AESA BASED IPM PACKAGE

Horsegram

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

National Institute of Plant Health Management
Rajendranagar, Hyderabad, Telangana

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

The AESA based IPM – Horsegram, was compiled by the NIPHM working group under the Chairmanship of Smt. V. Usha Rani, IAS, Director General, NIPHM, and guidance of Shri. Utpal Kumar Singh, IAS, JS (PP). The package was developed taking into account the advice of experts listed below on various occasions before finalization.

NIPHM Working Group:

Chairman : Smt. V. Usha Rani, IAS, Director General
Vice-Chairmen : Dr. S. N. Sushil, Plant Protection Advisor
: Dr. K. Vijaya lakshmi, Director (PHM)

Core Members:

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

Contributions by DPPQ&S Experts:

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

Contributions by External Experts:

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

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Horsegram -Plant Description:

Horsegram (*Macrotyloma uniflorum*) (Lam.) Verdc (Family: Fabaceae) (horsegram, kulthi bean, hurali, Madras gram) is one of the lesser known beans. The whole seeds of horsegram are generally utilized as cattle feed. The stems are slightly hairy. It has trifoliate leaves with each leaflet growing between 2.5 cm and 5 cm in breadth. The leaflets are oblong or lanceolate in shape. Small yellow flowers grow in clusters from the leaf axils. The flowers are 1.3 cm to 2 cm long. Their scimitar-shaped, compressed pods grow around 5 cm in length. The large seeds can be round or slightly flattened in shape. They turn nearly black when dried. These plants are indigenous to the south eastern regions of India. They are also found in other parts of the world including Africa, Malaysia, Australia and the West Indies. They are generally grown from the seeds. The plants can adapt to a wide range of soil types from granitic sands to heavy clays. Tropic and sub-tropic climates are ideal for their growth. They can tolerate saline soils with the preferred pH range being 6.0 to 7.5. Horsegram plants can grow in dry areas. But, they prefer 500 mm to 2500 mm rainfall. These plants do not survive in frost and extremely cold weather. Harvesting of the seeds can be done both by hands and by using a harvester. However, it is consumed as a whole seed, as sprouts, or as whole meal in India, popular especially in southern Indian states. Horsegram and moth bean are legumes of the tropics and subtropics, grown mostly under dry-land agriculture.

1. http://keys.trin.org.au/key-server/data/0e0f0504-0103-430d-8004-060d07080d04/media/Images/P023007.jpg
2. http://www.onlyfoods.net/wp-content/uploads/2012/09/Horse-Gram-Pictures.jpg

I. PESTS

A. Pests of National Significance

1. Insect pests

- **1.1. Sharpshooter leafhoppers: *Bothrogonia albidicans* (Walker) (Hemiptera: Cicadellidae)**
- **1.2. Little bean bug: *Chauliops choprai* Sweet and Schaeffer (Hemiptera: Malcidae)**
- **1.3. Pod borer: *Etiella zinckenella* (Treitschke) (Lepidoptera: Pyralidae)**
- **1.4. Weevils: *Alcidodes fabricii* (Fabricius) (Coleoptera: Curculionidae), *Apion* sp. (Coleoptera: Apionidae)**
- **1.5. Aphids: *Aphis craccivora* Koch (Hemiptera: Aphididae)**
- **1.6. Pulse beetles: *Bruchus* spp., *Callosobruchus* spp. (Coleoptera: Bruchidae)**

2. Diseases

- **2.1 Root rot: *Pelicularis filamentosa***
- **2.2 Cercospora leaf spot: *Cercospora dolichos* Ell. & Evir**
- **2.3 Bacterial leaf spot: *Xanthomonas phaseoli* var. sojansis**
- **2.4 Anthracnose: *Colletrotrichum lindemuthiannum* (Sacc. Angn.) Bri. and Cov.**
- **2.5 Powdery mildew: *Erysiphe polygoni* DC.**
- **2.6 Yellow mosaic virus**

3. Weeds

3.1 Major Broadleaf weeds

- **3.1.1 Pigweed: *Amaranthus viridis* Hook. F. Amaranthaceae**
- **3.1.2 Tick weed: *Cleome viscosa* L Capparidaceae**
- **3.1.3 Horse purslane: *Trianthema portulacastrum* L. Aizoaceae**
- **3.1.4 False amaranth: *Digera arvensis* Forssk. Amaranthaceae**

3.2 Grassy weeds

- **3.2.1 Rabbit/Crow foot grass: *Dactyloctenium aegyptium* (L.) Beauv. (Poaceae)**
- **3.2.2. Crab grass: *Digiteria sanguinalis* (L.) Willd. (Poaceae)**

3.3 Sedges

- **3.3.1. Purple nutsedge: *Cyperus rotundus* L. (Cypraceae)**

4. Nematode

- **4.1. Root-knot nematode*: Meloidogyne incognita***

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 (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 P: D ratio
- Take direct action when needed (e.g. collect egg masses, remove infested plants etc.)
- Observe the soil physical condition, moisture level, etc.
- Take representative soil sample and get the soil analysis report showing soil pH, electrical conductivity (EC), organic matter and nutrient status.
- Observe the number and species of weeds found in per square meter area each in five randomly selected spots/ha.
- Take representative soil samples from different spots and send to nearby soil testing laboratory.
- Discuss the soil analysis report and recommendation provided by soil testing laboratory.
- Arrange for required quantity of FYM/vermicompost/fertilizers/soil amendments etc.

http://www.trivediscience.com/wp-content/uploads/2013/03/Horse-gram_73-Blessed-02-big.jpg

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). 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. Re-growth 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 herbivorous insects; and 6. Compensation by growth of neighbouring plants e.g. early attack by the sorghum shoot fly on main shoot induced the production of a few synchronous tillers that grow rapidly and survive to produce harvestable ear heads. LRG 41 Red gram for *H. armigera.* Leaf webbers make young pigeon pea crop look untidy, they apparently cause no yield loss. The plants produce side shoots to compensate for the loss of terminal buds (Shanower *et al*. 1999).

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 red gram 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

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

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

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

- Keep the drawing for comparison purpose in the following weeks.

Data recording

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

- Maintain records to

analyse and draw conclusions.

Data to be recorded:

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

Some questions that can be used during the discussion

- Summarize the present situation of the field?
- 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.

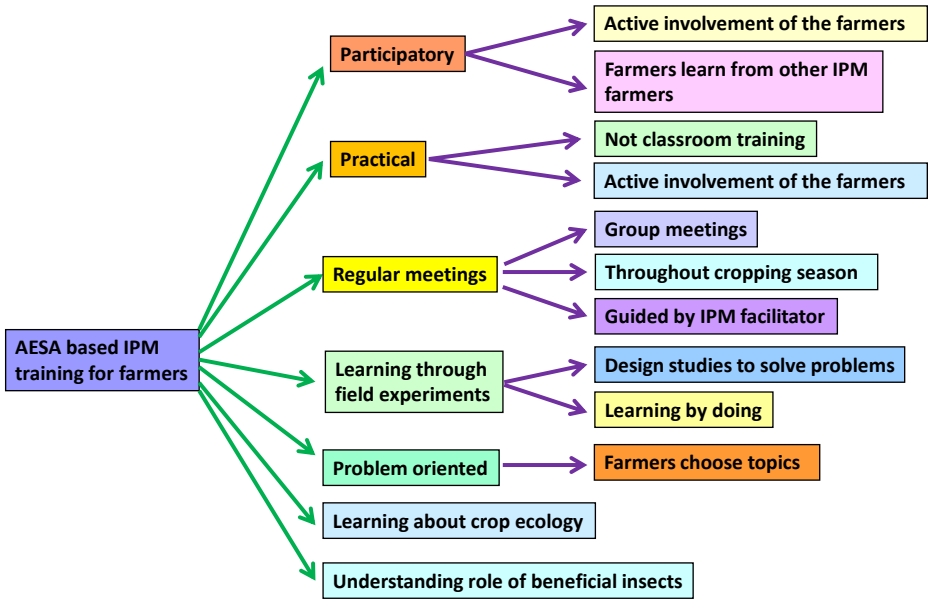
AESA and farmer field school (FFS)

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 build up
- 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

Sharp shooter leaf hopper: Count and record the number of both nymphs and adults on five randomly selected plants.

Pod borer: Total number of pods, damaged pods due to borer and number of larvae per pod from individual sampled 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 pseudo/stem 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 and pod sampling: Carefully examine the stems and pods of plants for signs of fungal material diseases or lesions. The stems and pod should be split or taken apart and examined for discoloration caused by fungi and bacteria. Count the number of stems and pods infected due to disease and incidence should be recorded.

C. Yellow pan sticky traps

Set up yellow pan sticky traps 15 cm above the canopy for monitoring aphids @ 4-6 traps/acre. Locally available empty tins can be painted yellow/ coated with grease/ vaseline/castor oil on outer surface may also be used as yellow sticky trap.

D. Light traps

Set up light traps @1 trap/acre 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).

E. 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. Ecological engineering for pest management is based on informed ecological knowledge rather than high technology approaches such as synthetic pesticides and genetically engineered crops (Gurr et al. 2004).

Ecological Engineering for Pest Management – Below Ground:

There is a growing realization that the soil borne, seed and seedling borne diseases can be managed with microbial interventions, besides choosing appropriate plant varieties. The following activities increase the beneficial microbial population and enhance soil fertility.

- Crop rotations with leguminous plants which enhance nitrogen content.
- Keep soils covered year-round with living vegetation and/or crop residue.
- To promote the below ground biodiversity and to enhance activities of beneficial microbes in soil, use Biofertilizers, *Trichoderma*, VAM, etc. along with FYM or Vermicompost
- Application of balanced dose of nutrients using biofertilizers based on soil test report.
- Application of biofertilizers with special focus on mycorrhiza and plant growth promoting rhizobacteria (PGPR)

Ecological Engineering for Pest Management – Above Ground:

Natural enemies play a very significant role in control of foliar insect pests. Natural enemy diversity contributes significantly to management of insect pests both below and above ground.

Natural enemies may require:

1. Food in the form of pollen and nectar.
2. Shelter, overwintering sites and moderate microclimate, etc.
3. Alternate hosts when primary hosts are not present.

In order to attract natural enemies following activities should be practiced:

- Raise the flowering plants / compatible cash crops along the field border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population
- Grow flowering plants on the internal bunds inside the field
- Not to uproot weed plants those are growing naturally such as *Tridax procumbens, Ageratum* sp, *Alternanthera* sp etc. which act as nectar source for natural enemies,
- Not to apply broad spectrum chemical pesticides, when the P: D ratio is favorable. The plant compensation ability should also be considered before applying chemical pesticides.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Select and plant appropriate companion plants which could be trap crops and pest repellent crops. The trap crops and pest repellent crops will also recruit natural enemies as their flowers provide nectar and the plants provide suitable microclimate.

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

Plants suitable for Ecological Engineering for Pest Management

Attractant plants

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

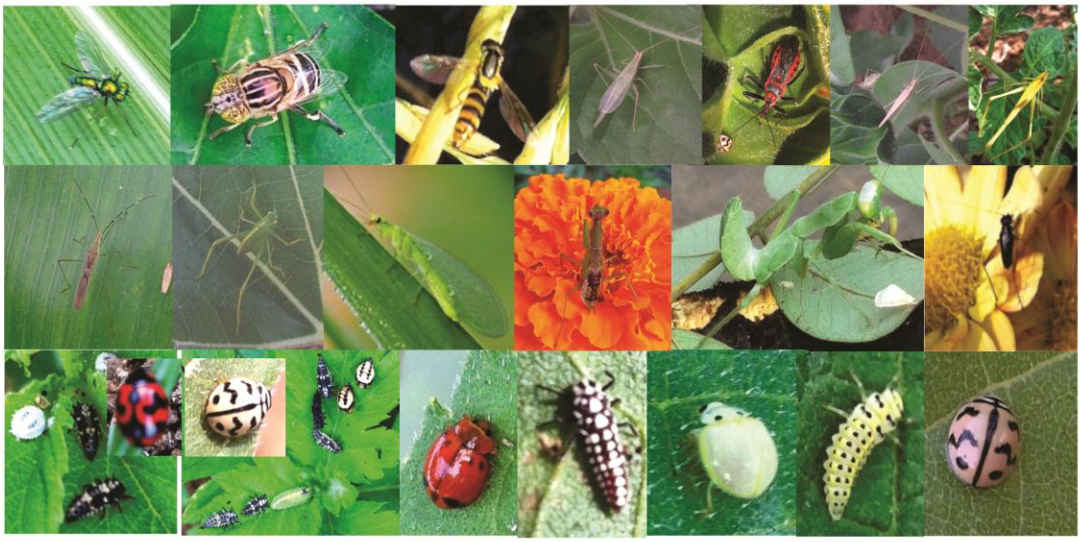
Groundnut

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.

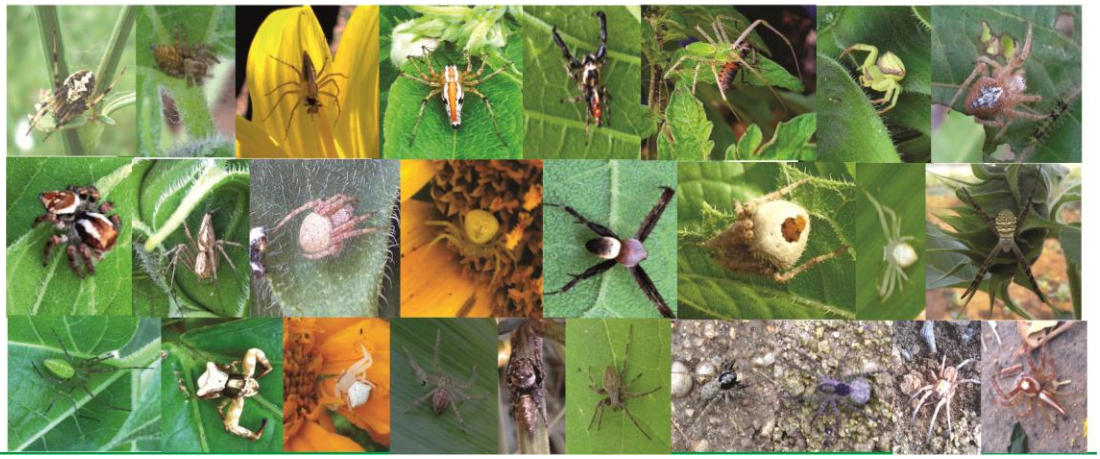
Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



IV. CROP STAGE WISE IPM

Management	Activity
Pre- sowing*	
	Common cultural practices: • Crop rotation with non host crops • Timely sowing should be done • Field sanitation, rogueing • Destroy the alternate host plants • Apply manures and fertilizers as per soil test recommendations
Nutrients	• Apply manures and fertilizers on soil test basis.
Weeds	• Destroy weeds manually or by deep summer ploughing.
Soil borne pathogens Nematodes, Resting stage of insects	**Cultural control:** • Deep ploughing of fields during summer to manage juvenile population of nematodes and insect pests. • **Soil solarization:** Cover the beds with polythene sheet of 75 gauge thickness for six weeks before sowing to reduce the soil borne pests.
Sowing/seedling*	
	Common cultural practices: • Do summer ploughing • Timely sowing should be done • Solarize the field in summer to help reduce the inoculums. • Use resistant varieties • Select seed from disease free fields
Nutrients	•
Weeds	• Always use certified and weed free seeds. • Timely sowing should be done. • Line sowing should be done to facilitate inter-culture operations. • Plant population should be maintained to its optimum right from its beginning to minimize the crop weed competition. • Adopt suitable crop rotation to minimize dodder and orobanche weeds.
Vegetative stage*	
	• Avoid excess application of nitrogen • Adopt the ecological engineering strategy. • Conserve natural enemies • Remove and destroy weeds periodically • Removal and destruction of infected/infested plants **Common biological practices:** • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies
Nutrients	• Correct micronutrient deficiency if any in standing crop. • Foliar application of Thiourea @500ppm solution twice: 1st spray during vegetative growth and 2nd spray at flowering stage. It is effective under all conditions.
Weeds	• Keep field boundary & bunds free from weeds. • The crop field should be weed free initially for 4-5 weeks by following timely

	hoeing and weeding. • Inter-culture operation/hoeing should be done twice at 20 and 35 days after sowing-using hand hoe to remove all weeds in between the row.
Leafhopper	**Biological control:** • Spray neem seed kernel extract (NSKE) 5%. • Spray neem oil @ 1%
Little bean bug	**Biological control:** • Spray neem seed kernel extract (NSKE) 5%. • Spray neem oil @ 1%
Anthracnose, Bacterial leaf blight,Cercospor aleaf spot	**Cultural control:** • 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	**Cultural control:** • Bower system (maintain gapping) of cropping reduces the disease incidence.
Root rot	**Cultural control:** • 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
Mosaic complex	• See the common cultural practices
Flowering	
Pod borer	**Cultural control:** • Follow the intercropping systems like horsegram +maize, horsegram+ finger millet **Biological control**: • Conserve and augment common predators and parasitoids
Reproductive (pod development)	
Pod borer	**Cultural control:** • Follow the intercropping systems like horsegram +maize, horsegram+ finger millet **Biological control**: • Conserve and augment common predators and parasitoids
Nutrients	Incorporate crop residues in soil immediately after harvest.
Weeds	Remove left over weeds to prevent weed seed spread in field.

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. Pig weed: *Amaranthus viridis* Hook. F.(Amaranthaceae)

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

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

4. False amaranth: *Digeria arvensis* Forssk.(Amaranthaceae)

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

6.Crabgrass: *Digiteria sanguinalis*(L.) Scop. (Poaceae)

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

VII. DESCRIPTION OF INSECT AND NEMATODE PESTS

1. Pod borer

Biology:

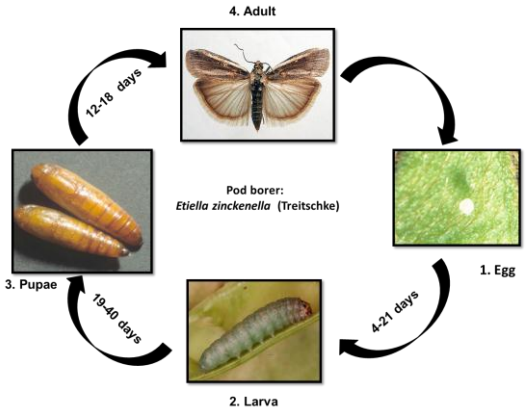
Eggs: Development of egg lasts 4-21 days depending on weather conditions. Average fecundity is about 100-300, maximum 600 eggs.

Larva: Coloration of larvae is variable, from dirty greenish-gray to reddish; body length 15-22 mm and larval period is about 19-40 days depending upon weather conditions.

Pupa: Pupa is brilliant, brown, fine punctured, to 7-10 mm in length; cocoon is thick, white, and usually covered with soil particles. Pupal period is about 12-18 days. Number of generations per year reaches three, though the third generation can be facultative. Overwinters as larva.

Adults: Body length 8-11 mm, wingspan 19-27 mm. Wings longer than abdomen, folding as roof. Forewing is yellow- or greyish-brown with characteristic light stripe along fore edge, with orange spot on basal third, and with dark fringe. Hind wings are light gray, with dark venation and dark double line near fringe; the fringe is long and light in colour. Top of abdomen with a tuft of golden-yellow hairs. Life span of adult is 20 days.

Life cycle:



http://www.agroatlas.ru/content/pests/Etiella_zinckenella/Etiella_zinckenella.jpg
http://bugwoodcloud.org/images/384x256/5368268.jpg
https://upload.wikimedia.org/wikipedia/commons/a/a3/Etiella_zinckenella_larva.jpg

Damage symptoms:

Dropping of flowers and young pods

- As the larva develops within the pod, faeces accumulate causing soft, rotten patches on the pod.
- Seeds are either partially or entirely eaten, and considerable frass and silk are present.
- Older pods marked with a brown spot where a larvae has entered

Natural enemies of pod borer:

Parasitoids:

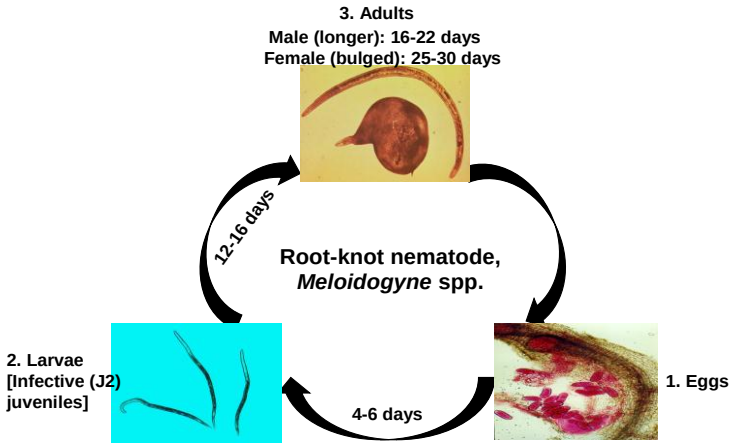
Eggparasitoids: *Trichogrammatoidea armigera*, Larval parasitoids: *Bracon hebetor, Phanerotoma* sp., *Tetrastichus* sp, *Phanerotoma planifrons*

2. 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

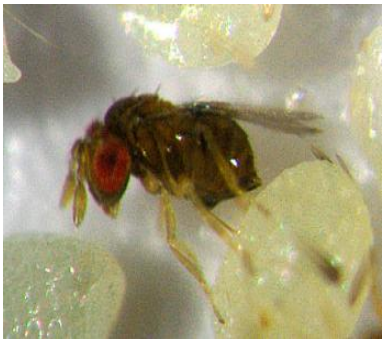
Survival and Spread:
Primary: Cysts and egg masses in infected plant debris and soil or collateral and other hosts like Solonaceous, Malvaceous and Leguminaceous plants act as sources of inoculums.
Secondary: Autonomous second stage juveniles that may also be water dispersed.
Favourable conditions:
Loamy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

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

Natural Enemies of Horsegram Insect Pests

Parasitoids

Egg parasitoids



1*. Tricogramma*

2. *Tetrastichus* spp.

3. *Telenomus* spp

Egg-larval parasitoid

4. *Chelonus* spp.

Larval parasitoids

5. *Bracon* spp.

6. *Ichneumon* spp.

7. *Carcelia* spp.

8. *Campoletis* 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

Predators

1. *Chrysoperla*

2. Coccinellid

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.

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

VIII. DESCRIPTION OF DISEASES

1. Cercospora leaf spot :

Disease symptoms:

- Moist weather and splashing 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 spotsfirst 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 horsegram plants and on infected plant debris.

Survival and spread:

- The fungus survives on diseased plant debris .Fungus spreads about 3 m through the soil in one season.

Favourable conditions

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

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

2.Bacterial leaf spot:

Disease symptoms:

- This is a common disease of horsegram occurring on the foliage at any stage of the growth.
- Thepathogen 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.

Survival and spread

- The bacterium is seed-borne

Favourable conditions

- Rain splashes play an important role in the development and spreadof the disease.
- Warm, rainy and wet weather is congenial.

*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 severe in cool and wet seasons.

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

4.Root rot:

Disease symptoms:

- The pathogens cause seed decay, root rot, damping-off, seedling blight, stem canker and leaf blight in horsegram
- The disease occurs commonly at pod development stage
- The affected leaves turn yellow in colour and brown irregular lesions appear on leaves.
- 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----------

5.Mosaic complex:

Disease symptoms:

- Initially mild scattered yellow spots appear on young leaves
- The next trifoliate leaves emerging from the growing apexshow 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 aphids and whiteflies.
- Aphids are more active in warm summer conditions and increased their population as well as spread the viruses .

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

6.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 offseason
- Secondary spread is through air-borne oidia produced in the season.

Favourable conditions

- Dry and moist weather (90% RH) favours disease development.

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

IX. SAFETY MEASURES

A. At the time pre-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 horsegram, 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 horsegram 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 up to 7.5 percent is estimated during storage. Quantitative losses result from spoilage, drianage, 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.

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 horsegram. Mud bins are most commonly used by farmers. Storage in jute bags is common in markets and horsegram mills. There is little difference in the storage structures meant for seeds or grains for consumption.

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 monocropping.
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	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	Do not apply long persistent

	technology.	pesticides on trap crop, otherwise it may not attract the pests and natural enemies.

XI. BASIC PRECAUTIONS IN PESTICIDES USAGE

A. Purchase

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

B. Storage

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

C. Handling

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

D. Precautions for preparing spray solution

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

E. 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; apply against the windy direction.
3. Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer
4. Wash the sprayer and buckets etc with soap water after spraying
5. Containers buckets etc used for mixing pesticides should not be used for domestic purpose
6. Avoid entry of animals and workers in the field immediately after spraying

G. Disposal

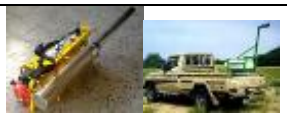
1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

XII. PESTICIDE APPLICATION TECHNIQUES

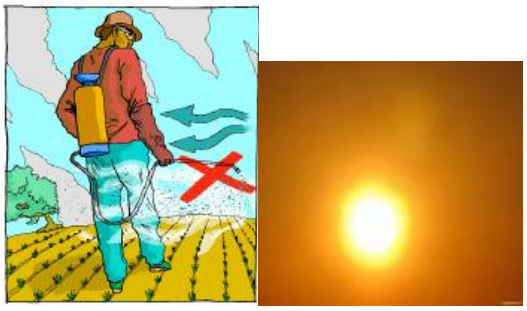
<table>
<tr><th></th><th></th><th colspan="2">Equipment</th></tr>
<tr><td colspan="4">Category A: Stationary, crawling pest/ disease</td></tr>
<tr><td>Vegetative stage

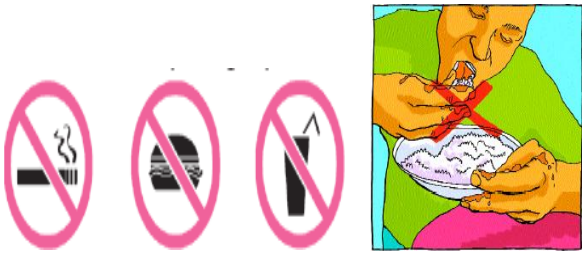
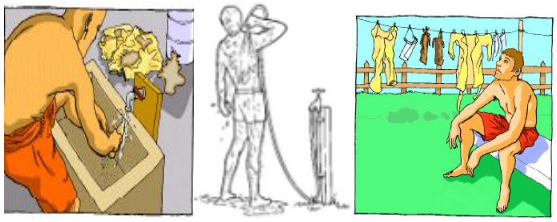
i) for crawling and soil borne pests

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

Category B: Field Flying pest/ airborne pest			
Vegetative stage Reproductive stage *(Field Pests)*	Insecticides and fungicides	• Motorized knapsack sprayer or mist blower (Droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle ***Or*** • Battery operated low volume sprayer (Droplets of small size) Spinning disc nozzle	 
Mosquito/ locust and spatial application *(migratory* Pests)	Insecticides and fungicides	• Fogging machine and ENV (Exhaust nozzle vehicle) (Droplets of very small size) • Hot tube nozzle	
Category C: Weeds			
Post-emergence application	Weedicide	• Lever operated knapsack sprayer (Droplets of big size) • Flat fan or floodjet nozzle @ 15 to 20 psi • Lever operating speed = 7 to 10 strokes/min	 
Pre-emergence application	Weedicide	• Trolley mounted low volume sprayer (Droplets of small size) • Battery operated low volume sprayer (Droplets of small size)	 

XIII. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

1.	For application rate and dosage see the label and leaflet of the particular pesticide.	
2.	It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.	
3.	Clean and wash the machines and nozzles and store in dry place after use.	
4.	It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides.	
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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