repeated at 5-10 minute intervals until signs of atropinization occur.	
2	Phorate				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	Weakness, headache, tightness of chest, blurred vision, nonreactive pinpoint pupils, salivation, sweating, nausea, vomiting, diarrhea and abdominal cramps.	Give atropine intramuscularly or intravenously, depending on severity of poisoning, 2 to 4 milligrams (3 to 6 tablets, 1/100 grain each) every 10 minutes until fully	

					mouth to an unconscious Person.		atropinized as shown by dilated pupils, dry flushed skin and tachycardia. Twenty to thirty milligrams, or more, may be required during the first 24 hours. Never give opiates or phenothiazine tranquilizers	
Carbamate insecticides								
3	Carbofuran	Extremely toxic		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	
Synthetic pyrethroids								
4	Fenpropathrin				Do not induce	Salivation, weakness, ataxia,	Possible mucosal	7

					vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious person	tremors, convulsions, gastrointestinal irritation, nausea, vomiting and diarrhea.	damage may contraindicate the use of gastric lavage. Treatment is supportive and symptomatic. Diazepam has been recommended to reduce the central nervous system effects	
Neonicotinoids								
5	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 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.	
Avermectins								
6	Milbemectin				Do not		No specific	7

					induce vomiting unless told to do so by a poison control center or doctor. Do not give anything by mouth to an unconscious		antidote. Treatment is essentially symptomatic	
Insect growth regulators								
7	Novaluron				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	Causes substantial but temporary eye injury.	No specific antidote. Treatment is essentially symptomatic.	3
8	Buprofezin				Have person sip a glass of	Causes substantial but temporary eye	No specific antidote. Treatment is	5

					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	injury.	essentially symptomatic.	
Other classes insecticides								
9	Spinosad				Do not induce vomiting unless told to do so by a doctor. Have person sip a glass of water if able to swallow. Do not give anything by mouth to an unconscious person	May be harmful if swallowed	No specific antidote. Treatment is essentially symptomatic	3
10	Fipronil				Do not	In severe cases of	No specific	7

					induce vomiting unless told to do so by a doctor. Have person sip a glass of water if able to swallow. Do not give anything by mouth to an unconscious person	overexposure by oral ingestion, lethargy, muscle tremors, and in extreme cases, possibly convulsions, may occur	antidote. Treatment is essentially symptomatic	
11	Indoxacarb				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	Altered blood chemistry Abnormal decrease in number of red blood cells (anaemia) which could produce tiredness, rapid heartbeat, dizziness, pale skin, leg cramps, shortness of breath, Central nervous system effects	No specific antidote. Treatment is essentially symptomatic.	5
Fungicides								

12	Wettable sulphur	Slightly toxic		Unlikely to present acute hazard in normal use		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose,throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic	
13	Captan	Moderately toxic		Class III slightly hazardous		----------do----------	--do------	5
14	Mancozeb	Slightly toxic		Unlikely produce acute hazard		----------do----------	-------do--------	
15	Copper oxychloride	Moderately toxic		Class III slightly hazardous		------do----------	----------do----------	

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

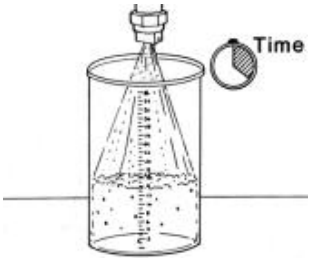
<table>
<tr><th></th><th></th><th>Equipment</th><th></th></tr>
<tr><td colspan="4">Category A: Stationary, crawling pest/ disease</td></tr>
<tr><td rowspan="2">Vegetative stage
i) for crawling and soil borne pests

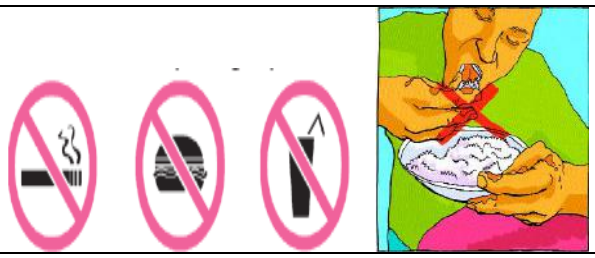
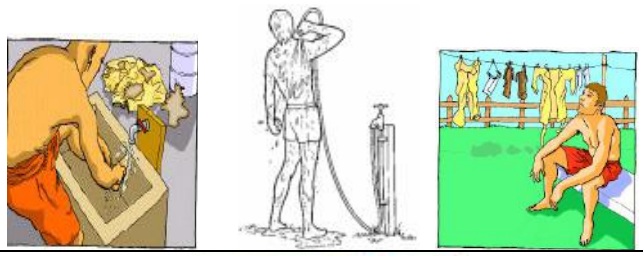
ii) for small sucking leaf borne pests</td><td rowspan="2">Insecticides and fungicides</td><td rowspan="2">• Lever operated knapsack sprayer (Droplets of big size)
• Hollow cone nozzle @ 35 to 40 psi
• Lever operating speed = 15 to 20 strokes/min
or
• Motorized knapsack sprayer or mist blower (Droplets of small size)
• Airblast nozzle
• Operating speed: 2/3rd throttle</td><td>  </td></tr>
<tr><td>  </td></tr>
<tr><td>Reproductive stage</td><td>Insecticides and fungicides</td><td>• Lever operated knapsack sprayer (Droplets of big size)
• Hollow cone nozzle @ 35 to 40 psi
• Lever operating speed = 15 to 20 strokes/min</td><td>  </td></tr>
<tr><td colspan="4">Category B: Field Flying pest/ airborne pest</td></tr>
</table>

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.	

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