AESA BASED IPM PACKAGE
Clove

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Ministry of Agriculture and Farmers Welfare
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The AESA based IPM – Clove was compiled by the NIPHM working group under the Chairmanship of Smt. V. Usha Rani, IAS, Director General, NIPHM, and guidance of Shri. Utpal Kumar Singh, IAS, JS (PP). The package was developed taking into account the advice of experts listed below on various occasions before finalization.

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AESA BASED IPM PACKAGE FOR CLOVE

Clove - Plant description:

Clove is the aromatic, dry, fully grown, unopened flower buds derived from *Syzygium aromaticum* (L.) Merr. & Perry (Family:Myrtaceae), a native to the Maluku Islands of Indonesia.The clove is monoecious (both male and female flowers present on the same plant) evergreen tree that grows up to 8–12 m height with leaves and flowers grouped in terminal clusters. Cloves are harvested when they are plump and rounded, before they turn pink and consist of a long calyx that terminates in four spreading sepals and four unopened petals that form a small central ball. Branches of the tree are semi-erect with smooth oval shaped leaves. The branches end with 3–4 flowers near the tip with one terminal flower and the others opening below. The leaves, flowers and bark have a distinct flavour. The flower buds initially have a pale hue which gradually turn green and later change to bright red colour when when they are harvest.

I. PESTS

A. Pests of National and Regional Significance

1. Insect pests

1.1 Stem borer: *Sahyadrassus malabaricus* Moore (Lepidoptera, Hepialidae)
1.2 Scale insects: *Parasaissetia nigra* Nietner, Green scale: *Lecanium psidii* Green, Wax scale: *Ceroplastes floridensis* Comstock, *Pulvinaria psidii* (Maskell),Masked scale: *Mycetaspis personata* Comstock, Soft scale*: Kilifia accuminata* Signoret (Hemiptera:Coccidae)
1.3 Mealy bugs: *Planococcus* sp. and *Psuedococus* sp.(Hemiptera: Pseudococcidae)

2. Diseases

2.1 Seedling Wilt: *Cylindrocladium* sp., *Fusarium* sp., *Rhizoctonia* sp.
2.2 Leaf rot: *Cylindrocladium quinquiseptatum* Boedijin and Reitsma
2.3 Leafspot and bud shedding:*Colletotrichum gloeosporioides*(Penz.) Penz. &. Sacc

3. Weeds

Broadleaf weeds

3.1. Pigweed: *Amaranthus viridis* Hook. F. Amaranthaceae
3.2. Common purselane: *Portulaca oleracea* L. Portualacaceae
3.3. False amaranth: *Digeria arvensis* Forssk. Amaranthaceae
3.4. Carrot grass: *Parthenium hysterophorus*L. Asteraceae
3.5. Goat weed: *Ageratum conyzoides*L. Asteraceae
3.6. Little mallow (cheese weed): *Malva parviflora* F. Malvaceae

Grassy weeds

3.7. Barnyard grass:*Echinochloacrusgalli*(L.) Beauv. Poaceae
3.8. Bermuda grass: *Cynodondactylon* (L.) Pers. Poaceae

Sedges

3.9. Nutsedge:*Cyperus rotundus/Cyperus iria/Cyperus difformis*L. Cyperaceae

4. Nematodes

4.1 Ring nematode:*Criconemoides*spp.(Tylenchida: Criconematidae)
4.2 Reniform nematode:*Rotylenchulusreniformis*Linford and Oliveira (Tylenchida: Hoplolaimidae)
4.3 Common spiral nematode:*Helicotylenchusdihystera*(Cobb) Sher(Tylenchida: Hoplolaimidae)

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

A. AESA

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

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

AESA is an approach, which can be gainfully employed by extension functionaries and farmers to analyze the field situations with regards to pests, defenders, soil conditions, plant health and the influence of climatic factors and their relationship for growing a healthy crop. The basic components of AESA are

- Plant health at different stages.
- Built-in compensation abilities of plants.
- Pest and defender population dynamics.
- Soil conditions.
- Climatic factors.
- Farmers past experience.

Principles of AESA based IPM:
Grow a healthy crop

- Select 18 months old healthy seedlings for planting. Prepare pits of size 75 x 75x 75cm at a spacing of 6 -7m about a month in advance of planting.
- Treat the seedlings/plant materials with recommended pesticides especially biopesticides.
- Observe the soil conditions, moisture level, etc.
- Take representative soil sample and get the soil analysis report showing soil pH, electrical conductivity (EC), organic matter and nutrient status.
- Observe the number and species of weeds found in per square meter area in five randomly selected spots/ha.
- Soil health improvement (mulching and green manuring wherever applicable).
- Nutrient management especially, organic manures and biofertilizers based on 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 adequate dose of fertlizers for better results. The phosphatic fertilizers should not be applied every season as the residual phosphate of the previous season will be available during he current season also.

- Proper irrigation.

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

Farmers should

- Monitor the tree situations at least once in a month (soil, water, plants, pests, natural enemies, weather factors etc.).
- Make decisions based on the field situations 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. The ability of the plant to compensate for the reduced acquisition of resources by the production of new organs or by remobilization of reserves may also mitigate biotic stress effects.

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 numberof 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 numberof 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 Clove pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens.

Model agro-ecosystem analysis chart

Date:
Village:
Farmer:

Decision taken based on the analysis of field situations

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

The general rule to be adopted for management decisions relying on the P: D ratio is 2: 1. However, some of the parasitoids and predators will be able to control more than 2 pests. Wherever specific P: D ratios are not found, it is safer to adopt the 2: 1, as P: D ratio. Whenever the P: D ratio is found to be favourable, there is no need for adoption of other management strategies. In cases where the P: D ratio is found to be unfavourable, the farmers

can be advised to resort to inundative release of parasitoids/predators depending upon the type of pest. In addition to inundative release of parasitoids and predators, the usage of microbial biopesticides and biochemical biopesticides such as insect growth regulators, botanicals etc. can be relied upon before resorting to synthetic chemical pesticides.

Decision making

Farmers become experts in crop management

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

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

AESA methodology

- Go to the field in groups (about 5 farmers per group). Walk across the field and choose 10 fields/ acre randomly. Observe keenly each of these plants and record your observations:
- Tree: 5-6 samples per tree (fruits/ leaves/ inflorescence /stem bark/roots/ soil/ insects) should be collected where, one sample from top, four samples from all the four sides (north, south, east, west) and one from bottom/soil, depending upon the requirement of study/observations and if necessary.
- Pests: Observe and count pests at different parts of the tree.
- Defenders (natural enemies): Observe and count parasitoids and predators.
- Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
- Water: Observe water situation in the field.
- Weather: Observe the weather condition.
- While walking in the field, manually collect insects in polythene 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 chloroform (if available) with 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

- Maintain records to analyze and draw conclusions.

Data to be recorded

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

Some questions that can be used during the discussion

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


Advantages of AESA over ETL

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

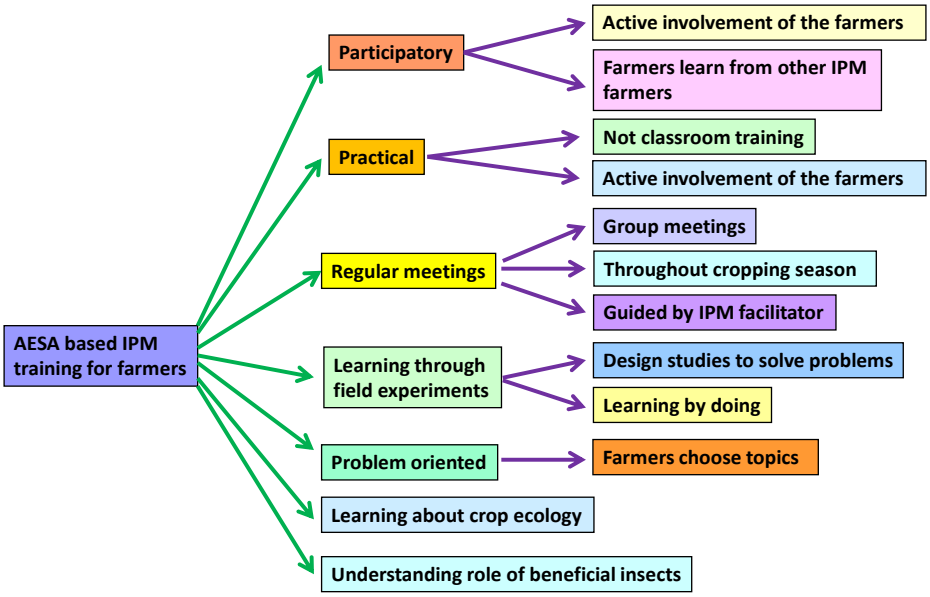
AESA and farmer field school (FFS)

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

Farmers can learn from AESA

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

FFS to teach AESA based IPM skills



B. Field scouting

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

Surveillance on pest occurrence in the field should commence soon after crop establishment and at weekly intervals thereafter. In each field, select five spots randomly (four in the corners, at least 5 feet inside of the field borders, and one in the centre).Select five random plants at each spot for recording counts of insects as per procedure finalized for individual insects.

For insect pests

Scale insect: Count and record the number of both nymphs and adults on five randomly selected leaves per tree.

Stem borer: Count and record the number of plants infested with stem borer.

For diseases:

Whenever scouting, be aware that symptoms of plant disease may be caused by any biotic factors such as fungal, bacterial, viral pathogens or abiotic factors such as weather, nutrient deficiencies and soil problems. In many cases, cause of the symptom is not obvious. Close examination, and laboratory culture and analysis are required for proper diagnosis of the causal agent of disease. Generally fungal diseases cause obvious symptoms like spots, rots, blights, wilts and irregular growth. However abiotic problems cause regular, uniform symptoms.

Pathogen presence (signs) on the symptoms can also be observed like fungal growth, bacterial ooze etc. Specific and characteristic symptoms of the important plant diseases are given in description of diseases section.

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

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

Stem, flower and buds: Carefully examine the stem, flower and buds of plants for symptoms and signs of fungal diseases. The stem, flower and fruit should be split or taken apart and examined for discolouration caused by fungi. Count the number of stems, flowers and buds infected due to disease and percent disease incidence should be recorded.

C. Surveillance through pheromone traps: Pheromone traps for insects *viz*.,stem borer @ 4-5 acre have to be installed. Install the traps separated by a distance of >75 feet in the vicinity of the selected fixed field. Fix the traps to the supporting pole at a height of one foot above the plant canopy. Change of lures should be made once a month. During each week of surveillance, the number of moths/trap should be counted and entered.
Procedure for observation: Total number of moths of stem borer / trap/week should be recorded year round. The trapped moths should be destroyed and removed after each recording.

D. Light traps

Set up light traps 1 trap/acre for monitoring and mass trapping of insects. Light traps with exit option for natural enemies of smaller size should be installed and operated during 6 pm to 10 pm.

E. Nematode extraction

Collect 100 to 300 cm^3 (200-300 g) representative soil sample. Mix soil sample and pass through a coarse sieve to remove rocks, roots, etc. Take a 600 cc subsample of soil, pack lightly into a beaker uniformly. Place soil in one of the buckets or pans half filled with water. Mix soil and water by stirring with paddle; allow to stand until water almost stops swirling. Pour all but heavy sediment through 20-mesh sieve into second bucket; discard residue in first bucket; discard material caught on sieve. Stir material in second bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 200-mesh sieve into first bucket; discard residue in second bucket. Backwash material caught on 200-mesh sieve (which includes large nematodes) into 250-ml beaker. Stir material in first bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 325-mesh sieve into second bucket; discard residue in first bucket. Backwash material caught on 325-mesh sieve (which includes small to mid-sized nematodes and silty material) into 250-ml beaker.

More than 90% of the live nematodes are recovered in the first 5-8 mm of water drawn from the rubber tubing and the sample is placed in a shallow dish for examination.

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

Ecological Engineering for Pest Management – Below Ground:

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

- Keep soils covered year-round with living vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance below ground biodiversity of beneficial microbes and insects.
- Application of balanced dose of nutrients using biofertilizers based on soil test report.
- Application of biofertilizers with special focus on mycorrhiza and plant growth promoting rhizobacteria (PGPR).

Ecological Engineering for Pest Management – Above Ground:

Natural enemies play a very significant role in control of foliar insect pests. Natural enemy diversity contributes significantly to management of insect pests both below and above ground.

Natural enemies may require:

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

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

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

- Select and plant appropriate companion plants which could be trap crops and pest repellent crops. The trap crops and pest repellent crops will also recruit natural enemies as their flowers provide nectar and the plants provide suitable microclimate.

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

Plants suitable for Ecological Engineering for Pest Management

Attractant plants

Cowpea

Carrot

Sunflower

Buckwheat

French bean

Alfaalfa

Mustard

Cosmos

Anise

Caraway

Dill

Parsley

White clover

Tansy

Yarrow

Marigold

Repellent plants

***Ocimum* sp**

Peppermint/Spearmint

Barrier plant

Rye grass

Trap plants

Tomato

Marigold

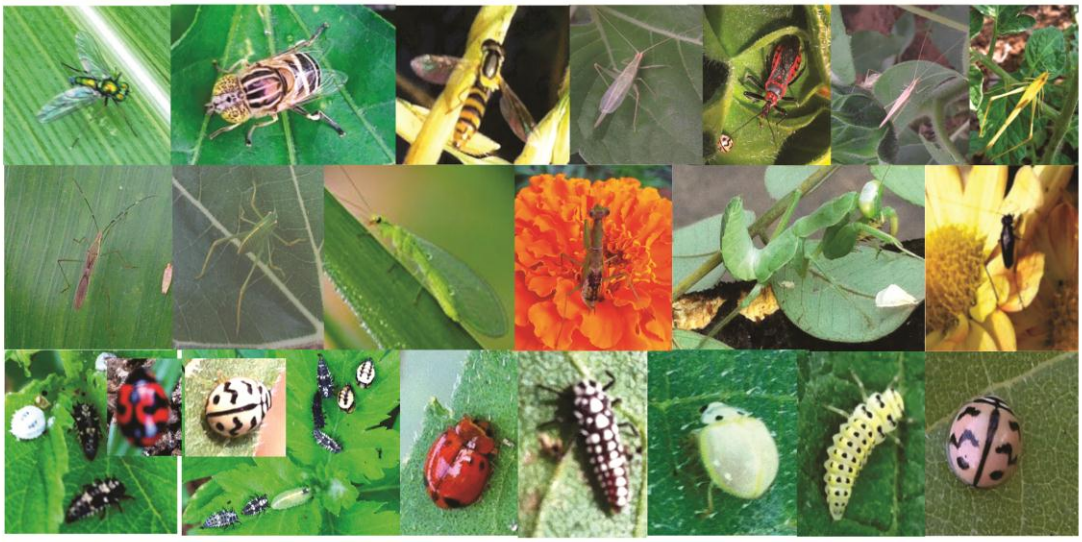
Pearl millets

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

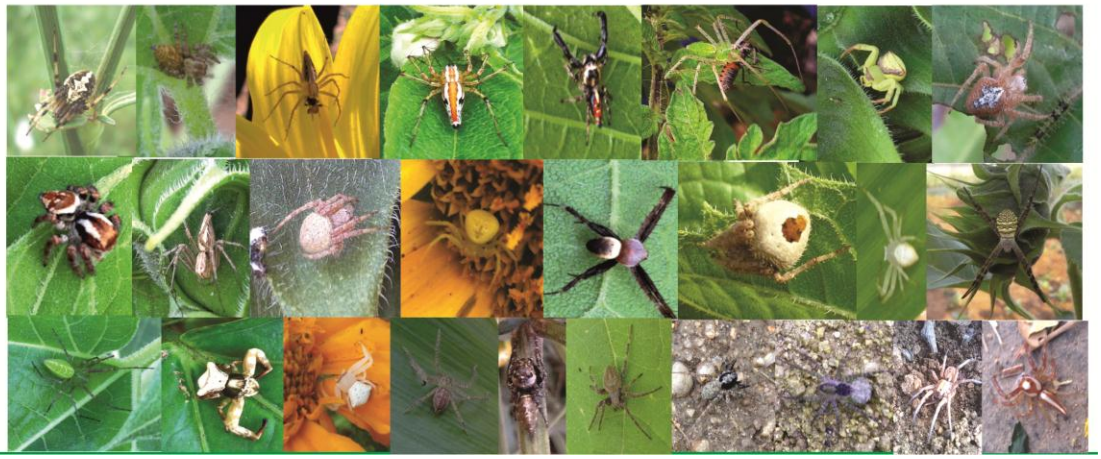
Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

Biodiversity of natural enemies: Parasitoids

Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



IV. CROP STAGE-WISE IPM

Management	Activity
Nursery*	
	<u>Common cultural practices:</u> • **Timely sowing should be done.** • **Field sanitation, rogueing.** • **Destroy collateral host Plants (if any)**
Nutrients	• **Clove requires deep loam soils with high humus content and black loams of semi-forest regions with good drainage.** • **Select partially shaded sites having adequate protection from high winds.** • **Prepare raised nursery beds with fertile soil rich in humus.** • **Sow the seeds at a depth of about 2 cm and a spacing of 2-3 cm. Water the beds regularly. The germinated seedlings are transplanted in polythene bags (25 cm x 15 cm dimension) containing a mixture of soil, sand and well decomposed cow dung in 3:3:1 ratio. The seedlings may again transplanted after 1 year of growth to large polythene bags. The seedlings are ready for transplanting in the field when they are 18 – 24 months old.**
Weeds	• **Destroy all the weeds from planting area by ploughing during summer (before preparing the nursery beds).** • **Remove all the perennial weeds and their rhizomes/suckers before onset of monsoon.**
Planting*	
	<u>Common cultural practices:</u> • **Use healthy seedlings** • **Do not delay irrigation until the crop exhibits moisture stress symptoms.**
Preparation of pits and planting	**Select 18 – 24 months old seedlings for planting. Prepare pits of size 75x 75x 75 cm at a spacing of 6 -7 m about a month in advance of planting. Fill the pits partially with compost, green leaf or well decomposed cattle manure and mixed with top soil.** **Plant the seedlings during the rainy season, upto September.**
Weeds	• Use weed free planting material.
Nematodes	**<u>Biological control:</u>** • Application of neem cake @ 80 Kg/acre for nematode control.
Scale insects	**<u>Cultural control:</u>** • Removal of affected leaves and branches will prevent the spread. • Grow attractant plants for natural enemies *viz*., sunflower family, carrot family plants, buckwheat.

	Mechanical control: • See the common mechanical control **Biological control:** • Apply mixture of manure compost tea, molasses and citrus oil. • Parasitoids such as *Encarsia* sp.and *Aphytis* sp. cause effective parasitization. • Coccinellids such as *Chilocorus* sp*., Pharoscymnus* sp may act as predators
Seedling wilt	**Cultural control:** • Avoid damp and low lying areas. **Mechanical control:** • Refer the common mechanical control.
Vegetative stage	
	Common cultural practices: • Inter-cultural operations and hand weeding. • Avoid growing in low-lying areas and water stagnation. • Timely irrigation and irrigation should be done by ring method to reduce possibility of wilt. • Avoid water stress . • Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed. **Common mechanical practices:** • Remove and destroy collateral wild hosts and weeds • Use of pheromone traps @ 4-5/acre. • Installation of light trap @ 1/ acre. • Collect and destroy the damaged twigs. **Common biological practices:** • Conserve natural enemies through ecological engineering. • Augmentative release of biocontrol agents.
Nutrients	• Fertilizers should be applied on the basis of soil test report and recommendation for the particular area. In general, fertilizers may be applied as mentioned in Table 1. • Apply organic manures in May-June with the commencement of south-west monsoon. • Apply fertilizers in two equal split doses in May-June along with the organic manures and in September-October in shallow trenches dug around the plant about 1 to 1.5 m away from the base. • If soil is highly acidic 500g lime per plant should be applied in alternate years. • Apply cattle manure or compost at the rate of 50 kg / tree/year. Nutrient management

<table>
<tr><td></td><td>Table 1. Fertilizer requirement of clove.

<table>
<tr><th>Age of plants</th><th>N (g/plant/year)</th><th>P_2O_5 (g/plant/year)</th><th>K_2O (g/plant/year)</th></tr>
<tr><td>1st year</td><td>20</td><td>18</td><td>50</td></tr>
<tr><td>2nd year</td><td>40</td><td>36</td><td>100</td></tr>
<tr><td colspan="4">Gradually increase the dose</td></tr>
<tr><td>15 years and above</td><td>300</td><td>250</td><td>750</td></tr>
</table></td></tr>
<tr><td>Weeds</td><td>• Remove weeds before flowering by 2-3 rounds of hand weeding.
• Slash weeding is a cost-effective method and to keep a cover always over the soil.
• Mulching with dry leaves or organic matter should be practiced to control weed growth.</td></tr>
<tr><td>Stem borer</td><td><u>Cultural control:</u>
• Keep field clean.
• Clean hole and insert cotton wool soaked in emulsion of kerosene or petrol in each hole and plug them with mud.
• Keep the basins free of weeds.

<u>Mechanical control:</u>
• Refer the common mechanical practices.</td></tr>
<tr><td>Scale insects</td><td>• Same as mentioned in the above planting</td></tr>
<tr><td>Mealy bug</td><td><u>Cultural control:</u>
• Prune affected shoots during winter.
• Destroy ant colonies.
• Grow attractant plants to attract the defenders.

<u>Mechanical control:</u>
• Use sticky barrier on trunk.

<u>Biological control:</u>
• Release parasitoids such as parasitic wasps,
• Release predators such as Cryptolaemus montrouzieri@10 beetles per tree.</td></tr>
<tr><td>Leaf rot</td><td><u>Cultural control:</u>
• Refer the common cultural practices.

<u>Mechanical control:</u>
• Remove the rotten portions from the spear and the two adjacent leaves.</td></tr>
</table>

Leaf spot	**<u>Cultural control:</u>** • Refer the common cultural practices. **<u>Mechanical control:</u>** • Pruning should be done during dry weather.
Maturity/ Fruiting stage	
Nutrients	• Apply deficient micronutrient if any.
Weeds	• Keep the field weed free.
Stem borer	Same as mentioned in the above Vegetative stage.
Scale insects	Same as mentioned in the above secondary nursery stage.
Mealy bug	Same as mentioned in the above Vegetative stage.
Seedlingwilt	Same as mentioned in the above secondary nursery stage.
Leaf rot	Same as mentioned in the above Vegetative stage.
Leaf spot and bud shedding	Same as mentioned in the above Vegetative stage.

V. INSECTICIDE RESISTANCE AND ITS MANAGEMENT

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

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

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

1) **Monitor pests:** Monitor insect population development in fields to determine if and when control measures are warranted. Monitor and consider natural enemies when making control decisions. After treatment, continue monitoring to assess pest populations and their control.
2) **Focus on AESA.** Insecticides should be used only as a last resort when all other non-chemical management options are exhausted and P: D ratio is above 2: 1. Apply biopesticides/chemical insecticides judiciously after observing unfavourable P: D ratio and when the pests are in most vulnerable life stage. Use application rates and intervals as per label claim.

3) **Ecological engineering for pest management:** Flowering plants that attract natural enemies as well as plants that repel pests can be grown as border/intercrop.
4) **Take an integrated approach to managing pests.** Use as many different control measures as possible viz., cultural, mechanical, physical, biological etc. Select insecticides with care and consider the impact on future pest populations and the environment. Avoid broad-spectrum insecticides when a narrow-spectrum or more specific insecticide will work. More preference should be given to green labeled insecticides.
5) **Mix and apply carefully.** While applying insecticides care should be taken for proper application of insecticides in terms of dose, volume, timing, coverage, application techniques as per label claim.
6) **Alternate different insecticide classes.** Avoid the repeated use of the same insecticide, insecticides in the same chemical class, or insecticides in different classes with same mode of action and rotate/alternate insecticide classes and modes of action.
7) **Preserve susceptible genes.** Preserve susceptible individuals within the target population by providing unsprayed areas within treated fields, adjacent "refuge" fields, or habitat attractions within a treated field that facilitate immigration. These susceptible individuals may outcompete and interbreed with resistant individuals, diluting the resistant genes and therefore the impact of resistance.

VI. COMMON WEEDS

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

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

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

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

5. Goat weed: *Ageratum conyzoides* L. Asteraceae

6. Little mallow: (cheese weed) *Malva parviflora* F. Malvaceae

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

8. Bermuda grass: *Cynodon dactylon* (L.) Pers. Poaceae

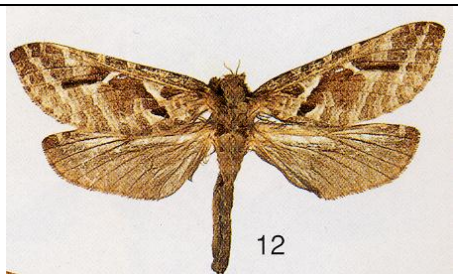
9. Purple nutsedge *Cyperus rotundus* L. Cypraceae

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

11.Flat sedge:*Cyperus difformis*L. Cypraceae

VII. DESCRIPTION OF INSECTPESTS

1.Stem borer:
<u>Biology</u>:   **Egg:** The eggs are laid on the weeds around the basins of clove trees.   **Larva:** Early instar larvae feed on the weed plants and the later instars migrate to the clove trees and bore into the stem. The larvae are creamy white with a black head and fully grown larvae measure about 90 mm in length. The dorsal sclerites of the thoracic and abdominal segments are brown.   **Pupa:** Pupation occurs within the larval tunnel.   **Adult:** The adult is a large sized moth with a wing span of about 110 mm with greyish-brown mottled forewings.



Damage symptoms:

- The larva of the stem borer girdles the stem of young clove trees at the basal region and bores downward into the root zone.
- The girdled region and the bore-hole are covered with frass consisting of coarse wood particles that are formed as a mat-like structure.
- The infested trees wilt and defoliate and succumb to the pest attack subsequently.

Natural enemies of Stem borer:

Predators: Bird: Wood-pecker

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

2. Scale insects

Many species of scale insects infest clove seedlings in the nursery and sometimes young plants in the field.

Black Scale: *Paraaissetia nigra*

Identification of pest: Female adults are elliptical, flattened and shiny black.

Masked scale: *Mycetaspis personata*

Identification of pest: Female adults are elliptical, flattened and black in colour.

Egg: Eggs are laid under or stay within the female body then hatch to produce nymphs or crawlers. Some species give birth to live young.

Nymph: First instar nymph is highly mobile. Later instars less so.

Adult: The mature female is sedentary, headless, legless and wingless and attaches herself to the plant by her mouthparts (stylet) and forms a waxy, leathery or cottony covering over her soft body. They can produce more than 150 eggs then die.

In some species fertilisation is not required and males have not been found. The males of other species live under their protective covering until mature then emerged as winged adults. They tend to live in colonies. They may be tended by ants who feed on the honey dew and protect them from predation.

Black Scale: *Parasaissetia nigra*

- It infests tender leaves, shoots and twigs.
- Sooty mould fungus is observed on leaves due to honey dew secretion.

Masked scale: *Mycetaspis personata*

- Dome shaped and greyish brown scale will be seen on the undersurface of leaves especially of young clove plants.
- The infested leaves become discoloured and completely yellowish and finally may fall down.

Green scale

Egg: Vary in size and color but are generally oval in shape.

Nymph: Nymphs are yellow "crawlers" migrate to the leaves and settle on the undersides along the midrib and veins.

Adult: Females vary in size and colour but are generally oval in shape

Damage symptoms:

- Flat and green coloured soft scales are found feeding on leaves and tender shoots.
- Infestation of scales is on leaves and tender shoots, and is serious in the nursery. Young seedlings if attacked are killed soon.

Damage symptom

Natural enemies of scale insect:

Parasitoids:*Encarsia* sp, *Aphytis* sp and *Comperiella* sp

Predators: Coccinellid and *Pharoscymnus flexibilis*

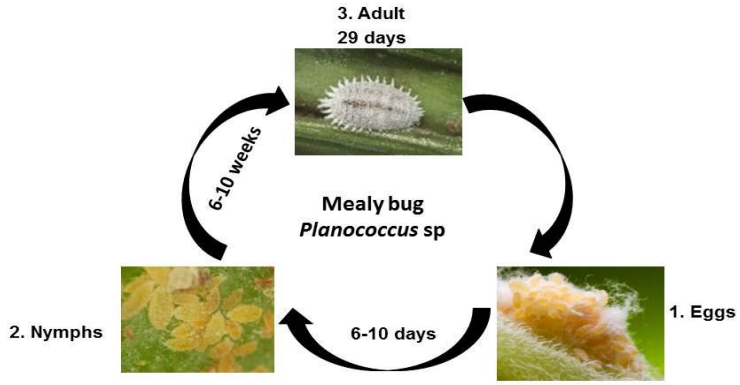
*For management refer to page number----------

3. Mealy bug:

Biology:

- **Eggs:** Eggs are deposited as white cottony masses called ovisacs on trunk and stems of plants, giving the appearance of cotton spread on plants. The glossy, light yellow eggs are oval and approximately 0.3 mm long. A female can lay from 300 to 600 eggs in her life period, which are deposited in groups of 5 to 20. Depending on the season, egg hatch may occur after 6 - 10 days or several weeks. An average of 29 eggs per day is laid by females.
- **Nymphs:** Nymphs emerge from the ovisacs and typically settle along midribs and veins on the underside of leaves, young twigs, and fruit buttons. Wax and honeydew secreted by crawlers are visible indicators of infestations. First instar female and male nymphs are called crawlers. The nymphs take 6 to 10 weeks to reach maturity. The nymphs are yellow, oval-shaped with red eyes, and covered with white waxy particles The female nymphs resemble the adult female in appearance, while male nymphs are more elongated. Female nymphs have four instars while males have three instars.
- **Adult**: Adult size ranges in length from 3 mm (females) to 4.5 mm (males). The females are wingless, white to light brown in color, with brown legs and antennae. The body of adult females is coated with white wax and bears a characteristic faint gray stripe along their dorsal side. Short waxy filaments can be seen around the margins of their oval body with a slightly longer pair of filaments present at the rear end of their body. Female mealybugs are wingless and, therefore, must be transported to subsequent host plants, although they are able to crawl for short distances. Females can live for up to 29 days depending on the host plant. Males are similar in color to females and have two long backward-projecting white wax threads.

Life cycle:



1http://www.alexanderwild.com/Insects/Insect-Orders/Bountiful-Bugs/i-MdBKP3b/2/S/Planococcus5-S.jpg .
2. http://cals.arizona.edu/crops/citrus/pcaphotos.html#mealybug-
3.http://www.bnhs.co.uk/focuson/scales/html/

Damage symptoms:

- Damages due to mealy bugs occur by sucking the sap from tender shoots. Affected portions dry up gradually.
- Soft green mealy bug with a white mealy ovisac is seen on the undersurface of tender leaves.
- The feeding causes yellowing and withering of leaves.
- Sooty mold develops on the honey dew secreted by the bug.

Natural enemies of mealy bug:

Parasitoids: Parasitic wasps,*Leptomastix dactylopii*
Predators: Hover flies, *Chrysoperla*, ladybugs or mealy bug destroyers (*Cryptolaemus montrouzieri*)

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

Natural Enemies of Clove Insect Pests

Parasitoids

Egg parasitoids

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

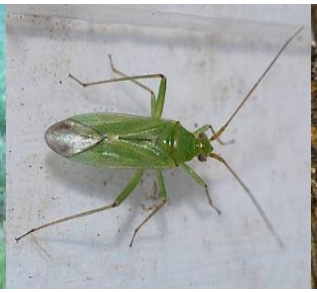
Predators

1. Lacewing 2. Ladybird beetle3. Reduviid bug 4. Spider




5. Robber fly **6. Fire ant** **7. Black drongo 8. Common mynah**






9. Preying mantid10. Hover fly **11. Mirid bug12. Woodpecker**

VIII. DESCRIPTION OF DISEASES

1.Seedling wilt:

Disease symptom:

- Seedling wilt is observed mainly in nurseries and causes 5 to 40% death of seedlings.
- Leaves of affected seedlings loose natural luster, tend to droop and ultimately die.
- The root system and collar region of the seedling show varying degrees of discolouration and decay.

Survival and spread:

- The fungus is soil-borne and remains in the soil as saprophyte for 2-3 years.
- The secondary spread is aided by wind, rain and irrigation water.

Favourable conditions:

- High day temperature (30-35˚C).
- Low humidity (50-60%).
- Low soil moisture and alkaline soils.

*****For the management refer page number.....

2.Leaf rot:

Disease symptom:

- It is noticed in the nurseries as well as in the main field both at young and mature stages.
- Infection starts as dark spots at the leaf margin and spreads sometimes with no definite pattern.
- Rotting may be in the whole leaf or at the tip resulting in defoliation.

Favourable conditions:

- The fungus survives on diseased twigs and mummified fruits, either on the tree or on the ground.
- The fungul spores are air-borne and are also spread by rain splash and insects. Moderate temperatures and moist weather during bloom favour the disease

*****For the management refer page number.....

3. Leaf spot and bud shedding

Disease symptom:

- Necrotic spots of variable size and shapes are noticed on the leaves.
- Severely affected leaves wither, droop and dry up.
- Twigs are infected as the symptoms extend from the leaves through petioles.
- The affected branches stand without leaves or only with young leaves at tips.
- Flower buds are attacked by spreading infection from the twigs.
- Shedding of flower buds occurs during periods of heavy and continuous rainfall.

Favourable conditions:

- The fungus survives on diseased twigs and mummified fruits, either on the tree or on the ground.
- The fungus spores are air-borne and also spread by rain splash.
- Moderate temperatures and moist weather during bloom favour twig blight.

Infected plant

http://www.celkau.in/karshikajalakam%20(F)/html/agri/images/Photo/10%20Grampoo%20(CLOVE)/P&D/twig%20blight%20and%20die%20back%20clove.jpg

*****For the management refer page number.....

IX. SAFETY MEASURES

A. At the time harvest:

Clove tree begins to yield from the seventh year of planting and full bearing stage is attained after 15 to 20 years. The flowering season is September to October in the plains and December to February at high altitudes.

Flower buds are formed on young flush. It takes about five to six months for the buds to become ready for harvest. The optimum stage for picking clove buds is when the buds are fully developed and the base of the calyx has turned from green to pink colour. Such clove buds are carefully picked by hand. Care should be taken to collect the buds at the correct stage as otherwise, if allowed to develop beyond this stage, the buds open, petals drop and an inferior quality spice is obtained on drying. When the trees are tall and the branches are beyond the reach, platform ladders are used for harvesting. Bending the branches or knocking down the bud clusters with sticks is not desirable as these practices will affect the future bearing. Prior to drying, buds are removed from the stem by holding the cluster in one hand and pressing it against the palm of the other with a slight twisting movement. The clove buds and stems are piled separately for drying. Buds may be sorted to remove over-ripe cloves and fallen flowers. Drying should be done immediately after the buds are separated from the clusters. If left too long in heaps, they ferment and the dried spice has a whitish shriveled appearance (khoker clove).

B. During the post harvest storage:

The buds after separation from the stalks are spread evenly to dry, in-the sun on mats or cement floors. During nights buds should be stored undercover, lest they re-absorb moisture. The period of drying depends on the prevailing climatic conditions. Normally, it is possible to dry cloves in four or five days under direct sun and in about four hours when they are heated on zinc trays over a regulated fire. Fully dried buds develop the characteristic dark brown colour and are crisp.During drying, clove loses about two-third of its original fresh green weight. When properly dried Improperly dried and stored cloves have much darker colour and some wheat wrinkled appearance. Such a produce is considered inferior in quality. About 8000 to 10,000 good quality clove buds would weigh one kilogram.

X. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Deep ploughing is to be done on bright sunny days during the months of May and June. The field should be kept exposed to sun light at least for 2-3 weeks.	Do not plant or irrigate the field after ploughing, at least for 2-3 weeks, to allow desiccation of weed's bulbs and/or rhizomes of perennial weeds.
2.	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
3.	Always treat the seeds with approved chemicals/biopesticides for the control of seed borne diseases/pests.	Do not use seeds without seed treatment with biopesticides/ chemicals.

4.	Sow in rows at optimum depths under proper moisture conditions for better establishment.	Do not sow seeds beyond 5-7 cm depth.
5.	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.
6.	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.
7.	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
8.	Use micronutrient mixture after sowing based test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
9.	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
10.	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
11.	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
12.	In case of pests which are active during night 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.
13.	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for mites, scales, thrips,etc.	Do not spray pesticides only on the upper surface of leaves.
14	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
15.	Follow the recommended procedure of trap or border crops technology.	Do not apply long persistent on trap crop, otherwise it may not attract the pests and natural enemies.

XI. BASIC PRECAUTIONS IN PESTICIDES USAGE

A. Purchase

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

B. Storage

1. Avoid storage of pesticides in house premises.
2. Keep only in original container with intact seal.
3. **Do not** transfer pesticides to other containers; **Do not** expose to sunlight or rain water; **Do not** store weedicides along with other pesticides.
4. Never keep them together with food or feed/fodder.
5. Keep away from reach of children and livestock.

C. Handling

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

D. Precautions for preparing spray solution

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

E. Equipments

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

F. Precautions for applying pesticides

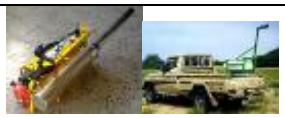
1. Apply only at recommended dose and dilution.
2. **Do not** apply on hot sunny day or strong windy condition; **Do not** apply just before the rains and after the rains; **Do not** apply against the windy direction.
3. Emulsifiable concentrate formulations should not be used for spraying with battery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

G. Disposal

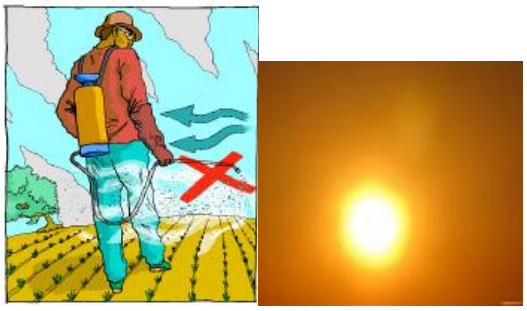
1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.

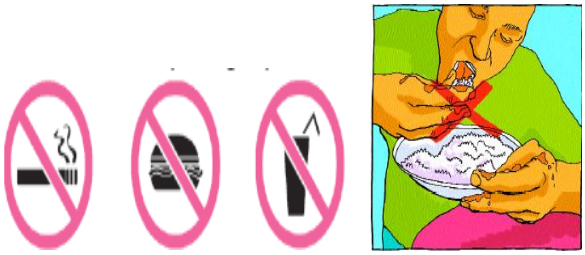
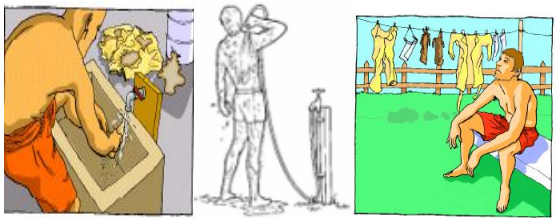
XII. PESTICIDE APPLICATION TECHNIQUES

		Equipment	
Category A: Stationary, crawling pest/ disease			
Vegetative stage i) for crawling and soil 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	
ii) for small sucking leaf borne pests			
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	Insecticides and fungicides	• Motorized knapsack sprayer or mist blower (Droplets of small size)	

Reproductive stage *(Field Pests)*		• 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)	 

XIII. 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.	
5.	Do not apply in hot or windy conditions.	

6.	Operator should maintain normal walking speed while undertaking application.	
7.	Do not smoke, chew or eat while undertaking the spraying operation	
8.	Operator should take proper bath with soap after completing spraying	
9.	Do not blow the nozzle with mouth for any blockages. Clean with water and a soft brush.	

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