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AESA BASED IPM PACKAGE

Moth bean

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

NIPHM Working Group:

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

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

Contributions by DPPQ&S Experts:

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

Contributions by External Experts:

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

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Moth bean-Plant description:

Moth bean (*Vigna aconitifolia* (Jacq.) Marechal; Family: Fabaceae)resembles a small mat, for it is a herbaceous, ground-hugging plant and only about a foot high. Moth bean is native to India and Pakistan, grown for consumption as a pulse crop. It is predominately grown at Rajasthan in India, although it is cultivated in the United States, Australia, Thailand and other parts of Asia. Plant bears alternate, green leaves, which are divided into three oval, smooth-edged leaflets, each 6–15 cm long and 3– 11 cm wide. The white and pink flowers are about 1 cm long, and they develop into pods 4–6 cm long and 0.5–0.7 cm wide. These may be green and yellow in color, each containing 4–6 seeds. The seeds are smooth and oblong.. The pods, sprouts and protein rich seeds of this crop are commonly consumed in India. Moth bean can be grown under rain fed conditions in light soils.

I. PESTS

A. Pests of national significance

1. Insect and mite pests

1.1. White grub: *Holotrichia* spp. (Coleoptera: Scarabaeidae)
1.1. Aphids: *Aphis craccivora* Koch (Hemiptera: Aphididae)
1.3. Spotted pod borer: *Maruca vitrata* Geyer (Lepidoptera: Crambidae)
1.4. Leaf hopper: *Empoasca kerri* Pruthi (Hemiptera: Cicadellidae)
1.5. Whitefly: *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae)
1.6. Pod bugs: *Riptortus pedestris* (Hemiptera: Alydidae); *Clavigralla gibbosa* (Hemiptera: Coreidae) and *Nezara viridula* (Hemiptera: Pentatomidae)

2. Diseases

2.1. *Fusarium* wilt: *Fusarium oxysporum* (Schlecht) Snyder & Hansen
2.2. Charcoal rot or ashy stem blight: *Macrophomina phaseolina* (Maubl.)
2.3. Mung bean yellow mosaic virus
2.4. Bacterial blight: *Pseudomonas syringae* pv*. phaseolicola* Van Hall,
2.5 Bacterial leaf spot: *Xanthomonas phaseoli* (Burkholder) Starr & Burkholder.
2.6. Cercospora leaf blight: *Cercospora spp.*

3. Weeds

3.1 Broad leaf

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 Grasses

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

4. Nematodes

4.1. Root-knot nematode: *Meloidogyne* spp.
4.2. Reniform nematode: *Rotylenchulus reniformis* (Linford & Oliveira)

B. Pests of Regional Significance

1. **Insect pests**

1.1. Hawk moth: *Acherontia styx* Westwood (Lepidoptera: Sphingidae) (Rajasthan)
1.2. Hairy caterpillar: *Amsacta* spp. (Lepidoptera: Arctiidae)

II. AGRO-ECOSYSTEM ANALYIS (AESA) BASED INTEGRAED PEST MANAGEMENT (IPM)

A. AESA

The IPM has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment ultimately affecting the interests of the farmers. The economic threshold level (ETL) was the basis for several decades but in modern IPM (FAO 2002) emphasis is given to AESA where farmers take decisions based on larger range of field observations. The health of a plant is determined by its environment which includes physical factors (i.e. soil, rain, sunshine hours, wind etc.) and biological factors (i.e. pests, diseases and weeds). All these factors can play a role in the balance which exists between herbivore insects and their natural enemies. Understanding the intricate interactions in an ecosystem can play a critical role in pest management.

Decision making in pest management requires a thorough analysis of the agro-ecosystem. Farmer has to learn how to observe the crop, how to analyze the field situation and how to make proper decisions for their crop management. This process is called the AESA. Participants of AESA will have to make a drawing on a large piece of paper (60 x 80 cm), to include all their observations. The advantage of using a drawing is that it requires the participants/farmers to observe closely and intensively. It is a focal point for the analysis and for the discussions that follow, and the drawing can be kept as a record.

AESA is an approach, which can be gainfully employed by extension functionaries and farmers to analyze the field situations with regards to pests, defenders, soil conditions, plant health and the influence of climatic factors and their relationship for growing a healthy crop. The basic components of AESA are

- Plant health at different stages
- Built-in compensation abilities of plants
- Pest and defender population dynamics
- Soil conditions
- Climatic factors
- Farmers past experience

Principles of AESA based IPM:

Grow a healthy crop

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

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

Farmers should

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

Plant compensation ability

Compensation can be defined as the replacement of plant biomass lost to herbivores and has been associated with increased photosynthetic rates and mobilization of stored resources from source organs to sinks (e.g., from roots and remaining leaves to new leaves) during active vegetative growth period. Plant tolerance to herbivory can arise from the interaction of a variety of plant traits and external environmental factors. Several studies have documented such compensation through increased growth and photosynthetic rate.

Understand and conserve defenders

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

Insect zoo

In field various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in crop field. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial and harmful insects. In this method, unfamiliar/unknown insect are collected in plastic containers with brush from the field and brought to a place for study. Each insect 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 Moth bean insect pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens.

Model Agro-Ecosystem Analysis Chart

Date:
Village:
Farmer:

Decision taken based on the analysis of field situation

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

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

Decision making

Farmers become experts in crop management

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

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

AESA methodology

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

Advantages of AESA over ETL

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

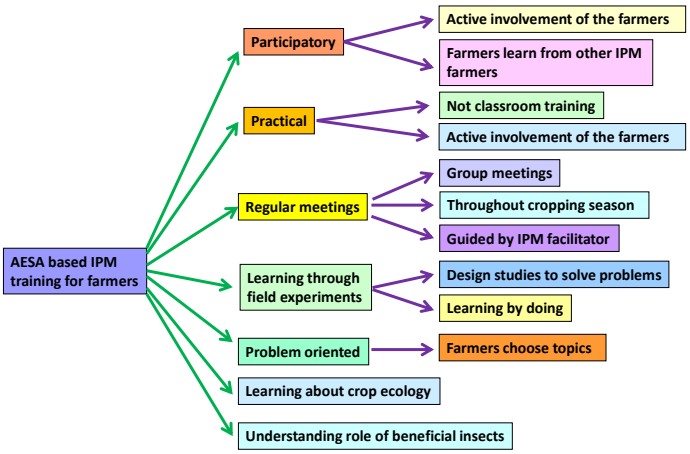
AESA and farmer field school (FFS)

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

Farmers can learn from AESA

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

FFS to teach AESA based IPM skills



B. Field scouting

AESA requires skill. So only the trained farmers can undertake this exercise. However, other farmers also can do field scouting in their own fields at regular intervals to monitor the major pest situation.

Surveillance on pest occurrence in the main field should commence soon after crop establishment and at weekly intervals thereafter. In each of the fields, select five spots randomly. Select five random plants at each spot for recording counts of insects as per procedure finalized for individual insects.

For insect pests:

Aphids, whitefly and jassids: Count and record the number of both nymphs and adults on leaves or tender parts from the five randomly selected plants. In later stages of crop growth, aphids are to be counted on the top 10cm shoot or on randomly selected pods, as they congregate on pods, feed and cause damage.

Pod borer: The total number of pods and damaged pods due to pod borer, shoot borer and cutworm as well as number of larvae on individual plants should be counted and recorded.

White grub: Count and record the number of damaged plants per unit area sampled (quadrats of 45cm x 45cm or suitable area).

For diseases:
Whenever scouting, be aware that symptoms of plant disease problems may be caused by any biotic factors such as fungal, bacterial, viral pathogens or abiotic factors such as weather, fertilizers, nutrient deficiencies, pesticides and abiotic soil problems. In many cases, the cause of the symptom is not obvious. Close examination, and laboratory culture and analysis are required for proper diagnosis of the causal agent of disease. Generally fungal diseases cause the obvious symptoms with irregular growth, pattern & colour (except viruses), however abiotic problems cause regular, uniform symptoms. Pathogen presence (signs) on the symptoms can also be observed like fungal growth, bacterial ooze etc. Specific and characteristic symptoms of the important plant diseases are given in description of diseases section.

Root sampling: Always check plants that appear unhealthy. If there are no obvious symptoms on plants, examine plants randomly and look for lesions or rots on roots and stems. Observe the signs of the causal organism (fungal growth or ooze). It is often necessary to wash the roots with water to examine them properly. If the roots are well developed, cut them to examine the roots for internal infections (discolouration & signs). Count the total number of roots damaged/infested/infected due to rot should be counted and incidence should be recorded.

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

Stem, flower, and pod sampling: Carefully examine the stem, flower, pod of plants for symptoms and signs of fungal or bacterial diseases. The stem, flower, pod should be split or taken apart and examined for discoloration caused by fungi and bacteria. Count the number of stems, flowers, pods infected due to disease and percent disease incidence should be recorded.

C. Surveillance through light traps for white grub:
Set up light traps @ 1 trap/acre for monitoring and mass collection of white grub adults with the onset of monsoon.

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

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

F. Nematode extraction
Collect 100 to 300 cm^3 (200-300 g) representative soil sample. Mix soil sample and pass through a coarse sieve to remove rocks, roots, etc. Take a 600 cc subsample of soil, pack lightly into a beaker uniformly. Place soil in one of the buckets or pans half filled with water. Mix soil and water by stirring with paddle; allow to stand until water almost stops swirling. Pour all but heavy sediment through 20-mesh sieve into second bucket; discard residue in first bucket; discard material caught on sieve. Stir material in second bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 200-mesh sieve into first bucket; discard residue in second bucket. Backwash material caught on 200-mesh sieve (which includes large nematodes) into 250-ml beaker. Stir material in first bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 325-mesh sieve into second bucket; discard residue in first bucket. Backwash material caught on 325-mesh sieve (which includes small to mid-sized nematodes and silty material) into 250-ml beaker. More than 90% of the live nematodes are recovered in the first 5-8 mm of water drawn from the rubber tubing and the sample is placed in a shallow dish for examination.

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

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.

- Keep soils covered year-round with living vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance below ground biodiversity of beneficial microbes and insects.
- Application of balanced dose of nutrients using biofertilizers based on soil test report.
- Application of biofertilizers with special focus on mycorrhiza and plant growth promoting 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 favourable. The plant compensation ability should also be considered before applying chemical pesticides.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Select and plant appropriate companion plants which could be trap crops and pest repellent crops. The trap crops and pest repellent crops will also recruit natural enemies as their flowers provide nectar and the plants provide suitable microclimate.

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

Plants Suitable for Ecological Engineering for Pest Management

Attractant plants

Sunflower

Buckwheat

French bean

Alfalfa

Maize

Mustard

***Coreopsis* spp.**

Cosmos

Dandelion

Anise

Caraway

Dill

Parsley

***Desmodium* sp**

Maize

***Chrysanthemum* spp.**

Ryegrass

Carrot

Repellent plants

***Ocimum* spp.**

Peppermint

Border plants

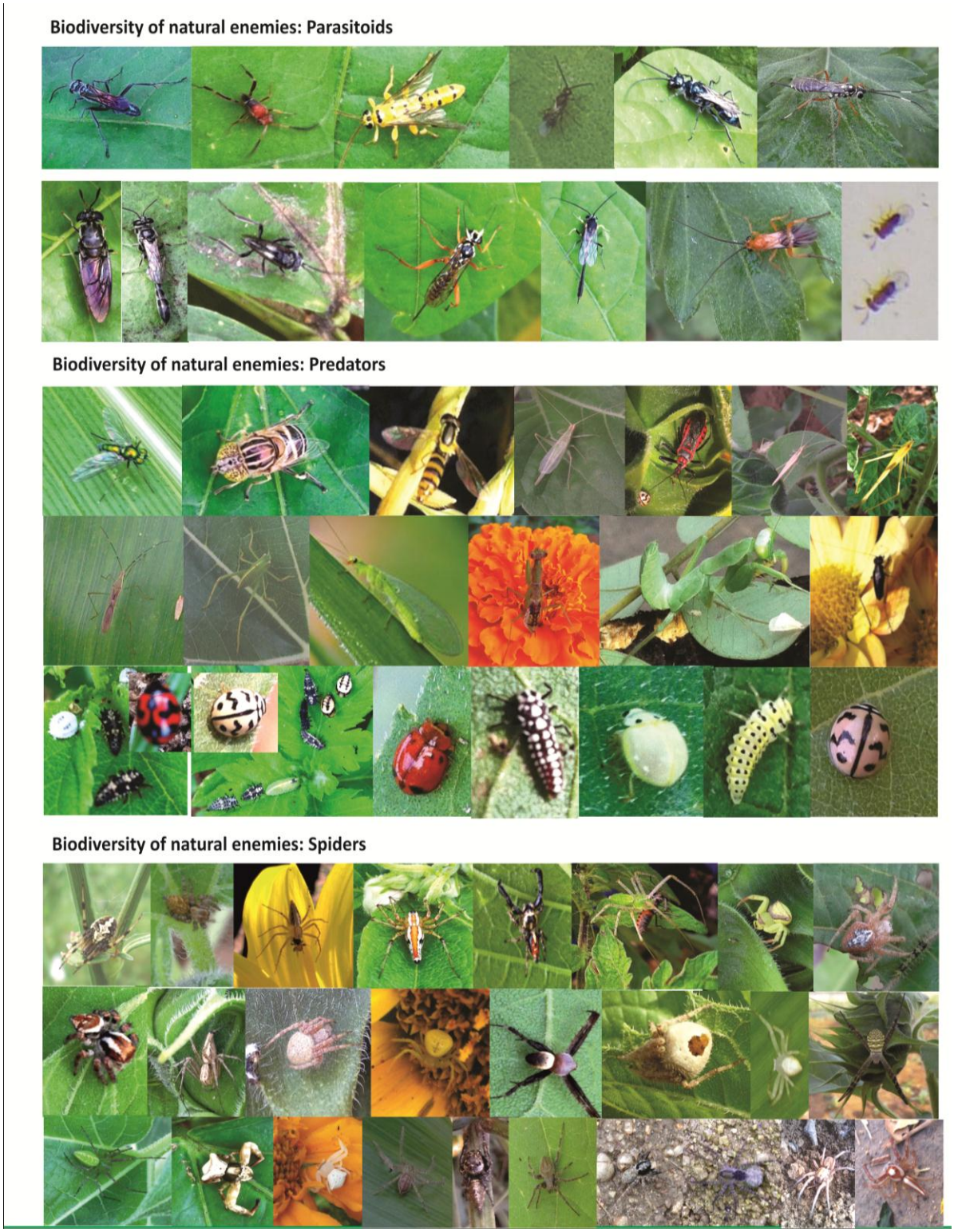
Sorghum

Maize

Bajra

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



IV. CROP STAGE-WISE IPM

Management	Activity
Pre-sowing*:	
	<u>Common cultural practices:</u> • Timely sowing should be done. • Field sanitation. • Destroy the alternate host plants • Plant tall border crops like pearl millet, sorghum for the management of aphids and whitefly. • Adopt ecological engineering by growing the recommended attractant, repellent, and trap crops around the field bunds.
Nutrients	• Get the soil sample tested and apply nutrients based on soil test report. Soil is brought to fine tilth by 2-3 ploughing with harrow or plough. • Incorporate 4 to 5 tonnes of Farm Yard Manure per acre in soil 2-3 weeks before sowing.
Weeds	• Solarisation of soil during summer reduces weed infestation.
Sowing*:	
	<u>Common cultural practices:</u> • Timely and line sowing should be done • Use healthy, certified and weed free seeds. • Sow with proper spacing
Nutrients	• Fertilizers should be applied on soil test basis
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
Vegetative stage	
	<u>Common cultural practices:</u> • Collect and destroy diseased and insect infested plant parts. • Provide irrigation at critical stages of the crop • Avoid water stress and water stagnation conditions. **<u>Common mechanical practices:</u>** • Collection and destruction of eggs, early stage larvae and adult beetles of white grub. • Use yellow sticky traps for aphids and whitefly. • Use light trap @ 1/acre and operate between 6 pm and 10 pm **<u>Common biological practices:</u>** • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies
Nutrients	• Correct micronutrient deficiency if any in standing crop. • Seed treatment of Thiourea @ 500 ppm in light soils. • Foliar application of Thiourea @500ppm solution twice in standing crops:
Weeds	• Keep field boundary & bunds free from weeds. • The crop field should be weed free initially for 3-4 weeks. • 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. • Mulches like straw, hay, plastic, etc. should be used in between the rows to suppress the weed growth.
Aphids	• Follow common cultural, mechanical and biological practices. **<u>Cultural control:</u>** • Apply optimum doses of nitrogen fertilizers • Regular field monitoring in the morning hours for monitoring of pests and defender population, barrier crops like pearl millet and sorghum around the field. **<u>Biological control:</u>** • Conserve predators such as ladybird beetles (*Coccinella septumpunctata, Menochilus sexmaculata* and *Brumoides suturalis.*
Root grub	• Follow common cultural, mechanical and biological practices **<u>Biological control:</u>** • Use Entomopathogenic nematodes
Whitefly	• Follow common cultural, mechanical and biological practices **<u>Biological control:</u>** • Spray neem seed kernel extract (NSKE) 5%. • Spray neem oil @ 1%
Spotted pod borer	• Follow common cultural, mechanical and biological practices. **<u>Cultural control:</u>** • Inter cropping are found to be effective. • Collect and destroy the larvae. • Keep the field weed free in the initial 25-40 days through intercultural operations and hand weeding
Pod bugs	• Follow common cultural, mechanical and biological practices **<u>Biological control:</u>** • Aggregation pheromone traps are widely used as a monitoring tool and partial control measure.
Fusarium wilt	• Follow common cultural, mechanical and biological practices
Mung bean Yellow mosaic virus	Follow common mechanical and biological practices **<u>Cultural practices:</u>** • All the infected plants should be removed carefully and destroyed. • Control the whitefly
Bacterial leaf spot/blight	Follow common mechanical and biological practices **<u>Cultural control:</u>** • Use disease free and certified seeds.
Charcoal rot or ashy stem blight	Follow common mechanical and biological practices **<u>Cultural control:</u>** • All the infected plants should be removed carefully and destroyed. • Follow intercropping cropping system (Mothbean: Sesame) (1:1 ratio). • Irrigate field every two weeks to avoid stress contitions
Reproductive stage	
Nutrients	• Incorporate crop residues in soil immediately after harvest.
Weeds	• Remove left over weeds to prevent weed seed spread in field.

Pod bugs	• Follow common cultural, mechanical and biological practices **Biological control:** • Aggregation pheromone traps are widely used as a monitoring tool and partial control measure.
Spotted pod borer	• 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 number of applications of insecticide made. For instance, insect pests that survive in large populations and breed quickly are at greater advantage of evolving insecticide, especially when insecticides are misused or over-used.

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

1) Monitor pests: Monitor insect population development in fields to determine if and when control measures are warranted. Monitor and consider natural enemies when making control decisions. After treatment, continue monitoring to assess pest populations and their control.
2) Focus on AESA. Insecticides should be used only as a last resort when all other non-chemical management options are exhausted and P: D ratio is above 2: 1. Apply biopesticides/chemical insecticides judiciously after observing unfavourable P: D ratio and when the pests are in most vulnerable life stage. Use application rates and intervals as per label claim.
3) Ecological engineering for pest management: Flowering plants that attract natural enemies as well as plants that repel pests can be grown as border/intercrop.
4) Take an integrated approach to managing pests. Use as many different control measures as possible viz., cultural, mechanical, physical, biological etc. Select insecticides with care and consider the impact on future pest populations and the environment. Avoid broad-spectrum insecticides when a narrow-spectrum or more specific insecticide will work. More preference should be given to green labeled insecticides.
5) **Mix and apply carefully.** While applying insecticides care should be taken for proper application of insecticides in terms of dose, volume, timing, coverage, application techniques as per label claim.
6) Alternate different insecticide classes. Avoid the repeated use of the same insecticide, insecticides in the same chemical class, or insecticides in different classes with same mode of action and rotate/alternate insecticide classes and modes of action.

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

VII. COMMON WEEDS

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

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

3. Horse purslane: (T*rianthema portulacastrum* L. (Aizoaceae)

Grasses

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

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

Sedges

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

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

VII. DESCRIPTION OF INSECT AND NEMATODE PESTS

1) White grub:

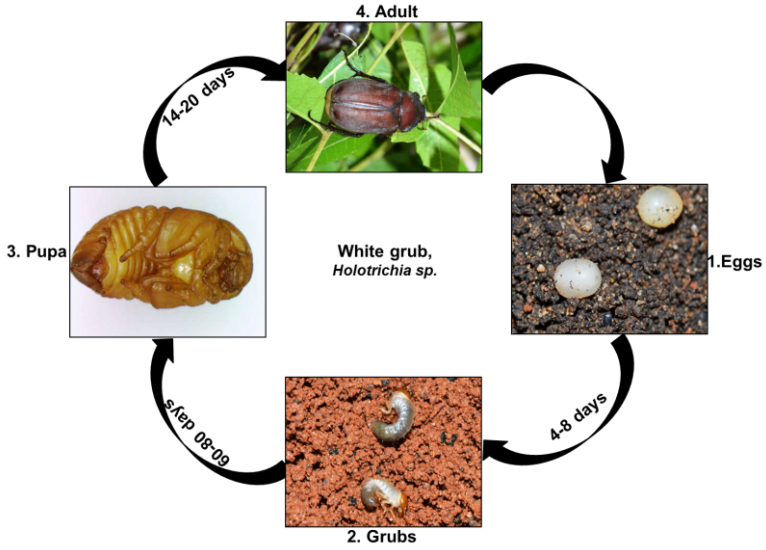
Biology:

Egg: A female lays on an average of 27 eggs in the soil, which are pear like white enclosed in earthen cells.

Grub: Fleshy ‘C’ shaped, whitish yellow in colour found close to the base of the clump.
Pupa: Pupae are tan to brown, and occur deeper in the soil in earthen chambers

Adult: Adult beetles are a rusty-red color just after emerging from the pupal stage, but turn nearly black.

Life cycle



Damage symptoms:

- Yellowing and wilting of leaves.
- Drying of entire crown.
- Affected canes come off easily when pulled.
- Cause extensive damage to roots and base of shoot.

Biological control of root grubs:

Entomo Pathogenic Nematodes seek out and kill all stages of harmful soil-dwelling insects. They can be used to control a broad range of soil-inhabiting insects and above-ground insects in their soil-inhabiting stage of life

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

2) Aphids:

Biology:

Egg: Eggs are very tiny, shiny-black, and are found in the crevices of bud and stems, of the plant. Aphids usually do not lay eggs in warmer parts of the world, but reproduce parthenogenetically all through the year on different host plants.

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

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

Damage symptoms:

- Nymphs and adult aphids suck plant sap from leaves, shoots, buds and floret.
- In addition, plants may become contaminated by honeydew produced by aphids and sooty mould growing on honeydew.
- Aphids are also vectors of diseases, including the common bean mosaic virus.

Damage symptom

http://img3.wikia.nocookie.net/__cb20110622135611/thewwcbritishwildlife/images/7/73/IMG_1126.JPG

Natural enemies of aphid:

Parasitoids: *Lysiphlebus* sp, *Diaeretiella* sp, *Aphidius colemani, Aphytis* spp., *Lipolexix scutellaris* etc.

Predators: Ladybird beetles (*Coccinella septempunctata, C. transversalis, Chilocorus* spp., *Chilomenes sexmaculatus, Brumoides suturalis*), *Chrysoperla* spp., anthocorid bug, mirid bug, nabid bug, carabid beetle, earwig, spider, hover flies, etc.

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

3) Spotted pod borer:

Crops may be infested from early budding onwards.

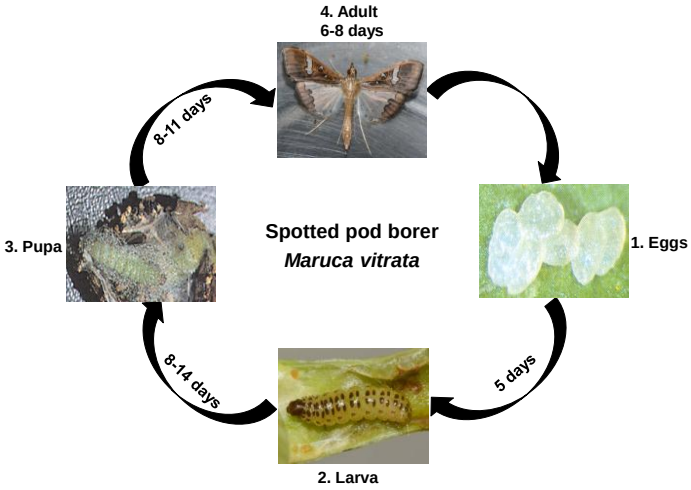
Biology:

Egg: Eggs of the pod borer are pale cream and flattened. The eggs are laid on or in the flowers (inserted between the petals).

Larva: Larvae are pale cream with two rows of distinctive paired black markings on their back. In the final instar, these markings are often very pale. Larvae can reach 18 mm in length. Young larvae feed inside flowers for 5-7 days before moving to the pods. After completing their development (10-15 days from egg hatch), larvae exit pods and pupate in the soil.

Adult: Moths have a 20-25 mm wingspan and a slender body. They have brown forewings with a white band extending two-thirds down the wing from the leading edge. Inside this band near the leading edge is a white spot. They live for an average of 6-10 days, each female can lay up to 200 eggs.

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 and pods
- Infested pods and flowers are webbed together.
- Seeds within damaged pods are totally or partially eaten out by the larvae.
- Entry holes also let in water, which stains the remaining non-eaten seeds.

Damage symptoms

http://thebeatsheet.com.au/wp-content/uploads/image/bean%20pod%20borer.jpg

Natural enemies of spotted pod borer:

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

Predators: Lacewing, ladybird beetle, spider, red ant, dragonfly, robber fly, reduviid bug, praying mantis, King crow, wasps, common mynah, *Geocoris* sp, earwig, ground beetle, pentatomid bug (*Eocanthecona furcellata*) etc.

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

4. Pod bugs: *Clavigralla* spp.

Damage is caused at flowering stage onwards to developing pods.

Biology:

Eggs: are laid on the pods or leaves in groups of 5-10. Females lay up to 437 eggs each over a period of 150 days. The mean incubation period varies 4 to 20 days depending on weather conditions.

Nymphs: develop into adults taking 10 to 30 days. There is considerable overlapping of generations and six generations often occur in a year.

Adults: The adults can live up to 150 days, the usual period being 1-2 months. Adults are brown (light to dark) in colour with typical protruding pronotal spines.

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

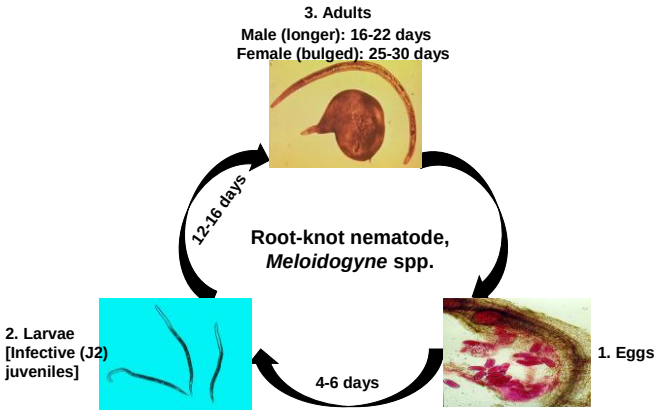
5. Root-knot nematode

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. They are microscopic in size.
- Development of the first stage larvae occurs within the egg where the first moult 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 4-8 weeks depending on temperature.
- Nematode development is generally most rapid within an optimal soil temperature range of 21-2680°F.

Life cycle:

Life stages are microscopic in size



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

Damage symptoms:

- Infections occur 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

1. **2.**

Damage symptom

1. http://utahpests.usu.edu/htm/utah-pests-news/up-summer12-newsletter/root-knot-nematodes/
2. http://extension.entm.purdue.edu/nematology/melonnems.html

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 inoculum

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

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

Natural enemies of Moth bean insect pests

Parasitoids

Egg parasitoids

1. *Trichogramma* spp.

2.*Tetrastichus* spp.

3. *Telenomus* spp.

Egg-larval parasitoid:

4. *Chelonus* spp.

Larval parasitoids

5. *Campoletis* sp

6. *Bracon* spp.

7. *Cotesia* (*Apanteles*) *ruficrus*

Larval-pupal parasitoid

8. *Carcelia* spp.

Nymphal and adult parasitoids

9. *Lysiphlebus* sp

10. *Diaeretiella* sp

11. *Aphidius colemani*

12. *Aphytis* spp.

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/Campoletis.htm
7. http://digiins.tari.gov.tw/tarie/collection013E.php?id=Taipei%2C+Taiwan
8. http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398
9.http://caribfruits.cirad.fr/production_fruitiere_integree/fiches_synthetiques/quelques_auxiliaires_du_verger
10. http://ponent.atspace.org/fauna/ins/fam/hymenoptera/ichneumonoidea_par.htm
11. http://www.goodbugs.org.au/Good%20bugs%20available/aphidius.html
12. http://californiaagriculture.ucanr.edu/landingpage.cfm?article=ca.v047n01p16&fulltext=yes

Predators:

1. Lacewing

2. Ladybird beetle

3. Spider

4. Red ant

5. Dragonfly

6. Robber fly

7. Reduviid bug

8. Praying mantis

9. Black drongo (King crow)

10. Nabid bug

11. Common mynah

12. Big-eyed bug (*Geocoris* sp)

13. Earwig

14. Ground beetle

15. Pentatomid bug

16. Carabid beetle (*Eocanthecona furcellata*)

17. Cantharid beetle

18. Mirid bug

19. Hover fly

20. Predatory mite

21. Predatory thrips

22. *Orius* spp. (Pirate/anthocorid bug)

4.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
5. http://en.wikipedia.org/wiki/Dragonfly
6. http://www.warpedphotosblog.com/robber-fly-and-prey
7.http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-of-predators,-parasites-and-pathogens/assassin-bugs
8. http://spirit-animals.com/praying-mantis/
9. http://nagpurbirds.org/blackdrongo/picture/1639
10. http://www.gwydir.demon.co.uk/insects/naboidea.htm
11. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
12. http://bugguide.net/node/view/598529
13. http://www.flickr.com/photos/johnhallmen/2901162091/
14.http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/ Ground%20Beetle%20-%20Pterostichus%20madidus.html
15. http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asopinae/ Eocanthecona.htm
16. http://tolweb.org/Carabidae/8895
17. http://www.kerbtier.de/cgi-bin/enFSearch.cgi?Fam=Cantharidae
18. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html
20. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
21. http://biocontrol.ucr.edu/hoddle/persea_mite.html
22. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg

VIII. DESCRIPTION OF DISEASES

1) *Fusarium* wilt:

Disease symptoms:

- The first symptom of the disease in the field is drooping of the plants followed by sudden death. The leaves may also turn yellow and drop off prematurely.
- Pod formation is severely affected. In collar regions of the wilted plants, necrosis and discolouration can be seen.
- The diseased plants can be pulled out easily than the healthy ones.
- When the diseased stem is cut, there is a dark brown, discoloured band around the vascular system. Infection occurs directly through the root hairs.
- The fungus survives for indefinite periods in the soil.

Survival and spread:

- This fungal disease may spread through infected plant debris and in seeds.

Favourable conditions:

- *Fusarium* wilt is more severe during hot, dry weather conditions and particularly when plants are under stress

Disease symptoms

http://www.forestryimages.org/browse/detail.cfm?imgnum=5365366

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

2) Charcoal rot or ashy stem blight:

Disease symptoms:

- The disease symptom starts as yellowing of lower leaves, followed by drooping and defoliation.
- The stem portion near the ground level shows dark brown lesions and bark at the collar region shows shredding.
- The sudden death of plants is seen in patches. In the grown-up plants, the stem portion near the soil level shows large number of black pycnidia.
- The stem portion can be easily pulled out leaving the rotten root portion in the soil.
- The infection when spreads to pods, they open prematurely and immature seeds shriveled and become black in colour.
- Minute pycnidia are also seen on the infected pods and seeds.
- The rotten root as well as stem tissues contains a large number of minute black sclerotia on the infected pods and seeds.

Disease symptom

https://www.pioneer.com/CMRoot/pioneer/US/images/agronomy/crop_focus/soybeans/diseases/charcoal_rot_soy_1b.jpg

Survival and spread:

- *M. phaseolina* survives as microsclerotia in the soil and on infected plant debris. The microsclerotia serve as the primary source of inoculum and have been found to persist within the soil up to three years.
- Seeds may also carry the fungus in the seed coat.

Favourable conditions:

- Germination of the microsclerotia occurs throughout the growing season when temperatures are between 28 ^{o}C and 35^{o}C.
- The rate of infection increases with higher soil temperatures and low soil moisture will further enhance disease severity.

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

3) Bacterial leaf spot and blight:

Disease symptoms:

- Halo blight occurs primarily when temperatures are cool.
- Light greenish-yellow circles that look like halos form around a brown spot or lesion on the plant. With age, the lesions may join together as the leaf turns yellow and slowly dies.
- Stem lesions appear as long, reddish spots. Leaves infected with common blight turn brown and drop quickly from the plant.

Disease symptom

http://s3.amazonaws.com/plantvillage/images/pics/000/001/530/large/Picture12.jpg?1379699590

Survival and spread:

- The bacterium survives in the infected plant debris and in seeds.
- The secondary spread is by rain water.

Favourable conditions:

- Rain and damp weather favor disease development.
- Blight occurs primarily when temperatures are cool and moist weather

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

4) Mung bean yellow mosaic virus

Disease symptoms:

- The leaves show sharply defined patches of unusual coloration.
- The causal agents of these symptoms may be nutrient imbalance

Survival and spread:

- Virus occurs worldwide in many agricultural crops, ornamentals and weeds. Many of these plants serve as reservoirs for season to season survival of the virus.
- The virus is transmitted by white fly

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

5) Cercospora leaf spot

Disease symptoms:

- On infected leaves (especially those more mature) look for brown or rust-coloured lesions that vary from circular to angular, are 2-10 mm, and may coalesce.
- Lesions may have a grey centre with a slightly reddish border.
- Conidia develop at the centre on short conidiophores.
- Severely affected leaves become chlorotic. Lesions may dry and portions may fall out, giving the leaf a shot-hole appearance.
- Lesions and blemishes may occur on branches, stems and pods.

Survival and spread:

- The fungus survives in the infected plant debris and in seeds.

Favourable conditions:

- Rain and damp weather favor disease development.
- Leaf spot occurs primarily when temperature are optimum and moist weather

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

IX. SAFETY MEASURES

A) At the time of the harvest

Moth bean may be harvested by hand and packed directly in the field for the fresh market and hauled to a packing shed for cleaning, packaging and cooling.

B) During post-harvest storage

Once harvested, field-packed boxes of Moth beans must be immediately transferred to shaded place away from direct sunlight. On arrival, Moth beans must be rapidly cooled, preferably by forced air pressure cooling, to approximately 45° F. At this temperature, human pathogens multiply slowly or not at all.

X. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The field should be kept exposed to sun light at least for 2-3 weeks.	Do not plant or irrigate the field after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Adopt crop rotation.	Avoid monocroping.
3.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
4	Sow early in the season	Avoid late sowing as this may lead to reduced yields and incidence of white grubs and diseases.
5	Always treat the seeds with approved biopesticides / chemicals for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with biopesticides/ chemicals.
6.	Sow in rows at optimum depths under proper moisture conditions for better establishment.	Do not sow seeds beyond 5-7 cm depth.
7.	Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
8.	Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition	Crops should not be exposed to moisture deficit stress at their critical growth stages.
9	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
10	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
11	Conduct AESA weekly in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.	Do not take any management decision without considering AESA and P: D ratio
12	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
13	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per field observation	Do not apply chemical pesticides within seven days of release of parasitoids.

14	Apply HaNPV or SINPV at recommended dose when a large number of egg masses and early instar larvae are noticed. Apply NPV only in the evening hours after 5 pm.	Do not apply NPV on late instar larva and during day time.
15	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. 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.
1. 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

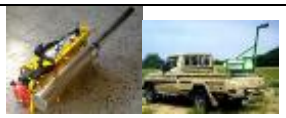
1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

XII. PESTICIDE APPLICATION TECHNIQUES

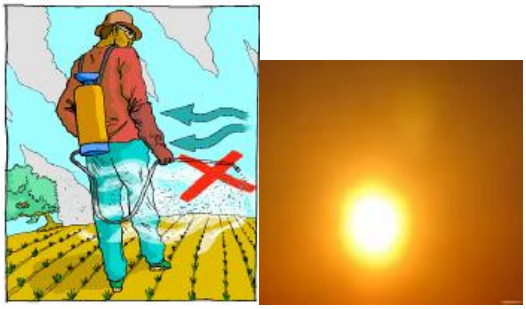
<table>
<tr><th></th><th></th><th>Equipment</th><th></th></tr>
<tr><td colspan="4">Category A: Stationary, crawling pest/ disease</td></tr>
<tr><td rowspan="2">Vegetative stage

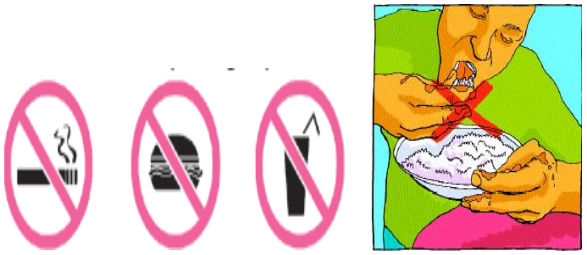
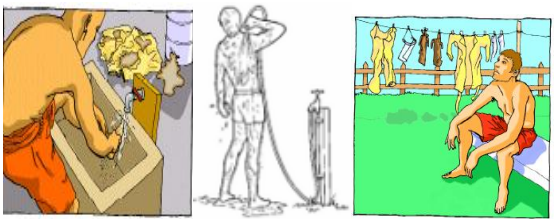
i) for crawling and soil borne pests

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

XII. 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.	

XIV. REFERENCES

- http://nhm.nic.in/Horticulture/IPM-Schedule-for-vegetables.pdf
- http://tnau.ac.in/eagri/eagri50/ENTO331/lecture22/peas/005.html
- http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=7499344
- http://www.ukbutterflies.co.uk/species.php?species=boeticus
- http://butterflycircle.blogspot.in/2009/09/life-history-of-pea-blue.html
- http://www.infonet-biovision.org/default/ct/181/crops
- http://www.infonet-biovision.org/default/ct/89/pests
- http://www.discoverlife.org/mp/20q?search=Aphis+craccivora
- http://www.infonet-biovision.org/default/ct/75/pests
- http://tnau.ac.in/eagri/eagri50/PATH272/lecture12/lec07.pdf
- http://www.cals.ncsu.edu/course/pp728/Macrophomina/macrophominia_phaseolinia.HTM
- http://tnau.ac.in/eagri/eagri50/PATH272/lecture15/002.html
- http://tnau.ac.in/eagri/eagri50/PATH371/lec15.pdf
- http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/bean-podborer
- http://advanceagripractice.in/cultivation-of-blackgram/
- http://www.agritech.tnau.ac.in/crop_protection/crop_prot_crop_insect_pul_red%20gram.html
- http://www.nbaii.res.in/insectpests/Adisura-atkinsoni.php
- http://www.lablablab.org/html/insects-management.html
- http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/bean-fly
- http://www7.inra.fr/hyppz/RAVAGEUR/6agrseg.htm
- http://extension.umd.edu/growit/insects/spider-mite
- Naidu, V.S.G.R. 2012, *Hand Book on Weed Identification* Directorate of Weed Science Research, Jabalpur, India Pp 354.
- APHU (2010). Package of practices of important Horticultural Crops. Venkataramannagudem, West Godavari District – 534 101 (A.P.).
- http://agritech.tnau.ac.in/agriculture/plant_nutri/
- http://plantsondeck.com/tag/bean-nutrient-deficiencies/
- http://pnwhandbooks.org/plantdisease/pathogen-articles/nonpathogenic-phenomena/plant-nutrition-diagnosis
- http://redgardens.org/index.php/2012/06/07/deficiencies-in-the-polytunnel/
- http://customers.hbci.com/~wenonah/min-def/beans.htm
- http://www.weedscience.org/images/weedid/287.jpg
- https://c1.staticflickr.com/7/6071/6098884754_6b3859dd92_z.jpg
- https://c2.staticflickr.com/6/5217/5521772545_86b34304b0_z.jpg
- http://www.plantsystematics.org/users/temp/Solanum1.jpg
- http://newfs.s3.amazonaws.com/taxon-images-1000s1000/Zygophyllaceae/tribulus-terrestris-ha-rold-b.jpg
- http://www.eflorakkl.in/FloraImages/Spermacoce%20hispida%20habit2.jpg
- http://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/images/Parthenium_hysterophorus_(Parthenium_Weed)/parthenium_hysterophorus86.jpg
- http://www.tropilab.com/tekeningen/euphorbiahirta-thum.gif
- http://upload.wikimedia.org/wikipedia/commons/4/4d/Agropyron_repens_(3738612411).jpg
- http://www.tropicalforages.info/key/Forages/Media/Html/images/Cynodon_dactylon/Cynodon_dactylon_05.jpg
- http://www.backyardnature.net/n/10/100808gg.jpg
- http://www.oisat.org/images/crowfootOIST.JPG
- http://threeissues.sdsu.edu/coquillofigurerotundus02b.jpg
- Package of Practices- Kharif, 2014. Rajasthan Agricultural University, Bikaner Zone Ic.
- Naidu, V.S.G.R. 2012, *Hand Book on Weed Identification.* Directorate of Weed Science Research, Jabalpur, India Pp 354.