AESA BASED IPM PACKAGE
RAJMAH

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

National Institute of
Plant Health Management
Rajendranagar, Hyderabad, Telangana

Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

Defenders

Pests

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

National Institute of
Plant Health Management
Rajendranagar, Hyderabad, Telangana

Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India
Important Natural Enemies of Rajmash Insect Pests

Parasitoids

- Trichogramma spp.
- Carcella spp.
- Telenomus spp.
- Bracon spp.
- Ichneumon spp.
- Campopleis spp.

Predators

- Robber fly
- Red ant
- Ladybird beetle
- Spider
- Praying mantis
- Black drongo

Plants Suitable for Ecological Engineering in Rajmash Field

- Alfalfa
- Sunflower
- Ocimum spp.
- Chrysanthemum spp.
- Spearmint
- Mustard
- Marigold
- Carrot
- French bean
- Cowpea
- Buckwheat
- Maize
The AESA based IPM – Rajmash was compiled by the NIPHM working group under the Chairmanship of Dr. Satyagopal Korlapati, IAS, DG, NIPHM, and guidance of Shri Utpal Kumar Singh, IAS, JS (PP). The package was developed taking into account the advice of experts listed below on various occasions before finalization.

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

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

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

Date: 6.3.2014

(Avinash K. Srivastava)
FOREWORD

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

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

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

(Utpal Kumar Singh)
PREFACE

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

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

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

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

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

(K. SATYAGOPAL)
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AESA BASED IPM PACKAGE FOR RAJMASH

Rajmash-Plant description:

Rajmash (*Phaseolus vulgaris* L.; Family: Fabaceae) also known as Kidney bean/french bean is one of the many varieties of common beans. It is an annual plant and is cultivated throughout the world for their edible beans. Kidney beans are red in colour and have a shape quite similar to that of a human kidney. The common bean is a highly variable species with a long history. Bush varieties form erect bushes 20–60 cm tall, while pole or running varieties form vines 2–3 m long. All varieties bear alternate, green or purple leaves, which are divided into three oval, smooth-edged leaflets, each 6–15 cm long and 3–11 cm wide. The white, pink, or purple flowers are about 1 cm long, and they give way to pods 8–20 cm long and 1–1.5 cm wide. These may be green, yellow, black, or purple in color, each containing 4–6 beans. The beans are smooth, plump, kidney-shaped, up to 1.5 cm long, range widely in color, and are often mottled in two or more colors.

I. PESTS

A. Pests of National Significance

1. **Insect pests**
   - 1.1 *Aphid: Aphis craccivora* Koch (Hemiptera: Aphididae)
   - 1.2 *Leaf miner: Melanagromyza trifolii* Burgess (Diptera: Agromyzidae)
   - 1.3 *Gram pod borer: Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae)

2. **Diseases**
   - 2.1 *Mosaic disease: Bean common mosaic virus (BCMV)*
   - 2.2 *Root rot: Rhizoctonia and Fusarium species*
   - 2.3 *Anthracnose: Colletotrichum lindemuthianum* Sacc. & Magnus
   - 2.4 *Watery soft rot/stem rot: Sclerotinia sclerotiorum* Lib. De Bary

3. **Weeds**
   - **Broadleaf**
     - 3.1 *False daisy: Eclipta alba* (L.) Hask. (Asteraceae)
     - 3.2 *Asthma herb: Euphorbia hirta* L. (Euphorbiaceae)
     - 3.3 *Scarlet pimpernel: Anagallis arvensis* L. (Primulaceae)
3.4 Sweet clover: *Melilotus indica* (L.) All. (Fabaceae)
3.5 Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)
3.6 Lambs quarters: *Chenopodium album* Linn. (Chenopodiaceae)

### Grasses
3.7 Rabbit/crow foot grass: *Dactyloctenium aegyptium* (L.) Willd (Poaceae)
3.8 Bermuda grass: *Cynodon dactylon* (L.) Pers. (Poaceae)
3.9 Barnyard grass: *Echinochloa crusgalli* (L.) Beauv. (Poaceae)

### Sedge
3.10 Purple nut sedge: *Cyperus rotundus* L. (Cyperaceae)

4. Nematode
4.1 Root-knot nematode: *Meloidogyne* spp.

5. Rodents
5.1 Lesser bandicoot: *Bandicota bengalensis* (Gray)
5.2 Soft furred field rat: *Millardia melitada* (Gray)
5.3 Field mouse: *Mus booduga* (Gray)

### B. Pest of Regional Significance
1. Insect pests
   1.1 Stem fly: *Ophiomyia phaseoli* Tryon (Diptera: Agromyzidae) (UP, Maharstra, Karnataka)
   1.2 Blister beetle: *Mylabris macilenta* Marseul (Coleoptera: Meloidae) (Himanchal Pradesh, MP)
   1.3 Flower beetle: *Popillia cyanea* Hope (Coleoptera: Scarabaeidae) (Himanchal Pradesh)

2. Diseases
   2.1 Rust: *Uromyces appendiculatus* Pers. (West Bengal, Orissa)
   2.2 Angular leaf spot: *Phaeoisariopsis griseola* (Sacc.) Ferr. (Himanchal Pradesh, UP, Sikkim, Meghalaya, Karnataka, Tamilnadu)

3. Weeds
   **Broadleaf**
   3.1 Pig weed: *Amaranthus viridis* L. (Amaranthaceae)
   3.2 Common purslane: *Portulaca oleracea* L. (Portulacaceae)
   3.3 False amaranth: *Digera arvensis* Forsk. (Amaranthaceae)
   3.4 Goat weed: *Ageratum conyzoides* L. (Asteraceae)

   **Grasses**
   3.5 Crab grass: *Digitaria sanguinalis* (L.) Scop (Poaceae)
   3.6 Canary grass: *Phalaris minor* Retz. (Poaceae)

### Sedges
3.7 Flat sedge: *Cyperus iria* L. (Cyperaceae)
3.8 Yellow sedge: *Cyperus esculentus* L. (Cyperaceae)

4. Nematode
4.1 Lesion nematode: *Pratylenchus* sp
II. AGRO-ECOSYSTEM ANALYSIS (AESA) BASED INTEGRATED PEST MANAGEMENT (IPM)

A. AESA:

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

Decision making in pest management requires a thorough analysis of the agro-ecosystem. Farmer has to learn how to observe the crop, how to analyze the field situation and how to make proper decisions for their crop management. This process is called the AESA. Participants of AESA will have to make a drawing on a large piece of 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 materials
- Treat the seeds/seedlings/planting materials with recommended pesticides especially biopesticides
- Follow proper spacing
- Soil health improvement (mulching and green manuring whenever applicable)
- Nutrient management especially organic manures and biofertilizers based on the soil test results. If the dose of nitrogenous fertilizers is too high the crop becomes too succulent and therefore susceptible to insects and diseases. If the dose is too low, the crop growth is retarded. So, the farmers should apply balanced dose of N 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 situations and Pest: Defender ratio (P: D ratio)
- Take direct action when needed (e.g. collect egg masses, remove infested plants etc.)
Plant compensation ability:
Compensation is defined as the replacement of plant biomass lost to herbivores and has been associated with increased photosynthetic rates and mobilization of stored resources from source organs to sinks (e.g., from roots and remaining leaves to new leaves) during active vegetative growth period. Plant tolerance to herbivory can arise from the interaction of a variety of plant traits and external environmental factors. Several studies have documented such compensation through increased growth and photosynthetic rate.

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 insects 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 rajmash insect pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens.

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 made based on 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

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 of field continue to change and new technologies become available, farmers need to continue improving their skills and knowledge.
- Farmers are capable of improving farming practices by experimentation
- Farmers can share their knowledge with other farmers

AESA methodology:
- Go to the field in groups (about 5 farmers per group). Walk across the field and choose 20 plants/acre randomly. Observe keenly each of these plants and record your observations:
  - Plant: Observe the plant health, crop stage, deficiency symptoms etc.
  - Insect pests: Observe and count insect pests at different places on the plant.
  - Defenders (natural enemies): Observe and count parasitoids and predators.
  - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
  - Rats: Count the number of plants affected by rats.
  - Weeds: Observe weeds in the field and their intensity.
  - Water: Observe the moisture level of the field.
  - Weather: Observe the weather conditions.
• 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 situations in detail and present their observations and analysis in a drawing (the AESA drawing).
• Each drawing will show a plant representing the field situation. The weather conditions, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
• Each group will discuss the situation and make a crop management recommendation.
• The small groups then join each other and a member of each group will now present their analysis in front of all participants.
• The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
• Formulate a common conclusion. The whole group should support the decision on what field management is required in the AESA plot.
• Make sure that the required activities (based on the decision) will be carried out.
• Keep the drawing for comparison purpose in the following weeks.

Data recording:
Farmers should record data in a notebook and drawing on a chart:
• Keep records of what has happened help us making an analysis and draw conclusions

Data to be recorded:
• Plant growth (weekly): Length of the plant, number of leaves
• Crop situation (e.g. for AESA): Plant health; pests, diseases, weeds; natural enemies; soil condition; irrigation; weather conditions
• Input costs: Seeds; fertilizer; pesticides; labour
• Harvest: Yield (Kg/acre); price of produce (Rs./Kg)

Some questions that can be used during the discussion:
• Summarize the present situation of the field.
• What crop management aspect is most important at this moment?
• Is there a big change in crop situation compared to last visit? What kind of change?
• Is there any serious pest or disease outbreak?
• What is the situation of the beneficial insects?
• Is there a balance in the field between pests and defenders?
• Were you able to identify all pests and diseases?
• Do you think the crop is healthy?
• What management practices are needed at this moment?
• When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.
• Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest buildup?
• What are the problems? How can we avoid it? How can we be prepared?
• Summarize the actions to be taken.
Advantages of AESA over ETL:
One of the problems of the ETL is that it is based on parameters that are changing all the time, and that are often not known. The damage or losses caused by a certain density of insects cannot be predicted at all. In ETL the due recognition of the role of natural enemies in decreasing pest population is ignored. Farmers cannot base their decisions on just a simple count of pests. They will have to consider many other aspects of the crop (crop ecology, growth stage, natural enemies, weather condition, etc.) and their own economic and social situation before they can make the right crop management decisions. In ETL based IPM, natural enemies, plant compensation ability and abiotic factors are not considered. In AESA based IPM emphasis is given to natural enemies, plant compensation ability, abiotic factors and P:D ratio.

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

Farmers can learn from AESA:
- Identification of pests and their nature of damage
- Identification of natural enemies
- Management of pests
- Water and nutrient management
- Influence of weather factors on pest buildup
- Role of natural enemies in pest management

FFS to teach AESA based IPM skills:

B. Field scouting:
AESA requires skill. So only the trained farmers can undertake their 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 at the main field should commence soon after crop establishment after transplanting 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:
Aphid: Count and record the number of both nymphs and adults on three randomly selected leaves (top, middle and bottom) per plant.
Leaf miner: Only the number of live mines on five randomly selected leaves per plant should be counted and recorded.

Helicoverpa: Count the number of young and grown up larvae on each plant and record.

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

C. Surveillance through pheromone trap catches:
Pheromone traps for Helicoverpa @ 4-5 traps/acre have to be installed. Traps for each species shall be separated by a distance of >75 feet in the vicinity of the selected field. Fix the traps to the supporting pole at a height of one foot above the plant canopy. Change of lures should be made at 2-3 week interval (regular interval). During each week of surveillance, the number of moths/trap should be counted and recorded. The trapped moths should be removed and destroyed after each recording.

D. Yellow pan water/sticky traps:
Set up yellow pan water/sticky traps 15 cm above the canopy for monitoring aphids and leaf miner @ 4-5 traps (15 X 7.5 cm)/acre. Locally available empty tins can be painted yellow and coated with grease/ Vaseline/castor oil on outer surface may also be used as yellow sticky trap. Count the number of aphids or leaf miner on the traps daily and take the appropriate decision regarding management practices.

E. Light trap:
Set up light traps @ 1 trap/acre 15 cm above the crop canopy for monitoring and mass trapping of nocturnal 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 200-300 g representative soil sample. Mix soil sample and pass through a coarse sieve to remove pieces of stones, 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 into first bucket; discard residue in second bucket.
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 rhizobia (PGPR)
- Application of *Trichoderma harzianum/viride* and *Pseudomonas fluorescens* for treatment of seeds/seedlings/planting materials in the field (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

**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

- Alfalfa
- Cowpea
- Carrot
- Sunflower
- Buckwheat
- French bean
- Mustard
- Cosmos
- Anise
- Caraway
- Dill
- *Chrysanthemum* sp.
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. RESISTANT/ TOLERANT VARIETIES*

1. PDR-14 (Uday): Tolerant to BSMV, red variegated seeds  
2. Utkarsh and Arun: Tolerant to BSMV, gulf red colour  
*For detailed and updated information nearest KVK, SAU / ICAR Institutes may be contacted*

## V. CROP STAGE-WISE IPM

<table>
<thead>
<tr>
<th>Management</th>
<th>Activity</th>
</tr>
</thead>
</table>
| **Pre-sowing*** | **Common cultural practices:**  
- Deep ploughing of fields during summer to control nematode population, to expose pupae; propagules of soil borne pathogens and to reduce the weeds infestation.  
- Soil solarization  
- Timely sowing should be done.  
- Field sanitation.  
- Destroy the alternate host plants  
- Growing pea or marigold as a trap crop for the management of leaf miner.  
- Plant tall border crops like mustard for the management of aphids.  
- Crop rotation with non leguminous crops especially cereals.  
- Adopt ecological engineering by growing the recommended attractant, repellent, and trap crops around the field bunds. |
| **Nutrients** | • Fertilizers should be applied on the basis of soil test values and recommendations for particular agro-ecological regions.  
• Apply 4-5 tons of FYM or vermicompost @1.5-2 t/acre at the time of last cultivation and incorporate in the soil 2 to 3 weeks before sowing.  
• Incubate *Trichoderma* spp. @ 500g in 100 Kg FYM for 15 days prior to its application in one acre field |
| **Weeds** | • At the time of field preparation, adopt stale seed bed technique i.e. pre sowing irrigation followed by shallow tillage to minimize the weeds menace in field. |
| **Root rot, stem rot, nematode** | • Application of FYM/neem or mahua cake @ 200 Kg/acre. |
| **Sowing*** | **Nutrients**  
• Seed treatment should be done with *Rhizobium* cultures @ 5-10 g/Kg seed.  
• French bean needs liberal N fertilization (40-45 Kg/acre) because of poor nodulation. The crop requires 25 Kg P₂O₅/acre. If K status in soil is marginal also apply 10-15 Kg K₂O/acre  
• In sulphur and zinc deficient areas, apply sulphur and zinc sulphate each @ 10 Kg/acre in soil at the time of sowing. |
| **Weeds** | • Always use certified and weed seed free seeds.  
• 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.  
• Intercropping with crops like maize in *kharif* and mustard in *rabi*. |
## Root rot, nematodes, stem fly**, anthracnose, BCMV

- For resistant / tolerant varieties consult ICAR Institute / KVK's / SAU's.

**Cultural control:**
- Select healthy and disease free seeds.
- The seeds should be thoroughly rinsed and dried in shade.
- Mulching with straw/pine needles/Eucalyptus leaves.
- Avoid dense sowing.
- Sowing in well drained soil.
- Follow optimum sowing depth of 5-7 cm.
- Intercropping with mustard where nematodes are the problem.

*Application of *Trichoderma harzianum/viride* and *Pseudomonas fluorescens* for treatment of seeds/seedlings/planting materials in the fields (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

### Vegetative stage

#### Common cultural practices:
- Provide irrigation at critical stages of the crop
- Avoid water stagnation conditions.

#### Common mechanical practices:
- Collection and destruction of eggs, and larvae
- Collect and destroy disease infected and insect infested plant parts
- Use yellow sticky traps for aphids and leaf miner @ 4-5 traps/acre.
- Use light trap @ 1/acre and operate between 6 pm and 10 pm
- Erecting of bird perches @ 20/acre for encouraging predatory birds such as King crow, common mynah etc.
- Set up bonfire during evening hours between 7-8 pm

#### Common biological practices:
- Conserve natural enemies through ecological engineering
- Augmentative release of natural enemies.
- Enhance parasitic activity by avoiding chemical spray, when larval parasitoids are observed

#### Nutrients
- Correct micronutrients deficiency if any in standing crop.

#### Weeds
- Rajmash suffers severe competition from weeds in initial stages. First 30-40 days after sowing is the critical period for crop- weed competition. Manual weeding at 20 & 40 days after sowing should be done for the management of weeds.

#### Aphid
- Follow common cultural, mechanical and biological practices (See page no. 13, 14).

**Cultural control:**
- Reflective mulches such as silver colored plastic can deter aphids from feeding on plants.
- Sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves

#### Leaf miner
- Follow common cultural, mechanical and biological practices (See page no. 13, 14).

### Mosaic
- For resistant / tolerant varieties consult ICAR Institute / KVK's / SAU's.

**Cultural control:**
- Control the vector by adopting common practices for the aphid.

**Mechanical control:**
- All the infected plants should be removed carefully from the field and destroyed.

### Angular leaf spot**, anthracnose and rust**
- For resistant / tolerant varieties consult ICAR Institute / KVK’s / SAU’s.

**Cultural control:**
- Balance use of manures and fertilizers.
- Mulching with pine needles or *Eucalyptus* leaves reduces the angular leaf spot.
**Flowering/Pod stage**

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Incorporate crop residues in soil immediately after harvest.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weeds</td>
<td>Remove left over weeds before shedding of seeds to prevent weed seed spread in the subsequent year.</td>
</tr>
</tbody>
</table>
| Gram pod borer | Follow common cultural, mechanical and biological practices (See page no. 13, 14).  
**Mechanical control:**  
- Install pheromone traps @ 4-5 traps/acre for monitoring adult moths activity (replace the lures with fresh lures after every 2-3 weeks)  
**Biological control:**  
- Inundative release of *Trichogramma pretiosum* @ 40,000/acre 4-5 times from flower initiation stage at weekly intervals.  
- Apply entomopathogenic nematodes (EPNs) *Steinernema feltiae* @ 1 billion infective juveniles/acre. |
| Stem fly**, blister beetle**, flower beetle** | Follow common cultural, mechanical and biological practices (See page no. 13, 14).  
- Collect the beetle and kill them. |
| Aphid, leaf miner | Same as in vegetative stage. |
| Angular leaf spot**, anthracnose and rust** | Same as in vegetative stage. |

**Post harvest**

| Seed borne fungi, rust**, white rot, anthracnose | Collect crop residue from the field after crop harvest and burn them.  
- Clean the seeds properly, remove broken or shriveled grains.  
- Dry the seeds properly and store in air tight seed bins. |

**Pests of regional significance.**

**VI. RODENT PEST MANAGEMENT**

- Disturb and destroy the habitat (burrows) of the rodents by practicing clean cultivation.
- Minimize the alternate food sources and secured habitation by removing the weeds and crop residues in/around the fields.
- Practice burrow smoking using paddy straw or other natural smoking materials in ANGRAU/NIPHM burrow fumigator for 2-3 minutes for each burrow.
- Encourage the establishment of natural predator like barn owls by establishing barn owl perches/wooden boxes in and around the crop fields.
- Practice burrow smoking as individual and community, preferably on a campaign approach.
- Organize community rodent control campaigns using rodenticide poison baits.
- Apply 2% Zinc phosphide poison baits (96 parts of broken rice + 2 parts of edible oil + 2 parts of 98% ZnP) when the rodent infestation is very high. Practice pre-baiting before apply ZNP poison baiting to avoid the bait shyness.
- Practice poison baiting with anticoagulant, bromadiolone @ 0.005% (96 parts of broken rice + 2 parts of edible oil + 2 Parts of 0.25% CB bromadiolone) on community approach.
VII. 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.
VIII. COMMON WEEDS

1. False daisy: *Eclipta alba* L. Hassk. (Asteraceae)
2. Asthma herb: *Euphorbia hirta* L. (Euphorbiaceae)
3. Scarlet/red pimpernel: *Anagallis arvensis* L. (Primulaceae)
4. Yellow sweet clover: *Melilotus indica* L. (Fabaceae)
5. Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)
6. Lambs quarter: *Chenopodium album* L. (Chenopodiaceae)
7. Rabbit/crow foot grass: *Dactyloctenium aegyptium* L. Willd. (Poaceae)
8. Bermuda grass: *Cynodon dactylon* (L) Pers (Poaceae)
10. Purple nut sedge: *Cyperus rotundus* L. (Cyperaceae)
11. Pig weed: *Amaranthus viridis* L. (Amaranthaceae)
12. Common purslane: *Portulaca oleracea* L. (Portulacaceae)
IX. DESCRIPTION OF INSECT AND NEMATODE PESTS

1) Leaf miner:

**Biology:**
- **Egg:** Eggs are minute in size and orange yellow in colour. The egg hatches in 4 days.
- **Maggot:** Apodous maggot feeds on chlorophyll mining in between epidermal layers. Full grown maggot measures 3 mm and duration is about 7 days.
- **Pupa:** Pupation takes place inside a thin loose mesh of silken cocoon either in soil or in leaves. Pupal period is about 7 days.
- **Adult:** It is a pale yellowish fly, measuring 1.5 mm in length. The female fly punctures upper surface of leaf to lay eggs singly. Total life cycle is completed in 3 weeks. Warm weather conditions are favourable for multiplication.

**Life cycle:**

1. Egg
2. Larva
3. Pupa
4. Adult

**Damage symptoms:**
- Leaves with serpentine mines
- Dropping and drying of leaves in severe cases

---

Natural enemies of leaf miner:
Parasitoids: Gronotoma micromorpha, Diglyphus sp, Halticoptera circulus, Opius sp, Chrysocharis sp, Neochrysocharis formosa etc.
Predator: Lacewings etc.
*For management refer to page numbers 14,15.

2) Gram pod borer:

Biology: It is a polyphagous pest, infesting gram, lablab, safflower, chillies, groundnut, tobacco, cotton etc.
Egg: Oval, sculptured, yellowish eggs are laid singly on tender plant parts and buds. The egg period lasts for 2-4 days.
Larva: Caterpillars are of varying colour, initially brown and later turn greenish with darker broken lines along the side of the body. Body covered with radiating hairs. When full grown, they measure 3.7 to 5 cm in length. The larval period lasts for 18-25 days.
Pupa: Pupation takes place inside the soil in an earthen cell. Pupal stage lasts for 7-15 days.
Adult: Moth is stout, medium sized with brownish/greyish forewings with a dark cross band near outer margin and dark spots near costal margins, with a wing span of 3.7cm.

Life cycle:

4. Adult
7-10 days

3. Pupa
18-25 days

2. Larva
3-4 days

1. Eggs
7-10 days

Damage symptoms:

• Early instar larvae scrap the chlorophyll of the leaves
• Mature larvae head bore inside the pods and the rest of the body remain hanging out.
• Pods with irregular big holes

Natural enemies of gram pod borer:
Parasitoids: Trichogramma spp., Tetrastichus spp., Chelonus spp., Telenomus spp., Bracon spp., Ichneumon spp., Carcelia spp., Campoletis spp. etc.
Predators: Lacewing, ladybird beetle, spider, red ant, dragonfly, robber fly, reduviid bug, praying mantis, black drongo (King crow), wasp, common mynah, big-eyed bug (Geocoris sp), earwig, ground beetle, pentatomid bug (Eocanthecona furcellata) etc.
*For management refer to page number 15.

3) Aphid:

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

**Aphid, Aphis crassivora**

- **Nymphs**: 1-2 days
- **Eggs**: 3-5 days
- **Adults**: 5-10 days

**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.
- Rajmash contaminated with honeydew and/or sooty moulds are not marketable.
- Aphids are also vectors of diseases, including the common bean mosaic virus.
- The black bean aphid is a widely distributed pest of beans. The black legume aphid usually attacks beans grown at low altitudes.

**Natural enemies of aphid:**
**Parasitoids:** Aphidius colemani, Aphelinus sp etc.
**Predators:** Red ant, robber flies, big-eyed bug (Geocoris sp), earwig, ground beetle, cecidomyiid fly, dragonfly, preying mantid, lacewing, ladybird beetle, spider, syrphid fly etc.

*For management refer to page numbers 14, 15.

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**4) Stem fly:**

**Biology:**
**Egg:** The stem fly inserts eggs on the underside of young leaves. Ovipositing sites show pale pinprick spots when infested leaves are held against the light.
**Maggot:** Whitish, torpedo-shaped maggots measure about 2 mm and they pupate after 8-11 days inside the stem. Before pupation, the maggot makes an exit hole for the emergence of the adult.
**Pupa:** Pupae are smooth, light brown to pale brown, cylindrical in shape with rounded ends. Pupal stage lasts for 6–12 days.
**Adult:** Adult flies are shiny black and about 2 mm long with a pair of clear wings with a wingspan of 4-5 mm.

**Life cycle:**

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

**Natural enemies of stem fly:**
**Parasitoid:** Tiny wasps etc.

*For management refer to page numbers 14, 15.

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.
- Development of the first stage larva occurs within the egg where the first moult occurs. Second stage larvae hatch from eggs and infest 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 ranging from 39-45 °C.

**Life cycle:**

- **Eggs**
- **Larvae** [Infective (J2) juveniles]
- **Adults**
  - Male (longer): 16-22 days
  - Female (bulged): 25-30 days

**Damage symptoms:**
- Infested plants appear 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 infested plants the root system is reduced and the rootlets are almost completely absent hampering 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 infestation predisposes plants to fungal and bacterial root pathogens.

**Survival and spread:**
- **Primary:** Egg masses in infested plant debris and soil or collateral and other hosts like Solanaceous, Malvaceous and Leguminaceous plants act as sources of inoculum.
- **Secondary:** Autonomous second stage juveniles that may also be water dispersed.
- **Favourable conditions:** Loamy light soils.

*For management refer to page numbers 13, 14.

**Natural Enemies of Rajmash Insect Pests**

**Parasitoids**

- **Egg parasitoids**
  - 1. *Trichogramma* spp.

- **Egg - larval parasitoid**
  - 4. *Chelonus* spp.
Larval parasitoids

5. *Bracon* spp.


7. *Carcelia* spp.

8. *Campoletis* spp.


10. Tiny wasps

Nymphal/larval and adult parasitoids


12. *Aphidius* spp.

13. *Diglyphus isaea*


15. *Gronotoma micromorpha*

Predators

1. Lacewing
2. Ladybird beetle
3. Spider
4. Red ant

5. Robber fly
6. Reduviid bug
7. Preying mantis
8. Mirid bug

9. Hover fly
10. Black drongo
11. Common mynah
12. Big-eyed bug

13. Earwig
14. Ground beetle
15. Pentatomid bug
16. Oligota spp.

17. Orius spp.
X. DESCRIPTION OF DISEASES

1) Anthracnose:

Disease symptoms:
- Symptoms of anthracnose can appear on any plant part. Pale brown sunken spots may appear on the cotyledons of infected seedlings. Spots may spread to the hypocotyle, which if girdled, kill the seedlings. Lesions on leaves are dark brown.
- They are restricted to the veins on lower leaf surface. On stems, lesions are elongated and sunken.
- On the pods, the fungus produces black, sunken lesions. These lesions penetrate deep into the pods and may cause shrivelling of the young pods.
- Infected seed become discoloured changing to yellow through brown to black. In damp weather, the centres of anthracnose lesions become covered with a pink spore mass.

Survival and spread:
- The disease is seed-borne and pathogen can also survive in soil. Secondary disease cycles continue until the weather remains favorable.

Favourable condition:
- Frequent showers, heavy dews, temperatures of 20-30°C, and overcrowding of plants favor the spread and development of anthracnose.

Disease symptoms

1. 2. 3.


*For management refer to page number 14.

2) Rust:

Disease symptoms:
- Rust-colored pustules form on the lower leaf surfaces.
- Severely infected leaves turn yellow, wilt, and then drop off of the plant.
- Stems and pods may also be infected. It affects most types of beans under humid conditions.

Survival and spread:
- The fungus survives mainly in alternate host.

Favourable conditions:
- Rust progresses most rapidly in susceptible hybrids or varieties when the temperature is near 27°C with high humidity and frequent dews.

Disease symptoms

1. 2.

1,2: http://www.extension.umn.edu/garden/yard-garden/vegetables/anthracanose-and-rust-of-garden-beans/

*For management refer to page number 14.
### 3) Root rot:

**Disease symptoms:**
- Many fungi, including *Rhizoctonia solani*, *Pythium* spp., *Fusarium solani*, *Macrophomina phaseolina*, survive in the soil and infect young seedlings or the seeds of bean plants.
- Seedlings fail to emerge after planting when the seeds rot in the soil or young seedlings may be stunted.
- Plants are usually affected slightly above or below the soil line with a watery soft rot. Leaves turn yellow and roots get rotten.

**Survival and spread:**
- Causal organisms survive in soil and seed as resting mycelia or sclerotia for long period. These organisms often survive as saprophytes, living on dead plant material, or as dormant mycelia or spores. Root exudates from germinating seedlings or growing roots stimulate the dormant fungi to become active.

**Favourable conditions:**
- Diseases are prevalent under cool wet conditions that keep the soil temperatures below 13°C.
- *Rhizoctonia* root rot is most damaging when cool, wet conditions in the spring are followed by hot (25 -29°C), dry conditions.

![Fusarium root rot](image1)

![Pythium root rot](image2)

*For management refer to page numbers 13, 14.

### 4) Bean common mosaic disease (BCMV):

**Disease symptoms:**
- Symptoms of bean common mosaic virus (BCMV) are cupping and twisting of leaves with a light and dark green mosaic pattern.
- The dark green tissue is often bubbled and/or in bands next to the veins. Affected plants produce smaller, curled pods with a greasy appearance resulting in poor yields.

**Transmission and favourable conditions:**
- The virus is seed borne and can also be transmitted by several aphid species.

![symptoms1](image3)

![symptoms3](image4)

*For management refer to page number 14.*
5) Watery soft rot/stem rot:

**Disease symptoms:**
- Small, soft, watery spots that are caused by the fungus *Sclerotinia sclerotiorum* occur on the stems, leaves and pods of beans.
- These spots enlarge rapidly under cool, moist conditions and girdle the stem.
- Infected areas of pods become soft, watery and covered by a white fungal growth.

**Survival and spread:**
- The fungus is soil-borne and infects lower parts of bean plants first. The most important survival mechanism of *S. sclerotiorum* is the formation of sclerotia. Infection is initially localized and spread rapidly in low lying moist and cool areas under furrow irrigation.
- Favourable conditions:
  - Wet and cold weather conditions towards the end of growing season are conducive to white mould epidemics.

![Image of disease symptoms](1,2,3: https://www.apsnet.org/edcenter/intropp/lessons/fungi/ascomycetes/Pages/WhiteMold.aspx; http://www.ext.colostate.edu/pubs/crops/02918.html)

*For management refer to page number 13.

6) Angular leaf spot:

**Disease symptoms:**
- Symptoms consist of small dark brown spots with angular edges and are often numerous to give the foliage a checkerboard appearance.
- The spots may increase in size, join together, and cause yellowing and necrosis of the affected leaves. This may lead to premature defoliation.

**Survival and spread:**
- The disease is seed-borne and the pathogens survives inside the seeds.

**Favourable conditions:**
- The disease is favoured by high moisture and moderate temperatures (20-25°C).

![Image of disease symptoms](Photo Courtesy: TNAU)

*For management refer to page number 14.*)
### Disease cycles:

1. **Anthracnose:**
   - [Diagram of Anthracnose]

2. **Rust:**
   - [Diagram of Rust]

3. **Root rot disease:**
   - [Diagram of Root Rot]

4. **Watery soft rot:**
   - [Diagram of Watery Soft Rot]

### XI. DESCRIPTION OF RODENT PESTS

#### 1) **Lesser bandicoot:**
- Distributed throughout India and infests almost all crops.
- Robust rodent (200 to 300 g body weight) with a rounded head and a broad muzzle. Dorsum covered with grey-brownish rough hairs. Tail is naked, shorter than head and body.
- Breeds throughout the season and litter size 6-8 in normal conditions.
- Nocturnal and fossorial. Burrows are characterized by the presence of scooped soil at the entrance and mostly burrow openings are closed with soil.

*For management refer to page number 15.

#### 2) **Soft furred field rat:**
- It is distributed in Punjab, Uttar Pradesh southwards to western and southern India, also distributed in foothills of eastern Himalayas.
- It occurs in regions where moderate soil moisture is available to the vegetation all the year round.
- Small rodent weigh 40-60g with soft fur, dorsum light grey and bicolored tail equal to the head and body.
- Inhabits irrigated fields, found mostly in semi arid areas.

*For management refer to page number 15.
XII. SAFETY MEASURES

A. At the time of harvest:
   During harvesting, proper care should be taken.
   • Harvesting should be done timely. Timely harvesting ensures optimum seed quality and consumer acceptance.
   • Dry beans should be harvested when most of the pods are fully mature and have turned color. To minimize shattering, harvesters should not shake the vines.
   • 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 Rajmash, results in shattering of pods and other losses caused by the pests.
   • Avoid harvesting during adverse weather conditions i.e. rains and overcast weather.
   • The best time to harvest the crop, when large 80 percent of the pods are fully matured. Right kind of harvest equipment (sickle) should be used. Avoid pest infestation prior to harvesting.
   • Rogue out the admixtures prior to harvesting, it helps in fetching good price in the market.
   • After cutting, if the weather permits, leave the harvested plant to dry in the field.

B. During post-harvest storage:
   To avoid post-harvest losses, following preventive measures should be considered:
   • The post-harvest losses of Rajmash can be minimized in the process of threshing, winnowing, storage, processing, handling and transportation.
     (i) Threshing and Winnowing: The loss at threshing yard is 0.5 per cent. 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 may be incurred to the extent of 0.5% necessitating quick transportation to reduce the losses.
     (iii) Storage: Due to improper and inefficient methods of storage, the loss upto 7.5 percent is estimated during storage. Quantitative losses result from spoilage due to infestation by insects, rodents or birds. Therefore, improved storage facilities should be adopted to reduce the losses.
   • Adopt suitable grading procedure for getting remunerative prices inter-alia to avoid financial loss.
   • Use good packaging materials for storage as well as for transport i.e. B-T will Jute bags or HDPE bags. Use pest control measures during storage. Avoid use of hooks by labour during handling.

3) Field mouse:
   • Distributed throughout India.
   • Present in crop fields especially irrigated fields
   • It is a tiny mouse weighing about 10g with slender, short, naked and bicolor tail
   • Nocturnal and fossorial. Breeds throughout the year and reproductive activity correlate with the availability of food in nature
   • Individually it is a minor pest but, accumulated loss will be more.
   *For management refer to page number 15.

Damage symptoms (pod formation and maturation stage):
   Rodent problem is found in early and mature pod stage. The seeds are more palatable. Rodent cause severe damage at this stage and hoard the mature pods inside the burrow.
### XIII. DO’S AND DON’TS IN IPM

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Do’s</th>
<th>Don’ts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>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</td>
<td>Do not plant or irrigate the field after ploughing, at least for 2-3 weeks, to allow desiccation of bulbs and/or rhizomes of perennial weeds.</td>
</tr>
<tr>
<td>2.</td>
<td>Adopt crop rotation</td>
<td>Avoid monocropping.</td>
</tr>
<tr>
<td>3.</td>
<td>Adopt inter-cropping of recommended crops.</td>
<td>Do not disturb the plant roots by adopting ploughing away from the pits.</td>
</tr>
<tr>
<td>4.</td>
<td>Grow only recommended varieties.</td>
<td>Do not grow susceptible varieties.</td>
</tr>
<tr>
<td>5.</td>
<td>Always treat the seeds with approved chemicals/bio products for the control of seed borne diseases/pests</td>
<td>Do not use seeds without seed treatment with biopesticide/chemicals.</td>
</tr>
<tr>
<td>6.</td>
<td>Plant in rows at optimum depths under proper moisture conditions for better establishment.</td>
<td>Do not plant seedlings beyond 5-7 cm depth.</td>
</tr>
<tr>
<td>7.</td>
<td>Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.</td>
<td>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.</td>
</tr>
<tr>
<td>8.</td>
<td>Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition</td>
<td>Crops should not be exposed to moisture deficit stress at their critical growth stages.</td>
</tr>
<tr>
<td>9.</td>
<td>Use NPK fertilizers as per the soil test recommendation.</td>
<td>Avoid imbalanced use of fertilizers.</td>
</tr>
<tr>
<td>10.</td>
<td>Use micronutrient mixture after sowing based on soil test recommendations.</td>
<td>Do not apply any micronutrient mixture after sowing without soil test recommendations.</td>
</tr>
<tr>
<td>11.</td>
<td>Conduct weekly AESA in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.</td>
<td>Do not take any management decision without considering AESA and P: D ratio.</td>
</tr>
<tr>
<td>12.</td>
<td>Install pheromone traps at appropriate period.</td>
<td>Do not store the pheromone lures at normal room temperature (keep them in refrigerator).</td>
</tr>
<tr>
<td>13.</td>
<td>Release parasitoids only after noticing adult moth catches in the pheromone trap or as per field observation</td>
<td>Do not apply chemical pesticides within seven days of release of parasitoids.</td>
</tr>
<tr>
<td>14.</td>
<td>Apply HaNPV at recommended dose when a large number of egg masses and early instar larvae of <em>H. armigera</em> are noticed. Apply NPV only in the evening hours after 5 pm.</td>
<td>Do not apply NPV on late instar larva and during day time.</td>
</tr>
<tr>
<td>15.</td>
<td>In case of pests which are active during night, spray recommended biopesticides/chemicals at the time of their appearance in the evening.</td>
<td>Do not spray pesticides at midday since, most of the insects are not active during this period.</td>
</tr>
<tr>
<td>16.</td>
<td>Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for aphids, and other sucking pests harbouring the lower side of leaves.</td>
<td>Do not spray pesticides only on the upper surface of leaves.</td>
</tr>
<tr>
<td>17.</td>
<td>Apply short persistent pesticides to avoid pesticide residue in the soil and produce.</td>
<td>Do not apply pesticides during preceding 7 days before harvest.</td>
</tr>
<tr>
<td>18.</td>
<td>Follow the recommended procedure of trap crop technology.</td>
<td>Do not apply long persistent pesticides on trap crop, otherwise it may not attract the pests and natural enemies.</td>
</tr>
</tbody>
</table>
XIV. BASIC PRECAUTIONS IN PESTICIDE USAGE

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

B. Storage
1. Avoid storage of pesticides in house premises.
2. Keep only in original container with intact seal.
3. Do not transfer pesticides to other containers; Do not store expose to sunlight or rain water; Do not 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; Do not apply against the windy direction
3. Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer
4. Wash the sprayer and buckets etc with soap water after spraying
5. Containers buckets etc used for mixing pesticides should not be used for domestic purpose
6. Avoid entry of animals and workers in the field immediately after spraying
7. Avoid tank mixing of different pesticides

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

### Equipments

<table>
<thead>
<tr>
<th>Category A: Stationary, crawling pests/diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vegetative stage</strong></td>
</tr>
<tr>
<td>i) For crawling and soil borne pests</td>
</tr>
<tr>
<td>Insecticides and fungicides</td>
</tr>
<tr>
<td>• Lever operated knapsack sprayer (droplets of big size)</td>
</tr>
<tr>
<td>• Hollow cone nozzle @ 35 to 40 psi</td>
</tr>
<tr>
<td>• Lever operating speed = 15 to 20 strokes/min or</td>
</tr>
<tr>
<td>• Motorized knapsack sprayer or mist blower (droplets of small size)</td>
</tr>
<tr>
<td>• Airblast nozzle</td>
</tr>
<tr>
<td>• Operating speed: 2/3rd throttle</td>
</tr>
<tr>
<td>ii) For small sucking leaf borne pests</td>
</tr>
</tbody>
</table>

| Reproductive stage Insecticides and fungicides |
| • Lever operated knapsack sprayer (droplets of big size) |
| • Hollow cone nozzle @ 35 to 40 psi             |
| • Lever operating speed = 15 to 20 strokes/min |

<table>
<thead>
<tr>
<th>Category B: Field flying pests/airborne pests</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vegetative stage</strong></td>
</tr>
<tr>
<td>Insecticides and fungicides</td>
</tr>
<tr>
<td>• Motorized knapsack sprayer or mist blower (droplets of small size)</td>
</tr>
<tr>
<td>• Airblast nozzle</td>
</tr>
<tr>
<td>• Operating speed: 2/3rd throttle Or</td>
</tr>
<tr>
<td>• Battery operated low volume sprayer (droplets of small size)</td>
</tr>
<tr>
<td>• Spinning disc nozzle</td>
</tr>
</tbody>
</table>

| Reproductive stage (Field Pests) Insecticides and fungicides |
| • Fogging machine and ENV (exhaust nozzle vehicle) (droplets of very small size) |
| • Hot tube nozzle                                      |

<table>
<thead>
<tr>
<th>Category C: Weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Post-emergence application</strong> Weedicide</td>
</tr>
<tr>
<td>• Lever operated knapsack sprayer (droplets of big size)</td>
</tr>
<tr>
<td>• Flat fan or floodjet nozzle @ 15 to 20 psi</td>
</tr>
<tr>
<td>• Lever operating speed = 7 to 10 strokes/min</td>
</tr>
</tbody>
</table>

| Pre-emergence application Weedicide |
| • Trolley mounted low volume sprayer (droplets of small size) |
| • Battery operated low volume sprayer (droplets of small size) |
# XVI. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

1. For application rate and dosage see the label and leaflet of the particular pesticide.

2. It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.

3. Clean and wash the machines and nozzles and store in dry place after use.

4. It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides. Do not apply pesticides without protective clothing and wash clothes immediately after spray application.

5. Do not apply in hot or windy conditions.

6. Operator should maintain normal walking speed while undertaking application.

7. Do not smoke, chew or eat while undertaking the spraying operation.

8. Operator should take proper bath with soap after completing spraying.

9. Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.
XVII. REFERENCES

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Important Natural Enemies of Rajmash Insect Pests

Parasitoids

- Trichogramma spp.
- Carcelia spp.
- Telenomus spp.
- Bracon spp.
- Ichneumon spp.
- Campoletis spp.

Predators

- Robber fly
- Red ant
- Ladybird beetle
- Spider
- Praying mantis
- Black drongo

Plants Suitable for Ecological Engineering in Rajmash Field

- Alfalfa
- Sunflower
- Ocimum spp.
- Chrysanthemum spp.
- Spearmint
- Mustard
- Marigold
- Carrot
- French bean
- Cowpea
- Buckwheat
- Maize
AESA BASED IPM PACKAGE
RAJMASH

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Ministry of Agriculture
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