AESA BASED IPM PACKAGE
SUNFLOWER

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

National Institute of Plant Health Management
Rajendranagar, Hyderabad, Telangana

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

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

Pests

Defenders

Ministry of Agriculture & Farmers Welfare
Balaji Scan Pvt. Ltd., Tel : 040-2330 3424
Important Natural Enemies of Sunflower Insect & Mite Pests

Parasitoids
- *Trichogramma* spp.
- *Cercela* spp.
- *Campoletis* spp.
- *Chelonus* spp.
- *Encarsia formosa*
- *Eretmocerus* spp.

Predators
- Robber fly
- Earwig
- Ladybird beetle
- Mirid bug
- Praying mantis
- Black drongo

Plants Suitable for Ecological Engineering in Sunflower Field
- Alfalfa
- French bean
- *Ocimum* spp.
- Cosmos
- Spearmint
- Mustard
- Marigold
- Carrot
- Castor
- Cowpea
- Buckwheat
- Maize
The AESA based IPM - Sunflower, 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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FOREWORD

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

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

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

Date: 6.3.2014

(Avinash K. Srivastava)
FOREWORD

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

During the late 90s FAO started advocating Agro-Ecosystem Analysis (AESA) based IPM. Experience in different countries have 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)
PREFACE

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

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

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

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

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

(K. SATYAGOPAL)
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**AESA BASED IPM PACKAGE FOR SUNFLOWER**

Sunflower- Plant description:

Sunflower (*Helianthus annuus* L., Family: Compositae) is one of the four most important annual crops in the world grown for oil along with soybean, rapeseed and groundnut. It is an important addition to the list of edible oilseed crops in India in the last four decades. Sunflowers are usually tall annuals, that grow to a height of 50–390 cm. The rough and hairy stem is branched in the upper part in wild plants but is usually unbranched in domesticated cultivars. The petiolate leaves are dentate and often sticky. The lower leaves are opposite, ovate or often heart-shaped. The upper leaves are alternate and narrower. They bear one or several to many wide, terminal capitula (flower heads), with bright yellow ray florets at the outside and yellow or maroon (also known as a brown/red) disc florets inside. The flower head is large disc outer reaching 10-30 cm diam. The outer florates are sterile and produce outer petals of the flower head, while the inner florate will mature into seeds in the central disc. Several ornamental cultivars have red-colored ray florets; all of them stem from a single original mutant. The genus associates the characteristic heliotropism exhibited during the flower period and *Helianthus annuus* was so named by Linnaeus, who encountered sunflowers living only for one season. The primary uses of sunflower are for human consumption. The consumption of oil from the seed and use of non-oilseed sunflower are the predominant uses of sunflower products worldwide. There is growing interest for non-oilseed sunflower as snack food in the developed economies. Sunflower also yields natural red food colorant derived from purple-hulled sunflower, flour and protein isolates for food products, pectin and sunflower oil as an energy source in fuels.
I. PESTS

A. Pests of National Significance

1. Insect and mite pests
   1.1 Tobacco caterpillar: Spodoptera litura Fabricius (Lepidoptera: Noctuidae)
   1.2 Head/capitulum/gram pod borer: Helicoverpa armigera Hübner (Lepidoptera: Noctuidae)
   1.3 Jassid: Amrasca biguttula biguttula Ishida (Hemiptera: Cicadellidae)
   1.4 Thrips: Scirtothrips dorsalis Hood (Thysanoptera: Thripidae)
   1.5 Green semilooper: Thysanoplusia orichalcea Fabricius (Lepidoptera: Noctuidae)
   1.6 Cabbage semilooper: Trichoplusia ni (Hubner) (Lepidoptera: Noctuidae)
   1.7 Bihar hairy caterpillar: Spilosoma obliqua Walker (Lepidoptera: Arctiidae)
   1.8 Cutworm: Agrotis ipsilon Rott (Lepidoptera: Noctuidae)
   1.9 Mealybug: Phenacoccus solenopsis Tinsley (Hemiptera: Pseudococcidae)
   1.10 Termites: Odontotermes obesus (Rambur) & Microtermes obesi Hol (Isoptera: Termitidae)

2. Diseases
   2.1 Alternaria leaf spot: Alternaria helianthi (Hansf.) Tubaki & Nishi
   2.2 Sunflower necrosis disease: Tobacco Streak Virus
   2.3 Downy mildew: Plasmopara halstedii Farl. Berl. & De Toni
   2.4 Rust: Puccinia helianthi Schwein
   2.5 Sclerotium wilt: Sclerotium rolfsii Sacc
   2.6 Charcoal rot: Macrophomina phaseolina (Tassi) Goid
   2.7 Sclerotinia wilt and rot: Sclerotinia sclerotiorum (Lib.) de Bary
   2.8 Septoria leaf spot: Septoria helianthi Ellis & Keller
   2.9 Verticillium wilt: Verticillium dahliae Kleb
   2.10 Yellow blotch disease
   2.11 Leaf crinkle disease

B. Pests of Regional Significance

1. Insect pests
   1.1 Whitefly: Bemisia tabaci Gennadius (Hemiptera: Aleyrodidae)
   1.2 Armyworm: Spodoptera exigua (Hubner) (Lepidoptera: Noctuidae)

2. Diseases
   2.1 Head rot: Rhizopus arrhizus Fischer
   2.2 Powdery mildew: Erysiphe cichoracearum f.sp. helianthi DC ex Meret and Sphaerotheca fuliginea (Schlecht.ex Fr) Pollacci

3. Weeds
   Broadleaf
   3.1 False amaranth: Digera arvensis Forsk (Amaranthaceae)
   3.2 Pigweed: Amaranthus viridis Hook. F. (Amaranthaceae)
   3.3 Swine cress: Coronopus didymus L. Sm. (Brassicaceae)
   3.4 Black nightshade: Solanum nigrum L. (Solanaceae)
   3.5 Common purselane: Portulaca oleracea L. (Portulacaceae)
   3.6 Carrot grass: Parthenium hysterophorus L. (Asteraceae)
   3.7 Tropical spiderwort: Commelina benghalensis L. (Commelinaceae)
   3.8 Stonebreaker: Phyllanthus niruri L. (Phyllanthaceae)
   3.9 Silver cockscob: Celosia argentea L. (Amaranthaceae)
   3.10 Devil's horsewhip: Achyranthes aspera L. (Amaranthaceae)
Grasses
3.11 Rabbit/crow foot grass: Dactyloctenium aegyptium Willd (Poaceae)
3.12 Goose grass: Eleusine indica L. Gaertner (Poaceae)
3.13 Crab grass: Digitaria sanguinalis L. Scop (Poaceae)
3.14 Bermuda grass: Cynodon dactylon (L) Pers (Poaceae)
3.15 Cannery grass: Phalaris minor Retz. (Poaceae)
3.16 Barnyard grass: Echinochloa colona (L.) Link, E. crusgalli (L.) Honda (Poaceae)
3.17 Viper grass: Dinebra retroflexa (Vahl) Panz (Poaceae)
3.18 Sweet signal grass: Brachiaria eruciformis (Sm.) Griseb (Poaceae)

Sedges
3.19 Purple nutsedge: Cyperus rotundus L (Cyperaceae)
3.20 Rice flatsedge: Cyperus iria L (Cyperaceae)
3.21 Yellow nutsedge: Cyperus esculentus L (Cyperaceae)

4. Vertebrate pest
   Birds
   4.1 Parakeet: Psittacula krameri

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

A. AESA:

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

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

AESA is an approach, which can be gainfully employed by extension functionaries and farmers to analyze the field situations with regards to pests, defenders, soil conditions, plant health and the influence of climatic factors and their relationship for growing a healthy crop. The basic components of AESA are:
- Plant health at different stages
- Built-in compensation abilities of plants
- Pest and defender population dynamics
- Soil conditions
- Climatic factors
- Farmers past experience

Principles of AESA based IPM:

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

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

**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 Fields. Insect zoo concept can be helpful to enhance farmers’ skill to identify beneficial and harmful insects. In this method, unfamiliar/unknown insects are collected in plastic containers with brush from the Fields and brought to a place for study. Each insect is placed inside a plastic bottle together with parts of the plant and some known insect pests. Insects in the bottle are observed for certain time and determined whether the test insect is a pest (feeds on plant) or a predator (feeds on other insects).

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

Model Agro-Ecosystem Analysis Chart

Date:
Village:
Farmer:

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

Decision taken based on the analysis of field situations

Decision making:
Farmers become experts in crop management:
Farmers have to make timely decisions about the management of their Fields. AESA farmers have learned to make these decisions based on observations and analysis viz., abiotic and biotic factors of the crop ecosystem. The past experience of the farmers should also be considered for decision making. However, as field conditions of Fields 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 observations:

- **Plant growth (weekly):** Length of the plant, number of leaves
- **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 condition.

- While walking in the fields, 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 of the fields. The weather conditions, water level, disease symptoms, etc. will be shown in the drawing. Insect pests 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 of the fields is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

**Data recording:**
Farmers should record data in a notebook and drawing on a chart:

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

**Data to be recorded:**

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

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

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

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

**FFS to teach AESA based IPM skills:**

**B. Field scouting**
AESA requires skill, so only the trained farmers can undertake this exercise. However, other farmers also can do field scouting in their own field at regular intervals to monitor the major pest situation. Surveillance on pest occurrence at the main field should commence soon after crop establishment and at weekly intervals thereafter.
For insect pests:
**Whitefly and mealybug:** Count and record the number of both nymphs and adults on five randomly selected leaves per plant.

**Thrips:** Count and record the number of nymphs and adults of thrips present on five terminal leaves per plant (tapping method also can be used to count thrips).

**Spodoptera** and cutworm: Count the number of young and grown up larvae on each plant and record.

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

For diseases:
Whenever scouting, be aware that symptoms caused by different biotic factors such as fungal, bacterial, viral pathogens or abiotic factors such as weather, fertilizers, nutrient deficiencies, pesticides 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 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 into them to examine the roots for internal infections (discolouration & signs). Count the total number of roots/infested/infected due to rot should be counted and incidence should be recorded.

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

**Stem and head sampling:** Carefully examine the stems and head of plants for signs of fungal material diseases or lesions. The stems and head should be split or taken apart and examined for discoloration caused by fungi and bacteria. Count the number of stems and head infected due to disease and incidence should be recorded.

**C. Surveillance through pheromone traps catches:**
Pheromone traps for two insects viz., **Helicoverpa armigera** and **Spodoptera litura** @ 4-5 traps/acre have to be installed. 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 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** and **Spodoptera litura** / trap/week should be recorded year round. The trapped moths should be destroyed and removed after each recording.

**D. Yellow/ blue pan water/ sticky trap:**
Set up yellow pan water/sticky traps 15 cm above the canopy for monitoring whitefly and blue sticky trap for thrips @ 4-5 traps/acre. Locally available empty tins can be painted yellow/ 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).
III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

Ecological Engineering for Pest Management – Below Ground:
There is a growing realization that the soil borne, seed and seedling borne diseases can be managed with microbial interventions, besides choosing appropriate plant varieties. The following activities increase the beneficial microbial population and enhance soil fertility.

- Keep soils covered year-round with live vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost and crop residue which enhance below ground biodiversity of beneficial microbes and insects.
- Application of balanced dose of nutrients using biofertilizers based on soil test report.
- Application of biofertilizers with special focus on mycorrhiza and plant growth promoting rhizobia (PGPR)
- Application of *Trichoderma harzianum/viride* and *Pseudomonas fluorescens* for treatment of seeds/seedlings/planting materials in the nurseries and field (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

Ecological Engineering for Pest Management – Above Ground:
Natural enemies play a very significant role in control of foliar insect pests. Natural enemy diversity contributes significantly to management of insect pests both below and above ground.

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

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

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

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

Attractant Plants

- Cowpea
- Carrot
- Marigold
- Buckwheat
- French bean
- Alfalfa
- Mustard
- Cosmos
- Anise
- Caraway
- Dill
- Dandelion
- Parsley
- White clover
- Tansy
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 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

<table>
<thead>
<tr>
<th>Pest</th>
<th>Tolerant/ Resistant Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistant Hybrids to Powdery mildew</td>
<td>KBSH-53</td>
</tr>
</tbody>
</table>

* For detailed information and further updates nearest KVK/State department/SAU / ICAR Institute may be contacted

### V. CROP STAGE-WISE IPM

<table>
<thead>
<tr>
<th>Management</th>
<th>Activity</th>
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<tbody>
<tr>
<td>Pre-sowing*</td>
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</tbody>
</table>

**Common cultural practices:**
- Deep ploughing during summer exposes the pests and weeds to high temperature and reduces their load present in the soil.
- Keeping field bunds and crop free of weeds to avoid high pest load as it favours the pest build up on the main crop.
- Crop rotation of 3-4 years reduces soil borne diseases
- Timely sowing should be done.

**Nutrients**
- Incorporate 3-4 t/acre of well decomposed FYM or compost or crop residues 2-3 week prior to sowing.
- Do not leave FYM or compost exposed to sunlight as nutrients may be lost.
- Apply adequate and balanced nutrients along with organics as per soil test report.

**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. Adopt integrated weed management to reduce weed competition.

**Soil borne diseases**

**Cultural control:**
- Uproot and burn infected plants early enough to avoid spread of the disease.
- Effective weed control.
- Maintain good fertility levels.
- Place the seeds at a depth of 3 cm along the furrows in which the fertilizer mixture is placed and cover with soil. Put two seeds per hole at the rate of 1.6-2.8 Kg/acre based on irrigated and rainfed land.

**Thrips**

**Cultural control:**
- Follow common cultural, mechanical and biological practices (see page no. 13, 14, 15).
- Mixed cropping of sunflower with cotton
- Growing of sorghum/pearl millet/maize 10 days before sowing of main crop 3-5 rows as a barrier against thrips

**Termites**

**Cultural control:**
- Destroying queen by digging it out from the termitorium in red soil areas.
- Field sanitation and use of fully decomposed FYM mixed with wood ash will reduce termite activity

**Biological control:**
- Entomopathogenic nematodes (EPNs) can be sprayed at the rate of 100 million nematodes per acre, in termite infested field.

**Sowing/seedling**

**Common cultural practices:**
- Application of balanced dose of NPK fertilizers
- Use healthy, clean, quality, certified and weed free seeds.
- Collection and destruction of plant parts.
- Timely sowing with recommended spacing
- Use tolerant/resistant varieties
- Sow trap crops like marigold, castor, okra etc. @ 50 plants/acre

**Nutrients**
- For efficient use of applied fertilizers, adopt fertilizer cum seed drill.
- Seed treatment should be done with Azotobacter /Azospirillum and PSB @ 250 g /acre and VAM inoculum @ 2 Kg /acre as soil application.
- Fertilizers should be applied on soil test basis. Generally, it is recommended to apply NPK @ 25, 20 and 16 Kg /acre.
- Apply 50% of N and full dose of P &K preferably in the form of band placement at the time of sowing.
- Apply sulphur @10-15 Kg/ acre through gypsum or Single Super Phosphate (SSP).
- Prefer SSP as a source of phosphorous as it also supply Sulphur to the crop.
- In boron deficient soils, apply boron @ 400 g / acre (4.5 Kg borax per acre) in alternate years.
- In saline soils, sow sunflower on ridges and apply additional N @ 8 Kg/ acre.
- Spray boron @0.2% as directed spray to head at ray floret opening stage.

**Weeds**
- Line sowing should be done to facilitate inter-cultural operations.
- Plant population should be maintained to its optimum right from beginning to minimize the weeds competition.
- Adopt crop rotation and follow Inter cropping with recommended short duration cereals/ millets/ pulse/oil seed crops e.g. black gram, finger millet, soybean, groundnut etc. to suppress weeds between rows.

**Verticillium wilt**
- Follow common cultural, mechanical and biological practices (See page no. 13, 14, 15).
- For resistant/ tolerant varieties consult ICAR institute/ KVK’s/ SAU’s

**Cultural control:**
- Use resistant varieties.
- Proper seed sanitation.
- Planting disease free plants in uncontaminated soil, planting resistant varieties, and refraining from planting susceptible crops in areas that have been used repeatedly for solanaceous crops.

**Vegetative stage**

**Common cultural practices:**
- Collect and destroy diseased and insect infected plant parts.
- Provide irrigation at critical stages of the crop.
- Avoid water stagnation.

**Common mechanical practices:**
- Collection and destruction of eggs and early stage larvae
- Handpick the older larvae during early stages of the crop
- The infested curd and seed capsules may be collected and destroyed
- Handpick the gregarious caterpillars and the pupae which are found on leaves and destroy them in kerosene mixed water.
- Use yellow sticky traps for aphids and whitefly and blue sticky traps for thrips @ 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)
- Erecting of bird perches @ 20/acre for encouraging predatory birds such as King crow, common mynah etc.
| **Nutrients** | • In dry lands, top dress of rest of nitrogen (12.5 kg N/acre) around 30 days after sowing depending on rainfall and soil moisture preferably at the time of inter-culture.  
• For the irrigated crop, apply remaining nitrogen in two equal splits, first at 30 days after sowing and second at 30 days thereafter.  
• Depending on specific deficiencies and based on soil test values, take up micronutrient correction. |
| **Weeds** | • Very shallow tillage after one week of sowing with spike tooth harrow/coil spring harrow/rotary hoe before germination of sunflower seeds.  
• Two hoeing or hand tool weeding at 20-25 days and 35-40 days after sowing.  
• Mulches like straw hay, black polyethylene etc. can be used in between the rows to suppress the weed growth provided intercrops not grown. |
| **Cutworm** | • Follow common cultural, mechanical and biological practices (see page no. 13, 14, 15).  
**Cultural control:**  
• Sowing sunflower seeds on ridges (6-8 cm height), in cutworm endemic areas  
**Biological control:**  
• Release of *Trichogramma chilonus* @ 20000/acre. |
| **Jassids** | • Follow common cultural, mechanical and biological practices (see page no. 13, 14, 15).  
**Cultural control:**  
• Close spacing reduces pest infestation particularly if the rainfall is heavy.  
• Apply adequate amount of nitrogen  
• Mixed cropping of sunflower with cotton  
• Intercropping sunflower with groundnut in the ratio (1:4)  
**Chemical control:**  
• Seed treatment with imidacloprid 48% FS @ 5-9 ml/Kg seed and imidacloprid 70% WS @ 7 ml/Kg seed.  
• Spray imidacloprid 17.8% SL @ 40ml/acre diluted in 200 l of water.  
• Mixed cropping of sunflower with cotton  
• Intercropping sunflower with groundnut in the ratio of 1:4  
**Biological control:**  
• Spray neem product (5% Neem oil before egg laying) or 5 Kg/acre neem kernel extract with any sticky material  
**Chemical control:**  
• Seed treatment with imidacloprid 48% FS @ 5-9ml/Kg seed and imidacloprid 70% WS 7ml/Kg seed.  
• Spraying of imidacloprid 17.8% SL @ 40ml/acre diluted in 200 l of water.  
• Malathion 50% EC @ 400 ml/acre diluted in 200-400 l of water. |
| **Thrips** | • Follow common cultural, mechanical and biological practices (see page no. 13, 14, 15).  
• As mentioned above in the pre-sowing stage. |
| **Whitefly** | • Follow common cultural, mechanical and biological practices (see page no. 13, 14, 15).  
**Cultural control:**  
• Intercropping sunflower with groundnut in the ratio of 1:4  
**Biological control:**  
• Spray neem product (5% Neem oil before egg laying) or 5 Kg/acre neem kernel extract with any sticky material  
**Chemical control:**  
• Seed treatment with imidacloprid 48% FS @ 5-9ml/Kg seed and imidacloprid 70% WS 7ml/Kg seed.  
• Spraying of imidacloprid 17.8% SL @ 40ml/acre diluted in 200 l of water.  
• Malathion 50% EC @ 400 ml/acre diluted in 200-400 l of water. |
<table>
<thead>
<tr>
<th>Pest</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mealybug</td>
<td>- Follow common cultural, mechanical and biological practices (see page no. 13, 14, 15). &lt;br&gt;  <strong>Cultural control:</strong> &lt;br&gt;  - Flooding of orchard with water in the month of October to kill the eggs. &lt;br&gt;  - Ploughing of orchard in November. &lt;br&gt;  - Raking of soil around tree trunk to expose the eggs to natural enemies and sun, removal of weeds &lt;br&gt;  - Fastening of alkathene sheet (400 gauge)/grease band of 25 cm wide afterwards mud plastering of trunk at 30 cm above the ground in the middle of December. &lt;br&gt;  - In July – August destruction of fallen leaves infested with scales &lt;br&gt;  <strong>Mechanical control:</strong> &lt;br&gt;  - Raking of soil around tree trunk to expose the eggs to natural enemies and sun, removal of weeds and releasing 10-15 grubs &lt;br&gt;  <strong>Biological control:</strong> &lt;br&gt;  - Releasing 10-15 grubs of coccinellid predator, <em>C. montrouzieri</em> per tree.</td>
</tr>
<tr>
<td>Tobacco caterpillar</td>
<td>- Follow common cultural, mechanical and biological practices (see page no. 13, 14, 15). &lt;br&gt;  <strong>Cultural control:</strong> &lt;br&gt;  - Intercropping sunflower with pigeon pea &lt;br&gt;  <strong>Biological control:</strong> &lt;br&gt;  - Spray 5% neem seed kernel extract preferably in the evening. &lt;br&gt;  - Spray SINPV @ 100LE/acre &lt;br&gt;  - Spray <em>Clerodendrum inerme</em> dust (25%) and plant extracts (10%) &lt;br&gt;  <strong>Chemical control:</strong> &lt;br&gt;  - Spray dichlorvos 76% EC @ 250ml/acre diluted in 200-400 l of water.</td>
</tr>
<tr>
<td>Green semilooper</td>
<td>- Follow common cultural, mechanical and biological practices (See page no. 13, 14, 15). &lt;br&gt;  <strong>Chemical control:</strong> &lt;br&gt;  - Spraying of dichlorvos 76% EC @ 250ml/acre diluted in 200-400 l of water.</td>
</tr>
<tr>
<td>Cabbage semilooper</td>
<td>- Follow common cultural, mechanical and biological practices (See page no. 13, 14, 15). &lt;br&gt;  <strong>Biological control:</strong> &lt;br&gt;  - Spray 5% neem seed kernel extract preferably in the evening.</td>
</tr>
<tr>
<td>Bihar hairy caterpillar</td>
<td>- Follow common cultural, mechanical and biological practices (See page no. 13, 14, 15). &lt;br&gt;  <strong>Cultural control:</strong> &lt;br&gt;  - Use of well rotten manures. &lt;br&gt;  - Intercropping with pigeon pea at a row ratio of 2:1 is effective in reducing the insect attack. &lt;br&gt;  - Hand collection and destruction of egg masses and skeletonized leaves along with first and second instar gregarious larvae. &lt;br&gt;  <strong>Biological control:</strong> &lt;br&gt;  - Spray 5% neem seed kernel extract preferably in the evening. &lt;br&gt;  <strong>Chemical control:</strong> &lt;br&gt;  - Spray cypermethrin 10% EC @ 260-300ml/acre diluted in 200 – 260 l of water.</td>
</tr>
<tr>
<td>Head borer</td>
<td>- Follow common cultural, mechanical and biological practices (See page no. 13, 14, 15). &lt;br&gt;  <strong>Cultural control:</strong> &lt;br&gt;  - Sow 3-4 lines of maize around the sunflower crop to monitor the moth. &lt;br&gt;  - Intercropping with pigeon pea, groundnut, finger millet and soybean. &lt;br&gt;  <strong>Biological control:</strong> &lt;br&gt;  - Release predators <em>Chrysoperla zasotri sillemi</em> @ 1 larva/ head &lt;br&gt;  - Release parasitoides like <em>Trichogramma</em> spp. @ 20,000/acre &lt;br&gt;  - Spray 5% neem oil or 5% neem seed kernel extract &lt;br&gt;  - Spray <em>Clerodendrum inerme</em> dust (25%) and plant extract (10%).</td>
</tr>
</tbody>
</table>
### Sunflower necrosis disease

- Follow common cultural, mechanical and biological practices (see page no. 13, 14, 15).
- For resistant/ tolerant varieties consult ICAR institute/ KVK’s/ SAU’s

**Cultural control:**
- Clean cultivation by removing the weeds specially *Parthenium, Commelina* etc both inside and neighbouring plots
- Follow optimum plant population in the field
- Roguing of infected plants before flowering. Grow 3-5 rows of sorghum as border crop.

### Downy mildew

- Follow common cultural, mechanical and biological practices (see page no. 13, 14, 15).
- For resistant/ tolerant varieties consult ICAR institute/ KVK’s/ SAU’s

**Cultural control:**
- Use downy mildew resistant hybrids LSH-1 and LSH-3 for endemic pockets of Maharashtra. Most of the recently released hybrids viz., BSH-1, KBH-1, MSFH-17, DSH-1, SPIC-105 are resistant to downy mildew.
- Remove volunteer sunflower plants, *Parthenium* weed around the field and clean cultivation.
- Shallow sowing (3 cm) is desirable to avoid downy mildew.
- Pre sowing irrigation followed by one irrigation at 10 or more days after sowing reduces disease
- Roguing of mildew infected seedlings during thinning, removal and destruction of infected plants.
- Crop rotation in sunflower with groundnut/ sorghum/ pigeonpea for six-years.

**Chemical control:**
- Seed treatment with metalaxyl-M 31.8% ES & metalaxyl 35% WS @ 2g/Kg and 6g/Kg seed has been found to give effective control.

### Charcoal rot

- Follow common cultural, mechanical and biological practices (see page no. 13, 14, 15).
- For resistant/ tolerant varieties consult ICAR institute/ KVK’s/ SAU’s

**Cultural control:**
- Avoid moisture stress and high temperature

### Alternaria leaf spot

- Follow common cultural, mechanical and biological practices (see page no. 13, 14, 15).
- For resistant/ tolerant varieties consult ICAR institute/ KVK’s/ SAU’s

**Cultural control:**
- Early planting during *Kharif* escapes from the leaf spot
- Occurrence and severity of the disease depend on the season and planting dates.
- Mid-September planting of sunflower remains free from most of the major diseases including *Alternaria*.
- Intercropping of sunflower with groundnut in the ratio of 6:2 reduces leaf spot.
- Spacing of 60 x 30cm or 45 x 30cm is optimum in reducing the buildup of leaf spot

### Sclerotium wilt

- Follow common cultural, mechanical and biological practices (see page no. 13, 14, 15).
- For resistant/ tolerant varieties consult ICAR institute/ KVK’s/ SAU’s

**Cultural control:**
- Avoid moisture stress.

### Sclerotinia wilt and rot

- Follow common cultural, mechanical and biological practices (see page no. 13, 14, 15).
- For resistant/ tolerant varieties consult ICAR institute/ KVK’s/ SAU’s

**Cultural control:**
- Soil amendment with FYM @ 5 tonnes/acre
- Avoid moisture stress during high summer and water logging conditions

**Biological control:**
- Seed treatment with *Trichoderma viride* @ 6g/Kg seed.
- Addition of *Trichoderma harzianum* in soil at 10g/kg and soil amendments like castor cake, neem cake, oat straw reduces disease incidence
### Rust
- Follow common cultural, mechanical and biological practices (See page no. 13, 14, 15).
- For resistant/ tolerant varieties consult ICAR institute/ KVK's/ SAU's

**Cultural control:**
- Avoid high nitrogen rates and high plant populations.

### Septoria leaf spot
- Follow common cultural, mechanical and biological practices (See page no. 13, 14, 15).
- For resistant/ tolerant varieties consult ICAR institute/ KVK's/ SAU's

**Cultural control:**
- Destruction of plant debris and tillage operations that bury and rapidly promote residue decomposition.
- Use resistant or tolerant varieties.
- Follow proper plant spacing.

### Viral disease (Yellow blotch, leaf crinkle etc.)
- Follow common cultural, mechanical and biological practices (See page no. 13, 14, 15).
- For resistant/ tolerant varieties consult ICAR institute/ KVK's/ SAU's

**Cultural control:**
- Since the sunflower mosaic is transmitted both by mechanical means and also by aphid vectors in a non-persistant manner, it is very difficult to protect the plants from infection of the virus through this type of vectors.
- Following clean cultivation by removing the weeds both inside and neighbouring plots which helps to destroy the virus source and avoid the primary inoculum to the crop.

**Mechanical control:**
- Careful destruction of the infected plants as soon as they are noticed in the field will help to avoid further spread of the viruses in the field by destroying the source of inoculum within the field.

### Powdery mildew**
- Follow common cultural, mechanical and biological practices (See page no. 13, 14, 15).
- For resistant/ tolerant varieties consult ICAR institute/ KVK's/ SAU's

**Cultural control:**
- Wild species of sunflower i.e., *Helianthus debilis, H. californicus, H. ciliaris, H. decapetalus, H. lacinatus* and *H. rigidus* show resistance to powdery mildew

### Flowering/seed formation stage

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Spray of boron (0.2%) to capitulum/head at ray floret opening stage.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weeds</td>
<td>Remove left over weeds to prevent weed seed spread in field.</td>
</tr>
<tr>
<td>Tobacco caterpillar</td>
<td>Same as in the sowing stage.</td>
</tr>
<tr>
<td>Bihar hairy caterpillar</td>
<td>Same as in the sowing stage.</td>
</tr>
<tr>
<td>Capitulum/head borer</td>
<td>Same as in the vegetative stage.</td>
</tr>
<tr>
<td>Alternaria leaf spot</td>
<td>Same as in the vegetative stage.</td>
</tr>
<tr>
<td>Rust</td>
<td>Same as in the vegetative stage.</td>
</tr>
<tr>
<td>Head rot**</td>
<td>Follow common cultural, mechanical and biological practices (See page no. 13, 14, 15).</td>
</tr>
<tr>
<td></td>
<td>For resistant/ tolerant varieties consult ICAR institute/ KVK's/ SAU's</td>
</tr>
<tr>
<td><strong>Cultural control:</strong></td>
<td>Avoid injury to flower head due to mechanical operations</td>
</tr>
</tbody>
</table>
| Birds** | Cultural control:  
- Grow sunflower in large continuous area to minimise localised damage.  
Mechanical control:  
- Apart from employing labour for bird scaring, use polypropylene metallic shining reflective bird scaring ribbon with red/yellow on one side and silver white on other side of 10-15 meter length at 4 to 8 meters distance (20-24/acre) |
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<tbody>
<tr>
<td>Storage</td>
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</table>
Store grain insect pests and seed mycoflora  
- Moisture content of seeds should not exceed 6.5% and relative humidity of storage containers should not exceed 70% to minimise losses due to insect pests and fungi during storage. |

**Note:** Pesticides dosage use is based on high volume sprayer. The recommended chemicals given are as per CIBRC list updated on 31.10.2014.

**Pests of regional significance**
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 labeled insecticides.

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

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

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

<table>
<thead>
<tr>
<th>Nutrients</th>
<th><strong>Fig.</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Nitrogen:</strong> Little new growth, yellow leaves: this being more pronounced in older leaves. Earlier fall leaf drop. New shoots may be red to red-brown.</td>
<td><img src="image" alt="Nitrogen" /></td>
</tr>
<tr>
<td>Apply recommended dose of N as top dressing.</td>
<td></td>
</tr>
<tr>
<td><strong>Phosphorous:</strong> Overall dark green with purple, blue or reddish cast to leaves particularly on underside, veins and stems and some plants respond to lack of P with yellowing. Foliage may be sparse, small and distorted becoming mottled and bronzy with maturity. Excess foliage with no flowers can also indicate lack of P.</td>
<td><img src="image" alt="Phosphorous" /></td>
</tr>
<tr>
<td><strong>Potassium:</strong> Sickly looking plants, undersized flowers and seeds, leaves showing marginal and interveinal yellowing. Yellowing starts on older leaves and progresses upwards. Leaves may crinkle, turn brown and roll upwards. Blossoms may be distorted and small. Plant has little resistance to heat, cold and disease problems.</td>
<td><img src="image" alt="Potassium" /></td>
</tr>
<tr>
<td><strong>Sulphur:</strong> Plants showing paling/yellowing of leaves. Yellowing spreads from the base to the apex. Growth of plants is reduced. The size of capitulum/head is severely restricted. Inflorescence may remain covered within the bracts. Maturity of flowers is delayed.</td>
<td><img src="image" alt="Sulphur" /></td>
</tr>
<tr>
<td><strong>Boron:</strong> Under severe deficiency at about 3 weeks growth, young and middle leaves of plants develop small chlorotic patches. Cotyledons of these plants become massive and the shoot apex becomes globose and deformed. Later, chlorotic patches become more pronounced and develop orange coloured necrotic areas in young leaves. Shoot apex may turn necrotic and cease to grow. Young leaves show severe curling and distortion. This leads to appearance of side branches bearing small leaves. Eventually all the young leaves turn necrotic. For remedy, give directed spray of 0.2% Borax (2g/l of water) to capitulum/head at ray floret opening stage.</td>
<td><img src="image" alt="Boron" /></td>
</tr>
</tbody>
</table>
### Calcium:
Young leaves are small and distorted with curled back leaf tips. Shoots may be stunted and show some dieback, reduced roots and shoot development. Small distorted leaves near branch tips, and terminal buds blacken and fail to continue to develop and reduces the seed formation.

### Zinc:
Light yellow stripes along with veins of leaf blade. Under acute condition-vein chlorosis and cessation of growth of terminal bud. Older leaves may show slight chlorosis. Apply foliar spray of $\text{ZnSO}_4 \times 0.5\%$.

### Iron:
Yellowing of young leaves; interveinal chlorosis. Apply foliar spray of $\text{FeSO}_4 \times 0.5\%$. 

VIII. COMMON WEEDS

1. Crab grass: *Digiteria sanguinalis* (L.) Scop. (Poaceae)
2. Rabbit/crow foot grass: *Dactyloctenium aegyptium* L. Willd. (Poaceae)
3. Goose grass: *Eleusine indica* (L.) Gaertner (Poaceae)
4. Bermuda grass: *Cynodon dactylon* (L.) Pers. (Poaceae)
6. Swine cress: *Coronopus didymus* (L.) Sm. (Brassicaceae)
7. False amaranth: *Digera arvensis* Forsk. (Amaranthaceae)
8. Black nightshade: *Solanum nigrum* L. (Solanaceae)
9. Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)
10. Common purselane: *Portulaca oleracea* L. (Portulacaceae)
11. Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)
13. Barnyard grass: Echinochloa colona (L.) Link, E. crusgalli (L.) Honda (Poaceae)

14. Viper grass: Dinebra retroflexa (Vahl) Panz (Poaceae)

15. Sweet signal grass: Brachiaria eruciformis (Sm.) Griseb (Poaceae)

16. Tropical spiderwort: Commelina benghalensis L. (Commelinaceae)

17. Stonebreaker: Phyllanthus niruri L. (Phyllanthaceae)

18. Silver cockscob: Celosia argentea L. (Amaranthaceae)


20. Rice flatsedge: Cyperus iria L. (Cyperaceae)

21. Yellow nutsedge: Cyperus esculentus L. (Cyperaceae)
IX. DESCRIPTION OF INSECT PESTS

1) Jassids:

**Biology:**

**Egg:** The female lays eggs inside the leaf veins in the parenchymatous tissues. Each female lays 10 to 15 eggs. The incubation period varies from 4 to 11 days.

**Nymph:** Nymphs are greenish yellow. The nymphal period occupies about 7 days in summer and 21 days in winter.

**Adult:** Adults are greenish yellow, wedge shaped with a pair of black spots on vertex and a black spot on each of the forewings. Adults survive for about 5 weeks in summer and 7 weeks in winter.

**Life cycle:**

**Damage symptoms:**

- The incidence starts from seedling stage and prevails right through entire crop growth period.
- Both nymphs and adults suck the cell sap from under surface of leaves and cause stunted growth of plant, yellowing, cupped and crinkled leaves, burnt appearance of leaf margins or entire leaf called *hopper burn* are symptoms of damage.

2) Whitefly:

**Biology:**

**Egg:** Eggs are pear shaped, light yellowish and stalked.

**Nymph:** Nymphs are oval, scale like and remain attached to the leaf surface.

**Adult:** Adults are tiny, moth like with yellowish body and wings coated with milky white waxy powder.

**Life cycle:**

**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 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 and rainy conditions are favourable for multiplication.

**Natural enemies of whitefly:**
- **Parasitoids:** Encarsia formosa, Chrysocaris pentheus, Eretmocerus spp etc.
- **Predators:** Mirid bug, green lacewing, ladybird beetle, big-eyed bugs etc.
*For management refer to page number 15.

### 3) Tobacco caterpillar:

**Biology:**
It is found throughout the tropical and subtropical parts of the world, wide spread in India. Besides tobacco, it feeds on sunflower, cotton, castor, groundnut, tomato, cabbage and various other cruciferous crops.

**Egg:** Female moth lays eggs in a mass on the under surface of leaves and covers them with brown hairs. The female lays 500 to 600 eggs which hatch in 4-5 days.

**Larva:** Grown up larva is stout, cylindrical, pale greenish brown with dark markings. Some have transverse and longitudinal grey and yellow bands and others have rows of dark spots. It feeds during night time. On an average, larval period lasts for 2-3 weeks.

**Pupa:** Pupation occurs in soil in an earthen cocoon at 5 cm depth or leaf debris and adults emerge in 6-7 days.

**Adult:** The moth is stout, dark with wavy white markings on the forewings and white hindwings, margin having a brown colour. The total life cycle is completed in 30 to 40 days.

**Life cycle:**

1. Eggs
2. Larva
3. Pupae
4. Adult

**Damage symptoms:**
- Initially, the neonate larvae feed gregariously on a single leaf on underside of leaves giving "mesh" like appearance to leaves.
- The full grown larva feeds voraciously on leaf leaving petiole and stalk during night time.
- It is reported to cause severe damage to the crop by damaging leaves, flower buds and capitulum whenever there is a severe outbreak.

**Favourable conditions:**
- Warm weather conditions and rainy conditions are favourable for multiplication.

**Natural enemies of tobacco caterpillar:**
- **Parasitoids:** Trichogramma spp., Tetrastichus spp., Telenomus spp., Chelonus spp., Bracon spp., Ichneumon spp., Carcelia spp., Campoletis spp. etc.
- **Predators:** Chrysoperla zastrowi sillemi, ladybird beetle, reduviid bug, spider, fire 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 management refer to page number 16.
4) Bihar hairy caterpillar:

**Biology:**
This pest occurs during October to December and of late it is also occurring from July. In recent years, it has become an important pest on sunflower also.

**Egg:** Female moth lays eggs in masses on lower surface of leaf which hatch within 3-4 days.

**Larva:** Larvae are hairy, gregarious in early instars (up to 14 days after egg-hatch), later disperse, fully grown larva are of 5 cm long. The larvae are pale yellow coloured with dark yellow hair over the body. Larval period varies from 14 -21 days

**Pupa:** Pupation takes place at 10-20 cm depth in soil

**Adult:** Adult moth has reddish black spots on both the pinkish wings. The life cycle of the pest occupies 38 days at 30 °C.

**Life cycle:**

![Life cycle diagram](image)

**Damage symptoms:**
- Young larvae feed gregariously mostly on the under surface of the leaves.
- Caterpillars feed on leaves and in severe infestation the whole crop is defoliated.
- Drying up of infected leaves is the main symptom

**Natural enemies of bihar hairy caterpillar:**
**Predators:** *Chrysoperla*, Coccinellids etc.

*For management refer to page number 16.

![Damage symptom](image)

5) Head/capitulum bore/gram pod borer:

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

**Biology:**

**Egg:** Each female moth can lay on an average of 700-1000 eggs. Eggs of *H.armigera* are nearly spherical, with a flattened base, giving dome shaped appearance, the apical area surrounding the micropyle is smooth, the rest of the surface sculptured in the form of longitudinal ribs; at first yellow-white, glistening, changing to dark brown before hatching. The diameter of the egg ranges from 0.40 to 0.55 mm. The incubation period of the egg is longer in cold weather and shorter in hot weather, it ranges from 2 to 5 days

**Larva:** The newly hatched larva is translucent and yellowish white in colour, with faint yellowish orange longitudinal lines. The head, thoracic and anal shields and legs are brown and the setae dark brown in colour. The full grown larva is about 35-42 mm long, the general body colour is externally variable, and the pattern may be in shades of green, straw yellow, and pinkish to reddish brown or even black with one broken stripe along each side of the body and one line on the dorsal side. The larval period vary from season to season, place to place and crop to crop.
6) Cutworm:

Biology:

Egg: Eggs are cream coloured, globular, laid in batches, on leaves, stems of weeds, crop plants, on or litter; up to 1800 eggs/female, hatch in 2-9 days.

Larva: Larvae are brownish above with a broad pale grey band mid line, black stripe laterally, sides greyish green, head capsule black with two white spots, 45 mm length when full grown; feed on foliage at night, hide in soil and debris during day.

Pupa: Pupation take place in soil and the pupa is dark brown in colour.

Adult: The adult is a large moth (40-50 mm wing span) with grey forewings and dark brownish black markings, pearly hindwings with a dark fringe. To complete one life cycle, it takes around 30 days.

Life cycle:

Damage symptoms:

- Cutworms usually feed at night or during overcast days. Newly hatched larvae feed on weeds, and/or young maize plants if present, leaving small irregular holes in the leaves. Such early feeding is of little significance to plants.
- Larger larvae may completely cut through stalks, which can cause plants to wilt and die. Severe stand reductions can result. They sometimes drag cut plants under soil clods or into small holes in the soil to continue their feeding during the daylight hours.
- When numerous, cutworms can destroy as much as 75% of a crop.

Natural enemies of cutworm:

Parasitoids: Cotesia spp, Meteorus spp, Campoletis spp

Predators: Ground beetle etc.

*For the management refer page number 15.
7) Green semilooper:

**Biology:**
*Egg:* Female moth lays greenish white eggs singly on the under surface of leaf concentrating more on mid canopy.
*Larva:* Larva is green in colour with a thin white lateral line and two white lines on the back, active and form loop in motion; swollen at posterior end and tapers anteriorly.
*Pupa:* Pupation takes place in white transparent silken cocoons in leaf litter or crop debris.
*Adult:* Adult is a dark brownish moth with golden coloured triangle on forewings with a tuft of hair on thoracic region. Total life cycle is completed in 30 days

**Damage symptoms:**
- Early instars feed on chlorophyll, tender leaves with transparent leaf spots, later feed from leaf margin and defoliate leaving midribs in case of severe incidence.

**Natural enemies of green semilooper:**
*Parasitoids:* *Trichogramma* spp, *Cotesia* spp, *Apanteles ruficrus*, *A. africanus*, *Euplecturs ceylonensis*, *Campoletis chloridae*, *Exorista xanthaspis*, *Copidosoma floridanum*, *Disophrys lurea* and *Enicospilus* sp. etc.
*Predators:* Ladybird beetles, *Chrysoperla*, praying mantids and spiders etc.

*For the management refer page number 16.

8) Semilooper or cabbage semilooper:

**Biology:**
*Egg:* The female moth lays greenish white, spherical sculptured eggs singly on the under surface of sunflower leaf.
*Larva:* The larva is slender, attenuated anteriorly and full grown larvae measures 38 mm. Larva is green with wavy white lines and broader lateral white stripe.
*Pupa:* It pupates in a thin transparent cocoon on the under surface of leaves.
*Adult:* The moth is stout, brown in colour with light wavy markings and a more slender white mark on fore wings. Total life cycle takes about one month.

**Damage symptoms:**
- Initially, early instars feed on chlorophyll and tender leaves.
- In case of severe incidence, grown up larvae feed from leaf margin and defoliate the entire plant leaving midribs.

*For the management refer page number 16.

9) Mealybug:

**Biology:**
*Egg:* Females lay their eggs directly on the host in a fluted ovisac that is attached to the body of the adult female. Inseminated eggs produce hermaphrodites and uninseminated eggs produce males.
*Nymph:* The first instar nymphs are also called as crawlers, which are mobile. They settle on the plants, start sucking the sap and form the colonies.
*Adult:* In general they have 4 female instars and 5 male instars, but unlike most other scale insects, the prepupa is quite mobile and although it may have wing buds, the legs and antennae are well developed. Females actually are hermaphrodites that frequently inseminate themselves. Adult males mate with females.
Life cycle:

- **Eggs**
- **Nymphs** (2-3 days)
- **Adults** (3-4 days)

Damage symptoms:

- The mealybug nymphs and adults attack all parts of the plant including young shoots, leaves and head.
- They form colonies on shoots, leaves and head, developing into white masses.
- They cause direct damage by sucking plant sap. Insects also produce large quantities of honeydew which encourages growth of black sooty mold on the leaves and twigs resulting in reduced photosynthetic capacity.
- Growth malformation characterized by curling and crinkling of leaves.
- Heavy infestations result in plant death. Infested flowers often drop and usually there is little or no seed production.

Natural enemies of mealybug:

**Predators:** Chilomenes sexmaculatus, Rodolia fumida, Cryptolaemus montrouzieri etc.

*For the management refer page number 16.*
Natural Enemies of Sunflower Insect Pests

**Parasitoids**

**Egg parasitoids**

**Egg-larval parasitoid**

**Larval parasitoids**
5. *Bracon* spp.
7. *Carcelia* spp.
8. *Campoletis* spp.

**Nymphal/larval and adult parasitoids**
9. *Encarsia formosa*

3. [http://baba-insects.blogspot.in/2012/02/telenomus.html](http://baba-insects.blogspot.in/2012/02/telenomus.html)
4. [http://www.nbaii.res.in/Featured%20insects/chelonus.htm](http://www.nbaii.res.in/Featured%20insects/chelonus.htm)
5. [http://www.nbaii.res.in/Featured%20insects/ichneumon-wasp.html](http://www.nbaii.res.in/Featured%20insects/ichneumon-wasp.html)
6. [http://www.nbaii.res.in/Featured%20insects/Bracon%20brevicornis.htm](http://www.nbaii.res.in/Featured%20insects/Bracon%20brevicornis.htm)
8. [http://www.nbaii.res.in/Featured%20insects/Campoletis.htm](http://www.nbaii.res.in/Featured%20insects/Campoletis.htm)
## Predators

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## X. DESCRIPTION OF DISEASES

### 1) Alternaria leaf spot:

**Disease symptoms:**
- Circular to oval, dark brown to black spots appear on the leaves. Later, the spots enlarge into round to irregular spots with concentric rings and coalesce causing blighting and withering of leaves. These are surrounded by chlorotic zone with grey white necrotic center.
- The spot appear first on the lower leaves and as the plant grows the spots subsequently appears on middle and upper leaves. Stem lesions begin as dark flecks which enlarge to form long, narrow lesions which may also coalesce to a larger blackened area resulting in stem breakage.
- In severe cases, the lesions appear on petioles, ray florets and head as brown round spots about 1cm diameter with a slight depression in the centre. Sometimes rotting of flower heads also occurs. *A. alternata* also causes leaf spots in rabi season.

**Survival and spread:**
- The fungus overwinters as mycelium on infected plant residues and in dry conditions survives for 20 weeks in soil.
- The fungus is seed borne with 22.9% seed transmissible nature.

**Favourable conditions:**
- The disease is favoured by 25-27°C temperature and 12 hrs of wet foliage.
- The disease spreads rapidly in rainy season. Hot weather and frequent rains during the milk and wax stages of plant development favour infection.

### 2) Rust:

**Disease symptoms:**
- Initially, small reddish brown circular uredial pustules, covered with rusty coloured dust appear on the lower leaves.
- Under severe conditions, the pustules are produced on younger leaves and spread over the entire vegetative surface covering stems, petioles, floral bracts and petals with pustules on stem being linear rather than round.
- Uredia often coalesce to cover large areas on the affected plant parts. The leaves become dry and towards maturity stage of crop, the uredosori are replaced by *Leilia* and the black rust appears.
- On susceptible cultivars, pustules are often surrounded by chlorotic halos and adjacent pustules may merge. In case of highly resistant varieties, uredia are not formed and only small chlorotic or necrotic flecks develop at the point of infection.

**Survival and spread:**
- The fungus mainly survives through teliospores (thick walled, resting spores) on leaves left in the field or on the soil surface.
- The disease spreads by wind-borne uredospores from infected crop.

**Favourable conditions:**
- Temperature ranging from 25.5 to 30.5°C with relative humidity of 86-92°C favours high intensity of rust.

*Leaf spot on the leaf & flower head*

![Leaf spot on the leaf & flower head](http://uasr.agropedia.in/sites/default/files/A.%20Leaf%20%26%20Flower%20head%20spot.jpg)  ![Leaf spot on the leaf & flower head](http://www7.inra.fr/hyp3/images/6030014.jpg)

*For management refer to page number 17.*
3) **Powdery mildew:**

**Disease symptoms:**
- White to grey powdery patches appear on upper surface of older leaves which are still green.
- Occasionally the symptoms appear on stem and bracts. White to grey areas enlarge, coalesce and cover most plant parts. As the season progresses, the mildewed leaves take on a dusty, powdery appearance.
- This powder is easily rubbed off. Small black dots, cleistothecia become visible as black pinpoints over the white mildew areas late in the season.
- Severely infected areas lose luster, curls, become permanently yellow and may dry up. Normally the lower leaves are more heavily infected than the upper leaves.

**Survival and spread:**
- The primary sources of inoculum are oospores present in the soil.
- Secondary infection by air-borne conidia

**Favourable conditions:**
- The disease is more under dry condition by the end of the winter months.

*For management refer to page number 18.

4) **Sclerotium wilt:**

**Disease symptoms:**
- Initial symptoms of the disease are noticed 40 days after sowing. Stem is usually infected at or near the soil line.
- A brownish lesion develops at the base of the stem and eventually girdles the plant. A white fan-like mycelial growth forms over the infected tissues and often radiates over the soil surface.
- Sickly appearance of plants can be spotted from a distance and a row effect can be observed in heavily infected soil.
- Later the entire plant withers and dies. The lesion grows up the stem, destroying the cortical tissue and leaving the fibrous vascular strands as the tissues dry out.
- White cottony mycelium and mustard seed type sclerotial bodies are conspicuous on the affected stem near soil level. This also causes collar rot in the seedling stage.

*For management refer to page number 18.
Survival and spread:
- The fungus survives as sclerotia or mycelium in infected plant residue and soil

Favourable conditions:
- Aerobic conditions, high temperatures and high humidity favour the germination of sclerotia and mycelial growth.

*For management refer to page number 17.

5) Sunflower necrosis disease:

Disease symptoms:
- The disease is observed at all growth stages of the crop, from seedling to maturity. Initially small, irregular necrotic patches appear on leaf lamina, more near to the mid rib.
- As the necrosis advances, it results into twisting of the leaf. Later, it extends from one side of the lamina to the petiole and stem in the form of black streaks and finally terminates at shoot of the plant leading to paralytic symptoms.
- Infected plants generally exhibit mosaic, motting and necrosis of tissues of leaf lamina which later spreads to all other aerial parts of the plant.
- The early-infected plants become stunted, weak and die before flowering. Necrosis at bud formation stage makes the capitulum to trend and twist.
- Most destructive symptoms of the disease include sudden necrosis, twisting and systemic infection of floral parts like calyx, bracts and capitulum.
- Black or brown streaks on petiole, stem, underneath of flower head followed by twisting and splitting is usually noticed in a typically necrosis affected plant.
- In late infected plants, flower heads become malformed resulting into complete failure of seed setting or with partial filling of deformed /chaffy grains.

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

*For management refer to page number 17.

6) Head rot:

Disease symptoms:
- Initial symptom appears as brown irregular water soaked spots on the back of ripening head usually adjacent to flower stalks.
- Spots gradually enlarge and become soft and pulpy and get covered with superficial white mycelium, which later becomes black due to formation of sporangia. In cases of severe infection, the rot spreads to flower stalk and the sunflower head drops off.
- Generally, some seeds of the rotted heads shed and those, which remain in the head, taste bitter. Susceptibility of the flower head is increased as its age advances. Maximum rotting is noticed at the soft dough stage. Injury to the flower head is necessary for infection.

*For management refer to page number 17.
• Larvae of *Helicoverpa armigera* have been reported to predispose heads to infection. Rhizopus enters the head through wounds caused by hail, birds and insects. The susceptibility of heads increases from the bud stage up to the full bloom and ripening stages.

• Oil from *Rhizopus* head rot infected seed has very much higher free fatty acid content. Disease development is most rapid in warm humid weather. In severe cases, the seeds are transformed into a black powdery mass. The spores of the fungus are carried away by the wind and infect the new host.

**Survival and spread:**

• The fungus survives as a saprophyte in host debris and other crop residues.

• The disease is spread by wind-blown spores.

**Favourable conditions:**

• Prolonged rainy weather at flowering.

• Damages caused by insects and caterpillars.

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### Infected sunflower heads

![Infected sunflower heads](http://www.forestryimages.org/images/768x512/5361537.jpg)

![Infected sunflower heads](http://www.ianrpubs.unl.edu/epublic/live/g1677/build/graphics/g1677-1.jpg)

*For management refer to page number 19.*

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### 7) Downy mildew:

**Disease symptoms:**

The fungus causes different types of symptoms as damping off of seedlings, systemic infection, Local foliar lesions and root galls.  

**Damping off**

• Damping off of the seedlings occurs particularly under cool and moist conditions. Seedlings are killed before or soon after emergence, resulting in reduced plant stand under field conditions. Affected plants dry and become wind-blown.

• The symptoms appear as yellowing of the first pair of true leaves. Under conditions of cool temperature and high humidity, whitish growth of downy mildew consisting of fungal mycelia and spores may appear on the cotyledonary leaves of young seedlings.

• As the plant grows, the fungus spreads to younger tissue, the chlorotic area expands and chlorosis appears on leaves and also on stem.

**Systemic infection**

• The affected plants are severely stunted and upper leaves are entirely chlorotic. At flowering stage, when healthy plants are 1.5 to 1.8 m tall, the height of severely infected plants may vary from 0.1 to 1.0m.

• Due to systemic infection, the fungal mycelium may be present in all plant tissues except meristems. Affected plants bear abnormally thick, downward curled leaves showing prominent yellow and green epipwilous mottling.

• White downy growth of the fungus develops on lower surface of the leaves and covers large areas. The stem becomes brittle and flower heads of the affected plant remain sterile, stiff and face upwards and seeds are not produced or rarely the seeds are formed on such heads.

• Systemically infected plants exhibit severe inhibition of the stem elongation and loss of phototropic and negative responses. Scopoletin, a fluorescent compound present naturally in small amounts in sunflower was found to be considerably increased in infected tissue.

• In affected plants, water permeability of the surface layers are adversely affected, reducing the water retention capacity. This sharply increases the transpiration rate and respiration with decrease in level of carbohydrates and accumulation of potassium and phosphorus in leaves of infected sunflower plants.
Local foliar lesions
- Greenish yellow small angular spots appear on leaves. The spots may enlarge and coalesce to infect a larger part of the leaf.
- Plants are susceptible to such infection for a longer period than to systemic infection. The fungal growth becomes visible at the lower surface of the diseased area and persists for some time under humid conditions.

Root galls
- Gall symptoms occur independently of systemic infection. The galls are formed at the base of plants on primary roots that took discoloured, scurfy and hypertrophied with reduced development of secondary roots. Such plants are less vigorous and subject to lodging.

Survival and spread:
- The pathogen survives through oospores in this residue of the preceding sunflower crop in soil or through oospores on pericarp any testa of seeds in systemically infected plant.
- Seed borne infection usually results in by percentage of systemically infected plants.

Favourable conditions:
- Cool weather with 16-18 temperature, cloudy weather with winds and drizzle or high relative humidity favours infection and disease development.

8) Septoria leaf spot:

Disease symptoms:
- Septoria leaf spot develops initially on the lower leaves and spreads to the upper leaves.
- The spots begin as water-soaked areas, which are angular with tan centers and brown margins. A narrow yellow halo often surrounds young spots. However, mature leaf spots may contain tiny black specks, the fungal fruiting bodies (pycnidia).
- The presence of pycnidia is the best means of distinguishing leaf spots caused by Septoria from those caused by Alternaria. Severe infections can cause defoliation, but if this affects only the lower leaves on mature plants, the yield impact may be minimal.

Survival and spread:
- It can be seed-borne and also survive on infected sunflower crop residue.

Favourable conditions:
- This disease can appear anytime during the growing season and is favoured by moderately high temperatures and abundant rainfall.
9) Verticillium wilt:

**Disease symptoms:**
- Symptoms usually are not observed until flowering, but may appear at the six-leaf stage under severe conditions.
- Initial symptoms begin as tiny chlorotic flecks that increase in size with time developing into extensive inter-veinal yellowing.
- Symptoms begin on the lower leaves and progress slowly up the plant and may eventually infect all leaves.
- Affected leaves quickly become dry. The vascular system may be discolored brown, apparent as a ring around the pith in cross section.
- In severely infected plants, the pith is blackened with a layer of tiny black fruiting bodies.

**Survival & spread:**
- Fungus is soil-borne and enters plants through the roots, invading the vascular system; pathogen can be spread to uninfested fields through contaminated irrigation water or movement of infested soils.

**Favourable conditions:**
- Cold weather and winters favours the development of diseases.

![Disease symptoms](http://www7.inra.fr/hyp3/images/6037412.jpg; https://upload.wikimedia.org/wikipedia/commons/7/78/Verticillium_wilt_dahliae.jpg)

*For management refer to page number 14.

10) Yellow blotch disease:

**Disease symptoms:**
- Distinct bright yellow blotches occur on leaves. Crinkling is absent. Short, irregular yellow vein bands appear in the beginning and later coalesce to form “Y” or concentric rings with either yellow or a green centre.
- Some yellow bands coalesce to form brilliant yellow blotches measuring 1-3 cm in diameter.
- In mildly affected plants, only a yellow vein-net involving some or all of the leaf surfaces observed.
- Under field conditions, some plants show more severe symptoms after yellow blotch appearance.
- The youngest leaves are twisted, reduced in size and often curled downwards.

![Disease symptom](http://agritech.tnau.ac.in/crop_protection/sunflower_disease/sunflower_d9.html)

*For management refer to page number 18.
11) Leaf crinkle disease

Disease symptoms:
- The symptoms of this disease always develop first as yellow blotch, but later leaf crinkling symptoms dominate.
- The electron microscopic studies of the group of symptoms of this disease revealed the presence of spherical particles measuring 26.8 mm in diameter.

*For management refer to page number 18.

Disease cycles:
1. *Alternaria* leaf spot:
   - The primary sources of inoculum are spores present in the soil and infected host
   - Secondary infection by windblown conidia
   - Symptoms on leaves

2. Rust:
   - The primary sources of inoculum are teliospores present in the soil
   - Symptoms on leaves

3. Powdery mildew:
   - The fungus survives in the plant debris and diseased leaves
   - Secondary infection by air
   - Symptoms on leaves

4. Head rot:
   - The fungus survives as saprophyte in the plant debris
   - Secondary infection through wind
   - Symptoms on flower head

5. Sunflower necrosis disease:
   - The primary source of inoculum are weeds
   - Symptoms on stem
   - Secondary infection through thrips

6. Downy mildew:
   - The primary source of inoculum are spores present in the soil and also infected leaves
   - Secondary infection by air
   - Symptoms on leaves
XI. SAFETY MEASURES

A. At the time of harvest:

Losses in the field occur at the time of harvesting due to untimely harvest, poor agricultural operations, careless handling, birds, rodents, bad weather conditions like heavy rainfall, hailstorm, etc. During harvesting, proper care should be taken to avoid quantitative and qualitative losses. Following care should be taken during harvesting:

Sunflower should be harvested when the plant attains physiological maturity i.e. when the back of the head turns from green to lemon yellow colour and the bottom leaves starts drying and withering. At physiological maturity, the seed attains maximum weight and oil concentration and harvesting at this stage, results in highest seed and oil yield. 10 percent of heads should turn brown and florets attached to the tip of the seeds drop off naturally. Delay in harvesting causes reduction in seed yield due to lodging of plants and more damage due to birds, rodents and termite attack. Harvesting should be done by adopting proper method. Chemical defoliation or, dessication using Diquat, magnesium chlorate or, dipyridyl phosphate should be used to accelerate drying of standing crops. Mechanical thresher should be used to separate seed from flower which is labour saving and economical. Avoid harvesting during adverse weather conditions i.e. rains and overcast weather.

B. During post-harvest storage:

Harvest timely to reduce losses. Adopt proper method of harvesting. Adopt modern mechanical methods to avoid the losses in threshing and winnowing. Use improved techniques of processing. Adopt the grading to get better price. Use good packaging materials for storage and transportation. Use proper techniques in storage. Moisture content of the seed should be less than 9.5 percent for storage. Adopt proper pest control measures during storage. Adopt timely and proper handling while loading and unloading. Avoid use of hooks during handling.
### XII. DO’S AND DON’TS IN IPM

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

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Pesticide Classification as per insecticide rules 1971 Colour of toxicity triangle</th>
<th>WHO classification of hazard</th>
<th>Symptoms of poisoning</th>
<th>First aid measures and treatment of poisoning</th>
<th>Safety interval (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insecticides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Imidacloprid Highly toxic</td>
<td></td>
<td>Harmful if swallowed, absorbed through skin or inhaled. Avoid breathing vapor or spray mist. Causes moderate eye irritation.</td>
<td><strong>First aid measures:</strong> 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.</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>Malathion Moderately toxic</td>
<td>Class III Slightly hazardous</td>
<td>—do—</td>
<td>—do—</td>
<td>3 days</td>
</tr>
<tr>
<td>3</td>
<td>Dichlorvos Extremely toxic</td>
<td>Class I b Highly hazardous</td>
<td>Moderate nausea, salivation, lacrimation, abdominal cramp, vomiting, sweating, slow pulse, muscular tremors, miosis</td>
<td><strong>First aid measures:</strong> Rush to the nearest physician. <strong>Treatment of poisoning:</strong> Speed is imperative. Atropine injection-1-4 mg. repeat 2 mg when symptoms begin to recur (15-16 min interval) excessive salivation- good sign, more atropine needed</td>
<td>—</td>
</tr>
<tr>
<td>4</td>
<td>Cypermethrin Highly toxic</td>
<td>Class II Moderately hazardous</td>
<td>Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin, allergic manifestation etc.</td>
<td><strong>Treatment of poisoning:</strong> No specific antidote. Treatment is essentially symptomatic.</td>
<td>14 days</td>
</tr>
<tr>
<td><strong>Fungicides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Metalaxyl MZ Moderately toxic</td>
<td>Class III slightly hazardous</td>
<td>Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.</td>
<td><strong>Treatment of poisoning:</strong> No specific antidote. Treatment is essentially symptomatic</td>
<td>60 days</td>
</tr>
</tbody>
</table>
XIV. BASIC PRECAUTIONS IN PESTICIDE USAGE

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

B. Storage
1. Avoid storage of pesticides in house premises.
2. Keep only in original container with intact seal.
3. Do not transfer pesticides to other containers; Do not 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.
## XV. PESTICIDE APPLICATION TECHNIQUES

### Equipments

#### Category A: Stationary, crawling pests/diseases

<table>
<thead>
<tr>
<th>Stage</th>
<th>Insecticides and fungicides</th>
<th>Equipment Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vegetative stage</strong>&lt;br&gt; i) For crawling and soil borne pests</td>
<td>• Lever operated knapsack sprayer (droplets of big size)&lt;br&gt; • Hollow cone nozzle @ 35 to 40 psi&lt;br&gt; • Lever operating speed = 15 to 20 strokes/min or&lt;br&gt; • Motorized knapsack sprayer or mist blower (droplets of small size)&lt;br&gt; • Airblast nozzle&lt;br&gt; • Operating speed: 2/3rd throttle</td>
<td><img src="image1.png" alt="Diagram" /></td>
</tr>
<tr>
<td>ii) For small sucking leaf borne pests</td>
<td>• Lever operated knapsack sprayer (droplets of big size)&lt;br&gt; • Hollow cone nozzle @ 35 to 40 psi&lt;br&gt; • Lever operating speed = 15 to 20 strokes/min</td>
<td><img src="image2.png" alt="Diagram" /></td>
</tr>
<tr>
<td><strong>Reproductive stage</strong></td>
<td>• Lever operated knapsack sprayer (droplets of big size)&lt;br&gt; • Hollow cone nozzle @ 35 to 40 psi&lt;br&gt; • Lever operating speed = 15 to 20 strokes/min</td>
<td><img src="image3.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

#### Category B: Field flying pests/airborne pests

<table>
<thead>
<tr>
<th>Stage</th>
<th>Insecticides and fungicides</th>
<th>Equipment Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vegetative stage</strong>&lt;br&gt; Reproductive stage (Field Pests)</td>
<td>• Motorized knapsack sprayer or mist blower (droplets of small size)&lt;br&gt; • Airblast nozzle&lt;br&gt; • Operating speed: 2/3rd throttle Or&lt;br&gt; • Battery operated low volume sprayer (droplets of small size)&lt;br&gt; • Spinning disc nozzle</td>
<td><img src="image4.png" alt="Diagram" /></td>
</tr>
<tr>
<td><strong>Mosquito/ locust and spatial application (migratory Pests)</strong></td>
<td>• Fogging machine and ENV (exhaust nozzle vehicle) (droplets of very small size)&lt;br&gt; • Hot tube nozzle</td>
<td><img src="image5.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

#### Category C: Weeds

<table>
<thead>
<tr>
<th>Application Type</th>
<th>Weedicide</th>
<th>Equipment Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Post-emergence application</strong></td>
<td>• Lever operated knapsack sprayer (droplets of big size)&lt;br&gt; • Flat fan or floodjet nozzle @ 15 to 20 psi&lt;br&gt; • Lever operating speed = 7 to 10 strokes/min</td>
<td><img src="image6.png" alt="Diagram" /></td>
</tr>
<tr>
<td><strong>Pre-emergence application</strong></td>
<td>• Trolley mounted low volume sprayer (droplets of small size)&lt;br&gt; • Battery operated low volume sprayer (droplets of small size)</td>
<td><img src="image7.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>
### XVI. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>For application rate and dosage see the label and leaflet of the particular pesticide.</td>
</tr>
<tr>
<td>2.</td>
<td>It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.</td>
</tr>
<tr>
<td>3.</td>
<td>Clean and wash the machines and nozzles and store in dry place after use.</td>
</tr>
<tr>
<td>4.</td>
<td>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.</td>
</tr>
<tr>
<td>5.</td>
<td>Do not apply in hot or windy conditions.</td>
</tr>
<tr>
<td>6.</td>
<td>Operator should maintain normal walking speed while undertaking application.</td>
</tr>
<tr>
<td>7.</td>
<td>Do not smoke, chew or eat while undertaking the spraying operation.</td>
</tr>
<tr>
<td>8.</td>
<td>Operator should take proper bath with soap after completing spraying.</td>
</tr>
<tr>
<td>9.</td>
<td>Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.</td>
</tr>
</tbody>
</table>
XVII. REFERENCES

- http://agmarknet.nic.in/sunflower_profile.pdf
- http://1.bp.blogspot.com/F_6HmNPY2_c/T7KEORxRWOI/AAAAAAAABdi/NJue83vCGA4/s1600/101_1180.JPG
- http://1.bp.blogspot.com/_qjbUEdDL4xY/SpC3jvskBKI/AAAAAAAAA5o/Ahgl7tf7NuU/s200/leafhopper_jassids.jpg
- http://uasr.agropedia.in/sites/default/files/sunflower%20whitefly%20front_0.jpg
- http://www nbaii.res.in/insectpests/images/Helicoverpa-armigera1.jpg
- http://uasr.agropedia.in/sites/default/files/thrips%20larva.jpg
- http://uasr.agropedia.in/sites/default/files/semilooper%20front.jpg
- http://m.animal.memozee.com/m.view.php?q=%EB%8B%B4%EB%B0%80%EB%A3%A8%EC%9D%B4&n=3
- http://www.forestryimages.org/browse/detail.cfm?imgnum=2511050
- http://uasr.agropedia.in/content/sunflower-whitefly
- http://baba-insects.blogspot.in/2012/05/blog-post_21.html
- http://llladybug.blogspot.in/
- http://commons.wikimedia.org/wiki/File:Spodoptera_litura_egg_mass.jpg
AESA based IPM – Sunflower

- http://uasr.agropedia.in/content/sunflower-tobacco-caterpillar
- http://www.agritech.tnau.ac.in/crop_protection/crop_prot_crop_insect_oil_sunflower.html
- http://uasr.agropedia.in/content/sunflower-bihar-hairy-caterpillar
- https://www.google.co.in/search?q=Bihar+hairy+caterpillar+in+sunflower
- http://www.agritech.tnau.ac.in/crop_protection/crop_prot_crop_insect_oil_sunflower.html
- http://llladybug.blogspot.in/
- http://www.nbaii.res.in/insectpests/Acanthodelta-janata.php
- http://uasr.agropedia.in/content/sunflower-semilooper
- https://extension.umd.edu/news/photos/cutworm
- http://entnemdept.ufl.edu/creatures/veg/black_cutworm.htm
- http://micropics.org.uk/Braconidae/Meteorus/1/meteorus%201.htm
- http://www.ipm.iastate.edu/ipm/icm/node/440
- http://nematology.umd.edu/rootknot.html
- http://uasr.agropedia.in/sites/default/files/A.%20Leaf%20spot.jpg
- http://ag.arizona.edu/plp/alternaria/online/picture_library/alternaria/helianthi/FrameSet.htm
- http://www.agro.basf.ru/agroportal/ru/media/productcatalogue/pests/720x405_1/sunflower_1/alternaria/alternarioz1.jpg
- http://upload.wikimedia.org/wikipedia/commons/3/34/Puccinia_helianthi.jpg
- http://www.plantprotection.hu/modulok/angol/sunflower/sunflower_images/rust02.jpg
- http://www.ianrpubs.unl.edu/epublic/live/g1995/build/graphics/g1995-3.jpeg
- https://dl.sciencesocieties.org/images/publications/books/agronomymonogra/sunflowertechno/386-ins22-Fig7-42.jpeg
• http://oilseeds.agropedia.in/sites/default/files/Sunflower%20Powdery%20Mildew%20(3).JPG
• http://objetoseducacionais2.mec.gov.br/bitstream/handle/mec/7504/829-girasol.jpg?sequence=1
• http://oilseeds.agropedia.in/sites/default/files/Sunflower%20Powdery%20Mildew%20(6).JPG
• http://www.agroatlas.ru/content/diseases/Olee/Olee_Macrophomina_phaseolina/Olee_Macrophomina_phaseolina.jpg
• http://www7.inra.fr/hypp3/images/6033411.jpg
• http://tnau.ac.in/eagri/eagriS0/PATH272/lecture11/001_clip_image002.jpg
• http://www.plantmanagementnetwork.org/pub/php/brief/2010/charcoal/
• http://1.bp.blogspot.com/-quxOg3Pfb7c/TduSvyUlUwI/AAAAAAAAAZ4/O4bURBmt-5w/s1600/8++NECROSIS+VIRUS.jpg
• http://www.scielo.br/img/revistas/fb/v30n4/a05fig03.gif
• http://uasr.agropedia.in/sites/default/files/Necrosis2.jpg
• http://oilseeds.agropedia.in/sites/default/files/Sunflower%20necrosis%20(2).JPG
• http://www.forestryimages.org/images/768x512/5361537.jpg
• http://www.ianrpubs.unl.edu/epublic/live/g1677/build/graphics/g1677-1.jpg
• http://bloximages.chicago2.vip.townnews.com/starherald.com/content/tncms/assets/v3/editorial/b/57/b57d7484-e56a-11e1-997f-0019bb2963f4/502936f281ed0.image.jpg.
• http://www.gopetsamerica.com/bio/pics/rhizopus-zygosporangia.jpg
• http://www.forestryimages.org/images/768x512/5365930.jpg
• http://www.ianrpubs.unl.edu/epublic/live/g1677/build/graphics/g1677-2.jpg
• http://www.forestryimages.org/images/768x512/0725009.jpg
• http://www.ianrpubs.unl.edu/epublic/live/g2075/build/graphics/g2075-7.jpg
• https://dl.sciencesocieties.org/images/publications/books/agronomymonogra/sunflowertechno/386-ins35-Fig7-68.jpeg
• http://www.ianrpubs.unl.edu/epublic/live/g2075/build/graphics/g2075-8.jpg
• 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://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=40633&pid=178398
• http://www.nbaii.res.in/Featured%20insects/Campoletis.htm
• http://eol.org/pages/28099/details
• http://nagpurbirds.org/blackdrongo/picture/1639
• http://en.wikipedia.org/wiki/Dragonfly
• http://www.warpedphotosblog.com/robber-fly-and-prey
• http://spirit-animals.com/praying-mantis/
• http://www.gov.mb.ca/agriculture/crops/production/images/sunflower-headrot.jpg
• http://landresources.montana.edu/soilandfertility/Imag/PSunflower%20P%20deficiency.jpg
• http://agritech.tnau.ac.in/agriculture/agri_min_fldcrops_oilseed.html
• http://upload.wikimedia.org/wikipedia/commons/thumb/5/56/Rose-ringed_Parakeet_RWD.jpg
• http://www.agro.basf.ru/agroportal/ru/media/productcatalogue/pests/720x405_1/sunflower_1/alternaria/alternarioz1.jpg
http://1.bp.blogspot.com/-quxOg3Pfb7c/TduSvyUIUwl/AAAAAAAAAZ4/O4bURBmt-5w/s1600/8++NECROSIS+VIRUS.jpg

http://www.agropedias.iitk.ac.in/sites/default/files/Sunflower%20Powdery%20Mildew%20(1).JPG


http://luirig.altervista.org/cpm/albums/bot-047/phalaris-minor1415.jpg

http://luirig.altervista.org/cpm/albums/02c/normal_008223-echinochloa-crus-galli.jpg

http://www.wildflowers.co.il/images/merged/1774-l-3.jpg?Dinebra%20retroflexa

http://pallano.altervista.org/alterpages/brachiariaeruciformis2.jpg

http://database.prota.org/dbtwwpd/protabase/Photfile%20Images%5CCommelina%20benghalensis%20Atamari%20Wiki.jpg

http://upload.wikimedia.org/wikipedia/commons/b/bd/Quebra-Pedra_..Phyllanthus_niruri.JPG


http://www.impgc.com/images/PlantPictures/Achyranthes%20aspera.jpg

http://flowers.la.coocan.jp/Cyperaceae/Cyperus%20iria/DSC03569.JPG

http://bugwoodcloud.org/images/768x512/1550104.jpg

Gurr, GM, Wratten, SD and Altieri MA (2004a) Ecological Engineering for Pest Management Advances in Habitat Manipulation for Arthropods. CSIRO PUBLISHING, Collingwood, Australia.

Important Natural Enemies of Sunflower Insect & Mite Pests

**Parasitoids**
- *Trichogramma* spp.
- *Carcelia* spp.
- *Campoletis* spp.
- *Chelonus* spp.
- *Encarsia formosa*
- *Eretmocerus* spp.

**Predators**
- Robber fly
- Earwig
- Ladybird beetle
- Mirid bug
- Praying mantis
- Black drongo

**Plants Suitable for Ecological Engineering in Sunflower Field**
- Alfalfa
- French bean
- *Ocimum* spp.
- Cosmos
- Spearmint
- Mustard
- Marigold
- Carrot
- Castor
- Cowpea
- Buckwheat
- Maize