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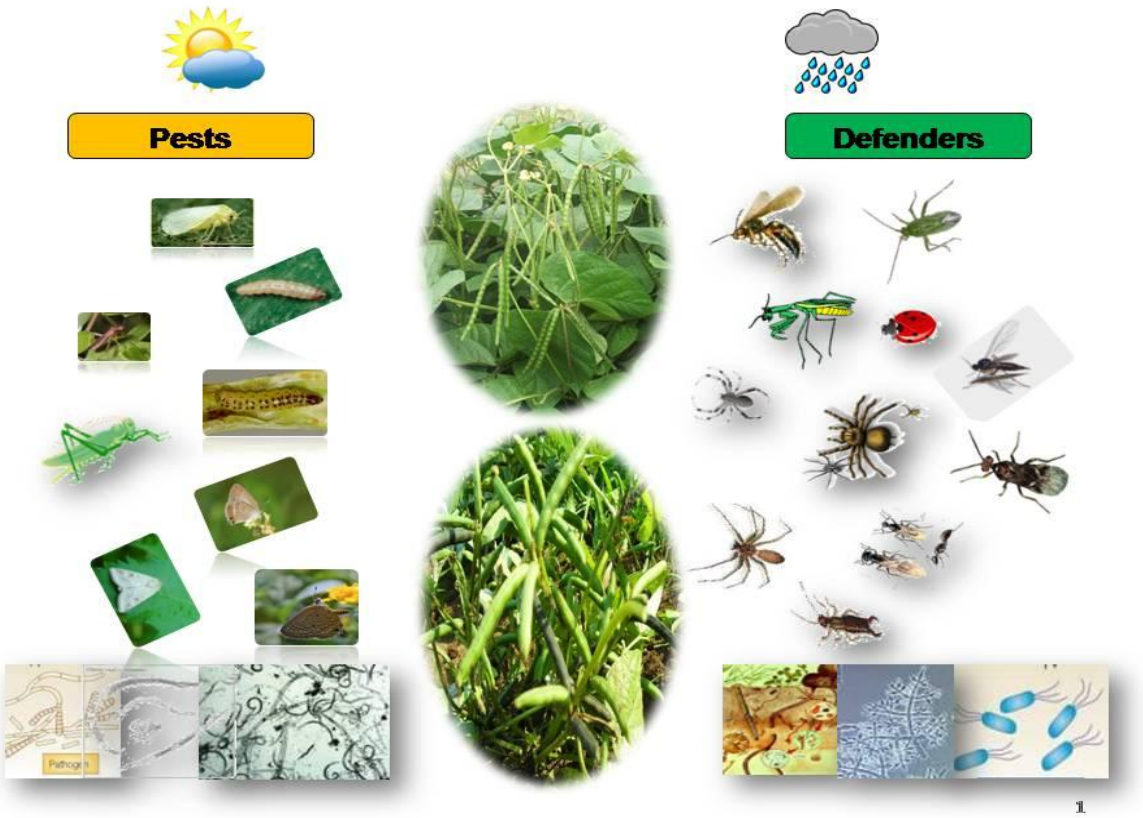
AESA BASED IPM PACKAGE
AESA based IPM- Black Gram (Urd) and Green Gram (Moong)



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FOREWORD

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

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

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

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(Avinash K. Srivastava)

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FOREWORD

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

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

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

(Utpal Kumar Singh)

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PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

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XIV. Operational, calibration and maintenance guidelines in brief

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AESA BASED IPM PACKAGE FOR BLACK GRAM (URD) AND GREEN GRAM (MOONG)

Black gram and Green gram plant description:

Black gram (*Vigna mungo* L.; Family: Fabaceae) (also known as Urad Dal or black lentil) is a bean grown in the Indian subcontinent. It, along with the mung bean, was placed in *Phaseolus*, but has since been transferred to *Vigna*. At one time it was considered to belong to the same species as the mung bean. The product sold as "black lentil" is usually the whole urad bean or *urad dal*. The product sold as "white lentil" is the same lentil with the black skin removed.

Black gram originated in India, where it has been in cultivation from ancient times and is one of the most highly prized pulses of India and Pakistan. The coastal Andhra region in Andhra Pradesh is famous for black gram after paddy. The Guntur District ranks first in Andhra Pradesh for the production of black gram. Black gram has also been introduced to other tropical areas mainly by Indian immigrants.

Green gram or golden gram (*Vigna radiate* L.; Family: Fabaceae) is also known as mung or moong bean is the seed of, native to the Indian subcontinent and mainly cultivated in Philippines, Thailand, India, Bangladesh, Vietnam, Cambodia, China, Burma and Indonesia, but also in hot and dry regions of Southern Europe and the Southern United States. It is used as an ingredient in both savory and sweet dishes.

Mungbean seeds are sprouted for fresh use or canned for shipment to restaurants. Sprouts are high in protein (21%–28%), calcium, phosphorus and certain vitamins. Because they are easily digested they replace scarce animal protein in human diets in tropical areas of the world. Because of their major use as sprouts, a high quality seed with excellent germination is required. The food industry likes to obtain about 9 or 10 grams of fresh sprouts for each gram of seed. Larger seed with a glassy, green color seems to be preferred.

If the mungbean seed does not meet sprouting standards it can be used as a livestock food with about 1.5 ton of mungbean being equivalent to 1.0 tons of soybean meal for protein content. Feeding trials have been conducted at Oklahoma State University for swine and young calves with good results.

Black gram

Green gram

I. PESTS

A. Pests of National Significance

1. Insect Pests

1.1. Borers

1.1.1 Pod borer: *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae)

1.1.2 Spotted pod borer: *Maruca vitrata* Geyer (Lepidoptera: Pyralidae)

1.1.3 Spiny pod borer: *Etiella zinckenella* Treitschke (Lepidoptera: Pyralidae)

1.1.4 Blue butterfly: *Lampides boeticus* Linnaeus (Lepidoptera: Lycaenidae)

1.1.5 Grass blue butterfly: *Euchrysops cnejus* Fabricius (Lepidoptera: Lycaenidae)

1.1.6 Bihar hairy caterpillar: *Spilosoma obliqua* Walker (Lepidoptera: Arctiidae)

1.1.7 Stem fly: *Ophiomyia phaseoli* Tryon (Diptera: Agromyzidae)

1.1.8 Pod weevil: *Apionam plum* Faust (Coleoptera: Curculionoidae)

1.2. Sap feeders

1.2.1 Bean Aphid: *Aphis craccivora* Koch (Hemiptera: Aphididae)

1.2.2 Leaf hopper: *Empoasca kerri* Latreille (Hemiptera: Cicadellidae)

1.2.3 Podfly: *Melanagromyza obtusa* (Malloch) (Diptera: Agromyzidae)

1.2.4 Lab lab bug : *Coptosoma cribraria* (Fabricius) (Hemiptera: Plataspididae)

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

1.2.6 Thrips: *Megalurothrips usitatus (*Bagnall) (Thysanoptera: Thripidae)

1.3. Flower feeder

1.3.1 Blister beetle: *Mylabris* spp (Coleoptera: Meloidae)

2. Nematodes

2.1 Cyst nematode: *Heterodera cajani* Koshi (Tylenchida: Heteroderidae)

2.2 Root Knot nematode: *Meloidogyne incognita* (Tylenchida: Heteroderidae)

3. Diseases

3.1 Anthracnose: *Colletotrichum lindemuthianum* (Sacc. & Magnus) Briosi & Cavara (Phyllachorales: Phyllachoraceae)

3.2 Bacterial Leaf Blight: *Xanthomonas phaseoli* Dowson (Xanthomonadales: Xanthomonadaceae)

3.3 Cercospora leaf spot: *Cercospora canescens* (Capnodiales: Mycosphaerellaceae)

3.4 Powdery Mildew: *Erysiphe polygoni* (Erysiphales: Erysiphaceae)

3.5 Root Rot and Leaf Blight: *Rhizoctonia solani* J.G. Kühn (Cantharellales: Ceratobasidiaceae)

3.6 Rust: *Uromyces phaseoli* G. Winter (Pucciniales: Pucciniaceae)

3.7 Macrophomina blight: *Macrophomina phaseolina* (Tassi) Goid. (Botryosphaeriales: Botryosphaeriaceae)

3.8 Yellow Mosaic Disease : *Mungbean yellow mosaic virus* (Geminiviridae)

3.9 Leaf Crinkle disease : Leaf crinkle virus

4. Weeds

4.1 Grassy weeds

4.1.1 Goose grass: *Eleusine indica* (L.) Gaertner (Poaceae)

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

4.1.3 Barnyard grass: *Echinocloa* crusgalli (L.) Beauv. And Jungle rice E. Colona (L.) Beauv. Poaceae

4.2 Broad leaf weeds

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

4.2.2 False amaranth: *Digera arvensis* Forssk (Amaranthaceae)

4.2.3 Horse purslane: *Trianthema portulacastrum* L. (Aizoaceae)

4.2.4 Tick weed: *Cleome viscosa* L. (Capparidaceae)

4.2.5 Stonebreaker: *Phyllanthus niruri* L. (Euphorbiaceae)

4.2.6 Common lambsquarter: *Chenopodium album* L.(Chenopodiaceae)

4.2.7 Burcloveru: *Medicago denticulata* Willd (Fabaceae)

4.2.8 Canada Thistle: *Cirsium arvensis* (L.) Scop (Asteraceae)

4.2.9 Field bindweed: *Convolvulus arvensis* L. (Convolvulaceae)

4.2.10 Three flowered tickerfoil: *Desmodium triflorum* (L.) DC (Fabaceae)

4.3 Sedges

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

B. Pests of Regional Significance

1. Insect and mite pests

1.1 White grub: *Holotrichia* sp (Coleoptera: Scarabaeidae) (Haryana)

1.2 Red Spider mite:*Tetranychus* sp (Trombidiformes: Tetranychus) (Gujarat)

2. Nematodes

2.1 Stunt nematode: *Telenchorhynchus* sp (Tylenchida: Belonolaimidae)

2.2 Lesion nematode: *Pratylenchus* sp (Tylenchida: Pratylenchidae)

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

A. AESA

The IPM has been evolved 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 abiotic (i.e. soil, rain, sunshine hours, wind etc.) and biological factors (i.e. insect 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 of crop growth
- 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 (Abiotic factors)

Farmers should

- Monitor the field situations 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.)

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. Tolerance is the ability of

plants to mitigate the negative fitness effects caused by herbivory. It is one of the general plant defense strategies against herbivores, the other being resistance, which is the ability of plants to prevent damage (Strauss and Agrawal 1999). Black gram and Green gram have some ability to compensate for the potential loss of flowers (sinks). Extension of growth period in response to flower removal provides an opportunity for yield compensation (Rahman, 2000).

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

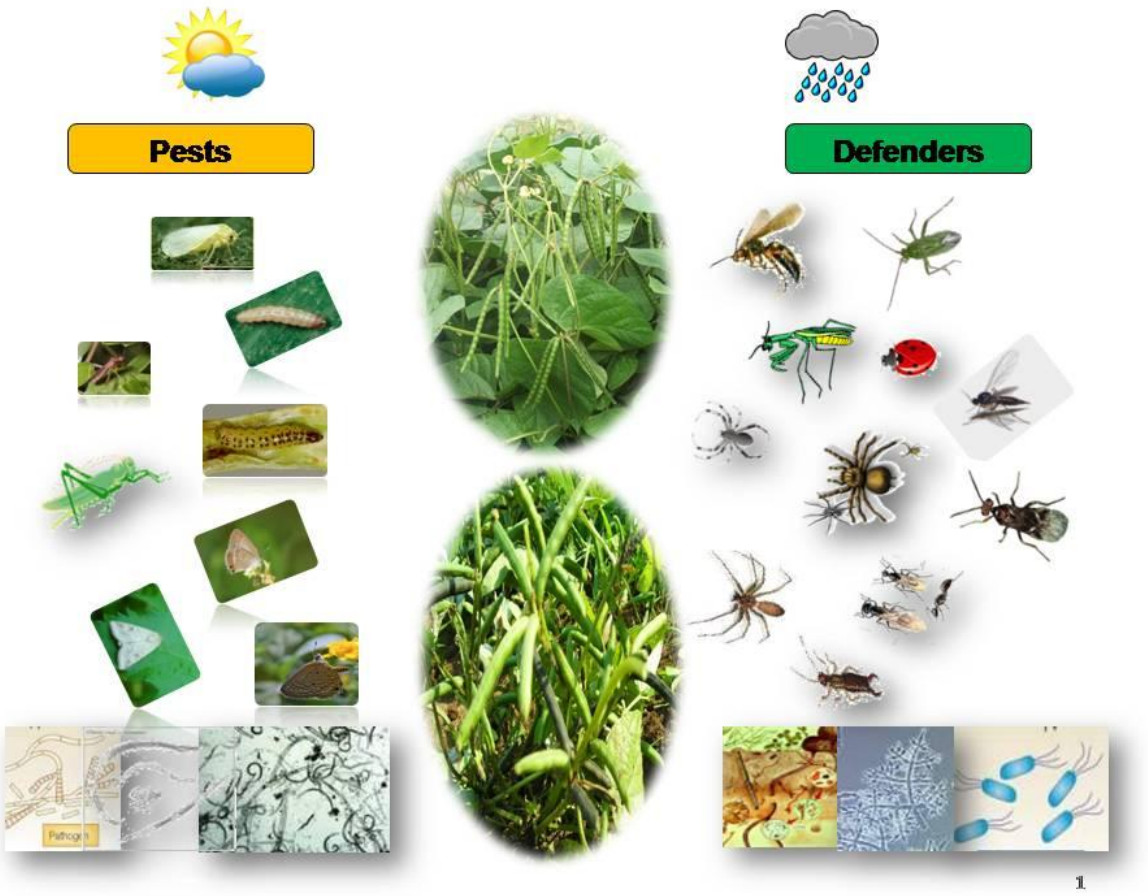
Insect zoo

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 Black gram & Green gram pests can be divided into 3 categories 1. Parasitoids; 2. Predators; and 3. Pathogens. The important natural enemies of Black gram & Green gram insect pests are given in ecological engineering table on page number…..

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 branches, crop stage, deficiency symptoms, no of pods etc.
    - Pests: Observe and count pests at different places on the plant.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
    - 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

- **Plant growth (weekly):** Height of plant; Number of leaves
- **Crop situation (e.g. for AESA):** Plant health; pests, diseases, weeds; natural enemies; soil condition; irrigation; weather conditions
- **Input costs:** Seeds; fertilizer; pesticides; labour
- **Harvest:** Yield (Kg/acre); Price of produce (Rs/Kg)

Some questions that can be used during the discussion

- Summarize the present situation of the field?
- Is there a big change in crop situation compared to last visit? What kind of change?
- Is there any serious pest or disease outbreak?
- What is the situation of the beneficial insects?
- Is there a balance in the field between pests and defenders?
- Were you able to identify all pests and diseases?
- Do you think the crop is healthy?
- What management practices are needed at this moment?
- When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.
- Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest buildup?
- What problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.


Advantages of AESA over ETL

One of the problems of the ETL is that it is based on parameters that are changing all the time, and that are often not known. The damage or losses caused by a certain density of insects

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

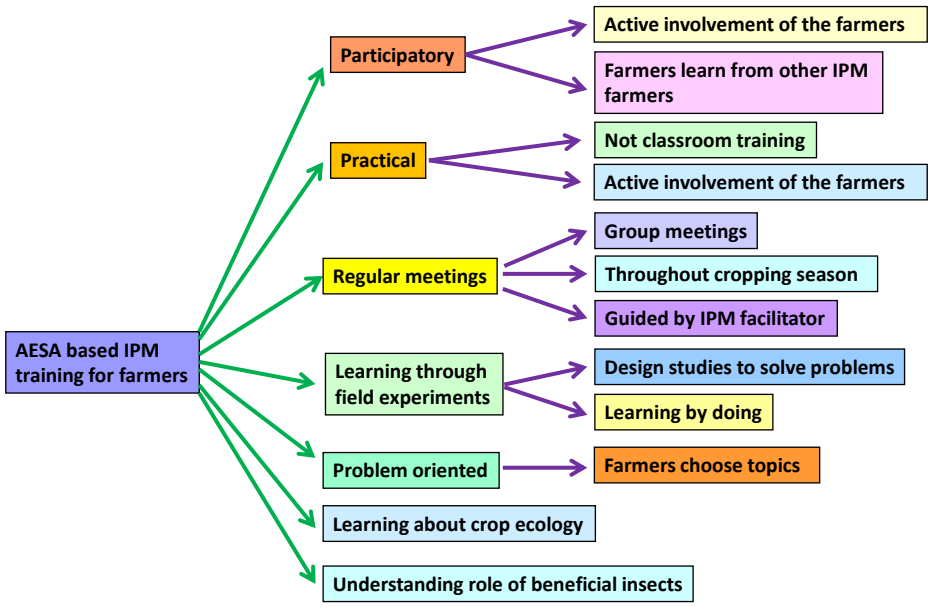
AESA and farmer field school (FFS)

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

Farmers can learn from AESA

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

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.

For Insects

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 as shown (four in the corners, at least 5 feet inside of the field borders, and one in the centre).Select five random plants at each spot for recording counts of insects as per procedure finalized for individual insects.

For insect pests:

Aphids, white flies, leaf hoppers: Count and record the number of both nymphs and adults on five randomly selected leaves per plant.

Borer complex: Total number of pods, damaged pods due to borer and number of larvae on individual plants should be counted and recorded.

Thrips: Count and record the number of nymphs and adults of thrips present on five terminal leaves per plant (tapping method also can be used to count thrips).

For 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 rotshould be counted and incidence should be recorded.

Leaf sampling

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

Stem, flower and pod sampling

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

C. Surveillance through pheromone trap catches for *Helicoverpa* and *Maruca*:

Pheromone traps for *Helicoverpa armigera* @ 4-5 per acre have to be installed. Install the traps for each species separated by a distance of >75 feet in the vicinity of the selected field. Fix the traps to the supporting pole at a height of one foot above the plant canopy. Change of lures should be made once a month. During each week of surveillance, the number of moths/trap should be counted and entered.

Procedure for observation: Total number of moths of Helicoverpa armigera trapped per week should be recorded. The trapped moths should be removed and destroyed after each recording.

D. Yellow/blue pan water/ sticky traps

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

E. Light traps

Set up light traps @1-2 trap/acre 15 cm above the crop canopy for monitoring and mass trapping of insects. Light traps with exit option for natural enemies of smaller size should be installed and operate around the dusk time (6 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 are informed by ecological knowledge rather than on high technology approaches such as synthetic pesticides and genetically engineered crops (Gurr et al. 2004).

Natural enemies may require

1. Food in the form of pollen and nectar for adult natural enemies.
2. Shelter such as overwintering sites, moderate microclimate, etc.
3. 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 non-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 *Mychorrhiza* and plant growth promoting rhizobacteria (PGPR)
- Apply *Trichoderma viride/harzianum* and *Pseudomonas fluorescens* as seed seed/seedling/planting material, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

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, ladybird beetles, long horned grasshoppers, *Chrysoperla,* earwigs, etc.

Ecological Engineering plants

Attractant plants

Cluster bean

Cowpea

Carrot

Sunflower

Buckwheat

French bean

Alfalfa

Mustard

Parsely

***Coreopsis* spp.**

Cosmos

Dandelion

Anise

Caraway

Dill

Marigold

Repellent plants

***Ocimum* sp**

Peppermint

Border plants

Sorghum

Maize

Bajra

Intercrops

Maize

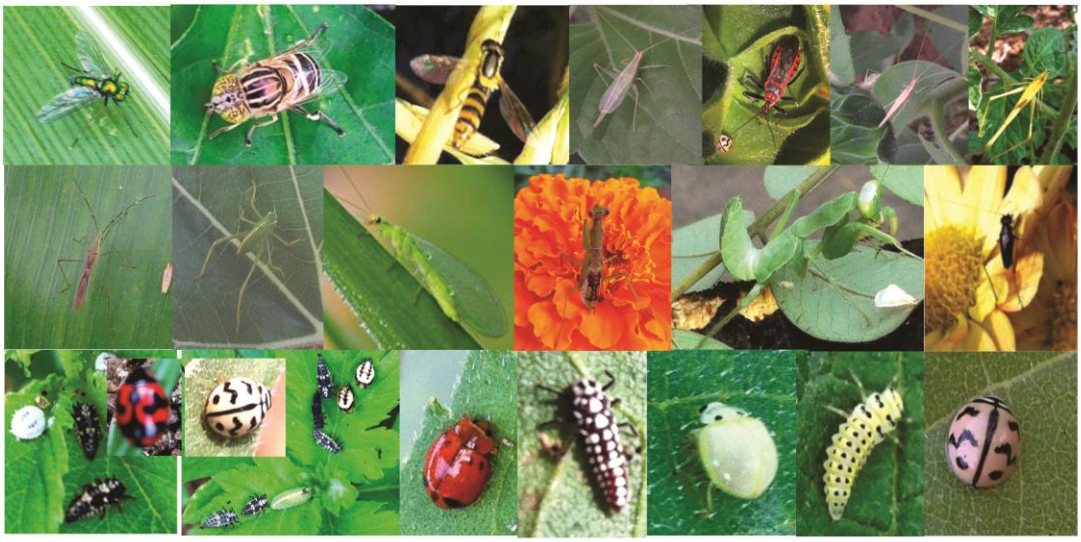
Groundnut

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.

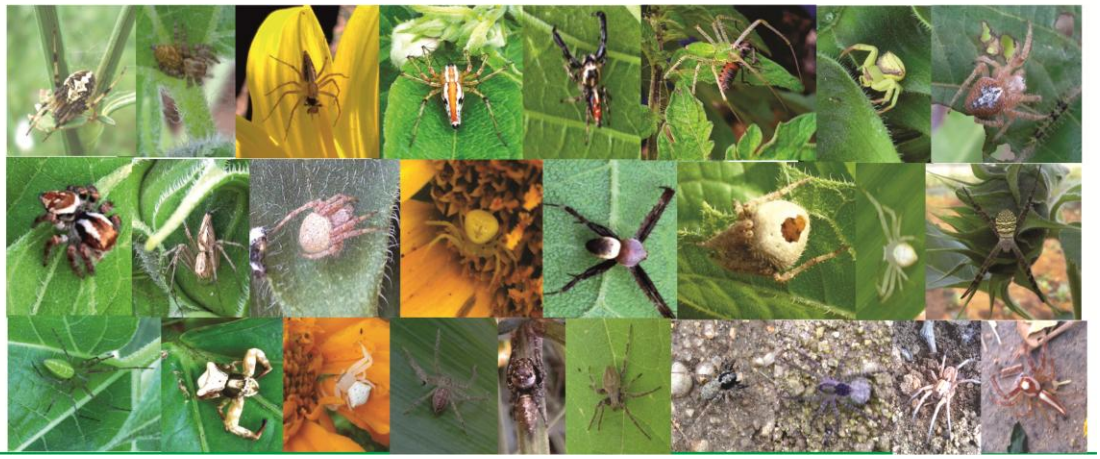
Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



A. Resistant/tolerant varieties

Pest	Tolerant /ResistantVariety
Powdery mildew	Moongbean-TARM 1, Pusa 9072 & Urdbean LBG 17
Yellow mosaic virus	Moong bean- Pant Mung , Pant Mung, PDM 54 (Moti), PDM 84-139(Samrat),PDM 84-143, PDM – 11.ML – 337, Pant Moong MUM 2,MH-88-111 and MUM-2 Urd bean- Pant U 19, Pant U – 30,UG 218, PDU 1, PDU 88 -31

***For detailed and updated information nearest KVK/state department/ SAU / ICAR Institute may be contacted**

IV. CROP STAGE-WISE IPM

Management	Activity
Pre- sowing*	
	Common cultural practices: • Deep ploughing of fields during summer • After summer ploughing field is left for solarization. • Timely sowing should be done • Field sanitation, rogueing • Destroy the alternate host plants • Apply manures and fertilizers as per soil test recommendations • Use tolerant/ resistant varieties • Sow the ecological engineering plants • Rotate the crop with a non host cereal crop, cucurbit, or cruciferous vegetable • Guard crop sorghum or maize in 4 rows all around black gram and green gram crop as guard crop.
Nutrients	• Apply well decomposed FYM @ 4 t/acre or vermicompost @ 2 t/acre treated with *Trichoderma* 2-3weeks before sowing.
Weeds	• At the time of field preparation, adopt stale seed bed technique i.e. pre sowing irrigation followed by shallow tillage to minimize the weeds menace in field.
Soil borne pathogens Nematodes, Resting stage of insects	**Cultural control:** • For anthracnose and BLB hot water treatment of seeds at 52^{o}C for 10 min. • Growing intercrops such as Pigeon pea, marigold and castor for the control of blister beetle, whitefly and leaf hoppers. **Biological control:** • Seed treatment with *Trichoderma viride*1% WP @ 4g per Kg seeds.
Sowing*	
	Common cultural practices: • Select healthy, certified, and weed seed free seeds

Nutrients	• Seed treatment should be done with, *Trichoderma* spp. (8-10 g/Kg seed) and *Rhizobium* spp., AMF/PSB cultures each @ 30 g/Kg seed. • Fertilizers should be applied on soil test basis. Generally, it is recommended to apply 10 to 12 Kg N, 20 to 30 Kg P_2O_5 and 12 to 18 Kg K_2O per acre as basal dose. • In sulphur and zinc deficiency areas, apply sulphur @ 10-12 Kg/acre and zinc sulphate @ 10 Kg/acre in soil at the time of sowing.
Weeds	• Line sowing should be done to facilitate inter-cultural operations. • Optimum plant population should be maintained from beginning to minimize the weed competition.
*Apply *Trichoderma viride/harzianum* and *Pseudomonas fluorescens* as seed treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).	
Vegetative stage*	
	<u>Common cultural practices:</u> • Collect and destroy crop debris • Collect and destroy disease infected and insect damaged plant parts • Avoid water logging • Judicious use of fertilizers • Install light traps in and around fields • Avoid any stress to the crop as much as possible • Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed • Avoid excessive use of nitrogenous fertilizers • Rogueing and destroying the infested plants. **<u>Common mechanical practices:</u>** • Collect and destroy eggs and early stage larvae • Handpick the older larvae during early stages • Handpick the gregarious caterpillars and the cocoons which are found on stem and destroy them in kerosene mixed water. • Use yellow/blue pan water/ sticky traps @ 4-5 trap/acre • Use light trap @ 1/acre and operate between 6 pm and 10 pm • Install pheromone traps @ 4-5/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 **<u>Common biological practices:</u>** • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies
Nutrients	• Correct micronutrient deficiency if any in standing crop.
Weeds	• Keep field boundary and bunds free from weeds. • The crop field should be weed free initially for 3-4 weeks by following timely hoeing and weeding by power hand tiller and/or hand tools at 20

	and 35 days after sowing. • Mulches like straw hay, plastic, etc. should be used in between the rows to suppress the weed growth. • If mechanical/physical control measures are not adopted apply Fenoxaprop-p-ethyl 9.3% w/w EC (9% w/v) @ 250-300ml/acre in 150 to 160 litre water at 15-20 DAS or Propaquizafop 10% EC @300-400ml/acre in 200 to 300 litre water or Quizalofop-ethyl 5% EC 300-400ml/acre in 200 litre water as per infestation of the specific weed species.
Grass butterfly	• See the common cultural and mechanical practices **Biological control:** • Release egg parasitoid *Trichogramma* spp.at weekly intervals @0.6 lakh/acre/ week for four times.
Bihar hairy caterpillar	**Cultural control:** • Irrigate once to avoid prolonged mid-season drought to prevent pre-harvest infestation. **Mechanical control:** • Dig the trenches of 1 inch depth between the fields & dust the trenches to kill the larvae in pits. **Chemical control:** • Spray Quinalphos 25% EC 600ml diluted in 200-400 l of water/acre (blackgram) • Spray Phenthoate 50% EC 320 ml diluted in 200-400 l of water/acre (blackgram & greengram)
Stem fly	• See the common cultural and mechanical practices **Chemical control:** • Phorate10%CG@4 Kg/acre (blackgram & greengram)
Pod weevil	• See the common cultural and biological practices
Bean aphid	**Cultural control:** • Abiotic factors such as rain and wind reduce aphid infestations. • Prune curled leaves or new shoots and dispose them.
Leaf hopper	**Biological control:** • Spray neem oil @ 5 ml/l
Pod fly	• See the common cultural and biological practices
Whitefly	**Chemical control:** • Phorate10%CG @4Kg/acre (Black gram)
Thrips	• See the common cultural practices
Blister beetle	• See the common cultural and biological practices

White grub**	**<u>Cultural control:</u>** • See the common cultural practices **<u>Biological control</u>** • Conserve natural enemies like *Typhia* (parasitic wasp),ground beetles, tiger beetles and wasps.
Red spider mite**	**<u>Cultural control:</u>** • Provide adequate irrigation • Sprays of water or soap water **<u>Biological control:</u>** • Spray neem or pongamia soap @ 1% on lower surface thoroughly.
Anthracnose, Bacterial leaf blight, *Cercospora*leaf spot	**<u>Cultural control:</u>** • Early planting i.e. immediately after onset of monsoon. • Grow crop on bower system to avoid soil contact. • Maintain proper drainage in the field.
Powdery mildew	**<u>Cultural control:</u>** • Bower system (maintain gapping) of cropping reduces the disease incidence. **<u>Chemical control:</u>** • Spray Penconazole 10% EC@ 20ml diluted in 200 l of water/acre (blackgram & greengram)
Rust	**<u>Cultural control:</u>** • Volunteer plants reduce the disease severity
Root rot, *Macrophomina* blight	**<u>Cultural control:</u>** • Plant in well-draining soils. • Prepare seed beds to enhance rapid germination • Proper irrigation is provided to prevent flooding and saturated soil conditions. • Soil amendment with farm yard manure @ 5 tonnes/acre
Yellow mosaic virus	• See the common cultural practices
Leaf crinkle virus	• See the common cultural practices
Flowering	
Blue butterfly, Grass butterfly, Bihar hairy caterpillar, Pod weevil, Bean aphid, Pod fly, Whitefly, Thrips, Anthracnose, Bacterial leaf blight, *Cercospora* leaf spot, Powdery mildew, Rust, Yellow mosaic virus, Leaf crinkle virus	• Same as in vegetative stage

Root rot, *Macrophomina* blight	• Same as in sowing/seedling stage
Reproductive (pod development)	
Nutrients	• Incorporate crop residues in soil immediately after harvest.
Weeds	• Remove left over weeds to prevent weed seed spread in field.
Gram pod borer, Spotted pod borer, Spiny pod borer	**Cultural control:** • Their flowers shall attract oviposition sites which can be plucked and disposed. • Ridge planting + cover crops like soybean, cowpea, moth bean. **Chemical control:.** • Spray Chlorantraniliprole 18.5% SC @ 40 ml in 200 l of water/ acre (Black gram) • Spray Lufenuron 5.4% EC @ 240 ml in 200 l of water/ acre (Black gram) • Spray Methyl Parathion 2% DP @ 10 Kg in 10000 l of water/acre (Black gram & Green gram) • Spray Monocrotophos 36% SL @ 250 ml in 200-400 l of water/acre (Black gram & Green gram) • Spray Phenthoate 50% EC @ 800 ml in 200-400 l of water/ acre (Black gram & Green gram) • Spray Thiodicarb 75% WP @ 250-300 g in 150-200 l of water/ acre (Black gram) • Spray Flubendiamide 39.35 % M/M SC @ 40ml in 200 l of water/acre (Black gram)
Blue butterfly, Grass butterfly, Bihar hairy caterpillar, Pod weevil, Bean aphid, Pod fly, Whitefly, Thrips, Anthracnose, Bacterial leaf blight, *Cercospora* leaf spot, Powdery mildew, Rust, Yellow mosaic virus, Leaf crinkle virus	• Same as in vegetative stage
Root rot, *Macrophomina* blight	• Same as in sowing/seedling stage

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

**** Regional pest**

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 num Black gram and Green gram 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. Goosegrass: *Eleusine indica* (L.) Gaertner (Poaceae)

2. Rabbit/Crow foot grass: *Dactyloctenium aegyptium* L. Willd. (Poaceae)

3. Barnyard grass: *Echinocloa crusgalli* (L.) Beauv. (Poaceae)

3. b Jungle rice E. colona (L.) Beauv. (Poaceae)

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

5. False amaranth: *Digera arvensis* Forssk. (Amaranthaceae)

6. Horse purslane: *Trianthema portulacastrum* L. (Aizoaceae)

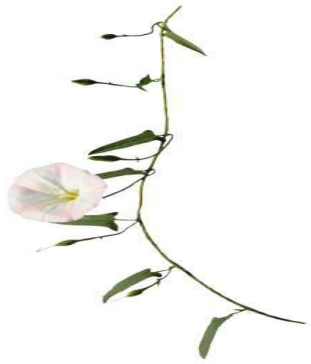
7. Tick weed: *Cleome viscose* L.(Capparidaceae)

8) Stonebreaker: *Phyllanthus niruri* L.(Euphorbiaceae)

9) Common lambs quarter: *Chenopodium album* L.(Chenopodiaceae)

10) Burcloveru: *Medicago denticulata* Willd. (Fabaceae)

11) Canada Thistle: *Cirsium arvensis* (L.) Scop (Asteraceae)



12) Field bindweed: *Convolvulus arvensis* L. (Convolvulaceae)

13) Three flowered tickerfoil: *Desmodium triflorum* (L.)DC (Fabaceae)

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

VII. DESCRIPTION OF INSECT, MITE AND NEMATODE PESTS

1) Gram pod borer:

Biology:

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

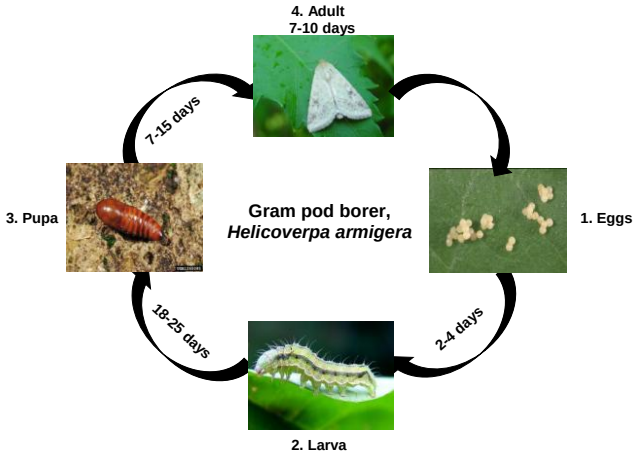
Egg: Spherical, yellowish eggs are laid singly on tender parts and buds of plants. The egg period lasts for 2-4 days.

Larva: Caterpillars are of varying 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:



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

Damage symptoms:

- Young larva feeds on the leaves for some time and then attacks fruits. Internal tissues are eaten severely and completely hollowed out. While feeding the caterpillar thrust its head inside leaving the rest of the body outside.
- Bored fruits with round holes.
- Fed leaves, shoots and buds.
- The activity of *Helicoverpa*starts on green gram, summer vegetables and maize and

continues their generation by Aug-Sept months synchronizing with main crop.

Favourable conditions:

- Warm weather conditions followed by light rains and dry spells are favourable for multiplication.

Natural enemies of gram pod borer

Parasitoids: *Trichogramma* spp, *Tetrastichus* spp, *Chelonus* spp, *Telenomus* spp, *Bracon* spp, *Ichneumon* spp, *Carcelia* spp, *Campoletis* spp.

Predators: Lacewing, ladybird beetle, spider, red ant, dragon fly, robber fly, reduviid bug, praying mantis, black drongo (King crow), wasp, common mynah, big-eyed bug (*Geocoris* sp), earwig, ground beetle, pentatomid bug etc.,

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

2 Spotted pod borer:

Biology:

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

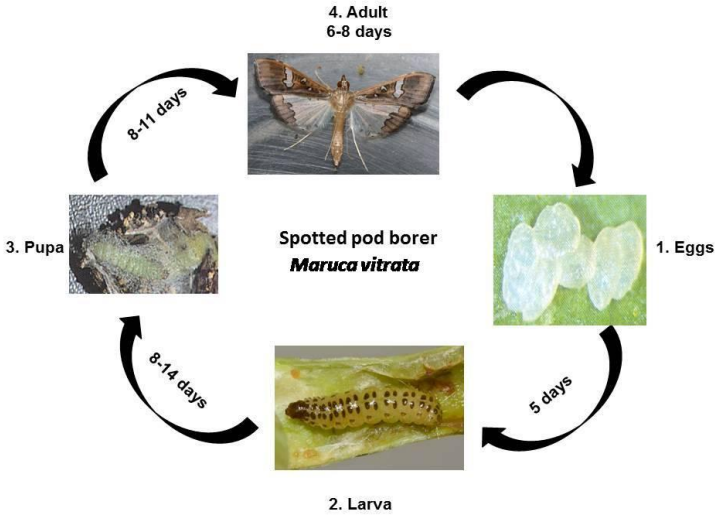
Egg: Eggs were laid on the under surface of leaves, terminal shoots and flower buds. The freshly laid eggs were milky white in colour and oval in outline, dorsoventraly flattened and glued to the surface.

Larva:15 –20 days.Greenish white with brown head

Pupa: Pupates in dry leaves and debris

Adult: Brown forewings and white hind wings

Life cycle:



Damage symptoms

- Bore holes on the buds, flower or pods
- Infested pods and flowers are webbed together

Natural enemies of spotted pod borer:

Parasitoids: *Trichogramma* spp, *Tetrastichus* spp, *Chelonus* spp, *Telenomus* spp, *Bracon* spp.

Predators: Lacewing, ladybird beetle, spider, red ant, dragon fly, robber fly, reduviid bug, praying mantis etc.,

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

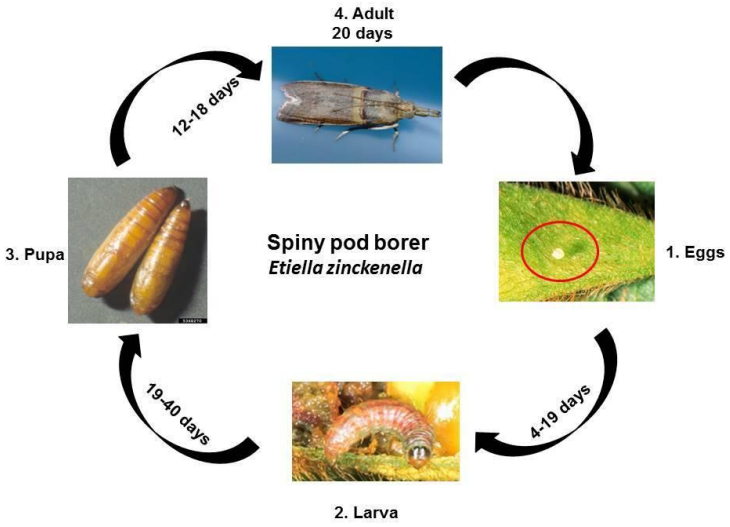
3. Spiny pod borer:

Biology:

Larval: greenish initially, turns pink before pupation. It has 5 black spots on the prothorax

Adult: Brownish grey moth. Prothorax – orange in colour**.** Fore wing has a white stripe along the anterior margin.

Life cycle:



1 http://ecoport.org/ep?SearchType=pdb&PdbID=38337
2 http://ecoport.org/ep?SearchType=pdb&PdbID=38335
3 http://www.insectimages.org/browse/detail.cfm?imgnum=5368270
4 http://www.nbaii.res.in/insectpests/images/Etiella-zinckenella12.jpg

Damage symptom:

- Dropping of flowers and young pods
- Older pods marked with a brown spot where a larvae has entered

4.Red spider mites:

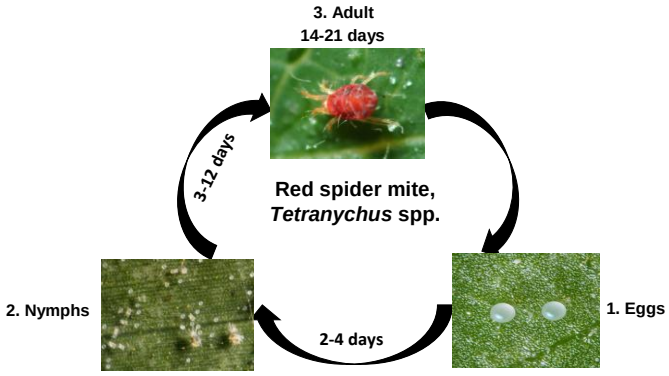
Biology:

Egg: Hyaline, globular laid in mass

Nymph: Yellowish in colour

Adult: Red coloured small size

Life cycle:



1. http://www.simplepestcontrol.com/spider-mite-control.htm
2. http://entomology.k-state.edu/extension/insect-photo-gallery/Corn-Insects.html
3. http://www.al.gov.bc.ca/cropprot/grapeipm/spidermites.htm

Damage symptoms:

- Affected leaves become reddish brown and bronzy
- Severe infestation larvae silken webbing on the leaves
- Leaves wither and dry
- Flower and fruit formation affected

Natural enemies of red spider mite:

Predators: Predatory mite, predatory thrips, *oligota* spp, *orius* spp, hover fly, Mirid bug etc.,

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

5.Bihar hairy caterpillar:

Biology:

This pest occurs during October to December and of late it is also occuring from July. In recent years, it has become an important pest on groundnut also.

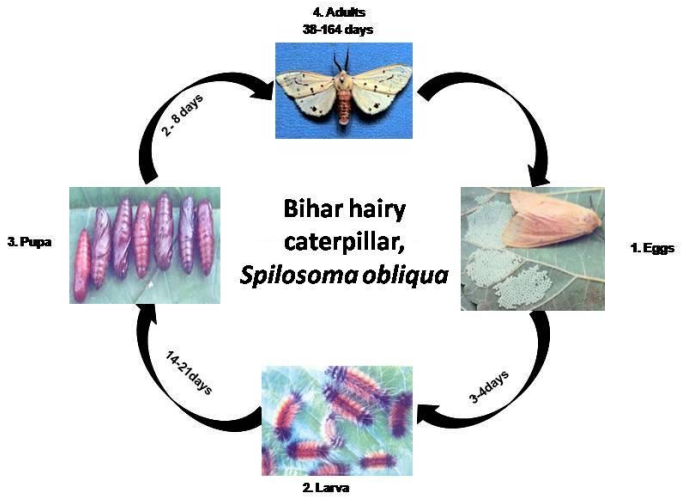
Egg: Female lays eggs in masses on leaves.

Larva: The larvae are pale yellow coloured with yellow hair over the body. They are polyphagous, feed on leaves and cause loss by way of defoliation. In severe cases only stems are left behind. In defoliated crops it also feeds on capsules.

Pupa: Pupates in leaf litter close to the plants. There are several generation per year.

Adult: Adult moth is reddish brown with black spots. Both the wings are pinkish and posses black spots

Life cycle:



1,2 http://uasr.agropedia.in/content/Black gram & Green gram-bihar-hairy-caterpillar
3,4 https://www.google.co.in/search?q=Bihar+hairy+caterpillar+in+Black gram & green gram

Damage symptoms:

- Young larvae feed gregariously mostly on the under surface of the leaves.
- Caterpillars feed on leaves and in severe infestation the whole crop is defoliated.
- Drying up of infected leaves is the main symptom

Natural enemies of bihar hairy caterpillar:

Parasitoids: *Trichogamma* sp, *Bracon* sp.

Predators: Lacewing, ladybird beetle, spider, red ant, dragon fly, praying mantis, ground beetle, shield bugs etc.,
*For management refer to page number----------

6. Aphids:

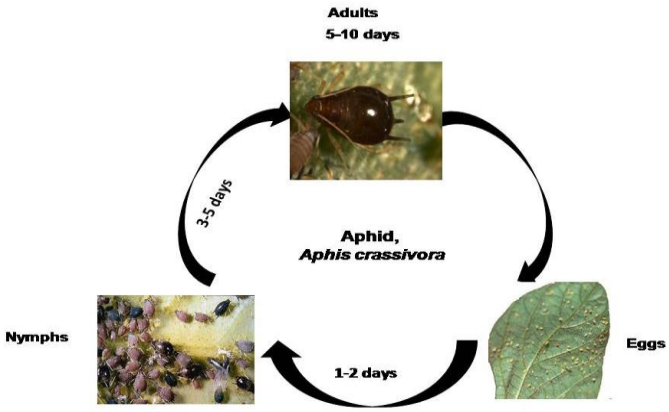
Biology:

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

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

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

Life cycle:



Damage Symptoms:

- In addition, plants may become contaminated by honeydew produced by aphids and sooty mould growing on honeydew.
- Black gram contaminated with honeydew and / or sooty moulds are not marketable.
- Aphids are also vectors of diseases, including the bean common mosaic virus.
- The black bean aphid is a widely distributed pest of beans. The black legume aphid usually attacks beans grown at low altitudes

Natural enemies of aphids:

Parasitoid: *Aphidius colemani, Aphelinus* sp

Predators: Syrphid larva, lacewing, ladybird beetle, spider etc.,

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

7. Stem fly:

Biology:

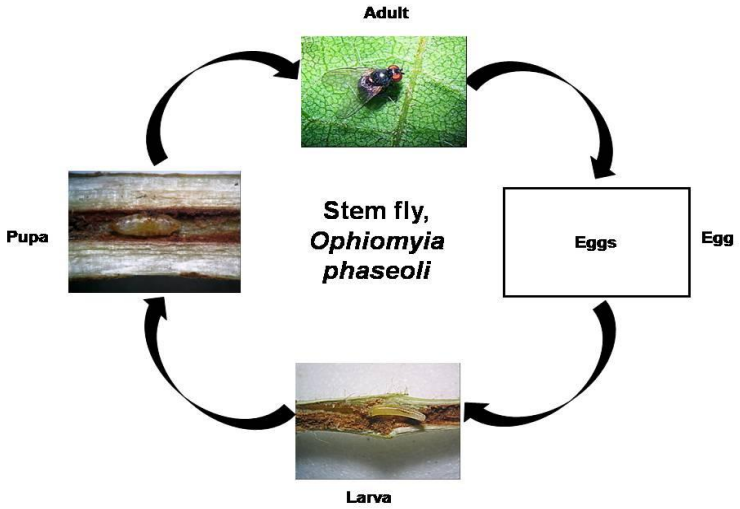
Egg: The stem fly inserts eggs on the underside of young leaves. Ovipositing sites present as pale pinprick spots when infested leaves are held up to the light.

Larva: The larvae are whitish, torpedo-shaped maggots that reach little more than 2mm. Larva pupate after 8-11 days. Before pupation, which takes place inside the stem, the larva makes an exit hole for the emergence of the adult.

Pupa: Pupae are smooth, light brown to pale brown, cylindrical in shape with rounded ends. Pupal stage lasts 6–12 days.

Adult: Adult flies are shiny black and about 2mm long with a pair of clear wings of wingspan 4-5 mm.

Life cycle:



1,2,3: http://thebeatsheet.com.au/-stem-fly-outbreak-in-gram-crops/

Damage Symptoms:

- Infected stems are often red inside (sometimes pale) and a distinct zig-zag tunnel may be observed — with maggots or pupae inside. Apart from the exit holes, the plants will initially appear healthy on the outside.
- Large infestations (3 or more maggots per plant) may cause wilting and may even cause plant death, especially in younger plants particularly if damage occurs in the plant's hypocotyl (basal stem) region.

Natural enemies of stem fly:

Parasitoids: Tiny wasps

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

8. Whitefly:

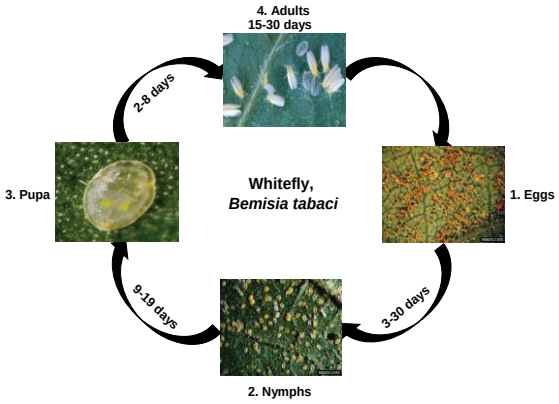
Biology:

Egg: Pear shaped, light yellowish.

Nymph: On hatching - Oval, scale-like, greenish white.

Adult: White, tiny, scale-like adult.

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 formosa, Eretmocerus* sp

Predators: Lady bird beetle

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

9. Thrips:

Biology:

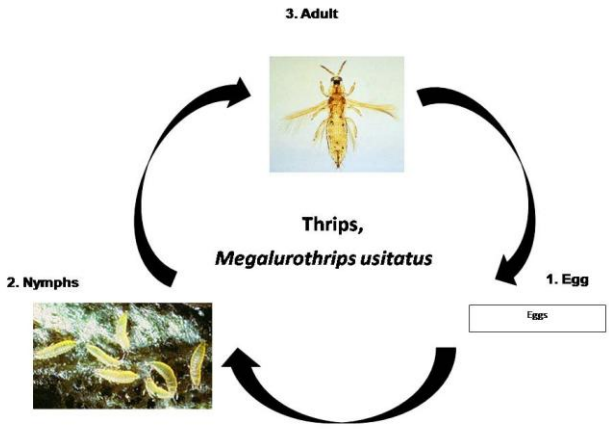
Egg: Eggs are microscopic and almost impossible to see. White or yellow. Eggs are inserted one by one by the females in the plant tissue. Only one end of the egg will be near the surface of the tissue to allow the immature to emerge. Adults prefer to lay their eggs in leaf, cotyledon, or flower tissues.

Nymph: Very small. Thrips pupae appear as an intermediate form between the immature and the adult. They have short antennae and the wing buds are visible but short and not functional.Pale yellow to brown. In the base of the plant neck or in the soil.At this stage thrips do not feed.

Adult: Up to 2 mm. Adults have fully developed wings. The wings are very different from other insects. They have a single longitudinal vein in which there are 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. Pale yellow to dark brown. The same as immatures. You can find them also in the flowers. Adults are more mobile than immatures and pupae because they can fly. They are attracted to yellow and white colors. They often will fly to one's clothes or land 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 piercing and rasping the leaf surface with their mouth parts to release the liquids from the plant cells. In this process, thrips release substances that help predigest the onion plant tissue. Later, with their mouth they suck up the plant content.
- The appearance of the damage is silvery patches or streaks on the leaves 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 and plant pathogens penetrate the injured plant easily.

Damage Symptom

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

Natural enemies of thrips:

Parsitoid: *Ceranisus menes*

Predators: Predatory mite, predatory thrips, *oligota* spp, *orius* spp, hover fly, mirid bug etc.,

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

10. Blister beetles:

The beetles are found to occur throughout the year in red gram, cowpea, green gram and black gram. Peak incidence is generally observed during September, causing a maximum flower damage of 95 per cent.

Adults feed on the flowers, tender pods and young leaves resulting in fewer pods. In locations where pigeon pea is grown over large areas, blister beetles cause little damage. However, in small plots that are in the flowering stage during the period of peak adult activity (August-October in southern India), most of the flowers may be eaten by the beetles and crop losses may be substantial. The adults are medium to large (2.5 cm in length), usually black with large yellow spots and a red band across the abdomen, which sometimes changes into yellow spots. The antennae are orange or yellow. The immature stages (larvae) do not feed on plants. They live in the soil and eat grasshopper eggs, and are therefore beneficial.

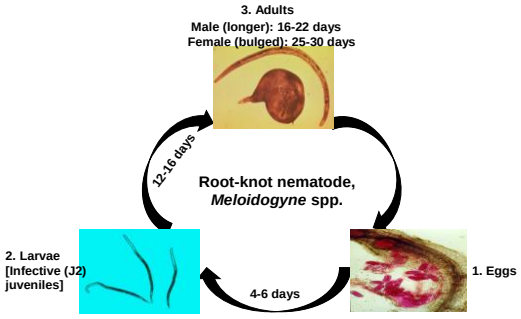
*For management refer to page number----------

11.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 molt occurs. Second stage larvae hatch from eggs to find and infect plant roots or in some cases foliar tissues.
- Under suitable environmental conditions, the eggs hatch and new larvae emerge to complete the life cycle within 4 to 8 weeks depending on temperature.
- Nematode development is generally most rapid within an optimal soil temperature range of 70 to 80°F.

Life cycle:



1.http://keys.lucidcentral.org/keys/sweetpotato/key/
2.http://nematology.umd.edu/rootknot.html
3.http://www.cals.ncsu.edu/pgg/dan_webpage/Introduction/Images/pyroform.htm

Damage symptoms:

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

Survival and Spread:

- **Primary**: Cysts and egg masses in infected plant debris and soil or collateral and other hosts like Solonaceous, Malvaceous and Leguminaceous plants act as sources of inoculums.
- **Secondary**: Autonomous second stage juveniles that may also be water dispersed.

Favourable conditions:

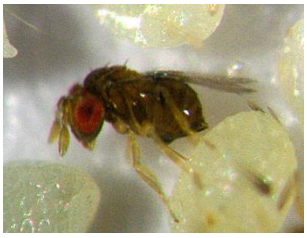
- Loamy light soils.

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

Natural enemies of redgram insect pests

Parasitoids

Egg parasitoids



1. *Tricogramma*

2. *Tetrastichus* spp.

3. *Telenomus* spp

Egg-larval parasitoid

6. *Chelonus* spp.

Larval parasitoids




5. *Bracon* spp. 6. *Ichneumon* sp 7. *Carcelia* spp. 8. *Campoletis* spp

Nymphal/larval and adult parasitoids



9. *Aphidius* 10 *Encarsia formosa* 11. *Eretmocerus* spp.

1. http://www.nbaii.res.in/Featured_insects/Trichogrammatids.php
2. http://www.pbase.com/image/135529248
3. http://baba-insects.blogspot.in/2012/02/telenomus.html
4. http://www.nbaii.res.in/Featured%20insects/chelonus.htm
5. http://www.nbaii.res.in/Featured%20insects/Bracon%20brevicornis.htm
6. http://www.organicgardeninfo.com/ichneumon-wasp.html
7. http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398
8. http://www.nbaii.res.in/Featured%20insects/Campoletis.htm
9. http://biobee.in/products-and-services/solutions/bio-aphidius/
10. http://www.buglogical.com/whitefly-control/encarsia-formosa/
11. 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 mantis

14. *Geocoris* spp.

15. Predatory mite

16. Predatory thrips

17. *Oligota* spp.

18. *Orius* spp.

19. Hover fly

20. Mirid bug

5. http://www.warpedphotosblog.com/robber-fly-and-prey
6.http://www.couriermail.com.au/news/queensland/queensland-launched-a-war-against-the-fire-ant-invasion-but-12-years-later-they8217re-still-on-the-march/story-fnihsrf2-1226686256021
7. http://nagpurbirds.org/blackdrongo/picture/1639
8. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/

9. http://bugguide.net/node/view/598529
10. http://www.flickr.com/photos/johnhallmen/2901162091/
11.http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/ Ground%20Beetle%20-%20Pterostichus%20madidus.html
12. http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asopinae/ Eocanthecona.htm
13. http://spirit-animals.com/praying-mantis/
14. http://nathistoc.bio.uci.edu/hemipt/Dicyphus.htm
15. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
16. http://biocontrol.ucr.edu/hoddle/persea_mite.html
17. http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33
18. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg
20. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html

VIII. DESCRIPTION OF DISEASES

1.*Cercospora* leaf spot :

Disease symptoms:

- Moist weather and splattering rains are conducive to disease development. Most outbreaks of the disease can be traced back to heavy rainstorms that occur in the area.
- Infected leaves show small, brown, water soaked, circular spots surrounded with yellowish halo.
- On older plants the leaflet infection is mostly on older leaves and may cause serious defoliation. The most striking symptoms are on the green fruit. Small, water-soaked spots.
- First appear which later become raised and enlarge until they are one-eighth to one-fourth inch in diameter.
- Centres of these lesions become irregular, light brown and slightly sunken with a rough, scabby surface.
- Ripe fruits are not susceptible to the disease. Surface of the seed becomes contaminated with the bacteria, remaining on the seed surface for some time.
- The organism survives in alternate hosts, on volunteer Black gram plants and on infected plant debris.

Survival and spread:

- The fungus is soil borne on diseased plant debris and it survives only on the tissues which it colonizes as a parasite.
- Fungus spreads abort 3 m through the soil in one season, apparently along roots.
- The fungus was found to survive in infected plant stubble for 2.5 in vertisols and 3 years in alfisols.

Favourable conditions

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

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

2.Bacterial leaf blight:

Disease symptoms:

- This is a common disease of black gram occurring on the foliage at any stage of the growth.
- The fungus attacks the foliage causing characteristic leaf spots and blight. Early blight is first observed on the plants as small, black lesions mostly on the older foliage.
- Spots enlarge, and by the time they are one-fourth inch in diameter or larger, concentric rings in a bull's eye pattern can be seen in the center of the diseased area.
- Tissue surrounding the spots may turn yellow. If high temperature and humidity occur at this

time, much of the foliage is killed.

- Lesions on the stems are similar to those on leaves, sometimes girdling the plant if they occur near the soil line.
- Transplants showing infection by the late blight fungus often die when set in the field. The fungus also infects the fruit, generally through the calyx or stem attachment.
  Lesions attain considerable size, usually involving nearly the entire fruit; concentric rings are also present on the fruit.

Survival and spread

- The bacterium is seed-borne and through vines grow perennially.
-

Favourable conditions

- Rain splashes play an important role in the development and spreading of the disease.
- Warm, rainy and wet weather.

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

3.Anthracnose:

Disease symptoms:

- Symptoms are circular, black, sunken spots with dark center and bright red orange margins on leaves and pods
- In severe infections, the affected parts wither off.
- Seedlings get blighted due to infection soon after seed germination.

Survival and Spread

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

Favourable Conditions

- The disease is more sever in cool and wet seasons.

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

4.Powdery mildew:

Disease symptoms:

- White powdery patches appear on leaves and other green parts which later become dull coloured
- These patches gradually increase in size and become circular covering the lower surface also
- When the infection is severe, both the surfaces of the leaves are completely covered by whitish powdery growth
- In severe infections, foliage becomes yellow causing premature defoliation
- The disease also creates forced maturity of the infected plants which results in heavy yield losses.

Survival and spread

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

Favourable conditions

- Cool (10-20 ºC) and wet weather (90% RH) favours disease development.

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

5.Root rot and leaf blight:

Disease symptoms:

- The pathogens cause seed decay, root rot, damping-off, seedling blight, stem canker and leaf blight in green gram
- The disease occurs commonly at pod development stage
- In the initial stages, the fungus causes seed rot, seedling blight and root rot symptoms.
- The affected leaves turn yellow in colour and brown irregular lesions appear on leaves.
- On coalescence of such lesions, big blotches are formed and the affected leaves start drying prematurely.
- Roots and basal portion of the stem become black in colour and the bark peels off easily.
- When the tap root of the affected plant is split open, reddening of internal tissues is visible.

Survival and spread

- Species are saprotrophic, occurring in the soil which is the source of primary infection.
- Secondary infection occurs by means of asexual spores.

Favourable conditions

- Moist soil and humid conditions favour the development of disease.

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

6.Rust:

Disease symptoms:

- The disease appears as circular reddish brown pustules which appear more commonly on the underside of the leaves
- When leaves are severely infected, both the surfaces are fully covered by rust pustules
- Shrivelling followed by defoliation resulting in yield losses.

Survival and Spread

- The pathogen survives in the soil through teliospores and as uredospores in crop debris. Primary infection is by the sporidia developed from teliospores. Secondary spread is by wind-borne uredospores. The fungus also survives on other legume hosts.

Favourable Conditions

- Cloudy humid weather, temperature of 21-26˚ C.
- Nights with heavy dews

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

7.Stem canker and *Macrophomina* blight:

Disease symptoms:

- In rice fallows, symptoms appear on 4 weeks old black gram crop as raised white cankers at the base of the stem
- These enlarge gradually and turn as raised brown streaks spreading upwards
- Plants are stunted and leaves dark green, mottled and reduced in size
- Normal leaves on the affected plants drop suddenly and dry
- Flowering and podding is greatly reduced.

Survival and spread

- The pathogens survive in soil and plant debris.

Favourable conditions

- Warm humid weather.
- The disease is severe generally during late *kharif* and *rabi* seasons.

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

8.Yellow Mosaic:

Disease symptoms:

- Initially mild scattered yellow spots appear on young leaves
- The next trifoliate leaves emerging from the growing apex show irregular yellow and green patches alternating with each other
- Spots gradually increase in size and ultimately some leaves turn completely yellow
- Infected leaves also show necrotic symptoms.
- Diseased plants are stunted, mature late and produce very few flowers and pods
- Pods of infected plants are reduced in size and turn yellow in colour.

Transmission and favourable conditions

- The disease is transmitted in semi persistent manner by aphid *Aphis gossypii.*
- Aphids are more active in warm summer conditions and increased their population as well as spread the viruses more.

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

9.Leaf Crinkle:

Disease symptoms:

- The symptoms appear on youngest leaves as chlorosis around some lateral veins and its branches near the margin
- The leaves show curling of margin downwards
- The veins show reddish brown discoloration on the under surface which also extends to the petiole
- Plants showing symptoms within 5 weeks after sowing invariably remain stunted and majority of these die due to top necrosis within a week or two.

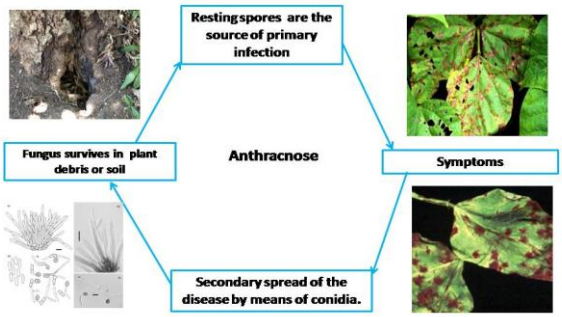
Transmission and Favourable conditions

- Virus is transmitted by *Henosepilachna dodecastigma.* The disease develops in the fields mainly through seed or rubbing of diseased leaves
-

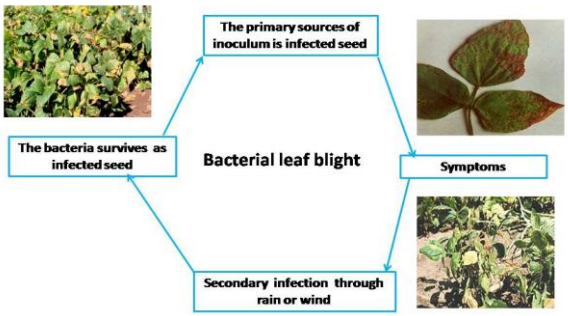
*For management refer to page number----------

Disease cycles:

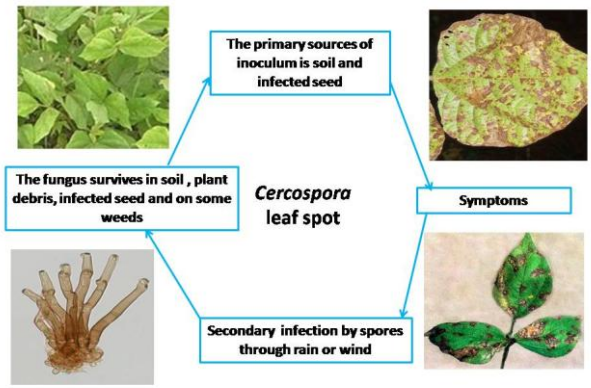
1. Anthracnose:



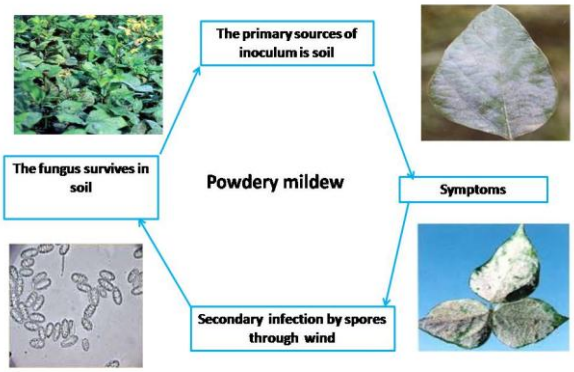
2. Bacterial leaf blight:



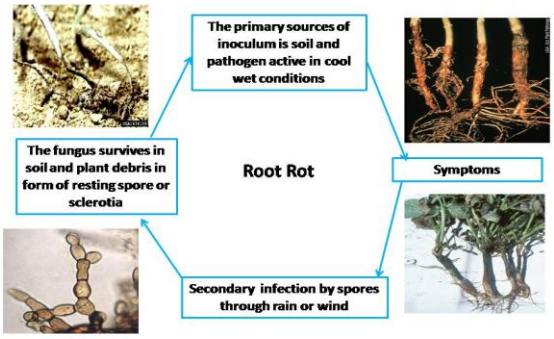
3.*Cercospora* leaf spot:



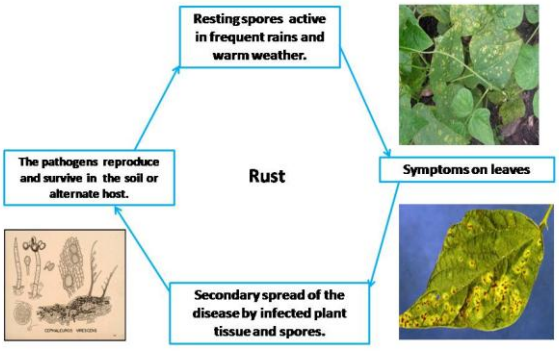
4.Powdery Mildew:



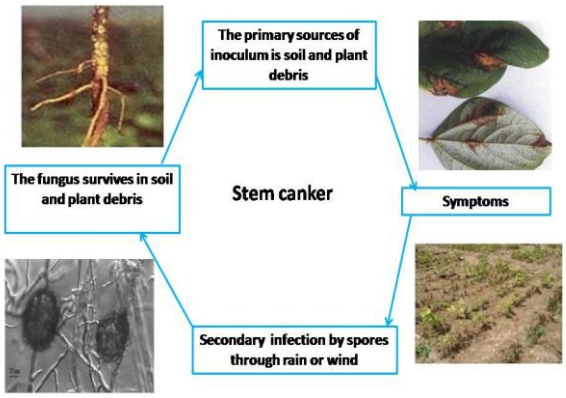
5.Root Rot and Leaf Blight:



6.Rust:



7.Stem canker and macrophomina blight:



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.
- Dry beans should be harvested when most pods are fully mature and have turned color. To minimize shatter, harvesters should not shake the vines.
- 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 rajmah, 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.
- Avoid pest infestation prior to harvesting.
- 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 Red gram 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, driage, 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. B-Twill 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 crop rotation.	Avoid monocroping
3.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
4	Sow early in the season	Avoid late sowing as this may lead to reduced yields and incidence of white grubs and diseases.
5	Always treat the seeds with approved biopesticides /chemicals for the control of seed borne diseases/ pests.	Do not use seeds without seed treatment with biopesticides/ chemicals.

6.	Sow in rows at optimum depths under proper moisture conditions for better establishment.	Do not sow seeds beyond 5-7 cm depth.
7.	Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
8.	Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition	Crops should not be exposed to moisture deficit stress at their critical growth stages.
9	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers
10	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
11	Conduct AESA weekly in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.	Do not take any management decision without considering AESA and P: D ratio
12	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
13	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per field observation	Do not apply chemical pesticides within seven days of release of parasitoids.
14	Apply HaNPV or SINPV at recommended dose when a large number of egg masses and early instar larvae are noticed. Apply NPV only in the evening hours after 5 pm.	Do not apply NPV on late instar larva and during day time.
15	In case of pests which are active during night like fruit moth 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.
16	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, whiteflies, thrips and other sucking pests harbouring the lower side of leaves.	Do not spray pesticides only on the upper surface of leaves.
17	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest
18	Follow the recommended procedure of trap crop technology.	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.

XI

. 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)
Insecticides					
1.	Dimethoate Highly toxic 	Class II Moderately hazardous	Mild-anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity	**Treatment of poisoning:** For extreme symptoms of OP poisoning, injection of atropine (2-4 mg for adults, 0.5-1.0 mg for children) is recommended. Repeated at 5-10 minute intervals until signs of atropinization occur.	--
2.	Imidacloprid Highly toxic 	--	Harmful if swallowed, absorbed through skin or inhaled. Avoid breathing vapor or spray mist. Causes moderate eye irritation.	**First aid measures:** Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious person **Treatment of poisoning:** No specific antidote. Treatment is essentially symptomatic.	3 days
3.	Monocrotophos Extremely toxic 	Class I b Highly Hazardous	Severe – diarrhoea, pinpoint and non - reactive pupils, respiratory difficulty, pulmonary edema, cyanosis, loss of sphincter control, convulsions, coma and heart block.	**First aid measures:** Atrophine sulphate **Treatment of poisoning:** For ingestion lavage stomach with 5 % sodium bicarbonate, if not vomiting. For skin contact, wash with soap and water (eyes – wash with isotonic saline). Wear rubber gloves while washing contact areas.	7 days

				In addition to atropine give 2 – PAM (2 – pyridine aldoximemethiodide). 1 g and 0.25g for infants intravenously at slow rate over a period of 5 minutes and administer again periodically as indicated. More than one injection may be required. Avoid morphine, theophylline, aminophylln, barbiturates Phenothiaznines	
4.	Oxydemeton-methyl Highly toxic 	Class Ib Moderately Hazardous	-do-	-do-	7 days
5.	Phorate Extremely toxic 	Class I a Extremely hazardous	Nausea, vomiting, restlessness, tremor, apprehension, convulsions, coma, respiratory failure and death Mild – anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity. Moderate- nausea, salivation, lacrimation, abdominal cramp, vomiting, sweating, slow pulse, muscular tremors, miosis.	**First aid measures:** Remove the person from the contaminated environment In case of (a) Skin contact Remove all contaminated clothings and immediately wash with lot of water and soap. (b) Eye contamination Wash the eyes with plenty of cool and clean water; (c) Inhalation – Carry the person to the open fresh air, loosen the clothings around neck and chest, and (d) Indigestion – If the victim is fully conscious, induce vomiting by tickling back of the throat. Do not administer milk, alcohol and fatty substances. In	-

			Severe – diarrhea, pinpoint and non-reactive pupils, respiratory difficulty, pulmonary edema, cyanosis, loss of sphincter control, convulsions, coma and heart block.	case the person is unconscious make sure the breathing passage is kept clear without any obstruction. Victim's head should be little lowered and face should be turned to one side in the lying down position. In case of breathing difficulty, give mouth to mouth or mouth to nose breathing. Medical aid: Take the patient to the doctor/Primary Health Centre immediately along with the original container, leaflet and label **Treatment of poisoning:** Gastric lavage with 2-4 L. tap water. Catharsis with 30 gm (10 oz) sodium sulphate in the cup of water - Barbiturates in appropriate dosages repeated as necessary for restlessness or convulsions. - Watch breathing closely, aspirate oxygen and/or artificial respiration, if needed. - Avoid oils, oil laxatives and epinephrine (Adrenalin) – do not give stimulants. - Give calcium gluconate (19% in 10 ml Ampules) intravenously every four hours. For extreme symptoms of O.P poisoning, injection of atropine (2-4 mg, for adults, 0/5-1.0 mg for children) is recommended, repeated at 5-10 minute intervals	

				until signs of atropinization occur. Speed is imperative - Atropine injection – 1 to 4 mg. Repeat 2 mg, when toxic symptoms begin to recur (15-16 minute intervals), Excessive salivation good sign, more atropine needed. - Keep airways open, Aspirate, use oxygen, insert endotracheal tube. Do tracheotomy and give artificial respiration as needed. - For ingestion lavage stomach with 5% sodium bicarbonate if not vomiting. For skin contact, wash with soap and water (eye wash with isotonic saline). Wear rubber gloves while washing contact areas. In addition to atropine give 2-PAM (2- pyridine aldoximemethiodide) 1g and 0.25 g for infants intravenously at a slow rate over a period of 5 minutes and administer again periodically as indicated. More than one injection may be required. Avoid morphine, theophylline, aminophyllin, barbituaratesofrphenothiazines. Do not give atropine to a cyanotic patients. Give artificial respiration first then administer atropine.	
6.	Quinalphos Highly toxic	Class II Moderately Hazardous	-do-	-do-	-

					
7.	Carbofuran Extremely toxic 	Class I b highly hazardous	Constriction of pupils, salivation, profuse sweating, muscle incordination, nausea, vomiting,diarrhea, epigastric pain, tightness in chest	**Treatment of poisoning:** Atropine injection-1-4 mg. repeat 2 mg when symptoms begin to recur (15-16 min interval) excessive salivation- good sign, more atropine needed	--
8.	Flubendiamide Slightly toxic	Unlikely produce acute hazard	--	**Treatment of poisoning:** Treat symptomatically as there is no known specific antidote	5 days
9.	Indoxacarb Moderately toxic Blue 		Altered blood chemistry Abnormal decrease in number of red blood cells (anaemia) which could produce tiredness, rapid heartbeat, dizziness, pale skin, leg cramps,shortness of breath, Central nervous system effects	**First aid measures:** Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a doctor. Do not give anything by mouth to an unconscious person **Treatment of poisoning:** No specific antidote. Treatment is essentially symptomatic.	5 days
Synthetic pyrethroids					
10.	Lambda-cyhalothrin		Toxic if swallowed or inhaled. Irritating to eyes and skin. Vapors may cause drowsiness and dizziness. May be harmful if swallowed and enters airway. May cause temporary itching, tingling, burning or numbness of exposed skin, called paresthesia	**First aid measures:** Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious person **Treatment of poisoning:** There is no specific antidote. Treatment is essentially symptomatic.	4 days

XII. BASIC PRECAUTIONS IN PESTICIDES USAGE

A. Purchase

1. Purchase only just required quantity e.g. 100, 250, 500, 1000 g/ml for single application in specified area.
2. **Do not** purchase leaking containers, loose, unsealed or torn bags; **Do not** purchase pesticides without proper/approved labels.
3. While purchasing insist for invoice/bill/cash memo

B. Storage

1. Avoid storage of pesticides in house premises.
2. Keep only in original container with intact seal.
3. **Do not** transfer pesticides to other containers; **Do not** store expose to sunlight or rain water; **Do not** weedicides along with other pesticides
4. Never keep them together with food or feed/fodder.
5. Keep away from reach of children and livestock.

C. Handling

1. Never carry/ transport pesticides along with food materials.
2. Avoid carrying bulk pesticides (dust/granules) on head shoulders or on the back.

D. Precautions for preparing spray solution

1. Use clean water.
2. Always protect your nose, eyes, mouth, ears and hands.
3. Use hand gloves, face mask and cover your head with cap.
4. Use polythene bags as hand gloves, handkerchiefs or piece of clean cloth as mask and a cap or towel to cover the head (Do not use polythene bag contaminated with pesticides).
5. Read the label on the container before preparing spray solution.
6. Prepare the spray solution as per requirement
7. **Do not** mix granules with water; **Do not** eat, drink, smoke or chew while preparing solution
8. Concentrated pesticides must not fall on hands etc while opening sealed container. Do not smell pesticides.
9. Avoid spilling of pesticides while filling the sprayer tank.
10. The operator should protect his bare feet and hands with polythene bags

E. Equipments

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

F. Precautions for applying pesticides

1. Apply only at recommended dose and dilution
2. **Do not** apply on hot sunny day or strong windy condition; **Do not** apply just before the rains and after the rains; **Do not** apply against the windy direction
3. Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer

4. Wash the sprayer and buckets etc with soap water after spraying
5. Containers buckets etc used for mixing pesticides should not be used for domestic purpose
6. Avoid entry of animals and workers in the field immediately after spraying
7. Avoid tank mixing of different pesticides

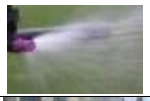
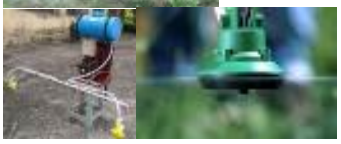
G. Disposal

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.

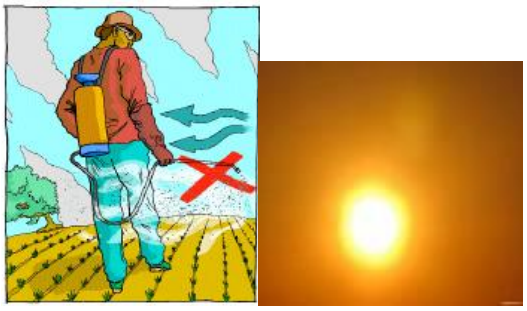
XIII. PESTICIDE APPLICATION TECHNIQUES

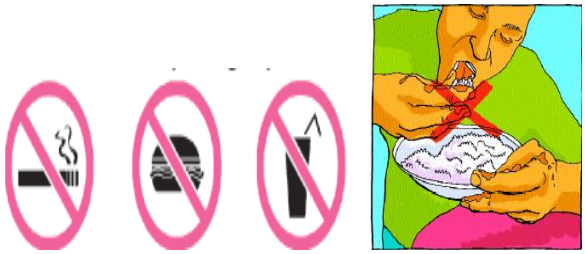
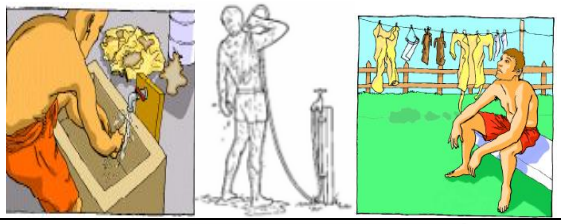
<table>
<tr><th></th><th></th><th colspan="2">Equipment</th></tr>
<tr><td colspan="4">Category A: Stationary, crawling pest/ disease</td></tr>
<tr><td rowspan="2">Vegetative stage
i) for crawling and soil borne pests

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

Reproductive stage *(Field Pests)*		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)	 

XIV. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

1.	For application rate and dosage see the label and leaflet of the particular pesticide.	
2.	It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.	
3.	Clean and wash the machines and nozzles and store in dry place after use.	
4.	It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides.	
5.	Do not apply in hot or windy conditions.	
6.	Operator should maintain normal walking speed while undertaking application.	

		
7.	Do not smoke, chew or eat while undertaking the spraying operation	
8.	Operator should take **properbath with soap** after completing spraying	
9.	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

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