AESA BASED IPM PACKAGE
LABLAB BEAN

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

National Institute of Plant Health Management
Rajendranagar, Hyderabad, Telangana state

Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

The AESA based IPM - Lablab bean (*Lablab purpureus*), 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.

NIPHM Working Group:

Chairman : Dr. Satyagopal Korlapati, IAS, Director General
Vice-Chairmen : Dr. S. N. Sushil, Plant Protection Advisor
: Dr. P. Jeyakumar, Director (PHM)
Core Members :

1. Er. G. Shankar, Joint Director (PHE), Pesticide Application Techniques Expertise.
2. Dr. O. P. Sharma, Joint Director (A and AM), Agronomy Expertise.
3. Dr. Satish Kumar Sain, Assistant Director (PHM), Pathology Expertise.
4. Dr. Dhana Raj Boina, Assistant Director (PHM), Entomology Expertise.
5. Mrs. N. Lavanya, Scientific Officer (BP and BC), Entomology Expertise.

Other Members :

1. Dr. B. S. Sunanda, Assistant Scientific Officer (PHM), Nematology Expertise.

Contributions by DPPQ and S Experts:

1. Shri. Ram Asre, Additional Plant Protection Advisor (IPM),
2. Dr. K. S. Kapoor, Deputy Director (Entomology),
3. Shri. R. Murali, Deputy Director (Entomology)
4. Dr. Sanjay Arya, Deputy Director (Plant Pathology),
5. Dr. Subhash Kumar, Deputy Director (Weed Science)
6. Dr. C. S. Patni, Plant Protection Officer (Plant Pathology)

Contributions by External Experts:

1. Dr. H. P. Patnik, Prof & Head (Entomology), College of Agriculture, Odisha Univ. of Agriculture and Technology, Bhubaneshwar-751003, Orissa.
2. Dr. K.C. Sahu, Prof & Head (Pathology), College of Agriculture, Odisha Univ. of Agriculture and Technology, Bhubaneshwar-751003, Orissa.
3. Dr. S. N. Mohapatra Prof & Head (Nematology), College of Agriculture, Odisha Univ. of Agriculture and Technology, Bhubaneshwar-751003, Orissa.
4. Dr. B. R. Patel, Prof & Head (Entomology), C.P. College of Agriculture, S.D. Agriculture University, Sardarkrushinagar-385506
5. Dr. SurajitKhalko, Assistant prof (Pathology)Uttar Banga Krishi Vishwavidyalaya, Cooch Behar, West Bengal
6. Dr. Nripendra Laskar, Assistant prof (Entomology)Uttar Banga Krishi Vishwavidyalaya, Cooch Behar, West Bengal
7. Dr. Ayon Roy, Associate prof (Pathology)Uttar Banga Krishi Vishwavidyalaya, Cooch Behar, West Bengal
8. Dr. Tapan Kumar Hath, Prof (Entomology)Uttar Banga Krishi Vishwavidyalaya, Cooch Behar, West Bengal
9. Dr. M. L. Kewat, Prof (Agronomy), Jawarlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P)
10. Dr. Nayak, Prof (Agronomy), Jawarlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P)

11. Dr. R. Pachori, Prof (Entomology),Jawarlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P)
12. Dr. S.B. Das, Prof (Entomology),Jawarlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P)
13. Dr. Om Gupta, Prof (Pathology), Jawarlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P)
14. Dr. Jayant Bhatt, Prof (Pathology), Jawarlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P)
15. Dr. A.K. Rawat, Prof (Soil science), Jawarlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P)
16. Dr. H.K. RaI, Prof (Soil science), Jawarlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P)
17. Dr. H.S. Yadava, Director of Research services, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior – 474002, M.P.
18. Dr. Sujoy Saha , Senior Scientist (Plant Pathology), Indian Institute Vegetable Research, Varanasi, Uttar Pradesh-221305.
19. Dr. Jaydeep Halder, Scientist (Entomology), Indian Institute Vegetable Research, Varanasi, Uttar Pradesh-221305.
20. Dr. A. B. Rai, Head and Principal Scientist (Crop Protection), Indian Institute Vegetable Research, Varanasi, Uttar Pradesh-221305.

For internal circulation only. Not for sale.

अपर सचिव
भारत सरकार
कृषि मंत्रालय
(कृषि एंव सहकारिता विभाग)
कृषि भवन, नई दिल्ली-110001

सत्यमेव जयते

Avinash K Srivastava
Additional Secretary
Government of India
Ministry of Agriculture
(Department of Agriculture
& Cooperation)
Krishi Bhawan, New Delhi - 110001

FOREWORD

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

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

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

A K Srivastava

Date: 6.3.2014

(Avinash K. Srivastava)

संयुक्त सचिव
भारत सरकार
कृषि मंत्रालय
(कृषि एवं सहकारिता विभाग)
कृषि भवन, नई दिल्ली- 110001

सत्यमेव जयते

Joint Secretary
Government of India
Ministry of Agriculture
(Department of Agriculture & Cooperatio
Krishi Bhawan, New Delhi-110001

FOREWORD

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

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

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

(Utpal Kumar Singh)

Dr.K. SATYAGOPAL IAS
Director General
Telephone : +91-40- 24015346,
E-mail : dgniphm@nic.in
Tele-Fax : +91-40- 24015346,

National Institute of Plant Health Management
Department of Agriculture & Cooperation
Ministry of Agriculture
Government of India

Rajendranagar,
Hyderabad- 500030.
http://niphm.gov.in

PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

CONTENTS

AESA BASED IPM FOR LABLAB BEAN

Lablab bean - Plant description:

Lab lab bean *(Lablab purpureu*s (L) Family: Fabaceae) is a species of bean. It is native to Africa and it is cultivated throughout the tropics for food. It is also called hyacinth bean, dolichos bean, seim bean, lablab bean, Egyptian kidney bean, Indian bean, chicharo and Australian pea. It is the only species in the monotypic genus Lablab.

The plant is variable due to extensive breeding in cultivation, but in general, they are annual or short-lived perennial vines. The wild species is perennial. The thick stems can reach six meters in length. The leaves are made up of three pointed leaflets each up to 15 cm long. They may be hairy on the undersides. The inflorescence is made up of racemes of many flowers. Some cultivars have white flowers, and others may have purplish or blue. The fruit is a legume pod variable in shape, size, and color. It is usually several centimeters long and bright purple to pale green. It contains up to four seeds. The seeds are white, brown, red, or black depending on the cultivar, sometimes with a white hilum. Wild plants have mottled seeds. The seed is about a centimeter long.

I. PESTS

1. Insect and mite Pests

1.1 Bean Aphids: *Aphis craccivora* Koch (Hemiptera: Aphididae)
1.2 Jassids: *Empoasca fabae* Harris (Hemiptera: Cicadellidae)
1.3 Whitefly*: Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae)
1.4 Red spider mite: *Tetrancychus cinnabarinus* Dufour (Trombidiformes: Tetranychidae)
1.5 Hairy caterpillar: *Spilosoma obliqua* Walker (Lepidoptera: Arctiidae)
1.6 Stem fly: *Ophiomyia phaseolina* Tryon (Diptera: Agromyzidae)
1.7 Pod borers: *Helicoverpa armigera* Hübner (Lepidoptera: Noctuidae), *Maruca vitrata* Geyer (Lepidoptera: Pyralidae)
1.8 Pod bugs: *Riptortus pedestris* Fabricius*, Clavigralla gibbosa* Spinola (Hemiptera: Coreidae) and *Nezara viridula* Linnaeus (Hemiptera: Pentatomidae)

2. Diseases

2.1 Anthracnose : *Colletotrichum lindemuthianum* (Sacc. and Magnus) Briosi and Cavara
2.2 Ashy stem blight: *Macrophomina phaseolina* (Tassi) Goid
2.3 Powdery mildew: *Erysiphe polygoni* DC
2.4 Rust: *Uromyces fabae* (Pers.) J. Schröt.)

2.5 Mosaic virus

2.6 Bacterial leaf spot: *Xanthomonas campestris* pv. *phaseoli* (Pammel) Dowson

3. Weeds

3.1 Grasses

3.1.1 Crow foot grass: *Dactyloctenium aegyptium* L. Willd (Poaceae)

3.1.2 Burmuda Grass: *Cynodon dactylon* (L) Pers (Poaceae)

3.1.3 Barnyard grass: *Echinochloa crusgalli* L. Beauv.(Poaceae)

3.1.4 Hairy crabgrass: *Digitaria sanguinalis* (L.) Scop. (Poaceae)

3.2 Broad leaf

3.2.1 False daisy: *Eclipta alba* L. Hassk. (Asteraceae)

3.2.2 Asthma herb: *Euphorbia hirta* L. (Euphorbiaceae)

3.2.3 Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)

3.2.4 Slender Amaranth/Green Amaranth*: Amaranthus viridis* L (Amaranthaceae)

3.2.5 Lamb's Quarters: *Chenopodium album* L (Amaranthaceae)

3.2.6 sweet clover: *Meliolotus indica* L (Fabaceae)

3.2.7 Scarlet/red pimpernel : *Anagallis arvensis* L (Primulaceae)

3.3 Sedges

3.3.1 Purple nut sedge: *Cyperus rotundus* L (Cyperaceae)

4. Nematode

4.1 Root knot Nematode: *Meloidogyne incognita* Göldi (Tylenchida: Meloidogynidae)

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

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

Farmers should

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

Plant Compensation ability

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

Understand and conserve defenders

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

Insect zoo

In field various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in crop field. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial and harmful insects. In this method, unfamiliar/unknown predators are collected in plastic containers with brush from the field and brought to a place for study. Each predator is placed inside a plastic bottle together with parts of the plant and some known insect pests. Insects in the bottle are observed for certain time and determined whether the test insect is a pest (feeds on plant) or a predator (feeds on other insects).

Pest: Defender ratio (P: D ratio):
Identifying the number of pests and beneficial insects helps the farmers to make appropriate pest management decisions. Sweep net, visual counts etc. can be adopted to arrive at the numbers of pests and defenders. The Pest: Defender ratio (P: D ratio) ratio can vary depending on the feeding potential of natural enemy as well as the type of pest. The natural enemies of Lablab bean 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 and the severity :
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 pesticides and insect growth regulators (IGRs), botanicals etc. can be relied upon before resorting to synthetic chemical pesticides.

Decision making

Farmers become experts in crop management

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

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

AESA methodology

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

    - Plant: Observe the plant height, number of branches, crop stage, deficiency symptoms etc.
    - Insect pests: Observe and count pests at different places on the plant.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves, stems and roots identify any visible disease symptoms and severity.
    - Weeds: Observe weeds in the field and their intensity.
    - Water: Observe the water situation of the field.
    - Weather: Observe the weather condition.

- While walking in the field, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyse 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

- Keep records of what has happened
- Help us making an analysis and draw conclusions

Data to be recorded

- **Check the plant growth (weekly):** 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 build up?
- 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.

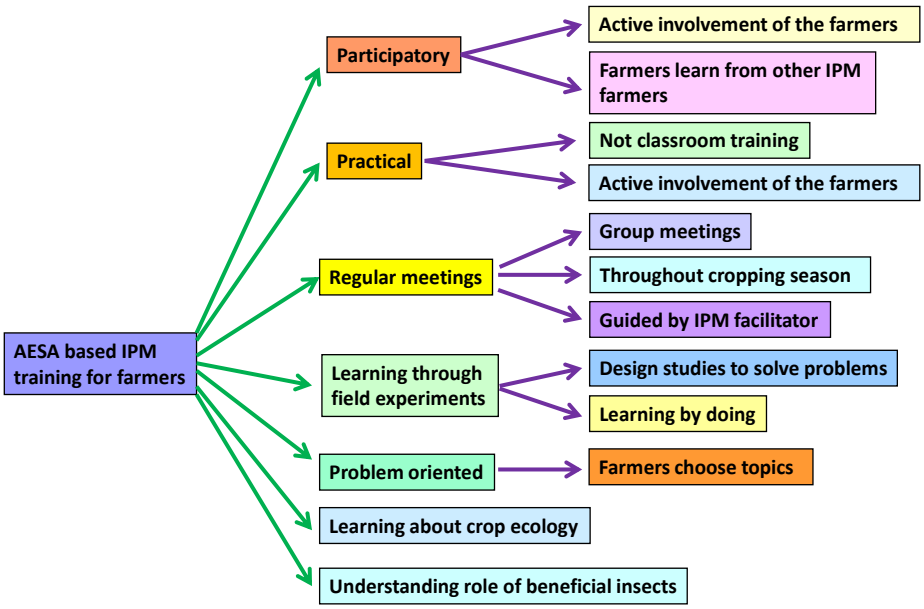
AESA and farmer field school (FFS)

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 build up
- 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 in the field should commence soon after crop establishment and at weekly intervals thereafter. In each field, 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 and mite pests:

Aphids, jassids, whiteflies and red spider mites: Count and record the number of both nymphs and adults on five randomly selected leaves per plant.

***Helicoverpa and Maruca*:** Total number of fruits, damaged fruits due to *Helicoverpa* and *Maruca* and number of larvae on individual plants should be counted and recorded.

For diseases:
Whenever scouting, be aware that symptoms of plant disease may be caused by any biotic factor such as fungal, bacterial, viral pathogens or abiotic factors such as weather, nutrient deficiencies, and 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 like spots, rots,

blights, wilts and irregular growth. 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 and 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, and pod of plants for symptoms and signs of fungal or bacterial diseases. The stem, flower, and pod should be split or taken apart and examined for discoloration caused by fungi and bacteria. Count the number of stems, flowers and capsules infected due to disease and percent disease incidence should be recorded.

C. Surveillance through pheromone traps: Pheromone traps for insects viz., *Helicoverpa armigera* @ 4/acre have to be installed. Install the traps for each species separated by a distance of >75 feet in the vicinity of the selected fixed field. Fix the traps to the supporting pole at a height of one foot above the plant canopy. Change of lures should be made once a month. During each week of surveillance, the number of moths/trap should be counted and entered.
Procedure for observation: Total number of moths of *Helicoverpa armigera*/ trap/week should be recorded year round. The trapped moths should be destroyed and removed after each recording.

D. Yellow pan water trap/sticky traps

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

E. Light traps

Set up light traps @ 1 trap/acre 15 cm 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).

Ecological Engineering for Pest Management – Below Ground:

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

- Crop rotations with non- leguminous plants which enhance nitrogen content.
- Keep soils covered year-round with living vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance below ground biodiversity 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 seed/seedling/planting materials in the nurseries and field application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

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, *Chrysoperla,* earwigs, etc.

Plants suitable for Ecological Engineering for Pest Management

Attractant plants

Cowpea

Carrot

Sunflower

Buckwheat

French bean

Alfaalfa

Mustard

Cosmos

Anise

Caraway

Dill

Parsley

White Clover

Tansy

Yarrow

Marigold

Repellent plants

***Ocimum* sp**

Peppermint/Spearmint

Barrier plant

Rye grass

Border plants

Maize

Sorghum

Crop rotation plants

***Sesbania* sp.**

***Crotalaria* sp.**

***Gaillardia* sp.**

Castor

Desmodium

Potato

Trap plants

Tomato

Marigold

Pearl millets

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

Pest	Tolerant/ Resistant Variety
Resistant to anthracnose	Kapasi, JNP-4 and Katargam

***For detailed information and further updates nearest KVK, SAU, state departments / ICAR Institute may be contacted**

V. CROP STAGE WISE IPM

Management	Activity
Pre-sowing*	
	Common cultural practices: • Deep summer ploughing and solarization of soil • Timely sowing should be done. • Field sanitation, rogueing • Destroy the alternate host plants • Apply manures and fertilizers as per soil test recommendations • Use resistant varieties • Use disease-free certified seeds • Crop rotation with non-leguminous crops especially cereals. • Avoid dense sowing • Soil amendment with farm yard manure @ 5 tonnes/acre
Nutrients	• Before sowing, circular pits of 0.5 m cube are dug during summer. • Apply well decomposed FYM @ 10-15 Kg per pit treated with *Trichoderma* at the time of field preparation.
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.
Stem blight, Nematode, Pod borer	**Cultural control:** • Follow optimum sowing depth of 5-7 cm. • Intercropping with mustard and American marigold where nematodes are a problem • Besides this American marigold also act as trap crop for *Helicoverpa armigera*. • Application of FYM/Neem cake or Mahua cake @ 200 Kg/acre. **Chemical control:** • Spray chlorpyrifos 20% EC@ 1200ml diluted in 200-400 l of water/acre.(Pod borer)

Sowing/ seedling*	
	<u>Common cultural practices:</u> • Timely and line sowing should be done • Use healthy, certified and weed free seeds. • Sow with proper spacing
Nutrient	• Seed treatment should be done with *Rhizobium* cultures @ 250 g/acre. • At the time of sowing apply phosphatic fertilizers @ 30 g per pit. • In sulphur and zinc deficient areas, apply sulphur and zinc sulphates as per soil test recommendation in soil at the time of sowing. • Grow sorghum or bajra as intercrop.
Weed management	• Line sowing should be done to facilitate inter-culture operations. • Plant population should be maintained by gap filling to achieve the optimum plant population and minimize the competition from weed.
Nematodes	**<u>Cultural control:</u>** • Mulching with straw/pine needles/eucalyptus leaves.
Bean mosaic virus	**<u>Mechanical control:</u>** • Rougeing of BMV infected plants.
Note: Apply *Trichoderma viride/harzianum* and *Pseudomonas fluorescens* for treatment of seed/seedling/planting materials in the nurseries and field application (if commercial products are used, check for label claim and date of expiry. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).	
Vegetative stage	
	<u>Common cultural practices:</u> • Provide irrigation at critical stages of the crop • Avoid water stress and water stagnation conditions. • Enhance parasitic activity by avoiding chemical spray, when larval parasitoids are observed **<u>Common mechanical practices:</u>** • Collection and destruction of eggs, and larvae • Collect and destroy diseased infected and insect infested plant parts • Use yellow sticky traps for aphids @ 4-5 traps/acre. • Use light trap @ 1/acre and operate between 6 pm and 10 pm • Install pheromone traps @ 4-5/acre for monitoring adult moths activity (replace the lures with fresh lures after every 2-3 weeks) • Erecting of bird perches @ 20/acre for encouraging predatory birds such as King crow, common mynah etc. • Set up bonfire during evening hours at 7-8 pm **<u>Common biological practices:</u>** • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies

Nutrient	• Correct micronutrient deficiency if any in standing crop
Weed	• Beans suffer severe competition from weeds in initial stages. First 20-30 days after planting is the critical period for crop weed competition. Hand tool weeding at 25 days after sowing is beneficial.
Bean aphid	**Cultural control:** • Regular field monitoring and use sweep net in the morning hours for monitoring of pest and defender population, barrier crops like mustard crop around the field. • Attractant plants like sunflower are helpful for attraction of predator. • Plant tall border crops like maize, sorghum or millet to reduce pest population. **Mechanical control:** • Set up yellow sticky traps @4-5 traps/acre • Pruning of affected plant parts • Use of reflective mulches • Spray with a strong jet of water to knock aphids from leaves. **Biological control:** • Conserve predators such as ladybird beetles viz., *Cocciniella septumpunctata*, *Menochilus sexmaculata, Hippodamia variegata , Brumus suturalis* and *Cheilomones vicina* etc. Adult beetle feed @10 to15 adults/day. • Conserve predators such as syrphid flies i.e., *Sphaerophoria* spp., *Eristallis* spp., *Metasyrphis* spp., *Xanthogramma* spp and *Syrphus* spp. etc. • Conserve predators such as lacewing, *Chrysoperla zastrowii* sillemi etc. • Spraying of *Lecanicillium* (*Verticilium*) *lecanii* @ 5 g/litre of water • Spray insecticidal soaps or oils such as neem or canola oil
Red spider mite	**Cultural control:** • Frequent irrigation during summer season reduces the mite infestation • Apart from aforesaid practices, regular monitoring is also mandatory for mites. **Biological control:** • Conserve predators such as *Chrysoperla zastrowii sillemi*, anthocorid bug, predatory mite (*Amblyseius fallacis*), coccinellid (*Stethorus punctum*) etc
Mosaic virus	**Cultural practices:** • All the infected plants should be removed carefully and destroyed.
Bacterial leaf spot	**Cultural control:** • Avoid irrigation at flowering stage when the probability of symptom appearance is maximum

Powdery Mildew	**Cultural control:** • See the common cultural practices as in vegetative stage **Chemical control:** • Spray benomyl 50 % WP @ 80gm diluted in 240 l of water/acre. Or • Spray carbendazim 50%WP @ 140gm diluted in 300 l of water/acre. Or • Spray sulphur 40% WP @ 2.26-3 kg diluted in 300-400 l of water/acre. Or • Spray sulphur 85% DP @ 6-8 kg /acre.
Ashy stem blight	**Cultural control:** • See the common cultural practices as in vegetative stage
Anthracnose and Rust	**Cultural control:** • Balanced use of FYM and fertilizers. • Planting in well drained soil. **Mechanical control:** • Mulching with pine needles or eucalyptus leaves reduces the angular leaf spot. **Chemical control:** • Spray benomyl 50 % WP @ 80gm diluted in 240 l of water/acre (Anthracnose) • Spray lime Sulphur 22% SC @ 1% 0.8-2 l /acre (Rust)
Flowering stage	
Nutrients	• Top dress plants with 100 g of Di-ammonium phosphate (DAP) in each pit at the time of flowering, mixed well in soil and then irrigate. • Incorporate healthy crop residues in soil immediately after harvest.
Weeds	• Remove left over weeds before shedding of seeds to prevent their spread.
Bean Aphid	• As mentioned in the vegetative stage
Jassid	• As mentioned in the vegetative stage
Pod borers	**Cultural control:** • Growing intercrops such as onion, maize, coriander in 1:2 ratio, Guard crop sorghum or maize in 4 rows all around main crop • Rotate the crop with a non-host cereal crop, cucurbit, or cruciferous vegetable. **Mechanical control:** • Use of ovipositional trap crops such as marigold for *Helicoverpa*. • Pheromone trap @ 4-5 traps/ acre for *Helicoverpa* • Erecting of bird perches @ 20/acre **Biological control:** • Grow repellant plant(s): Basil

	• Attractant plants: Carrot family, Sunflower family, Buck wheat, hairy vetch, alfalfa, corn, shrubs (Minute pirate bug and Lace wing) • Nectar rich plants with small flowers i.e anise, caraway, dill, parsley, mustard, Sun flower, hairy vetch, buck wheat and cowpea (*Braconid* wasp) • Release of egg parasitoid, *Trichogramma chilonis*
Anthracnose	As mentioned above in the vegetative stage
Mosaic virus	As mentioned above in the vegetative stage
Powdery mildew	As mentioned above in the vegetative stage
Fruiting stage	
Anthracnose	As mentioned above in the vegetative stage
Mosaic virus	As mentioned above in the vegetative stage

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

VI. 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 labelled 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. False daisy: *Eclipta alba* L. Hassk. (Asteraceae)

3 **Asthma herb*: Euphorbia hirta* L. (Euphorbiaceae)**

4 Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)

5 Slender Amaranth/Green Amaranth: *Amaranthus viridis* L (Amaranthaceae)

6 Lamb's Quarters: *Chenopodium album* L (Amaranthaceae)

7 Sweet clover: *Meliolotus indica* L (Fabaceae)

8 Scarlet/red pimpernel : *Anagallis arvensis* L (Primulaceae)

9 Crow foot grass: *Dactyloctenium aegyptium* L. Willd (Poaceae)

10 Burmuda Grass: *Cynodon dactylon* (L) Pers (Poaceae)

11 Barnyard grass: *Echinochloa crusgalli* L. Beauv.(Poaceae)

12 Hairy crabgrass: *Digitaria sanguinalis* (L.) Scop. (Poaceae)

13 Purple nut sedge: *Cyperus rotundus* L (Cyperaceae)

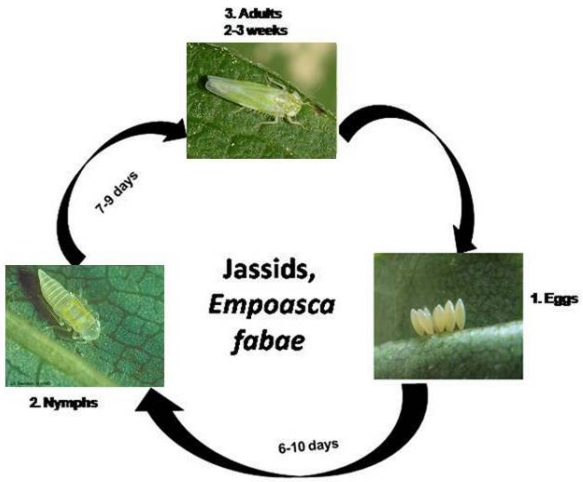
VIII. DESCRIPTION OF INSECT AND MITE PESTS

1.Jassid:

Biology:

- **Egg:** Female inserts eggs into leaf veins on the underside. Eggs hatch in 6-10 days
- **Nymph:** Nymphs are pale greenish almost translucent and walk diagonally. Nymphal period is 6-10 days.
- **Adult:** Adults are greenish yellow, wedge shaped with a pair of black spots on vertex and a black spot on each of the forewings. Adult stages last for 35-50 days depending upon weather conditions. There are a total of 7-8 generations in a year.

Life cycle:



1.http://zaraimedia.com/wp-content/uploads/2013/08/jassid5.jpg
2.http://i184.photobucket.com/albums/x97/EZscience/leafhopper_nymph_l3.jpg
3.http://bugguide.net/images/raw/90FQ903QG0YQRQNRZQYRU0H0QQFRSQQ050CQG0JQJKVRG0YQM0OQYK3QU0DR3KDQRQURHQTQJKTQ.jpg

Damage symptoms:

- The infected leaves show pale yellow coloration.
- In case of heavy infestation, the leaves curl .
- The leaf edges turn light pinkish brown.
- Stunted growth of plant, cupped and crinkled leaves, burnt appearance of leaf margins are symptoms of damage.

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

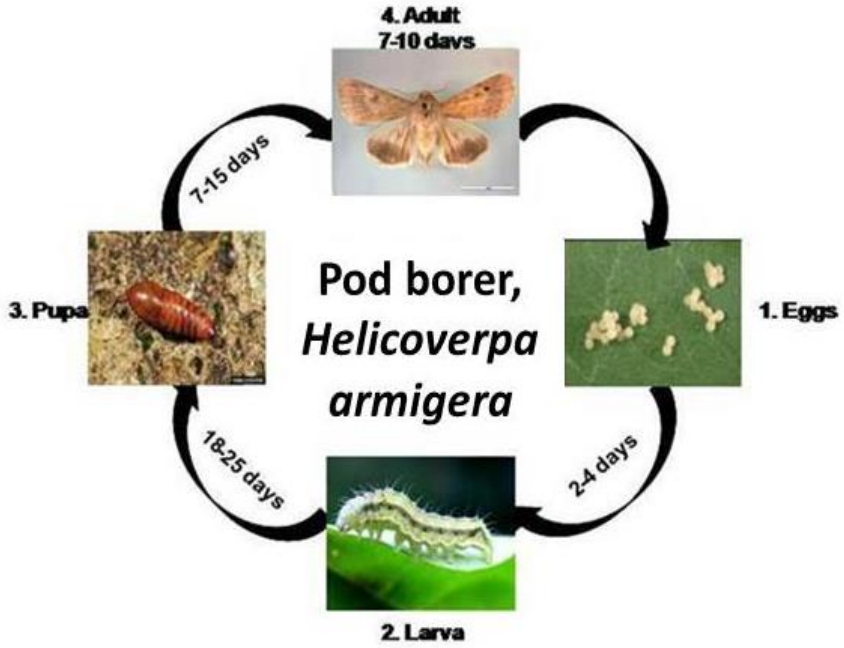
2. Pod borer:

It is a polyphagous and polymorphous pest infesting, pea, lablab, safflower, sunflower, chillies, pulses, groundnut, tobacco, cotton etc.

Biology:

- **Egg:** The spherical, yellowish eggs are laid singly on tender parts and buds of plants. The egg period lasts for 2-5 days.
- **Larva:** Caterpillars vary in colour, initially brown and later turn greenish with darker broken lines along the side of the body. The larval period lasts for 18-25 days. Body covered with radiating hairs. When full grown, they measure 3.7 to 5 cm in length. The full grown caterpillar pupates in the soil in an earthen cell and emerges in 16-21 days.
- **Pupa:** Pupation takes place inside the soil. Pupal stage lasts 7-15 days.
- **Adult:** Moth is stout, medium sized with brownish/greyish forewings with a dark cross band near outer margin and dark spots near costal margins, with a wing expanse of 3.7cm.

Life cycle:



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

Damage symptoms:

- Young larva feeds on flower and flower buds and then attacks pods. Internal tissues are eaten severely and completely hollowed out. While feeding the caterpillar typically thrust its head inside leaving the rest of the body outside.
- Infested pods can be easily be identified by bores with round holes.

Damage symptom

http://www.lablablab.org/images/flashImages/insects-management.jpg

Natural enemies of pod borer:

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

Ichneumon spp, *Carcelia* spp,*Campoletis* spp, *Senometopia illota*

Predators: Lacewing, lady beetle, spider, fire ant**,** dragon fly, robber fly, reduviid bug, preying mantid**,** black drongo, wasp, common mynah

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

3. Pod borer:

It is a serious pest of leguminous vegetables viz., cowpea, red gram, mung bean, urd bean, lablab, French bean etc.

Biology:

- **Egg:** The eggs of are laid either singly or in small batches on flowers, flower buds, tender pods. The eggs hatch in 3- 7 days depending up on weather conditions.
- **Larva**: Neonate larvae initially may be found in-group on flowers, later they disperse moving from one flower to another so that each larva damages number of flowers, flower buds. They also feed on the young pods and thereby making them unfit for human consumption. The larval stage lasts for 13-17 days.
- **Pupa:** There is a brief pre-pupal for 1-2 days and the pupal stage takes about 6-7 days.
- **Adult:** Moth in medium sized with brownish-black wings. Fore wings have a conspicuous transverse white elongate marking.

Damage symptoms:

- During flowering stage, it feeds on the flower buds and flowers and causing premature flower dropping.
- At later stage they feed on the seeds of the tender pods resulting in economic loss. The damaged pod has a large emergence hole made by the pupating larva.

Natural enemies of pod borer:

Parasitoids: *Trichogramma* spp, *Bracon pectoralis* and *Phanerotoma planifrons* are the parasitoids.

Predators: Lacewing, lady beetle, spider, fire ant**,** dragon fly, robber fly, reduviid bug, preying mantid**,** black drongo, wasp, common mynah

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

4.Bean aphids:

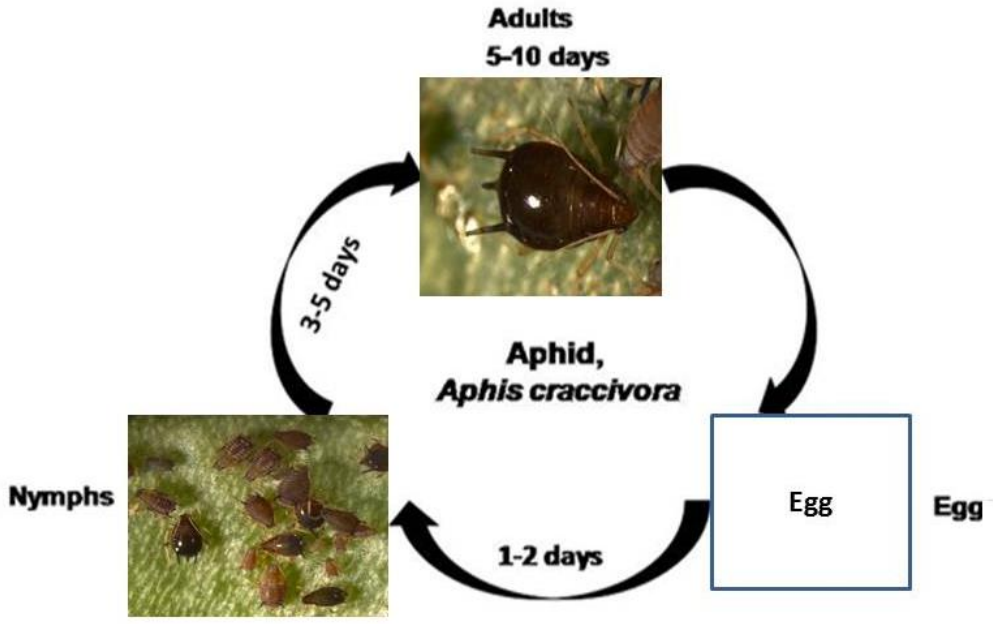
Biology:

- **Nymph**: Aphids are mostly viviparous and reproduce thorough parthenogenesis. There are four nymphal stages (instars). The general appearance of each stage is similar except for increase in size during subsequent instars. The first, second, third and fourth

nymphal stages generally last for 1-2, 2, 2 and 3 days respectfully.

- **Adult**: Aphids are small, soft-bodied, pear-shaped insects that have a pair of cornicles (wax-secreting tubes) projecting out from the fifth or sixth abdominal segment. Wingless (apterous) female aphids are black or blackish brown with a white waxy bloom covering the body. The aphid attacks generally during 2nd and 3rd week of December and continues till March.

Life cycle:



2.http://simonleather.files.wordpress.com/2013/09/aphis-craccivora.jpg
3.http://www.nbaii.res.in/Aphids/images/Aphiscraccivora/Aphis-craccivora.jpg

Damage symptoms:

- Both nymph and adults suck the sap from leaves, buds, flowers and pods.
- Curling may occur for infested leaves and at advanced stage plants may wither and die.
- Plants remain stunted and sooty molds grow on the honey dew excreted by these insects.

Damage symptom

http://www.infonet-biovision.org/res/res/files/1832.280x185.clip.jpeg
http://tnau.ac.in/eagri/eagri50/ENTO331/lecture05/001.html

Natural enemies of bean aphids:

Parasitoids: *Diaeretiella rapae, Aphelinus abdominalis* etc.

Predators: Lacewing, lady bird beetle, hover fly etc**.**

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

5.Red spider mite:

Biology:

The red spider mite normally completes its life-cycle from egg to adult in about a week. All stages of this mite are present throughput the year. Reproduction is most favorable when the weather is hot and dry.

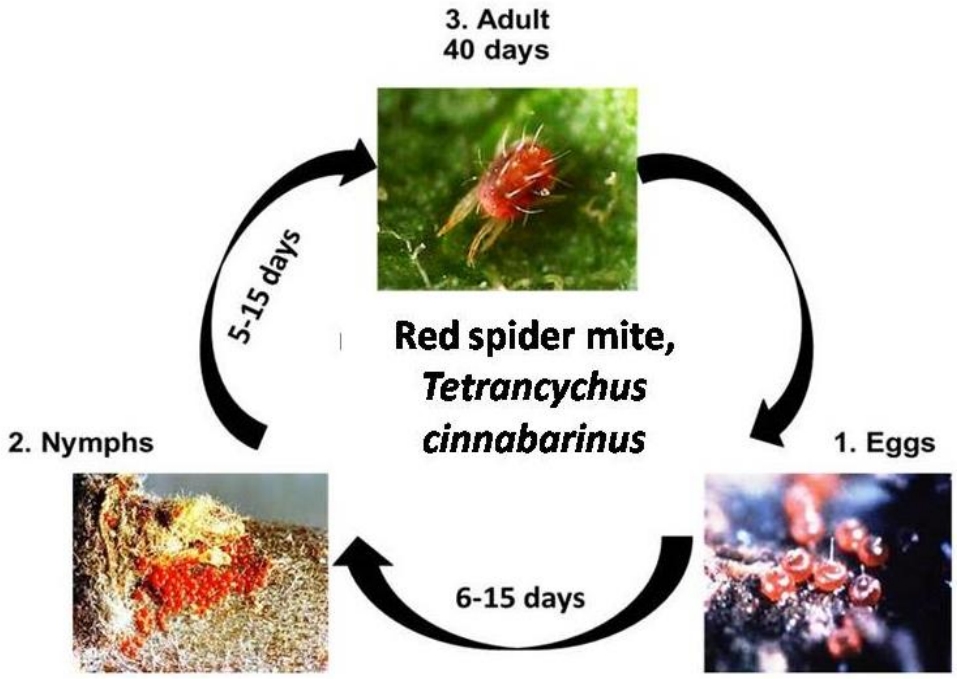
Egg: Eggs are spherical, shiny, straw colored, and hatch in 3 days. They are only about 1/254 inch in diameter. They are laid singly on the underside of the leaf surface or attached to the silken webs spun by the adults.

Larva: Larvae are slightly larger than the egg, pinkish, and have three pairs of legs. This stage lasts a short time, perhaps a day.

Nymph: There are two nymphal stages, the protonymph and deutonymph. The nymphal stage differs from the larval stage by being slightly larger, reddish or greenish, and having 4 pairs of legs. This nymphal stage lasts about 4 days.

Adult: Adult females are about 1/50 inch long, reddish, and more or less elliptical. The males are slightly smaller and wedge shaped. They have a black spot on either side of their relatively colorless bodies. The adult female may live for up to 24 days and lay 200 eggs.

Life cycle:



1.http://archive.agric.wa.gov.au/PC_94923.html?s=1001
2.http://pnwhandbooks.org/insect/tree-fruit/apple/apple-spider-mite

3.http://www.agf.gov.bc.ca/cropprot/grapeipm/spidermites.htm

Damage symptoms:

- Red spider mite feeds on leaves.
- Severe mite injury produces browning and loss of colour in the leaves i.e. yellowing, bronzing and curling of leaves.

Natural enemies of red spider mite:

Predators: Coccinellid, lace wing, predatory mite

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

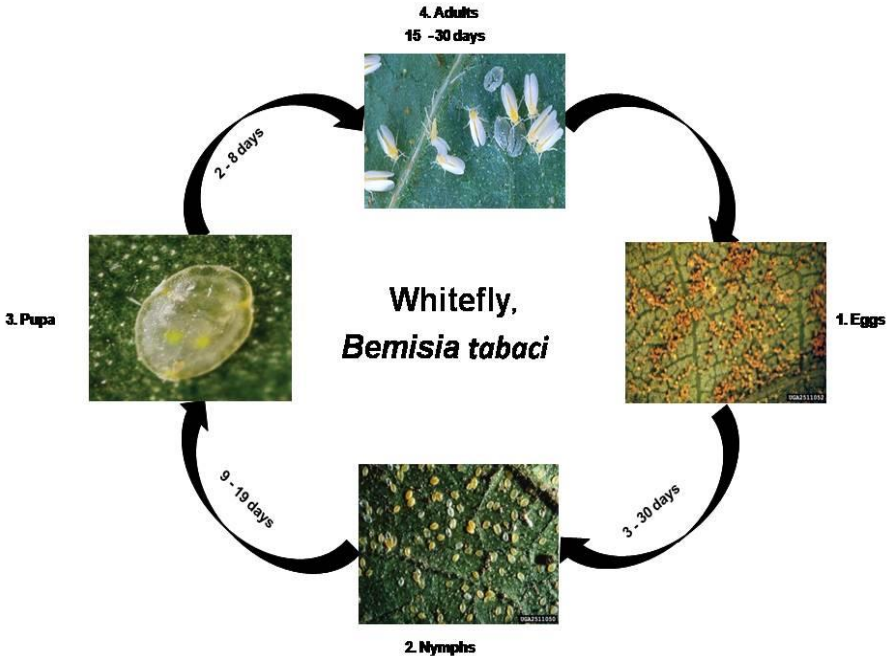
6. Whitefly

Biology:

Nymphs are oval, scale like and remain attached to the leaf surface. Adults are tiny, moth like with yellowish body and wings coated with milky white waxy powder.

- **Egg:** Pear shaped, light yellowish Stalked
- **Nymph:** On hatching Oval, scale-like, greenish white
- **Adult:** White, tiny, scale-like adult

Life cycle:



1. http://animal.memozee.com/Arch03/1132935290.jpg
2. http://www.forestryimages.org/images/192x128/2511050.jpg
3 http://www.fera.defra.gov.uk/plants/publications/documents/factsheets/bemisia.pdf
4. http://www.entomology.umn.edu/cues/inter/inmine/Whitefg.html

Damage symptoms:

- Nymphs and adults suck sap and excrete honeydew.
- A secondary infection develops when a black sooty mould fungus grows on the sticky honeydew.
- There are no visible damage symptoms with low numbers of whiteflies.
- Under very heavy infestations, plants lose vigour and damage is manifested under severe moisture stress, causing leaf wilting and failure to set seed.

Favourable conditions:

- Warm weather conditions are favourable for multiplication.

Natural enemies of whitefly:

Parasitoids: *Encarsia formosa, Chrysocharis pentheus*, *Eretmocerus* spp.

Predators: Mirid bug, green lacewing, lady beetle, big-eyed bugs

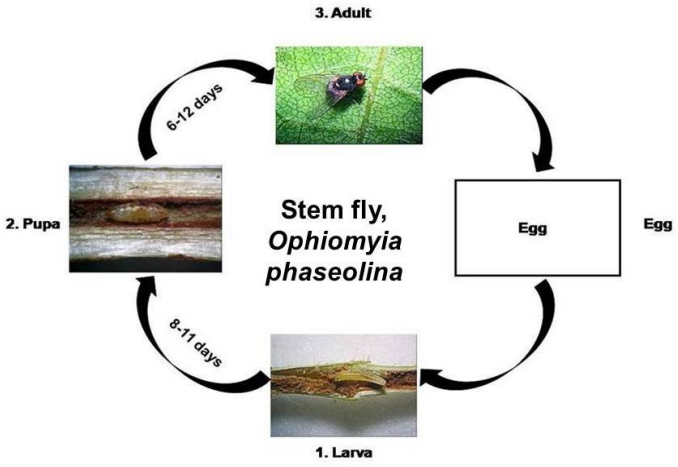
*For management refer to page number----------

7.Stem fly:

Biology:

- **Egg:** The stem fly inserts eggs on the underside of young leaves on tender stems. Ovipositing sites present as pale pinprick spots when infested leaves are held up to the light.
- **Larva:** The larvae are apodus, whitish, cigar -shaped maggots that reach little more than 2mm. Larva pupate after 8-11 days. Before pupation, which takes place inside the stem, the larva makes an exit hole for the emergence of the adult.
- **Pupa:** Pupae are smooth, light brown to pale brown, cylindrical in shape with rounded ends. Pupal stage lasts 6–12 days.
- **Adult:** Adult flies are shiny black and about 2mm long with a pair of clear wings of wingspan 4-5 mm.

Life cycle



1. http://thebeatsheet.com.au/wp-content/uploads/image/close%20up%20of%20maggot.jpg

2. http://thebeatsheet.com.au/wp-content/uploads/image/pupae.jpg

3. http://thebeatsheet.com.au/wp-content/uploads/image/adult%20fly.jpg

Damage symptoms

- Infected stems are often red inside (sometimes pale) and a distinct zig-zag tunnel filled with frassy excreta may be observed with maggots or pupae inside. Apart from the exit holes, the plants may apparently appear healthy from outside.
- Severe infestations (3 or more maggots per plant) may cause wilting, yellowing, drying and finally pre-mature plant death, especially in younger plants particularly if damage occurs in the plant's hypocotyl (basal stem) region.

Natural enemies of stem fly:

Parasitoids: Tiny wasps

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

8.Pod bug:

Biology:

Pod bugs are serious pests in many parts of the country particularly Andhra Pradesh, Tamil Nadu, Madhya Pradesh, Delhi, Uttar Pradesh, Bihar, West Bengal etc.

- **Egg:** Adult lays eggs in small batches of 8-15 mostly on pods. Incubation period ranges from 3-6 days depending upon weather condition.
- **Nymph:** Nymphs are smaller in size and devoid of wings, nymphal period completes within 8-17 days.
- **Adults:** Adult legs are bigger in size and with two pairs of wings.

Source - http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Species_Nezarini/Nezara_viridula.htm

Damage symptoms:

- Both the nymphs and adults sucks the sap from seeds of developing pods through pod wall.
- Affected pods show clear brown spots on the pods, seeds become shrivelled and lose viability

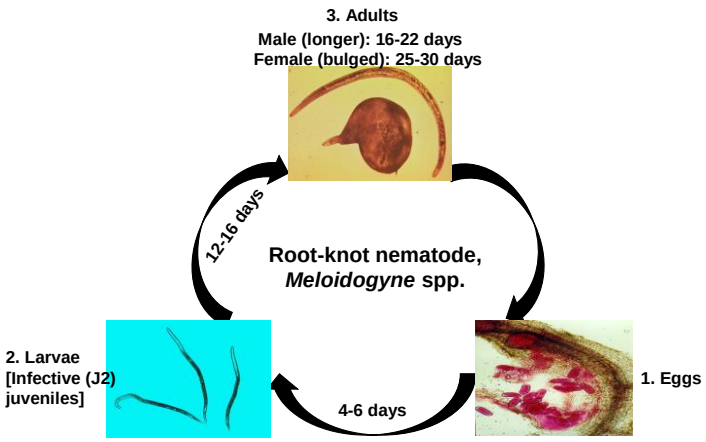
*For management refer to page number----------

9..Root-knot nematode:

- The life cycles root-knot (*Meloidogyne* sp.), its sedentary endoparasites.
- The invasive or second stage juvenile (J2) hatches from the egg and seeks a feeding site within a root.
- The juvenile moults to the J_3 and begins enlarging as the reproductive system develops. Nematodes which become females are no longer able to leave the root.
- They continue to enlarge as they go through the J3 and J4 stages. Root-knot nematode, galls will typically develop on the root.
- Upon becoming adults, root-knot nematodes will begin to lay eggs (up to several hundred) which are contained in a gelatinous matrix at the posterior end of the body.
- The egg mass may be within the root or partly or wholly exposed on the root surface while the swollen body of the female remains within the root.
- Eggs in matrices often remain attached to root fragments in the soil after the female dies.
- Root-knot egg and juvenile populations decline by up to 70 to 90 percent during winter in the absence of reproduction.

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 by root-knot nematode cause decline in the host, and under some conditions, may kill the plant.
- Infected plants may be stunted and chlorotic, usually wilt easily, and are not productive. However, the extent of damage caused by root-knot nematode infections varies with host, timing of infection, and cultural conditions. Root-knot nematode infection often is easy to identify because of the swellings in roots that look like “knots.”
- The swellings become large and easy to see on some hosts such as squash, but may be smaller and less conspicuous on others such as chile pepper.

- Multiple infections on one root result in a swollen, rough appearance. Root-knot nematodes are very small and can only be observed using a microscope.

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

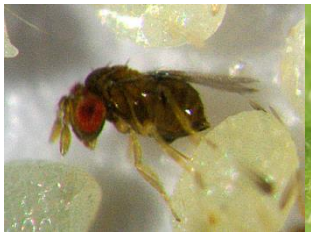
Favourable conditions:

- Loamy light soils

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

Natural Enemies of Lablab bean Insect Pests

Parasitoids
Egg parasitoids



1. *Trichogramma* **2. *Tetrastichus* spp.** **3. *Telenomus* spp**

Egg-larval parasitoid

4. *Chelonus* spp.

Larval parasitoids




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

1. http://www.nbaii.res.in/Featured_insects/Trichogrammatids.php
2. http://www.pbase.com/image/135529248
3. http://baba-insects.blogspot.in/2012/02/telenomus.html
4. http://www.nbaii.res.in/Featured%20insects/chelonus.htm
5. http://www.nbaii.res.in/Featured%20insects/Bracon%20brevicornis.htm
6. http://www.organicgardeninfo.com/ichneumon-wasp.html
7. http://72.44.83.99/forum/viewthread.php?thread_id=40633andpid=178398
8. http://www.nbaii.res.in/Featured%20insects/Campoletis.htm

Predators

1. Lacewing

2. Ladybird beetle

3. Reduviid bug

4. Spider

5. Robber fly

6. Fire ant

7. Black drongo

8. Common mynah

9. Preying mantis

10. Predatory mite

11 Hover fly

5. http://www.warpedphotosblog.com/robber-fly-and-prey
6. http://www.couriermail.com.au/news/queensland/queensland-launched-a-war-against-the-fire-ant-invasion-but-12-years-later-they8217re-still-on-the-march/story-fnihsrf2-1226686256021
7. http://nagpurbirds.org/blackdrongo/picture/1639
8. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
9. http://spirit-animals.com/praying-mantis/
10. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies
11. http://freepages.misc.rootsweb.ancestry.com/~larsonmorgan/flies/flies.html

IX. DESCRIPTION OF DISEASES

1. Anthracnose:

Disease symptoms:

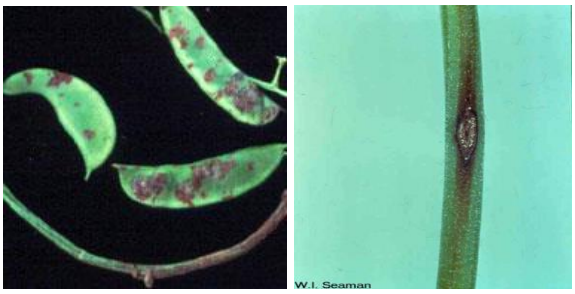
- Bean pods with black, sunken lesions or reddish-brown blotches caused by *Colletotrichum lindemuthianum*.
- Black, sunken lesions about ½ inch in diameter develop on stems, pods and seedling leaves (cotyledons) but are most prominent on pods.
- A salmon-colored ooze on lesions and the veins on lower leaf surfaces turns black. On lima beans, symptoms are sooty- appearing spots on leaves and pods.
- Anthracnose develops primarily during the spring and fall when the weather is cool and wet, and not during hot, dry summers. Lima beans are particularly susceptible.

Survival and spread:

- The fungus survives in the winter primarily in bean seed. Survival in soil or in plant residue varies greatly, depending on environmental conditions.
- The fungal spores are easily carried to healthy plants in wind-blown rain and by people and machinery moving through contaminated fields when the plants are wet.

Favourable conditions:

- The disease is favored by warm (20^{o} C to 24^{o} C) weather and infection will only take place if the leaves remain wet for 18 to 24 hours.



Infected pod and twig

http://www.lablablab.org/images/flashImages/diseases-management.jpg
http://www.oregon.gov/ODA/CID/PLANT_HEALTH/PublishingImages/191/beananthracnoseleaf.jpg

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

2.Rust:

Disease symptom:

- Bean rust is mainly a disease of leaves that causes rust-colored spots formation on the lower leaf surfaces.
- Severely infected leaves turn yellow, wilt, and drop off the plant.
- Stems and pods may also be infected.

- It affects most types of beans under humid conditions.

Survival and spread:

- The pathogen survives in the volunteer Lablab bean plants and in infected plant debris in the soil as teliospores.
- The disease spreads by wind-borne uredospores from infected crop.

Favourable conditions:

- Day temperature of 25.5° to 30.5°C with relative humidity of 86 to 92 per cent enhances intensity of rust.

Infected twig and leaves

http://upload.wikimedia.org/wikipedia/commons/e/e1/Uromyces_appendiculatus,_telia,_5365358.jpg
http://www.forestryimages.org/images/768x512/2175020.jpg

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

3.Powdery mildew:

Disease symptom:

- Leaves are covered with patches of a whitish to grayish powdery growth.
- New growth appears contorted, curled or dwarfed and may turn yellow and drop. Pods are dwarfed and distorted.
- This is mostly a problem of all beans. Powdery mildew is spread by wind and rain.

Survival and spread:

- The primary sources of inoculum are oospores present in the soil.
- Secondary infection is by air

Favourable conditions:

- The disease is more under dry conditions at the end of the winter months.

Infected plant

http://www.viarural.com.ar/viarural.com.ar/agricultura/aa-enfermedades/erysiphe-polygoni-01.jpg;
http://umuhinzi.com/files/uploads/2013/09/Indwara-ya-Milidiyu.jpg

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

4.Bacterial leaf spot:

Disease symptom:

- There are two widespread bacterial blights that affect most types of beans, common blight (*Xanthomonas campestris* pv *phaseoli*) and halo blight (*Pseudomonas syringae* pathovar *phaseolicola).*
- The stems, leaves and fruits of bean plants can be infected by either disease. Rain and damp weather favour disease development.
- 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.
- Common blight infected pods do not have the greenish-yellow halo around the infected spot or lesion. Common blight occurs mostly during warm weather.

Survival and spread:

- The bacteria overwinter in dead plant material, but do not survive for long in water or soil.
- Bacteria are weak pathogens and need a natural opening (stomata's and lenticels) or an injury (mechanical, insect or another disease) to infect. The disease is spread by splashing water and by implements or workers in the field when the plants are wet.

Favourable conditions:

- Warm temperature (24- 30^{o}C) along with sprinkler irrigation or heavy rains favour disease development.

Infected plants and pod

http://www.forestryimages.org/images/768x512/5359931.jpg
http://www.agriculture.gov.sk.ca/adx/aspx/adxGetMedia.aspx?DocID=974,3728,14613,81,1,DocumentsandMediaID=7864andFilename=image008.jpg

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

5.Lablab bean Mosaic virus

Disease symptom:

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

result from infection by one of several viruses. Southern beans can be infected by Cowpea aphid-borne mosaic virus, Bean common mosaic virus and several others.

- It is not possible to distinguish between the viruses based on symptoms alone.
- Laboratory tests (ELISA) are required to identify the viruses and confirm that they may be responsible for the mosaic symptoms.

Survival and spread:

- Virus spreads through transmission by thrips.
- Weed hosts serve as natural virus reservoirs.
- Long and continuous dry spell increases the disease incidence.

Virus infected leaf and plant

http://www.infonet-biovision.org/res/res/files/1575.280x185.clip.jpeg
http://cropgenebank.sgrp.cgiar.org/images/management/common_bean_smogs/bean%20common%20mosaic1.png

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

6.Ashy stem blight:

Disease symptom:

- Symptoms may appear after soil-borne mycelia or sclerotia germinate and infect seedling stems near the soil line at the base of developing cotyledons.
- The fungus produced black, sunken, cankers which have a sharp margin and often contain concentric rings.
- The plant's growing tip may be killed or the stem broken where it is weakened by the canker. Infection may continue into the hypocotyl and root region or the primary leaf petioles.
- Older seedling and plant infections may cause stunting, leaf chlorosis, premature defoliation, and plant death [Schwartz, 1989].

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.
- Wind-borne conidia cause secondary spread.
- 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.

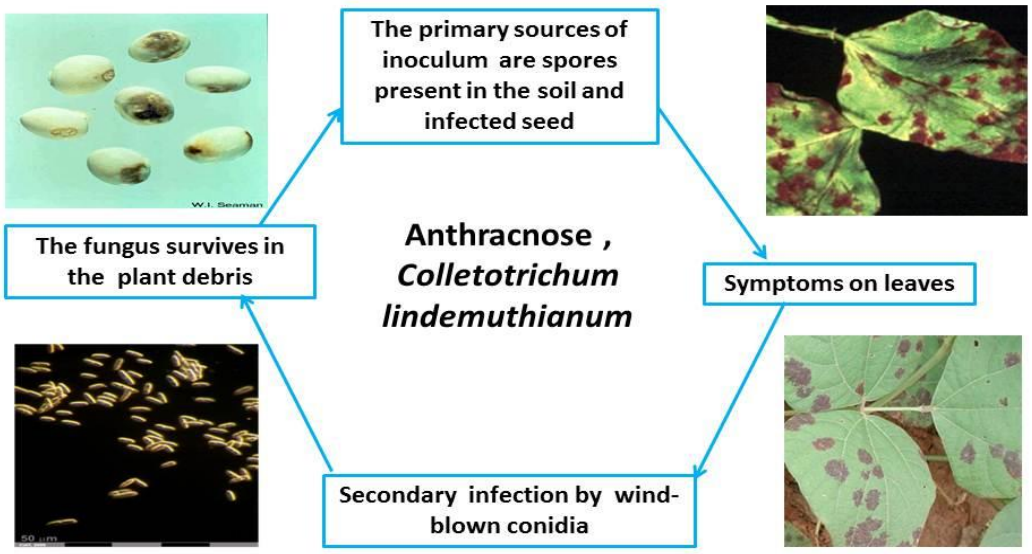

Infected stem

http://www.forestryimages.org/images/768x512/5365950.jpg
http://www.insectimages.org/images/768x512/5365956.jpg

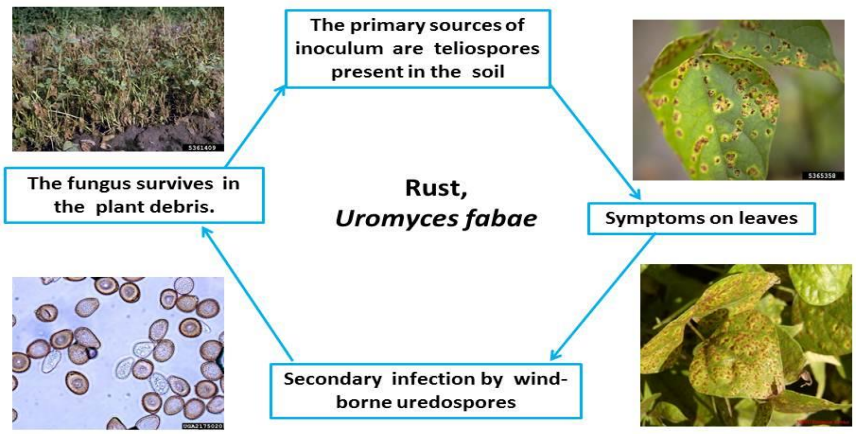
*For management refer to page number----------

Disease cycles:

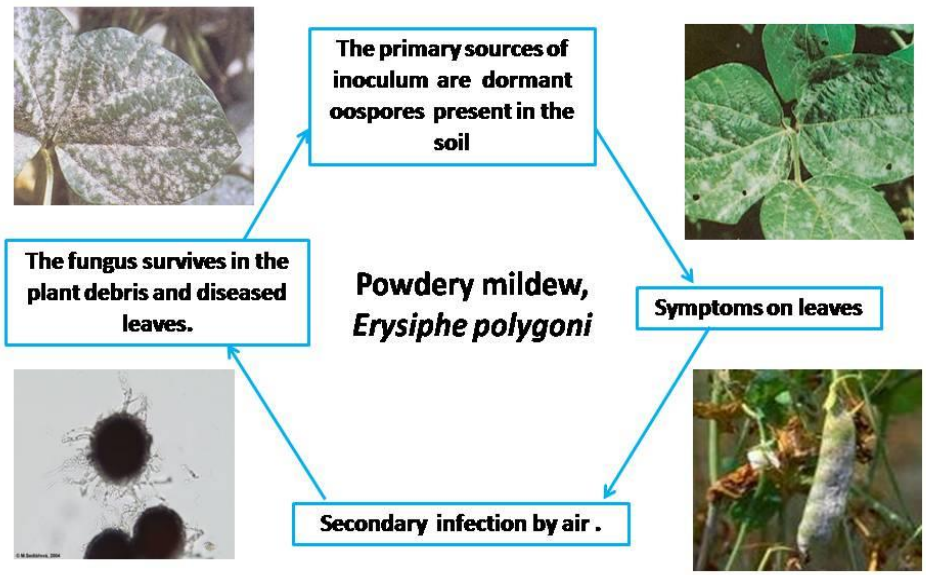
1. Anthracnose:



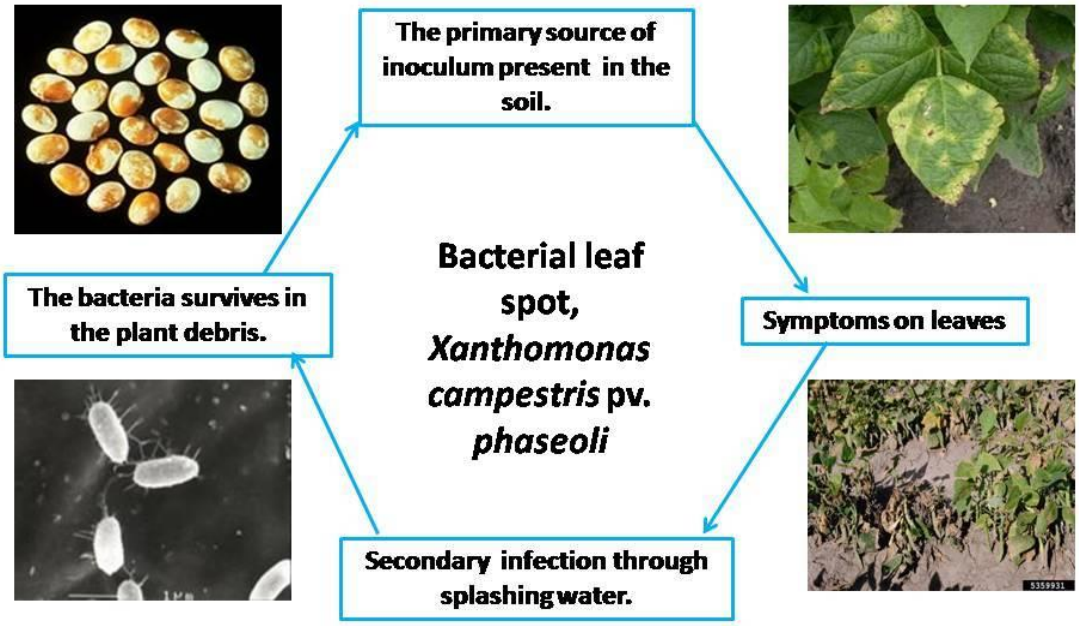
2. Rust:



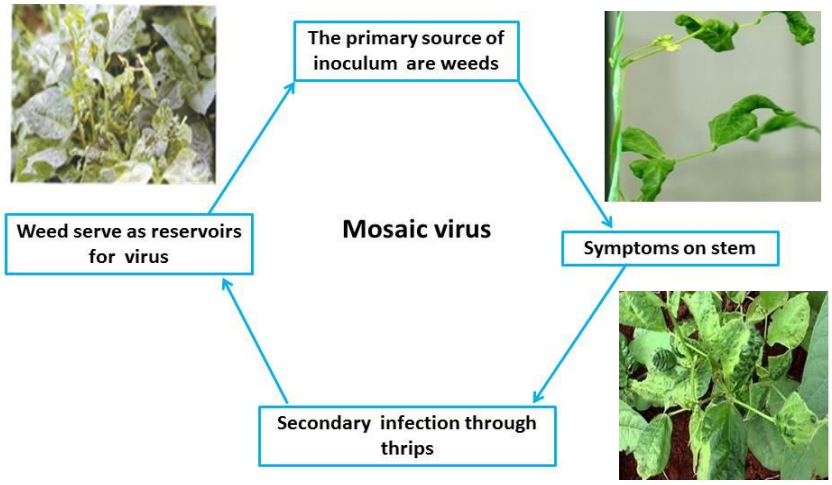
3. Powdery mildew:



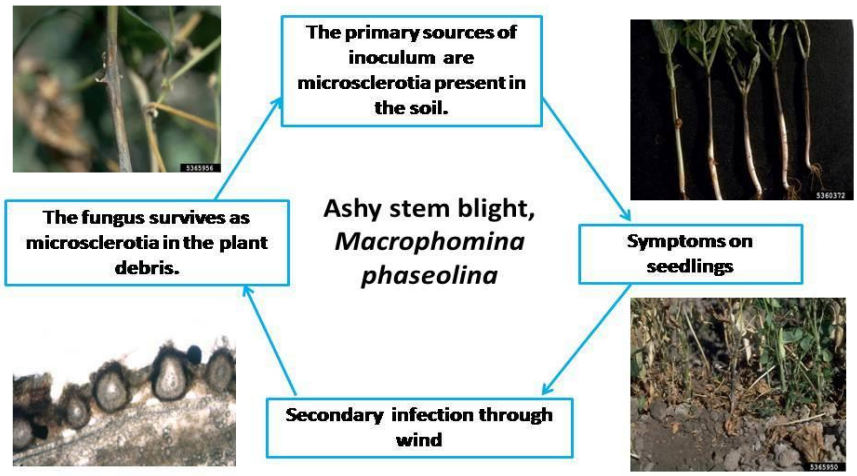
4. **Bacterial leaf spot:**



5. **Mosaic virus:**



6. Ashy stem blight :



X. SAFETY MEASURES

A. At the time of harvest:

When planted early in the growing season, Lablab Beans start bearing pods in 60-70 days and continue for 90-100 days. For use as a pulse or to save seed for the following year, the lablab seed should be allowed to mature approximately 150-210 days after planting The seed crop comes to harvest 140 days for Co 1 and 90 days for Co 2 after sowing. At this time, 70% the pods turn straw coloured. Prior to harvest there is an important pest to be controlled. Bruchids are the major pests of stored pulse seeds. Bruchids lay eggs on the surface, the grubs bore into the seeds and eat the cotyledon. The seeds thus store poorly and loose viability faster. It has been found that bruchids lay their eggs on the pods in the field itself. Hence control of these pests must start from the field itself. Spraying of neem seed kernel extract (NSKE) 5% and stickers (0.5 g / litre) is beneficial.

Upon ripening, the pods will turn from green to straw coloured. This is the right stage for harvest for seed purpose. Delaying will lead to infection by diseases, pests and sometimes seed vigor will be lost due to untimely rains. The first five harvests are alone used for seed extraction. During harvest, the shrunken, damaged and immature pods if any are removed. If the plants come to even harvest, ripe pods are picked and then spread out to dry. The pods will dry and become brown and may start splitting. The pods are then beaten using pliable sticks to prevent damage to seeds. After thorough beating, the seeds are separated from pods. The plant debris are removed and seeds cleaned by winnowing. Cleaned seeds are then dried on tarpaulin on the threshing floor until the moisture content is reduced to 10%. This is the safe moisture content for storing seeds and maintaining their viability.

B. Post-harvest storage:

One of the main characteristics of seed quality is the right size. Plumpy seeds are better than ill-filled puny seeds. Grading is one simple method by which we can separate the filled seeds from broken and puny seeds. Grading is done using round holed sieves. Such sieves are easily available in the market. The sieve size for lab lab is 7.00 mm. After sieving, those seeds that are broken, fungal infected, seed coat damaged seeds are removed. Seeds after harvest have to be stored so that they are viable and healthy for sowing during the ensuing season. Hence, proper after care during storage is very essential part of seed production.

Seed moisture is the most important physical quality. Seed moisture determines the length of seed storage life. Higher the moisture, the longevity of seed is reduced drastically. Seeds with moisture are attacked by fungal and other storage pests like Bruchids. Further, seeds being living organisms tend to utilize all their stored energy and loose vigor. Hence, reducing seed moisture is the first step in ensuring longer seed life.The moisture content must be reduced to 9% for short term storage of 6-8 months. Seeds with 9% moisture can be stored in cloth bag or gunny. Seeds that have to be stored for long term i.e. 1-2 yrs, have to be dried to 7% moisture. Such seeds have to be stored in polythene bag.

After seed treatment, seeds have to be stored in bags or containers. Choosing the right type of container is necessary. This depends on the quantity of seeds to be stored and storage environment. Seeds absorb moisture and even if the seed is dried to safe moisture content before storage, during storage depending upon the prevailing climatic conditions, seeds tend to absorb moisture. If the storage is attempted in an environment with high humidity, seed absorb moisture until they equilibrate with the atmosphere. Hence high humidity in the environment will lead to increase in seed moisture that is detrimental to seed storage. Such high humid conditions exist at sea shores, near lakes and rivers. Most of the places of peninsular India are highly humid especially during the monsoon periods between the months of June-December.

In case of short term storage, cloth bag can be preferred. Cloth bag is porous and hence it can hold seeds for short period. However, cloth bags are cheaper and easily made using local tailor. Large quantity of seeds can stored in gunny bag. If the seeds are to be stored for longer period that thick polythene bags can be used. Seed bags can be stacked one upon other upto 6 layers. Stacking beyond this will damage the seeds present in the lower layers. To prevent damage to seeds in the bottom layers, the layers can be rotated periodically by shifting the lower layers to the top and vice -versa. Stacking must also be done on dunnages. Dunnages are wooden rafts that keep the seeds above floor and allow aeration. Tarpaulins and thick plastic sheet can also be used. Seed treatment is most effective in combating fungal pathogens.

XI. 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 and intercropping	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 pests
5	Always treat the seeds with approved chemicals/biopesticides 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.	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.
8	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
9	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
10	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
11	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
12	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.
13	Apply HaNPV at recommended dose when a large number of eggs 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.
14	Spray approved pesticides thoroughly to treat the entire foliage	Do not spray pesticides only on the upper/lower surface of leaves.
15	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7-10 days before harvest. Prior to spraying all the mature fruits should be harvested.
16	Follow the recommended procedure of trap crop technology.	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.

XII. SAFETY PARAMETERS IN PESTICIDE USAGE

S. No	Pesticide Classification as per insecticide rules 1971 Colour of toxicity triangle	WHO classification of hazard	Symptoms of poisoning	First aid measures and treatment of poisoning	Safety interval (days)
INSECTICIDES					
1.	Chlorpyrifos Highly toxic 	Class II - Moderately hazardous	Severe – diarrhoea, pinpoint and non - reactive pupils, respiratory difficulty, pulmonary edema, cyanosis, loss of sphincter control, convulsions, coma and heart block.	**First aid measures:** Atrophine sulphate **Treatment of poisoning:** For ingestion lavage stomach with 5 % sodium bicarbonate, if not vomiting. For skin contact, wash with soap and water (eyes – wash with isotonic saline). Wear rubber gloves while washing contact areas. In addition to atropine give 2 – PAM (2 – pyridine aldoximemethiodide). 1 g and 0.25g for infants intravenously at slow rate over a period of 5 minutes and administer again periodically as indicated. More than one injection may be required. Avoid morphine, theophylline, aminophylln, barbiturates Phenothiaznines	-
2.	Carbendazim Slightly toxic 	Unlikely to present acute hazard in normal use	Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin, allergic manifestations etc.	**First aid measures:** Rush to the nearest physician. **Treatment of poisoning:** No specific antidote. Treatment is essentially symptomatic	-

XIII. 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. Read the label on the container before preparing spray solution.
7. Prepare the spray solution as per requirement
8. **Do not** mix granules with water; **Do not** eat, drink, smoke or chew while preparing solution
9. Concentrated pesticides must not fall on hands etc. while opening sealed container. Do not smell pesticides.
10. Avoid spilling of pesticides while filling the sprayer tank.
11. The operator should protect his bare feet and hands with polythene bags

E. Equipment

1. Select right kind of equipment.
2. Do not use leaky and defective equipment
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

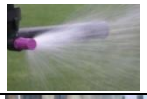
G. Disposal

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.

XIV. PESTICIDE APPLICATION TECHNIQUES

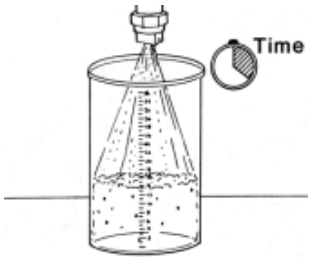
<table>
<tr><td colspan="4">Equipment</td></tr>
<tr><td colspan="4">Category A: Stationary, crawling pest/disease</td></tr>
<tr><td rowspan="2">Vegetative stage
i) for crawling and soil borne pests

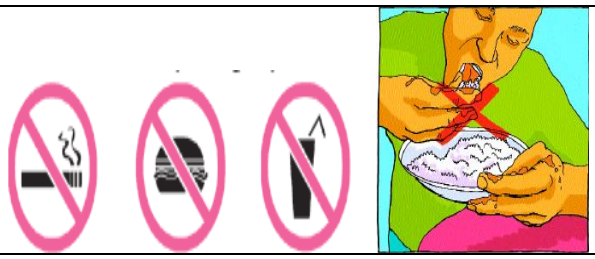
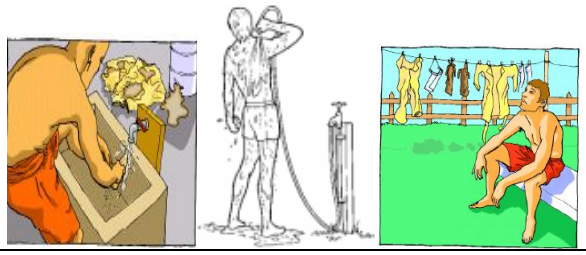
ii) for small sucking leaf borne pests</td><td rowspan="2">Insecticides and fungicides</td><td rowspan="2">• Lever operated knapsack sprayer (Droplets of big size)
• Hollow cone nozzle @ 35 to 40 psi
• Lever operating speed = 15 to 20 strokes/min
or
• Motorized knapsack sprayer or mist blower (Droplets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

Reproductive stage *(Field Pests)*	fungicides	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)	 

XV. 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.	

XVI. REFERENCES

- http://www.tecomate.com/images/products/seed/field_lablab.jpg
- http://www.dirtdoctor.com/pics/content_img.8240.img.jpg
- http://www.vegetableipmasia.org/docs/Ecological%20Guide/Green%20Bean%20Integrated%20Pest%20Management.pdf
- http://c.ymcdn.com/sites/www.echocommunity.org/resource/collection/59800F4C-2723-4074-9CA3-DB23AA9F576A/Lablab_purpureus_LablabBean.pdf
- http://agritech.tnau.ac.in/seed_certification/seed_pul_field%20bean.html
- http://www2.ca.uky.edu/entomology/dept/ipages/images/jwhite/aphiscrav.jpg
- http://www.vegedge.umn.edu/IMG/plh.JPG
- http://www.arc.agric.za/uploads/images/4206_mite2.gif
- http://www.nbaii.res.in/insectpests/images/Spilosoma-obliqua15.jpg
- http://1.bp.blogspot.com/-7Vxpz4LIx9I/UYCuS0OztYI/AAAAAAAAAjM/ADoOGnMyN78/s1600/ophiomyia+phaseoli.jpg
- http://upload.wikimedia.org/wikipedia/commons/b/b4/Helicoverpa_armigera_larva.jpg
- http://www.finegardening.com/CMS/uploadedImages/Images/Gardening/Plants/lablabpurpureus_jwb_2_lg.jpg
- http://www.lablablab.org/images/flashImages/diseases-management.jpg
- http://www.oregon.gov/ODA/CID/PLANT_HEALTH/PublishingImages/191/beananthracnoseleaf.jpg
- http://www.2020seedlabs.ca/sites/default/files/Anthracnose%20-%20fieldbean%20seed%20damage.jpg
- http://cropgenebank.sgrp.cgiar.org/images/management/common_bean_smogs/anthracnose.png
- http://www.oregon.gov/ODA/CID/PLANT_HEALTH/PublishingImages/191/beananthracnosebean.jpg
- http://www.2020seedlabs.ca/sites/default/files/Anthracnose%20-%20fieldbean%20stem%20lesion.jpg
- http://upload.wikimedia.org/wikipedia/commons/e/e1/Uromyces_appendiculatus,_telia,_5365358.jpg
- http://www.forestryimages.org/images/768x512/2175020.jpg

- http://tiennong.vn/Uploads/UserFiles/images/dau_gisat23.jpg
- http://www.forestryimages.org/images/768x512/5361409.jpg
- http://www.forestryimages.org/images/768x512/5363944.jpg
- http://www.agripests.cn/cash_fungus/ed275-1.jpg
- http://www.viarural.com.ar/viarural.com.ar/agricultura/aa-enfermedades/erysiphe-polygoni-01.jpg
- http://umuhinzi.com/files/uploads/2013/09/Indwara-ya-Milidiyu.jpg
- http://agritech.tnau.ac.in/crop_protection/crop_prot_crop%20diseases_veg_cauliflower_clip_image004_0001.jpg
- http://botany.upol.cz/atlasy/system/images/ascomycetes/erysiphales/erysiphe-polygoni.jpg
- http://www.fungiworld.com/img/pilze/3101_3_k.jpg
- http://www.agrolink.com.br/agromidias/problemas/g/Erysiphe_polygoni51.jpg
- http://www.forestryimages.org/images/768x512/5359931.jpg
- http://www.agriculture.gov.sk.ca/adx/aspx/adxGetMedia.aspx?DocID=974,3728,14613,81,1,DocumentsandMediaID=7864andFilename=image008.jpg
- http://www.eppo.int/QUARANTINE/bacteria/Xanthomonas_phaseoli/XANTPH_04.jpg
- https://colloque4.inra.fr/var/xgc2012/storage/fckeditor/file/img%20accueil%201.jpg
- http://ecoport.org/PDB/000020/20376.jpg
- http://www.forestryimages.org/images/768x512/0454014.jpg
- http://www.infonet-biovision.org/res/res/files/1575.280x185.clip.jpeg
- http://cropgenebank.sgrp.cgiar.org/images/management/common_bean_smogs/bean%20common%20mosaic1.png
- http://pvo.bio-mirror.cn/images/d2.jpg
- http://cropgenebank.sgrp.cgiar.org/images/management/cowpea_smogs/cymv.png
- http://cropgenebank.sgrp.cgiar.org/images/management/forage_legumes_smogs/Bean_common_mosaic.jpg
- http://omicsonline.org/2157-7471/images/2157-7471-3-130-g002.gif
- http://www.forestryimages.org/images/768x512/5365950.jpg
- http://www.insectimages.org/images/768x512/5365956.jpg
- http://www.forestryimages.org/images/768x512/5360372.jpg
- http://www.google.co.in/imgres?imgurl=http%3A%2F%2Fcropgenebank.sgrp.cgiar.org%2Fimages%2Fmanagement%2Fforage_legumes_smogs%2Fmacrophomina%252520phaseolina.bmpandimgrefurl=http%3A%2F%2Fcropgenebank.sgrp.cgiar.org%2Findex.php%2Fmanagement-mainmenu-433%2Fstogs-mainmenu-238%2Fforage-legumes%2Fguidelines%2Ffungiandh=221andw=540andtbnid=p-Pj2qeMcW-T2M%3Aandzoom=1anddocid=VzwqgB3x5ueHqMandei=gj8-U5iwN4mQrgel2oG4CAandtbm=ischandved=0CL8BEIQcMCIandiact=rcanddur=489andpage=2andstart=16andndsp=24
- http://www.forestryimages.org/images/768x512/5365951.jpg
- http://www.forestryimages.org/images/768x512/5365954.jpg
- http://zaraimedia.com/wp-content/uploads/2013/08/jassid5.jpg
- G:\Lablabbean\Lablabbean Jassid UAS Raichur.htm
- http://uasr.agropedia.in/content/Lablabbean-bihar-hairy-caterpillar
- https://www.google.co.in/search?q=Bihar+hairy+caterpillar+in+Lablabbean
- http://www.macro-world.cz/image.php?id_foto=514andgal=29
- http://llladybug.blogspot.in/
- http://www7.inra.fr/hyppz/RAVAGEUR/6helarm.htm
- http://www.infonet-biovision.org/default/ct/120/crops
- http://www.invasive.org/browse/subinfo.cfm?sub=9408
- http://en.wikipedia.org/wiki/Helicoverpa_armigera
- http://www.lablablab.org/images/flashImages/insects-management.jpg
- http://gsquaredbugs.com/?page_id=318
- http://www.pbase.com/image/135529248
- http://www.nbaii.res.in/Featured%20insects/chelonus.htm
- http://baba-insects.blogspot.in/2012/02/telenomus.html
- http://www.nbaii.res.in/Featured%20insects/Bracon%20brevicornis.htm

- http://www.organicgardeninfo.com/ichneumon-wasp.html
- http://72.44.83.99/forum/viewthread.php?thread_id=40633andpid=178398
- http://www.nbaii.res.in/Featured%20insects/Campoletis.htm
- http://eol.org/pages/28099/details
- http://www.macro-world.cz/image.php?id_foto=514andgal=29
- http://llladybug.blogspot.in/
- http://en.wikipedia.org/wiki/Wolf_spider
- 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
- http://en.wikipedia.org/wiki/Dragonfly
- http://www.warpedphotosblog.com/robber-fly-and-prey
- 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
- http://spirit-animals.com/praying-mantis/
- http://nagpurbirds.org/blackdrongo/picture/1639
  http://somethingscrawlinginmyhair.com/2011/09/17/yellowjacket-with-prey/
- http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
- https://www.google.co.in/search?q=life+cycle+of+lablab bean+aphidandespv=210andes_sm
- http://www.infonet-biovision.org/res/res/files/1832.280x185.clip.jpeg
- http://tnau.ac.in/eagri/eagri50/ENTO331/lecture05/001.html
- https://www.google.co.in/search?q=Diaeretiella+rapaeandespv=210andes_sm=93andsource=lnmsand
- https://www.google.co.in/search?q=Aphelinus+andespv=210andes_sm=93andtbm=ischandi
- http://archive.agric.wa.gov.au/PC_94923.html?s=1001
- http://pnwhandbooks.org/insect/tree-fruit/apple/apple-spider-mite
- http://www.agf.gov.bc.ca/cropprot/grapeipm/spidermites.htm
- http://www.evergreengrowers.com/mite-control.html
- http://keys.lucidcentral.org/keys/sweetpotato/key/Sweetpotato%20Diagnotes/Media/Html/TheProblems/Nematodes/RootKnotNematode/Root-knot.htm
- http://nematology.umd.edu/rootknot.html
- http://www.cals.ncsu.edu/pgg/dan_webpage/Introduction/Images/pyroform.htm
- http://www.jbiopest.com/users/LW8/efiles/Vol_5_0_50_52F.pdf
- http://www2.fiskars.com/var/fiskars_amer/storage/images/media/images/march-project-images/week-1/erica-annual-vines/dolichos-lablab-sept-at-abg/652196-1-eng-US/Dolichos-lablab-Sept-at-ABG_width579.jpg
- 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://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Species_Nezarini/Nezara_viridula.htm
- http://4.bp.blogspot.com/_H_nGP6c0vxs/TIHuVL9sUkI/AAAAAAAAALI/j6R-sxNAXKo/s1600/Lablab.jpg