AESA BASED IPM PACKAGE

AESA based IPM – Safflower

Directorate of Plant Protection
Quarantine and Storage
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National Institute of
Plant Health Management
Rajendranagar, Hyderabad, Telangana

Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

Important Natural Enemies of Safflower Insect Pests

Parasitoids

***Trichogramma* spp.**

***Bracon* spp.**

***Aphidius* sp**

***Ichneumon* spp.**

***Campoletis* spp.**

***Carcelia* spp.**

Predators

Lacewing

Ladybird beetle

Reduviid bug

Spider

Red ant

Pentatomid bug
(Eocanthecona furcellata)

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

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Back cover picture Safflower field

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FOREWORD

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

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

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

Date : 6.3.2014

(Avinash K. Srivastava)

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FOREWORD

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

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

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

(Utpal Kumar Singh)

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PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

CONTENTS

AESA BASED IPM PACKAGE FOR SAFFLOWER

Safflower plant description:

Safflower (*Carthamus tinctorius* L.; Family: Asteraceae) is a flowering annual plant. It is native to parts of Asia and Africa (central India through the Middle East to the upper reaches of the Nile River and into Ethiopia). The safflower plant grows from 0.3 to 1.2 metres (1 to 4 feet) high and has flowers that may be red, orange, yellow, or white. The dried flowers may be used to obtain carthamin, a red textile dye that was commercially important at one time but has since been replaced by synthetic aniline dyes, except in local areas of southwestern Asia. Safflower has been used as an adulterant of the condiment saffron.

Oil obtained from the seed is the main modern use of the plant. Safflower oil does not yellow with age, making it useful in preparing varnish and paint. Most of the oil, however, is consumed in the form of soft margarines, salad oil, and cooking oil. It is highly valued for dietary reasons because of its high proportion of polyunsaturated fats. The meal, or cake residue, is used as a protein supplement for livestock. Safflower, grown mainly in India, has been introduced as an oil crop into the United States, Australia, Israel, Turkey, and Canada.

I. PESTS

A. Pests of National Significance

1. Insect pests

1.1 Gram pod borer/capsule borer: *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae)

1.2 Safflower caterpillar: *Perigaea capensis* (Thunberg) (Lepidoptera: Noctuidae)

1.3 Safflower aphid: *Uroleucon carthami* (Theo) (Hemiptera Aphididae)

1.4 Capsule fly/safflower bud fly: *Acanthiophilus helianthi* (Rossi) (Diptera: Tephritidae)

2. Diseases

2.1 *Alternaria* blight: *Alternaria carthami* S. Chowdhury

2.2 *Cercospora* leaf spot: *Cercospora carthami* Sundaram & T.S. Ramakr

2.3 Powdery mildew: *Erysiphe cichoracearum* DC.

2.4 Mosaic: *Cucucmber mosaic virus*

2.5 Head rot and wilt: *Sclerotinia sclerotiorum* (L) de Bary

2.6 *Ramularia* leaf spot: *Ramularia carthami* (Zaprometov)

2.7 Rust: *Puccinia carthami* (Corda)

2.8 Wilt: *Fusarium oxysporum* f. sp. *carthami* Klis. & Houston

2.9 Root rot: *Rhizoctonia bataticola* Taubenn (Butler)

3. Weeds

Broadleaf

3.1 Lamb's quarter: *Chenopodium album* L. (Chenopodiaceae)

3.2 Scarlet pimpernel: *Anagallis arvensis* L. (Primulaceae)

3.3 Sweet clover: *Melilotus indica* (L.) All. (Fabaceae)

3.4 Fine leaf fumitory: *Fumaria parviflora* Lam. (Fumariaceae)

3.5 Corn spurry: *Spergula arvensis* L. (Caryophyllaceae)

3.6 Onion weed: *Asphodelus tenuifolius* Cav. (Asphodelaceae)

3.7 Common vetch: *Vicia sativa* L. (Fabaceae)

3.8 Wild safflower: *Carthmus oxycantha* M. Bieb. (Asteraceae)

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

3.10 Wild poinsettia: *Euphorbia zeniculata* Ortega (Euphorbiaceae)

3.11 Camel thorn: *Alhagi maurorum* Kedik. (Fabaceae)

3.12 Field bindweed: *Convolvulus arvensis* L. (Convolvulaceae)

Grasses

3.13 Blue grass: *Poa annua* L. (Poaceae)

3.14 Canary grass: *Phalaris minor* Retz. (Poaceae)

3.15 Bermuda grass: *Cynadon dactylon* (L.) (Poaceae)

3.16 Annual beard grass/annul rabbits foot grass: *Polypogon monspliensis* (L.) Desf. (Poaceae)

Sedges

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

3.18 Flat sedge: *Cyperus difformis* L. (Cyperaceae)

4. Parasitic plant

4.1 Broom rape: *Orobanche aegyptiaca* (Orobanchaceae)

B. Pests of Regional Significance

1. Insect pests

1.1 Gujhia weevil: *Tanymecus indicus* Faust (Coleoptera: Curculionidae)

II. AGRO-ECOSYSTEM ANALYSIS (AESA) BASED INTEGRATED PEST MANAGEMENT (IPM)

A. AESA:

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

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

AESA is an approach, which can be gainfully employed by extension functionaries and farmers to analyse field situations with regard to pests, defenders, soil conditions, plant health, the influence of climatic factors and their inter-relationship for growing healthy crop. Such a critical analysis of the field situations will help in taking appropriate decision on management practices. The basic componenets of AESA are:

- Plant health at different stages
- Built –in-compensation abilities of the plants
- Pest and defender population dynamics
- Soil conditions
- Climatic factors
- Farmer 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

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

Farmers should :

- Monitor the field situations at least once a week (soil, water, plants, pests, natural enemies, weather factors etc.)
- Make decisions based on the field situation and 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.

Safflower plants have ability to produce new branches and heads to compensate for insect damage, yield are not significantly reduced until high level of infestation occurs over a long period. In general, it is advisable to plant safflower early to minimize damage from a late season buildup of safflower insect pests (Parker, 2009).

Understand and conserve defenders:

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

Insect zoo:

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

Pest: Defender ratio (P: D ratio):

Identifying the number of pests and beneficial insects helps the farmers to make appropriate pest management decisions. Sweep net, visual counts etc. can be adopted to arrive at the numbers of pests and defenders. The P: D ratio can vary depending on the feeding potential of natural enemy as well as the type of pest. The natural enemies of safflower insect pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens.

Model Agro-Ecosystem Analysis Chart

Date:
Village:
Farmer:

Decision taken based on the analysis of field situations

Soil conditions	**:**
Weather conditions	**:**
Diseases types and severity	**:**
Weeds types and intensity	**:**
Rodent damage (if any)	**:**
No. of insect pests & damage 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 biopesticides and biochemical biopesticides such as insect growth regulators, botanicals etc. can be relied upon before resorting to synthetic chemical pesticides.

Decision making:

Farmers become experts in crop management:

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

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

AESA methodology:

- Go to the field in groups (about 5 farmers per group). Walk across the field and choose 20 plants/acre randomly. Observe keenly each of these plants and record your observations:
    - Plant: Observe the plant length, number of leaves, crop stage, deficiency symptoms, no of pods etc.
    - Insect pests: Observe and count insect pests at different places on the plant.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
    - Weeds: Observe weeds in the field and their intensity.
    - Water: Observe the water situation of the field.
    - Weather: Observe the weather conditions.
- While walking in the field, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the field situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on what field management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording:

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

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

Data to be recorded:

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

Some questions that can be used during the discussion:

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

Advantages of AESA over ETL:

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

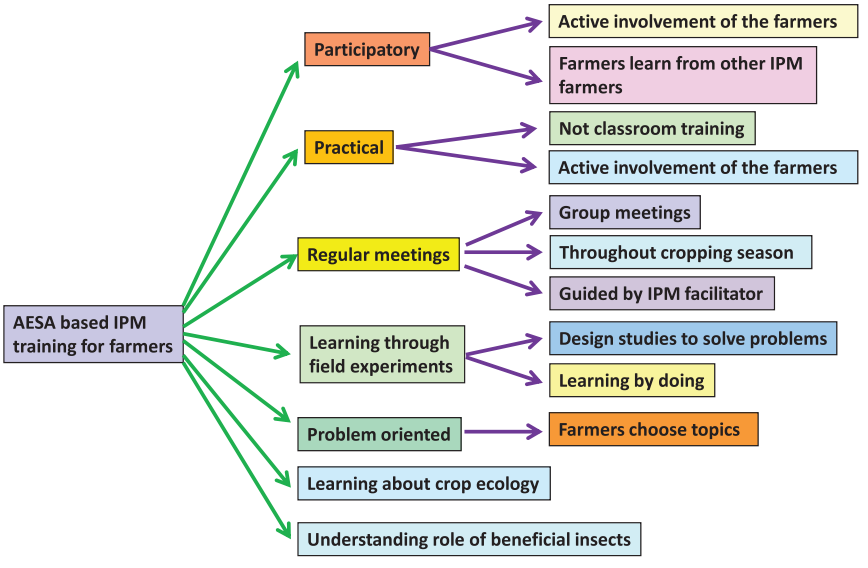
AESA and farmer field school (FFS):

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

Farmers can learn from AESA:

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

FFS to teach AESA based IPM skills:



Group discussion & decision making:

- 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. A different person will present each week.
- 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 IPM plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison in the following weeks.

B. Field scouting:

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

Surveillance on pest occurrence in the field should commence soon after crop establishment transplanting 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 pests:

Aphids: Count and record the number of both nymphs and adults on five randomly selected leaves per plant.

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

For diseases:

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

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

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

Stem, flower and capsule sampling: Carefully examine the stem, flower, and capsule of plants for symptoms and signs of fungal or bacterial diseases. The stem, flower, and capsule 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 trap catches for *Helicoverpa* and *Perigaea*:

Pheromone traps for two insects viz., *Helicoverpa* and *Perigaea* @ 4-5/acre have to be installed, if available. Install the traps for each species separated by a distance of >75 feet in the vicinity of the selected field. Fix the traps to the supporting pole at a height of one foot above the plant canopy. Change of lures should be made at 2-3 week interval (regular interval). Total number of moths of *Helicoverpa* and *Perigaea*/trap/week should be recorded. The trapped moths should be removed and destroyed after each recording.

D. Yellow pan water/sticky traps:

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

E. Light traps:

Set up light traps @ 1 trap/acre 15 cm above the crop canopy for monitoring and mass trapping of insects. Light traps with exit option for natural enemies of smaller size should be installed and operate around the dusk time (6 pm to 10 pm).

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

Natural enemies may require:

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

Ecological engineering for pest management – Above ground:

- 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.

Ecological engineering for pest management – Below ground:

- Crop rotations with 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.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Apply balanced dose of nutrients using biofertilizers.
- Apply mycorrhiza and plant growth promoting rhizobacteria (PGPR).
- Apply *Trichoderma viride/harzianum* and *Pseudomonas fluorescens* as seed/seedling/planting material, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

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

Ecological engineering plants

Attractant plants


Cluster bean


Cowpea


Carrot


Sunflower


Buckwheat


French bean


Alfalfa


Maize


Mustard


Coreopsis spp.


Cosmos


Dandelion


Anise


Caraway


Dill


Parsley


Marigold


Ryegrass

Repellent plants

***Ocimum* spp.**

Peppermint

Border plants

Sorghum

Maize

Bajra

Intercrops

Wheat

Barley

Sorghum

Coriander

The flowering plants suggested under Ecological Engineering for pest management strategy are known as attractant plants to the natural enemies of the selected pests. The information is based on published research literature. However, the actual selection of flowering plants could be based on availability, agro-climatic conditions and soil types

Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators

Biodiversity of natural enemies: Spiders

IV. CROP STAGE-WISE IPM

Management	Activity
Pre-sowing*	
	Common cultural practices: • Deep summer ploughing to control juveniles and adults of nematodes, and resting stages of insect pests. • Follow crop rotation with non-host crops • Destroy the alternate host plants • Sow the ecological engineering plants • Sow sorghum/maize/bajra in 4 rows all around the main crop as a guard/barrier crop
Nutrients	• Nutrients should be applied based on the soil test report and recommendations for the particular agro-climatic zone. • In preceding *kharif* season, grow soybean/ mungbean/ cowpea etc. pulse crops. • Generally, safflower crop remove 25 – 30 Kg N, 12-15 Kg P_2O_5, 15-20 Kg K_2O and 10-15 Kg S per acre. • Add well decomposed FYM @ 4 t/ acre or vermicompost @ 2 t/ acre treated with *Trichoderma* spp. and VAM. • Incorporate treated FYM at the time of field preparation at 2 to 3 weeks before sowing and vermicompost at 1 week before sowing. • Application of sulphur @ 6-18 Kg/acre significantly increases yield
Weeds	• Summer deep ploughing • In *kharif* fallow fields, check the weed growth by harrowing during monsoon rains. • At the time of field preparation, adopt stale seed bed technique to minimize the weeds menace in the field
Seed sowing*	
Nutrients	**Common cultural practices:** • Use resistant/tolerant varieties • Use healthy, certified, weed seed free seeds • Timely sowing should be done. • Nitrogen is applied in two splits - ½ as basal and ½ at flowering. • At the time of sowing, apply 15-20 Kg N and 12-15 Kg P_2O_5, 12-15 Kg K_2O and 10-15 Kg S/ acre. • Under rainfed conditions, entire fertilizers are applied by drilling at sowing. • Under irrigated conditions, ½ N and whole P, K & S fertilizers are applied at sowing. • Based on soil test for micronutrient, the deficient micronutrient should be applied in soil at sowing. • Biofertilizers: Seed/seedling treatment with *Azotobacter* and phosphorous solubilizing bacteria (PSB) cultures @ 250 g each /acre seed.

Management	Activity
Weeds	• Adopt the recommended agronomic practices such as timely sowing, line sowing, proper spacing, gap filling etc. • Intercropping with chick pea/wheat/linseed/coriander may be adopted for better utilization of inter row space and suppressing the weeds as per regional recommended agronomic practices.
*Apply *Trichoderma viride/harzianum* and *Pseudomonas fluorescens* as seed/seedlings/planting material, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).	
Vegetative stage	
Nutrients	**<u>Common cultural practices:</u>** • Field sanitation and rogueing • Judicious use of fertilizers • Collect and destroy crop debris • Provide irrigation at critical stages of the crop • Avoid water logging • Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed **<u>Common mechanical practices:</u>** • Collect and destroy disease infected and insect infested plant parts • Collection and destruction of eggs and early stage larvae • Handpick the older larvae during early stages of the crop • Handpick the gregarious caterpillars and the cocoons which are found on stem and destroy them in kerosene mixed water • Use yellow sticky traps @ 4-5 trap/acre • Use light trap @ 1/acre and operate between 6 pm and 10 pm • Install pheromone traps @ 4-5/acre for monitoring adult moths activity (replace the lures with fresh lures after every 2-3 weeks) • Erect bird perches @ 20/acre for encouraging predatory birds such as King crow, common mynah etc. • Set up bonfire during evening hours at 7-8 pm **<u>Common biological practices:</u>** • Conserve natural enemies through ecological engineering • Augmentative release of natural enemies • Apply second dose (top dressing) of N i.e. 15-20 Kg N/ acre at 35 days after sowing • Micronutrient deficiency should be corrected by foliar spray of particular micronutrient i.e. foliar application of zinc 3 ppm + copper 1 ppm + boron 0.5 ppm

Management	Activity
Weeds	• Use the black plastic mulch to suppress the weeds germination and growth between the rows. • Practice one or two had tool weeding/hoeing at 25 to 30 and 45 to 50 days after sowing depending on the length of rosette period and the severity of weed infestation.
Gram pod borer/capsule borer	**Cultural control:** • Growing intercrops such as cowpea, onion, maize, coriander, urd bean etc. • Rotate the safflower crop with a non-host cereal crop such as wheat or barley, cucurbit, or cruciferous vegetable • Grow repellant plants: Ocimum/Basil • Plant ovipositional trap crops such as marigold for *Helicoverpa* • Intercropping with non-host crop like wheat or barley • Avoid chickpea as intercrop **Biological control:** • Inundatively release *Trichogramma pretiosum* @ 40,000/acre 4-5 times from flower initiation stage at weekly intervals • Application of NPV @ 100 LE/acre in combination with jaggery 1 Kg, sandovit 100 ml or Robin Blue 50 g thrice at 10-15 days interval on observing the eggs or first instar larvae in the evening hours • Apply entomopathogenic nematodes (EPNs) @ 100 crore infective juveniles of *Steinernema feltiae*/acre
Safflower caterpillar	**Cultural control:** • Intercropping with non-host crop such as wheat • Follow common cultural, mechanical and biological practices
Safflower bud fly	• Follow common cultural, mechanical and biological practices
Safflower aphid	**Cultural control:** • If the attack is observed in the border rows take control measures • Intercultural operations such as harrowing and hoeing reduce weeds such as *Parthenium hysterophorus* in safflower field which serve as alternate hosts for safflower aphids • Intercropping with sorghum, wheat and coriander reduces aphid infestation • Intercropping with niger should be avoided **Biological control:** • Release of *Chrysoperla* larva @ 2-3/plant or 70,000/acre • Spray neem oil emulsion @ 0.25% • Spray NSKE 4% **Chemical control:** • Spray acephate 75% SP @ 312 ml in 200-400 l of water/acre or dimethoate 30% EC @ 264 ml in 200-400 l of water/acre or phenthoate 2% DP @ 8,000 g/acre or quinalphos 1.5% DP @ 8,000 g/acre

Management	Activity
***Alternaria* leaf blight**	• Follow common cultural, mechanical and biological practices **Cultural control:** • Avoid growing in low-lying and flooding areas • Do not delay irrigation until the crop exhibits moisture stress symptoms
***Cercospora* leaf spot**	• Follow common cultural, mechanical and biological practices **Cultural control:** • Avoid growing in low-lying and flooding areas • Avoid continuous cropping/follow crop rotation
Powdery mildew	• Follow common cultural, mechanical and biological practices **Cultural control:** • Do not plant spineless genotypes (more susceptible)
Rust	• Follow common cultural, mechanical and biological practices **Cultural control**: • Avoid growing in low-lying areas and flooding under irrigation • Do not delay irrigation until the crop exhibits moisture stress symptoms
***Ramularia* leaf spot, root rot and wilt**	• Follow common cultural, mechanical and biological practices **Cultural control:** • Same as rust disease
Reproductive stage	
Nutrients	• Under rainfed conditions, spray cycocel @ 500 ppm using 200 l per acre water at flower initiation to get higher seed yields
Weeds	• Left over weeds should be removed from the field by manual weeding before they flowering or shedding their seeds to avoid further spread of weed seeds
Insects and diseases	• Same as in vegetative stage • Follow common cultural, mechanical and biological practices
Head rot and wilt	• Follow common cultural, mechanical and biological practices **Cultural control:** • Don't pileup the soil around the stem during rains • Follow crop rotation in heavily infested soils
Bird damage	**Cultural control:** • Cultivate safflower in large contiguous blocks • Safeguard the crop through bird scaring objects

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

V. INSECTICIDE RESISTANCE AND ITS MANAGEMENT

Insecticide resistance: Resistance to insecticides may be defined as 'a heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species' (IRAC). Cross-resistance occurs when resistance to one insecticide confers resistance to another insecticide, even where the insect has not been exposed to the latter product.

Causes of resistance development: The causes and rate at which insecticide resistance develops depend on several factors, including the initial frequency of resistance alleles present in the population, how rapidly the insects reproduce, the insects' level of resistance, the migration and host range of the insects, the insecticide's persistence and specificity, and the rate, timing and number of applications of insecticide made. For instance, insect pests that survive in large populations and breed quickly are at greater advantage of evolving insecticide, especially when insecticides are misused or over-used.

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

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

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

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

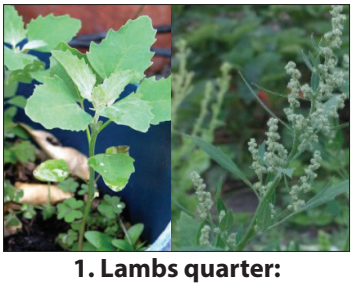
4) Take an integrated approach to managing pests: Use as many different control measures as possible viz., cultural, mechanical, physical, biological etc. Select insecticides with care and consider the impact on future pest populations and the environment. Avoid broad-spectrum insecticides when a narrow-spectrum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

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

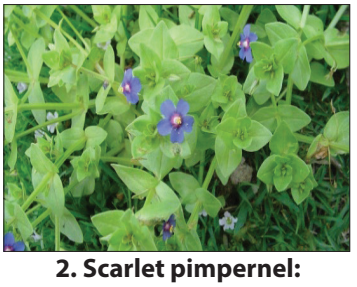
6) Alternate different insecticide classes: Avoid the repeated use of the same insecticide, insecticides in the same chemical class, or insecticides in different classes with same mode of action and rotate/alternate insecticide classes and modes of action.

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

VI. COMMON WEEDS



1. Lambs quarter:
***Chenopodium album* L.**
(Chenopodiaceae)



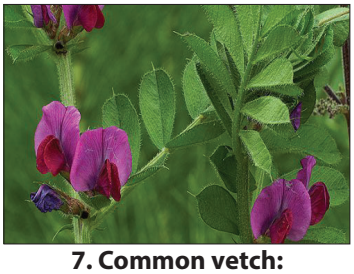
2. Scarlet pimpernel:
***Anagallis arvensis* L.**
(Primulaceae)

3. Sweet clover:
***Melilotus indica* (L.) All.**
(Fabaceae)

4. Fine leaf fumitory:
Fumaria parviflora **Lam.**
(Fumariaceae)

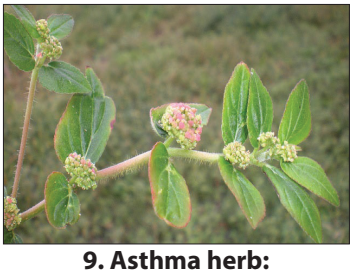
5. Corn spurry:
Spergula arvensis **L.**
(Caryophyllaceae)

6. Onionweed:
Asphodelus tenuifolius **Cav.**
(Asphodelaceae)

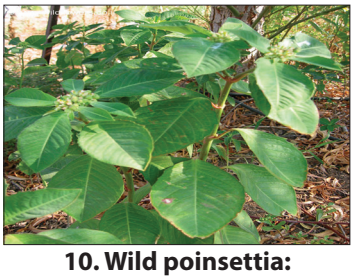


7. Common vetch:
Vicia sativa **L.**
(Fabaceae)

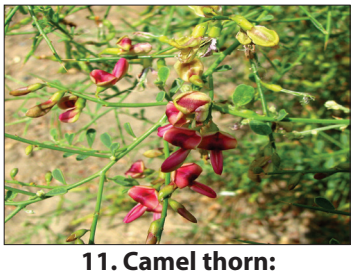
8. Wild safflower:
Carthmus oxycantha **M. Bieb.**
(Asteraceae)



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



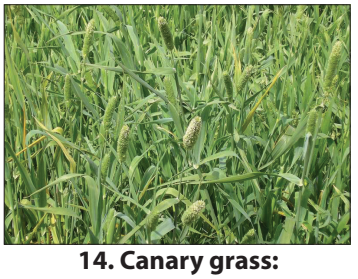
10. Wild poinsettia:
Euphorbia zeniculata **Ortega**
(Euphorbiaceae)



11. Camel thorn:
Alhagi maurorum **Kedik.**
(Fabaceae)

12. Field bindweed:
Convolvulus arvensis **L.**
(Convolvulaceae)

13. Blue grass:
Poa annua **L.**
(Poaceae)

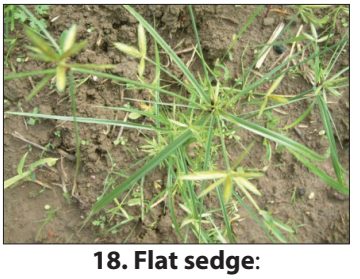


14. Canary grass:
Phalaris minor **Retz.**
(Poaceae)

15. Bermuda grass:
Cynadon dactylon **(L.)**
(Poaceae)

16. Annual beard grass/
annul rabbits foot grass:
Polypogon monspliensis
(L.) Desf. (Poaceae)

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



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

VII. DESCRIPTION OF INSECT PESTS

1) Gram pod borer:

Biology:

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

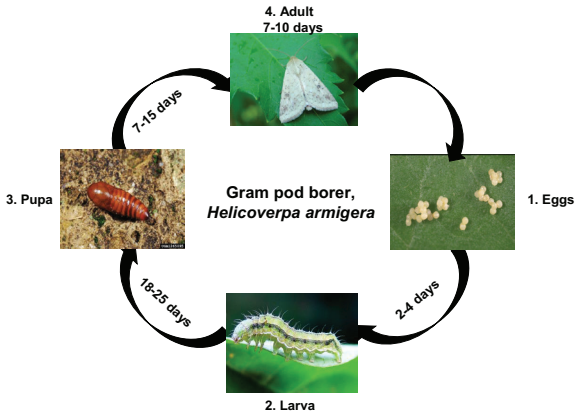
Egg: Spherical, yellowish eggs are laid singly on tender parts and buds of plants. The egg period lasts for 2-4 days.

Larva: Caterpillars are of varying colour, initially brown and later turn greenish with darker broken lines along the side of the body. Body covered with radiating hairs. When full grown, they measure 3.7 to 5 cm in length. The larval period lasts for 18-25 days. The full grown caterpillar pupates in the soil.

Pupa: Pupation takes place inside the soil in an earthen cell. Pupal stage lasts 7-15 days.

Adult: Moth is stout, medium sized with brownish/greyish forewings with a dark cross band near outer margin and dark spots near costal margins, with a wing expanse of 3.7cm.

Life cycle:



Damage symptoms:

- In early stage of crop growth larvae feed on leaves and shoot apices.
- Later, the larvae shift to the developing capitula.
- The symptoms are perforated leaves, perforated involucral bracts, partially or completely eaten capitula in the bud stage and bored developing capitula.

Natural enemies of gram pod borer:

Parasitoids: *Trichogramma* spp., *Tetrastichus* spp., *Telenomus* spp., *Chelonus* spp., *Microchelonus curvimaculatus*, *Enicospilus* sp, *Eriborus argenteopilosus*, *Bracon* spp., *Ichneumon* spp., *Carcelia illota*, *Palexorista solennis*, *Sturmiopsis inferens*, *Goniophthalmus halli*, *Campoletis chlorideae* etc.

Predators: Lacewing, ladybug beetle, reduviid bug, spider, red ant, robber fly, black drongo (King crow), common mynah, big-eyed bug (*Geocoris* sp), earwig, ground beetle, pentatomid bug (*Eocanthecona furcellata*), preying mantis etc.

*For the management refer page number 16

2) Safflower caterpillar:

The insect occurs throughout India. It is a regular pest of safflower

Biology:

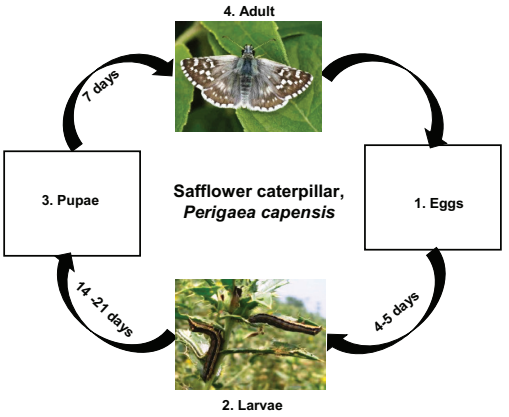
Egg: The female lays an average of 345-371 green coloured eggs either singly or in clusters on the crop foliage. The incubation period varies from 4 to 5 days.

Larva: The larval duration varies from 2-3 weeks.

Pupa: The pest pupate in soil and it last about a week.

Adult: The adult is a dark brown in colour, medium sized moth with pale wavy marks on forewings. Caterpillar is stout, green and smooth. The anal segment is humped and the body has some purple markings.

Life cycle:



2.http://oilseeds.agropedia.in/content/safflower-safflower-caterpillar-insect-pests;4.http://www.wildlifeinsight.com/Insight/?page_id=11561

*For the management refer page number 16

Damage symptoms:

- The larva feeds on the leaves and sometimes on capitulum too.
- It also feeds on bracts, flowers, capsule Enormous yield losses of 62.6 to 100% have been encountered due to excessive foliage feeding by a large number of larvae.

Natural enemies of safflower caterpillar:

Parasitoids: *Apanteles ruficrus, Rogas percurrens, Euplectrus euplexiae, Eriborus argenteopilosus, Pteromalus* sp etc.

Predators: Lacewing, ladybug beetle, reduviid bug, spider, red ant, robber fly, black drongo (King crow), common mynah, big-eyed bug (*Geocoris* sp), earwig, ground beetle, pentatomid bug (*Eocanthecona furcellata*), preying mantis etc.

3) Safflower fly/capsule bud fly:

Biology:

Egg: Eggs are laid in clusters of 6 to 24 which hatch in a day.

Pupa: Pupation takes place in flower buds.

Adult: The adult flies are ash coloured with light brown legs.

The flies are active during March and infestation of flower buds takes place after a week.

Adult

http://www.biolib.cz/en/image/id109297/

Damage symptoms:

- Newly hatched maggots feed on the soft parts (ovaries of florets and thalami of capitula) of capsules and later instars feed on the soft part within.
- The infested buds rot and give an offensive smelling fluid.

Natural enemies of safflower fly/capsule bud fly:

Parasitoids: *Orymurus* sp., *Eurytoma* sp, *Bracon* spp. etc.

Predators: Lacewing, ladybug beetle, reduviid bug, spider, red ant, robber fly, black drongo (King crow), common mynah, big-eyed bug (*Geocoris* sp), earwig, ground beetle, pentatomid bug (*Eocanthecona furcellata*), preying mantis etc.

*For the management refer page number 16

4) Safflower aphid:

Both nymphs and adults when on stem are found with their head directed towards the soil. Alate and apterous forms are commonly seen an aphid colony. The alates are found in the beginning of the season (November-December) and again towards the maturity of the crop, while apterous forms are abundantly found between the two extremes mentioned above.

Biology:

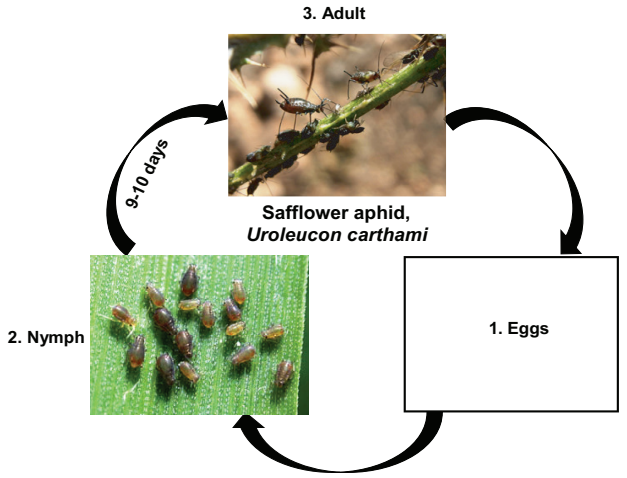
An asexual-viviparous mode of reproduction is reported in this aphid species.

Nymph: Nymphs are reddish brown. Nymphal stage with four instars lasted in an average of 9.34 days.

Adult: Aphids are soft bodied insects and 1.5 to 2 mm in length.

Adults are large sized, black with pear-shaped body and conspicuous cornicles, winged or wingless. An average fecundity of 89 offsprings per female has been reported. Adult longevity, pre-reproductive and reproductive periods last for 14.9, 1.28 and 14.6 days, respectively.

Life cycle:



Damage symptoms:

- During pre-flowering stage both nymphs and adults suck the cell sap from shoot apices, peduncles, leaves and stem, secrete a honey dew like secretion on upper surface of the leaves and plant parts forming a black sooty mold which hinders photosynthetic activity resulting in stunted growth.
- Finally the plants dry up.
- Honey dew excreted gets deposited on the upper surface of the leaves, on which sooty molds grow and hinder the photosynthesis, resulting in stunted growth and poor yields.
- In case of heavy infestation the plants dry and die. Infestation may start even when the crop is 15 days old.
- About 40-50% yield losses are observed due to this insect.
- Infestation may occur 30-45 days old crop.

2. http://extension.entm.purdue.edu/pestcrop/2006/issue23/;3. http://bichosdepuertollano.wordpress.com/insectos/hemipteros/aphididae/uroleucon-mordvilko-1914/

Natural enemies of safflower aphid:

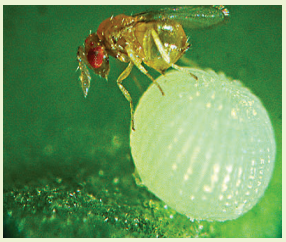
Parasitoids: *Aphelinus* sp, *Aphidencyrtus aphidivorus, Pseudendaphis* sp

Predators: Lacewing, ladybug beetles (*Coccinella arcuta*, *Micromus cinearis*, *Ischiodon scutellaris*, *Harmonia octomacuiata*, *Coccinella repanda*), reduviid bug, spider, red ant, robber fly, hover fly, big-eyed bug (*Geocoris* sp), earwig, ground beetle, pentatomid bug (*Eocanthecona furcellata*), preying mantis etc.

*For the management refer page number 16

Natural Enemies of Safflower Insect Pests
Parasitoids

Egg parasitoids:



1. *Trichogramma* spp.

2. *Tetrastichus* spp.

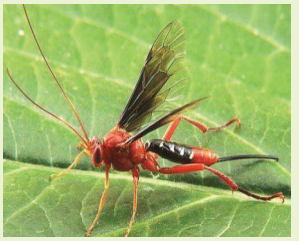
3. *Telenomus* spp.

Egg-larval parasitoids:

4. *Chelonus* spp.

Larval parasitoids:

5. *Bracon* spp.



6. *Ichneumon* spp.

7. *Carcelia* spp.

8. *Campoletis* spp.

9. *Enicospilus* sp

10. *Eriborus argenteopilosus*

11. *Palexorista solennis*

Nymphal and adult parasitoids:

12. *Aphelinus* sp

13. *Aphidencyrtus aphidivorus*

1. http://gsquaredbugs.com/?page_id=318; 2. http://www.pbase.com/image/135529248; 3. http://baba-insects.blogspot.in/2012/02/telenomus.html; 4. http://www.nbaii.res.in/Featured%20insects/chelonus.htm; 5. http://www.nbaii.res.in/Featured%20insects/Bracon%20brevicornis.htm; 6. http://www.organicgardeninfo.com/ichneumon-wasp.html; 7. http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398; 8. http://www.nbaii.res.in/Featured%20insects/Campoletis.htm; 9. http://www.pbase.com/stuartwilson/image/111751079; 10. http://www.nbaii.res.in/Featured%20insects/Eriborusargent.htm; 11. http://www.hkwildlife.net/viewthread.php?tid=66490; 12. http://taxondiversity.fieldofscience.com/2013/05/aphelinus.html; 13. http://elhocino-adra.blogspot.in/2010/12/por-que-falla-el-aphidius.html

Predators

1. Lacewing

2. Ladybird beetle

3. Reduviid bug

4. Spider

5. Robber fly

6. Red ant

7. Black drongo

8. Common mynah

9. Big-eyed bug

10. Earwig

11. Ground beetle

12. Pentatomid bug

13. Preying mantis

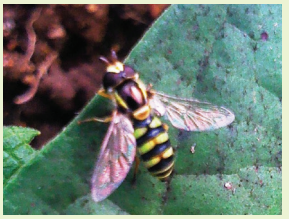
14. Wing beetle

15. Predatory mite

16. Predatory thrips

17. *Oligota* spp.

18. *Orius* spp.



19. Hover fly

20. Mirid bug

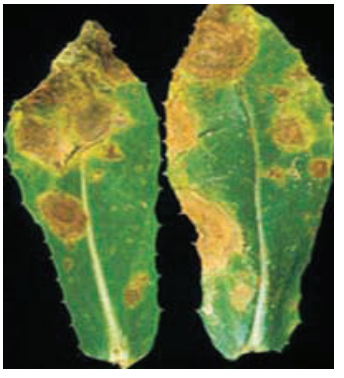
5. http://www.warpedphotosblog.com/robber-fly-and-prey; 6. http://www.couriermail.com.au/news/queensland/queensland-launched-a-war-against-the-fire-ant-invasion-but-12-years-later-they8217re-still-on-the-march/story-fnihsrf2-1226686256021; 7. http://nagpurbirds.org/blackdrongo/picture/1639; 8. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/; 9. http://bugguide.net/node/view/598529; 10. http://www.flickr.com/photos/johnhallmen/2901162091/; 11. http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/Ground%20Beetle%20-%20Pterostichus%20madidus.html; 12. http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asopinae/Eocanthecona.htm; 13. http://spirit-animals.com/praying-mantis/; 14. http://nathistoc.bio.uci.edu/hemipt/Dicyphus.htm; 15. http://www.dragonfli.co.uk/natural-pest-control/natural-enemies; 16. http://biocontrol.ucr.edu/hoddle/persea_mite.html; 17. http://www.fugleognatur.dk/forum/show_message.asp?MessageID=560188&ForumID=33; 18. http://en.wikipedia.org/wiki/File:Orius_insidiosus_from_USDA_2_(cropped).jpg; 20. http://www.britishbugs.org.uk/heteroptera/Miridae/blepharidopterus_angulatus.html

VIII. DESCRIPTION OF DISEASES

1) *Alternaria* blight:

Disease symptoms:

- It is the most destructive disease.
- Dark necrotic lesions 2-5 mm in diameter are formed first on hypocotyls and cotyledons.
- In mature plants, small brown to dark brown concentric spots of 1-2 mm appear on leaves.
- Symptoms also appear on stem and severely infected plant gets blighted.
- Brown discolouration appears on the stem, dark brown spots with concentric rings up to 1 cm in diameter appear on the leaves which later develop into large lesions.
- Seeds also may be affected. Dark sunken lesions are produced on the testa. It may rot and damping off of seedlings occur.



Disease symptoms

Survival and spread:

- The disease is externally and internally seed borne. The pathogen survives through spores (conidia) or mycelium in diseased plant debris or weed.

Favourable conditions:

- Moist (more than 70% relative humidity) and warm weather (12-25 ºC) and intermittent rains favours disease development.

*For the management refer page number 17

2) *Cercospora* leaf spot:

Disease symptoms:

- Safflower plants few weeks after planting or at flowering stage are commonly attacked.
- Circular to irregular brown sunken spots of 3-10 mm diameter are formed on leaves.
- Spots are surrounded by yellow halos.
- Symptoms first appear on lower leaves and spread to upper leaves.
- Stems and nodes may also be affected.
- In severe infections bracts are also affected with reddish brown spots.
- Affected flower buds turn brown and die.

Disease symptoms

Survival and spread:

- The fungus survives in seed and affected plant debris and spreads through wind borne spores.

Favourable conditions:

- Warm humid weather favours the disease development.

https://www.google.co.in/search?q=cercospora+leaf+spot+of+safflower&espv=210&es_sm=93&source=lnms&tbm=isch&sa=X&ei=NqDoUqWmFYOCrAf4lYCI

*For the management refer page number 17

3) Powdery mildew:

Disease symptoms:

- The disease is characterized by whitish powdery growth on leaves
- Later the fungus spreads over the entire leaf. Leaves turn yellow and dry up

Survival and spread:

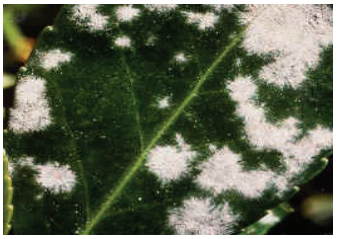
- The pathogen survives as oospores on the affected plant tissues and on weed hosts

Favourable conditions:

- Cool (10-20ºC) and wet weather (90% RH) favours disease development

1.http://ag.arizona.edu/pubs/diseases/az1124/;2.http://agritech.tnau.ac.in/crop_protection/crop_prot_crop%20diseases_oilseeds_safflower.html

*For the management refer page number 17



Disease symptoms

4) Head rot and wilt:

Disease symptoms:

- Plants become yellowish, turn brown and ultimately die
- Large black sclerotia of the fungus are formed on the crown inside the stem, floral heads and adjoining roots
- Shredding of the stem takes place

*For the management refer page number 17

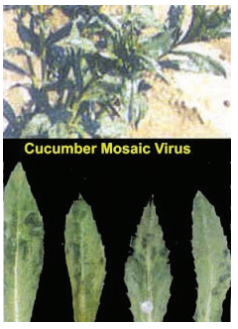
5) Mosaic:

Disease symptoms:

- In CMV infected safflower plants young leaves show irregular yellow or light patches alternating with normal green areas.
- Leaves may become blistered and distorted and infected plants are stunted.
- In few plants primary leaves are produced, forming a rosette of leaves exhibiting mosaic mottling and from the centre of this, the axis bearing secondary leaves are produced.

Transmission and favourable conditions

- The disease is transmitted in semi persistent manner by aphid *Aphis gossypii*.
- Aphids are more active in warm summer conditions and increased their population as well as spread the viruses more.



http://mrgoutham.blogspot.in/2011/05/safflower-disease-photo-gallery_24.html;

Disease symptoms

6) *Ramularia* leaf spot:

Disease symptoms:

- Round and irregular spots of 100 mm or more in diameter occur on both sides of leaves
- Whitish dense mass of conidia remain at the center which reflects light, dry spots are brown in color

http://agropedia.iitk.ac.in/content/safflower-ramularia-leaf-spot

*For the management refer page number 17

Disease symptoms

7) Rust:

Disease symptoms:

- Seedling infection causes twisting towards one side
- Chesnut brown postules are formed on hypocotyl leading to collapse of seedling
- On older plants girdling and hypertrophy of the stem base may occur
- Small powdery chesnut brown postules of 1-2 mm in size develop on leaf surface which later turn black

*For the management refer page number 17

Disease symptoms

http://www.forestryimages.org/browse/detail.cfm?imgnum=5408122

8) Wilt:

Disease symptoms:

- Yellowing of leaves on one side of plant starts particularly from lower leaves followed by wilting the progresses upwards
- Lesion at soil line is first symptom noticed which extends inside and affects the vascular system
- Plant starts to wilt, drooping more often
- Infected heads have aborted seed

http://agropedia.iitk.ac.in/content/safflower-wilt

*For the management refer page number 17

Disease symptoms

9) Root rot:

Disease symptoms:

- Dark cortical lesions occur slightly below or at the soil level on the stem, which later extend upwards
- Lesions frequently girdle the stem
- Root development is reduced and finally seedlings die

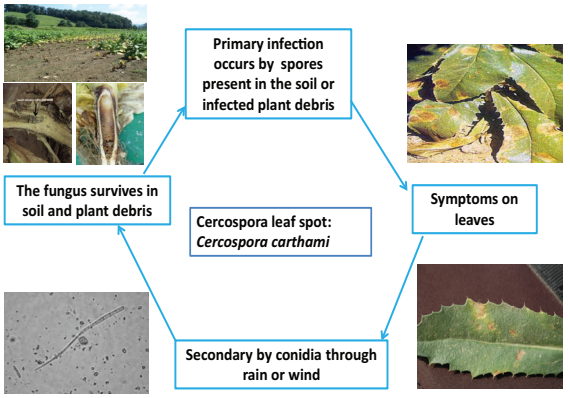
http://oilseeds.agropedia.in/content/safflower-root-rot-disease

*For the management refer page number 17

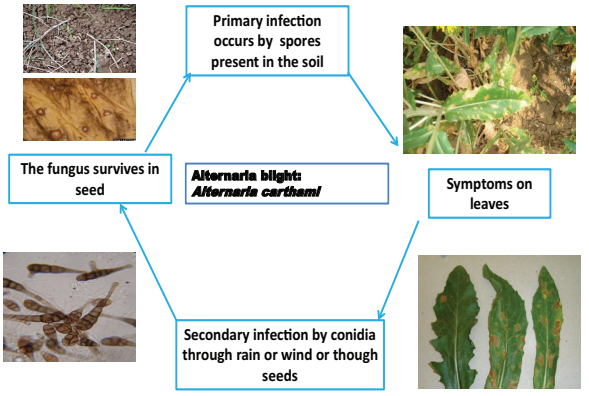
Disease symptoms

Disease cycle:

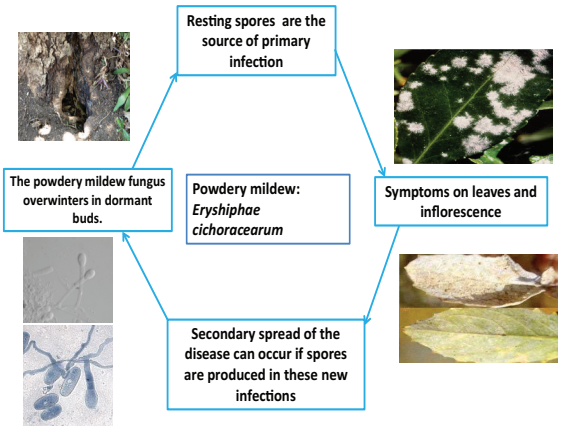
1. *Cercospora* leaf spot:



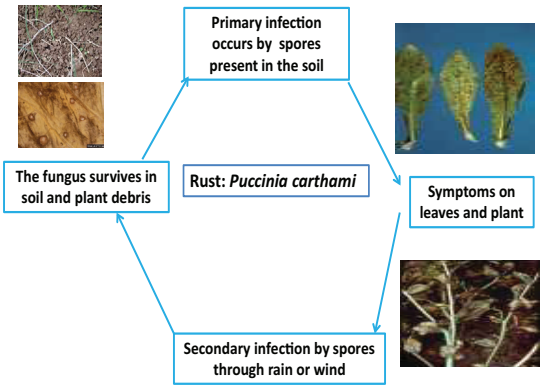
2. *Alternaria* blight:



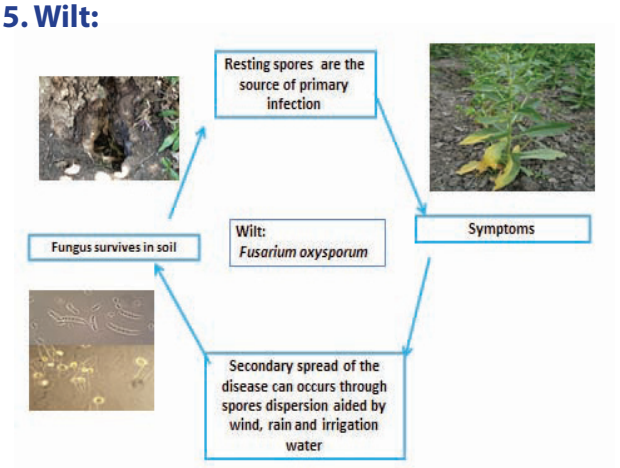
3. Powdery mildew:



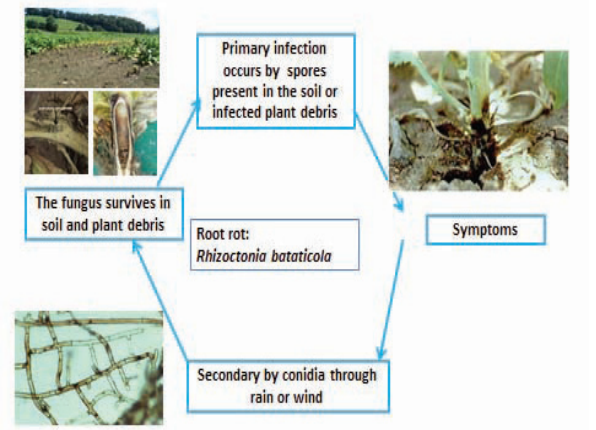
4. Rust:



5. Wilt:



6. Root rot



IX. SAFETY MEASURES

A. At the time of harvest

The crop is ready for harvest when the leaves and most of the bracteoles except a few on last formed flower head become dry and brown. Harvest the crop preferably in the early hours when shattering would be minimum and spines relatively soft. Cut the plants with the help of sickles at the base or wherever possible uproot (black soil) by pulling and stack them in the field in the form of small and well pressed heaps until they are fully dried.

X. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The field should be kept exposed to sun light at least for 2-3 weeks.	Do not plant or irrigate the field after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/ or rhizomes of perennial weeds.
2.	Adopt crop rotation.	Avoid monocropping.
3.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
4.	Sow early in the season.	Avoid late sowing as this may lead to reduced yields and incidence of white grubs and diseases.
5.	Always treat the seeds with approved chemicals/ biopesticide for the control of seed borne diseases/ pests.	Do not use seeds without seed treatment with biopesticide/chemicals.
6.	Sow in rows at optimum depths under proper moisture conditions for better establishment.	Do not sow seeds beyond 5-7 cm depth.
7.	Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
8.	Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition.	Crops should not be exposed to moisture deficit stress at their critical growth stages.
9.	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
10.	Use micronutrient mixture after sowing based on test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
11.	Conduct weekly AESA in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.	Do not take any management decision without considering AESA and P: D ratio.
12.	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
13.	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per field observation.	Do not apply chemical pesticides within seven days of release of parasitoids.
14.	Apply *Ha*NPV at recommended dose when a large number of egg masses and early instar larvae are noticed. Apply NPV only in evening hours after 5 pm.	Do not apply NPV on late instar larva and during day time.
15.	In case of pests which are active during night spray recommended biopesticides/ chemicals at the time of their appearance in the evening.	Do not spray pesticides at midday since, most of the insects are not active during this period.
16.	Spray pesticides thoroughly to treat the undersurface of the leaves.	Do not spray pesticides only on the upper surface of leaves.
17.	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
18.	Follow the recommended procedure of trap crop technology.	Do not apply long persistent pesticides on trap crop, otherwise it may not attract the pests and natural enemies.

XI. SAFETY PARAMETERS IN PESTICIDE USAGE

S. No.	Pesticide; Classification as per insecticide rules 1971; Colour of toxicity triangle	WHO classification of hazard	Symptoms of poisoning	First aid measures; Treatment of poisoning	Harvesting period (days)
Organophosphate insecticides					
1.	Dimethoate Highly toxic 	Class II Moderately hazardous	Mild-anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity	**First air measures:** Rush the victim to the nearest physician **Treatment of poisoning:** For extreme symptoms of OP poisoning, injection of atropine (2-4 mg for adults, 0.5-1.0 mg for children) is recommended. Repeated at 5-10 minute intervals until signs of atropinization occur.	--

XII. 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** store expose to sunlight or rain water; **Do not** weedicides along with other pesticides
4. Never keep them together with food or feed/fodder.
5. Keep away from reach of children and livestock.

C. Handling

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

D. Precautions for preparing spray solution

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

E. Equipments

1. Select right kind of equipment.
2. **Do not** use leaky and defective equipments
3. Select right kind of nozzles
4. Don't blow/clean clogged nozzle with mouth. Use old tooth brush tied with the sprayer and clean with water.
5. **Do not** use same sprayer for weedicide and insecticide.

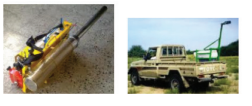
F. Precautions for applying pesticides

1. Apply only at recommended dose and dilution
2. **Do not** apply on hot sunny day or strong windy condition; **Do not** apply just before the rains and after the rains; **Do not** apply against the windy direction
3. Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer
4. Wash the sprayer and buckets etc with soap water after spraying
5. Containers buckets etc used for mixing pesticides should not be used for domestic purpose
6. Avoid entry of animals and workers in the field immediately after spraying
7. Avoid tank mixing of different pesticides

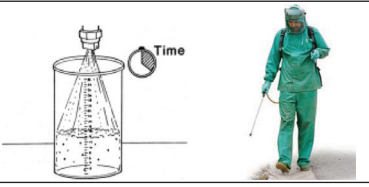
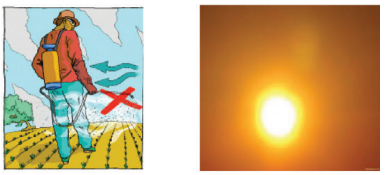
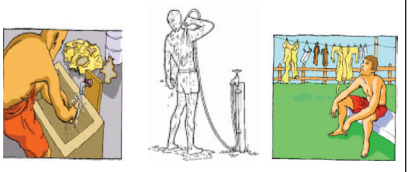
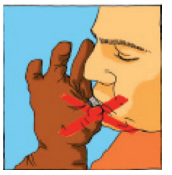
G. Disposal

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

XIII. PESTICIDE APPLICATION TECHNIQUES

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

XIV. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

1.	For application rate and dosage see the label and leaflet of the particular pesticide.	
2.	It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.	
3.	Clean and wash the machines and nozzles and store in dry place after use.	
4.	It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides. Do not apply pesticides without protective clothing and wash clothes immediately after spray application.	
5.	Do not apply in hot or windy conditions.	
6.	Operator should maintain normal walking speed while undertaking application.	
7.	Do not smoke, chew or eat while undertaking the spraying operation.	
8.	Operator should take proper bath with soap after completing spraying.	
9.	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

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Ecological Engineering Plants for Safflower

Alfalfa

Cowpea

Carrot

Sunflower

Buckwheat

French bean

Mustard

Parsley

Dill

Spearmint

Caraway

Maize

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

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