सत्यमेव जयते

AESA BASED IPM Package No.19

AESA based IPM – Cruciferous Vegetables
(Cabbage, Cauliflower, Knol-Khol, Radish, Broccoli)

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The AESA based IPM – Cabbage and Cauliflower, was compiled by the NIPHM working group under the Chairmanship of Dr. K. Satyagopal DG, NIPHM, and guidance of Shri. Utpal Kumar Singh 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 wide spread ecological imbalances resulting in serious problems of insecticide resistance, pest resurgence and pesticide residues. There is a growing awareness world over on the need for promoting environmentally sustainable agriculture practices.

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

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

Date: 6.3.2014

(Avinash K. Srivastava)

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FOREWORD

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

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

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

(Utpal Kumar Singh)

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PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

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1.2 Head borer, *Hellula undalis* (Fabricius) (Lepidoptera: Crambidae) (Andhra, Pradesh, Bihar, Delhi, Karnataka, Madhya Pradesh, Maharashtra, Punjab)

1.3 Leaf webber, *Crocidolomia binotalis* (Zeller) (Lepidoptera: Pyralidae) (Andhra Pradesh, Bihar, Karnataka, Maharashtra, Uttar Pradesh)

1.4 Cabbage aphid, *Brevicoryne brassicae* Linnaeus (Hemiptera: Aphididae) (Delhi, Himachal Pradesh, Karnataka, Maharashtra, Manipur, Meghalaya, West Bengal)

1.5 Cabbage butterfly, *Pieris brassicae* (Linnaeus) (Lepidoptera: Pieridae) (Bihar, Himachal Pradesh, Manipur, Meghalaya, Punjab, West Bengal)

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Grassy weeds

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1. Insect pests

1.1 Tomato fruit borer, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae)
(Himachal Pradesh, Karnataka, Uttar Pradesh)

1.2 Leaf eating caterpillar, *Spilosoma oblique* Walker (Lepidoptera: Arctiidae)

1.3 Serpentine leaf miner, *Liriomyza trifoli* (Burgess) (Diptera: Agromyzidae)

1.4 Mustard aphid, *Lipaphis erysimi* (Kaltenbach) (Homoptera: Aphididae) (Gujarat, Himachal Pradesh, Karnataka, Maharashtra, Punjab, Rajasthan, Tripura)

1.5 Cut worm, *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae)

1.6 Painted bug, *Bagrada cruciferorum* Kirkaldy (Hemiptera: Pentatomidae)

2. Diseases

2.1 Club root: *Plasmodiophora brassicae* Wor. (Bihar, Kerala, West Bengal)

2.2 Cauliflower mosaic virus (CaMV): CaMV (Himachal Pradesh)

2.3 Ring spot: *Mycosphaerella brassicicolaI* (Fries ex Duby) Lindau

2.4 Black leg: *Phoma lingam* (Tode) Desm (*Leptosphaeria maculans*).

2.5 Alternaria spot*: Alternaria brassicae* (Berk.) Sacc.*, A. brassicicola* (Schow.) Wiltshire (Bihar, Himachal Pradesh, Rajasthan)

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2.7 Root rot: *Pythium* spp.

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3. Nematodes

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II AESA based IPM

A. Agro-ecosystem analysis

The integrated pest management (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. sun, rain, wind and soil nutrients) and biological factors (i.e. sun, rain, sunshine hours, wind etc.). 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 forces 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 Integrated Pest Management (IPM):

Grow a healthy crop

- Select a variety resistant/tolerant to major pests
- Treat the seed with recommended pesticides especially biopesticides
- Select healthy seeds and seedlings
- Follow proper spacing

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

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

Farmers should

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

Plant Compensation ability

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

Understand and conserve defenders

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

Insect zoo

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

Pest: Defender ratio (P: D ratio):

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

Model agro-ecosystem analysis chart

Date:
Village:
Farmer:

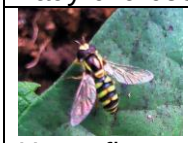
Decision taken based on the analysis of field situation

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

The general rule to be adopted for management decisions relying on the P: D ratio is 2: 1. However, some of the parasitoids and predators will be able to control more than 2 pests. Wherever specific P: D ratios are not found, it is safer to adopt the 2: 1, as

P: D ratio. Whenever the P: D ratio is found to be favourable, there is no need for adoption of other management strategies. In cases where the P: D ratio is found to be unfavourable, the farmers can be advised to resort to inundative release of parasitoids/predators depending upon the type of pest. In addition to inundative release of parasitoids and predators, the usage of microbial biopesticides and biochemical biopesticides such as insect growth regulators, botanicals etc. can be relied upon before resorting to synthetic chemical pesticides.

Feeding/egg laying potential of different parasitoids/predators

Predators/ Parasitoids	Feeding potential/ Egg laying capacity
 Lady bird beetle	Predatory rate of adult coccinellid on aphids is 50 aphids per day
 Hover fly	1st instar larva can consume 15-19 aphids/day 2nd instar larva can consume 45-52 aphids/day 3rd instar larva can consume 80-90 aphids/day In total life cycle they can consume approx. 400 aphids.
 Green Lace wing	Each larva can consume 100 aphids, 329 pupa of whitefly and 288 nymphs of jassids
 Reduviid bug	1st & 2nd nymphal instars can consume 1 small larva/day 3rd & 4th nymphal instars can consume 2 to 3 medium larvae/day 5th nymphal instar & adult can consume 3 to 4 big larvae/day In total life cycle they can consume approx. 250 to 300 larvae
 Spider	5 big larvae/day
 Predatory mite http://www.eduwebs.org/bugs/predatory_mites.htm	Predatory rate of adult is 20-35 phytophagous mites/female/day
 *Bracon hebetor*	Egg laying capacity is 100-200 eggs/female. 1-8 eggs/larva

 *Trichogramma* sp	Egg laying capacity is 20-200 eggs/female.

Decision making

Farmers become experts in crop management

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

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

AESA methodology

- Go to the field in groups (about 5 farmers per group). Walk across the field and choose 20 plants/acre randomly. Observe keenly each of these plants and record your observations:
    - Plant: Observe the plant height, number of branches, crop stage, deficiency symptoms etc.
    - Pests: Observe and count pests at different places on the plant.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
    - Rats: Count number of plants affected by rats.
    - Weeds: Observe weeds in the field and their intensity.
    - Water: Observe the water situation of the field.
    - Weather: Observe the weather condition.

- While walking in the field, manually collect insects in plastic bags. Use a sweep net to collect additional insects. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the field situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write

the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on what field management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording

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

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

Data to be recorded

- Plant growth (weekly)
  - Height of plant
  - Number of leaves
- Crop situation (e.g. for AESA)
  - Plant health
  - Pests, diseases, weeds
  - Natural enemies
  - Soil condition
  - Irrigation
  - Weather conditions
- Input costs
  - Seeds
  - Fertilizer
  - Pesticides
  - Labour
- Harvest
  - Yield (kg/acre)
  - Price of produce (Rs./kg)

Some questions that can be used during the discussion

- Summarize the present situation of the field?
- What crop management aspect is most important at this moment?
- Is there a big change in crop situation compared to last visit? What kind of change?
- Is there any serious pest or disease outbreak?
- What is the situation of the beneficial insects?
- Is there a balance in the field between pests and defenders?

- Were you able to identify all pests and diseases?
- Do you think the crop is healthy?
- What management practices are needed at this moment?
- When will it be done? Who will do it? Make sure that responsibilities for all activities are being discussed.
- Are you expecting any problems to emerge during the coming week such as congenial weather conditions for pest buildup?
- What problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.

Advantages of AESA over ETL

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

AESA and farmer field school (FFS)

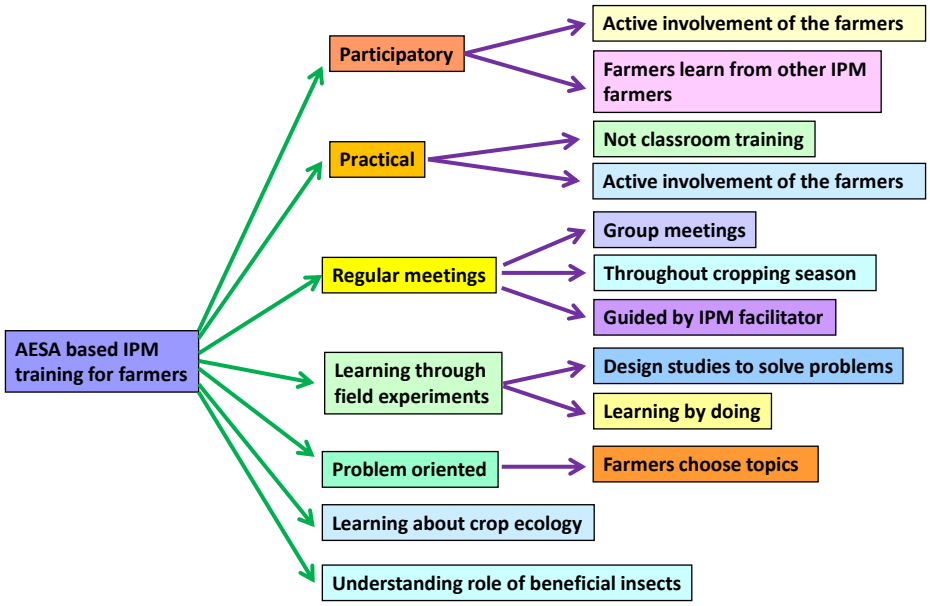
AESA is a season-long training activity that takes place in the farmer field. It is season-long so that it covers all the different developmental stages of the crop and their related management practices. The process is always learner-centered, participatory and relying on an experiential learning approach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

Farmers can learn from AESA

- Identification of pests and their **nature of damage**
- Identification of natural enemies

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

FFS to teach AESA based IPM skills



B. Field Scouting

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

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

C. Surveillance through pheromone trap catches for *Spodoptera* and diamondback moth:

Pheromone traps for two insects viz., DBM and *Spodoptera litura* @ 10-12/fixed field have to be installed. Install the traps for each species separated by a distance of >75 feet in the vicinity of the selected fixed field. Fix the traps to the supporting pole at a height of one foot above the plant canopy. Change of lures should be made once in 2-3 weeks (on regular basis). During each week of surveillance, the number of moths/trap should be counted and entered.
Procedure for observation: Total number of moths of DBM and *S. litura*/trap/week should be recorded year round. The trapped moths should be destroyed and removed after each recording.

D. Yellow pan water trap/ sticky traps
Set up yellow pan water trap/ sticky traps 15 cm above the canopy for monitoring aphids etc. @ 10 traps/ac. Locally available empty tins can be painted yellow/ coated with grease/ Vaseline/castor oil on outer surface may also be used as yellow sticky trap.

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

III. Ecological engineering for pest management

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

Natural enemies may require

1. Food in the form of pollen and nectar for adult natural enemies.
2. Shelters such as overwintering sites, moderate microclimate, etc are needed.
3. Natural enemies may also require alternate host when primary host are not present.

Ecological Engineering for Pest Management – Above Ground :

- Raising 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
- Growing flowering plants on the internal bunds inside the field
- Not to uproot weed plants those are growing naturally like *Tidax procumbens, Ageratum* sp. *Alternanthera* sp., which act as nectar source for natural enemies,
- Not to apply broad spectrum chemical pesticides, when the . P: D is favourable. The plant compensation ability should also be considered before applying chemical pesticides.

Ecological Engineering for Pest Management – Below Ground :

- Crop rotations with leguminous plants which enhance nitrogen content.
- Keeping soils covered year-round with living vegetation and/or crop residue.
- Adding organic matter in the form of FYM, Vermicompost, crop residue which enhance below ground biodiversity.
- Reducing tillage intensity so that hibernating natural enemies can be saved.
- Applying balanced dose of nutrients using biofertilizers.
- Applying *Trichoderma* as seed and nursery treatment and *Pseudomonas fluorescens* as seed, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

Due to enhancement of biodiversity by the flowering plants, parasitoids and predatory natural enemies number also will increase due to availability of nectar, pollen, fruits, insects, etc. The major predators are a wide variety of spiders, lady bird beetles, long horned grasshoppers, *Chrysoperla,* earwigs, etc.

Good insectary plants belonging to Compositae, Leguminaceae, Umbelliferae, Brassicaceae etc. families

French bean

Marigold

Carrot

Sunflower

Buckwheat

Mustard

Alfalfa

Dill

Cowpea

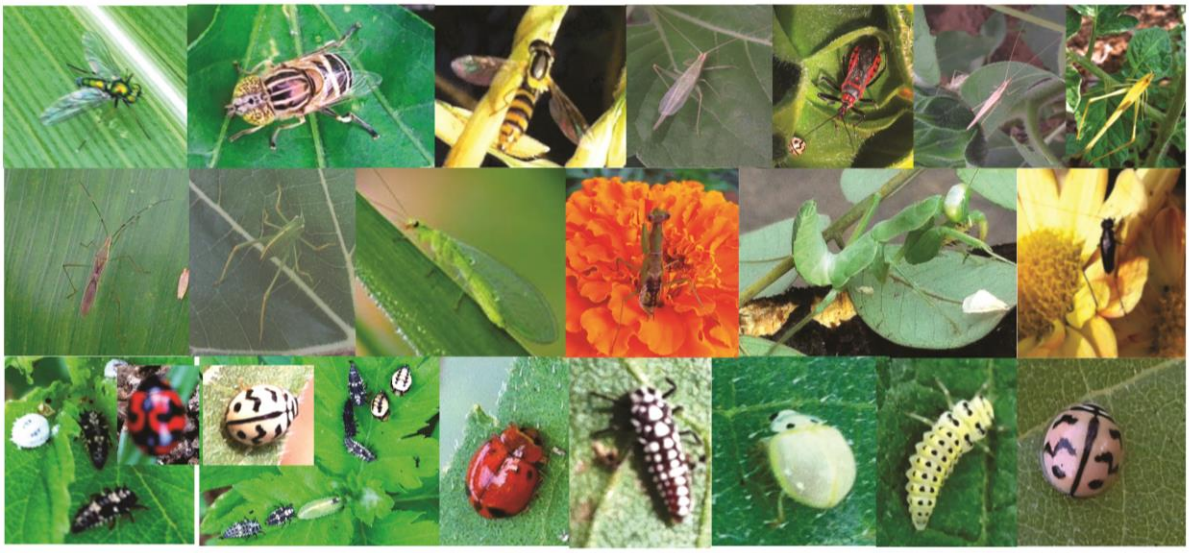
Spearmint

Caraway

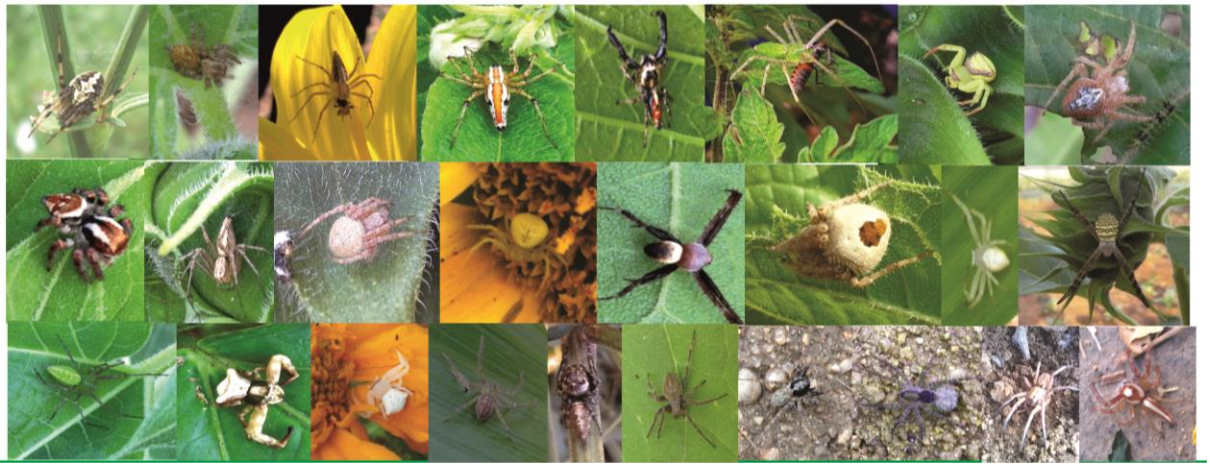
White Clover

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



Flowering plants that attract natural enemies/repel pests

S. No.	Insect	Natural enemies	Attractant Plants
1	Diamondback moth	**Parasitoids:** *Trichogramma* sp (egg) *Apanteles glomeratus* (larval), *Bracon gelechiae* (larval), *Bracon* sp, (larval), *Mesochorus* spp. (larval), *Brachymeria* spp. (larval), *Eriborus* spp. (larval), *Diadegma semiclausum*, (larval) *D. fenestralis* (larval), *Tetrastichus sokolowskii* (larval) and *Cotesia plutellae* (larval), *Diadromus collaris* (pupal), *Diadromus* spp. (pupal), *Brachymeria excarinata* (pupal) etc. **Predators:** *Chrysoperla carnea*, coccinellids, King crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants, big eyed bugs (*Geocoris* sp), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc. **Fungal pathogens:** *Paecylomyces* spp., *Zoophthora radican* etc.	• Attractant plants for natural enemies: Dill, anise, spearmint, buckwheat, yarrow, white clover, tansy, cowpea, fennel, and cosmos (chalcid wasps) • Nectar rich plants with small flowers i.e. anise, caraway, dill, parsely, mustar, sunflower, buck wheat and cowpea (wasp)
2	Cabbage head borer	**Parasitoids:** *Trichogramma* spp. (egg), *Bracon gelechiae* (larval), *B. Hebetor* (larval) etc. **Predators:** *Chrysoperla carnea*, coccinellids, King crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants, big eyed bugs (*Geocoris* sp), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc. **Fungal pathogens:** *Paecylomyces* spp., *Zoophthora radican* etc.	• Attractant plants: Dill, anise, caraway, spearmint, buckwheat, yarrow, white clover, tansy, cowpea, fennel, and cosmos (chalcid wasps) • Nectar rich plants with small flowers i.e. anise, caraway, dill, parsely, mustar, sunflower, buck wheat and cowpea (wasp)
3	Leaf webber	**Parasitoids:** *Trichogramma* sp (egg), *Bracon hebetor* (larval),	• Attractant plants: Dill, anise, caraway, spearmint,

		Cotesia crocidolomiae (larval), *Palexorista solennis* (larval) etc. **Predators:** *Chrysoperla carnea*, coccinellids, King crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants, big eyed bugs (*Geocoris* sp), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc. **Fungal pathogens:** *Paecylomyces* spp., *Zoophthora radican* etc.	buckwheat, yarrow, white clover, tansy, cowpea, fennel, and cosmos (chalcid wasps) • Nectar rich plants with small flowers i.e. anise, caraway, dill, parsely, mustar, sunflower, buck wheat and cowpea (wasp)
4	Cabbage aphids	**Parasitoid:** *Aphidius colemani* (adult and nymph), *Diaeretiella* spp. (adult and nymph), *Aphelinus* spp. (adult and nymph) etc. **Predators:** Anthocorid bugs/pirate bugs (*Orius* spp.), mirid bugs, syrphid/hover flies, green lacewings (*Mallada basalis* and *Chrysoperla carnea*), predatory coccinellids (*Stethorus punctillum*), staphylinid beetle (*Oligota* spp.), predatory cecidomyiid fly (*Aphidoletis aphidimyza*) and predatory gall midge, (*Feltiella minuta*), earwigs, ground beetles, rove beetles, spiders, wasps etc.	• Carrot family, sunflower family, marigold, buck wheat, spearmint (syrphid flies, lace wings, minute pirate bug, damsel bug and conccinellids) • French bean (predatory thrips) • Strips of Rye, grains, cover crops and mulch beds (rove beetle) • Mustard, sweet clove, dill (aphid midge (*Aphidoletes aphidimyza*) • Nectar rich plants with small flowers i.e. anise, caraway, dill, parsely, mustard (aphid parasite and braconid wasp) • Sunflower, buckwheat and cowpea (braconid wasp)
5	Tobacco caterpillar	**Parasitoids:** *Trichogramma chilonis* (egg), *Tetrastichus* spp. (egg), *Telenomus* spp. (egg), *Chelonus blackburni* (egg-larval), *Carcelia* spp. (larval-pupal), *Campoletis chlorideae* (larval), *Eriborus argentiopilosus* (larval), *Microplitis* sp (larval) etc. **Predators:** *Chrysoperla carnea*, coccinellids, King crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants, big eyed bugs	• Repellant plants: Osimum/Basil • Attractant plants: Carrot family, sunflower family, buckwheat, alfalfa, corn, and shrubs (minute pirate bug and lacewing) • Nectar rich plants with small flowers i.e. anise, caraway, dill, parsely, mustard, sunflower, buckwheat and cowpea (braconid wasp)

		(*Geocoris* sp), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc. *Ovomermis albicans*, a nematode,	
6	Cabbage butterfly	**Parasitoids:** *Trichogramma chilonis* (egg)*, T. Japonicum* (egg)*.* **Predators:** Lacewings (*Chrysoperla carnea*), coccinellids*,* King crow, common mynah, wasp, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants, big eyed bugs (*Geocoris* sp), pentatomid bug (*Eocanthecona furcellata*), earwigs, ground beetles, rove beetles etc.	• Attractant plants: Carrot family, sunflower family, buckwheat, alfalfa, corn, and shrubs (minute pirate bug and lacewing) • Nectar rich plants with small flowers i.e. anise, caraway, dill, parsely, mustard, sunflower, buckwheat and cowpea (braconid wasp)

Resistant/ Tolerant varieties of Cruciferous vegetables

Pest	Resistant/ Tolerant variety*
Cabbage	
Black leg	Pusa Drum Head,
Black rot	Pusa Mukta
Cauliflower	
Downy mildew	Pusa Hybrid-2, Pusa Kartik Sankar,
Black rot	Pusa Shubra, Pusa Snowball K-1, Pusa Snowball Kt-25,

***For detailed and updated information nearest KVK, SAU / ICAR Institute may be contacted**

IV. Crop stage-wise IPM:

Crop stage	Management	Activities
Pre-sowing*	**Nutrients**	• Add well rotten farm yard manure (FYM) @ 8-10 t/acre or vermicompost @ 5 t/ acre treated with *Trichoderma*spp. and /or *Pseudomonas*sp @ 2 kg/acre. Incorporate at the time of field preparation 1 week (vermicompost) or 2 to 3 weeks (FYM) before transplanting.
	Weeds	• At the time of field preparation, adopt stale seed bed technique to minimize the weeds menace in field. • Keep the nursery weed free by hand pulling of the weeds. • Black plastic mulch prevents entry of light, which restricts germination of weed seeds and growth.
	Resting stages of pests and nematodes	• Deep summer ploughing • **Soil solarization:** Cover the beds with polythene sheet of 45 gauge (0.45 mm) thickness for three weeks before sowing for soil solarization which will help in reducing the **soil borne pests.** • Apply neem cake @ 100 kg/acre at the time of transplanting for reducing nematodes and borer damage. • In nematode severe area apply carbofuran3% CG @ 20,000 g/acre
	DBM	**Cultural control:** • Removal and destruction of plant remnants, stubbles, debris after harvest and ploughing the field. • Trap crop: Sowing 2 rows of bold seeded mustard as a trap crop for every 25 rows of cabbage to attract moths to mustard. Plant the first row 12 days before transplanting and the second row 25 days after transplanting • Grow intercrops such as tomato, garlic, coriander and carrot in alternate rows with cabbage
Seed Sowing/ Transplanting stage*	**Nutrients**	• Before sowing, soil testing should be done to find out the soil fertility status. Nutrient should be provided as per soil test recommendations. • For varieties apply 32 kg N/acre in three equal splits. The first one (33.3%) at the time of transplanting as basal dose. • For hybrids apply 48 kg N/acre in three equal splits. The first one (33.3%) at the time of

		transplanting as basal dose. • For varieties apply entire quantity of P and K @ 60 and 40 kg /acre, respectively, at the time of sowing. • For hybrids apply entire quantity of P and K @ 90 and 60 kg/acre, respectively, at the time of sowing. • Micronutrient deficiency should be corrected by foliar application. • Biofertilizers: For seed treatment with *Azotobacter* and phosphorous solubilizing bacteria (PSB) cultures @ 8-10 g/kg seed • For seedling root dip treatment with *Azotobacter* and phosphorous solubilizing bacteria (PSB) cultures @ 250 g /acre seedlings
	Weed management	• Keep the nursery weed free by hand weeding. • Avoid carrying weed seedlings along with cabbage seedlings.
Sowing/Planting*	**Black rot**	**<u>Cultural control:</u>** • Crop sanitation • Resistant varieties: • Crop rotation for 2-3 years with non-cruciferous crops
	Damping off	**<u>Cultural control:</u>** • Quality seed and a chemical or heat pasteurized planting medium should be used. • Excessive watering and poorly drained areas of field should be avoided • **Use raised beds:** more than 15cm height is better for water drainage or use pro trays for raising seedlings **<u>Chemical control:</u>** • Soil drench with captan 75% WP @ 1000 g in 400 l of water/acre • Treatment with captan 75% WP @ 20-30 g/kg seed.
	Alternaria leaf spot	**<u>Cultural control:</u>** • Long rotations (3 years) without crucifer crops or cruciferous weeds such as wild mustard. • Plant later plantings upwind of earlier plantings. • Allow for good air circulation (i.e. wide spacings, rows parallel to prevailing winds, not close to hedgerows). **<u>Chemical control:</u>** • Spray zineb 75% WP @ 600-800 g in 300-

		400 l of water/acre or mancozeb 75% WP @ 600-800 g in 300 l of water/acre
***** Applying *Trichoderma* as seed and nursery treatment and *Pseudomonas fluorescens* as seed, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).		
Vegetative stage	**Nutrients**	**<u>Top Dressing</u>** • Apply second dose (33.3%) 30 days after transplanting and irrigate the crop immediately after fertilizer application. • Micronutrient deficiency should be corrected by foliar spray of particular micronutrient.
	Weeds	• Weeding and hoeing should be done once within 20-25 days after transplanting and second time 45 days after transplanting. Deep hoeing should be avoided. • Mulching with black Low Density Polyethylene (LDPE) sheets of 30micron thickness by burying both the ends into the soil to a depth of 10 cm will avoid weed growth.
	DBM	**<u>Cultural control:</u>** • Install pheromone traps @ 4-5/acre for monitoring. **<u>Biological control:</u>** • Release egg parasitoid, *T. chilonis/pretiosum* @ 20,000/acre 4-6 times at weekly interval. • Release larval parasitoids, *Diadegma semiclausm* @ 1,00,000/acre (Hills – below 25 –27ºC) or *Cotesia plutellae* (plains) @ 20,000/acre from 20 days after planting • Conserve other parasitoids such as *Brachymeria* spp., *Eriborus* spp. etc. • Fungal pathogens, for example, *Paecilomyces* spp. and *Zoophthora radican* are effective. • Foliar spray with 5% NSKE or azadirachtin 0.03% (300 ppm) neem oil based WSP @ 1000-2000 ml in 200-400 l of water/acre **<u>Chemical control:</u>** • Spray flubendiamide 20% WG @ 15 g in 150 l of water/acre or lufenuron 5.4% EC @ 240 g in 200 l of water/acre or spinosad 2.5% SC @ 240–280 in 200 l of water/acre

		or indoxacarb 15.8% EC @ 106.4 ml in 200–400 l of water/acre or emamectin benzoate 5% SG @ 60- 80 g in 200 l of water/acre or fipronil 5% SC @ 320–400 ml in 200 l of water/acre. (last spray should be 15 days before harvesting).
	Cabbage borer	**Cultural control:** • Collect and destroy caterpillars mechanically in the early stages of attack. **Chemical control:** • Malathion 50 EC @ 600 ml in 200-400 l of water/acre..
	Cabbage leaf webber	**Cultural control:** • Remove and destroy the webbed leaves with caterpillars within. • Set up light traps @ 1/acre. **Biological control:** • Conserve parasitoids such as *Cotesia crocidolomiae* etc.
	Cabbage Aphid	**Cultural Control:** • Install yellow sticky traps, yellow water pan traps @ 12/acre to monitor alates (winged adult). **Biological control:** • Conserve parasitoids such as *Aphidius colemani* (adult and nymph)*, Diaeretiella* spp. (adult and nymph), *Aphelinus* spp. (adult and nymph) etc. • Conserve predators such wasps, green lacewings, earwigs, ground beetles, rove beetles, spiders etc. **Chemical control:** • Foliar spray with dimethoate 30% EC @ 264 ml in 200-400 l of water/acre or fenvalerate 20% EC @ 120-150 ml in 240-300 l of water/acre or phosalone 35% EC @ 571 ml in 200-400 l of water/acre or acetamiprid 20 % SP @ 300 ml in 200-240 l of water/acre.
	Tobacco caterpillar	**Cultural control:** • Field sanitation and rouging • **Repellant plants: Ocimum/Basil** • Setting up light traps for adults @ 1/acre. • Erecting of bird perches for encouraging predatory birds such as mynah, drongo etc. • Use of ovipositional trap crops such as

		castor @ 250 plants/acre and collection of larvae from flowers • Installing pheromone traps @ 4-5/acre for monitoring insect activity **Biological control:** • Spray NSKE 5% against eggs and first instar larvae. • Spray NPV @ 40LE/ac in combination with jaggery 1 kg, sandovit 100 ml or Robin Blue 50 g thrice at 10-15 days interval on observing the eggs or first instar larvae in the evening hours. • Conserve parasitoids such as *Trichogramma chilonis* (egg), *Tetrastichus* spp. (egg), *Telenomus* spp. (egg), *Carcelia* spp. (larval-pupal), *Campoletis chlorideae* (larval) etc. • Conserve predators such as lacewings (*Chrysoperla carnea*), coccinellids, king crow, dragonfly, spider, robber fly, reduviid bug, praying mantis, fire ants etc. **Chemical control:** • Spray **trichlorfon 5% GR @ 300 g/acre or t**hiodicarb 5% GR @ 300g/acre or chlorfluazuron 5.4% EC @ 600 ml in 200 l of water/acre
	Cabaage butterfly	**Cultural control:** • Fine-mesh netting in nursery will stop butterflies from reaching the crop and lay eggs. Collect and destroy eggs or caterpillars mechanically by hand- usually on the underside of the leaves. • Intercropping cabbages with *Nasturtium* results in fewer eggs laid on cabbage by the butterflies. **Biological control:** • Release *Trichogramma* spp. • Erect bird perche • Conserve parasitoids such as *Cotesia glomeratus* (larval), *Pteromalus puparum* (larval) etc.
	Club rot diseases	**Cultural control:** • Use disease free seedlings • A pH slightly above neutral (usually about pH 7.2) helps to minimize disease • Add hydrated lime to soil to increase pH to 7.2

		(6 weeks before planting @ 1.5 t/ac) • Avoid excess irrigation
	Downy mildew	**<u>Cultural control:</u>** • Destruction of infected plant debris • Avoid of thick sowing and excessive moist conditions • Use a 3- year rotation without cruciferous crops • Avoid overhead irrigation • Allow for good air movement (i.e. wide spacing, rows parallel to prevailing winds, not close to hedgerows)
	Powdery mildew	**<u>Cultural control:</u>** • Destruction of infected plant debris • Maintain proper spacing
	White rot	**<u>Cultural control:</u>** • Sanitary measures and destruction of weeds • Crop rotation <u>with non-cruciferous crops</u>
	Black rot	• Same as in seedling stage
	Alternaria leaf spot	• Same as in seedling stage
	DBM and other lepidopteran insects	• Same as in vegetative stage
Head state	**Nutrients**	• The third dose (33.3%) 50-60 days after transplanting and if they are long duration varieties third dose at 75-80 days after transplanting. Micronutrient deficiency should be corrected by foliar spray of particular micronutrient.

V. Insecticide resistance and its management

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

Causes of resistance development: The causes and rate at which insecticide resistance develops depend on several factors, including 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.
3) **Take an integrated approach to managing pests.** Use as many different control measures as possible. 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.
4) **Time applications correctly.** Apply insecticides when the pests are most vulnerable. Use application rates and intervals recommended by the manufacturer, university insect management specialist, county Extension agent, or crop consultant.
5) **Mix and apply carefully.** While applying insecticides care should be taken for proper application of insecticides in terms of dose, volume, timing, coverage, using techniques recommended by the manufacturer etc.
6) **Alternate different insecticide classes.** Avoid the repeated use of the same insecticide, insecticides in the same chemical class, or insecticides in different classes with same mode of action and rotate/alternate insecticide classes and modes of action.
7) **Preserve susceptible genes.** Preserve susceptible individuals within the target population by providing unsprayed areas within treated fields, adjacent "refuge" fields, or habitat attractions within a treated field that facilitate immigration. These susceptible individuals may outcompete and interbreed with resistant individuals, diluting the resistant genes and therefore the impact of resistance.

VI. Nutritional deficiencies:

S. No.	Nutrients and their deficiency symptoms	
1	**Whip-tail:** In this condition, the leaf blades do not develop properly and become strap like. The growing point is severely deformed and no marketable curd is formed. This condition in cauliflower results because of the deficiency of molybdenum which occurs in acidic soils below 4 -5 pH. **Correction measures:** It may be controlled by liming the soil which reduces the acidity and increases the soil pH up to 6.5. It may also be controlled by the application of 1-2 kg/ac of sodium or ammonium molybdate.	  **Characteristic symptom**
2	**Browning:** Browning is a common problem in cauliflower. In this the stem becomes hollow and the curd becomes brown. Affected curds develop a bitter taste. Browning occurs because of the deficiency of boron. **Correction measures:** This condition may be controlled by the application of borax or sodium borate @ 20 kg per hectare. In case of acute deficiency, spray of 0.25 to 0.50% solution of borax @ 1-2 kg/ac will give satisfactory results. It has been reported that boron and molybdenum increase curd size and weight as well as ascorbic acid content when applied together.	
3	**Buttoning:** This disorder of cauliflower is identified by the development of small curd or 'button' while the plants are small and consequently the curd gets open. This is caused due to the deficiency of nitrogen, by planting seedlings older than 6 weeks, or any other factors that cause check in growth in the early stage of seedlings. These factors may be insufficient moisture supply, water logging, hot and dry weather, carelessness in proper and timely weeding and pest and disease attack. If an early variety is grown	

	late, its growth is checked due to lower temperature and the curds remain under sized or buttoned. Such factors should be avoided to get proper size of the curd.	

4	**Riceyness:** A premature initiation of floral buds in cauliflower is characterized by riceyness. In this case the peduncle elongates and the curd becomes granular and loose. Such curds are considered to be of poor quality for marketing. This condition may result from any temperature higher or lower than the optimum required for a particular variety. Rampant growth, heavy nitrogen dressing and high relative humidity may also play some role in developing this condition. It may also appear when the harvesting of curds is delayed and they become over mature.	
5	**Blindness:** When the terminal bud does not develop or gets broken or eaten away by the insects, the condition is called 'blindness. In other words the plant grows without the terminal bud with no formation of curd or head. The leaves become large, dark green and leathery. These types of plants should be removed from the field.	
6	**Internal tipburn:** Tipburn is a nonpathogenic internal disorder that is associated with the death of leaf tissue, usually along the leaf margins in the interior of the head. At first the tissue turns tan or light brown, but later may appear to be dark brown or even black. The affected tissue loses moisture and takes on a papery appearance. The extent of the symptoms may vary from a narrow band along the leaf margin(s) of one or a few leaves to a rather extensive zone involving a number of leaves. The condition is not progressive, but does become increasingly evident as head maturity approaches. If an affected head is harvested at an early state of maturation, little evidence of the disorder may be observed. For this reason, fresh market cabbage does not as often show visible symptoms of tipburn as do more-mature processing cabbage heads. Affected tissue may be invaded by secondary pathogens	

	(i.e., bacterial soft rot), which can cause further breakdown. Because tipburn cannot be detected externally, the head must be cut open to determine whether the disorder is present	
7	**Phosphorus:** Pigmentation in old leaves; curd size and quality will be affected **Correction measure** Soil application of recommended dose phosphorus.	 **Characteristic phosphorous (P) deficiency symptom**
8	**Zinc:** Young leaves become small; curd color will be affected. **Correction measure:** Foliar spray of ZnSO4 @ 0.5%	 **Characteristic zinc (Zn) deficiency symptom**

VII. Description of common weeds

Major kharif weeds

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

It is an erect 6 to 100 cm tall annual herb with especially upwards glabrous to pubescent stem. Leaves are also glabrous or pubescent on the veins of the lower surface; petioles long (up to 10 cm), occasionally longer than the blade; blade ovate to rhombic-oblong, base tapered to blunt, tip rounded. Flowers green, unisexual, male and female intermixed, in slender axillary to terminal paniculate spikes 2-12 cm long and 2-5 mm wide, or in dense axillary clusters in the lower part of the stem. Fruits are capsule almost round shaped 1.25-1.75 mm long with rough surface. Seeds 1-1.25 mm, round, slightly compressed, dark brown to black with a paler thick border.

2. Swine cress: *Coronopus didymus* (L.) Sm. Brassicaceae

An annual herb with , horizontal or ascending stem, multiple from the base, radiating from a central point; glabrous, green. Leaves are alternate, petiolate, pinnate, 4-5 cm long, 2 cm broad, glabrous. Divisions of the leaves opposite, lobed or devided, linear-elliptic to linear oblong. Inflorescence is a small raceme, up to 4 cm long, opposite to one of the stem leaves, compact. Flowers minute, greenish. Fruits are glabrous, 3-4 mm broad, 2 mm long, slightly compressed, sub-globose, 2-seeded.

3. Black nightshade: ***Solanum nigrum* L. Solanaceae**

A variable annual herb upto 1 m tall with an erect, glabrous or sparsely pubescent stem and staggered branching pattern. Leaves are 2.5-9 cm long and 2-5 cm wide, ovate, glabrous, thin,

margins toothed, tapering into the petiole, apex subacute. Flowers small, white, borne in drooping, umbellate 3-8 flowered cymes. Fruits berries globose, 5-8 mm in diameter, red, yellow or purplish-black. when ripened, fruits having numerous, disc-shaped, 1.5 mm in diameter, yellow, minutely pitted seeds.

4. Common purselane: ***Portulaca oleracea* L. Portualacaceae**

An annual glabrous herb with prostrate and succulent stem. Leaves spatulate, flattened, apex round nearly truncate. Flowers 3-10 mm diameter and yellow. Fruits capsules ovoid, 4-9 mm diameter. Seeds black or dark brown, orbiculate or elongate, flattened, 0.6-1.1 mm; surface cells sooth, granular, or stellate, with rounded tubercles.

5. False amaranth: *Digera arvensis* Forssk. Amaranthaceae

An annual herb, 30-60 cm high with spreading branches. Leaves variable, 2-7.5 cm long and 1.3-4.5 cm wide, ovate or elliptic, acute or rounded at the apex, sometimes with reddish margins, glabrous. Flowers pink, borne in threes axillary, pedunculate spikes, 2.5-12.5 cm long. Fruits globose, approximately 0.3 cm in diameter having yellowish-brown.

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

Annual, very variable, grass, 10-44 cm high. Stem erect or creeping culms, rooting from the profusely branched nodes. Leaves are linear, tapering to a fine point, 2-10 cm long and 0.2-0.4 cm wide, flat, glaucous, glabrous or hispid; leaf sheaths striate, the lower whitish; ligules membranous, very short. Inflorescence comprised of 2-6 digitate spikes, 0.5-4 cm long, olive-grey; spikelets 2-5 flowered, spreading at right angles, pendulous, strongly striate. Grain 0.5-1 mm long, subglobose, reddish, very rugose.

7. Crabgrass: *Digiteria sanguinalis* (L.) Scop. Poaceae

A prostrate or ascending annual grass with spreading, branched stem having rooting at nodes. Leaves are 3-20 cm long, 3-10 mm wide, with hairs on both the surfaces. Stem sheaths hairy and closed. Leaves and sheaths may turn dark red or maroon with age. Seed head composed of 4-6 branches (spikes) at the top of the stems, each approximately 3-15 cm long. Fruit caryopsis shiny, yellowish-brown, 2-3 mm long.

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

Robust, tufted annual grass, erect or at the base decumbent and rooting at the nodes, 20-150 cm tall. Culms cylindrical, glabrous, filled with white spongy pith. Leaf sheaths glabrous and 9-13 cm long. Leaf blades merging into the sheath, linear, with a broad, rounded base and acute top; rough margined, glabrous or at the base with a few long hairs, smooth or the upper surface minutely bristly. Inflorescence is an apical panicle of 5-40 spikes like racemes. Fruit are caryopsis ovoid to obovoid, compressed, 1.5-2 mm long.

Sedges

9. Purple nutsedge: *Cyperus rotundus* L. Cypraceae

A perennial sedge, hard, fragrant, globose-ovoid tubers, up to 1.2 cm long and 0.3-0.7 cm in diameter; culms solitary or few together, sparsely tufted, erect, 10-75 cm tall, 3-angled at top. Leaves narrowly linear, sometimes longer than stem, 0.4-0.8 cm wide, dark green above, pale beneath. Inflorescence is a simple or compound umbel, rays 2-8, each up to 7.5 cm long, bearing short spikes of 3-10 spreading, red-brown spikelets. Nuts oblong to ovate-oblong, 3-sided, 1.3-1.5 mm long and 0.5-0.7 mm wide, maturing brown.


10. Flat sedge: ***Cyperus iria* L. Cypraceae**

Annual sedge, sometimes behaving as a perennial with 8 to 60 cm high. The culms are tufted, triangular, smooth, green and 0.6-3.0 mm thick. The roots are numerous, short and yellowish-red. Leaves are linear-lanceolate, usually all shorter than the culm, 1-8 mm wide, flat, and rough on the margin and major ribs; leaf sheaths are green to reddish-brown, membraneous and envelope the culm at the base. Inflorescence is simple or compound, usually open, 1-20 cm long and 1-20 cm wide, with groups of spikes which are either attached directly to stem or on 0.5-15.0 cm long peduncles (rays). Spikelets are erect-spreading, crowded, 6-24-flowered, 2-13 mm long, 1.5-2.0 mm wide, golden to yellowish green. Nutlet, 1.0-1.5 mm long, 0.6-0.7 mm wide, obovate, triangular in cross section, dark-brown to almost black; the surface is almost smooth.

Major rabi weeds

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

It is an annual weed found in agricultural fields. It is a polymorphous, non-aromatic, erect herb**,** 0.3-3 m tall with angled stems that are often striped green, red or purple. Leaves are variable in size and shape, lower leaves are toothed or irregularly lobes, 10-15 cm long, with petioles often as long as leaf blades. Flowers are green, borne in clusters forming a compact or loosely panicled axillary spike. Fruits utricle, seeds round, compressed, black and shining.



2. Scarlet pimpernel: *Anagallis arvensis* Primulaceae L

A low-growing annual, up to 30 cm tall with branched or erect herbaceous, 4-angled, glabrous to pubescent stem. Sometimes rooting observed at the nodes. Leaves are opposite, entire, sessile, ovate variously pubescent, margins somewhat tuberculate. Flowers are bright blue, solitary arising from the area between the stem and leaves (leaf axils) and occur on relatively long stalks (pedicels). Fruits capsule, globose, seeds1.3 mm long, trigonous, brown.

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

It is a sweet-smelling erect herb, up to 10-60 cm high with hairless, spreading or erect stem. Leaves odd-1-pinnate; leaflets 1-2.5 cm, inverted, lance-shaped to wedge-shaped, generally sharply toothed on the broader part. Flowers yellow; appear in slender, compact racemes that are 1-2 inches in length. Plant bear papery, small, round, 2-3 mm long, yellow or grey, reticulately wrinkled and slightly hairy pods. Seeds 2 mm long; 1.5 mm wide; broadly oval, one side plane, the other side rounded; yellowish green; roughened by minute tubercles.

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

Annual herb, up to 60 cm tall. Stem Slender, much branched and succulent. Leaves 2-3 pinnatisect, 2-5 cm long, segments linear oblanceolate, apiculate. Flowers Purplish-red, spurred, in terminal or leaf opposed bracteate racemes. Fruits are rounded nuts, 2-3 mm in diameter, wrinkled when dry.

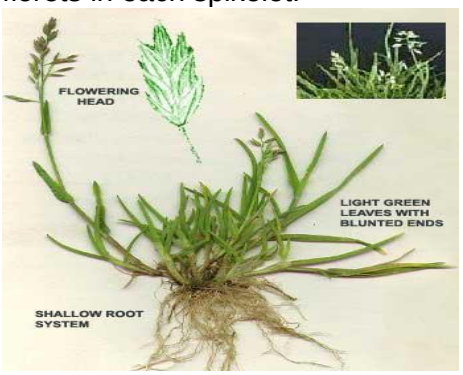
5. Corn spurry: ***Spergula arvensis*** **L. Caryophyllaceae**

A diffuse annual herb. Stem branched from the root, grooved. Leaves are in pseudo whorls, fleshy, linear-subulate, spreading. Flowers small, white. Fruits capsule rounded, five valved. Seeds are circular, thick lens shaped in cross section; margins winged with one small notch. Seeds are greyish black to black with margins usually light brown.

6. Bluegrass: ***Poa annua*** **L. Poaceae**

Annual cool-season grass grows 6 to 8 inches high when left unmowed. It has light green flattened stems that are bent at the base and often rooted at the lower stem joint. Leaf blades are often

crinkled part way down and vary from 1 to 3 inches long with typical *Poa* boat-shaped leaf tips- a key characteristic of annual bluegrass. Inflorescence is branched with three to eight flattened florets in each spikelet.



7. Canary grass: *Phalaris minor* Retz. Poaceae

A tufted annual bunchgrass, up to 1.8 meters in height. Stem is erect or horizontal with long, linear leaves. Ligule is an oblong hyaline membrane, about 2-5 mm long, often truncate and/or fringed; auricles absent, sheath smooth. Panicle more or less protruding or entirely protruding from the uppermost swollen leaf sheath, ovate to oblong, 5-8 cm long, green. Spikelets green, broadly lanceolate on short pedicels, shining, 4 -6 mm long, strongly laterally compressed.

VIII. Description of insect pests:

1) Diamondback moth:

It is distributed worldwide infesting cruciferous plants of *Brassica* spp*.* such as cauliflower, *Brassica oleracea var. capitata* , turnip *Brassica rapa* etc.

Egg: Each female lays 50-60 small whitish eggs singly along the veins on underside of leaves at night times. Egg hatches in about 7 days.

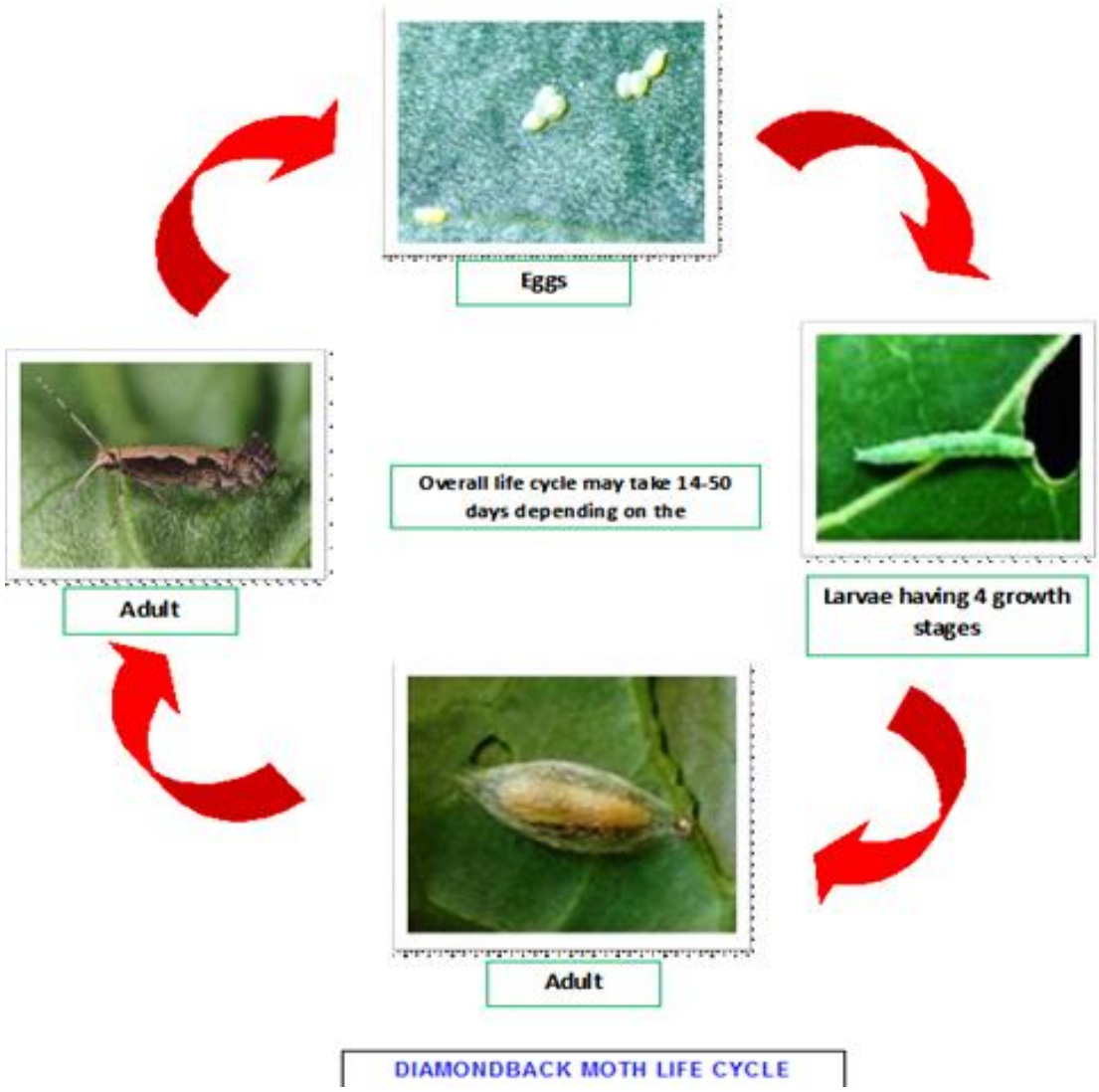
Larva: Larva is greenish with short thin hairs on the body. Full grown caterpillar measures 1-1.5 cm and its body tapers towards both ends. Larval period is 14 days.

Pupa: Pupation takes place inside a thin loose mesh of silken cocoon. Pupal period is about 7 days.

Adult: The moth is greyish brown with narrow wings having pale white triangular markings on inner margin of each forewing which form three diamond shaped white patches dorsally when wings are folded over back at rest. Hence the name, diamondback moth.

The pest is active throughout the year.

Life cycle:



http://www.infonet-biovision.org/default/ct/90/pests

Damage symptoms:

- Caterpillars feed on undersurface of leaves and bite holes in leaves and cause serious damage
- Withered appearance of affected leaves.
- Skeletonized leaves.


Egg parasitoids:

1. *Trichogramma* spp.

Larval parasitoids:

1. *Brachymeria* spp. **2. *Eriborus* spp.**


3. ***Brachymeria excarinata*** **4. *Cotesia plutellae***


2) Cabbage head borer:

It infests cabbage, cauliflower, knolkhol and beetroot

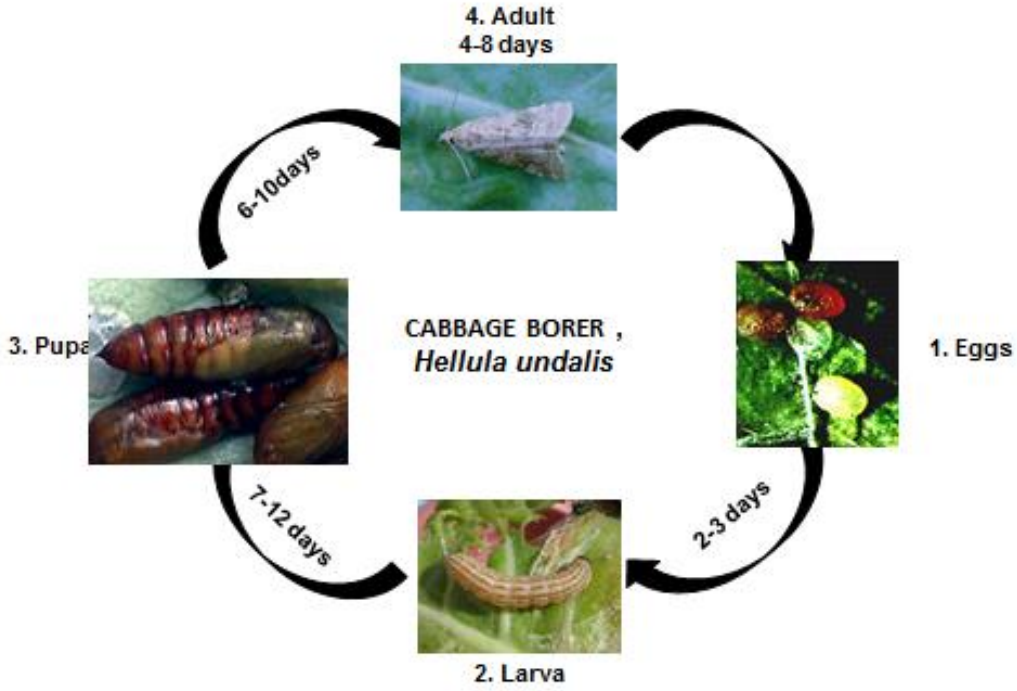
Egg: Female moth lays yellowish shiny eggs on leaves. Eggs hatch in about 4 days.

Larva: The caterpillar becomes full grown in about 9 days. Full grown caterpillar is 12-15 mm, greyish yellow with seven purplish brown longitudinal stripes on the body

Pupa: Full grown larva pupates in the larval burrow itself or in the soil. Pupal period is about 6 days.

Adult: Adult is pale yellowish-brown moth having grey wavy lines on the forewing.

Life cycle:



1 http://www.extento.hawaii.edu/kbase/view/files/pictures/h_undal1.jpg
2 http://www.ent.uga.edu/veg/colecrops/images/cabbagewebworm2.jpg
3 http://www.malaeng.com/blog/tmp/2010/08/4hellula.jpg
4 http://www.infonet-biovision.org/default/ct/106/pests

Damage symptoms:

- Caterpillars web the leaves and bore into stem, stalk or leaf veins.
- They bore into the cabbage head also making it unfit for consumption. The damage results in Webbed leaves
- Holes in cabbage head with fecal matter

Egg parasitoids:

1. *Trichogramma* spp.

2. Larval Parasitoids:

Brachymeria spp, *Eriborus* spp *Apanteles ruficrus,*



Brachymeria excarinata *Cotesia plutellae*


3) Cabbage leaf webber:

It infests cabbage, radish, mustard and other cruciferous plants.

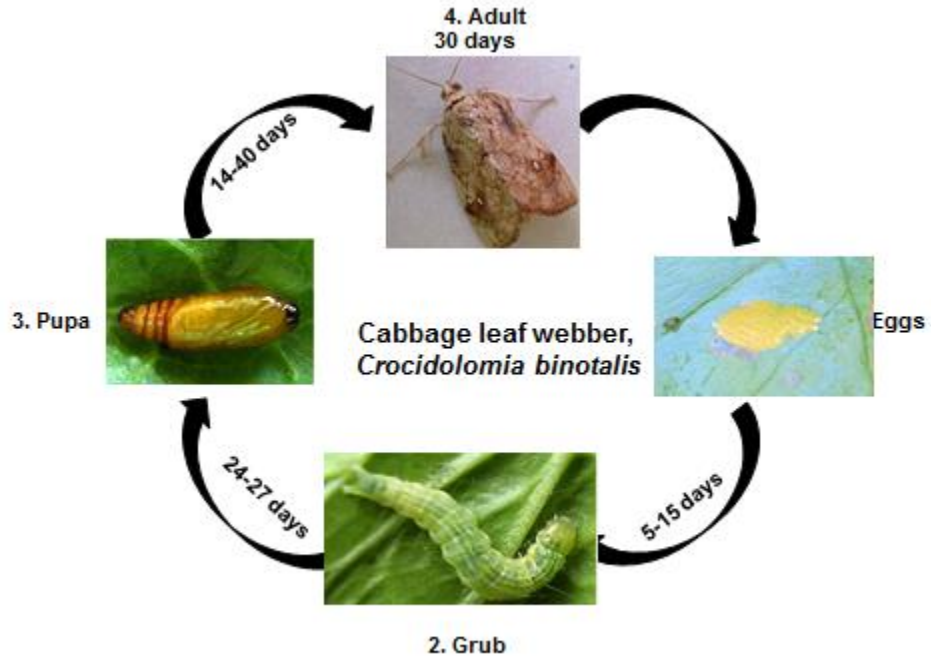
Eggs: Female moth lays eggs in masses of 40 -100 on underside of leaves. They hatch in 5 -15 days

Larva: Caterpillar webs together the foliage and feeds on leaves. It also feeds on flowers and pods in the case of mustard and flower heads in cabbage and cauliflower. Caterpillar bears red head with brown longitudinal stripes and rows of tubercles on the body. Larval period is 24-27 days.

Pupa: Pupation takes place in a cocoon within the webbed leaves. Pupal period is 14-40 days.

Adult: Adult is small with light brownish forewings.

Life cycle:



1. http://ecoport.org/ep?SearchType=pdb&PdbID=38333
2,3,4 http://infohamapenyakittumbuhan.blogspot.in/2012/04/crocidolomia-binotalis-zell.html

Damage symptoms:

- Webbed leaves with fecal matter
- Skeletonized leaves

Egg parasitoid:

1. *Trichogramma*

Larval parasitoids:

Brachymeria spp,

Eriborus spp.

Apanteles ruficrus,

Brachymeria excarinata

Cotesia plutellae

4) Cabbage aphids:

The aphids are yellowish green (*B. brassicae)*) and multiply parthenogenetically.

Eggs

Nymph

Adults

Damage symptoms:

This pest infests crucifers in cold season.
Both the nymphs and adults suck sap from plant causing loss of vigour. Sooty mould develops on excreted honeydew reducing the photosynthesis.


Parasitoid:

1. *Aphidius colemani* 2. *Aphelinus* spp.


1. http://biobee.in/products-and-services/solutions/bio-aphidius/
2. http://australianmuseum.net.au/image/Aphelinus-wasp-stings-aphid-Denis-Crawford/

Predators:

1. Lacewing 2. Lady beetle 3. Spider 4. Syrphid larva




1.http://www.macro-world.cz/image.php?id_foto=514&gal=29
2. http://llladybug.blogspot.in/
3. http://en.wikipedia.org/wiki/Wolf_spider
4. http://en.wikipedia.org/wiki/Aphid

5) Painted bug:

Nymphs are reddish in colour. Adult is yellow with black markings

Nymph Adult


Symptoms of damage:

- It is a serious pest of cruciferous crops and widely distributed. Both nymphs and adults suck sap from leaves, shoots and pods resulting in wilting and loss of vigour of the plant.
- It feeds on cabbage, caluliflower, radish etc.

Predators:

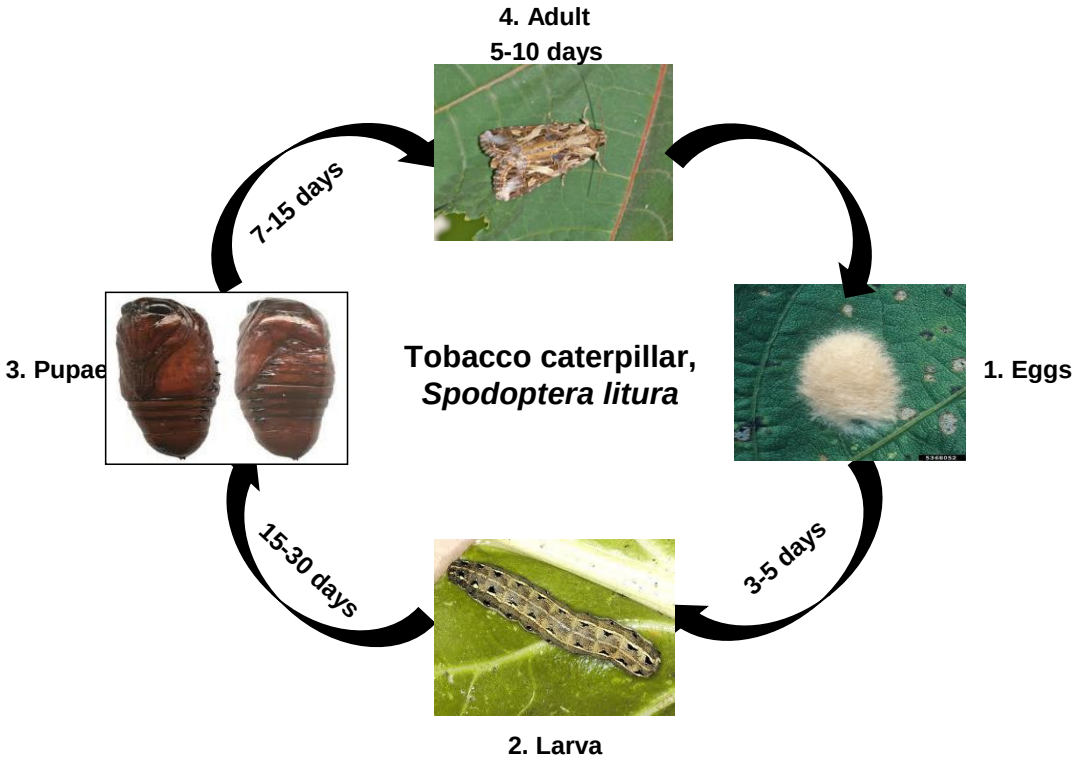
Big–eyed bugs

6) Tobacco caterpillar:

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

Eggs: Female lays about 300 eggs in clusters. The eggs are covered over by brown hairs and they hatch in about 3-5 days.
Larva: Caterpillar measures 35-40 mm in length, when full grown. It is velvety, black with yellowish – green dorsal stripes and lateral white bands with incomplete ring – like dark band on anterior and posterior end of the body. It passes through 6 instars. Larval stage lasts 15-30 days
Pupa: Pupation takes place inside the soil. Pupal stage lasts 7-15 days.
Adult: Moth is medium sized and stout bodied with forewings pale grey to dark brown in colour having wavy white crisscross markings. Hind wings are whitish with brown patches along the margin of wing. Pest breeds throughout the year. Moths are active at night. Adults live for 7-10 days. Total life cycle takes 32-60 days. There are eight generations in a year.

Life cycle:



1. http://commons.wikimedia.org/wiki/File:Spodoptera_litura_egg_mass.jpg
2. http://lepidoptera.butterflyhouse.com.au/lynf/lynf.html
3. http://www.ccs-hk.org/DM/butterfly/Noctuid/Spodoptera-litura.html
4. http://www.nbaii.res.in/insectpests/images/Spodoptera-litura11.jpg

Damage symptoms:

- In early stages, the caterpillars are gregarious and scrape the chlorophyll content of leaf lamina giving it a papery white appearance. Later they become voracious feeders making irregular holes on the leaves.
- Irregular holes on leaves initially and later skeletonization leaving only veins and petioles
- Heavy defoliation.
- Bored fruits with irregular holes

Parasitoid:

1. *Trichogramma* spp.

2. *Tetrastichus* spp.

3. *Chelonus* spp.

4. *Telenomus* spp.

5. *Bracon* spp.

6. *Ichneumon* spp.

7. *Carcelia* spp.

8. *Campoletis* spp.

1. http://gsquaredbugs.com/?page_id=318
2. http://www.pbase.com/image/135529248
3. http://www.nbaii.res.in/Featured%20insects/chelonus.htm
4. http://baba-insects.blogspot.in/2012/02/telenomus.html
5. http://www.nbaii.res.in/Featured%20insects/Bracon%20brevicornis.htm
6. http://www.organicgardeninfo.com/ichneumon-wasp.html
7. http://72.44.83.99/forum/viewthread.php?thread_id=40633&pid=178398
8. http://www.nbaii.res.in/Featured%20insects/Campoletis.htm

Predators:

1. Lacewing

2. Lady beetle

3. Spider

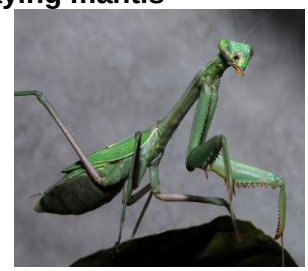
4. Fire ant

5. Dragon fly

6. Robber fly

7. Reduviid bug

8. Praying mantis



9. Black drongo (King crow) **10. Wasp** **11. Common mynah** **12. Big-eyed bug (*Geocoris* sp)**




13. Earwig **14. Ground beetle** **15. Pentatomid bug (*Eocanthecona furcellata*)**



1. http://www.macro-world.cz/image.php?id_foto=514&gal=29
2. http://llladybug.blogspot.in/
3. http://en.wikipedia.org/wiki/Wolf_spider
4.http://www.couriermail.com.au/news/queensland/queensland-launched-a-war-against-the-fire-ant-invasion-but-12-years-later-they8217re-still-on-the-march/story-fnihsrf2-1226686256021
5. http://en.wikipedia.org/wiki/Dragonfly
6. http://www.warpedphotosblog.com/robber-fly-and-prey
7.http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-of-predators,-parasites-and-pathogens/assassin-bugs
8. http://spirit-animals.com/praying-mantis/
9. http://nagpurbirds.org/blackdrongo/picture/1639
10. http://somethingscrawlinginmyhair.com/2011/09/17/yellowjacket-with-prey/
11. http://nickdobbs65.wordpress.com/tag/herbie-the-love-bug/
12. http://bugguide.net/node/view/598529
13. http://www.flickr.com/photos/johnhallmen/2901162091/
14.http://www.mattcolephotography.co.uk/Galleries/insects/Bugs%20&%20Beetles/slides/Ground%20Beetle%20-%20Pterostichus%20madidus.html
15.http://www.ndsu.nodak.edu/ndsu/rider/Pentatomoidea/Genus_Asopinae/ Eocanthecona.htm

7) Cabbage butterfly:

Larva: The caterpillar is velvety green and measures about 4.2 cm in length.
The caterpillars are gregarious initially but disperse as they grow.

Pupa: Pupation is in damaged leaves.
Adult: Adult is a butterfly with its fore wings snow white having black distal margins. Hind wings pure white with black apical spots.

Eggs Larva Pupa Adult




Symptoms of damage:

- They skeletonise leaves and bore into heads of cabbage and cauliflower


Egg parasitoids:

Trichogramma

Predators:

Wasps

Mynah

IX. Description of diseases:

1) Damping Off: *Pythium aphinidermatum (Eds.)Fitz.*; *Rhizoctonia sonali* Kuhn

Symptoms:

- Damping off of Cabbage occurs in two stages, i.e. the pre-emergence and the post-emergence phase.
- In the pre-emergence the phase the seedlings are killed just before they reach the soil surface.
- The young radical and the plumule are killed and there is complete rotting of the seedlings.
- The post-emergence phase is characterized by the infection of the young, juvenile tissues of the collar at the ground level.
- The infected tissues become soft and water soaked. The seedlings topple over or

collapse.


Favourable Conditions:

- High humidity, high soil moisture, cloudiness and low temperatures below 24° C for few days are ideal for infection and development of disease.
- Crowded seedlings, dampness due to high rainfall, poor drainage and excess of soil solutes hamper plant growth and increase the pathogenic damping-off.

Survival and spread:

Primary: Soil, Seed, Water
Secondary: Conidia through rain splash or wind

Raised nursery beds **Pro-trays**


2) Club root of crucifers or Finger and toe disease: *Plasmodiophora brassicae* Woronin

Symptoms:

- Stunting and yellowing of plants
- Leaves become yellowish and wilt on hot days.
- Club like swelling of root and root lets
- Club root is particularly prevalent on soils with a pH below 7, whereas it has been observed that the disease is often less serious on heavy soils and on soils containing little organic matter

http://www.moaf.gov.bt/moaf/wp-content/uploads/2011/09/DSC04222.jpg

Survival and spread:

Primary: Soil borne resting spores, which survive for longer periods in soil (10yrs.) Collateral hosts: Broccoli, Brussels sprout, cabbage, cauliflower, Chinese cabbage, mustard, raddish, turnip
Secondary: Resting spores or zoospores carried through irrigation water or by root contact.

Favourable conditions:

- It occur at a temp range of 12-27^0 C (25^0 C)
- High soil moisture
- Neutral to acidic soils 5-7.0 pH

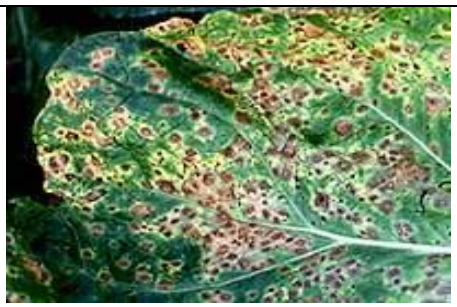
3) Alternaria leaf spot*: Alternaria brassicae* (Berk.)Sacc; *A. brassicicola* (Schw.) Wiltshire

Common on cabbage, cauliflower and mustard.

Symptoms:

- Spots are small, dark coloured
- They enlarge, soon become circular & 1mm. in diameter
- Under humid conditions groups of conidiophores will be formed in the spot
- Spots develop concentric rings
- Finally the spots coalesce leading to blighting of leaves.
- The fungus is seed borne and cause shriveling of seeds and poor germination
- Linear spots also appear on petioles, stems, pods & seeds

http://www.clemson.edu/extension/hgic/graphics/cabbagedis/altern.jpg



Survival and spread:

Primary: Mycelium persisting in the seed or as spores on seed or from debris
Secondary: Wind or insect borne conidia

Favourable conditions:

- Soil temperature of around 28^0 C
- High humidity or persistent dew
- Moist weather with intermittent showers

4) Black rot *Xanthomonas campestris* pv. *Campestris* (Dowson) *Dye, et al.*

Serious on cabbage, cauliflower, knol-khol and raddish

Symptoms:

- First appear as chlorotic or yellow (angular) areas near the leaf margins
- Yellow area extends to veins and midrib forming characteristic 'v' shaped chlorotic spots which later turn black
- Veins and veinlets turn brown and finally black
- Vascular blackening extend beyond affected veins to midrib, petiole and stem
- In advanced stages, infection may reach the roots system and blackening of vascular bundles occurs. Bacterial ooze can also be seen on affected parts
- If the infection is early, the plants wilt and die
- If the infection is late plants succumb to soft rot and die.

1. **2.**

1. http://ohioline.osu.edu/hyg-fact/3000/images/3125_3.jpg
2. Photo by: SK Sain

Survival and spread:

Primary : Bacterial cells **internally seed borne** and soil borne
Secondary: Bacterial cells dispersed through irrigation water and rain splashes.

Favourable conditions:

- Relative humidity > 90%
- High soil moisture
- Frequent rains

5) Downy Mildew *Peronospora parasitica* (Pers.) Fr. Syno. (*Hyaloperonospora parasitica* (Pers.) Constant., 2002

Severe in raddish, cabbage, cauliflower, mustard, and knol-khol.

Symptoms:

- Small purplish brown spots on under surface of leaves
- Small, pale yellow angular spots on upper surface of leaves, with downy growth on the under surface. The spots coalesce and the leaves shrivel and dries up prematurely
- In cabbage, these spots expose the heads to soft rot
- Cauliflower curds look brownish at the t
- Stems show dark brown and depressed lesions or streaks which later develop downy growth of fungus.

1. **2.**


1. http://pnwhandbooks.org/plantdisease/cabbage-and-cauliflower-brassica-sp-downy-mildew-staghead
2. http://extension.umass.edu/vegetable/sites/vegetable/files/diseases/broccoli_downey_mildew_leaf.

Survival and spread:

Primary: Oospores in infected plant debris or in soil
Secondary: Wind borne and rain splashed sporangia

Favourable conditions:

- It occur at a moderate temperature range of 12-270 C
- High soil moisture
- Neutral to acidic soils 5-7.0 pH

6) Powdery mildew ***Erysiphe cruciferarum Opiz.ex Junnell***

Infects mostly cabbage and cauliflower

Symptoms:

- White powdery spots on the upper surface of leaves, stems, flower parts etc.
- Finally the mildew may cover the entire surface
- Infected plants may show rotting and do not have normal growth

http://www.infonet-biovision.org/res/res/files/931.400x400.jpeg

Survival and spread:

Primary: Dormant mycelium in infected plant debris
Secondary: Wind borne conidia.

Favourable conditions:

- It occur at a moderate temperature range of 12-270 C
- Dry conditions with morning relative humidity of 80%

7) White rust: *Albugo candida* (Pers. ex Lév.) Ktze

Symptoms:

- White, shiny raised blisters (pustules) on the lower surfaces of leaves, stems and flowers
- Pustules coalesce to form irregular patches
- The epidermis ruptures exposing white spore mass which gives the pustule a powdery appearance
- Distortion of the floral parts including petals, pistils and anthers due to hypertrophy and Hyperplasia
- Plants malformed beyond recognition

http://www.uoguelph.ca/~gbarron/MISC2006/march22.jpg

Survival and spread:

Primary: Oospores in soil and sporangia from perennial weed hosts in the vicinity
Secondary: Wind borne and rain splashed conidia (sporangia) or autonomous zoospores

Favourable conditions:

- Relative humidity > 90%
- High soil moisture
- Frequent rains

X. Safety measures:

A. At the time of the harvest

Heads should be firm-to-hard at harvest, but delaying harvest may increase the risk of splitting mature heads if soil moisture increases suddenly. Heads are cut at the base and the outer leaves are trimmed off. For the fresh market, fields may be cut 3 to 5 times. When hybrid varieties are used, a higher percentage of the plants can be harvested at one time.

B. Post-harvest storage

Heads must be cooled immediately after harvest. Cabbage can be stored at 0-2 °C and 95% relative humidity for 3 to 6 weeks (early crop) or 5 to 6 months (late crop). Storage life can be prolonged even further at low O2 (2%) and high CO2 (5%) and with controlled atmosphere storage systems, where available.

XI. Do's and Don'ts

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The field should be kept exposed to sun light at least for 2-3 weeks 	Do not plant or irrigate the field after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Adopt crop rotation.	Avoid growing monocrop.
3.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
4	Sow early in the season	Avoid late sowing as this may lead to reduced yields and incidence of white grubs and diseases.
5	Always treat the seeds with approved chemicals/bio products for the control of seed borne diseases/pests. 	Do not use seeds without seed treatment with biocides/chemicals.
6.	Sow in rows at optimum depths under proper moisture conditions for better establishment. 	Do not sow seeds beyond 5-7 cm depth.
7.	Apply only recommended herbicides at recommended dose, proper time, as appropriate spray solution with standard equipment along with flat fan or flat jet nozzles.	Pre-emergent as well as soil incorporated herbicides should not be applied in dry soils. Do not apply herbicides along with irrigation water or by mixing with soil, sand or urea.
8.	Maintain optimum and healthy crop stand which would be capable of competing with weeds at a critical stage of crop weed competition	Crops should not be exposed to moisture deficit stress at their critical growth stages.

	 .	
9	Use NPK fertilizers as per the soil test recommendation. 	Avoid imbalanced use of fertilizers.
10	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
11	Conduct AESA weekly in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only. 	Do not take any management decision without considering AESA and P: D ratio
12	Install pheromone traps at appropriate period. 	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
13	Release parasitoids only after noticing adult moth catches in the pheromone trap or as pheromone trap or as per field observation 	Do not apply chemical pesticides within seven days of release of parasitoids.

14	Apply HaNPV or SINPV at recommended dose when a large number of egg masses and early instar larvae are noticed. Apply NPV only in the evening hours after 5 pm. 	Do not apply NPV on late instar larva and during day time.
15	In case of pests which are active during night like *Spodoptera* spray recommended biocides/ chemicals at the time of their appearance in the night.	Do not spray pesticides at midday since, most of the insects are not active during this period.
16	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, whiteflies, *Spodoptera* etc. 	Do not spray pesticides only on the upper surface of leaves.
17	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
18	Follow the recommended procedure of trap crop technology. 	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.

XII. Safety parameters in pesticides usage

S. No.	Pesticide	Classification as per insecticide rules 1971	Colour of toxicity triangle	WHO classification of hazard	First Aid measures	Symptoms poisoning	Treatment of poisoning	Waiting period (days)
Organophosphate insecticides								
1.	Dimethoate	Highly toxic		Class II Moderately hazardous		Mild-anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity	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.	
2.	Malathion	Moderately toxic		Class III slightly hazardous		Mild-anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity	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.	
3	Trichlorfon				Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious person	Headache, fatigue, dizziness, loss of appetite with nausea, stomach cramps and diarrhoea; blurred vision associated with excessive tear ing; contracted pupils of the eye; excessive sweating and salivation; slowed heartbeat, often fewer than 50 per minute; rippling of surface muscles just under the skin	Give atropine tablet (0.6 mg) one every 5 minutes until dryness of the mouth occurs. Activated charcoal may also be given	
4	Phosalone				Have person sip a glass of water if able to swallow. Do not	Headache, weakness, tightness in the chest,	No specific antidote. Treatment is essentially	

					induce vomiting unless told to do so by a doctor. Do not give anything by mouth to an unconscious person	blurred vision, non-reactive pinpoint pupils, salivation, sweating, nausea, vomiting, diarrhea, abdominal cramps.	symptomatic	
5	Quinalphos	Highly toxic		Class II Moderately hazardous		Excessive salivation, sweating, rhinorrhea and tearing. - Muscle twitching, weakness, tremor, incoordination. - Headache, dizziness, nausea, vomiting, abdominal cramps, diarrhea. - Respiratory depression, tightness in chest, wheezing, productive	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.	

						cough, fluid in lungs. - Pin-point pupils, sometimes with blurred or dark vision. - Severe cases: seizures, incontinence, respiratory depression, loss of consciousnes s.		
Carbamates pesticides								
6	Carbofuran	Extremely toxic		Class I b highly haardous		Constriction of pupils, salivation, profuse sweating, muscle incordination, nausea, vomiting,diarrhe a, epigastric pain, tightness in chest	Atropine injection-1-4 mg. repeat 2 mg when symptoms begin to recur (15-16 min interval) excessive salivation-good sign, more atropine needed	
Synthetic pyrethroids								
7	Fenvalerate				Do not induce vomiting unless told to do so by a doctor, do not	Ingestion may cause nonspecific discomfort,	If on skin, after drying apply vitamin E cream or	7

					give anything by mouth to an unconscious person	such as nausea, vomiting, headache, or weakness; temporary nervous system effects such as muscular weakness, tremors and incoordination.	oil if available. If not available, apply vegetable oil liberally over painful areas. The oil or cream may be used repeatedly until relief is achieved	
Neonicotinoids								
8	Acetamiprid			Do not induce vomiting unless told to do so by a doctor. Have person sip a glass of water if able to swallow. Do not give anything by mouth to an unconscious person		May be harmful if swallowed	No specific antidote. Treatment is essentially symptomatic	7
Avermectins								
9	Emamectin benzoate				Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious person	Pupil dilation, muscular incooridnation, muscular tremors	Administer repeatedly medical charcoal in large quantity of water or ipecac	3

Insect growth regulators								
10	Lufenuron				Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious person	Aspiration may cause pulmonary oedema an d pneumonitis.	No specific antidote. Treatment is essentially symptomatic	14 days for cabbage and 5 days for cauliflower
11	Chlorfluazuro n					Not likely to be toxic in amounts that could be ingested in a single dose	No specific antidote. Treatment is essentially symptomatic	7
Anthranilic diamides								
12	Flubendiami de	Slightly toxic		Unlikely to produce acute hazard		----------	Treat symptomatic ally as there is no known specific antidote	7
Other classes insecticides								
13	Indoxacarb				Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a doctor. Do not give anything by mouth to an unconscious person	Altered blood chemistry Abnormal decrease in number of red blood cells (anaemia) which could produce tiredness, rapid heartbeat, dizziness,	No specific antidote. Treatment is essentially symptomatic.	7

						pale skin, leg cramps, shortness of breath, Central nervous system effects		
14	Spinosad				No emergency medical treatment necessary	Very low toxicity if swallowed. Harmful effects not anticipated from swallowing small amounts	No specific antidote. Treatment is essentially symptomatic.	3
15	Thiodicarb				Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious person	Salivation, muscle tremors, nausea, watery eyes, difficult breathing, vomiting, pinpoint eye pupils, excessive sweating, diarrhea, blurred vision,	Atropine sulf ate is highly effective as an antidote	7

						abdominal cramps, weakness, headache .		
16	Metaflumizone				Do not induce vomiting unless told to do so by a doctor, do not give anything by mouth to an unconscious person	May cause moderate eye irritation. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals.	No specific antidote. Treatment is essentially symptomatic.	3
Fungicides								
17	Streptocycline	Slightly toxic		Unlikely produce acute hazard		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose,throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic.	
18	Captan	Moderately toxic		Class III slightly hazardous		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose,throat, eyes and skin	No specific antidote. Treatment is essentially symptomatic.	

						etc.		
19	Mancozeb	Slightly toxic		Unlikely produce acute hazard		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose,throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic.	
20	Wettable sulphur	Slightly toxic		Unlikely to present acute hazard in normal use		Headache, palpitation, nausea, vomiting, flushed face, irritation of nose,throat, eyes and skin etc.	No specific antidote. Treatment is essentially symptomatic.	

XIII. Basic precautions in pesticides usage

A. Purchase
   1. Purchase only just required quantity e.g. 100, 250, 500, 1000 g/ml for single application in specified area.
   2. Do not purchase leaking containers, loose, unsealed or torn bags.
   3. Do not purchase pesticides without proper/approved labels.
   4. 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.
   4. Never keep them together with food or feed/fodder.
   5. Keep away from reach of children and livestock.
   6. Do not expose to sunlight or rain water.
   7. Do not store weedicides along with other pesticides.

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

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

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

F. Precautions for applying pesticides
   1. Apply only at recommended dose and dilution

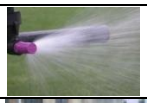
2. Do not apply on hot sunny day or strong windy condition
3. Do not apply just before the rains and after the rains.
4. Do not apply against the windy direction
5. Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer
6. Wash the sprayer and buckets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

G. Disposal

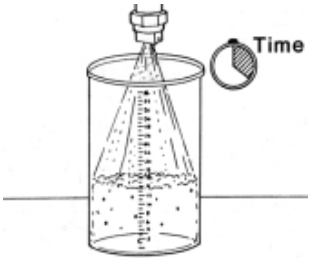
1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

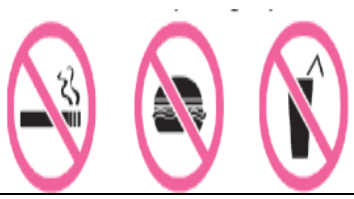
XIV. Pesticide application techniques

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

		• Lever operating speed = 7 to 10 strokes/min	
Pre-emergence application	Weedicide	• Trolley mounted low volume sprayer (Droplets of small size) • Battery operated low volume sprayer (Droplets of small size)	

XV. Operational, calibration and maintenance guidelines in brief

1.	For application rate and dosage see the label and leaflet of the particular pesticide.	 
2.	It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.	 
3.	Clean and wash the machines and nozzles and store in dry place after use.	
4.	It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides. Do not apply pesticides without protective clothing and	

	wash clothes immediately after spray application.	 
5.	Do not apply in hot or windy conditions.	 
6.	Operator should maintain normal walking speed while undertaking application.	
7.	Do not smoke, chew or eat while undertaking the spraying operation	 
8.	Operator should take **proper bath with soap** after completing spraying	  
9.	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

XVI. References

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