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AESA BASED IPM Package

Mint

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Department of Agriculture, Cooperation and Farmers Welfare
Ministry of Agriculture and Farmers Welfare
Government of India

The AESA based IPM – Mint was compiled by the NIPHM working group under the Chairmanship of Smt. V. Usha Rani, IAS, Director General, NIPHM, and guidance of Shri. Utpal Kumar Singh, IAS, JS (PP). The package was developed taking into account the advice of experts listed below on various occasions before finalization.

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Contents

AESA BASED IPM PACKAGE FOR MINT

Mint - plant description:

Mint (*Mentha arvensis* L.) belongs to the family Lamiaceae is an aromatic, almost exclusively perennial and rarely annual herb. It has wide-spreading stolons with erect and square branched stem. Leaves are lanceolate-oblong, sharply toothed; petiole is small about 5 mmin length. The leaf lamina varies from 5 to 15 cm. The lower surface of the leaf is covered with dense hairy growth of glandular trichomes. Flowers are borne in axillary and terminal verticillaster, abundant in number, purplish in colour. The flowers are small with corolla measuring 4-5 mm, calyx 2-3 mm, narrowly deltoid and acuminate. It does not produce seed and propagation is through vegetative means only. The fruit is a nutlet, containing one to four seeds. The species that make up the genus *Mentha* are widely distributed and can be found best in wet environment and moist soils. Mint grows up to120 cm tall and can spread over an indeterminate area.


I. PESTS

A. Pests of National Significance

1. Insect and Mite pests

1.1. Cutworms: *Agrotis* spp., *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae)
1.2. Tobacco caterpillar: *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae)
1.3. Aphids (Peach aphid): *Myzus persicae* Sulzer (Hemiptera: Aphididae)
1.4. Mealy bug: *Planococcus citri* Risso (Hemiptera: Pseudococcidae)
1.5. Flea beetle: *Longitarsus ferrugineus* Foudras (Coleoptera: Chrysomelidae)
1.6. Hairy Caterpillar: *Spilosoma obliqua* Walker (Lepidoptera: Arctiidae)
1.7. Red Pumpkin Beetle: *Aulocophora foevicolli*s Lucas (Coleoptera: Chrysomelidae)
1.8. Leaf webber: *Syngamia abruptalis* Walker (Lepidoptera: Pyralidae)
1.9. Semilooper: *Thysanoplusia orichalcea* (Lepidoptera: Nocuidae)
2.0. Spider mites (Two-spotted spider mite): *Tetranychus urticae* C. L. Koch. *Peanonychus* spp. (Acari: Tetranychidae)

2. Diseases

2.1 Mint rust: *Puccinia menthae* Pers.
2.2 *Verticillium* wilt: *Verticillium dahliae* Kleb
2.3 Stem and stolon canker: *Rhizoctonia solani* Kühn
2.4 Powdery Mildew: *Erysiphe cichoracearum* DC.
2.5 Black Stem Rot: *Phoma strasseri* Moesz
2.6 Anthracnose: *Sphaceloma menthae* Jenk.
2.7 Septoria leaf spot: *Septoria menthae* Oudem.
2.9 Ramularia leaf spot: *Ramularia menthicola* Sacc.
2.10 Stolon decay: *Fusarium solani* (Mart.) Sacc
2.11 Leaf blight: *Cephalosporium* sp.

3. Weeds

Broad leaf

1. Pigweed: *Amaranthus viridis* Hook. F. Amaranthaceae
2. Swine cress: *Coronopus didymus* (L.) Sm. Brassicaceae
3. Black nightshade: *Solanum nigrum* L. Solanaceae
4. False amaranth: *Digera arvensis* Forssk. Amaranthaceae
5. Common purselane: *Portulaca oleracea* L. Portualacaceae
6. Carrot grass: *Parthenium hysterophorus* L. Asteraceae

Grasses

7. Rabbit/crow foot grass: *Dactyloctenium aegyptium* (L.) Willd Poaceae
8. Crab grass: *Digiteria sanguinalis* (L.) Scop. Poaceae
9. Goose grass: *Eleusine indica* (L.) Gaertner. Poaceae
10. Burmuda grass: *Cynodon dactylon* (L.) Pers. Poaceae

Sedges

11. Nutsedge: *Cyperus rotundus/ Cyperus iria/Cyperus difformis* L. Cyperaceae

4. Nematodes

4.1 Root lesion nematode: *Pratylenchus penetrans* Cobb Pratylenchidae
4.2 Pin nematodes: *Paratylenchus hamatus* Thorne & Allen, *P. microdorus* Andrassy, *P. macrophallus* (de Man) Goodey (Tylenchulidae)

II AGRO-ECOSYSTEM ANALYSIS (AESA) BASED INTEGRATED PEST MANAGEMENT (IPM)

A. AESA

The 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 requires 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 IPM:
Grow a healthy crop

- Select a variety resistant/tolerant to major pests.
- Select planting material
- Treat the planting material with recommended pesticides especially biopesticides.
- Follow proper spacing.
- Soil health improvement (mulching and green manuring wherever applicable).

- 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.

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

Farmers should

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

https://foodgardenkitchen.files.wordpress.com/2011/06/june26-017.jpg

Plant compensation ability

Compensation can be defined as the replacement of plant biomass lost to herbivores and has been associated with increased photosynthetic rates and mobilization of stored resources from source organs to sinks (e.g., from roots and remaining leaves to new leaves) during active vegetative growth period. Plant tolerance to herbivory can arise from the interaction of a variety of plant traits and external environmental factors. The ability of the plant to compensate for the reduced acquisition of resources by the production of new organs or by remobilization of reserves may also mitigate biotic stress effects.

Understand and conserve defenders

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

Insect zoo

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

Pest: Defender ratio (P: D ratio):

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

Model agro-ecosystem analysis chart

Date:
Village:
Farmer:

Decision taken based on the analysis of field situations

Soil conditions :
Weather conditions :
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.

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:
- Insect Pests: Observe and count pests at different places on the plantplant.
- Defenders (natural enemies): Observe and count parasitoids and predators.
- Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
- Weeds: Observe weeds in the field and their intensity.
- Water: Observe the water situation in 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

- Maintain records to analyse 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 are the problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.

Advantages of AESA over ETL

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

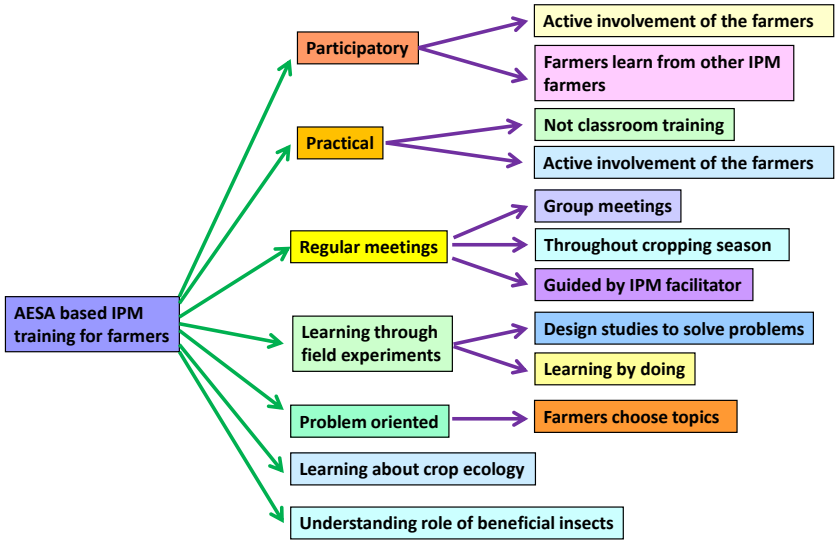
AESA and farmer field school (FFS)

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

Farmers can learn from AESA

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

FFS to teach AESA based IPM skills



B. Field scouting

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

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

For sucking pests:

Aphids and mites: Count and record the number of both nymphs and adults from leaves of five randomly selected plant; however, in later stages of crop growth, aphids should be counted on the top 10cm of terminal shoot per plant to be sampled.

For diseases:

Whenever scouting, be aware that symptoms of plant disease problems may be caused by any biotic factors such as fungal, bacterial, viral pathogens or abiotic factors such as weather, fertilizers, nutrient deficiencies, pesticides and abiotic soil problems. In many cases, the cause of the symptom is not obvious. Close examination, and laboratory culture and analysis are required for proper diagnosis of the causal agent of disease. Generally fungal diseases cause the obvious symptoms with irregular growth, pattern & colour (except viruses), however abiotic problems cause regular, uniform symptoms. Pathogen presence (signs) on the symptoms can also be observed like fungal growth, bacterial ooze etc. Specific and characteristic symptoms of the important plant diseases are given in description of diseases section.

Root sampling: Always check plants that appear unhealthy. If there are no obvious symptoms on plants, examine plants randomly and look for lesions or rots on roots and stems. Observe the signs of the causal organism (fungal growth, ooze). Always check plants that appear unhealthy. It is often necessary to wash the roots with water to examine them properly. If the roots are well developed, cut into them to examine the roots for internal infections (discolouration & signs). Count the total number of branched stem/damaged/infested/infected due to rot should be counted and incidence should be recorded.

Leaf sampling: Examine all leaves on each plant for lesions and determine the amount area of leaf infection. Leaf diseases cause most damage during the seedling and flowering stages of plant growth. Observe for the symptoms and signs on the infected plant parts. Count the number of leaves (leaf area diameter)/plant infected due to disease and incidence should be recorded.

Stem and flower sampling: Carefully examine the branched stems, flowers of plants for signs of fungal or bacterial diseases. The infected stem should be split or taken apart and examined for discoloration caused by fungi and bacteria. Count the number of branches, flowers infected due to disease and incidence should be recorded.

C. Surveillance through pheromone trap catches

Set up light traps @ 1 trap/acre for monitoring and mass collection of *Spodoptera litura* moths

D. Yellow pan water trap/sticky traps

Set up yellow pan water trap/sticky traps 15 cm above the canopy for monitoring aphids @ 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 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 extraction

Collect 100 to 300 cm^3 (200-300 g) representative 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. Ecological engineering for pest management is based on informed ecological knowledge rather than high technology approaches such as synthetic pesticides and genetically engineered crops (Gurr et al. 2004).

Ecological Engineering for Pest Management – Below Ground:

There is a growing realization that the soil borne, seed and seedling borne diseases can be managed with microbial interventions, besides choosing appropriate plant varieties. The following activities increase the beneficial microbial population and enhance soil fertility.

- Crop rotations with leguminous plants which enhance nitrogen content.
- Keep soils covered year-round with living vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance below ground biodiversity of beneficial microbes and insects.
- Application of balanced dose of nutrients using biofertilizers based on soil test report.
- Application of biofertilizers with special focus on mycorrhiza and plant growth promoting rhizobacteria.

Ecological Engineering for Pest Management – Above Ground:

Natural enemies play a very significant role in control of foliar insect pests. Natural enemy diversity contributes significantly to management of insect pests both below and above ground.

Natural enemies may require:

1. Food in the form of pollen and nectar.
2. Shelter, overwintering sites and moderate microclimate etc.
3. Alternate hosts when primary hosts are not present.

In order to attract natural enemies following activities should be practiced:

- Raise 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
- Grow flowering plants on the internal bunds inside the field
- Not to uproot weed plants those are growing naturally such as *Tridax procumbens, Ageratum* sp, *Alternanthera* sp etc. which act as nectar source for natural enemies,
- Not to apply broad spectrum chemical pesticides, when the P: D ratio is favourable. The plant compensation ability should also be considered before applying chemical pesticides.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Select and plant appropriate companion plants which could be trap crops and pest repellent crops. The trap crops and pest repellent crops will also recruit natural enemies as their flowers provide nectar and the plants provide suitable microclimate.

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

Plants suitable for Ecological Engineering for Pest Management

Attractant plants

Cowpea

Carrot

Sunflower

Buckwheat

French bean

Alfalfa

Mustard

Cosmos

Anise

Caraway

Dill

Parsley

White clover

Tansy

Yarrow

Marigold

Repellent plants

***Ocimum* sp**

Barrier plant

Rye grass

Border plants

Maize

Sorghum

Crop rotation plants

***Sesbania* sp.**

***Crotalaria* sp.**

***Gaillardia* sp.**

Castor

Desmodium

Potato

Trap plants

Tomato

Marigold

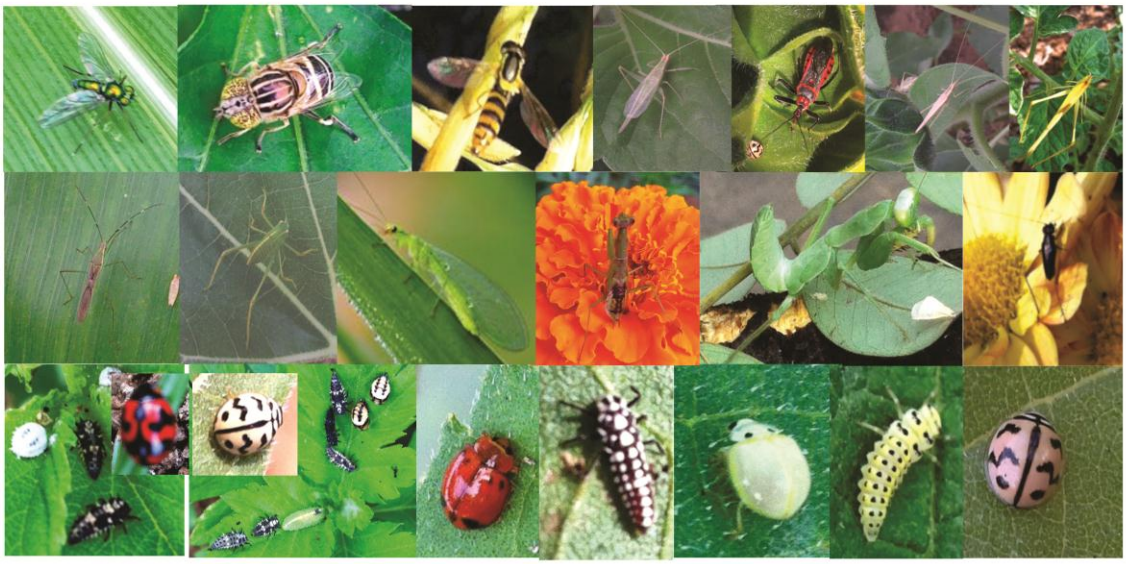
Pearl millet

The flowering plants suggested under Ecological Engineering for pest management strategy are known as attractant plants to the natural enemies of the selected pests. The information is based on published research literature. However, the actual selection of flowering plants could be based on availability, agro-climatic conditions and soil types.

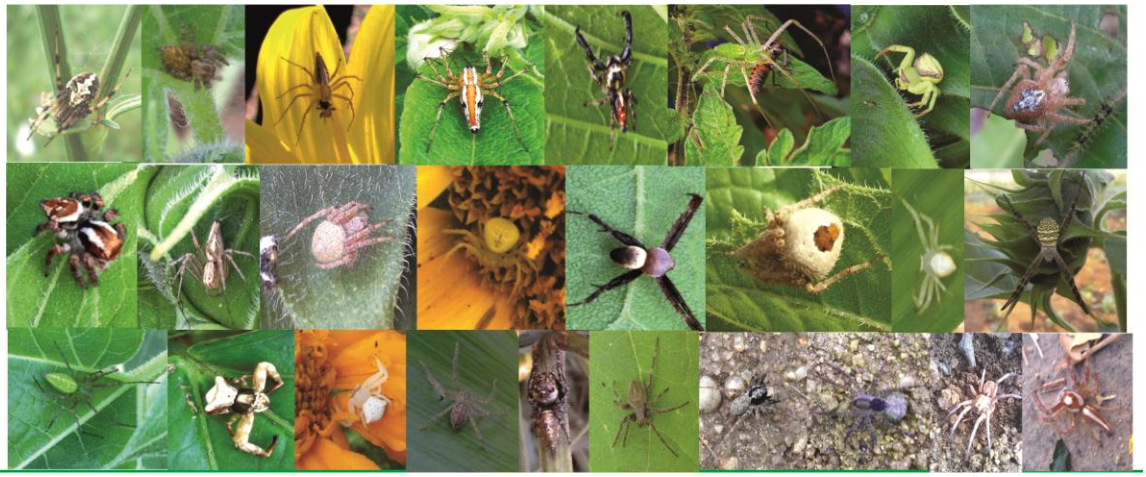
Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



IV Resistant/ tolerant Varieties:

Japanese mint: CIMAP-MAS-1 and CIMAP-Hybrid-77, Shivalik, EC- 41911, Gombi, Himalaya, Kalka, Kosi, Gomati, Damroo,Sambhav,and Saksham
Spearmint: CIMAP-MSS-1, CIMAP-MSS-5 and CIMAP-MSS-98, Punjab, spearmint-1, Ganga, Neerkalka
Bergamot mint: Kiran
Pepper mint: Kukrail, Pranjal, Tushar

For detail contact nearest KVKs, SAU, ICAR institutes

V. CROP STAGE - WISE IPM

Management	Activity
Pre-sowing*	
	Common cultural practices: • Timely planting should be done. • Field sanitation, rogueing
Nutrients	• Nutrients should be applied on the basis of soil test report and recommendation for particular agro climatic zone. • For production of stolons, select fertile soil with high organic matter content. • Apply farmyard manure @ 4 to 5 tons per acre in the last ploughing and incorporate in the soil 2 to 3 weeks before sowing.
Weeds	• Summer ploughing should be done before planting. • The rotation of mint crop with other crops should be followed. The best rotations are; • Mint: Rice, Mint: Potatoes and Mint: Vegetables : Peas etc. depending upon cropping system followed in the region.
Soil-borne pathogens, and resting stages of insects	• Deep summer ploughing is helpful for minimizing soil borne pathogen and resting stages of insect pests by exposing them to unfavorable environmental conditions and predation by predators. • Avoid water logging conditions.
Sowing / planting	
	Common cultural practices: • Use resistant varieties/disease free propagation material. • Practice field sanitation. • Timely sowing/planting.
Nutrients	• Apply fertilizers as per soil test recommendations
Weeds	• Adopt stale seed bed in which field is irrigated and allow the weed seeds to germinate. The field is ploughed immediately before sowing to destroy the germinated weeds.

Vegetative stage	
	Common cultural practices: • Keep the field clean and healthy • Remove and destroy alternate wild hosts and weeds • Removal of weeds and infected young leaves for the control of powdery mildew. **Common mechanical practices:** • Remove the affected plant parts. • Set up light trap@1trap/acre. • Collect and destroy egg mass and larvae. • Use yellow sticky traps @ 8-10/acre
Nutrients	• Apply 20 kg of nitrogen per acre as top dressing twice after each harvest at 30 and 60 days after planting. • Based on soil test report, micro nutrient deficiency should be corrected by foliar spray of particular nutrient.
Weeds	• The crop requires intensive weeding during initial stage of the crop. • Weeding with hand or mechanical hoes within the first six weeks of planting is required to control weeds at an interval of two to three weeks, after the first weeding. • Adopt integrated weed management approach.
Cutworm/Tobacco caterpillar	**Mechanical control:** • Installation of light traps. **Biological control:** • Conservation and augmentation of natural predators like coccinellids, *Chrysoperla*, spiders, dragonflies should be followed. • Augmentation of biocontrol agents like *Trichogramma brasiliensis, T. chilonis and T. pretiosum* should be carried out.
Aphids	**Cultural control:** • Sowing of border crops like maize, sorghum or millet to reduce pest population and encourage natural enemies **Biological control:** • Conservation and augmentation of predators such as syrphid fly, lacewing, ladybird beetle, praying mantis, minute pirate bug, damselfly, predatory thrips, and parasitoids, braconid wasp, *Aphidius* spp
Mealy bug	**Cultural control:** • Remove and destroy all the infested plant parts to prevent further spread of pests. • Deep summer ploughing to expose soil inhabiting or resting stage of insect pests.

	Biological control: • Conservation and augmentation of predators such as ladybird beetle, *Cryptolaemus montrouzieri,* chrysopids, different species of parasitic wasps and predatory mites should be adopted.
Flea beetle	**Cultural control:** • Remove the weeds • Follow crop rotation
Red pumpkin beetle	**Cultural control:** • Deep summer ploughing. • Follow crop rotation with non-host crops. • Destroy the weeds growing in the field. **Biological control:** • Conservation and augmentation of predators such as assassin bug (*Rhynocoris fuscipes*) and parasitoids like *Gregarina crenata* should be followed.
Hairy caterpillar	**Mechanical control** • Collection and destruction of egg masses, skeletonized leaves along with first and second instar gregarious larvae. **Biological control:** • Conserve parasitoid such as *Meteorus arctiicida*
Two spotted mite	**Cultural control:** • Observe the plants weekly for signs of mite damage, which first appears as flecks and stipples on the leaves. Collect leaf samples and examine the lower surface for all stages of mites. **Biological control** • Conserve predatory mites like *Amblyseius, Metaseiulus*, and *Phytoseiulus*; the minute pirate bugs, *Orius*, *Leptothrips*; *Chrysopa, Cheilomenes sexmaculatus,* and *Stethorus*.
Mint rust	**Mechanical control:** • In an infected bed, try to locate any uninfected stems and carefully dig these out and move to another location in an attempt to start a new, healthy nursery.
***Verticillium* wilt**	**Cultural control:** • Applying optimal rates of nitrogen and enhanced dose of potash reduces the severity of *Verticillium* wilt. • Limiting the amount of water applied to the field can reduce severity of the disease • Follow crop rotation.

	Biological control: • Use bioagents like *Trichoderma* sp. as per CIBRC recommendations.
Powdery mildew	**Cultural control:** • Maintain proper row spacing • Use resistant or tolerant varieties. • Improve air circulation by thinningto reduce the disease severity.
Black Stem Rot	**Cultural control:** • Use certified planting material to reduce the introduction and spread of black stem rot. • Avoid transportation of contaminated planting materials
Stem and stolon canker	Follow the common cultural, mechanical and biological practices
Septoria leaf spot	**Cultural control:** • Use clean and certified planting materials
Ramularia leaf spot	Follow the common cultural, mechanical and biological practices
Leaf blight	Follow the common cultural, mechanical and biological practices
Anthracnose	**Cultural control:** • Use resistant plants or healthy plant materials.

VI. INSECTICIDE RESISTANCE AND ITS MANAGEMENT

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

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

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

1) **Monitor pests:** Monitor insect population development in fields to determine if and when control measures are warranted. Monitor and consider natural enemies when making control decisions. After treatment, continue monitoring to assess pest populations and their control.

2) **Focus on AESA.** Insecticides should be used only as a last resort when all other non-chemical management options are exhausted and P: D ratio is above 2: 1. Apply biopesticides/chemical insecticides judiciously after observing unfavourable P: D ratio and when the pests are in most vulnerable life stage. Use application rates and intervals as per label claim.

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

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

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

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

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

VII. COMMON WEEDS

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

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

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

4. False amaranth : *Digera arvensis* Forsk. (Amaranthaceae)

5. Common purselane:*Portulaca oleracea* L.(Portualacaceae)

6. Carrot grass: *Parthenium hysterophorus* L.(Asteraceae)

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

8. Goose grass *Eleusine indica* (L.) Gaertner (Poaceae)

9. Crab grass:*Digiteria sanguinalis* (L.) Scop.(Poaceae)

10. Burmuda grass: *Cynodon dactylon* (L.) Pers. (Poaceae)

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

12. *Cyperus iria* L. Cyperaceae

13. *Cyperus difformis* L. Cyperaceae

http://agritech.tnau.ac.in/horticulture/horti_spice%20crops
http://customers.hbci.com/~wenonah/min-def/plate154.jpg
http://nhb.gov.in/Horticulture%20Crops%5CMint%5CMint1.htm
Naidu, V.S.G.R. 2012, *Hand Book on Weed Identification.* Directorate of Weed Science Research, Jabalpur, India Pp 354
http://agropedia.iitk.ac.in/content/production-technology-package

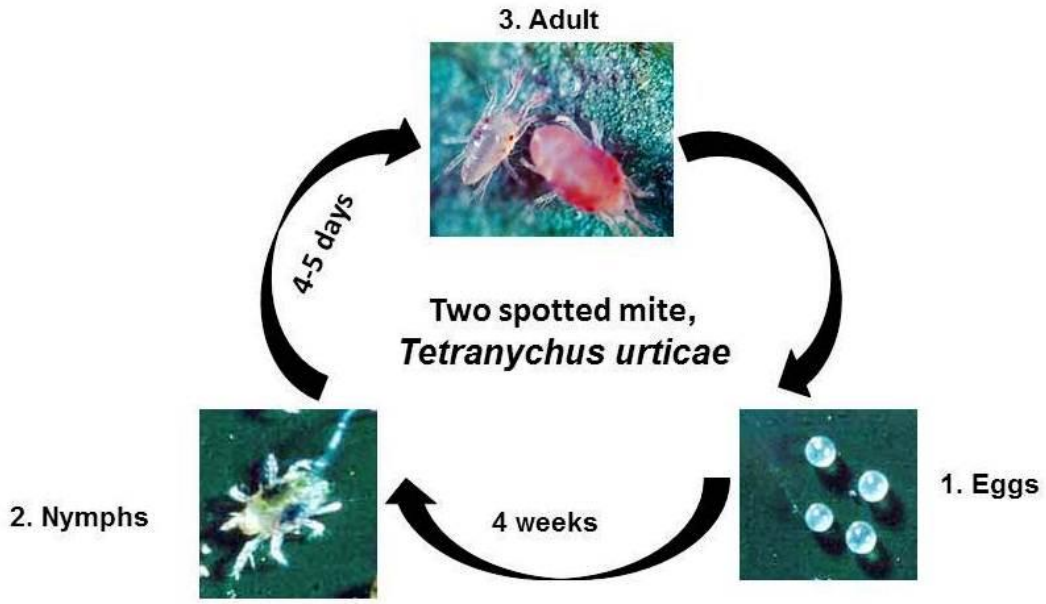
VIII. DESCRIPTION OF INSECT, MITE AND NEMATODE PESTS

1.Two spotted spider mite

Biology:

Each female lays 10-20 eggs per day, 80-120 altogether during its lifetime of up to 4 weeks. They are mostly attached to the silk webbing. The six-legged larvae hatch after 3-15 days. They molt three times within 4-5 days, towards protonymph, then deutonymph and at last adult. These instars all have eight legs. Before each molt there is a short quiescent stage. At favorable conditions the life cycle can be completed in about 1-2 weeks, including a pre oviposition period of 1-2 days. Often a change towards hot and dry weather leads to a very rapid increase of population density.

Life cycle:



http://www.aces.edu/~azm0024/extension/images/twospotspmite_adult1.jpg
http://www.cropscience.bayer.com/~/media/Bayer%20CropScience/Global-Portal/Compendium/Pests/Tetranychus-urticae/tetranychus_urticae3b_600-jpg.ashx?w=600&bc=ffffff&as=true

Damage symptoms:

- Stippling on leaves
- Webbing and defoliation

Stippling on leaves

Webbing and defoliation

http://www.omafra.gov.on.ca/english/crops/pub360/notes/rasptssm.htm

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

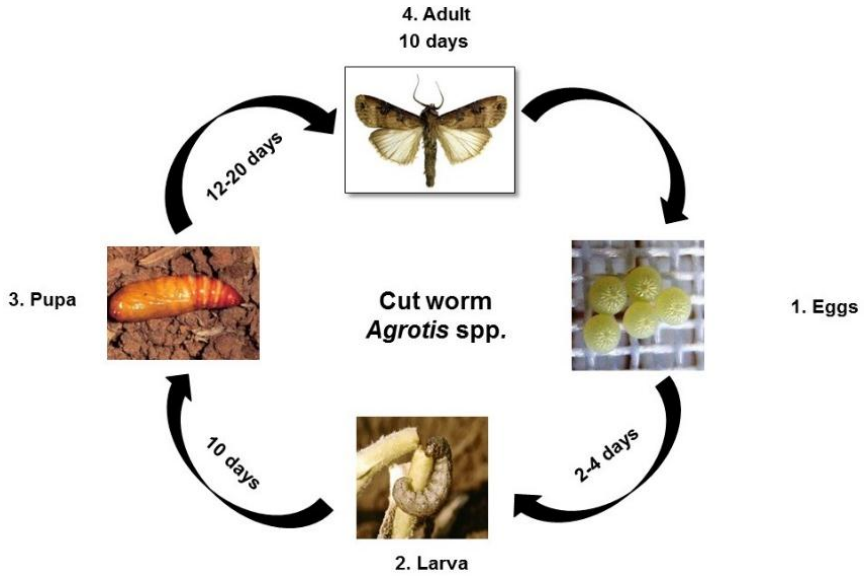
2.Cut worm:

Biology:

Egg: Females lay about 500 eggs under surface of leaves over a period of 2- to 3 weeks.
Larvae: They feed for 3 to 4 weeks, and are fully grown to 1½ to 2 ” long. Cutworm larvae have 6 growth stages, or instars. The final instar lasts about 10 days.
Pupae: Some species overwinter as pupa in the soil, while some continue to develop through winter. Duration of the pupal stage is normally 12 to 20 days.

Adults: The adult pre oviposition period is about seven to 10 days. Adult period varies around 10-20 days.

Life cycle:



https://c1.staticflickr.com/5/4063/4383708066_bfb2da9fb2.jpg
http://bugwoodcloud.org/images/768x512/1402110.jpg
http://www.infonet-biovision.org/res/res/files/308.300x200.jpeg
http://www.agroatlas.ru/content/pests/Agrotis_ipsilon/Agrotis_ipsilon.jpg

Damage symptoms:

- The larvae feed on all portions of the plant, but are usually found under the canopy rather than on the top of the plants. It is not uncommon, however, to find larvae feeding on the terminal buds.
- The mature variegated cutworm larva is about 2 inches and varies from pale gray to dull brown.

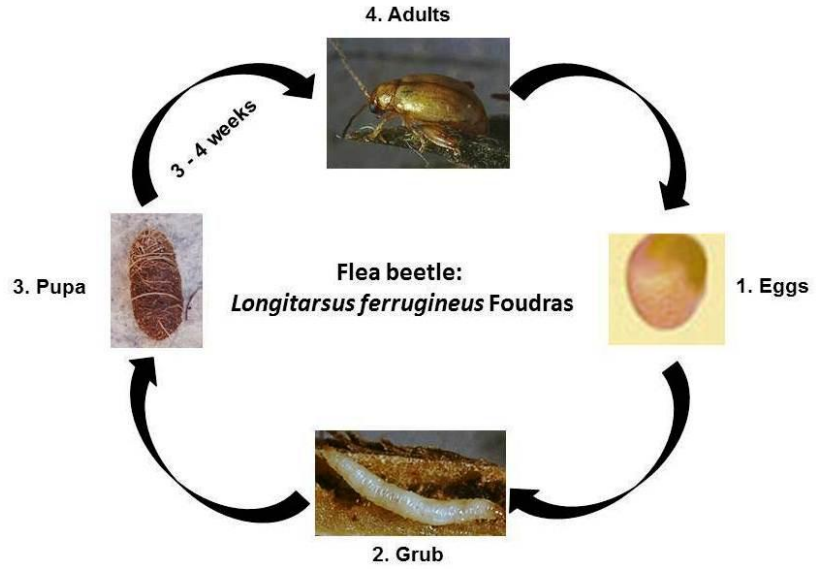
*For management refer to page number----------

3.Flea beetle:

Biology:

- Flea beetle larvae are very small, slender and worm-like.
- A full-grown larva is only about 1/4 inch long when mature.
- Larvae are white, with a shiny, pale-brown head and three pairs of legs.
- Adults are small, about 1/8 inch long, elongate-oval beetles, with brownish-yellow bodies, darker elytra, some with reddish-brown heads.
- Flea beetles overwinter as eggs in the soil near the crown of mint plants.
- Eggs hatch early April through early May.
- Larval development is completed during late May and early June. Pupation is in the soil near the rhizomes
- The pupal stage is completed in about 3 to 4 weeks

Life cycle:



http://mint.ippc.orst.edu/images/mfleabla.JPG
http://mint.ippc.orst.edu/images/mintfleabad.JPG
http://upload.wikimedia.org/wikipedia/commons/1/17/Rhynchophorus_ferrugineus_pupal_cases_and_adults.JPG

Damage symptoms:

- After hatching, the young larvae feed first on the fine hair roots and then tunnel into stolons rhizomes and underground parts of the stem, where they continue to feed, for about 4 to 5 weeks

Damage symptom

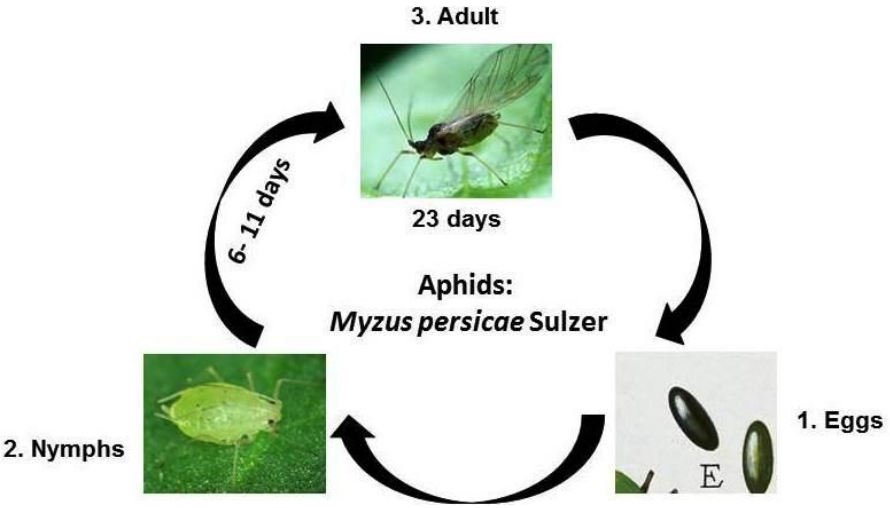
*For management refer to page number----------

4. Aphids:

Biology:

Eggs: In temperate regions, these aphids overwinter during the egg stage.
Nymphs: Immature aphids are called nymphs. They are pale yellowish-green in color with three dark lines on the back of the abdomen that are not present on the adult. Nymphal development is completed in 6 to 11 days
Adults: The wingless adult aphids vary in color from green to pale yellow. Winged adults are green with black or dark brown markings on their abdomens. Adults are small to medium sized aphids from 1/25 to 1/12 inch long and their antennae are 2/3 as long as the body. Adult females give birth to approximately 50 nymphs.

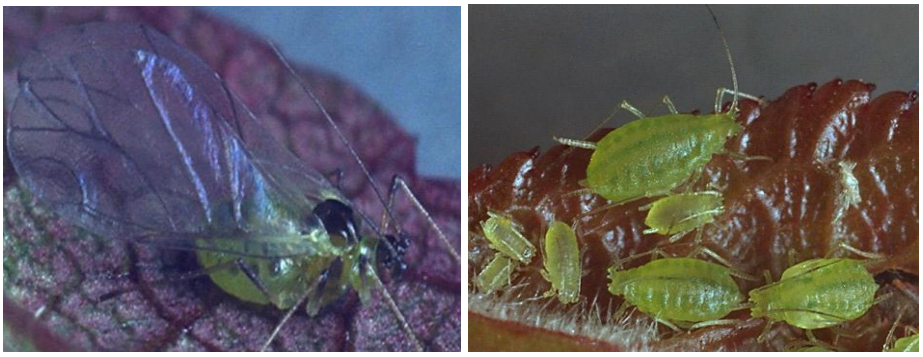
Life cycle:



http://www.cabi.org/portfolio/compendia/normal/35642_01.img
http://media.eol.org/content/2012/09/07/23/84782_orig.jpg
http://upload.wikimedia.org/wikipedia/commons/c/cb/Snodgrass_Aphis_pomi.jpg

Damage symptoms:

- Aphids are sucking insects those feed by thrusting a long beak into the plant tissue.
- They withdraw great quantities of sap, some of which they execrete as "honeydew".
- The honeydew makes the plant sticky. When plantplants are heavily infested with aphids, sidewalks, lawn furniture, and automobiles may become wet with honeydew.
- A sooty mold often develops with the honeydew blackening stems and foliage.



Damage symptom

http://mint.ippc.orst.edu/images/mintaphid2.JPG
http://mint.ippc.orst.edu/images/mintaphid.JPG

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

5.Red pumpkin beetles:

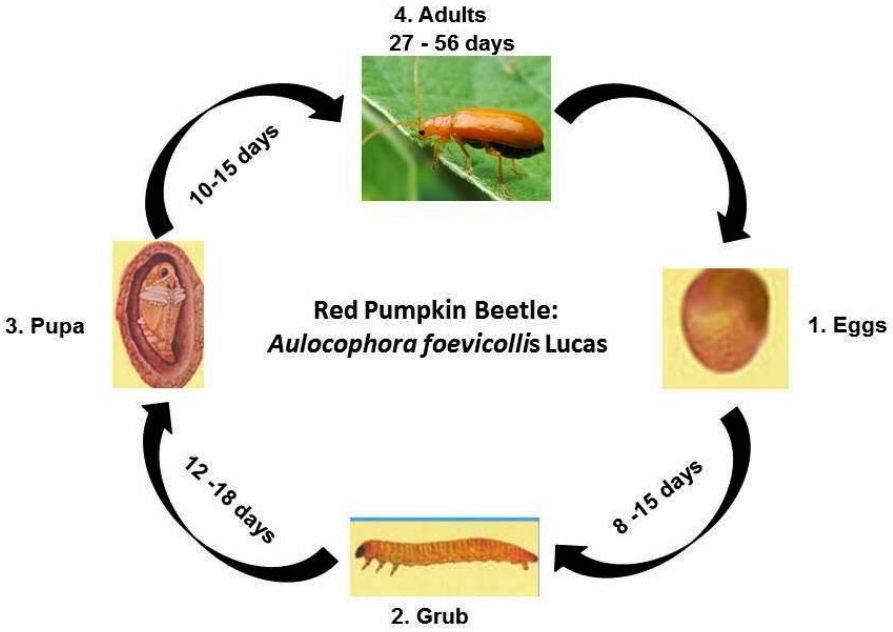
Biology:

Egg: Brownish elongate eggs are laid in the soil and each female may lay about 150 to 300 eggs singly or in groups of 8-9 near the base of plants. Egg period is 8-15 days.

Grub: Grubs are creamy white with darker oval shield at back. Grub period is 12-18 days.

Pupa: Pupation takes place in an earthen cocoon. Pupal period is 10-15 days.
Adult: *Raphidopalpa foveicollis* has reddish brown elytra; *A. intermedia* has blue black elytra; and *A. cincta* has grey elytra with black border.
Total life cycle takes 27-56 days. There are 5 to 8 generations/year.

Life cycle:



http://www.natureloveyou.sg/Plant%20Story/Plant%20Story%20-%20Beetles/DSC08152%20(11).jpg
http://www.iaszoology.com/wp-content/uploads/image/insect/Raphidopalpa.jpg

Damage symptoms:

- The pest feeds on the growing leaves and buds.
- They bite holes on leaves.
- Grubs after hatching, feed on roots of plants below soil surface.

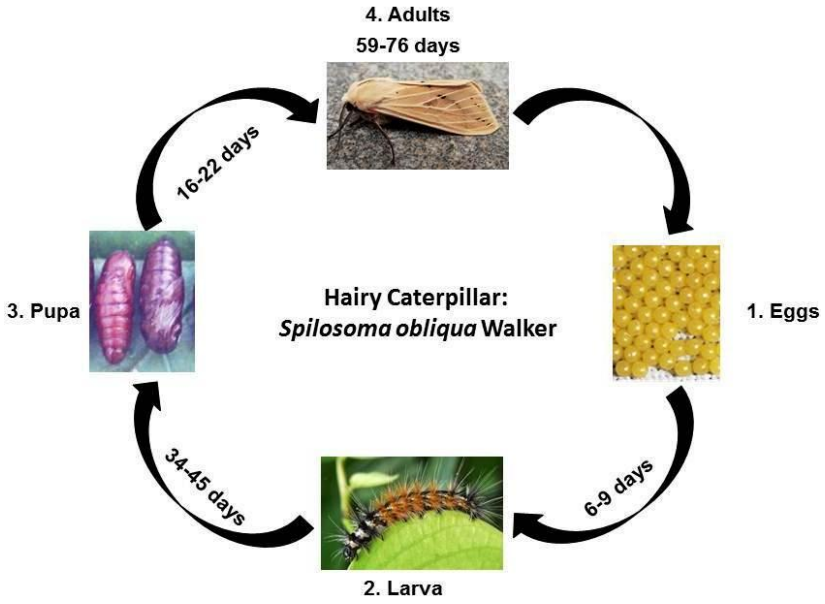
*For management refer to page number----------

6.Hairy caterpillar:

Biology:

- **Eggs**: Laid in clusters of 50-100 on the lower side of leaves
- **Larva**: Orange coloured with broad transverse band with tufts of yellow hairs that are dark at both ends
- **Pupa:** Forms a thin silken cocoon by interwoven shed hairs of the larvae.
- **Adult**: Crimson coloured moth with black dots and a red abdomen. Pinkish wings with numerous black spots

Life cycle:



http://farm5.static.flickr.com/4101/4944515979_e35e137306_m.jpg

Damage symptoms:

- Young larvae feed gregariously mostly on the under surface of the leaves
- Feed on leaves and cause defoliation
- In severe cases only stems are left behind

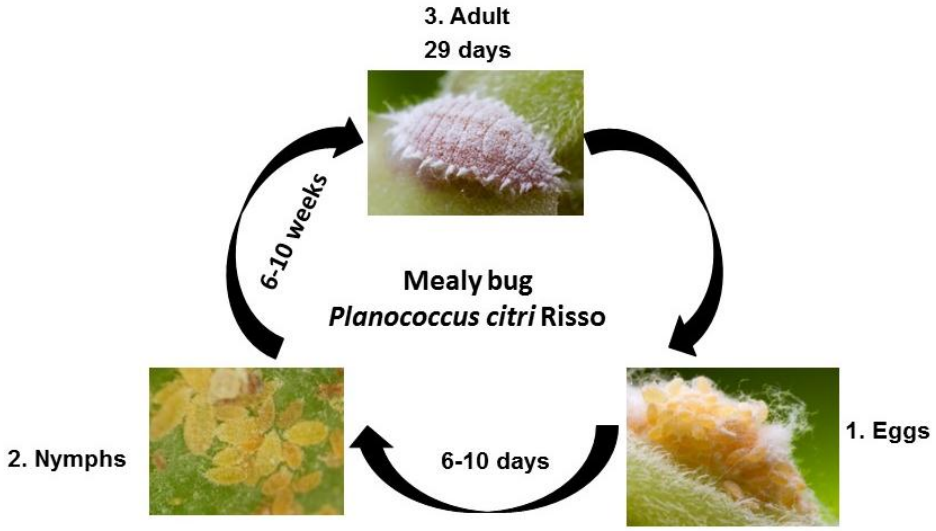
*For management refer to page number----------

7.Mealy bug

Biology:

- **Eggs:** Eggs are deposited as white cottony masses called ovisacs. The glossy, light yellow eggs are oval and approximately 0.3 mm long. A female lay 300 to 600 eggs in a life period, which are deposited in groups of 5 to 20.
- **Nymphs:** Nymphs emerge from the ovisacs and typically settle along midribs and veins on the underside of leaves and young twigs. Wax and honeydew secreted by crawlers are visible indicators of infestations. The nymphs are yellow, oval-shaped with red eyes, and covered with white waxy particles The female nymphs resemble the adult female in appearance, while male nymphs are more elongated. Female nymphs have four instars.
- **Adult**: Adult size ranges in length from 3 mm (females) to 4.5 mm (males). The females are wingless, white to light brown in color, with brown legs and antennae. The body of adult females is coated with white wax and bears a characteristic faint gray stripe along their dorsal side. Short waxy filaments can be seen around the margins of their oval body with a slightly longer pair of filaments present at the rear end of their body.

Life cycle:



http://www.alexanderwild.com/keyword/planococcus%20citri/
http://cals.arizona.edu/crops/citrus/photos/figure21.jpg

Damage symptoms:

- The bugs feed by sucking on the plant juices of new tender leaves, the leaves wither and yellow.
- They secrete a sticky substance called honeydew which attracts ants and reduce plant respiration.

Damage symptom

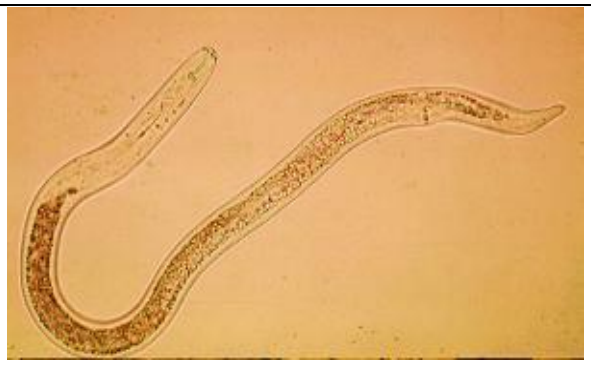
http://heavypetal.ca/wp-content/uploads/2008/09/mealybug.jpg
http://bugwoodcloud.org/images/768x512/5383599.jpg

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

8. Root-lesion Nematode:

Biology:

- Root-lesion nematodes are migratory endoparasites.
- Females lay about 1 to 2 eggs/day for about 35 days, with a maximum of 68 eggs laid by one female.
- Eggs are laid singly or in clusters in both soil and roots.
- Males are required for reproduction by *P. penetrans*
- Root-lesion nematodes prefer to invade roots 3 to 13 mm behind the root tip with some preference for the dense root-hair zone.



Damage symptoms:

- Young feeder roots are generally selected, with a reduction in attack as tissues age.
- Feeding by *P. penetrans* produces lesions on roots, which initially appear as water soaked areas at the root surface.
- These sites later become yellow, and eventually develop dark brown centers. Discreet brown lesions of necrosis usually appear in two to four weeks.
- Field symptoms of damage generally occur as circular to irregular patches, perhaps 30-150 feet in diameter that have thin stand and stunted plants.
- Mint often has a reddish color. Presence of root-lesion nematodes can be detected by looking for reddish-brown lesions on roots of groundsel.

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

Natural Enemies of Mint Insect Pests

Egg parasitoids

1. *Trichogramma pretiosum*

Larval/ nymphal and adult parasitoids

2. *Ceranisus menes*

3. Parasitic Wasps

4. Braconid wasp

1. http://www.nbair.res.in/Biocontrol_Agents/images/Tpretios1.jpg
2. http://www.cabi.org/portfolio/compendia/normal/cera_men.img
3. http://www.fargro.co.uk/products/biologicalControl/images/aphidius.png
4. http://nathistoc.bio.uci.edu/hymenopt/Braconid2.htm

Predators

1. Ladybird beetle

2. *Cryptolaemus montrouzieri*

3. Minute pirate bug

4. *Rhynocoris fuscipes*

5. Spider

6. Predatory thrips

7. *Phytoseiulus persimilis*

8. Predatory mites

9. Praying mantis

10. Syrphid fly

11. Damsel fly

12. Dragon fly

13. Lacewing

1. http://llladybug.blogspot.in/
2. http://www.naturalinsectcontrol.com/productimageszoom/000000034.jpg
3. http://www.phytoma.com/uploads/phytogallery/13382787794fc4837b04ead.jpg
4. http://www.malaeng.com/blog/tmp/2010/08/rhinocoris-fuscipes2.jpg
5. http://en.wikipedia.org/wiki/Wolf_spider
6. http://biocontrol.ucr.edu/hoddle/persea_mite.html
7.http://www.evergreengrowers.com/media/catalog/product/cache/1/thumbnail/9df78eab33525d08d6e5fb8d27136e95/p/h/phytoseiulus persimilis 1.jpg
8. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
9. http://spirit-animals.com/praying-mantis/
10. http://www.lloydspitalnikphotos.com/d/2465-3/syrphid_fly_MG_9774-01.jpg
11.http://upload.wikimedia.org/wikipedia/commons/6/67/Ceriagrion_coromandelianum,_Burdwan,_West_Bengal,_India_23_09_2012_(1).JPG
12. http://en.wikipedia.org/wiki/Dragonfly
13. http://www.macro-world.cz/image.php?id_foto=514&gal=29

IX. DESCRIPTION OF DISEASES

1. Mint rust:
Disease symptoms: • Pale and distorted shoots in spring • Dusty orange pustules on the stems and leaves. • Pustule may change to dusty yellow or black in colour in later stage • Large areas of leaf tissue die and plants may lose leaves


Disease symptom

http://www.aphotofungi.com/images/basidiomycota_rusts_smuts/rust_puccinia_menthae_18-07-13_1.jpg
http://visualsunlimited.photoshelter.com/img/pixel.gif

Survival and spread:

- When the orange spore pustules mature and break open in June or July, the spores are spread to other plants by the wind.
- The fungus enters the plant through the leaves lNewly infected plants seldom show symptoms until the following spring.

Favorable conditions:

- Dry weather with high relative humidity
- Pathogens overwinter on mint stubble & on wild mint.
- It spreads through propagation material and air

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

2. Verticillium wilt

Disease symptoms:

- Symptoms first appear in the foliage at the top of the plant.
- Symptomatic upper leaves are sickle-shaped and initially chlorotic or red, soon becoming necrotic.
- Premature defoliation and death of the plant can result.
- Vascular discoloration in stems and roots may be observed and diseased plants are often stunted.


Disease symptoms

http://www.apsnet.org/edcenter/intropp/lessons/fungi/ascomycetes/Article%20Images/VerticilliumWilt03.jpg
http://www.apsnet.org/edcenter/intropp/lessons/fungi/ascomycetes/Article%20Images/VerticilliumWilt04.jpg

Survival and spread:

- The transport of infected planting materials can transmit the pathogen to long distances.
- Spread of the pathogen occurs primarily by soil and movement of soil and water.

Favourable conditions:

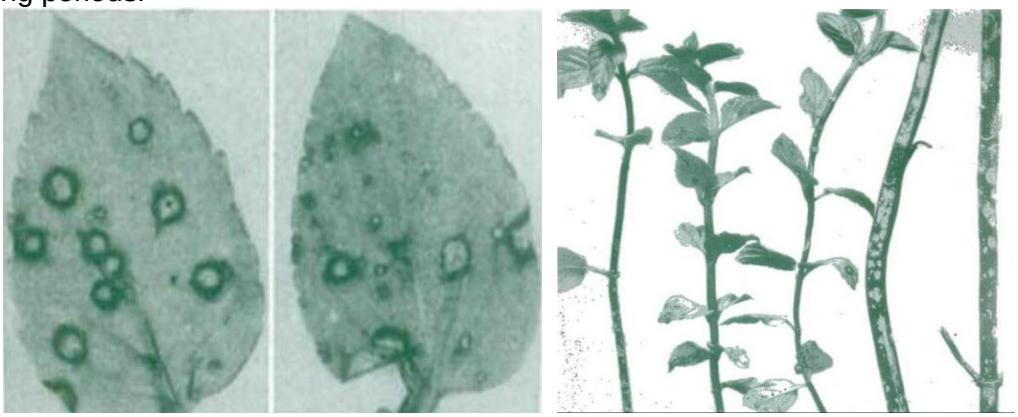
- Verticillium wilt is favored by moist soils and a temperature range of 21-27° C.
- Micro-sclerotia are stimulated to germinate by root exudates of host plants

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

3. Anthracnose:

Disease symptoms:

- Mint anthracnose, also known as "leopard spot".
- The fungus causes small, sunken brown spots to appear on the lower leaves and stems. These spots enlarge to form oval lesions with light gray centers and reddish-brown borders, and may unite.
- Mint anthracnose may cause defoliation and cankers, which may lead to splitting of the stem.
- Heavily-infected plants are weakened and oil yields are reduced.
- Anthracnose may become severe during wet seasons when the mint foliage is wet for long periods.



Disease symptom

https://books.google.co.in/a?id=P2mxJzPZXxIC&pg=PA13&lpg=PA13&dq=mint+Stem+and+stolon+canker&source=bl&ots=g5g6fIAzuK&sig=RHai6JVajadmXU_Ul3UJ719-EqY&hl=en&sa=X&ei=F8eHVMfMEcGzmwW0hIC4Cg&ved=0CDAQ6AEwAw#v=onepage&q&f=true

Survival and spread:

- Conidia are rain-splashed from overwintering infected plant in the spring and throughout the summer to new growth.

Favourable conditions:

- Infection requires three to twelve hours of wetness.

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

4. Powdery mildew

Disease symptoms:

- Powdery white patches are developed on the upper and lower surfaces of the leaves and stems.
- Under favourable conditions, the disease causes severe lossess. It also reduces the oil

content up to 50%.


Disease symtom

http://visualsunlimited.photoshelter.com/img/pixel.gif
http://www.omafra.gov.on.ca/CropOp/images/crop_images/herbs/culinary/mint/mintf7_zoom.jpg

Survival and spread:

- Resting spores is responsible for primary spread and airborne spores for secondary spread.

Favourable conditions:

- Disease becomes severe when weather is dry and air circulation is poor (warm and humid weather)

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

5. Black Stem Rot:

Disease symptoms:

- Black stem rot is considered a moderate to serious problem in mint production.
- The fungus is most active during periods of cool and wet weather.
- Symptoms of infection include dark brown or black cankers on stems.
- Cankers may girdle the stem and cause plant parts above the infection to wilt and die.


Disease symptom

http://www.oardc.ohio-state.edu/fruitpathology/organic/strawberry/images/strawb54.jpg
http://pnwhandbooks.org/plantdisease/sites/default/files/images/069.jpg

Survival and spread:

- Pathogen survive in soil and on plant tissue for many years by producing small (1 to 3-mm diameter), irregular-shaped, brown to black sclerotia.

Favourable conditions:

- Disease become more severe in soils that are moderately wet and a temperature range

of 15-25°C

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

6.Stem and stolon canker:

Disease symptoms:

- Roots and stolon have brown or black progressively rotting areas. Plant stand may be greatly reduced.

Survival and spread:

- Pathogen survive on crop debris and in soil as black to brownish resting structures (sclerotia) or as resting fungal mycelium.

Favourable conditions:

- Warm soil with high humidity is favorable for disease development.
- Temperatures between 26-32°C, soil moisture between 30-60% and soil pH above 6.6 are conducive for disease development.

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

7. Septoria leaf spot:

Disease symptom:

- Septoria leaf spots are dark brown/black, up to 3mm (⅛in) diameter and angular in shape (being constricted between leaf veins).
- Spores are sometimes visible within leaf spots on the underside of the leaf.

Survival and spread:

- The fungus survive in plant debris and on weeds .

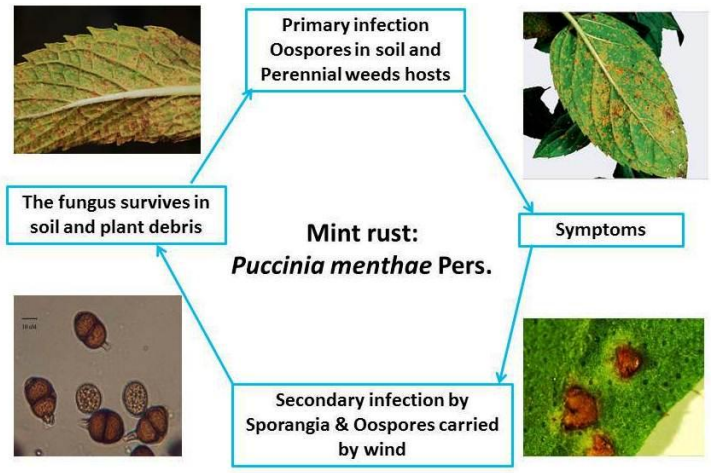
Favourable conditions:

- Moist (more than 70% relative humidity) coupled with warm weather and intermittent rains favours disease development.

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

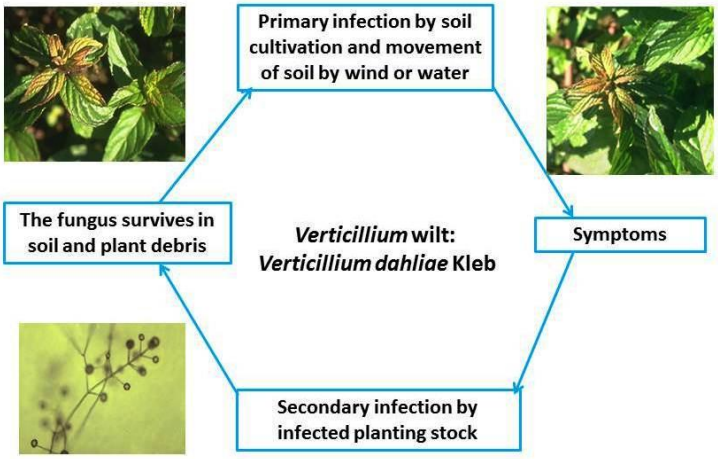
Disease cycles:

1. Mint rust:



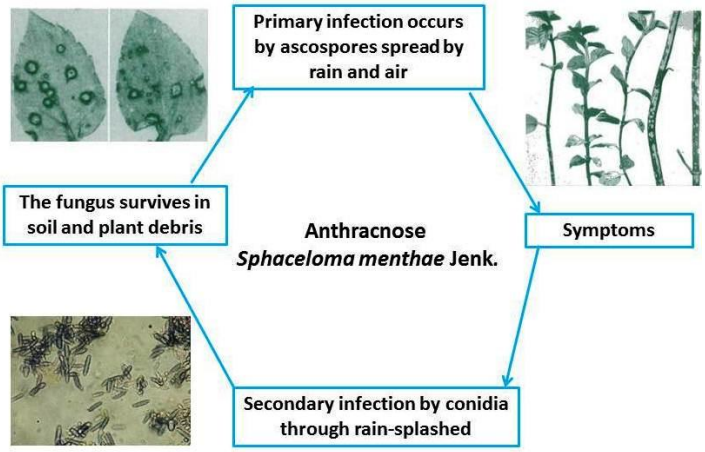
http://upload.wikimedia.org/wikipedia/commons/9/99/Puccinia_menthae_Pers._2174041.jpg
http://upload.wikimedia.org/wikipedia/commons/d/de/Puccinia_menthae_Pers._5479873.jpg

2. *Verticillium* wilt:



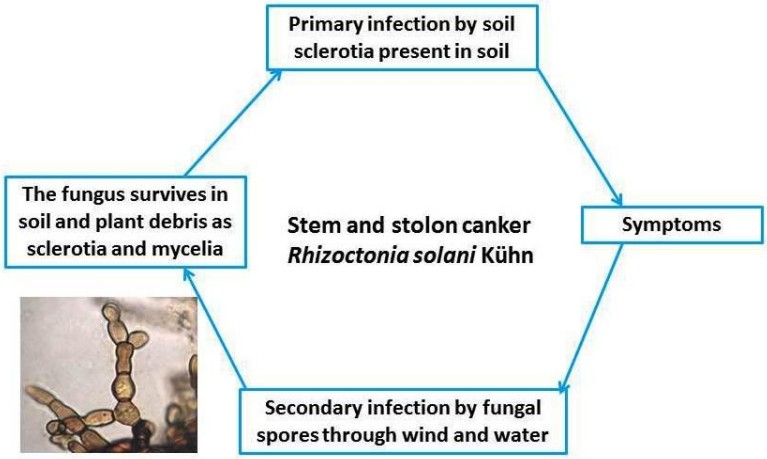
http://www.cals.ncsu.edu/course/pp728/Verticillium/verticillium_conidia_conidiophore.jpg

3. Anthracnose:.



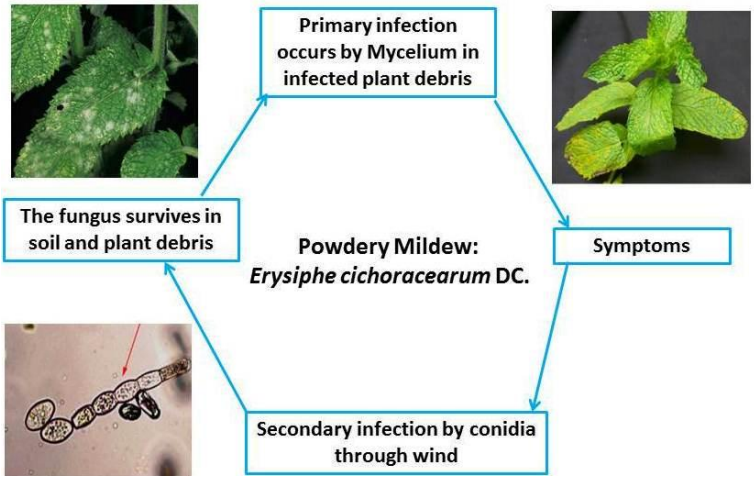
http://www.plantmanagementnetwork.org/pub/php/review/xmasflower/images/poinsettia16.jpg

4. Stem and stolon canker:



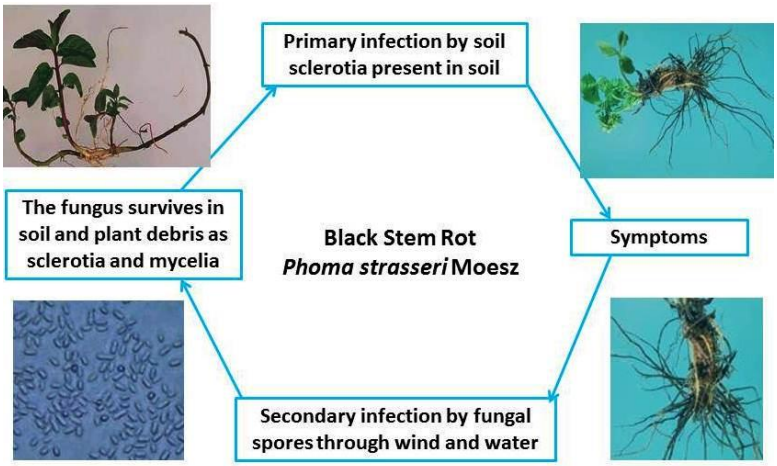
http://www.apsnet.org/edcenter/intropp/lessons/fungi/Basidiomycetes/Article%20Images/Rhizoctonia21.jpg

5. Powdery Mildew:



http://www.plante-doktor.dk/Sphaerotheca%20fuliginea2.jpg

6. Black Stem Rot:



http://bugwoodcloud.org/images/768x512/5369018.jpg

X. SAFETY MEASURES

Storage of Herbage

Mint herbage should be shade dried for about a day before it is distilled. Care should be taken so that decomposition of the herbage does not initiate during the drying process. There would be some reduction in oil yield if wilted herbage crop is stored for a longer period of 2-3 days. As such, storage of herbage for a longer period is not recommended.

Distillation: The recovery of oil from the herb is 0.5-0.8%. Oil is obtained through steam distillation. The oil is of golden yellow colour, containing not less than 75% menthol. The duration of steam distillation is 2-2.5 hours for complete recovery of the oil. About 80% of the oil is received in the receiver in about one hour's time. The oil that is received later is richer in menthol. The fresh or semi dried herbage is placed in a tank and treated with passing steam under pressure. The steam that comes out of the tank is then passed through a condenser. The condenser receiving the steam, carrying the oil extracted from the herbage in the tank is kept constantly cool by circulating cold-water over/around it. The condensed oil and water

mixture is collected in a receiver. Since the water and oil have different densities, oil floats on the surface of the water in the receiver. The oil is skimmed off and collected.

Purification of Oil: The oil that is skimmed off must be cleaned of traces of water that it may carry. For this purpose, a separator funnel is used. Treating with anhydrous sodium sulphate and decanting removes any remnant moisture in the oil. The whole process is highly critical. Steam rectification process may be applied in case the colour of the oil changes due to rusting.

Storage & Packing of Oil: PVC drums of good quality (20-200l capacity) and galvanized iron (GI) drums or aluminum containers are suitable for short and long term storage respectively. The containers should be kept in cool and dark place.

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.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
3.	Always treat the seeds with approved chemicals/biopesticides for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with biopesticides/ chemicals.
4.	Sow in rows at optimum depths under proper moisture conditions for better establishment.	Do not sow seeds beyond 5-7 cm depth.
5.	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.
6.	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.
7.	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
8.	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
9.	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
10.	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).

11.	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
12.	In case of pests which are active during night 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.
13.	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, scales, thrips,etc.	Do not spray pesticides only on the upper surface of leaves.
14	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
15.	Follow the recommended procedure of trap or border crops technology.	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.

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

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. Prepare the spray solution as per requirement
7. **Do not** mix granules with water; **Do not** eat, drink, smoke or chew while preparing solution.
8. Concentrated pesticides must not fall on hands etc while opening sealed container. Do not smell pesticides.
9. Avoid spilling of pesticides while filling the sprayer tank.
10. The operator should protect his bare feet and hands with polythene bags

E. Equipments

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

F. Precautions for applying pesticides

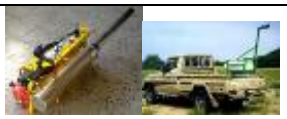
1. Apply only at recommended dose and dilution
2. **Do not** apply on hot sunny day or strong windy condition; **Do not** apply just before the rains and after the rains; **Do not** apply against the windy direction.
3. Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer
4. Wash the sprayer and buckets etc with soap water after spraying
5. Containers buckets etc used for mixing pesticides should not be used for domestic purpose
6. Avoid entry of animals and workers in the field immediately after spraying

G. Disposal

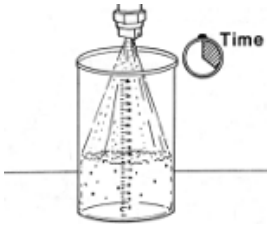
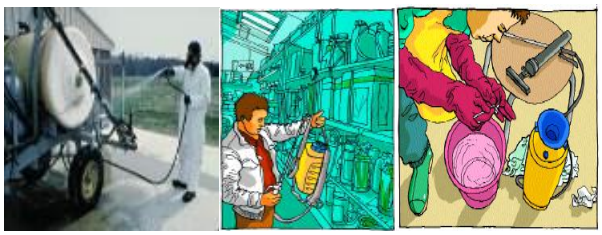
1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

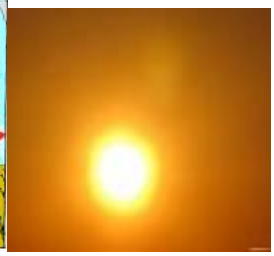
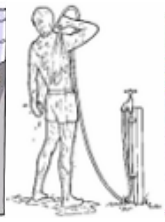
XIII. PESTICIDE APPLICATION TECHNIQUES

		Equipment	
Category A: Stationary, crawling pest/ disease			
Vegetative stage i) for crawling and soil borne pests	Insecticides and fungicides	• Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min ***or*** • Motorized knapsack sprayer or mist blower (Droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle	 
ii) for small sucking leaf borne pests			
Reproductive stage	Insecticides and fungicides	• Lever operated knapsack sprayer (Droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min	
Category B: Field Flying pest/ airborne pest			
Vegetative stage	Insecticides and fungicides	• Motorized knapsack sprayer or mist blower (Droplets of small size)	

Reproductive stage *(Field Pests)*		• 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)	 

XIV. 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.	 
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.	

XV. REFRENCES

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- http://www.apsnet.org/edcenter/intropp/lessons/fungi/ascomycetes/Pages/VerticilliumWilt.aspx
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