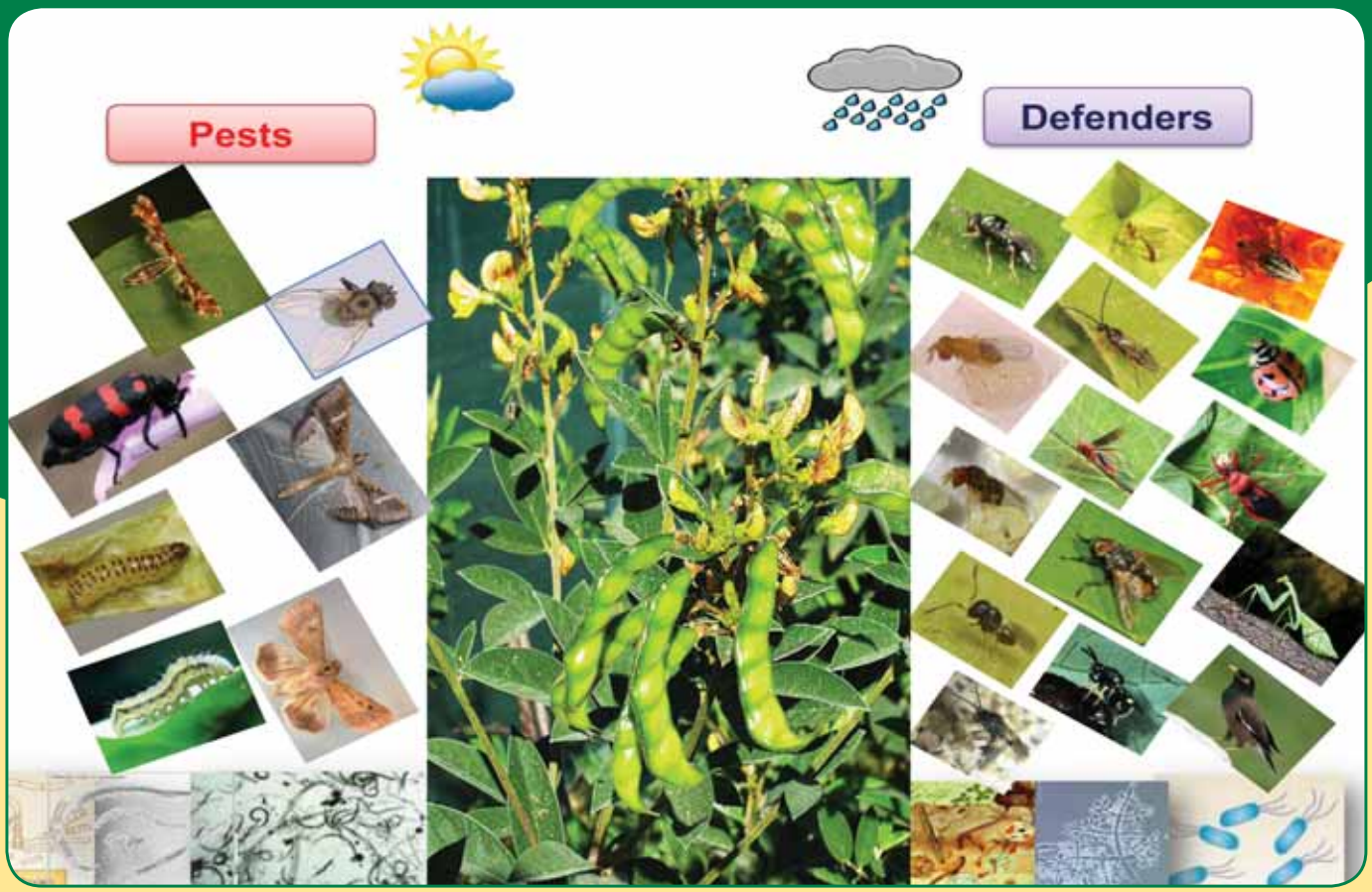
AESA BASED IPM PACKAGE

AESA based IPM – Redgram



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

National Institute of Plant Health Management
Rajendranagar, Hyderabad, Telangana

Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

Important Natural Enemies of Redgram Insect Pests

Parasitoids

***Trichogramma* spp.**

***Tetrastichus* spp.**

***Campoletis* spp.**

***Bracon* spp.**

***Diaeretiella* spp.**

***Aphidius* spp.**

Predators

Robber fly

Earwig

Pentatomid bug

Reduviid bug

Ground beetle

Black drongo

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

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Back cover picture Redgram field

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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.

Date : 6.3.2014

(Avinash K. Srivastava)

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FOREWORD

IPM as a holistic approach of crop protection based on the integration of multiple strategies viz., cultural, physical, mechanical, biological, botanical 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, through 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 sine show 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 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, through 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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AESA BASED IPM PACKAGE FOR REDGRAM

Redgram plant description:

The pigeon pea (*Cajanus cajan* L.; Family: Fabaceae) is a perennial legume. Since its domestication in South Asia at least 3500 years ago, its seeds have become a common food grain in Asia, Africa, and Latin America. The cultivation of the pigeon pea goes back at least 3,500 years. The centre of origin is the eastern part of peninsular India, including the state of Orissa, where the closest wild relatives (Mansi) occur in tropical deciduous woodlands.

Pigeon peas are both a food crop (dried peas, flour, or green vegetable peas) and a forage/cover crop. In combination with cereals, pigeon peas make a well-balanced human food. The dried peas may be sprouted briefly, then cooked, for a flavor different from the green or dried peas. Sprouting also enhances the digestibility of dried pigeon peas via the reduction of indigestible sugars that would otherwise remain in the cooked dried peas. In India, split pigeon peas (toor dal) also called Kandhi pappu in Telugu, Togari bele in Kannada and Tuvaram paruppu in Tamil are one of the most popular pulses, being an important source of protein in a mostly vegetarian diet. In regions where it grows, fresh young pods are eaten as a vegetable in dishes such as sambar. In Ethiopia, not only the pods, but also the young shoots and leaves are cooked and eaten.

I. PESTS

A. Pests of National Significance

1. Insect pests

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

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

1.3 Leaf webber: *Grapholita critica* Meyr (Lepidoptera: Tortricidae)

1.4 Spotted pod borer: *Maruca vitrata* Fabricius (Lepidoptera: Pyralidae)

1.5 Plume moth: *Exelastis atom osa* Walsingham (Lepidoptera: Pterophoridae)

1.6 Pulse beetle: *Callosobruchus chinensis* Linn., *C. maculatus* Fab. (Coleoptera: Bruchidae)

2. Diseases

2.1 Wilt: *Fusarium udum* E.J. Butler

2.2 Pigeon pea sterility mosaic: *Pigeon pea sterility mosaic virus*

2.3 Stem blight: *Phytophthora draschalari* f.sp. *cajani* Mahendra Pal, Grewal & Sarbhoy

3. Weeds

Broadleaf

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

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

3.3 Coat buttons: *Tridax procumbens* L. (Asteraceae)

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

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

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

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

Grasses

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

3.9 Yellow foxtail: *Setaria glauca* (L.) P. Beauv. Poaceae

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

3.11 Bermuda grass*: Cynodon dactylon* (L.) Pers. (Poaceae)

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

Sedges

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

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

4. Nematode

4.1. Pigeonpea cyst nematode: *Heterodera cajani* Koshy (Tylenchida: Heteroderidae)

B. Pests of Regional Significance

1. Insect pests

1.1 Bihar hairy caterpillar: *Spilosoma obliqua* Walker (Lepidoptera: Arctiidae) (U.P, Bihar, Haryana)

1.2 **Red headed hairy caterpillar: *Amsacta moori* B, *A. albistriga* W. (Lepidoptera: Arctiidae) (Rajasthan)**

1.3 **Blister beetle: *Mylabris pustulata* Thunberg (Coleoptera: Meloidae) (Meghalaya, Himachal Pradesh, Tamil Nadu, Karnataka, Orissa, Punjab)**

1.4 **Pod bug: *Clavigralla gibbosa* Spinola (Hemiptera: Coreidae) (Himachal Pradesh, Madhya Pradesh,Uttar Pradesh, Delhi, Bihar, Haryana, Orissa, Gujarat)**

1.5 **Grey weevil: *Myllocerus undecimpustulatus* Faust (Coleoptera: Curculionidea) (Uttar Pradesh)**

1.6 **Cowbug: *Otinotus oneratus* W, *Oxyrachis tarandus* F. (Hemiptera: Membracidae) (West Bengal)**

1.7 **Aphid: *Aphis craccivora* Koch (Hemiptera: Aphididae) (Uttar Pradesh, Orissa, Karnataka)**

1.8 **Pod weevil: *Ceuthorrhynchus asperulus* (Coleoptera: Curculionidae) (Karnataka)**

1.9 **Scale: *Ceroplastodes cajani* Maskell (Hemiptera: Coccidae) (Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Gujarat)**

1.10 **Mealybug: *Phenacoccus solenopsis* T, *Coccidohystrix insolita* Green (Hemiptera: Pseudococcidae)**

2. Diseases

2.1 **Mungbean yellow disease: *Mungbean yellow mosaic virus* (Tamil Nadu, Uttar Pradesh, Gujarat, Odisha)**

2.2 **Dry root rot: *Macrophomina phaseolina* Tassi Goid (Uttar Pradesh,Tamil Nadu, Karnataka, Madhya Pradesh, Maharashtra, Delhi)**

3. Nematodes

3.1 **Lance nematode: *Hoplolaimus* spp (Uttar Pradesh, Gujarat, Karnataka, Andhra Pradesh)**

3.2 **Root-knot nematode: *Meloidogyne* spp. (Gujarat,Uttar Pradesh, Gujarat, Uttar Pradesh)**

3.3 **Reniform nematode: *Rotylenchulus reniformis* Linford and Oliveira (Gujarat,Uttar Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Andhra Pradesh)**

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 seed /seedlings/planting material with recommended pesticides especially biopesticides
- Follow proper spacing
- Soil health improvement (mulching and green manuring wherever applicable)
- Nutrient management especially organic manures and biofertilizers based on the soil test results. If the dosage of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dosage is too low, the crop growth is retarded. So, the farmers should apply an adequate amount for best results. The phosphatic fertilizers should not be applied each and every season as the residual phosphate of the previous season will be available for the current season also.
- Proper irrigation
- Crop rotation

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

Farmers should

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

Plant compensation ability:

Compensation 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.

Plant defence strategies play important roles in the survival of plants as they are fed upon by many different types of herbivores, especially insects, which may impose negative fitness effects (Strauss and Zangerl 2002). Pigeon pea has a good ability to compensate for defoliation up to 50% even if it occurs in the podding stage (Sharma and Chaudhary, 1984). Plants withstand the damage caused by the insect by producing more number of tillers, roots, leaves etc. in the place of damaged plant parts such plants are said to be tolerant to that particular

pest. Tolerance usually results from one or more of the following factors 1. general vigour of the plant; 2. regrowth of the damaged tissues; 3. strength of stems and resistant to lodging; 4. production of additive branches; 5. efficient utilization of non vital plant parts by the insect; and 6. compensation by growth of neighbouring plants

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:

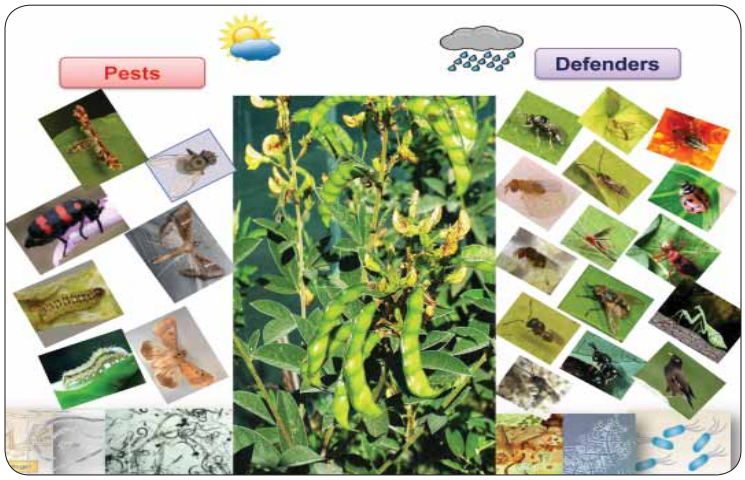
In field various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in crop field. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial 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 redgram insect pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens.

Model Agro-Ecosystem Analysis Chart

Date:
Village:
Farmer:



Decision taken based on the analysis of field situations

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

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

Decision making:

Farmers become experts in crop management:

Farmers have to make timely decisions about the management of their crops. AESA farmers have learned to make these decisions based on observations and analysis viz. abiotic and biotic factors of the crop ecosystem. The past experience of the farmers should also be considered for decision making. However, as field conditions continue to change and new technologies become available, farmers need to continue improving their skills and knowledge.

- Farmers are capable of improving farming practices by experimentation
- Farmers can share their knowledge with other farmers

AESA methodology:

- Go to the field in groups (about 5 farmers per group). Walk across the field and choose 20 plants/acre randomly. Observe keenly each of these plants and record your observations:

    - Plant: Observe the plant height, number of branches and leaves, crop stage, deficiency symptoms, no of pods etc.
    - Insect pests: Observe and count insect pests at different places on the plant.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
    - Weeds: Observe weeds in the field and their intensity.
    - Water: Observe the water situation of the field.
    - Weather: Observe the weather condition.

- While walking in the field, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the field situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on what field management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording:

Farmers should record data in a notebook and drawing on a chart

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

Data to be recorded:

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

Advantages of AESA over ETL:

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

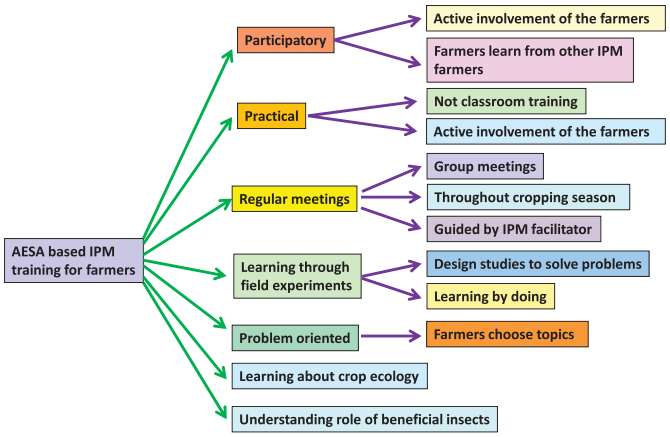
AESA and farmer field school (FFS):

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

Farmers can learn from AESA:

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

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:

Aphid, scale, pod bug, mealybug: 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.

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 roots damaged/infested/infected due to rot should be counted and incidence should be recorded.

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

Stem, 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, Maruca, Exelastis*:

Pheromone traps for *Helicoverpa armigera, Maruca, Exelastis* @ 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, if available. Fix the traps to the supporting pole at a height of one foot above the plant canopy. Change of lures should be made once in 2-3 weeks. During each week of surveillance, the number of moths/trap should be counted and entered. The trapped moths should be removed and destroyed after each recording.

D. Yellow pan water/sticky traps:

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

E. Light traps:

Set up light traps @1 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.* 2004a,b).

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 hosts when primary hosts are not present.

Ecological engineering for pest management–Above ground:

- Rais 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 like *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:

- Keep soils covered year-round with living vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance below ground biodiversity.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Apply balanced dose of nutrients using biofertilizers.
- Apply *Mycorrhiza* and plant growth promoting rhizobacteria (PGPR)
- Apply *Trichoderma viride/harzianum* and *Pseudomonas fluorescens* as 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


Parsley


Coreopsis spp.


Cosmos


Dandelion


Anise


Caraway


Dill

Repellent plants

***Ocimum* spp.**

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/disease	Tolerant/ resistant variety*
Phytophthora blight	BDN1, ICPL 150, ICPL 288, ICPL 304 and KPBR 80-1-4
Pigeon pea sterility mosaic	ICPL 157, NP(WR)15, Bahar

***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: • Timely sowing should be done. • Field sanitation, rogueing • Deep summer ploughing to control juveniles and adults of nematodes, and resting stages of insect pests. • Sow the ecological engineering plants • Sow/plant sorghum/maize/bajra in 4 rows all around cumin crop as a guard/barrier crop • Destroy the alternate host plants • Apply manures and fertilizers as per soil test recommendations • Follow crop rotation with non host crops such as rice, maize, sorghum, tobacco or castor
Nutrients	• Nutrients should be applied based on the soil test report and recommendations for the particular agro-climatic zone. • Apply well decomposed FYM @ 4.0 t/acre or vermicompost @ 2.0 t/acre treated with *Trichoderma* 4 Kg/acre at the time of field preparation. • Apply vermicompost and FYM at 1 week and 3-4 weeks before sowing, respectively.
Weeds	• At the time of field preparation, adopt stale seed bed technique i.e. pre sowing irrigation followed by shallow tillage after emergence of weeds.
Soil borne pathogens nematodes and resting stages of insects	**Cultural control:** • Deep ploughing of fields during summer to control nematodes and *Helicoverpa*. • Three summer ploughings at 10 days interval reduce juvenile population of pests. • **Soil solarization:** Cover the beds with polythene sheet of 45 gauge (0.45 mm) thickness for three weeks before sowing for soil solarization which will help in reducing the soil borne pests. • Conserve the entamopathogenic fungi such as *Paecilomyces lilacinus*
Seed sowing/seedling*	
	Common cultural practices: • Use resistant/tolerant varieties • Select seeds from disease free fields • Grow pigeon pea intercropped or mixed with cereal crops like sorghum. • Use certified and weed seed free seeds.

Nutrients	• Seed treatment should be done with *Rhizobium* and VAM (AMF)/PSB (Phosphate Solubilizing Bacteria) cultures each @ 240 g/acre. • Fertilizers should be applied on soil test basis. Generally, it is recommended to apply 10 to 12 Kg nitrogen (N), 20 to 30 Kg phosphorous (P) and 12 to 18 Kg potassium (K) per acre as basal dose. • In sulphur and zinc deficient areas, apply sulphur @ 10 to 12 Kg/ acre and zinc sulphate @ 10 Kg/acre in soil at the time of sowing.
Weeds	• Always use certified and weed free seeds. • Adopt recommended agronomic practices with respect to timely sowing, row spacing, plant population etc. to obtain the healthy plant stand. • Intercropping with suitable crops as per regional recommendations.
Wilt, stem blight, dry root rot	**Cultural control:** • Select a field with no previous record of wilt for at least past 3 years. • Uproot the wilted plant and use them as firewood or destroy them. • Avoid sowing redgram in fields with low-lying patches that are prone to water logging. **Biological control:** • *Trichoderma viride* 1% WP@ 8 g/Kg seed and @ 200 g/acre for soil treatment (wilt & dry root rot) **Chemical Control** • Carboxin 37.5% + thiram 37.5% DS @ 4 g/Kg seed and 200 g/acre for soil treatment (wilt, stem blight and dry root rot) • Thiophanate methyl 70% WP @ 572 g in 300-400 l of water/acre (wilt)
*Apply *Trichoderma viride/harzianum* and *Pseudomonas fluorescens* as seed/seedling/planting material 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*	
	Common cultural practices: • Collect and destroy crop debris • Judicious use of fertilizers • Provide irrigation at critical stages of the crop • Avoid water logging • Avoid any stress to the crop as much as possible • Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed **Common mechanical practices:** • Collect and destroy disease infected and insect infested plant parts • Collect and destroy eggs and early stage larvae • Handpick the older larvae during early stages of the crop • Handpick the gregarious caterpillars and the cocoons which are found on stem and destroy them in kerosene mixed water. • Use yellow 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) • Erect bird perches @ 20/acre for encouraging predatory birds such as King crow, common mynah etc. • Set up bonfire during evening hours at 7-8 pm **Common biological practices:** • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies
Nutrients	• Correct micronutrient deficiency if any in standing crop.
Weeds	• The crop should be maintained weed free initially for 6-8 weeks by following timely hoeing and weeding by using power hand tiller/ or manual tools, twice at 20 and 45 days after sowing. • Mulches like straw, plastic, etc. can be used in between the rows to suppress the weed growth.
Leaf webber	• Follow the common cultural, mechanical and biological practices **Cultural control:** • Growing intercrops such as marigold, castor etc.
Bihar hairy caterpillar**	• Follow the common cultural, mechanical and biological practices **Cultural control:** • Pre-monsoon deep ploughing (two/three times) to expose the hibernating pupae to sunlight and predatory birds. • Irrigate once to avoid prolonged mid season drought to prevent pre-harvest infestation.
Aphid**	• Follow the common cultural, mechanical and biological practices
Mealybug**	• Follow the common cultural, mechanical and biological practices
Scale**	• Follow the common cultural, mechanical and biological practices
Dry root rot, wilt, stem blight**	• Follow the common cultural, mechanical and biological practices • Same as in seedling stage
Pigeon pea sterility mosaic (PSM), mung bean yellow disease (MBYD)**	• Follow the common cultural, mechanical and biological practices **Cultural control:** • The spacing between the lines should be maintained at 30 to 40 cm. **Mechanical control:** • Destroy sources of sterility mosaic inoculum. • Use yellow sticky traps for the control of whitefly insect vector of MBYD.
Flowering	
	• Follow the common cultural, mechanical and biological practices
Gram pod borer, spotted pod borer	• Follow the common cultural, mechanical and biological practices **Cultural control:** • Growing trap crop like marigold on the borders and in between rows as intercrop. • Their flowers shall attract oviposition which can be plucked and disposed off. • Follow ridge planting + cover crops like soybean, cowpea, blackgram, greengram, moth bean.

	• Raise one row of sunflower as intercrop for every 9 rows of pigeon pea. **Biological control:** • *Bacillus thuringiensis sero* var *kurstaki* (3a, 3b, 3c) 5% w WP @ 400-500 g/acre in 200-400 l of water or *Bacillus thuringiensis* var. *kurstaki*, serotype h-CA, 3b, strain z-52 @ 200-300 g/acre or NPV of *Helicoverpa armigera* 2.0% AS @100-200 ml/acre in 200-300 l of water or NPV of *Helicoverpa armigera* 2.0% AS strain no. GBS/HNPV-01 @ 100-200 ml/acre in 200-300 l of water or Bio-tech international strain no. IBH/HV-9 @ 100-200 ml/acre in 200-300 l of water or Indore bio-tech input & research strain no. IBL-17268 @ 100-200 ml/acre in 200-300 l of water. Azadiractin 0.03% (300 ppm) neem oil based WSP @ 1000-2000 g in 200-300 l of water/acre. **Chemical control:** • Benfuracarb 40% EC @ 1000 ml in 200 l of water/acre or chlorantraniliprole18.5% SC @ 60 ml in 200-300 l of water/acre or dimethoate 30% EC @ 494.8 ml in 200-400 l of water/acre or emamectin benzoate 5% SG @ 88 g in 200-300 l of water/acre or flubendiamide 39.35% M/M SC @ 40 ml in 200 l of water/acre or indoxacarb14.5% SC @ 141-160 ml in 200-400 l of water/acre or indoxacarb15.8% EC @ 133 ml/acre in 200-280 l of water or lambda-cyhalothrin 5% EC @160-200 ml in 160-240 l of water/acre or lufenuron 5.4% EC @ 240 ml in 200-400 l of water/acre or methomyl 40% SP @ 300-450 ml in 200-400 l of water/acre or monocrotophos 36% SL @ 500 ml in 200-400 l of water/acre or quinalphos 20% AF @ 1000 ml in 300-400 l of water/acre or quinalphos 25% EC @ 560 ml in 200-400 l of water/acre or quinalphos 1.5% DP @ 9320 g/acre or spinosad 45.0% SC @ 50-64 ml in 320-400 l of water/acre or ethion 50% SC @ 200-400 ml in 200-400 l of water /acre
Pod fly	• Follow the common cultural, mechanical and biological practices **Chemical control:** • Dimethoate 30% EC @ 264 ml in 200-400 l of water/acre or monocrotophos 36% SL @ 250 ml in 200-400 l of water/acre or quinalphos 25% EC @ 560 ml in 200-400 l of water/acre or lufenuron 5.4% EC @ 240 ml in 200-400 l of water/acre or lambda-cyhalothrin 5% EC @ 160-200 ml in 160-240 l of water/acre or carbaryl 10% DP @ 8000 g/acre.
Leaf webber	• Same as in vegetative stage
Bihar hairy caterpillar**	• Same as in vegetative stage
Blister beetle**	• Follow the common cultural, mechanical and biological practices
White bug**	• Follow the common cultural, mechanical and biological practices
Scale**	• Same as in vegetative stage
Mealybug**	• Same as in vegetative stage
Pigeon pea sterility mosaic disease, mung bean yellow disease**	• Same as in vegetative stage
Reproductive (pod development)	
Nutrients	• Incorporate crop residues in soil immediately after harvest.
Weeds	• Remove left over weeds before shedding of seeds to prevent weed seed spread in field.
Gram pod borer	• Same as in flowering stage
Pod fly	• Same as in flowering stage

Leaf webber	• Same as in vegetative stage
Spotted pod borer	• Same as in flowering stage
Plume moth	• Follow the common cultural, mechanical and biological practices **Chemical control:** • Carbaryl 10% DP @ 8000 g/acre or monocrotophos 36% SL @ 250 ml in 200-400 l of water/acre
Bihar hairy caterpillar**	• Same as in vegetative stage
Blister beetle**	• Same as in flowering stage
White bug**	• Same as in flowering stage
Pod weevil**	• Follow the common cultural, mechanical and biological practices
Pod sucking bug**	• Follow the common cultural, mechanical and biological practices
Scale**	• Same as in vegetative stage
Mealybug**	• Same as in vegetative stage
Pigeon pea sterility mosaic disease, mung bean yellow disease**	• Same as in vegetative stage

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

** **Pests of regional significance**

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 Redgram of applications of insecticide made. For instance, insect pests that survive in large populations and breed quickly are at greater advantage of evolving insecticide, especially when insecticides are misused or over-used.

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

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

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

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

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

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

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

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

VI. COMMON WEEDS

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

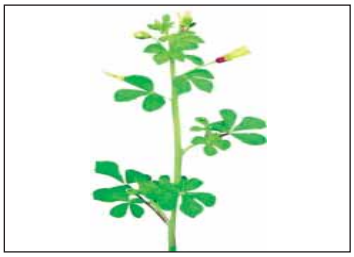
2) Yellow foxtail: *Setaria glauca* (L.) P. Beauv. (Poaceae)

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

4) Bermuda grass: *Cynodon dactylon* (L.) Pers. (Poaceae)

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

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



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

8) Coat buttons: *Tridax procumbens* L. (Asteraceae)

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

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

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

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

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

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

VII. DESCRIPTION OF INSECT AND NEMATODE PESTS

1) Gram pod borer:

Biology:

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

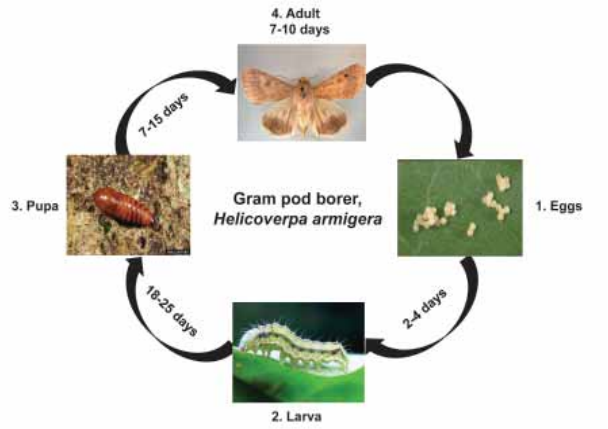
Egg: Spherical, yellowish eggs are laid singly on tender parts and buds of plants. The egg period lasts for 2-4 days.

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 3.7 cm.

Life cycle:



Damage symptoms:

- Defoliation in early stages
- Larva's head alone thrust inside the pods and the rest of the body hanging out.
- Pods with round holes

***Helicoverpa* feeding on pods**

http://www.crida.in/naip/comp4/american.html

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

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* sp etc.

Predators: Lacewing, ladybird beetle, spider, red ant, dragonfly, robber fly, reduviid bug, praying mantis, black drongo, common mynah, big-eyed bug (*Geocoris* sp),_earwig, ground beetle, pentatomid bug *(Eocanthecona furcellata*) etc.

*For management refer to page numbers 16,17

2) Spotted pod borer:

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

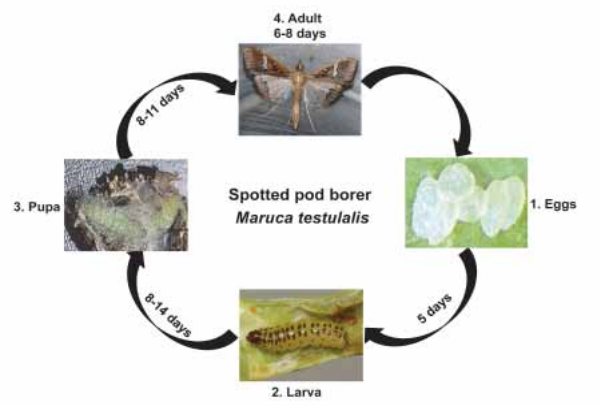
Egg: Eggs are laid on the under surface of leaves, terminal shoots and flower buds. The freshly laid eggs are milky white in colour and oval in outline, dorsoventraly flattened and glued to the surface.

Larva: Larvae are greenish white with brown head. Larval period is 15-20 days

Pupa: Pupation takes place in dry leaves and debris

Adult: Adults have brown forewings and white hind wings

Life cycle:



1. http://oar.icrisat.org/6608/1/IB%20no%20%2055.pdf
2 http://www.nbaii.res.in/insectpests/images/Maruca-vitrata9.jpg
3. http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insect_pul_red%20gram.html
4 http://www.nbaii.res.in/insectpests/images/Maruca-vitrata9.jpg

Damage symptoms:

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

Damage symptoms of spotted pod borer

http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insect_pul_red%20gram.html

Natural enemies of spotted pod borer:

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

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

*For management refer to page numbers 16,18

3) Pod fly:

It is widely distributed in India and causes major economic losses in northern parts of India causing significant losses especially in long duration varieties. This pest alone accounts for 70-80% of the total pod damage by pod borer complex. The infected seeds do not germinate.

Biology:

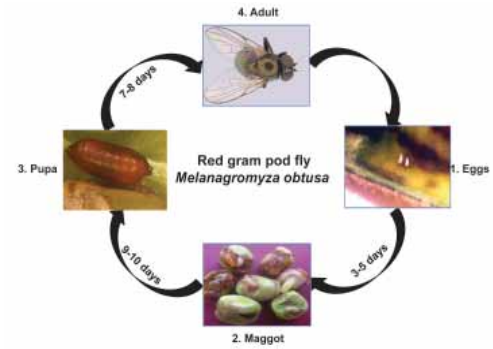
Egg: The adult female oviposits in the tender pods. Eggs measure about 0.97 mm in length and 0.15 mm in breadth.

Larva: The freshly eclosed maggots are transparent, Mature larvae are white and up to about 3.5 mm long.

Pupa: Pupal cases are orange-brown, about 3 mm long, with a pair of closely spaced anterior spiracles projecting forward, and a pair of prominently projecting posterior spiracles on tubercles that are joined basally.

Adult: Both sexes are 2-3 mm long, and may appear black to the naked eye, but the thorax and abdomen have a distinct, green metallic sheen if examined under magnification. The head has a prominent ocellar triangle, also metallic green that extends to the lunule (recessed crescent above the antennae). The wings are clear. The female has an unusually long, black ovipositor sheath.

Life cycle:



1, 2, 3, 4. http://www.nbaii.res.in/insectpests/Melanagromyza-obtusa.php
Larva http://freshfromflorida.s3.amazonaws.com/melanagromyza-obtusa.pdf

Damage symptoms:

- Dark brown encrustation on the pod wall
- Dry pods showing pin head size hole
- Seeds shriveled, striped and partially eaten

Seed tunnelling by maggots

http://www.ncipm.org.in/A3P/UI/Home/publish/Pest%20of%20Pigeonpea.pdf

Natural enemies of pod fly:

Parasitoids: *Euderus lividus*, *Eurytoma* spp., *Senegalella* spp., *Ormyrus orientalis* etc.

Predator: Spiders, reduviid bug, robber fly, dragonfly etc.

*For management refer to page number 17

4) Leaf webber:

Biology:

Egg: Adult female lays eggs on the leaf buds and young leaves.

Larva: The larva is creamy-yellow in colour,

Pupa: The fully-grown larvae pupate within web.

Adult: The moth of *G. critica* is small brown in colour.

Damage symptoms:

- Larvae often found binding leaves together and feeds on the chlorophyll while remaining inside the web.
- Leaflets are webbed together with silk and the larva feeds within the web.
- As the web often includes the terminal bud, further growth of that shoot is prevented.
- Infestation starts at the seedling stage and may persist to the reproductive stage when the larvae feed inside flower buds and in young pods.
- If infestation starts at the seedling stage, the crop is severely affected and infestation remains throughout the crop season and may affect the flower buds also.

Webbed by the larvae

http://www.ncipm.org.in/A3P/UI/Home/publish/Pest%20of%20Pigeonpea.pdf

*For management refer to page numbers16,17, 18

5) Blister beetle:

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

Biology:

Egg: Adults lay eggs in the soil at the base of the plant.

Larva: The immature stages (larvae) do not feed on plants. They live in the soil and eat grasshopper eggs, and are therefore beneficial.

Pupa: The larva pupates in the soil.

Adult: 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 some times changes into yellow spots. The antennae are orange or yellow.

Damage symptoms:

- 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.

Adult beetle feeding on flowers

http://agritech.tnau.ac.in/about_us/abt_us_reserach_vamban.html

*For management refer to page numbers 17, 18

6) Plume moth:

The pest is active throughout the year depending on the availability of the host plants. Apart from redgram, it is also recorded in horse gram and lablab.

Biology:

Egg: The female lays green oval eggs singly on buds and pods. Each female can lays 60 green coloured eggs on the tender developing pods. The egg period is 48-96 hours.

Larva: The larvae are green in colour with spine like hairs all over the body and are spindle shaped. The larva feeds on the developing parts/tender seeds.

Pupa: The pupa which appear like a larva, is often found attached to the pod surface or on the pedicel.

Adult: The plume moths usually appear at flowering time of the crop or sometimes in pre-flowering stage. The adults have brown, plume like wings. One generation can be completed in about 4 weeks.

Plume moth adult

*For management refer to page number 18

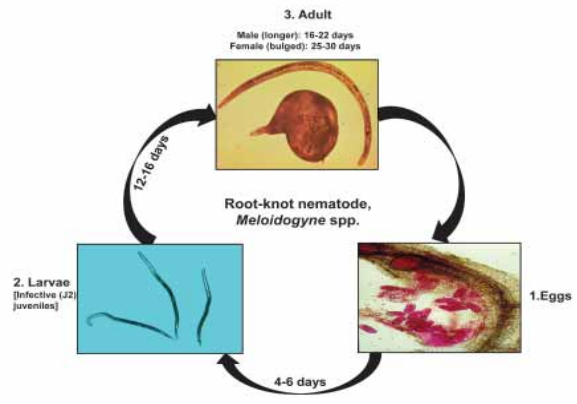
http://www.ncipm.org.in/A3P/UI/Home/publish/Pest%20of%20Pigeonpea.pdf

7) Root-knot nematode:

Biology:

- Most species of plant parasitic nematodes have a relatively simple life cycle consisting of the egg, four larval stages and the adult male and female.
- Development of the first stage larvae occurs within the egg where the first 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:



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

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

- 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: Egg masses in infected plant debris and soil or collateral and other hosts like Solonaceous, Malvaceous and Leguminaceous plants act as sources of inoculum.

Secondary: Autonomous second stage juveniles that may also be water dispersed.

Favourable conditions:

Loamy light soils.

*For management refer to page number 14

Natural Enemies of Redgram Insect Pests

Parasitoids

Egg parasitoids

1. *Trichogramma* spp.

2. *Tetrastichus* spp.

3. *Telenomus* spp.

Egg-larval parasitoid

4. *Chelonus* spp.

Larval parasitoids

5. *Bracon* spp.

6. *Campoletis* spp

Larval-pupal parasitoid

7. *Carcelia* spp.

Pupal parasitoid

8. *Ichneumon* spp.

Nymphal and adult parasitoids

9. *Lysiphlebus* sp

10. *Diaeretiella* spp.

11. *Aphelinus* spp.

12. *Aphidius colemani*

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.html;6.http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398;7.http://www.nbaii.res.in/Featured%20insects/Campoletis.html;8.http://www.organicgardeninfo.com/ichneumon-wasp.html;9.http://www.nuetzlinge.de/uploads/pics/lysiphlebus_Aphis_gossypii.jpg;10.http://www.nbaii.res.in/Featured%20insects/diaeretiella4.jpg;11.http://australianmuseum.net.au/Uploads/Images/23077/Pro%20019_big.jpg;12.http://www.goodbugs.org.au/Good%2bugs%20available/Resources/aphidius254a.jpeg

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. *Dicyphus hesperus*


15. Hover fly


16. Dragonfly

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.html; 16. http://en.wikipedia.org/wiki/Dragonfly;

VIII. DESCRIPTION OF DISEASES

1) Wilt:

Disease symptoms:

- Symptoms can appear 4 to 6 weeks after sowing. The initial visible symptoms are loss of turgidity in leaves, and slight interveinal clearing.
- The foliage shows slight chlorosis and sometimes becomes bright yellow before wilting.
- Leaves are retained on wilted plants. The initial characteristic internal symptom of wilt is the browning of the xylem vessels from the root system to the stems.
- The xylem gradually develops black streaks, and brown or dark purple bands appear on the stem surface of partially wilted plants extending upwards from the base.
- When the bark of such bands is peeled off, browning or blackening of the wood beneath can be seen. in wilt-tolerant genotypes these bands are confined to the basal part of the plant.
- Sometimes, especially in the later stages of crop growth, the branches dry from the top downwards, but symptoms are not seen on the lower portions of the main stem or branches.
- Small branches on the lower part of the plant also dry.
- When the main stem of such plants is split open, intensive blackening of the xylem can be seen.
- In humid weather, a pinkish mycelial growth is commonly observed the basal portions of the wilted plants.
- Partial wilting is usually associated with lateral root infection. Tap root infection results in complete wilting.

Survival and spread:

- The fungus is soil borne and survive in the soils. Fungus spreads about 3 m through the soil in one season, apparently along roots.
- The fungus was found to survive in infected plant stubble for 2.5 years Vertisols and 3 years in Alfisols.

Favourable conditions:

- Low soil temperature and increasing plant maturity favours wilt.
- Fungal population is highest at 30% soil water-holding capacity and at the soil temperatures between 20 and 30° C.

*For management refer to page numbers 15, 16

2) Pigeon pea sterility mosaic disease:

Disease symptoms:

- Bushy and stunted appearance of the infected plants due to reduction in the size of the leaves and proliferation of the branches.
- Light and dark green mosaic pattern on the infected leaves of younger plants.
- Partial or complete sterility of the plant resulting in low or no flowering and podding.
- When infections occurs at 45 days after emergence or later only some parts of the plant may show disease symptoms, while the remaining parts appear normal.
- Leaves become small and cluster near branch tips.
- Diseased plants are pale green and bushy in appearance, without of flowers and pods.
- Diseased plants are usually in groups.
- Sometimes a plant may not show symptoms in the first flush, but when ratooned the new growth shows clear symptoms and tend to disappear as the plants mature.

Survival and spread:

- A single eryophid mite *(A. cajani)* (vector) is sufficient to transmit the disease.
- Perennial and volunteer pigeon pea and the ratooned growth of harvested plants provide reservoirs of the mite vector and the pathogen.

Favourable conditions:

- Shade and humidity encourage multiplication of the virus.

Disease symptom

http://agritech.tnau.ac.in/crop_protection/crop_prot_crop%20diseases_pulses_redgram.html

*For management refer to page numbers 16, 17, 18

3) Stem blight:

Damage symptoms:

- This cause seedling to die suddenly.
- Water soaked, irregular lesions on the leaves often cause blighting of the leaf/leaflets and younger plant.
- Infected leaves loss turgidity and become dessicated.
- Brown sunken lesions on the stem and branches causing girdling and makes the infected stem weak and leads to breakage and drying of the plant/branches.
- Infection mostly confined to basal portion of the stem.

Survival and spread:

- The fungus is soil borne.
- The fungus survives as dormant mycelium in soil and on infected plant debris.

Favourable conditions:

- Soils with poor drainage
- Low lying areas
- Heavy rain.
- Temperature 28-30° C.

*For management refer to page numbers 15, 16

4) Mung bean mosaic disease:

Disease symptoms:

- This disease was probably reported first from Sri Lanka.
- The disease first appears in the form of yellow, diffused spots scattered on the leaf lamina, not limited by veins and veinlets.
- Such spots slowly expand and in later stages of disease development, affected leaflets show broad, yellow patches alternating with green colour.
- Sometimes the entire lamina turns yellow.
- Leaf size is conspicuously reduced in early infections.
- In peninsular India, disease incidence is relatively higher in late-sown pigeon pea.
- The vector is whitefly (*Bemisia tabaci*)

Survival and spread:

- A single whitefly vector is sufficient to transmit the disease.
- Perennial and volunteer pigeon pea and the ratooned growth of harvested plants provide reservoirs of the vector and the pathogen.

Favourable conditions:

- Shade and humidity encourage multiplication of the virus.

Disease symptom

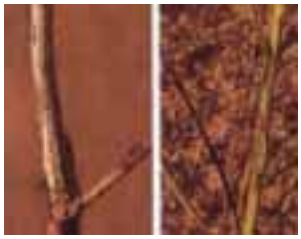
http://agritech.tnau.ac.in/crop_protection/crop_prot_crop%20diseases_pulses_redgram.html

*For management refer to page numbers 16, 17, 18

5) Dry root rot:

Disease symptoms:

- Typical symptoms include root and basal stem rot with a large number of minute, fungal sclerotia visible under the bark.
- Plants dry prematurely, particularly when they face drought stress.
- Disease incidence severe in off-season, irrigated, summer crops in several parts of India, and it is a minor one in the normal-season crop. The pathogen is both soil- and seed borne.



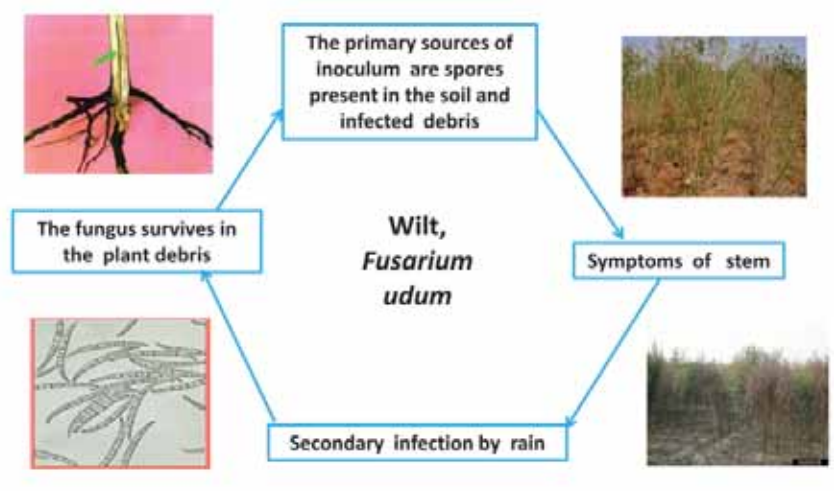
Disease symptom

http://agritech.tnau.ac.in/crop_protection/crop_prot_crop%20diseases_pulses_redgram.html

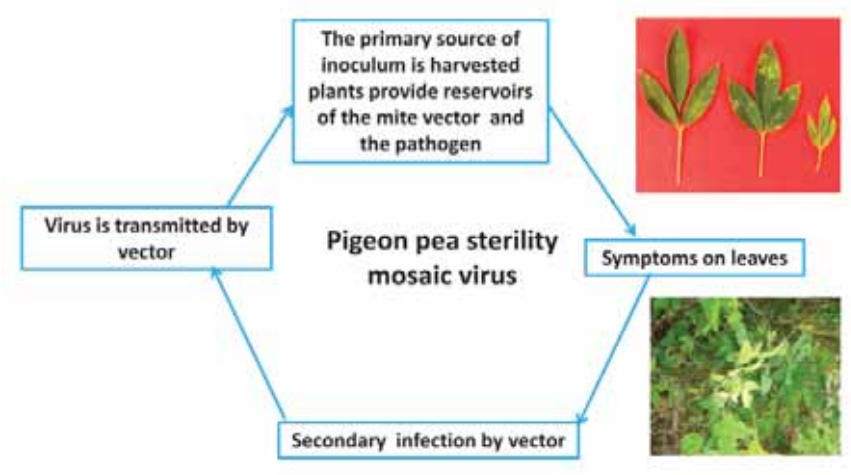
*For management refer to page numbers 15, 16

Disease cycles:

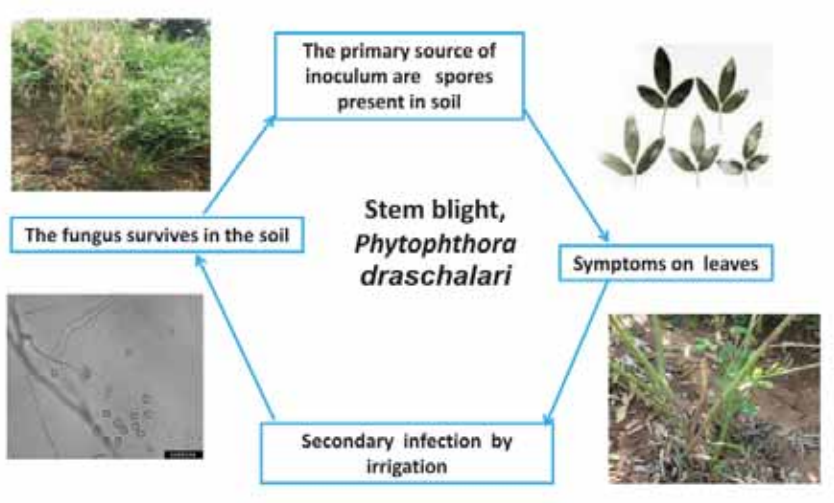
1. Wilt:



2. Pigeon pea sterility mosaic disease:



3. Stem 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.
- 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 redgram, 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. During post-harvest storage:

- The post-harvest losses of redgram 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:

- 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 labourers during handling.

Storage:

After threshing, grain should be dried in the sun so that moisture content is reduced to around 10 per cent. Dried grains should be stored in dry clean stores or gunny bags.

Methods of storage:

The methods of storage play an important role in reducing storage losses. It is often observed that farmers adopt various methods to prevent losses but they are only partially successful because of poor storage conditions, particularly store construction. At the farm level, storage structures made of steel, mud, wood, plastic and concrete and jute bags are frequently used to store pigeonpea. Mud bins are most commonly used by farmers. Storage in jute bags is common in markets and urban dhal mills. There is little difference in the storage structures meant for seeds or grains for consumption.

The coating of stored pulses with a thin film of edible oils to protect them against insect infestation is an age-old traditional practice in the villages of India. Oil treated pigeonpea seeds were not preferred by pulse beetles, and suggested that oil treatment could be useful for the safe storage of pigeonpea. Use of mustard, sunflower, safflower, castor, cotton, neem (*Azadirachta indica*), and karanj or honge (*Pongamia glabra*) oils to check infestations of pulse beetle in pigeonpea, and observed that honge and neem oils at 1.0 per cent were effective as surface protectants against attack by pulse beetles. According to this study, there was complete protection from infestation for 319 days honge oil and 161 days using neem oil. There is less pulse beetle infestation if pigeonpea is stored in the form of dhal. In order to avoid storage losses, and to make consumable stocks safer, pigeon pea seeds should be preferably processed and stored as dhal.

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 on test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
11	Conduct weekly AESA 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 at recommended dose when a large number of egg masses and early instar larvae are noticed. Apply NPV only in the evening hours.	Do not apply NPV on late instar larva and during day time.
15	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
16	Follow the recommended procedure of trap crop technology.	Do not apply long persistent pesticides 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	Harvesting Interval (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. Harmful if swallowed, absorbed through skin or inhaled. Avoid breathing vapor or spray mist. Causes moderate eye irritation. Severe – diarrhoea, pinpoint and non - reactive pupils, respiratory difficulty, pulmonary edema, cyanosis, loss of sphincter control, convulsions, coma and heart block.	**First aid measures:** Rush the victim to the nearest physician **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 			**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		**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. In addition to atropine give 2 – PAM (2 – pyridine aldoximemethiodide). 1 g and 0.25g for infants intravenously	7 days

				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	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. 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	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	

			Severe – diarrhea, pinpoint and non-reactive pupils, respiratory difficulty, pulmonary edema, cyanosis, loss of sphincter control, convulsions, coma and heart block.	conscious, induce vomiting by tickling back of the throat. Do not administer milk, alcohol and fatty substances. In 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  		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 PESTICIDE 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

Equipment			
Category A: Stationary, crawling pest/disease			
Vegetative stage i) For crawling and soil borne pests ii) For small sucking leaf borne pests	Insecticides and fungicides	• Lever operated knapsack sprayer (droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min *or* • Motorized knapsack sprayer or mist blower (droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle	 
Reproductive stage	Insecticides and fungicides	• Lever operated knapsack sprayer (droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min	
Category B: Field flying pest/airborne pest			
Vegetative stage Reproductive stage *(Field Pests)*	Insecticides and fungicides	• Motorized knapsack sprayer or mist blower (droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle *Or* • Battery operated low volume sprayer (droplets of small size) • Spinning disc nozzle	 
Mosquito/ locust and spatial application *(migratory* Pests)	Insecticides and fungicides	• Fogging machine and ENV (exhaust nozzle vehicle) (droplets of very small size) • Hot tube nozzle	
Category C: Weeds			
Post-emergence application	Weedicide	• Lever operated knapsack sprayer (droplets of big size) • Flat fan or floodjet nozzle @ 15 to 20 psi • Lever operating speed = 7 to 10 strokes/min	 
Pre-emergence application	Weedicide	• Trolley mounted low volume sprayer (droplets of small size) • Battery operated low volume sprayer (droplets of small size)	

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. Do not apply pesticides without protective clothing and wash clothes immediately after spray application.	
5.	Do not apply in hot or windy conditions.	
6.	Operator should maintain normal walking speed while undertaking application.	
7.	Do not smoke, chew or eat while undertaking the spraying operation	
8.	Operator should take proper bath with soap after completing spraying	
9.	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

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Ecological Engineering Plants for Redgram

Cluster bean

Sunflower

***Ocimum* spp.**

***Coreopsis* spp.**

Spearmint

Mustard

Parsley

Dandelion

French bean

Cowpea

Buckwheat

Maize

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