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AESA BASED IPM PACKAGE

LENTIL

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

National Institute of Plant Health Management
Rajendranagar, Hyderabad, Telangana

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

The AESA based IPM – Lentil 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.

NIPHM Working Group:

Chairman : Smt. V. Usha Rani, IAS, Director General
Vice-Chairmen : Dr. S. N. Sushil, Plant Protection Advisor
: Dr. K. Vijaya lakshmi, 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. Dr. S. Jesu Rajan, Assistant Scientific Officer (PHM), Entomology Expertise.

Contributions by DPPQ&S Experts:

1. Dr. M. Saleem, Assistant Director, Plant Pathology
2. Dr. D.K. Nagaraju, Assistant Director, Entomology
3. Dr. Gnansambandhan, Assistant Director (Weed Science)

Contributions by External Experts:

1. Dr. M. P. Thakur, Director of Extension Services,Indira Gandhi Krishi Vidyapeeth, Raipur. (C.G.)
2. Dr. R. Swaminathan, Professor & Head, Department of Entomology, Rajasthan College of Agriculture, Maharan Pratap University of Agriculture and Technology, Udaipur, Rajasthan
3. Dr. S. L. Godara, Professor (Plant Pathology) Zonal Director Research, Agricultural Research Station, Swami Keshwanand Rajasthan Agricultural University, Beechwal, Bikaner.
4. Dr. R.S. Gill, Professor and Head, Department of Entomology, Punjab Agricultural university, Ludhiana, Punjab.
5. Dr. G.N. Hazarika, Director of Research, Assam Agricultural University, Assam.
6. Dr. A.P. Bhagat, Chairman, Department of Plant Pathology, Bihar Agriculture University, Sabour, Bihar.
7. Dr. S.N. Ray,Chairman, Department of Entomology, Bihar Agriculture University, Sabour, Bihar.
8. Dr.Shoumidra B. Das, Principal Scientist (Ent.) Department of Entomology College of Agriculture Jawaharlal Nehru Agricultural University Adhartal, Krishinagar, Jabalpur - 482

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Lentil plant description:

Lentil (*Lens culinaris*), is a legume crop that belongs to Leguminosae family.Theseeds are lens-shaped, rich in protein and is one of the most ancient crops. The seeds are used chiefly in soups and the herbage as fodder. Lentils are a good source of vitamin B, iron, and phosphorus. The plant varies from 15 to 45 cm (6 to 18 inches) in height and has many long, ascending branches.. The pods are about 15–20 mm long, broadly oblong, slightly inflated and contain two seeds the shape of a doubly convex lens and about 4–6 mm in diameter. There are many cultivated varieties of the plant, differing in size, hairiness, and colour of the leaves, flowers, and seeds. The seeds may be more or less compressed in shape, and the colour may vary from grey to dark brown; they are also sometimes mottled or speckled.

I. PESTS

A. Pests of National Significance:

1. Insect pests

1.1. Cow pea aphid: *Aphis craccivora* Koch (Hemiptera: Aphididae)
1.2. Pea aphid: *Acyrthosiphon pisum* Haris (Hemiptera: Aphididae)
1.3. Leaf weevil: *Sitona* spp. (Coleoptera: Curculionidae)
1.4. Lygus bugs: *Lygus* spp. (Hemiptera: Miridae)
1.5. Cut worm: *Agrotis ipsilon* (Hufnagel) (Lepidoptera: Noctuidae)
1.6. Thrips: *Thrips tabaci* Lindeman (Thysanoptea: Thripidae)
1.7. Pod borers: *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae)
1.8. Spiny pod borer: *Etiella zinckenella* (Treit.) (Lepidoptera: Pyralidae)
1.9 Pulse beetles: *Bruchus* spp., *Callosobruchus* spp. (Coleoptera: Bruchidae)

2. Diseases

2.1. Root rot and seedling disease: *Pythium ultimum* Trow, *Rhizoctonia solani* Kühn
2.2. Fusarium wilt : *Fusarium oxysporum (*Schlecht)Snyder & Hansen (Hypocreales: Nectriaceae)
2.3. Lentis rust: *Uromyces fabae* (Pers.) Schröt.
2.4. Ascochyta blight: *Ascochyta lentis* Jellis & Punith
2.5. Anthracnose: *Colletotrichum truncatum* (Schwein.) Andrus & Moore
2.6. Powdery mildew: *Erysiphe pisi* DC.,
2.7. *Sclerotinia* rot/collar rot: *Sclerotinia rolfsii* Sacc.
2.8. Pea enation mosaic virus
2.9. Bean yellow mosaic virus
2.10. Pea seed borne mosaic virus (PSBMV).

3. Weeds

Broadleaf weeds

3.1. Field bind weed: *Convolvulus arvensis* L. (Convolvulaceae)
3.2. Lambs quarter: *Chenopodium album* L. (Chenopodiaceae)
3.3. Sweet clover: *Melilotus indica* (L.) All. (Fabaceae)
3.4. Scarlet pimpernel: *Anagalis arvensis* (Primulaceae)
3.5. Onion weed: *Asphodelus tenuifolius* Cav. (Liliaceae)
3.6. *C*arrot grass: *Parthenium hysterophorus* L. (Asteraceae)
3.7. Benghal dayflower: *Commelina benghalensis* L. (Commelinaceae)

Grasses

3.8. Wild oat: *Avena ludoviciana* (L.) Nees. (Poaceae)
3.9. Canary grass: *Phalaris minor* Retz. (Poaceae)

Sedges

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

Parasitic weed

3.12. Dodder: *Cuscuta* spp.(Convolvulaceae)
3.13. Broomrape: *Orobanche* spp. (Orobanchaceae)

4. Nematode

4.1 Cyst nematode: *Heterodera ciceri* (Tylenchida: Heteroderidae)

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 white 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 material
- Treat the seeds/seedlings/planting material with recommended pesticides especially biopesticides
- Follow proper spacing
- Soil health improvement (mulching and green manuring wherever applicable)
- Nutrient management especially organic manures and biofertilizers based on the soil test results. If the dosage of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dosage is too low, the crop growth is retarded. So, the farmers should apply an adequate 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

- Observe the soil physical condition, moisture level, etc.
- Take representative soil sample and get the soil analysis report showing soil pH, electrical conductivity (EC), organic matter and nutrient status.
- Observe the number and species of weeds found in per square meter area each in five randomly selected spots/ha
- Monitor the field situation of the orchrad at least once a week (soil, water, plants, pests, natural enemies, weather factors etc.)
- Make decisions based on the field situation and P: D ratio
- Take direct action when needed (e.g. collect egg masses, remove infested plants etc.)

http://www.centrestateexports.com.au/services/lentils.aspx

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

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

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

- Visit field in groups (about 5 farmers per group). Walk across the field diagonally and observe 20 plants randomly. Observe keenly each of these plants and record your observations:

    - Plant: Observe the plant height, number of branches, crop stage, deficiency symptoms etc.
    - Pests: Observe and count insect pests from different parts of the plant.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
    - Rats:. Look for live burrows and observe damage caused.
    - Weeds: Observe the growth and intensity of weeds.
    - 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 conditions, 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 brances, 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.

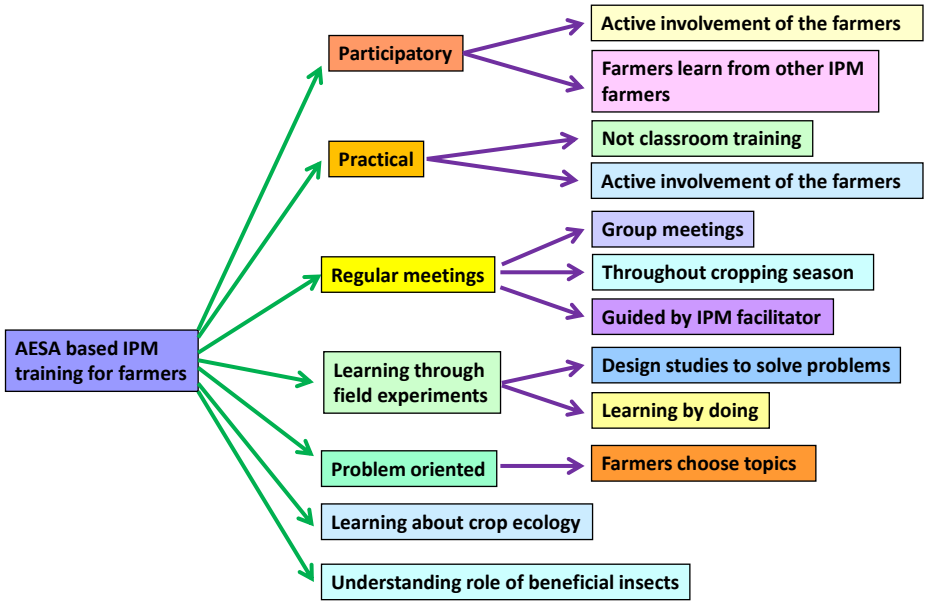
AESA and farmer field school (FFS):

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 field should commence soon after crop establishment and at weekly intervals thereafter. In each 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: Count and record the number of both nymphs and adults from top 10 cm terminal shoot of the randomly selected plants.

Spiny pod borer: Count and record the number of pods damaged by the borer.

Cut worms: Count and record the number of plants damaged by the cutworms per meter row length.

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

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

Stem and pods sampling: Carefully examine the stemsand pods of plants for signs of fungal material diseases or lesions. The stemsand pods should be split or taken apart and examined for discoloration caused by fungi and bacteria. Count the number of plant, and pods infected due to disease and incidence should be recorded.

C. Surveillance through pheromone trap catches:

Pheromone traps for *Helicoverpa* @ 4/acre have to be installed.. Fix the traps to the supporting pole at a height of one foot above the plant canopy. Change of lures should be made at 2-4 weeks interval (regular interval). During each week of surveillance, the number of moths/trap/week should be counted and recorded during the crop season. The trapped moths should be removed and destroyed after each recording.

D. Blue pan water/sticky traps

Set up blue sticky traps 1 foot above the canopy for monitoring thrips @ 4 traps (15 X 7.5 cm)/acre. Locally available empty tins can be painted blue/ coated with grease/ vaseline/castor oil on outer surface may also be used as blue sticky trap. Count the number of thrips on the traps daily and take up the intervention when the population exceeds approximately 100 thrips per trap.

E. Light traps

Set up light traps 1 trap/acre 1 foot 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 rocks, roots, etc. Take a 600 cc subsample of soil, pack lightly into a beaker uniformly. Place soil in one of the buckets or pans half filled with water. Mix soil and water by stirring with paddle; allow to stand until water almost stops swirling.

Pour all but heavy sediment through 20-mesh sieve into second bucket; discard residue in first bucket; discard material caught on sieve. Stir material in second bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 60 mesh sieve to collect cysts into first bucket; discard residue in second bucket. Stir material in first bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 325-mesh sieve into second bucket; discard residue in first bucket. Backwash material caught on 325-mesh sieve (which includes small to mid-sized nematodes and silty material) into 250-ml beaker. More than 90% of the live nematodes are recovered in the first 5-8 mm of water drawn from the rubber tubing and the sample is placed in a shallow dish for examination.

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

Natural enemies may require

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

Ecological engineering for pest management – Above ground:

- 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.

Ecological engineering for pest management – Below ground:

- 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.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Apply balanced dose of nutrients using biofertilizers.
- Apply mycorrhiza and plant growth promoting rhizobacteria (PGPR)

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

Plants suitable for Ecological Engineering for Pest Management

Attractant plants

Cluster bean

Cowpea

Carrot

Sunflower

Buckwheat

French bean

Alfalfa

Maize

Mustard

***Coreopsis* spp.**

Cosmos

Dandelion

Anise

Caraway

Dill

Parsley

Repellent plants

***Ocimum* sp**

Peppermint

Border plants

Sorghum

Maize

Bajra

Intercrops

Black gram

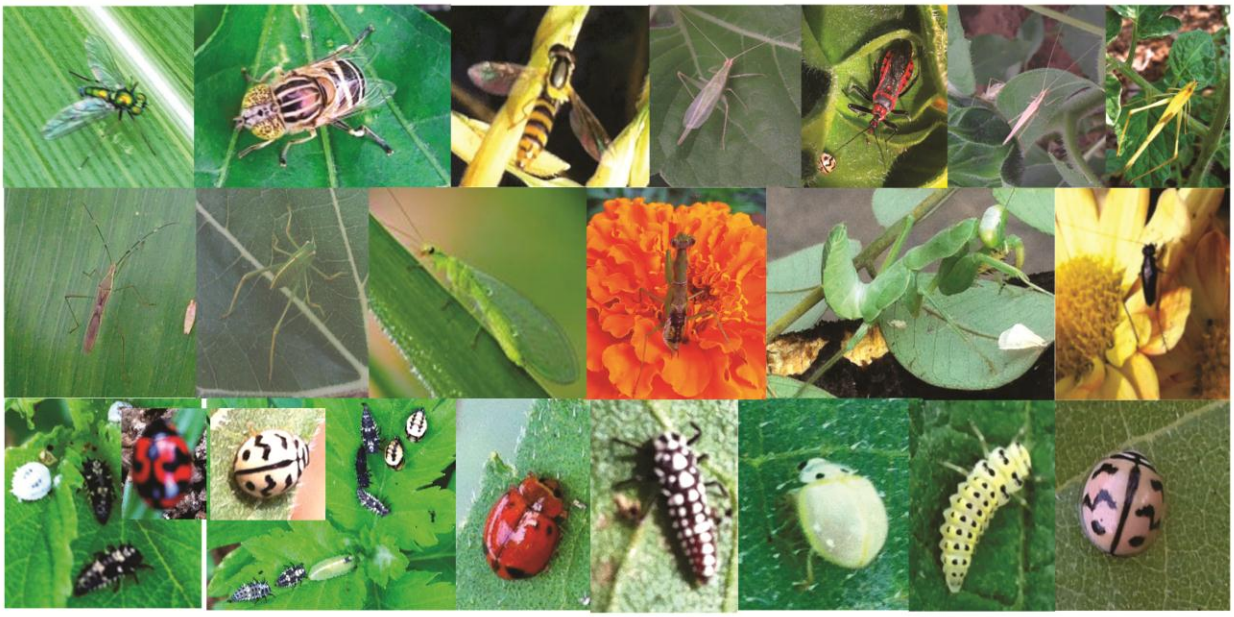
Groundnut

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. CROP STAGE-WISE IPM

Management	Activity
Pre-sowing*	
	<u>Common cultural practices:</u> • Summer deep ploughing • Follow crop rotation with non host crops • Field sanitation, rogueing • Destroy the alternate host plants
Nutrients	• Apply well decomposed FYM @ 4-5 tons / acre incorporated with *Trichoderma* 2-3 weeks before sowing.
Weeds	• Destroy weeds manually or by deep summer ploughing.
Sowing*	
	<u>Common cultural practices:</u> • Do summer ploughing • Timely sowing should be done • Solarize the field in summer to help reduce the inoculums. • Use resistant varieties • Select seed from disease free fields
Nutrients	• Seed treatment should be done with Rhizobium culture @ 200 g/ acre. • Fertilizers should be applied on soil test basis. Generally, it is recommended to apply 8 to 10 kg N, 16 kg P_2O_5 , 8 kg K_2O, 8 kg sulphur and 6 kg $ZnSO_4$ per acre at the time of sowing as basal application..
Weeds	• Always use certified and weed free seeds. • Timely sowing should be done. • 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. • Adopt suitable crop rotation to minimize dodder and orobanche weeds.
Pests, Soil-borne pathogens	• Deep ploughing of fields during summer to manage juvenile population of nematodes and insect pests. • **Soil solarization:** Cover the beds with polythene sheet of 75 gauge thickness for six weeks before sowing to reduce the soil borne pests.
Vegetative *	
	<u>Common cultural practices</u>: • Avoid excess application of nitrogen • Adopt the ecological engineering strategy. • Conserve natural enemies • Remove and destroy weeds periodically • Removal and destruction of infected/infested plants
Nutrients	• Correct micronutrient deficiency if any in standing crop.
Weeds	• Keep field boundary & bunds free from weeds. • The crop field should be weed free initially for 4-5 weeks by following timely hoeing and weeding. • Inter-culture operation/hoeing should be done twice at 20

	and 35 days after sowing-using hand hoe to remove all weeds in between the row.
Cow pea aphid	**Mechanical control:** • Use yellow sticky trap **Biological control:** • Conserve the predators such as Syrphid flies, Rove beetle, Green lacewing, Ladybird beetle and parasitoids such as *Aphidius* spp. *Aphelinus* sp.
Cut worm	**Biological control:** • Conserve and augment the predators and parasitoids.
Thrips	**Cultural control:** • Ploughing,harrowing and solarisation can kill pupae in the soil from previously infested crops. **Mechanical control:** • Adult thrips can be monitored by mass trapping with blue sticky traps or water pan traps in field. **Biological control:** • Conserve and augument the various biological control agents, including minute pirate bugs, *Orius* spp., Big eyed predatory bug, *Geocoris* sp. and entomopathogenic nematodes,
Pod borers	**Biological control:** • Conserve and augument biocontrol agents.
Fusarium wilt and root rot diseases	**Cultural control:** • Use resistant varieties (PL 406, PL 639 and PL 234) • Follow crop rotation Weeds control • Delayed sowing can reduce disease incidence • Use of clean and certified seed. • Deep ploughing over summer and removal of infected trash can reduce inoculum levels of Fusarium wilt **Mechanical control:** • Solarisation of soil by covering the soil with transparent polythene sheet (75 gauge) for 6-8 weeks during the summer for effective management.
Lentil rust	**Cultural control:** • Use resistant varieties (PL 234, PL 406, LL 931, LL 699 and Narendra Masur-1)
Ascochyta blight	**Cultural control:** • Use of resistant cultivars (LL 699) • Use of disease free seed, • Follow crop rotation,
Powdery mildew	**Cultural control:** • Use of resistant varieties

Mosaic virus	**Cultural control:** • Use of disease free seeds **Mechanical control:** • Use yellow sticky traps for vector monitoring.
Reproductive*	
Nutrients	• Incorporate crop residues in soil immediately after harvest.
Aphids	• Same as vegetative stage
Lygus bug	**Cultural control:** • Removal of weeds along field borders to prevent buildup of lygus bugs. **Biological control:** • Conserve and augment biocontrol agents.
Cut worm and Thrips	• Same as vegetative stage

V.INSECTICIDE RESISTANCE AND ITS MANAGEMENT

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

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

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

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

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

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

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

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

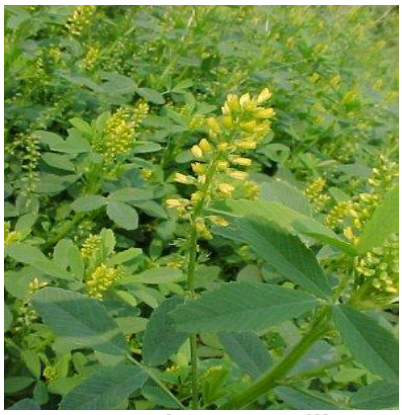
6) **Alternate different insecticide classes.** Avoid the repeated use of the same insecticide, insecticides in the same chemical class, or insecticides in different classes with same mode of action and rotate/alternate insecticide classes and modes of action.

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

VI. COMMON WEEDS

1. Field bind weed: *Convolvulus arvensis* L. (Convolvulaceae)

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



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

4.Scarlet pimpernel: *Anagalis arvensis* (Primulaceae)

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

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

7. Benghal dayflower: *Commelina benghalensis* L. (Commelinaceae)

8. Wild oat: *Avena ludoviciana* (L.) Nees. (Poaceae)

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

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

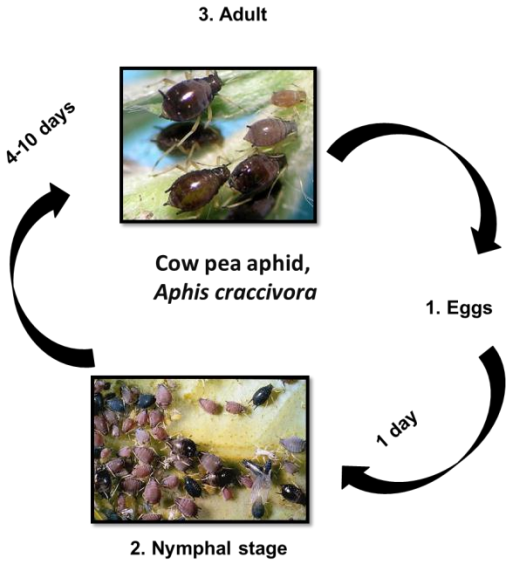
11. Yellow nutsedge: *Cyperus esculentus* L. (Cyperaceae)

12. Dodder: *Cuscuta spp*. L. (Convolvulaceae)

13.Broomrape:*Orobanche* spp. L. Pers (Orobanchaceae)

VII. DESCRIPTION OF INSECT PESTS

1. Cow pea aphid
Biology **Egg:** Eggs are laid on the growing region from which nymphs emerge. **Nymphs:** Eggs hatch into nymphs. The nymphs are slate grey. **Adult:** Adults are small (up to 2.5 mm long) and are shiny black. Females reproduce parthenogentically in the tropics and subtropics. **Life cycle:**



http://aphid.aphidnet.org/images/Aphis_craccivora/life1_big.jpg

Damage symptoms:

- Cowpea aphids are phloem feeders and inject toxins into the plant while feeding; they most likely reduce vigour and yields. Aphid-feeding also produces honeydew, which grows sooty mould that reduces photosynthesis and makes harvesting difficult.
-

Aphid infestation

http://www.sardi.sa.gov.au/__data/assets/image/0008/173897/cowpeaaphids_non-wingedadul.jpg

Natural enemies of cowpea aphid:

Ladybird beetles, Syrphid flies, Rove beetle, Damsel bug, Green lacewing and parasitoids such as *Aphidius* spp. (aphid parasitoid).

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

2. Leaf weevil:

Biology:

Eggs: Females lay eggs in the soil near to growing plants.

Larva: Larvae develop under the soil and are “C” shaped and milky-white with a dark-brown head capsule ranging in length from 3.5-5.5 mm. Larvae develop through five instar stages. After hatching, larvae seek and enter the roots of a lentil plant. Larvae enter and consume the contents of the nodules of the legume host plant.

Pupa: Pupation takes place in the soil.

Adults:

Adults. Adults are slender, greyish-brown measuring approximately 5 mm in length).The weevil has a short snout and feed upon the leaf margins and growing points of legumes.

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

3. Lygus bugs

Biology:

Eggs: Eggs are slightly curved and approximately 1 mm long with an eye-shaped cap. After mating and once the eggs mature, females seek suitable host plants, on which lay their eggs. Eggs are laid individually into the stems and leaves of host plants.

Nymphs: There are five nymphal instars. Young nymphs are light green and wingless. Older nymphs develop black dots on the top of the thorax and abdomen. Wing buds are evident in

the fourth and fifth instars.

Adults: Adult lygus bugs are about 3 mm wide and 6 mm long. They vary from pale green to reddish brown to black and from fairly uniform color to mottled. Lygus bugs share characteristics with all ,true bugs, the distinctive, triangular or , 'V'- shaped marking in the upper centre of their backs and membranous wingtips. Adults are active and fly readily when approached.

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

4. Cut worm

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. Females may deposit eggs, duration of the egg stage is 3 to 6 days

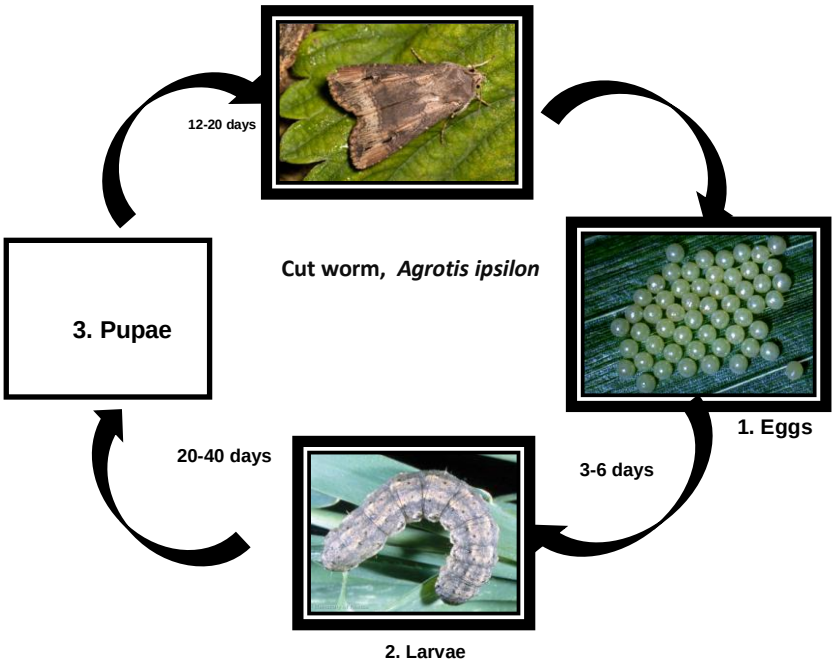
Larva: The caterpillar is rather uniformly colored on the dorsal and lateral surfaces, ranging from light gray or gray-brown to nearly black. The head is brownish with numerous dark spots. They sever plants at the soil surface and cause extensive damage; the caterpillars are cannibalistic.

Pupa: Pupation occurs in the soil 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.

Adults: 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 preoviposition period is about 7 to 10 days.

Life cycle:



http://entnemdept.ufl.edu/creatures/veg/black_cutworm02.jpg

http://www.wildaboutbritain.co.uk/pictures/data/19/Dark_Sword-grass_-_Agrotis_ipsilon.jpg

Damage symptoms:

Larvae cut off the plant at or just below ground level.

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

5. Thrips

Biology:

Egg: White to yellow; kidney-bean shaped; microscopic in size. Develop within leaf tissue with one end near the leaf surface. Hatch in 5-10 days.

Nymph: Nymphs are active feeding stages.

Adults: About 0.06 inch (1.5 mm) long; elongate, yellow and brown body with two pairs of fringed (hairy) wings. Mouthparts are beak-like and antennae are 7-segmented.

Natural enemy of Thrips:

Minute pirate bugs, *Orius* spp.

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

6. Pod borer: *Helicoverpa armigera*

Biology:

It is a polyphagous pest, infesting gram, lablab, safflower, chillies, groundnut, tobacco, cotton etc.

Egg: Spherical, yellowish eggs are laid singly on tender parts and buds of plants. The egg period lasts for 2-4 days.

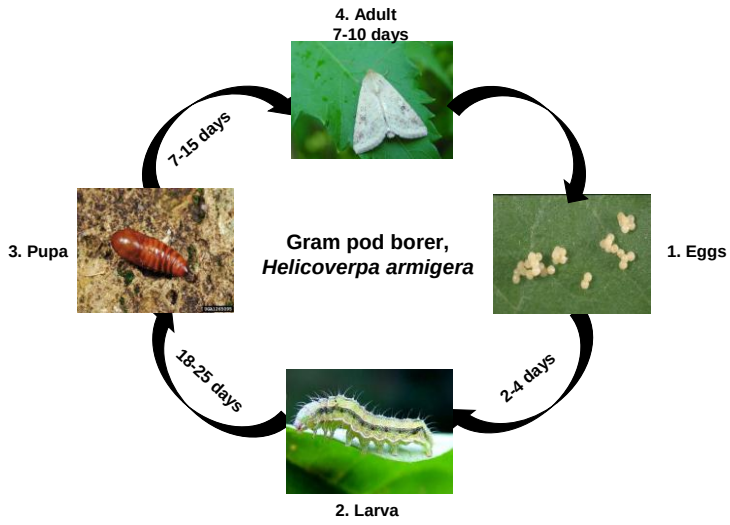
Larva: Caterpillars are of varying in colour, initially brown and later turn greenish with darker broken lines along the side of the body. Body covered with radiating hairs. When full grown, they measure 3.7 to 5 cm in length. The larval period lasts for 18-25 days. The full grown caterpillar pupates in the soil.

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

Adult: Moth is stout, medium sized with brownish/greyish forewings with a dark cross band near outer margin and dark spots near costal margins, with a wing expanse of 3.7cm.

Life cycle:

https://upload.wikimedia.org/wikipedia/commons/7/78/Helicoverpa_armigera.jpg



https://upload.wikimedia.org/wikipedia/commons/7/78/Helicoverpa_armigera.jpg

http://www.infonet-biovision.org/sites/default/files/styles/juicebox_small/public/plant_health/cropsfruitsvegetables/1019_0.jpeg?itok=C7A7WH1c

http://www7.inra.fr/hyppz/IMAGES/7031873.jpg

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

Natural enemies of pod borer:

- Common mynah, spider, assassin bugs, *Trichogramma* spp., *Bacillus thuringiensis* var *kurstaki,* entomopathogenic nematodes (EPNs), Yellow wasps, etc.

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

Natural Enemies of Lentil Insect Pest

Parasitoids

Egg Parasitoids

1. *Polynema* spp.

2. *Gonatocerus* sp

3. *Tetrastichus* sp

Larval Parasitoids

4. ***Fopiusarisanus***

5. ***Diachasmimorpha kraussi***

6. ***Hormius*** **sp**

7. ***Pediobius bruchicida***

8. Tetrastichus **spp.**

9. ***Bracon greeni***

10***. Aprostocetus*** **spp.**

Nymphal and adult parasitoids

11. **Tiny parasitic wasp**

12. ***Inostemmaapsyllae***

13. ***Platygaster*** **sp.**

14*. Systasis dasyneurae*

1. http://www.nps.gov/media/photo/gallery.htm?id=5FF8FFF8-1DD8-B71C-072E5FF3ED6B0884
2. http://biocontrol.ucr.edu/irvin/gwssbiocontrol.html
3. http://www.pbase.com/tmurray74/image/125304607
4. http://www2.hawaii.edu/~messing/projects.htm
5. https://www.spc.int/pacifly/Control/Biocontrol.htm
6. http://tribes.eresmas.net/fotos/ins/Hymenop/Ichneumon/Braconidae/Hormiinae/Hormius/H_moniliatus/hormius_moniliatus_01_p05219_juncosa_1.jpg
7. http://www.waspweb.org/Chalcidoidea/Eulophidae/Entedoninae/Pediobius/index.htm
8. http://www.pbase.com/tmurray74/image/125304607
9. http://www.flickr.com/photos/king777/6965853794/
10. http://bugguide.net/node/view/679101
11. http://bugguide.net/node/view/205018/bgimage
12. http://species.wikimedia.org/wiki/File:Inostemma_boscii.jpg
13. http://www.pbase.com/tmurray74/image/122701891
14. http://www.nbaii.res.in/Pteromalidae/gallery.php

Predators

1. *Mallada boninensis*

2. *Plexippus paykullii*

3.*Menochilus sexmaculatus*

4. *Rodolia fumida*

5.*Cryptolaemus montrozieri*

6. *Rhizoglyphus* sp

7.*Camponatus spoecophylla*

8. *Smaragdina* sp.

9. Purplish pirate bug

10. Brown lacewings

11. Carabid beetle

12. Reduviid bug

1. http://www.nabg-nbaii.res.in/patent.php?key=1
2. http://www.eurospiders.com/Plexippus_paykulli.htm
3. http://cyy4993.blogspot.in/2012/11/beetle-coccinellidae-coccinella.html
4. http://www.nbaii.res.in/Featured_insects/Rodolia-fumida.php
5. https://uribotanicalgardens.wordpress.com/tag/biocontrol/
6. http://wiki.cannaweed.com/index.php/Rhizoglyphus
7. http://www.naturephoto-cz.com/ant-camponotus-fallax-photo-4381.html
8. http://www.cabi.org/cpc/?compid=1&dsid=16434&loadmodule=datasheet&page=868&site=161
9. http://extension.umd.edu/hgic/insects/predators-minute-pirate-bugs
10. http://www.ozanimals.com/Insect/Brown-Lacewing/Micromus/sp.html
11. http://www.biology.ualberta.ca/bsc/news16_2/alvar.htm

VIII. DESCRIPTION OF DISEASE

1. Fusarium Wilt

Disease symptoms:

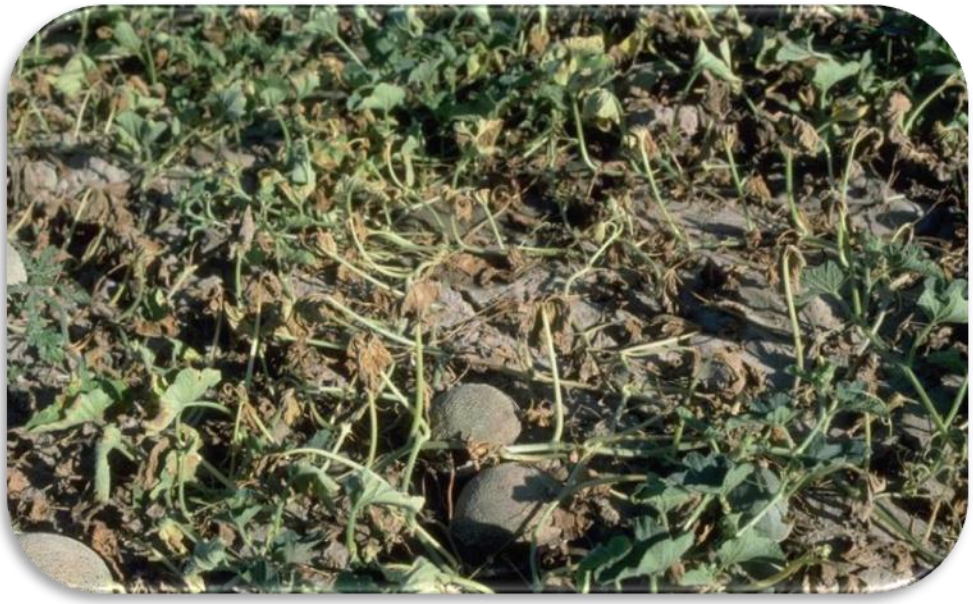
- Symptoms can occur at both the seedling and plant developmental stages and appear as patches in the field The root system appears healthy, but with a reduced proliferation and nodulation rate.
- In most cases, there is no discolouration of the vascular system. Other symptoms at the seedling stage include seed rot.
- It usually occurs near or at the reproductive stages (flowering to pod-filling) of crop growth. Symptoms include the drooping and wilting of the uppermost leaflets
  . Plants become completely yellow and die.
  Plants are affected during the mid- to late-pod filling stages, seeds are often shrivelled

Survival and spread:

- Chlamydospores of the pathogen can survive in the soil for many years in the absence of a host plant. The pathogen can also survive within infected plant material in the field. This indicates that the pathogen is well adapted to survive adverse conditions.

Favourable conditions:

- Moist soil, warm and humid conditions favour the development of wilt.



Disease symptom

http://s3.amazonaws.com/plantvillage/images/pics/000/000/735/large/Fusarium_wilt.jpg?1370373138

*For the management refer page no.....

2. Lentil rust

Disease symptoms:

- First sign of infection is small white pustules on the leaves.
- Minute yellowish slightly raised pustules, that as they enlarge change to orange-brown in colour, often surrounded by a light coloured halo.

Survival and spread:

- Rust spores are small, light and may survive for several days. They can be spread to large distances by wind.

Favourable conditions:

- Rusts can build up rapidly and are mostly seen as the weather warms above 20ºC. Leaves, stems and pods can be infected.

Disease symptom

http://www.ndsu.edu/pubweb/pulse-info/images/lentilpic/11.jpg

*For the management refer page no.....

3. **Ascochyta blight**

Disease symptoms:

- Grey to tan spots or lesions on leaflets, stems, flowers and pods, with dark margins and often with tiny black fruiting bodies (pycnidia) in the centers
- Lesions first appear on lower leaflets close to soil surface and spread up the plant canopy. Lesions on stems can girdle the plant resulting in wilting. Leaves may turn brown and die off.

Survival and spread:

- It can be spread to large distances by wind and infected plant debris.

Favourable conditions:

- Ascochyta blight is present at commencement of flowering in susceptible varieties.
- Cloudy and humid weather for a week period favours the disease development and its spread.

Disease symptom

http://www.agriculture.gov.sk.ca/Default.aspx?DN=169aa880-cf4f-4305-b42d-c966eb170357

*For the management refer page no.....

4. Anthracnose

Disease symptom:

- Tan lesions with darker borders on leaves which often appear prior to flowering or shortly after bloom.
- Diseased leaves may drop from the plant prematurely.
- Tan to light brown lesions appear on lower stems and begin to spread upwards, appearing higher on the plant; lesions may contain numerous black dots; as plant matures, the lesions expand and may cover large areas of the stem
- Lesions may also be present on pods and are light to tan brown with a dark margin; diseased pods often produced discolored seeds; disease can cause severe losses in yield.

Survival and spread:

- The pathogens survive on seed and plant debris
- Disease spreads in the field through air-borne conidia

Favourable condition:

- Disease emergence is favored by wet conditions; fungus is spread by splashing water

*For the management refer page no.....

5. Root rot and seedling diseases:

Disease symptoms:

- Failure of seedling to emerge.
- Light brown, seedlings with light brown to red, .water-soaked roots and stems.
- Infected plants dry up and die.
- Stunted plant growth, rotting taproot with few lateral roots

Survival and spread:

- Pathogens survive in soil as well as seed as resting mycelia or sclerotia for longperiod.
- These organisms often survive as saprophytes, living on dead plant material, or as dormant mycelia or spores.
- Root exudates from germinating seedlings or growing roots stimulate the dormant fungi to become active.

Favourable conditions:

- Diseases are prevalent under cool wet conditions that keep the soil temperatures below 13°C.

*For the management refer page no.....

6. Powdery mildew

Disease symptom:

- Powdery mildew appears as gray-white areas which coalesce to cover entire plant
- If plant is heavily infected it may die.

Survival and spread:

- The pathogen has a wide host range and survives in conidial form on various hosts in off-season.
- Secondary spread is through air-borne conidia produced in the season.

Favourable conditions:

- Cool and dry weather favours disease development.

*For the management refer page no.....

7. Sclerotinia rot/collar rot:

Disease symptom:

- Lesions girdle stem causing upper plant parts to become chlorotic and wilted.
- Plants become necrotic after they die; disease often causes a patchwork of symptomatic plants throughout a field with plants initially becoming chlorotic and finally dying.

- Fungus causes characteristic white lesions on stems which may be covered in a fluffy white growth during periods of wet weather.

Survival and spread:

- The fungus survives as sclerotia or mycelium in infected plant residue and soil

Favourable conditions:

- Disease emergence is favored by cool, wet conditions.

*For the management refer page no.....

8. Pea enation mosaic virus, pea seed borne mosaic virus and bean yellow mosaic virus

Disease symptoms:

- Infected plants develop mosaic and chlorotic vein flecking and veinal enations (blister like outgrowths), which are very characteristic for PEMV.
- Plants are stunted, and proliferation of basal branches is common. Pods are distorted, split open, and may show prominent enations.
- Distinct mottling of the foliage is the most conspicuous symptom.
- The tissue yellows between the veins, leaving patches normal green tissues scattered irregularly over the surfaces of both leaves and stipules.

Survival and spread:

- Mainly it is spread through aphids as well as seeds.
- Occupying of perennial legumes bordering the planting area also increase the primary virus reservoir.

Favourable conditions:

- Normal temperature and moisture are satisfactory for disease development. Warm, dry, weather which encourages aphid population build-up, may aid virus spread in the field.
- Seed transmission may be suppressed by high temperatures

*For the management refer page no.....

IX. SAFETY MEASURES:

A. At the time of harvest:

- During harvesting, proper care should be taken.
- Harvesting should be done timely. Timely harvesting ensures optimum grain quality and consumer acceptance.
- The cutter consists of 2 broad blades set to cut 2 adjacent rows about 5 cm below the ground. Then prongs pull plants from both rows into one windrow in wet weather; plants are forked into field stacks ca 1.3 m in diameter and 2–3 m high that are supported by a center stake.
- Harvesting before the crops mature, usually result lower yields, higher proportion of immature seeds, poor grain quality and more chances of disease attack during storage.
- Delay in harvesting of lentil, results in shattering of pods and other losses caused by birds, rats, insects etc.
- Avoid harvesting during adverse weather conditions i.e. rains and overcast weather.
- The best time to harvest the crop, when large (80) percent of the pods are fully matured.

- Right kind of harvest equipment (sickle) should be used.
- Rogue out the admixtures prior to harvesting, it helps in fetching good price in the market.
- After cutting, if the weather permits, leave the harvested plant to dry in the field.

B. Post-harvest storage

• The post-harvest losses of lentil can be minimised in the process of threshing, winnowing, storage, processing, handling and transportation. • (i) Threshing and Winnowing: The loss at threshing yard is 0.5 percent. In order to reduce the losses, threshing and winnowing operations are required to be completed within a short period through improved equipments.
• (ii) Transport losses: During transportation, the losses are report to be extent of 0.5% percent and necessitating quick transportation to reduce the losses.
• (iii) Storage: Due to improper and inefficient methods of storage, the loss upto 7.5 percent is estimated during storage. Quantitative losses result from spoilage, drainage, infestation by insects, rodents or birds. Therefore, improved storage facilities should be adopted to reduce the losses.

To avoid post-harvest losses, following preventive measures should be considered:

- Harvest timely to reduce losses.
- Use proper method of harvesting.
- Avoid the losses in threshing and winnowing by adopting modern mechanical methods.
- Use improved techniques of processing. Adopt grading for getting remunerative prices inter-alia to avoid financial loss.
- Use good packaging materials for storage as well as for transport i.e. Jute bags or HDPE bags.
- Use proper techniques in storage.
- Use pest control measures during storage.
- Timely and proper handling (loading and unloading) with suitable transportation facilities at farm and market level.
- Avoid use of hooks by labour during handling.

X. 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 inter-cropping of recommended crops.	Do not disturb the plant roots by adopting ploughing away from the pits.
3.	Grow only recommended varieties.	Do not grow susceptible varieties.
4	Always treat the seedlings with approved chemicals/bio products for the control of seed borne diseases/pests	Do not use seedlings without seed treatment with biocides/chemicals.
5	Plant in rows at optimum depths under proper moisture conditions for better establishment.	Do not plant seedlings beyond 5-7 cm depth.
6	Apply only recommended herbicides at recommended dose, proper time, as appropriate	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils.

	spray solution with standard equipment along with flat fan or flat jet nozzles.	Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
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 normal room temperature (keep them 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 NPV of respective Lepidopteran moth if available at recommended dose when a large number of egg masses and early instar larvae are noticed. Apply NPV only in the evening hours after 5 pm.	Do not apply NPV on late instar larva and during day time.
14	In case of pests which are active during night spray recommended biopesticides/chemicals at the time of their appearance in the evening.	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 other sucking pests harbouring the lower side of leaves.	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 on trap crop, otherwise it may not attract the pests and natural enemies.

XI. 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.

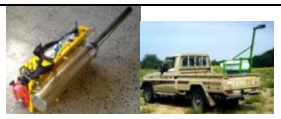
F. Precautions for applying pesticides

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

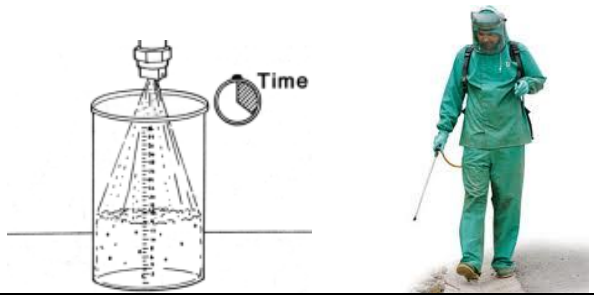
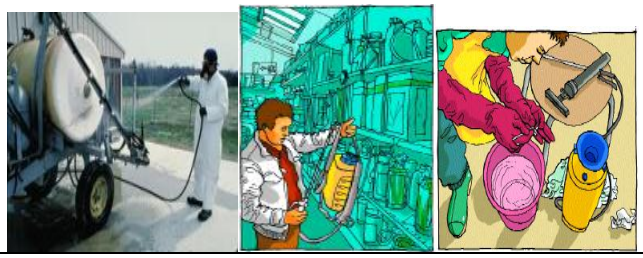
1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

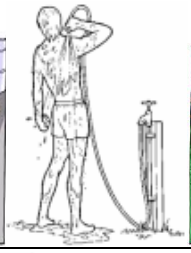
XII. PESTICIDE APPLICATION TECHNIQUES

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

Post-emergence application	Weedicide	• Lever operated knapsack sprayer (droplets of big size) • Flat fan or floodjet nozzle @ 15 to 20 psi • Lever operating speed = 7 to 10 strokes/min	
Pre-emergence application	Weedicide	• Trolley mounted low volume sprayer (droplets of small size) • Battery operated low volume sprayer (droplets of small size)	

XIII. 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.	

XIV. REFERENCES

- http://www.nzpps.org/journal/50/nzpp_500370.pdf
- http://www.ipm.ucdavis.edu/PMG/r734300111.html
- http://biozoojournals.ro/nwjz/content/v10n2/nwjz_141201_Lotfalizadeh.pdf
- http://www.academicjournals.org/article/article1381488633_Cikman.pdf
- http://link.springer.com/article/10.1007%2FBF01991956
- file:///C:/Users/Guest1/Downloads/4%20(1).pdf
- http://upload.wikimedia.org/wikipedia/commons/c/cd/Orobanche_sp.JPG
- http://upload.wikimedia.org/wikipedia/commons/3/33/Cuscuta_europaea_bgiu.jpg
- http://www.westernforum.org/Documents/IPMN%20Protocols/2011_PeaLeafWeevil%20protocol.pdf
- http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/~/media/4716E66135E04DC48833D9F115326336.JPG
- http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex741
- http://www.westernforum.org/Documents/IPMN%20Protocols/2013_Lygus%20bug%20Monitoring%20protocol.pdf
- http://www.wildaboutbritain.co.uk/pictures/data/19/Dark_Sword-grass_-_Agrotis_ipsilon.jpg
- http://www.omafra.gov.on.ca/english/crops/pub811/13cornf8.jpg
- http://entnemdept.ufl.edu/creatures/veg/black_cutworm.htm
- https://extension.usu.edu/files/publications/factsheet/ENT-117-08PR.pdf
- http://onlinelibrary.wiley.com/doi/10.1111/j.1439-0418.1969.tb03040.x/abstract
- http://www.tarimmarketi.com/images/mercimekte_apion_(Apion_arrogan)_A_1.jpg
- http://www7.inra.fr/hyppz/IMAGES/7031343.jpg
- http://www7.inra.fr/hyppz/RAVAGEUR/6cydnig.htm
- http://www3.syngenta.com/global/Bioline/SiteCollectionImages/content-images/pests/leafminer.jpg
- http://gerbera.org/image-files/diseases-leafminers-1-3.jpg
- http://entnemdept.ufl.edu/creatures/veg/leaf/a_serpentine_leafminer.htm
- http://www.sardi.sa.gov.au/pestsdiseases/pests/crop_pasture_pests/pea_weevil/?SQ_DESIGN_NAME=printer_friendly
- http://www7.inra.fr/hyppz/RAVAGEUR/6brupis.htm
- http://www.planthealthaustralia.com.au/wp-content/uploads/2013/03/Fusarium-wilt-of-chickpea-lentil-and-lupin-CP-2009.pdf
- http://oar.icrisat.org/5351/1/Integratedfoliar_diseases_management_of_legumes.pdf
- http://www.planthealthaustralia.com.au/wp-content/uploads/2013/03/Fusarium-wilt-of-chickpea-lentil-and-lupin-CP-2009.pdf
- http://www.pulseaus.com.au/pdf/lentil%20disease%20management%20strategy.pdf
- http://www.learningstore.uwex.edu/assets/pdfs/A1167.pdf
- Naidu, V.S.G.R. 2012, *Hand Book on Weed Identification.* Directorate of Weed Science Research, Jabalpur, India Pp 354
- http://agropedia.iitk.ac.in/content/production-technology-package-lentil-rabi-lalitpur-uttar-pradesh
- http://cropgenebank.sgrp.cgiar.org/images/management/lentil_smogs/orobanche1.pn