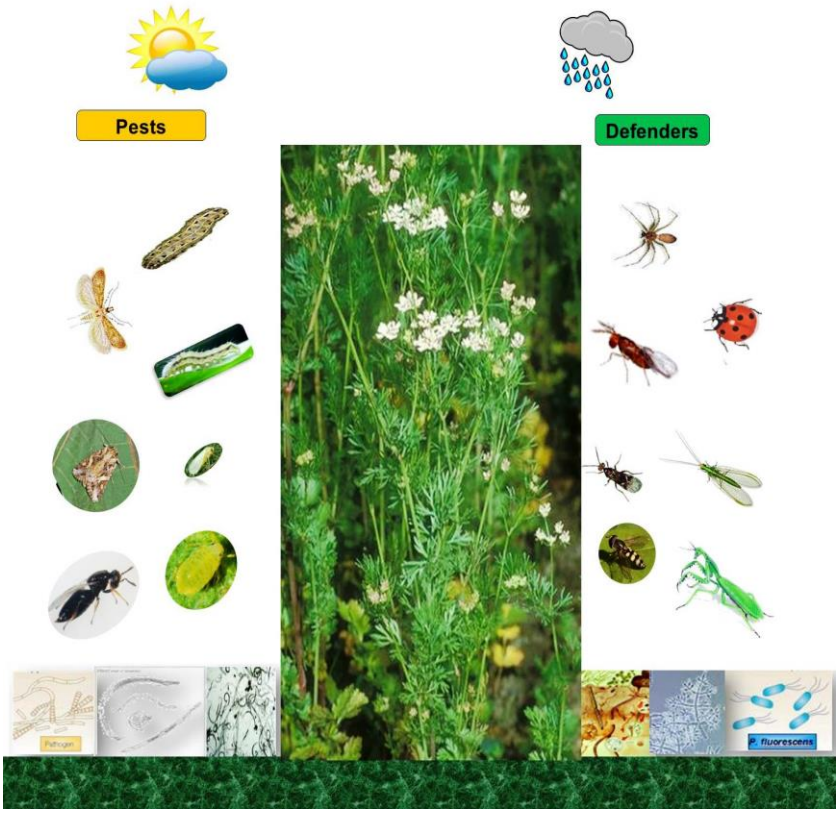
सत्यमेव जयते

AESA BASED IPM PACKAGE
CORIANDER



Directorate of Plant Protection, Quarantine and Storage
N. H. IV, Faridabad, Haryana

National Institute of Plant Health Management
Rajendranagar, Hyderabad, Telangana State

Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

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

NIPHM Working Group:

Chairman : Dr. Satyagopal Korlapati, IAS, Director General
Vice-Chairmen : Dr. S. N. Sushil, Plant Protection Advisor
: Dr. P. Jeyakumar, Director (PHM)
Core Members :

1. Er. G. Shankar, Joint Director (PHE), Pesticide Application Techniques Expertise.
2. Dr. O. P. Sharma, Joint Director (A & AM), Agronomy Expertise.
3. Dr. Satish Kumar Sain, Assistant Director (PHM), Pathology Expertise.
4. Dr. Dhana Raj Boina, Assistant Director (PHM), Entomology Expertise.
5. Sri. D. Chatopadhyaya, Assistant Director (PHM), Entomology Expertise.

Other Members :

1. Dr. B. S. Sunanda, Assistant Scientific Officer (PHM), Nematology Expertise.

Contributions by DPPQ&S Experts:

1. Shri. Ram Asre, Additional Plant Protection Advisor (IPM),
2. Dr. K. S. Kapoor, Deputy Director (Entomology),
3. Shri. R. Murali, Deputy Director (Entomology)
4. Dr. Sanjay Arya, Deputy Director (Plant Pathology),
5. Dr. Subhash Kumar, Deputy Director (Weed Science)
6. Dr. C. S. Patni, Plant Protection Officer (Plant Pathology)

Contributions by External Experts:

1. Dr. H. P. Patnik, Prof & Head (Entomology), College of Agriculture, Odisha Univ. of Agriculture and Technology, Bhubaneshwar-751003, Orissa.
2. Dr. K.C. Sahu, Prof & Head (Pathology), College of Agriculture, Odisha Univ. of Agriculture and Technology, Bhubaneshwar-751003, Orissa.
3. Dr. S. N. Mohapatra Prof & Head (Nematology), College of Agriculture, Odisha Univ. of Agriculture and Technology, Bhubaneshwar-751003, Orissa.
4. Dr. B. R. Patel, Prof & Head (Entomology), C.P. College of Agriculture, S.D. Agriculture University, Sardarkrushinagar-385506
5. Dr. SurajitKhalko, Assistant prof (Pathology)Uttar Banga Krishi Vishwavidyalaya, Cooch Behar, West Bengal
6. Dr. Nripendra Laskar, Assistant prof (Entomology)Uttar Banga Krishi Vishwavidyalaya, Cooch Behar, West Bengal
7. Dr. Ayon Roy, Associate prof (Pathology)Uttar Banga Krishi Vishwavidyalaya, Cooch Behar, West Bengal
8. Dr. Tapan Kumar Hath, Prof (Entomology)Uttar Banga Krishi Vishwavidyalaya, Cooch Behar, West Bengal
9. Dr. M. L. Kewat, Prof (Agronomy), Jawarlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P)
10. Dr. Nayak, Prof (Agronomy), Jawarlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P)

11. Dr. R. Pachori, Prof (Entomology),Jawarlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P)
12. Dr. S.B. Das, Prof (Entomology),Jawarlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P)
13. Dr. Om Gupta, Prof (Pathology), Jawarlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P)
14. Dr. Jayant Bhatt, Prof (Pathology), Jawarlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P)
15. Dr. A.K. Rawat, Prof (Soil science), Jawarlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P)
16. Dr. H.K. RaI, Prof (Soil science), Jawarlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P)
17. Dr. H.S. Yadava, Director of Research services, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior – 474002, M.P.

अपर सचिव
भारत सरकार
कृषि मंत्रालय
(कृषि एंव सहकारिता विभाग)
कृषि भवन, नई दिल्ली-110001

सत्यमेव जयते

Avinash K Srivastava
Additional Secretary
Government of India
Ministry of Agriculture
(Department of Agriculture
& Cooperation)
Krishi Bhawan, New Delhi - 110001

FOREWORD

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

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

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

A K Srivastava

Date: 6.3.2014

(Avinash K. Srivastava)

संयुक्त सचिव
भारत सरकार
कृषि मंत्रालय
(कृषि एवं सहकारिता विभाग)
कृषि भवन, नई दिल्ली- 110001

Joint Secretary
Government of India
Ministry of Agriculture
(Department of Agriculture & Cooperatio
Krishi Bhawan, New Delhi-110001

FOREWORD

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

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

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

(Utpal Kumar Singh)

Dr.K. SATYAGOPAL IAS
Director General
Telephone : +91-40- 24015346,
E-mail : dgniphm@nic.in
Tele-Fax : +91-40- 24015346,

National Institute of Plant Health Management
Department of Agriculture & Cooperation
Ministry of Agriculture
Government of India

Rajendranagar,
Hyderabad- 500030.
http://niphm.gov.in

PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

CONTENTS

AESA Based IPM Package for Coriander

Coriander - **Plant description:**

Coriander (*Coriandrum sativum* L.; Family: Apiaceae) also known as **cilantro**, **Chinese parsley** or **dhania** is an annual herb. Coriander is native to regions spanning from southern Europe and North Africa to southwestern Asia. It is a soft plant growing to 50 cm (20 in) height. The leaves are variable in shape, broadly lobed at the base of the plant, and slender and feathery higher on the flowering stems. The flowers are borne in small umbels, white or very pale pink, asymmetrical, with the petals pointing away from the centre of the umbel longer (5–6 mm) than those pointing toward it (only 1–3 mm). The fruit is a globular, dry schizocarp 3–5 mm (0.12–0.20 in) in diameter. Although sometimes eaten alone, the seeds often are used as a spice or an added ingredient in other foods.

All parts of the plant are edible, but the fresh leaves and the dried seeds are the parts most traditionally used in cooking. Coriander is common in South Asian, Southeast Asian, Indian, Middle Eastern, Caucasian, Central Asian, Mediterranean, Tex-Mex, LatinAmerican, Portuguese, Chinese, African, and Scandinavian cuisine. In India it is cultivated in Rajasthan, Gujarat, Madhya Pradesh, Tamil Nadu, U.P., etc.

I. PESTS

A. Pests of National Significance

1. Insect pests:

1.1 Cotton whitefly: *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae)

1.2 Aphid: *Hyadaphis coriandri* Das, *Aphis gossypii* Glover (Hemiptera: Aphididae)

1.3 Cutworm: *Agrotis* sp. (Lepidoptera: Noctuidae)

1.4 Seed Chalcid fly: *Systole coriandri* Gussakovsky (Hymenoptera: Chalcidoidea)

2. Diseases:

2.1 Powdery mildew: *Erysiphe polygoni* DC

2.2 Wilt: *Fusarium oxysporum* f.sp. *corianderii*

2.3 Stem gall: *Protomyces macrosporus* Unger

2.4 Blight disease complex: *Alternaria poonensis* Ragunath & *Colletotrichum* sp.

3. Weeds:

Grasses

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

3.2. Bermuda grass: *Cynodon dactylon* (Poaceae)

Broad leaf

3.3. Lambs quarter: *Chenopodium album* . L. (Chenopodiaceae)

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

3.5. Onion weed: *Asphodelus tenuifolius* Cav. (Liliaceae)

3.6 Scarlet pimpernel: *Anagallis arvensis* L. (Primulaceae)

Sedge

3.7 Purple nut sedge: *Cyperus rotundus* L. (Cyperaceae)

B. Pest of Regional significance:

1. Insect and mite pests:

1.1 Thrips: *Thrips tabaci* Lindeman (Thysanoptera: Thripidae)

1.2 Indigo caterpillar: *Spodoptera exigua* Hubner (Lepidoptera: Noctuidae)

1.3 Mite: *Petrobia latens* Muller, *Tetranychus telarius* Linn. (Tetranychidae: Acarina)

2. Diseases:

2.1 Stem rot: *Rhizoctonia solani* Kuhn

2.2 Root rot: *Pythium sulcatum* Pratt and Mitchell

2.3 Grain mould: *Alternaria* sp., *Helminthosporium* sp.

3. Nematodes:

3.3 Root knot Nematode: *Meloidogyne* spp.

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 healthy seeds/seedlings/planting materials
- Select a variety resistant/tolerant to major pests
- Treat the seeds/seedlings/planting materials 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 amount for best results. The phosphatic fertilizers should not be applied each and every season as the residual phosphate of the previous season will be available for the current season also.
- Proper irrigation
- Crop rotation

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

Farmers should:

- Monitor the field situations at least once a week (soil, water, plants, pests, natural enemies, weather factors etc.)
- Make decisions based on the field situations 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 is defined as the replacement of plant biomass lost to herbivores and has been associated with increased photosynthetic rates and mobilization of stored resources from source organs to sinks (e.g., from roots and remaining leaves to new leaves) during active vegetative growth period. Plant tolerance to herbivory can arise from the interaction of a variety of plant traits and external environmental factors. Several studies have documented such compensation through increased growth and photosynthetic rate.

Understand and conserve defenders:

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

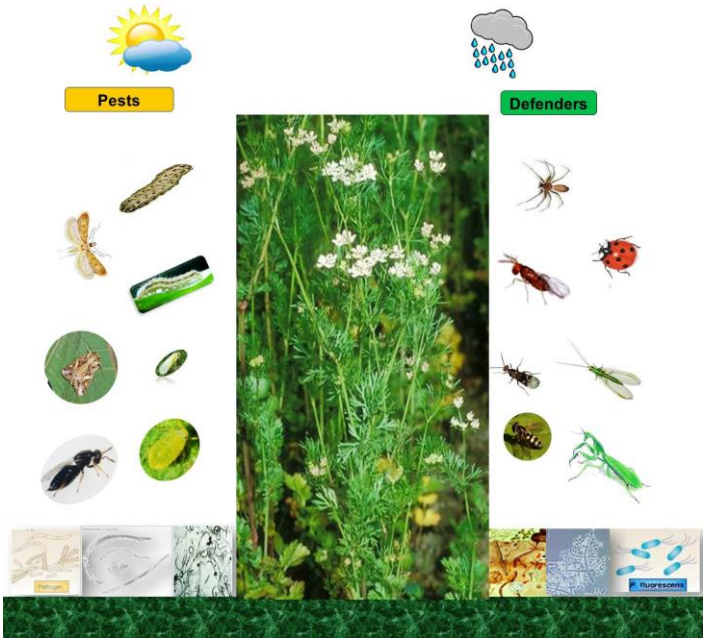
Insect zoo:

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

Pest: Defender ratio (P: D ratio):
Identifying the number of pests and beneficial insects helps the farmers to make appropriate pest management decisions. Sweep net, visual counts etc. can be adopted to arrive at the numbers of pests and defenders. The P: D ratio can vary depending on the feeding potential of natural enemy as well as the type of pest. The natural enemies of coriander 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 situation

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 height, number of leaves, 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 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

- Keeping records of what has happened help us making an analysis and draw conclusions

Data to be recorded:

- **Check the plant growth (weekly):** 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**; I**abour
- **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.

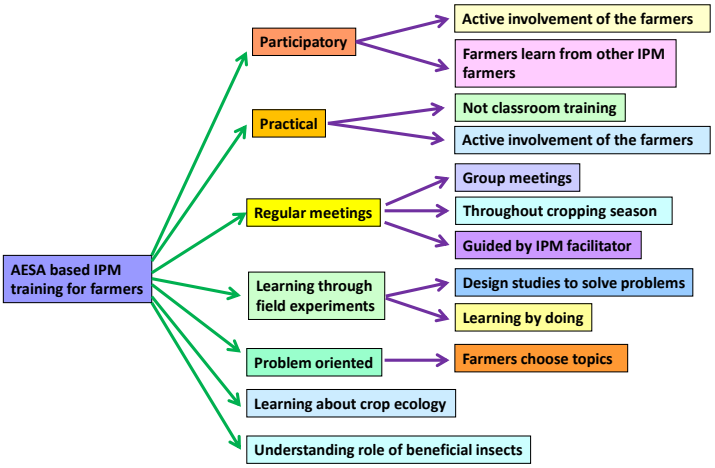
AESA and farmer field school (FFS):

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:

Aphids, white fly: Count and record the number of both nymphs and adults on three randomly selected leaves (top, middle and bottom) per plant.

***Spodoptera*:** Count the number of young and grown up larvae on each plant and record.

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. Surveillance through pheromone trap catches:

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

D. Yellow pan water/blue sticky traps:

Set up yellow pan water traps 15 cm above the canopy for monitoring aphids and blue sticky traps for thrips @ 4-5 traps (15 X 7.5 cm)/acre. Locally available empty tins can be painted yellow/blue and coated with grease/ Vaseline/castor oil on outer surface may also be used as yellow sticky trap. Count the number of aphids on the traps daily and take the appropriate decision regarding management practices.

E. Light traps:

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

F. Nematode extraction:

Collect 100 to 300 cm^3 (200-300 g) representative soil sample. Mix soil sample and pass through a coarse sieve to remove pieces of stones, 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 60-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 rhizobia (PGPR)
- Application of *Trichoderma harzianum/ viride* and *Pseudomonas fluorescens* for treatment of seed/seedling/planting materials in the nurseries and field application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

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

Alfaalfa

Mustard

Cosmos

Anise

Caraway

Dill

***Chrysanthemum* sp.**

Repellent plants

***Ocimum* sp**

Peppermint/Spearmint

Border plants

Maize

Sorghum

Trap plants

Castor

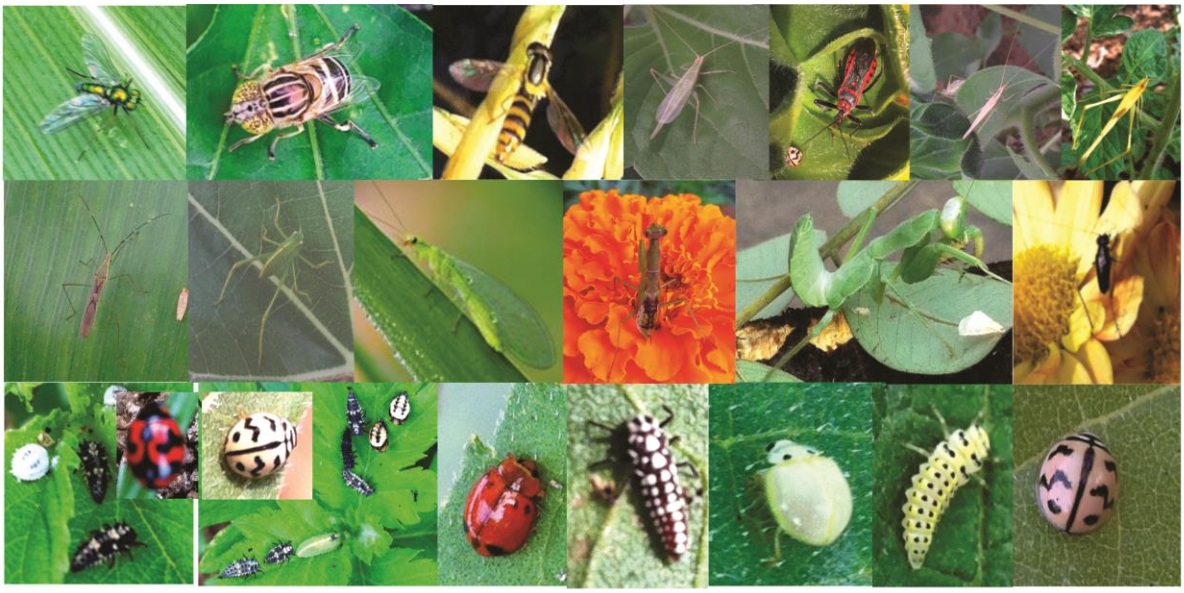
Marigold

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.

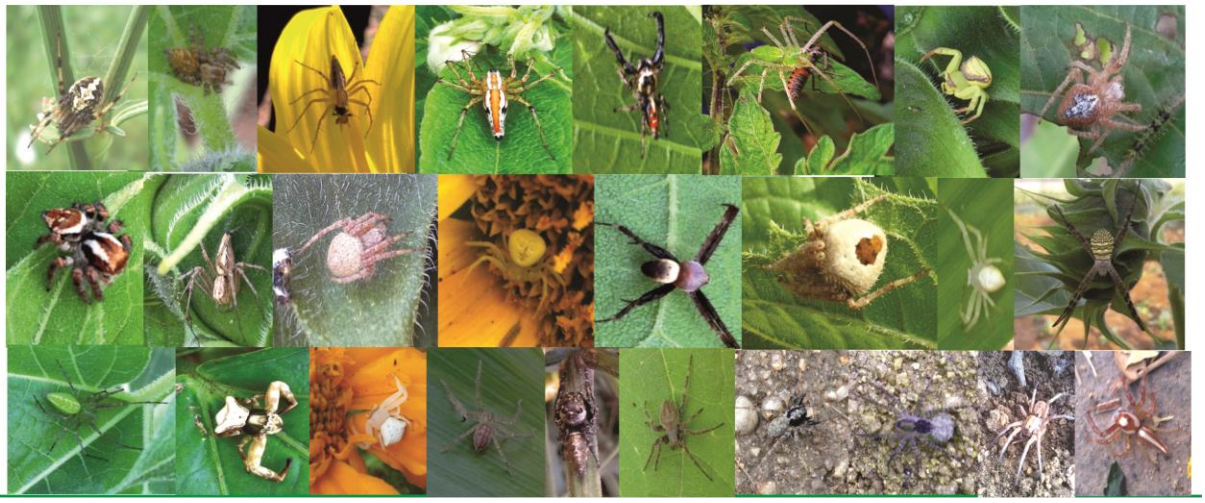
Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



IV. Resistant/tolerant varieties:*

- Co.2: High yielding dual purpose variety, tolerant to drought
- Co.3: Less susceptible to wilt and grain mould
- CS 287: Tolerant to wilt and grain mould
- Karan: Highly resistant to wilt and stem gall disease.
- DH 206: High yielding resistant to powdery mildew
- Hisar Bhoomit: High oil content and resistant to stem gall disease

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

V: CROP STAGE-WISE IPM

Stage wise management	**Activity**
Pre-sowing*	
	<u>Common cultural practices:</u> • Deep ploughing of fields during summer to control nematodes population, to expose pupae, propagules of soil borne pathogens and weeds. • Soil solarization: Cover the beds with polythene sheet of 45 gauge (0.45 mm) thickness for three weeks before sowing for soil solarization which will help in reducing the soil-borne pests including weeds. • Timely and line sowing should be done. • Field sanitation, rogueing • Destroy the alternate host plants • Soil test based application of manures and fertilizers. • Growing castor or marigold as a trap crop for the management of *Spodoptera*. • 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	• Nutrients should be applied on the basis of soil test report and recommendation for particular agro climatic zone. • Apply 4-5 tons of farmyard manure or vermicompost @1.5-2.0 t/acre at the time of last cultivation and incorporate in the soil 2 to 3 weeks before sowing. • Incubate *Trichoderma* @ 500 g in 100 Kg FYM for 15 days prior to its application in one acre field
Weeds	• Summer ploughing should be done in hottest month of the year (May –June).and soil solarization should be done with transparent polyethylene sheet or Adopt stale seed bed in irrigated fields and allow the weed seeds to germinate. Then field is cultivated immediately before sowing of crop to

	destroy the germinating weed seeds.
Soil and seed borne pathogens, nematodes	**<u>Cultural control:</u>** • Plant resistant varieties if nematodes are known to be present in the soil; check roots of plants mid-season or sooner if symptoms indicate nematodes.
Sowing *	
Nutrients	• Seed inoculation with *Azotobacter* (10^7 CFU per g) @ 5 g /Kg seed and PSB @ 8-10g/Kg seed. • Apply 12 Kg of N, 16 Kg P_2O_5 and 8 Kg K_2O per acre as a single basal dose in the black cotton soils. • In light soils under irrigated conditions, apply 18kg of N, 12 Kg of P_2O_5 and 12 Kg of K_2O as basal dose at the time of sowing.
Weeds	• Always use certified and weed free seeds. • Line sowing should be done to facilitate inter-culture operations. • Plant population should be maintained to its optimum right from its beginning to minimize the crop- weed competition. • or adopt soil .
Wilt, blight, root rot, Nematodes and insects**	**<u>Cultural control:</u>** • Select healthy and disease free seeds. • Use resistant /tolerant varieties. • Over irrigation should be avoided to minimize the wilt.
* Application of *Trichoderma harzianum/ viride* and *Pseudomonas fluorescens* for treatment of seed/seedling/planting materials in the nurseries and field application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).	
Vegetative stage	
	<u>Common cultural practices:</u> • Provide irrigation at critical stages of the crop • Avoid water stress and water stagnation conditions. • Enhance parasitic activity by avoiding chemical spray, when larval parasitoids are observed **<u>Common mechanical practices:</u>** • Collection and destruction of eggs, and larvae • Collect and destroy diseased and insect infected plant parts. • Use yellow sticky traps for whitefly and aphids and blue sticky trap for thrips @ 4-5 traps/acre. • Use light trap @ 1/acre and operate between 6 pm and 10 pm • Install pheromone traps @ 4-5 traps/acre for monitoring adult moths activity (replace the lures with fresh lures after every 2-3 weeks) • Erecting of bird perches @ 20/acre for encouraging predatory birds such as King crow, common mynah etc. • Set up bonfire during evening hours at 7-8 pm

	Common biological practices: • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies.
Nutrients	• Apply 12 Kg of N/acre as top dressing at 30 days after sowing. • Micro nutrient deficiency should be corrected by foliar spray of particular nutrient, if required.
Weeds	• During early stages of growth, coriander plants grow very slow, hence weeding during this period is very essential to save the plants from weed competition. • Two hand hoeing should be done at 25 and 50 days after sowing to keep the field weed free before flowering. • In rain fed crop, first weeding should be done at about 25-30 days after sowing and in irrigated crop about 30-35 days after sowing and second weeding at 50-60 days after sowing. • Thinning of plants should be done before first irrigation to maintain a spacing of 5 to 10 cm between plants.
Aphids	• See common cultural and biological practices. • Insecticidal soaps or oils such as neem or canola oil or NSKE 5% are usually the best method of control • Always check the labels of the products for specific usage guidelines prior to use.
Whitefly	• See common cultural and biological practices.
Indigo caterpillar**	• See common cultural and biological practices.
Mite**	• See common cultural and biological practices. • See management practices of Aphids
Cutworm	• See common cultural and mechanical practices. **Biological control:** • Release of *Trichogramma* sp. @ 20,000/acre.
Wilt, stem gall, Stem rot**	**Cultural control:** • Maintain the optimum moisture to minimize the stem gall. • See common cultural and biological practices.
Flowering/Maturity stage	
Nutrients	• Micronutrient deficiency should be corrected by foliar spray of particular micronutrient.
Weeds	• Left over weeds should be removed from the field to avoid further spread of weed seeds.
Thrips, Seed Chalcid fly**	• See common cultural and biological practices.
White fly, aphids, caterpillar, other pests	• Same as vegetative stage.
Stem gall, Stem rot, wilt**	• Same as vegetative stage.
Grain Mould, Powdery Mildews**	**Cultural control** • Harvesting of the mature crop should not be delayed to avoid powdery mildew attack. **Chemical control:**

	• Sulphur 85% DP @ 6-8 kg/acre
Storage	
Pest (khapra beetle) & diseases	• Store in gunny bags with moisture proof lining.

Note: The pesticide dosages and spray fluid volumes are based on high volume spray.

** Regional pests

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

2. Bermuda grass: *Cynodon dactylon* (Poaceae)

3. Lamb's quarter: *Chenopodium album* L. (Chenopodiaceae)

4. Scarlet Pimpernel: *Anagallis arvensis* (Primulaceae)

5. Sweet clover: *Melilotus indica* L. (Fabaceae)

6. Onion weed: *Asphodelus tenuifolius* Cav. (Liliaceae)

7. Purple nut sedge: *Cyperus rotundus* L. (Cyperaceae)

VIII. NUTRITIONAL DEFICIENCIES/DISORDER

Nutrients	Fig.
Nitrogen: Yellowing of old leaves; stunted plant growth. **Correction Measure:** Foliar spray of urea@1-2%.	
Phosphorous: Plant growth is stunted. Leaves become purple to reddish colour. **Correction Measure:** Top dressing of Pfertilizers through soil incorporation @4-5kg P_2O_5 /acre or foliar spray of DAP @ 2%.	 http://4.bp.blogspot.com/_

http://www.indianspices.com/html/spices_spfarm_cori.html
http://agritech.tnau.ac.in/horticulture/horti_spice%20crops_corinader.html
http://www.indianspices.com/html/spices_spfarm_cori.html
http://customers.hbci.com/~wenonah/min-def/plate154.jpg

IX. DESCRIPTION OF INSECT PESTS, MITE AND NEMATODE

1. Whitefly:

Biology:

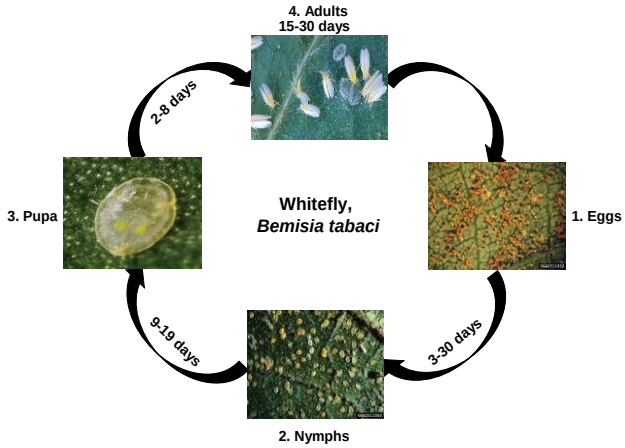
Egg: The females mostly lay eggs near the veins on the underside of leaves. They prefer hairy leaf surfaces to lay more eggs. Each female can lay about 300 eggs in its lifetime. Eggs are small (about 0.25 mm), pear-shaped, and vertically attached to the leaf surface through a pedicel. Newly laid eggs are white and later turn brown. The eggs are not visible to the naked eye, and must be observed under a magnifying lens or microscope. Egg period is about three to five days during summer and 5 to 33 days in winter.

Nymph: Upon hatching, the first instar larva (nymph) moves on the leaf surface to locate a suitable feeding site. Hence, it is commonly known as a “crawler.” It then inserts its piercing and sucking mouthpart and begins sucking the plant sap from the phloem. The first instar nymph has antennae, eyes, and three pairs of well-developed legs. The nymphs are flattened, oval-shaped, and greenish-yellow in color. The legs and antennae are atrophied during the next three instars and they are immobile during the remaining nymphal stages. The last nymphal stage has red eyes. This stage is sometimes referred to puparium, although insects of this order (Hemiptera) do not have a perfect pupal stage (incomplete metamorphosis). Nymphal period is about 9 to 14 days during summer and 17 to 73 days in winter (David 2001). Adults emerge

from puparia through a T-shaped slit, leaving behind empty pupal cases or exuviae.

Adult: The whitefly adult is a soft-bodied, moth-like fly. The wings are covered with powdery wax and the body is light yellow in color. The wings are held over the body like a tent. The adult males are slightly smaller in size than the females. Adults live from one to three weeks.

Life cycle:



1.http://m.animal.memozee.com/m.view.php?q=%EB%8B%B4%EB%B0%B0%EA% B0%80%EB%A3%A8%EC%9D%B4&p=3
2. http://www.forestryimages.org/browse/detail.cfm?imgnum=2511050
3 http://www.fera.defra.gov.uk/plants/publications/documents/factsheets/bemisia.pdf
4. http://www.entomology.umn.edu/cues/inter/inmine/Whitefg.html

Natural enemies of whitefly:

Parasitoids: *Encarsia* sp.*, Eretmocerus mundus*, *Amitus aleurolobi. Platygaster* sp.
Predators: Spiders, *Chelomenus sexmaculatus, Verania discolor, Coccinella septumpunctata, Harmonia octomaculata* etc.

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

2. Indigo caterpillar:

Biology:

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

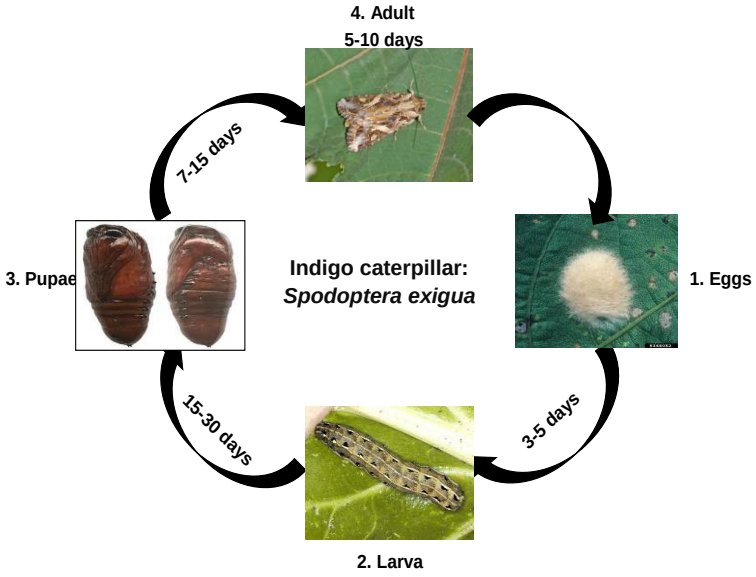
Eggs: Female lays about 300 eggs in clusters. The eggs are covered over by brown hairs and they hatch in about 3-5 days.

Larva: Caterpillar measures 35-40 mm in length, when full grown. It is velvety, black with yellowish – green dorsal stripes and lateral white bands with incomplete ring – like dark band on anterior and posterior end of the body. It passes through 6 instars. Larval stage lasts 15-30 days
Pupa: Pupal stage lasts for 7-15 days and pupation takes place inside the soil.

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

margin of wing. Pest breeds throughout the year. Moths are active at night. Adults live for 7-10 days. Total life cycle is completed in 32-60 days depending on environmental conditions. There are upto eight generations in a year.

Life cycle:



1.http://m.animal.memozee.com/m.view.php?q=%EB%8B%B4%EB%B0%B0%EA% B0%80%EB%A3%A8%EC%9D%B4&p=3
2. http://www.forestryimages.org/browse/detail.cfm?imgnum=2511050
3 http://www.fera.defra.gov.uk/plants/publications/documents/factsheets/bemisia.pdf
4. http://www.entomology.umn.edu/cues/inter/inmine/Whitefg.html

Damage symptoms:

- In early stages, the caterpillars are gregarious and scrape the chlorophyll content of leaf lamina giving it a papery white appearance.
- Irregular holes are produced on leaves initially and later skeletonisation occurs, leaving only veins and petioles

Damage symptoms

Natural enemies of indigo caterpillars:

Parasitoids: *Trichogramma chilonis, Telenomus* spp*., Campoletis chloridae, Peribea orbata, Glipapanteles africanus, Cotesia ruficrus, Chelonus carbonator, Blepherella setigera, Bracon* spp., *Sarcophaga dux* , *Sarcophaga albiceps, Brachimeria lasus, Lasiochalcidia erythropoda.*

Predators: *Chrysoperla zastrowi sillemi*, *C. crassinervis*, King crow, Braconid wasp, Dragon fly, Spider, Reduviid, Preying mantid, *Harpactor costalis, Rhynocoris fuscipes, R. squalis , Polistes stigma, Coranus spiniscutis, Andrellus spinidens,* etc

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

3. Aphid:

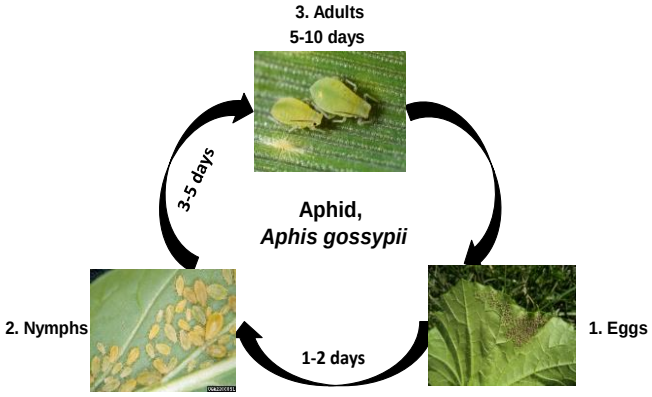
Biology:

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

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

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

Life cycle:



1.. http://www.flickr.com/photos/23293858@N04/2672985270/
2. http://pubs.ext.vt.edu/2902/2902-1081/2902-1081.html
3. http://www.flickr.com/photos/25848431@N02/7479982150/

Damage symptoms:

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

http://itallgrows.com/tag/aphids/

Natural enemies of aphid:

Parasitoids: *Aphidius colemani* and *Diaeretiella* sp

Predators: Fire ant, Robber fly, Big-eyed bug (*Geocoris* sp), Earwig, Ground beetle, Cecidomyiid fly, Lacewing, Ladybird beetle, Spider, Preying Mantid, Reduviid, Dragon fly, hoverfly, etc.

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

4. Cutworm:

Biology:

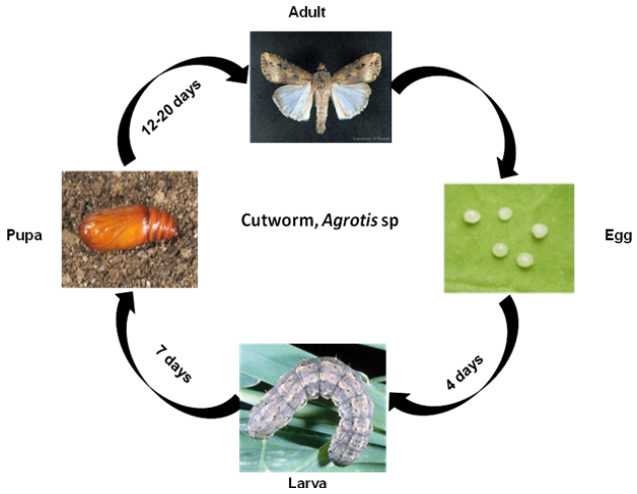
Egg: The egg is white in color initially, but turns brown with age. It measures 0.43 to 0.50 mm high and 0.51 to 0.58 mm wide and is nearly spherical in shape, with a slightly flattened base. The eggs normally are deposited in clusters on foliage. Females may deposit 1200 to 1900 eggs. Duration of the egg stage is three to six days.

Larva: There are five to nine instars, but six to seven instars are most common. Head capsule widths are about 0.26-0.35, 0.45-0.53, 0.61-0.72, 0.90-1.60, 2.1-2.8, 3.2-3.5, 3.6-4.3, and 3.7-4.1 mm for instars one to eight respectively. Head capsule widths are very similar for instars one to four, but thereafter those individuals that display eight or nine instars show only small increments in width at each moult and eventually attain head capsule sizes no larger than those displaying only six or seven instars.

Pupa: Pupation occurs belowground at a depth of 3 to 12 cm. The pupa is 17 to 22 mm long and 5 to 6 mm wide, and dark brown. Duration of the pupal stage is normally 12 to 20 days.

Adult: The adult is fairly large in size, with a wingspan of 40 to 55 mm. The forewing, especially the proximal two-thirds, is uniformly dark brown. The distal area is marked with a lighter irregular band, and a small but distinct black dash extends distally from the bean-shaped wing spot. The hind wings are whitish to gray, and the veins marked with darker scales. The adult pre-oviposition period is about seven to 10 days.

Life cycle:



http://en.wikipedia.org/wiki/Agrotis_ipsilon

Damage symptoms:

- The larva cuts the plants from ground level and makes them to fall down. Infestation of this pest starts at the initial stage of plants resulting in heavy loss to the crop.

Natural enemies of cutworm:

Parasitoids: *Apanteles merginiventris, Chelonis insularis, Hyposoter exigua, Chelonis insularis, Lespesia archippivora.*

Nematode: *Hexameris arvalis*

Predators: *Broscus punctatus*, *Liogryllus bimaculatus.*

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

5. Thrips:

Biology:

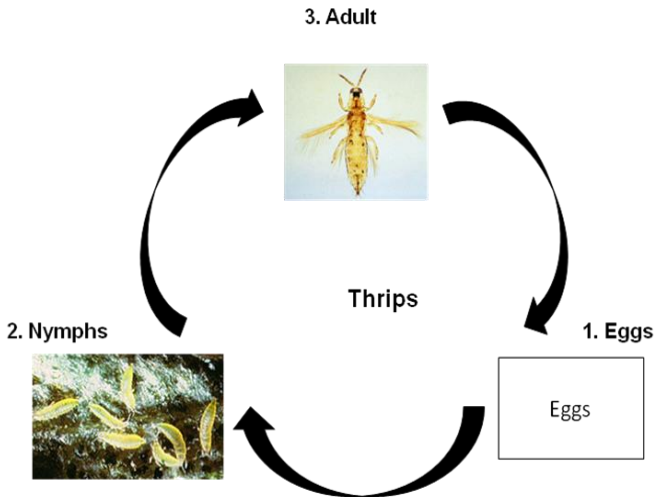
Egg: Eggs are microscopic and white or yellow in color which is inserted one by one in the plant tissues by the females. Only one end of the egg will be near the surface of the tissue to allow the immature to emerge. Adults prefer to lay their eggs in leaf, cotyledon or flower tissues.

Nymph: Nymphs are very small, pale yellow to brown in color and the pupae appear as an intermediate form between the immature and the adult. Nymphs have short antennae and the wing buds are visible but short and not functional. They are found at the base of the plant neck or in the soil.

Adult: Adults are up to 2 mm in size, pale yell**ow to** dark brown in color and have fully developed wings which are very different from other insects. They have a single longitudinal vein in which there is several hairs connected perpendicular to the vein. The wing appears as fringe with hairs. When at rest, the wings are folded along the back of the insect... Besides undersurface of leaves, they can also be found in the flowers. Adults are more mobile than immature and are attracted to yellow and white colors. They often alight on one's clothes or on

exposed skin.

Life cycle:



1,2, http://web.entomology.cornell.edu/shelton/veg-insects-global/english/thrips.html

Damage symptoms:

- Thrips have a very peculiar feeding behavior. They start the feeding by rasping and sucking and they lacerate the leaf surface with their mouth parts to release the liquids from the plant cells. In this process, thrips release chemicals substances that help to predigest the cell sap. Which they suck up.
- The damaged leaves show silvery patches or streaks that shine in the sun. When damage is severe, these small patches can occupy most of the surface of the leaf and the plant cannot adequately photosynthesize. The plant loses more water than normal through the damaged tissues which are the entry points for plant pathogens.

Natural enemies of thrips:

Parasitoid: *Ceranisus menes*

Predators: Predatory mite, Predatory thrips, *Oligota* spp., *Orius* spp. (pirate bug), Hover fly, Mirid bug, etc.

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

6. Mites:

Biology:

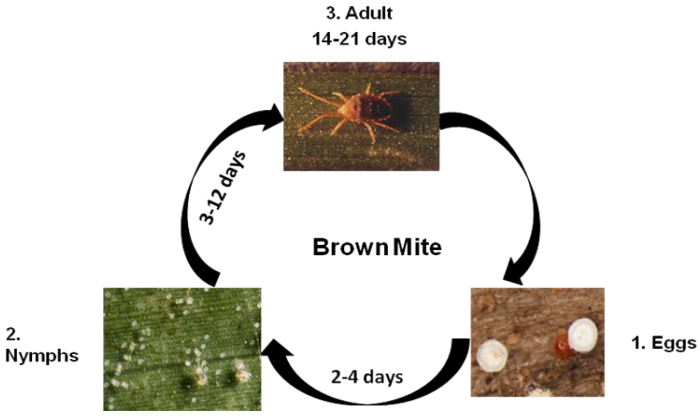
Egg: Eggs are microscopic, hyaline, globular, laid in masses beneath clods and are either active (red in colour) or dormant (iwhite in colour).

Nymphs: Yellowish in colour

Adult: The mites are very small measuring about 0.5 mm in length, metallic brown to black with

pale yellow legs. Their forelegs are distinctively longer than the other three pairs

Life cycle:



1,2,3:

https://www.google.co.in/search?q=Petrobia+lateen&espv=210&es_sm=93&source=lnms&tbm=isch&sa=X&ei=dYINU6btCMK-rgetp

Damage symptoms

- The mites frequently attack the coriander crop and whole plant becomes whitish yellow and appears sickly. It mostly feeds on young leaves and the infestation is more severe on young inflorescence.
- Mites are seen on the lower side of the leaves and when serious, cause webbing and feed from within the web. Plants get stunted at severe infestation.

Damage Symptom

Natural enemies of mites:

Predators: Anthocorid bugs (*Orius* spp.), mirid bugs, syrphid/hover flies, green lacewings (*Mallada basalis* and *Chrysoperla zastrowi sillemi* .), predatory mites (*Amblyseius alstoniae*, *A. womersleyi, A. fallacies* and *Phytoseiulus persimilis*), predatory coccinellids (*Stethorus punctillum*), staphylinid beetle (*Oligota* spp.), predatory cecidomyiid fly (*Anthrocnodax occidentalis*), predatory gall midge (*Feltiella minuta*), Predatory thrips etc.

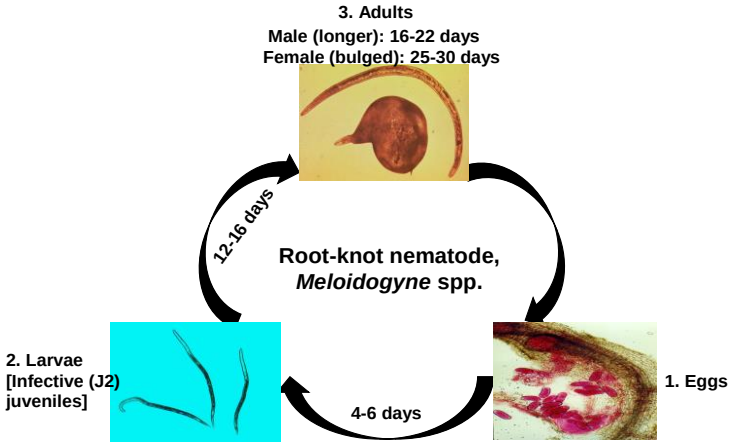
*For management refer to page number----------

7. Root knot nematode:

Biology:

- Most species of plant parasitic nematodes have a relatively simple life cycle consisting of the egg, four larval stages and the adult, male and female.
- Development of the first stage larvae occurs within the egg where the first moult occurs. Second stage larvae hatch from eggs and infest plant roots or in some cases foliar tissues.
- Under suitable environmental conditions, the eggs hatch and new larvae emerge to complete the life cycle within 4 to 8 weeks depending on temperature.
- Nematode development is generally most rapid within an optimal soil temperature ranging from 39-45^0 C.

Life cycle:



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

Damage symptoms:

- Infested plants appear in patches in the field
- Formation of galls on host root system is the primary symptom
- Roots branch profusely starting from the gall tissue causing a '**beard root**' symptom
- Infected roots become knobby and knotty
- In severely infested plants the root system is reduced and the rootlets are almost completely absent hampering their function of uptake and transport of water and nutrients.
- Plants wilt during the hot part of day, especially under dry conditions and are often stunted.
- Nematode infestation predisposes plants to fungal and bacterial root pathogens.

Damage symptoms

Survival and spread:
Primary: Egg masses in infested plant debris and soil or collateral and other hosts like Solonaceous, Malvaceous and Leguminaceous plants act as sources of inoculum.
Secondary: Autonomous second stage juveniles that may also be water dispersed.
Favourable conditions:
Loamy light soils.
*For management refer to page number----------

Natural Enemies of Coriander Insect Pests

Parasitoids

Egg parasitoids

1. *Trichogramma* spp.

2. *Telenomus* spp.

Egg-larval parasitoid

4. *Chelonus* spp.

Larval parasitoids

5. ***Bracon*** **spp.**

6. ***Ichneumon*** **spp.**

7. ***Carcelia*** **spp.**

8. ***Campoletis*** **spp.**

9. ***Apanteles sp***

10. ***Microgaster*** **sp.**

Pupal parasitoid

11. ***Brachymeria euploeae***

Nymphal/larval and adult parasitoids

12. ***Chrysocharis*** **sp**

13. ***Aphidius*** **sp**

14. ***Encarsia formosa***

15. ***Eretmocerus*** **spp.**

3 http://baba-insects.blogspot.in/2012/02/telenomus.html
4 http://www.nbaii.res.in/Featured%20insects/chelonus.htm
6 http://www.organicgardeninfo.com/ichneumon-wasp.html
7 http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398
8. http://www.nbaii.res.in/Featured%20insects/Campoletis.htm
9 http://www.european-lepidopteres.fr/Videos-parasites-Apanteles.html
10.http://www.commanster.eu/commanster/Insects/Bees/SuBees/Microgaster.rufipes.html
11http://www.nhm.ac.uk/researchcuration/research/projects/chalcidoids/database/media.dsml?IMAGENO=chalc519&VALGENUS=Brachymeria&VALSPECIES=euploeae
12. http://baba-insects.blogspot.in/2012/05/blog-post_
13 http://biobee.in/products-and-services/solutions/bio-aphidius/
14.http://www.buglogical.com/whitefly-control/encarsia-formosa/
15.http://www.dongbufarmceres.com/main/mboard.asp?strBoardID=c_product01_en

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 mantid

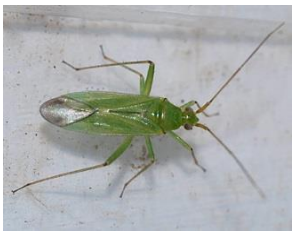
14. Predatory mite

15. Predatory thrips

16. *Oligota* spp.

17. *Orius* spp.

18. Hover fly



19. Mirid bug

20.*Broscus punctatus*

21. *Liogryllus bimaculatus*

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://www.dragonfli.co.uk/natural-pest-control/natural-enemies
15. http://biocontrol.ucr.edu/hoddle/persea_mite.html
16. http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33
17. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
19. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html
20. http://en.wikipedia.org/wiki/Broscus
21. http://lapastbknk.blogspot.in/2012/09/ramai-ramai-melirik-budi-daya-jangkrik.html

X. DESCRIPTION OF DISEASES

1. Powdery mildew:

Disease symptoms:

- It appears as small, white, powdery patches on young parts of stems, leaves and buds which increases in size, and coalesce to cover entire area of leaf surface.
- Affected leaves are reduced in size and distorted. Premature sterility is also common. in serve cases, the umbels dry up.
- Seed formation may not take place in affected plants due to this disease.

Survival and spread:

- Fungus can survive in plant debris in the form of cleistothecia and spread long distances by air.

Favourable conditions:

- Disease emergence is favored by high humidity and moderate temperatures (cloudy weather); infection is most severe in shaded areas.


1,2: http://frontrangefoodgardener.blogspot.in/2011_06_01_archive.html

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

2. Wilt:

Disease symptoms:

- The disease can easily be recognized in the field by drooping of the terminal portions, followed by withering and drying up of leaves, eventually resulting in death.
- Discoloration of vascular system of the root is observed. Partial wilting is also found. In partially wilted plants, growth is arrested.
- The leaves become pinkish yellow to yellow. Sterility is often noticed in such plants. Seeds, if formed are immature and light in weight.
- Severe infection in the early stage results in total failure of the crop.

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.


1. **2.**

Disease symptoms

1,2: http://www.agriculture.gov.sk.ca/Default.aspx?DN=bbd5605d-c129-478d-bde3-

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

3. Stem gall:

Disease symptoms:

- The disease appears in the form of tumor-like swellings of leaf veins, leaf stalks, peduncles, stems as well as fruits. The infected veins show a swollen hanging appearance to the leaves.
- Initially the tumors are glossy which rupture later on and become rough. They are about 3 mm broad and up to 12.5 mm long.
- Badly affected plants may be killed. In the presence of excessive soil moisture, especially under shaded conditions, when the stem fails to harden and remain succulent, the tumors are numerous.

Survival and spread:

- The disease is soil borne and the inocula present in the soil are the source of primary infection. Pathogen may survive in soil as resting spore for several years.

Favourable conditions:

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

Disease symptoms

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

4. Blight disease:

Disease symptoms:

- Dark brown spots appear on the stem and leaves of infected plants and emerging umbels with young flowers get killed.
- L**a**ter in the season when plants are beginning to mature it may be difficult to recognise a diseased field except reduced seed production.

Survival and spread:

- The pathogen survives through conidia or mycelia in diseased plant debris or weed or in soil.

Favourable conditions:

- Moist (More than 70% relative humidity) and warm weather (12-25 ºC temp) and intermittent rains favour disease development.

1. **2.** **3.**

Disease symptoms

1,2,3: http://www.usask.ca/agriculture/plantsci/vegetable/med/mcumin.htm

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

5. Stem rot:

Disease symptoms:

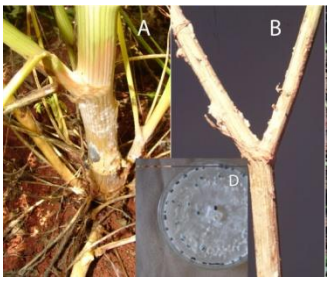
- Infected seeds fail to germinate; rapid death of germinating seeds prior to emergence; water-soaked reddish lesions girdling the stem at the collar region results in the collapsing of emerged seedlings .

Survival and spread:

- The pathogen survives as mycelium in dead or live plants and as sclerotia in infected plant parts or on the soil surface or with seed as contaminant.
- The fungus can spread in water, contaminated soil or on equipment.

Favourable conditions:

- Rainy season favours the development of disease.



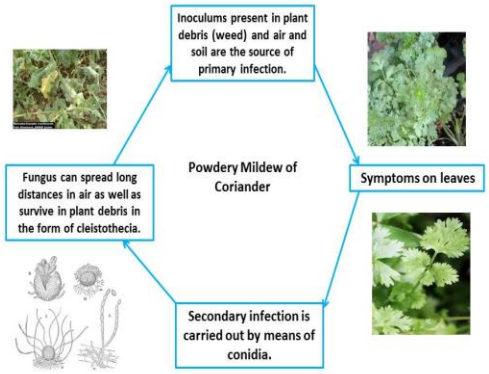
Disease symptom

https://www.google.co.in/search?q=stem+rot+of+corian der&espv= 210& es_sm=93& source=lnms&tbm=isch&sa =X&e

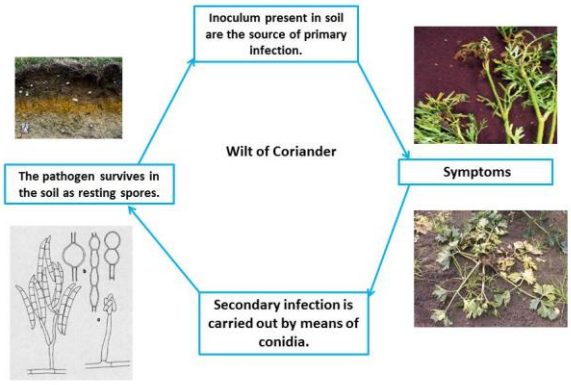
*For management refer to page number----------

Disease cycle:

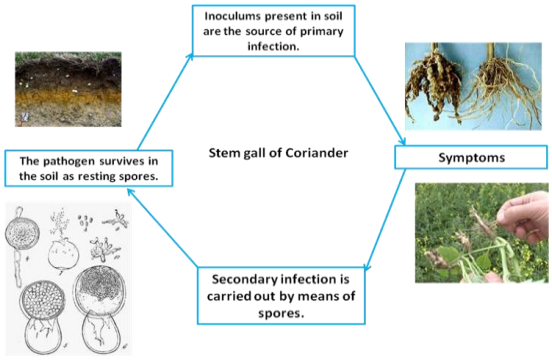
1. Powdery mildew:



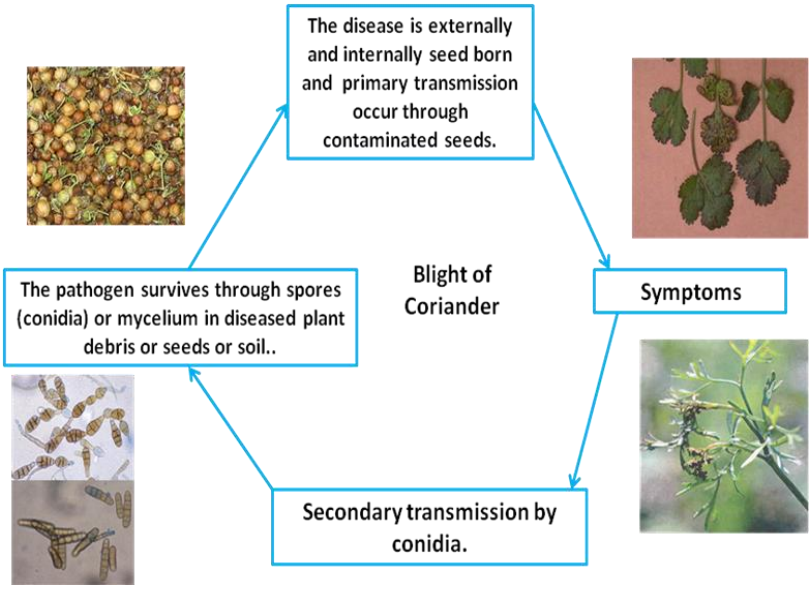
2. Wilt:



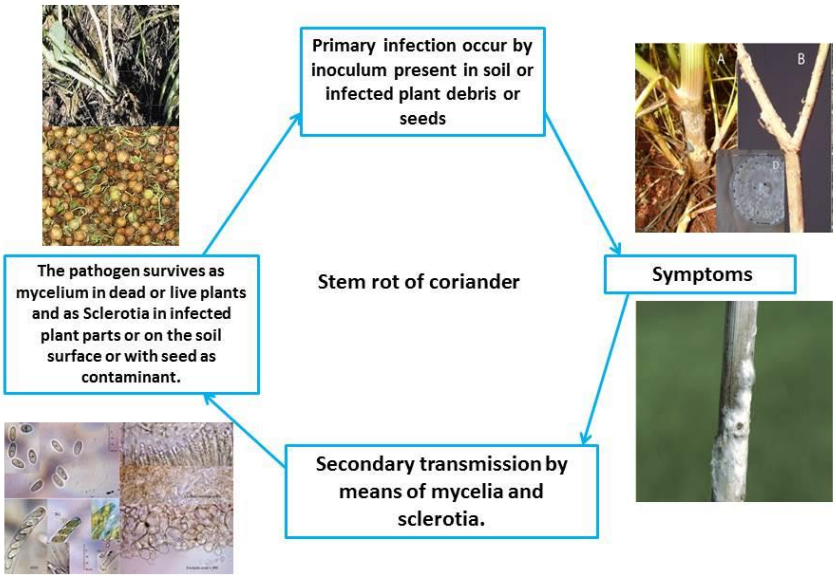
3. Stem gall:



4. Blight:



5. Stem rot:



XI. SAFETY MEASURES

A. During pre-harvest:

- Straight combining coriander when it is fully mature is preferred over swathing and combining, as coriander is prone to shattering.
- If not straight combining, coriander should be swathed when 80 per cent of the seeds turn purple-brown.
- Swathes should not be left out too long due to the potential for shattering. Swathing when there is dew or high humidity will reduce shattering losses.
- Combining is usually done when seed moisture content is less than 15 per cent. At 10 per cent moisture, coriander is considered dry, but buyers prefer 9 per cent. Cylinder/rotor speeds should be set at approximately 500 rpm under dry conditions.
- An initial setting of 0.5 in. (12 mm) at the front and 0.25 in. (6 mm) at the back is suggested. Wind speed should be enough to reduce dockage, return speed should be reduced to the minimum and ground speed should be slowed.
- Crop samples must be free of rodent droppings and have very low foreign material (2 per cent). If samples have greater than 5 per cent split fruit, the shipment is usually discounted by the buyer.

B. During post-harvest harvest storage:

- Coriander oil is very volatile, so the seed must be dried gently up to 9% moisture; avoid hot air drying.
- Aeration is useful for reducing moisture content; however, coriander seed readily takes up other odours, so store away from gasoline, herbicides etc.

- Remove green material such as weed seeds as quickly as possible, since aeration will be diverted around these areas in the storage bin, resulting in the potential for spoilage.

XII. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The field should be kept exposed to sun light at least for 2-3 weeks.	Do not plant or irrigate the field after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Adopt crop rotation	Avoid monocropping.
3.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or region.
4	Sow early in the season	Avoid late sowing as this may lead to reduced yields and incidence of pests.
5	Always treat the seeds with approved chemicals/bio products for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with biocides/chemicals.
6.	Adopt line sowing and plant proper spacing in the field.	Do not broadcast the seeds
7.	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.
8.	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
9.	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
10	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
11	Install pheromone traps at appropriate period.	Do not store the pheromone lures at high temperature and preferably store in refrigerator.
12	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.

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

XIII. SAFETY PARAMETERS IN PESTICIDE USAGE

S. No.	Pesticide Classification as per insecticide rules 1971 Colour of toxicity triangle	WHO classification of hazard	Symptoms poisoning	First aid measures and treatment of poisoning	Waiting period from last application to harvest (days)
1.	Sulphur Slightly toxic 	-	Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc	No specific antidote. Treatment is essentially symptomatic	-

XIV. 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. Equipment
   1. Select right kind of equipment.
   2. **Do not** use leaky and defective equipment
   3. Select right kind of nozzles
   4. **Do not** 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
7. Avoid tank mixing of different pesticides

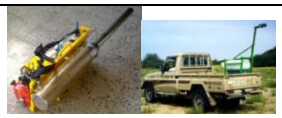
G. Disposal

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

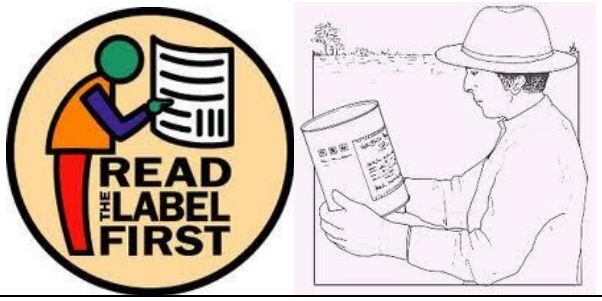
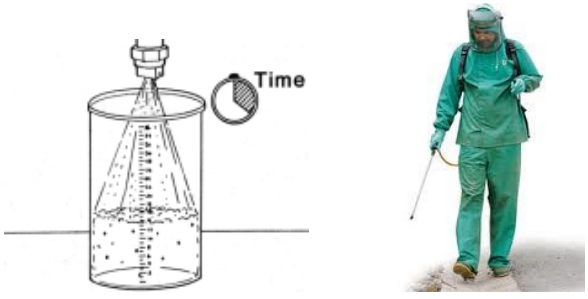
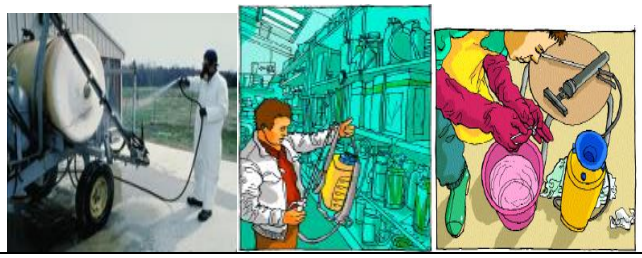
XV. PESTICIDE APPLICATION TECHNIQUES

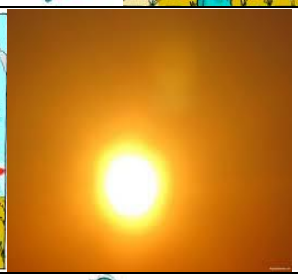
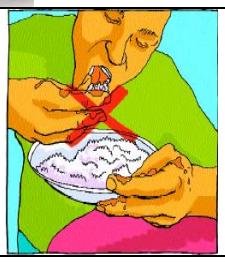
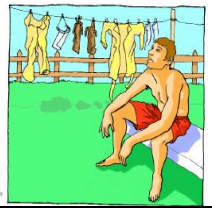
<table>
<tr><td colspan="4">Equipments</td></tr>
<tr><td colspan="4">Category A: Stationary, crawling pest/disease</td></tr>
<tr><td rowspan="2">Vegetative stage
i) For crawling and soil borne pests

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

Reproductive stage *(Field Pests)*	fungicides	sprayer or mist blower (Droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle ***Or*** • Battery operated low volume sprayer (Droplets of small size) Spinning disc nozzle	
Mosquito/ locust and spatial application *(migratory* Pests)	Insecticides and fungicides	• Fogging machine and ENV (Exhaust nozzle vehicle) (Droplets of very small size) • Hot tube nozzle	

XVI. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

1.	For application rate and dosage see the label and leaflet of the particular pesticide.	
2.	It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.	
3.	Clean and wash the machines and nozzles and store in dry place after use.	

4.	It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides. Do not apply pesticides without protective clothing and wash clothes immediately after spray application.	 
5.	Do not apply in hot or windy conditions.	 
6.	Operator should maintain normal walking speed while undertaking application.	
7.	Do not smoke, chew or eat while undertaking the spraying operation	 
8.	Operator should take **proper bath with soap** after completing spraying	  

9.	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

XVII. References:

- http://www.eduwebs.org/bugs/predatory_mites.htm
- http://m.animal.memozee.com/m.view.php?q=%EB%8B%B4%EB%B0%B0%EA%B0%80%EB%A3%A8%EC%9D%B4&p=3
- http://www.forestryimages.org/browse/detail.cfm?imgnum=2511050
- http://www.fera.defra.gov.uk/plants/publications/documents/factsheets/bemisia.pdf
- http://www.entomology.umn.edu/cues/inter/inmine/Whitefg.html
- http://www.buglogical.com/whitefly-control/encarsia-formosa/
- http://www.dongbufarmceres.com/main/mboard.asp?strBoardID=c_product01_en
- https://www.google.co.in/search?q=Harmonia+octomaculata&espv=210&
- https://www.google.co.in/search?q=Verania+discolor&btnG=
- http://llladybug.blogspot.in/
- http://commons.wikimedia.org/wiki/File:Geocoris_punctipes.jpg
- http://m.animal.memozee.com/m.view.php?q=%EB%8B%B4%EB%B0%B0%EA%B0%80%EB%A3%A8%EC%9D%B4&p=3
- http://www.forestryimages.org/browse/detail.cfm?imgnum=2511050
- http://www.fera.defra.gov.uk/plants/publications/documents/factsheets/bemisia.pdf
- http://www.entomology.umn.edu/cues/inter/inmine/Whitefg.html
- http://baba-insects.blogspot.in/2012/02/telenomus.html
- http://www.nbaii.res.in/Featured%20insects/chelonus.htm
- http://www.nbaii.res.in/Featured%20insects/Campoletis.htm
- http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398
- http://www.organicgardeninfo.com/ichneumon-wasp.html
- http://spirit-animals.com/praying-mantis/
- http://en.wikipedia.org/wiki/Dragonfly
- http://www.warpedphotosblog.com/robber-fly-and-prey
- http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
- http://somethingscrawlinginmyhair.com/2011/09/17/yellowjacket-with-prey/
- http://www.flickr.com/photos/23293858@N04/2672985270/
- http://pubs.ext.vt.edu/2902/2902-1081/2902-1081.html
- http://www.flickr.com/photos/25848431@N02/7479982150/
- http://biobee.in/products-and-services/solutions/bio-aphidius/
- 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
- http://www.warpedphotosblog.com/robber-fly-and-prey.
- http://bugguide.net/node/view/598529
- http://www.flickr.com/photos/johnhallmen/2901162091/
- http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/ Ground%20Beetle%20-%20Pterostichus%20madidus.htm
- http://jenny.tfrec.wsu.edu/opm/displaySpecies.php?pn=740
- http://en.wikipedia.org/wiki/Agrotis_ipsilon
- http://www.commanster.eu/commanster/Insects/Bees/SuBees/Microgaster.rufipes.html
- http://en.wikipedia.org/wiki/Broscus
- http://lapastbknk.blogspot.in/2012/09/ramai-ramai-melirik-budi-daya-jangkrik.html

- http://web.entomology.cornell.edu/shelton/veg-insects-global/english/thrips.html
- http://web.entomology.cornell.edu/shelton/veg-insects-global/english/thrips.html
- http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
- http://biocontrol.ucr.edu/hoddle/persea_mite.html
- http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33
- http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
- http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html
- https://www.google.co.in/search?q=Petrobia+lateen&espv=210&es_sm=93&source=lnms&tbm=isch&sa=X&ei=dYINU6btCMK-rgetp
- http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
- http://biocontrol.ucr.edu/hoddle/persea_mite.html
- http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33
- http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
- http://freepages.misc.rootsweb.ancestry.com/~larsonmorgan/flies/flies.html
- http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html
- http://keys.lucidcentral.org/keys/sweetpotato/key/Sweetpotato%20Diagnotes/Media/Html/TheProblems/Nematodes/RootKnotNematode/Root-knot.htm
- http://nematology.umd.edu/rootknot.html
- http://www.cals.ncsu.edu/pgg/dan_webpage/Introduction/Images/pyroform.htm
- http://frontrangefoodgardener.blogspot.in/2011_06_01_archive.html
  http://www.agriculture.gov.sk.ca/Default.aspx?DN=bbd5605d-c129-478d-bde3-
- http://www.usask.ca/agriculture/plantsci/vegetable/med/mcumin.htm
- https://www.google.co.in/search?q=stem+rot+o f+ coriander &espv= 210&es_ sm=93&sourc e =lnm s&tbm =isch &sa=X& ei=F5YhU 9mfKomQr QfUuIC wCA&ve d=0CAkQ_ AUoAQ&biw= 1280&bih=6 56.
- http://www.indianspices.com/html/spices_spfarm_cori.html
- http://agritech.tnau.ac.in/horticulture/horti_spice%20crops_corinader.html
- http://www.indianspices.com/html/spices_spfarm_cori.html
- http://customers.hbci.com/~wenonah/min-def/plate154.jpg