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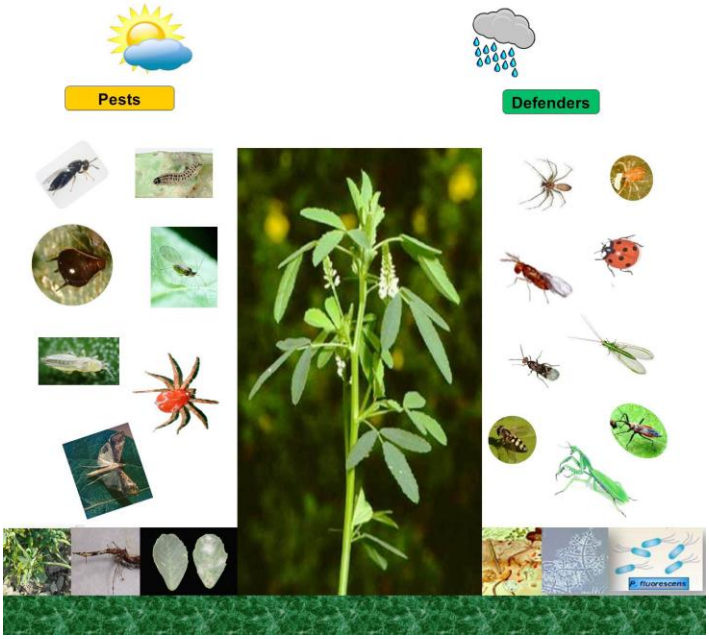
AESA BASED IPM PACKAGE

FENUGREEK



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Ministry of Agriculture and Farmers Welfare
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The AESA based IPM – Fenugreek 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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Fenugreek-Plant description:

Fenugreek (*Trigonella foenum-graecum* L.; Family: Fabaceae) is an herbaceous annual plant grown for its leaves and seeds. It is one among the oldest medicinal plants in the world. The fenugreek plant may have a single stem or may be branched at the stem base. The plant has an erect growth habit and a strong, sweet aroma. The leaves of the plant are small and trifoliate with oval leaflets, which are green to purple in color. The plant produces solitary pale white or purplish flowers and a straight or occasionally curved yellow pod which houses the seeds. Between 10 and 20 seeds are produced per pod and they are small, smooth and brown, each divided into two lobes. Fenugreek can reach a height of 60 cm (23.6 in) and as an annual, survives only one growing season. Fenugreek is a sun-loving plant which is usually grown as a cool season crop. The origin of fenugreek is unknown but it is indigenous to the western Mediterranean.

Fenugreek is used as herb (dried or fresh leaves), spice (seeds) and vegetable (fresh leaves, sprouts, and microgreens). Sotolon is the chemical responsible for fenugreek's distinctive sweet smell.

I. PESTS

A. Pests of National Significance

1. Insect and mite pests:

1.1. Stem fly: *Ophiomyia* spp., (Diptera: Agromyzidae)
1.2. Cowpea aphid: *Aphis craccivora* Koch (Hemiptera: Aphididae)
1.3. Serpentine leaf miner: *Liriomyza trifolii* Burgess (Diptera: Agromyzidae)
1.4. Thrips: *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae)
1.5. Lucerne weevil: *Hypera postica* Gyllenhal (Coleoptera: Curculionidae)
1.6. Spotted pod borer: *Maruca testulalis* Geyer (Lepidoptera: Crambidae)
1.7. Mite: *Tetranychus cucurbitae* Rahman and Sapra (Arachnida: Tetranychidae)

2. Diseases

2.1 *Cercospora* leaf spot: *Cercospora traversiana* Sacc.
2.2 Charcoal rot: *Macrophomina phaseolina* (Tassi) Goid
2.3 Powdery mildew: *Erysiphe polygoni* DC, *Leveillula taurica* (Lev.) Arm
2.4 Downy mildew: *Peronospora trigonellae* Gaum
2.5 Rust: *Uromyces trigonellae* Pass
2.6 Root rot /collar rot/ Foot rot : *Rhizoctonia solani* Kuhn, *Sclerotium rolfsii* Sacc.
2.7 Damping off : *Pythium aphanidermatum* (Edson) Fitzp
2.8 Fusarium wilt: *Fusarium oxysporum* (Schlecht.)
2.9 Yellow mosaic disease: *Bean yellow mosaic virus*

3. Weeds

Broadleaf

3.1 Lamb's quarter: *Chenopodium album* L. (Chenopodiaceae)
3.2 Scarlet Pimpernel: *Anagallis arvensis* L. (Primulaceae)
3.3 Sweet clover: *Melilotus indica* (L.) All. (Fabaceae)
3.4 Fine leaf fumitory: *Fumaria parviflora* Lam. (Fumariaceae)
3.5 Corn spurry: *Spergula arvensis* L. (Caryophylliaceae)
3.6 Carrot grass *Parthenium hysterophorus* L. (Asteraceae)
3.7. Onion weed: *Asphodelus tenuifolius* Cav. (Liliaceae)
3.8. Bind weed: *Convolvulus arvensis* L. (Convolvulaceae)

Grasses

3.8 Blue grass: *Poa annua* L. (Poaceae)

3.9 Canary grass: *Phalaris minor* Retz. (Poaceae)

3.10. Doob: *Cynodon dactylon* (L.) Pers. . (Poaceae)

Sedges

3.11 Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)

3.12. Flat sedge: *Cyperus iria* L. (Cyperaceae)

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 healthy seeds/seedlings/planting materials

- Treat the seeds/seedlings/planting materials with recommended pesticides especially biopesticides
- Observe the soil physical condition, moisture level, etc.
- Follow proper spacing
- Take representative soil sample and get the soil analysis report showing soil pH, electrical conductivity (EC), organic matter and nutrient status.
- Nutrient management especially through organic manures and biofertilizers based on the soil test results should be followed. If the dose of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dosages are too low, the crop growth is retarded. So, the farmers should maintain proper soil fertility level through integrated nutrient management approach for best results.
- Proper irrigation
- Crop rotation
- Observe the number and species of weeds found in per square meter area each in five randomly selected spots/ha.

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

Farmers should:

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

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. Several studies have documented such compensation through increased growth and photosynthetic rate.

Understand and conserve defenders:

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

Insect zoo:

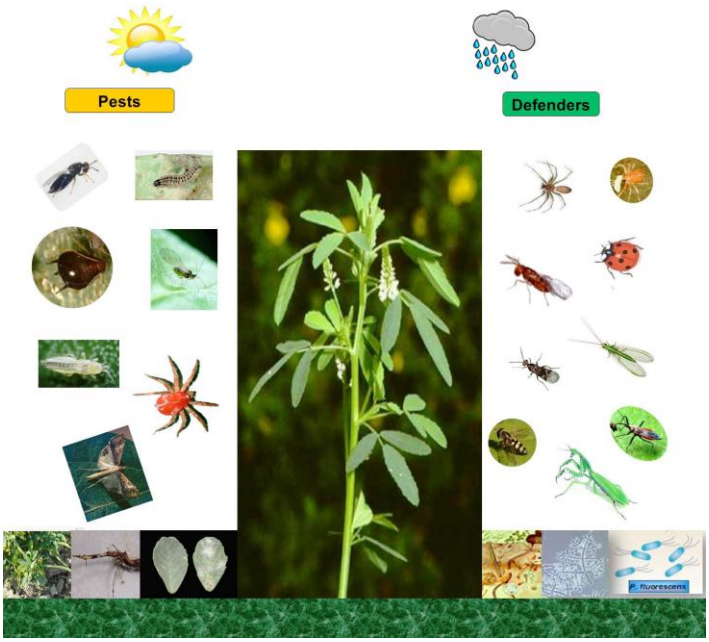
In field various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers') which feed on pests are not easy to observe in crop field. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial and harmful insects. In this method, unfamiliar/unknown insect are collected in plastic containers with brush from the field and brought to a place for study. Each insect 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 fenugreek insect 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:
    - Plant: Observe the plant length, crop stage, deficiency symptoms etc.
    - Insect pests: Observe and count insect 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.
    - Weeds: Observe weeds in the field and their intensity.
    - Water: Observe the water situation of the field.
    - Weather: Observe the weather conditions.
- 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 situations 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, etc.,
- **Crop situation (e.g. for AESA):** Plant health; insect 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.

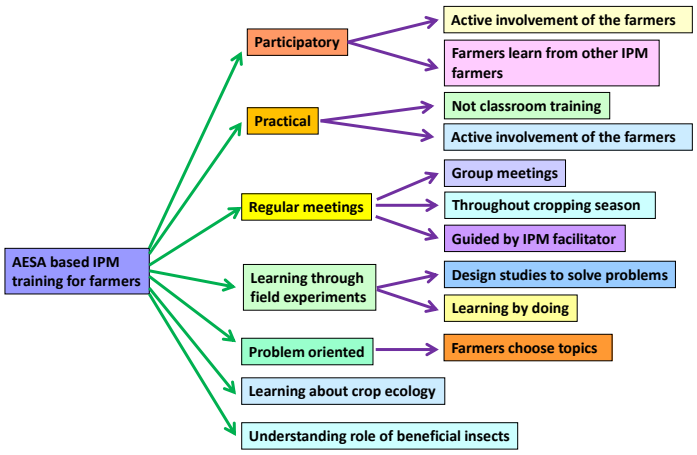
AESA and farmer field school (FFS):

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

For insect pests:

Stem fly: Count and record the number of damaged plants (in any 10 rows from one spot).

Lucerne weevil: Damaged plants can be counted in 1m x 1m quadrats. Alternatively, plants with damage symptoms (scraping of leaves by weevil grubs) can be counted per m-row.

Aphids, mites and thrips: Count and record the number of both nymphs and adults from five or ten randomly selected plants; on leaves for mites and thrips, while on top 10cm shoot for aphids.

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

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 or ooze). It is often necessary to wash the roots with water to examine them properly. If the roots are well developed, cut them to examine the roots for internal infections (discolouration & signs). Count the total number of roots damaged/infested/infected due to rot should be counted and incidence should be recorded.

Leaf sampling: Examine all leaves and/or sheaths of each plant for lesions. 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. Determine the percent area of leaf infection by counting the number of leaves (leaf area diameter)/plant infected due to disease and incidence should be recorded.

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

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

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 (PGPR)

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, lacewing, 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

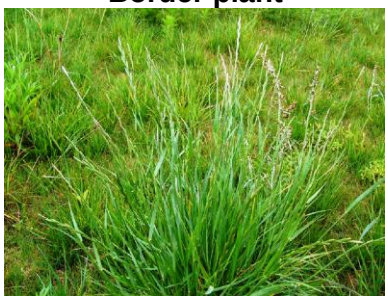
Repellent plants

***Ocimum* spp.**

Peppermint

Marigold

Border plant



Ryegrass

Barrier/guard plants

Bajra

Maize

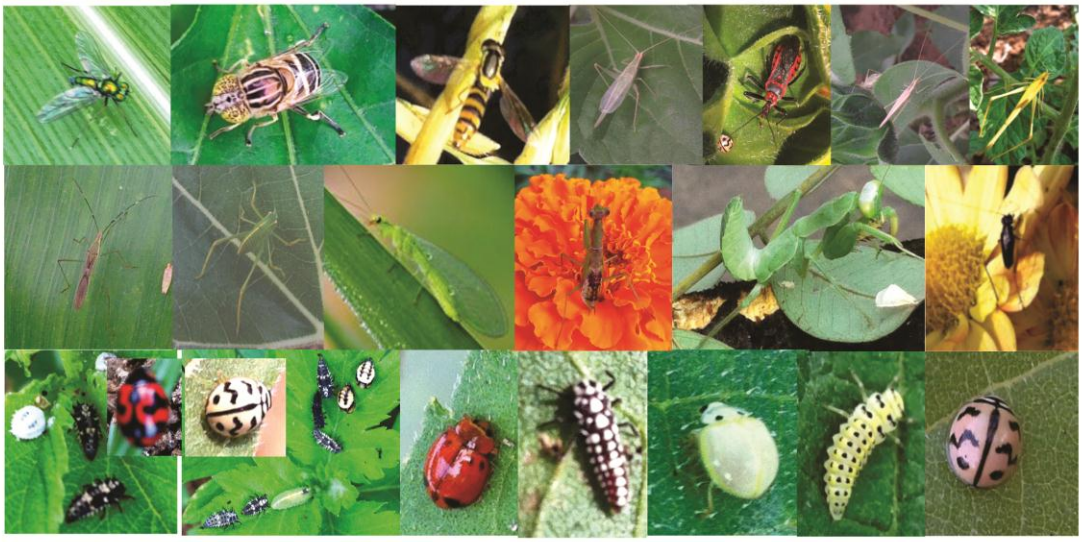
Sorghum

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.

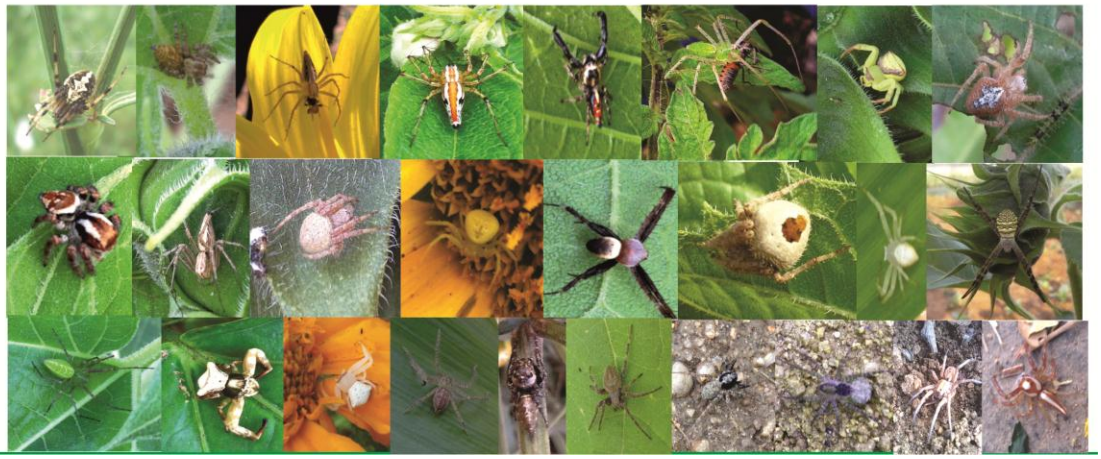
Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



IV. RESISTANT/TOLERANT VARIETIES

Variety*	Pests
Lam selection 1	Tolerant to powdery mildew, root rot, caterpillars and aphids
Pusa Early Bunching	Resistant to downy mildew, rots
Kasuri methi	Resistant to leaf miner
Rajendra Kranti	Tolerant to leaf spot, suitable for intercropping
Hissar sonali	Moderately tolerant to root rot, aphids
Co.1	Dual purpose variety evolved at TNAU Tolerant to root rot
RMt- 1	Moderately resistant to root rot and tolerant to powdery mildew
RMt- 143	Seeds mature 140-150 days after sowing, Moderately resistant to powdery mildew
RMt- 305	Resistant to powdery mildew

***For detail contact nearest KVKs, SAU, ICAR institutes**

V. CROP STAGE-WISE IPM

Management	Activity
Pre-sowing*	
	Common cultural practices: • Deep ploughing of fields during summer to control soil borne pathogens and weeds. • Soil solarization: Cover the beds with polythene sheet of 75 gauge thickness for six weeks during summer months . It will help in reducing the soil-borne pathogens, insect pests and weeds. • Timely and line sowing should be done. • Field sanitation, rogueing • Destroy the alternate host plants • Soil test based application of manures and fertilizers. • Plant tall border crops like maize, sorghum for the management of mites and thrips. • Follow crop rotation of non-host crops like cereal crops for 3 years. • Adopt ecological engineering by growing the attractant, repellent, and trap crops around the field bunds.
Nutrients	• Get the soil sample tested and apply nutrients based on soil test report. Soil is brought to fine tilth by 2-3 ploughing with harrow or plough. • Incorporate 4 to 5 tonnes of Farm Yard Manure per acre in soil 2-3 weeks before sowing.
Weeds	• Solarisation of soil during summer reduces weed infestation.
Sowing*	
Nutrients	• Apply 8 kg N, 20 kg phosphorus and 20 kg potash per acre at the time of sowing as basal dose.
Soil borne fungus, resting stages of insects and weeds	**Cultural control:** • Soil solarization should be followed.

	Biological control: • Apply neem cake @ 80 Kg/acre at the time of sowing for reducing borer damage as well as to reduce the soil borne diseases while preparing the nurseries.
Root rot and collar rot	**Cultural control:**. • Avoid excessive watering • Use raised beds: more than 15 cm height is better for water drainage
Damping off	**Cultural control:**. • Avoid excessive watering • Follow crop rotation **Biological control:** • Apply neem cake @ 80 Kg/acre at the time of sowing for reducing the disease • **Soil application:** Apply *Trichoderma viride* @ 2kg/100kg of FYM/acre.
Weeds	• Sowing should be done in lines to facilitate hoeing and weeding operations during vegetative stage.
Diseases and insect pests	• Select resistant varieties.
Vegetative stage	
	Common cultural practices: • Avoid water stress and water stagnation conditions. • Collect and destroy diseased and insect infected plant parts. • Conserve natural enemies through ecological engineering **Common mechanical practices:** • Collection and destruction of eggs of pests and early stage larvae • Use yellow/blue pan water/ sticky traps for aphids @ 4-5 trap/acre. **Common biological practices:** • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies.
Nutrients	• Apply second half of N as top dressing in two splits i.e. 4 kg per acre at 25-30 days after sowing and remaining 4 kg at 40-45 days after sowing.
Weeds	• The crop should be kept free from weeds for proper growth and development of plants. Generally, 2-3 hand weeding are required to keep the weeds under control. • In drilled crop light intercultural operation is beneficial. 1st weeding and hoeing should be done at 25-30 days after sowing and 2nd weeding at one month after 1st weeding.
Aphids	• See common cultural and biological practices. **Cultural control:** • If aphid population is limited to just a few shoots then the infested plant can be pulled out **Biological control**

	• Conserve and augment lady bird beetles and lacewings. • Spraying with tobacco decoction (1 kg tobacco boiled in 10 l of water for 30 minutes and making up to 30 l + 100 g soap). • Insecticidal soaps or oils such as neem or NSKE 5% are usually the best method of control
Leaf miner	**Cultural control:** • Avoid excess use of nitrogen. **Biological control:** • Conservation of natural enemies. • Spray NSKE 5%.
Stem fly	**Cultural control:** • Follow crop rotation **Biological control** • Apply neem cake @ 80 Kg/acre at the time of sowing for reducing damage
Lucerne weevil	**Cultural control:** • Follow crop rotation **Biological control** • Apply neem cake @ 80 Kg/acre at the time of sowing for reducing damage • Spray NSKE 5% or Neem oil 0.5 to 1% (max. 2%).
Mites	**Cultural control:** • Keep the field free of weeds • Remove and destroy infested crop residues **Biological control:** • Spray NSKE (5%)
Thrips	**Cultural control:** • Use blue sticky traps/water pan traps 5/acre.
***Cercospora* leaf spot**	**Cultural control:** • Follow field sanitation.
Charcoal rot	**Cultural control:** • Organic soil amendments such as the addition of manure or neemcake can be used to reduce levels of inoculum in the soil • Follow crop rotation
Powdery mildew	**Cultural control:** • Use adequate spacing when planting to avoid overcrowding
Mosaic	**Cultural control:** • Manage the vector by adopting common practices for the aphid. **Mechanical control:** • The infected plants should be removed in the early stage of plant growth. . • Remove weed host • Install yellow sticky traps 4-5 per acre.

Rust	**Cultural control:** • Balanced use of manures and fertilizers. • Uproot the alternate host.
Downy mildew	**Cultural control:** • Use adequate spacing when planting to avoid overcrowding
Fusarium wilt	**Cultural control:**. • Avoid excessive watering • Follow crop rotation **Biological control:** • Apply neem cake @ 80 Kg/acre at the time of sowing for reducing the disease • **Soil application:** Apply *Trichoderma viride* 2kg/100kg of FYM/acre.
Reproductive/fruiting stage	
Weeds	• Remove weeds to prevent weed seed spread in field.
Pests and disease	• Same as vegetative stage.
Spotted pod borer	**Cultural control:** • The avoidance of broad-spectrum pesticides prior to flowering may help conserve natural enemies; however, beneficial insects are unlikely to control populations above about 10 per square metre. • Follow common mechanical and biological practices

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 num Redgram 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.Lambs quarter: ***Chenopodium album*** **L. Chenopodiaceae**

2. Scarlet pimpernel: ***Anagallis arvensis*** **L. Primulaceae**

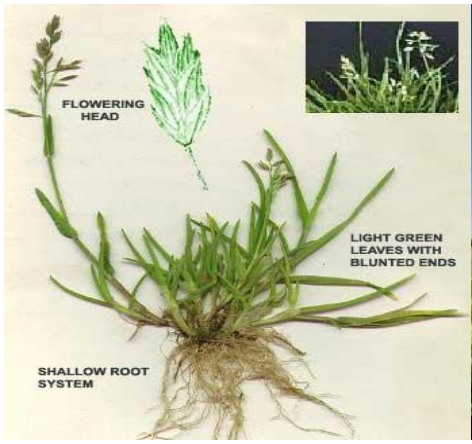
3. Sweet clover: ***Melilotus indica*** **(L.) All.Fabaceae**

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

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

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

7. Onion weed: *Asphodelus tenuifolius* Cav. Liliaceae



8. Bluegrass: *Poa annua* L. Poaceae

9. Canary grass: *Phalaris minor* Retz. (Poaceae)

10.Purple nutsedge: *Cyperus rotundus* L. (Cypraceae)

11. Flat sedge: *Cyperus iria* L. (Cypraceae)

VIII. DESCRIPTION OF INSECT AND MITE PESTS

1. Aphid:

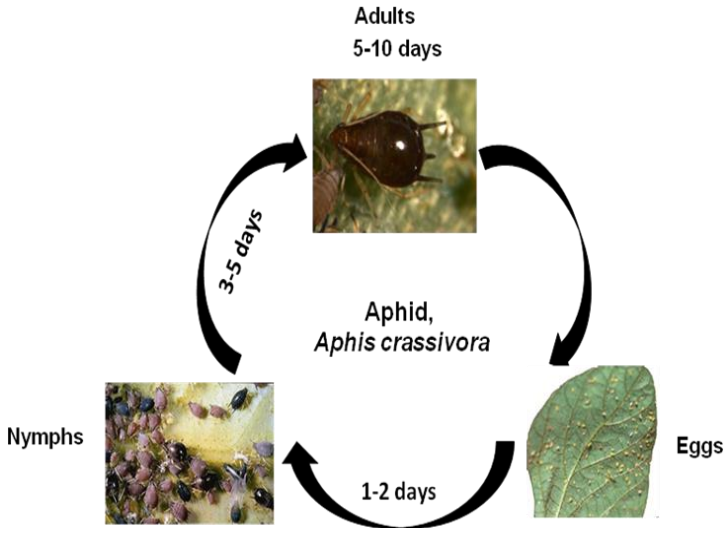
Biology:

Egg: Eggs are very tiny, shiny-black, and are found in the crevices of bud and stems, of the plant, especially in colder regions of the world and may overwinter as eggs. In warmer parts of the world aphids usually do not lay eggs and parthenogenic reproduction takes place throughout the year.

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

Adult: Adults are small, back to dark brownish colour, 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. A female aphid lives for 9 to 25 days and can produce from 25 to 125 young during its life. There may be up to twenty generations in the year.

Life cycle:



https://simonleather.files.wordpress.com/2013/09/aphis-craccivora.jpg

Damage symptoms:

- Nymphs and adult aphids suck plant sap from leaves, shoots, buds and floret.
- In addition, plants may become contaminated by honeydew produced by aphids and sooty mould growing on honeydew.
- Fenugreek contaminated with honeydew and / or sooty mould are not marketable.
- Aphids are also vectors of diseases, including the common bean mosaic virus.
- The black bean aphid is a widely distributed pest of fenugreek.

Natural enemies of aphid:

Parasitoids: *Aphidius colemani, Aphelinus* sp, *Diaeretiella* sp

Predators: Red ant, Big-eyed bug (*Geocoris* sp), Earwig**,** Cecidomyiid fly, Dragon fly, Lacewing, Ladybird beetles, Syrphid flies, etc.

*For management refer to page number……

2. Leaf Miner:

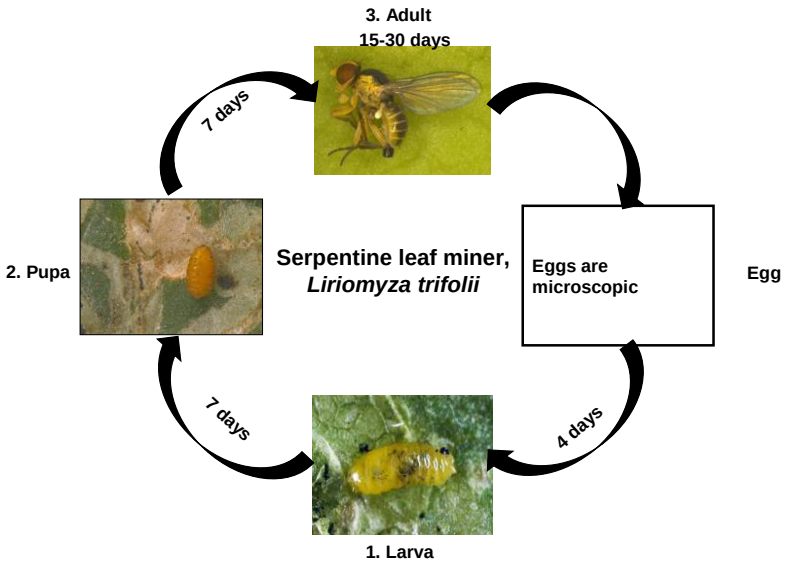
Biology:

Egg: Minute orange yellow, apodous maggot feeds on chlorophyll mining in between epidermal layers.

Larva: Full grown maggot measures 3 mm. Larval duration is about 7 days. Pupation is in soil. Some pupae are found in leaves. Total life cycle takes 3 weeks. **Pupa:** Pupation takes place inside a thin loose mesh of silken cocoon. Pupal period is about 7 days.

Adult: It is a pale yellowish fly, measuring 1.5 mm in length. The female fly punctures upper surface of leaf to lay eggs singly. The egg hatches in 4 days. Serpentine leaf miner is polyphagous pest, native of Florida (USA) and believed to be accidentally introduced into India. It is widely distributed in Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra causing damage to fibre crops, pulses, ornamentals, vegetables, fodder etc. It is a serious pest on cucurbits, cotton, ridge gourd, brinjal, and potato.

Life cycle:



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

Damage symptoms:

- Leaves with serpentine mines. The maggot punctures the epidermal layers and scraps the chlorophyll content between the layers. In severe cases, the photosynthetic activity is reduced and leads to death of the plant.
- In severe cases, defoliation occurs.

Favourable conditions:

- Warm weather conditions are favourable for multiplication.

Natural enemies of leaf miner:

Parasitoids: *Gronotoma micromorpha* (larva and pupa), *Diglyphus* sp (larva), *Halticoptera circulus* and *Opius* sp (pupal), *Chrysocharis* sp, *Neochrysocharis formosa* (Westwood).

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

3. Mites:

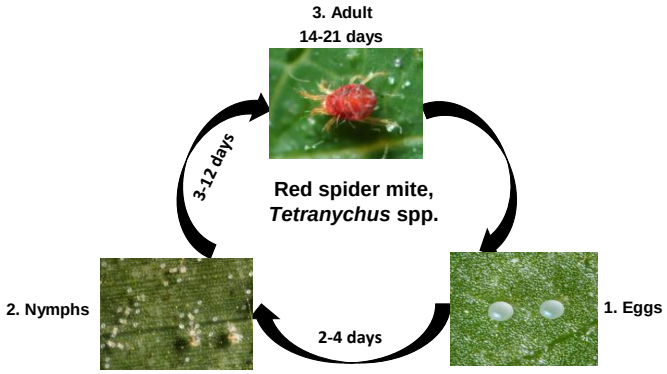
Biology:

Egg: Gravid females lay reddish, hyaline, spherical eggs in mass on undersurface of leaf. Eggs hatch in 2-5 day.

Nymph: After hatching neonates are light brown in colour with three pairs of legs. After feeding underneath the leaf in webs, larvae become nymphs with four pairs of legs. Developmental stages include six-legged larva. Protonymph and deutonymph.

Adult: Adults are red coloured, smaller in size. Females are oval, pyriformin shape, bright crimson anterior and dark purplish brown posterior. Mites spin a web of silken threads undersurface of leaf. Total life cycle is completed in 10-18 days depending upon the environmental conditions.

Life cycle:



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

Damage symptoms:

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

Natural enemies of red spider mites:

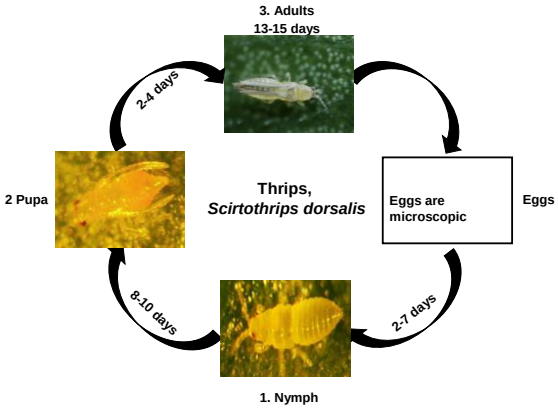
Predators: Anthocorid bugs (*Orius* spp.), mirid bugs, syrphid/hover flies, lacewings (*Mallada*

basalis and *Chrysoperla carnea*), predatory mites (*Amblyseius alstoniae*, *A. womersleyi, A. fallacies* and *Phytoseiulus persimilis*), predatory coccinellids (*Stethorus punctillum*), staphylinid beetle (*Oligota* spp.), cecidomyiid fly (*Anthrocnodax occidentalis*), midge (*Feltiella minuta*) etc.
Entomopathogen: *Beauveria bassiana*

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

4. Thrips:

Biology:
Egg: Eggs are hyaline, globular laid in mass inside the leaf tissues of leaves and shoots.
Nymph: Nymphs are tiny, slender, fragile and straw yellow in colour.
Adult: Adults are slender, yellowish brown with heavily fringed wings. There are several overlapping generations in a year.
Life cycle:



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.. Besides chilli, it also infests brinjal, cotton, groundnut, castor, bottle gourd, guava, tea and grapevine. It is more common on un-irrigated chilli crop than irrigated one.

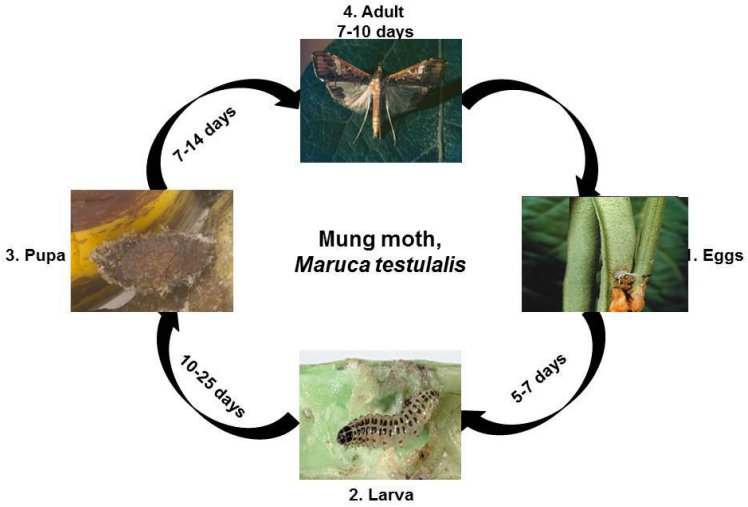
Natural enemies of thrips:
Predators: Predatory mite, predatory thrips, *Oligota* spp., *Orius* spp. (pirate bug), hover flies, mirid bug etc.,
*For management refer to page number----------.

5. Spotted pod borer:

Biology
Egg: Eggs of the moth are pale cream and flattened.
Larva: Larvae are pale cream with two rows of distinctive paired black markings on their back.

In the final instar, these markings are often very pale. Larvae can reach 18 mm in length.
Pupa: Pupa elongated and reddish brown in colour.
Adult: Adults have a 20-25 mm wingspan and a slender body. They have brown forewings with a white band extending two-thirds down the wing from the leading edge. Inside this band near the leading edge is a white spot. The hindwings are predominantly a translucent white with an irregular brown border. When at rest, they adopt a characteristic pose with outspread wings and the front of the body raised.

Life cycle:



https://www.daf.qld.gov.au/__data/assets/image/0010/65089/Insects-beanpodborer-webbedpods-250.jpg
http://www.nbair.res.in/insectpests/images/Maruca-vitrata7.jpg
http://nature.berkeley.edu/~oboyski67/Lepidoptera/images/Maruca_vitrata.jpg

Damage symptoms:

- Seeds within damaged pods are totally or partially eaten out by bean pod borer larvae. Entry holes also let in water, which stains the remaining non-eaten seeds.
- Fenugreek pod borer larvae may web young leaves together and may tunnel in plant stems. Such damage is not typical of its behaviour on other legumes.

Natural enemies of mung moth:

Parasitoids: *Trichogramma* sp., *Bracon* sp., *Apanteles taragamae*, *Carcellia* etc.
Predators: Spider, red ant, reduviid bugs, praying mantids
*For management refer to page number----------.

Natural Enemies of Fenugreek Insect Pests

Parasitoids

Egg parasitoids

1. ***Trichogramma*** **sp**

Larval parasitoids

2. ***Bracon*** **spp.**

3. ***Ichneumon*** **spp.**

4. ***Carcelia*** **spp**

5. ***Apanteles*** **sp**

Larval/pupal parasitoid

6. ***Gronotoma micromorpha***

Pupal parasitoids

7. ***Opius*** **sp**

8. ***Halticoptera circulus***

Nymphal/larval/adult parasitoids

9. *Chrysocharis* sp

10. *Aphidius*

11. *Diglyphus isaea*

12. *Aphelenus*

13. *Diaeretiella*

3. http://www.organicgardeninfo.com/ichneumon-wasp.html
4. http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398
5. http://www.european-lepidopteres.fr/Videos-parasites-Apanteles.html
6. http://www.ento.csiro.au/science/Liriomyza_ver3/key/Eucoilidae_Key/Media/Html/ gronotoma_sp.html
7. http://www.cedarcreek.umn.edu/insects/album/025013089ap.html
8. http://www.nogyo.tosa.pref.kochi.lg.jp/info/dtl.php?ID=5996
9. http://baba-insects.blogspot.in/2012/05/blog-post_
10. http://biobee.in/products-and-services/solutions/bio-aphidius/
11. http://www.evergreengrowers.com/diglyphus-isaea-114.html
12. http://australianmuseum.net.au/image/Aphelinus-wasp-stings-aphid-Denis-Crawford/
13. http://nathistoc.bio.uci.edu/hymenopt/Diaeretiella%20rapae.htm

Predators

1. Lacewing

2. Ladybird beetle

3. Reduviid bug

4. Spider

5. Robber fly

6. Red ant

7. Black drongo

8. Common mynah

9. Big-eyed bug

10. Earwig

11. Ground beetle

12. Pentatomid bug

13. Preying mantis

14. *Geocoris* spp.

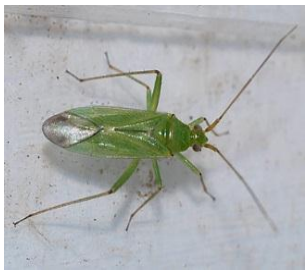
15. Predatory mite

16. Predatory thrips

17. *Oligota* spp.

18. *Orius* spp.

19. Hover fly



20. Mirid bug

5. http://www.warpedphotosblog.com/robber-fly-and-prey
6.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
7. http://nagpurbirds.org/blackdrongo/picture/1639
8. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
9. http://bugguide.net/node/view/598529
10. http://www.flickr.com/photos/johnhallmen/2901162091/
11.http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/ Ground%20Beetle%20-%20Pterostichus%20madidus.html
12. http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asopinae/ Eocanthecona.htm
13. http://spirit-animals.com/praying-mantis/
14. http://nathistoc.bio.uci.edu/hemipt/Dicyphus.htm

15. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
16. http://biocontrol.ucr.edu/hoddle/persea_mite.html
17. http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33
18. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
20. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html

IX. DESCRIPTION OF DISEASES

1. *Cercospora* leaf spot:

Disease symptoms:

- Circular sunken lesions with chlorotic halos on leaves; necrotic areas on leaves; discolored areas on pods

Survival and spread:

- Pathogen survives mainly in plant debris as desiccation-resistant pseudostromata, but can also survive as conidia in debris or seeds.
- When moisture is sufficient, new conidia are formed and spread via rain-splash or wind to new leaves or plants.

Favourable conditions:

- Optimum conditions are 25° to 35° C with night temperatures above 16.1° C, and a relative humidity of 90-95%. Infection is greatly reduced or nonexistent at temperatures less than 15° C or during periods of leaf wetness less than 11 hours.

Disease symptom

http://www.cropj.com/acharya_8_6_2014_822_830.pdf

*For the management refer page no ……

2. Charcoal rot:

Disease symptoms:

- Cankers on stem may spread upwards; leaves may wilt and drop from plant.
- Numerous small black sclerotia (fungal fruiting bodies) develop in affected tissues and can be used to diagnose the disease

Survival and spread:

- *M. phaseolina* survives as microsclerotia in the soil and on infected plant debris.
- The microsclerotia serve as the primary source of inoculum and have been found to persist within the soil up to three years.

Favourable conditions:

- Hot, dry weather promotes infection and development of charcoal rot.

*For the management refer page no ……

3 Powdery mildew:

Disease symptoms:

- White, powdery spots on leaves which expand over time.
- Yellow spots may be visible on leaf underside

Survival and spread:

- The fungus survives the winter attached to plant parts and plant debris such as fallen

leaves..

Favourable conditions:

- Humidity is an important factor related to the onset and spread of powdery mildew. High relative humidity favors spore formation, and low relative humidity favors spore dispersal, which explains why powdery mildew tends to be a problem when the days are cool and the nights are humid.

Disease symptoms

http://www.eoearth.org/view/article/51d2d7950cf2ac58f77c3c77/?topic=51cbfc79f702fc2ba812a04a

*For the management refer page no ……

4. Root/ collar rot/ Foot rot:

Disease symptoms:

- *Rhizoctonia* root rot develops from infection of the growing tip of small lateral roots. The fungus then progressively grows from the root tip and may cause rot of the main root. *Rhizoctonia* infection of a rootlet often results in the 'spear-point' symptom of roots.
- Small chlorotic, water-soaked lesions appear randomly over both surfaces of the leaflets. They enlarge, become irregular in shape, and are brown with darken brown margins. The central portion later become pale, dry rapidly and disintegrate.

Root and Collar rot

Disease symptoms

http://www.omafra.gov.on.ca/CropOp/en/herbs/culinary/fenu.html

Survival and spread:

- They survive in soil for long periods in the absence of a host, and inoculum levels in soil increase slowly over several years (crop cycles).

Favourable conditions:

- High humidity and warm weather favours the development of disease.

*For the management refer page no ……

5.Downy mildew:

Disease symptoms:

- The symptoms of downy mildew are quite distinct from the other diseases.
- The adaxial surfaces of the leaves showed yellow patches or small chlorotic spots which appear often at the margins.
- The abaxial surface of the leaf showed white cottony mycelial growth which often appears as grayish violet.
- The disease also causes stunted growth of the plant

Survival and spread:

- The fungus survives in plant parts and plant debris such as fallen leaves.

Favourable conditions:

- The disease is favored by a maximum temperature range of 18-24˚C to minimum temperature range of 4-10˚C and a relatively high humidity which is more than 80%.

*For the management refer page no ……

6.Rust:

Disease symptoms:

- Rust commonly appears as a colored powder, consisting of minute aeciospores that land on the fenugreek plant generating pustules (uredia) on the ventral leaf surface.
- During late spring or early summer of the disease cycle, yellowish orange to dark brown, hair-like (ligulate) structures called telia develop on the leaves.
- Small, round or oblong, dark brown pustules on the leaves and petioles are commonly observed.

Survival and spread:

- The fungus mainly survives through teliospores (thick walled, resting spores) on leaves left in the field or on the soil surface.
- The disease spreads by wind-borne uredospores from infected crop.

Favourable conditions:

- Temperature ranging from 20 to 25° C with relative humidity of 86-92%RH favours high intensity of rust.

*For the management refer page no ……

7. Damping off:

Disease symptom:

- The emerged seedlings exhibit water soaked discoloured, soft basal rot of the stem due to the death of cortical tissues.
- The rotted seedlings emit bad odour, the whole seedling topples over.

Survival and spread:

- The fungus survives in soil. Primary infection occurs through soil and secondary by conidia through rain or wind.

Favourable conditions:

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

*For the management refer page no ……

8.Fusarium wilt:

Disease symptom:

- The symptoms are first seen as minor clearings in veins on the external part of young leaflets finally accompanied with downward drooping of mature leaves.
- At the seedling stage, plants may wilt and die soon after the appearance of the symptoms.
- In mature plants, vein clearing and downward drooping of the leaf are seen which is followed by stunting, yellowing of the lower leaves and subsequent wilting of leaves and young stems.
- This is followed by marginal necrosis of the infected leaves, rapid defoliation and death of the plant. In addition, browning of vascular tissue occurs..
- These symptoms become more prominent in mature plants during the period between blossoming and fruit maturation.

Survival and spread:

- The disease is soil borne and primary infection occurs through inoculum present in the soil.

Favourable conditions:

- Relatively high soil moisture and soil temperature are favourable for the infection.

*For the management refer page no ……

9. Yellow mosaic disease:

Disease symptom:

- Mosaic virus disease with symptoms of vein clearing, severe molting, leaves curled at the margin and reduced leaf size.
- Pods if formed are very small, curled with thin and shrunken seeds.

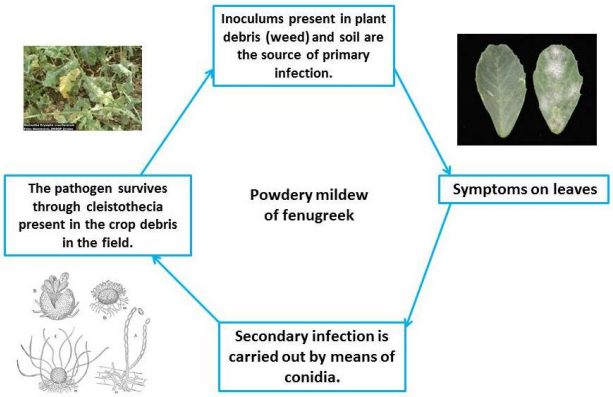
Transmission and favourable conditions

- The disease is transmitted in semi persistent mannerby aphid.
- Aphids are more active in warm conditions and increase their population as well as spread the virus.

*For the management refer page no ……

Diseases cycle:

1. Powdery mildew:



X. SAFETY MEASURES

A. At the time of harvest:

- Fenugreek is harvested within three months after planting when the colour of leaves and pods turn yellow. Harvesting should be done when the lower leaves started shedding and the pods have become yellowish.
- The plants are harvested by uprooting and are then hung up to dry to allow seeds to be collected. In India, where the plant is grown as a vegetable crop, young shoots and leaves are harvested earlier and the plant is allowed to re-grow before harvesting again.
- Harvest during cooler parts of the day to reduce moisture loss and cooling costs. Remove field heat as soon as possible after harvest (herb).
- Harvesting should be done by cutting the plants with sickles. Delay in harvesting leads to shattering of seeds. The harvested plants are tied in bundles and allowed to dry for 4-6 days. Threshing should be done on clean cemented floor or tarpaulin. The grains are separated by beating followed by winnowing or threshing which may be done by mechanical threshers.
- The average yield of fenugreek is 10-1 q/ha. Under good management condition and use of high yielding varieties, an average yields of 15-20 q/ha can be obtained.

B. During post-harvest storage:

1. Storage precautions:

- Cleaned, dried seeds are filed in bags and stored in damp-free aerated storehouses. On commercial scale seeds are cleaned with the help of vacuum gravity separator and spiral gravity separator.
- To get god price and easy marketing, the produce should be categorized in different grades and stored properly.
- The material should be stored ensuring protection from dampness. Drainage should be provided to stack the packed bags to prevent moisture ingress from the floor.
- Care should be taken to stack the bags 50 to 60 cm, away from the wall. Under any circumstances, no insecticide should, be used directly on the dried material.
- Stored material should be subjected to periodic fumigation for which only authorized persons should be engaged.
- Insects, rodents and other animals should be effectively prevented from getting aces to the premises where the material is stored. Stored product should be periodically exposed to the sun. If care is taken in all stages of cultivation, harvesting, post-harvest handling, processing, packing, storage and transportation by following sound methods and practices we will be able to prevent contamination in any farm produce and ensure consumer

2. Storage:

- The dried seeds are usually packed into sacks and stored in cool dry room. It should be stored at room temperature (25°-28°C) where the critical moisture level and relative humidity should not be more than 13-19 percent and 81 percent, respectively. During prolonged storage of spices, free fatty acids are increased by lipolytic action on fixed oil. This value is a good indicator of the period of storage.

- ❖ The spice seed can be stored in gunny bags for one year without significant loss of volatile oil contents.
- ❖ No insecticide should, under any circumstances, be used directly on spices. Stored material should be subjected to periodic fumigation for which only authorized persons should be engaged.
- ❖ Seeds should be below 12% moisture and stored under dry and cool conditions to avoid spoilage. Fenugreek leaves are often dried. The conditions below apply to the fresh herb.
- ❖ Relative humidity (RH): 95-100% (herb); Temperature: 0°C (herb); Duration: 10-14 days (herb)

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.

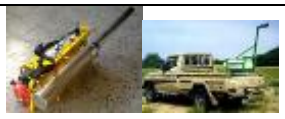
F. Precautions for applying pesticides

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

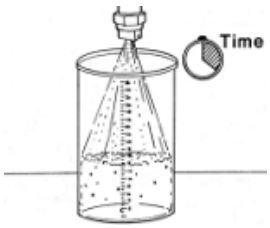
1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

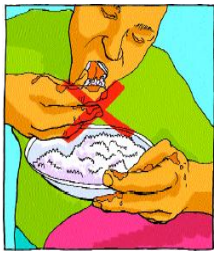
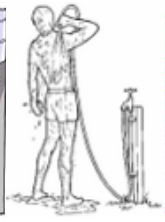
XIII. PESTICIDE APPLICATION TECHNIQUES

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

application *(migratory* Pests)		• 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.	

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