



सत्यमेव जयते

AESA BASED IPM PACKAGE

LARGE CARDAMOM



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Department of Agriculture and Cooperation
Ministry of Agriculture
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The AESA based IPM — Large cardamom (*Amomum subulatum* Roxb.), was compiled by the NIPHM working group under the Chairmanship of Dr. Satyagopal Korlapati, IAS, DG, NIPHM, and guidance of Shri. Utpal Kumar Singh, IAS, JS (PP). The package was developed taking into account the advice of experts listed below on various occasions before finalization.

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FOREWORD

Intensive agricultural practices relying heavily on chemical pesticides are a major cause of 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 (AESAs) 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

Ak Srivastava
(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.


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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)

CONTENTS

Large cardamom- Plant description

I. Pests

A. Pests of National Significance

1. Insect pests
2. Diseases
3. Weeds
4. Nematode

B. Pest of Regional Significance

1. Insect pests
2. Diseases

II. Agro-Ecosystem Analysis (AESA) based Integrated Pest Management (IPM)

A. AESA

B. Field scouting

C. Surveillance through pheromone trap catches

D. Yellow/blue pan water/sticky traps

E. Light traps

F. Nematode extraction

III. Ecological Engineering for Pest Management

IV. Crop stage-wise IPM

V. Insecticide resistance and its management

VI. Nutritional deficiency

VII. Common weeds

VIII. Description of insect pests

IX. Description of diseases

X. Safety measures

XI. Do's and Don'ts in IPM

XII. Basic precautions in pesticides usage

XIII. Pesticide application techniques

XIV. Operational, calibration and maintenance guidelines in brief

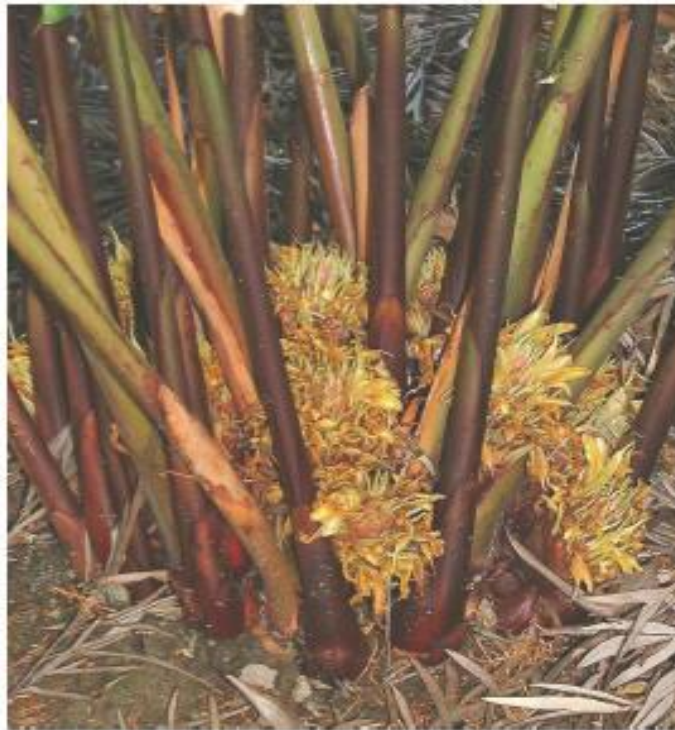
XV. References

AESA BASED IPM PACKAGE FOR LARGE CARDAMOM

Large cardamom - Plant description:

Large cardamom (*Amomum subulatum* Roxb.; Family: Zingiberaceae) is a spice cultivated in the sub-Himalayan regions of north-eastern India, especially in Sikkim. Sikkim is the largest producer of large cardamom; the annual production in India is about 3500-4000 mt of cured Large cardamom.

Cardamom is a perennial herb on consists of subterranean rhizomes and several leafy aerial shoots/tillers. Numbers of such rhizomatous leafy shoots vary between 15 and 140 inches in a single plant (a clump). Height of leafy shoot ranges from 1.7 to 2.6 mt depending on cultivar and possess 9-13 leaves in each tiller. Leaves are distichous, simple, linear and lanceolate, glabrous on both sides with a prominent mid rib. Inflorescence is a condensed spike on a short peduncle. Flowers are bisexual, zygomorphic, epigynous and cuspidated. The yellowish perianth is differentiated into calyx, corolla and anther crest. Each spike contains about 10-15 fruits (capsules) and rarely up to 20-25 capsules, depending on cultivars. Flowering season begins early at lower altitude with peak flowering during March-April, whereas it starts at higher altitudes in May with a peak during June-July. Harvesting begins during August-September at lower altitudes and in October-December at higher altitudes. The fruit is a round or oval shaped capsule, trilocular with many seeds. Capsule wall is echinated, reddish brown to dark pink. Seeds are white when immature and become bigger and bolder than others.



I. PESTS

A. Pest of Major Significance

1 Insect pests

- 1.1 Leaf eating caterpillar: *Artona chorista* (Jordon,) (Lepidoptera: Zygaenidae)
- 1.2 Banana aphid: *Pentalonia nigronervosa* (Goot) (Hemiptera: Aphididae)
- 1.3 Shoot fly: *Merochlorops dimorplrus* (Cherian) (Diptera: Chloropidae)

2 Diseases

- 2.1 Chirkey virus disease
- 2.2 Foorkey virus disease
- 2.3 Wilt: *Fusarium oxysporum* Schlecht. emend. Snyder & Hansen
- 2.4 Seedling rot & collar rot: *Fusarium oxysporum* Schlecht. Emend. Snyder & Hansen

3. Weeds

Grasses

- 3.1 Bermuda grass: *Cynodon dactylon* (L.) Pers (Poaceae)
- 3.2 Switchgrass: *Panicum* sp (Poaceae)
- 3.3 Crowfoot grass: *Dactyloctenium aegyptium* (L.) Willd, (Poaceae)
- 3.4 Large crabgrass: *Digiteria sanguinalis* (L.) (Poaceae)
- 3.5 Common barnyardgras: *Echinocholoa crus-galli* (L.), *E. colona* (Poaceae)
- 3.6 Goosegrass: *Eleusine indica* (L.) Gaertner. (Poaceae)
- 3.7 Wrinkled duck-beak: *Ischaemum rugosum* Salisb. (Poaceae)
- 3.8 Signalgrass: *Brachiaria* sp (Poaceae)
- 3.9 Torpedograss: *Panicum repens* L. (Poaceae)
- 3.10 Southern cutgrass: *Leersia hexandra*, Swartz (Poaceae)

Broadleaf

- 3.11 Pigweed: *Amaranthus viridis* Hook. F. (Amaranthaceae)
- 3.12 Lesser swine-cress: *Coronopus didymus* (L.) Sm. (Brassicaceae)
- 3.13 Black nightshade: *Solanum nigrum* L. (Solanaceae)
- 3.14 False amaranth: *Digera arvensis* Forssk. (Amaranthaceae)
- 3.15 Common purslane: *Portulaca oleracea* L. (Portulacaceae)
- 3.16 Goat weed: *Ageratum conyzoides* L. (Asteraceae)
- 3.17 Broadleaf woodsorrel: *Oxalis latifolia* Kunth, (Oxalidaceae)
- 3.18 False daisy: *Eclipta alba*, (L.) Hassk. Asteraceae
- 3.19 Cock's comb: *Celosia argentea* L. (Amaranthaceae)
- 3.20 Asthma herb/Spurge: *Euphorbia hirta* L. (Euphorbiaceae)
- 3.21 Yellow spider flower: *Cleome viscosa* L. (Capparidaceae)
- 3.22 Carrot grass: *Parthenium hysterophorus* L. (Asteraceae)

Sedges

- 3.23 Purple nutsedge: *Cyperus rotundus* L. (Cyperaceae)
- 3.24 Flat sedge: *Cyperus iria* L (Cyperaceae)

4. Nematode

- 4.1 Root knot nematode: *Meloidogyne incognita*

B. Pests of Minor Significance

1. Insect pests

- 1.1 Hairy caterpillar: *Eupterote* spp. (Lepidoptera: Eupterotidae)
- 1.2 Aphid: *Micromyzus kalimpongensis* (Hemiptera: Aphididae)
- 1.3 Maize aphid: *Rhopalosiphum maidis* Fitch, (Hemiptera: Aphididae)
- 1.4 Stem borer: *Glyphipterix* spp (Lepidoptera: Glyphipterigidae)
- 1.5 Leaf thrips: *Heliothrips haemorrhoidalis* Bouche, *Rhipiphorothrips cruentatus* Hood (Thysanoptera: Thripidae)
- 1.6 Lace-wing bug: *Stephanitis typica* Distant, (Hemiptera: Tingidae)
- 1.7 White grub: *Holotrichia* sp, (Coleoptera: Scarabaeidae)
- 1.8 Green beetle: *Basilepta femorata*, Jacob, (Coleoptera: Eumolpidae)
- 1.9 Rhizome weevil: *Prodiectes haemeticus* Cherro Jat, (Curculionidae :Coleoptera)

2. Diseases

- 2.1 Flower rot: *Fusarium* & *Rhizoctonia* sp.
- 2.2 Leaf spot: *Pestalotiopsis versicolor*, (Speg.) Steyaert,
- 2.3 Leaf streak: *Pestalotiopsis roynae*, Speg
- 2.4 Leaf blight: *Colletotrichum* sp.

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

A. AESA

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. soil, rain, sunshine hours, wind etc.) and biological factors (i.e. pests, diseases and weeds). All these factors can play a role in the balance which exists between herbivore insects and their natural enemies. Understanding the intricate interactions in an ecosystem can play a critical role in pest management.

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

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

- Plant health at different stages.
- Built-in compensation abilities of plants.

- Pest and defender population dynamics.
- Soil conditions.
- Climatic factors.
- Farmers past experience.

Principles of AESA based IPM:

Grow a healthy crop

- Select a variety resistant/tolerant to major pests.
- 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 situations at least once a week (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.).



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 large cardamom pests can be divided into 3 categories 1. parasitoids; 2. predators; and 3. pathogens.

Model agro-ecosystem analysis chart

Date:

Village:

Farmer:



Decision taken based on the analysis of field situation

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

The general rule to be adopted for management decisions relying on the P: D ratio is 2: 1. However, some of the parasitoids and predators will be able to control more than 2 pests. Wherever specific P: D ratios are not found, it is safer to adopt the 2: 1, as P: D ratio. Whenever the P: D ratio is found to be favourable, there is no need for adoption of other management strategies. In cases where the P: D ratio is found to be unfavourable, the farmers can be advised to resort to inundative release of parasitoids/predators depending upon the type of pest. In addition to inundative release of parasitoids and predators, the usage of microbial biopesticides and biochemical biopesticides such as insect growth regulators, botanicals etc. can be relied upon before resorting to synthetic chemical pesticides.

Decision making

Farmers become experts in crop management

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

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

AESA methodology

- Go to the field in groups (about 5 farmers per group). Walk across the field and choose 20 plants/acre randomly. Observe keenly each of these plants and record your observations:
 - Plant: Observe the plant height, number of aerial tillers, 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 (monthly)
 - 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 are the problems? How can we avoid it? How can we be prepared?
- Summarize the actions to be taken.



Advantages of AESA over ETL

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

AESA and farmer field school (FFS)

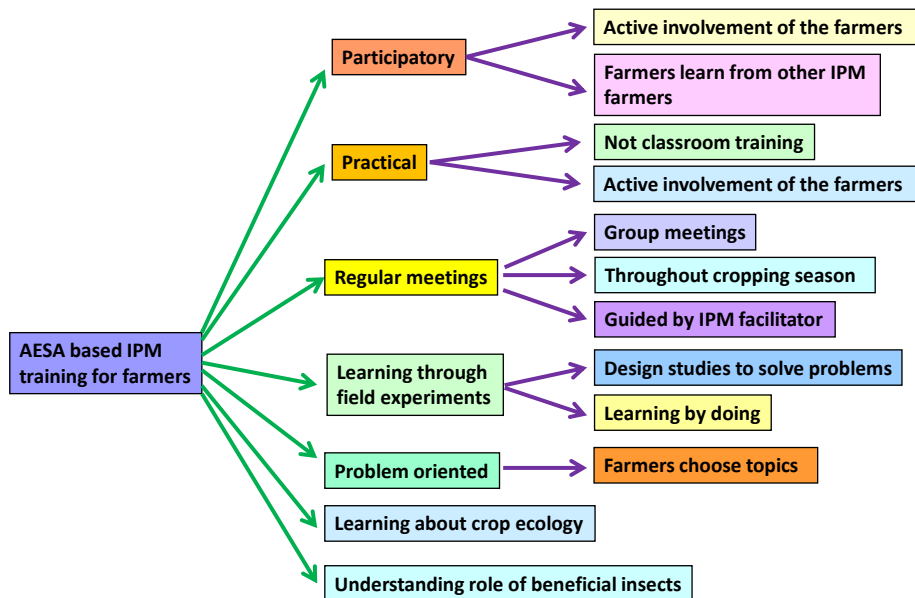
AESA is a season-long training activity that takes place in the farmer field. It is season-long so that it covers all the different developmental stages of the crop and their related management practices. The process is always learner-centered, participatory and relying on an experiential learning approach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

Farmers can learn from AESA

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



FFS to teach AESA based IPM skills



B. Field scouting

AESA requires skill. So only the trained farmers can undertake this exercise. However, other farmers also can do field scouting in their own 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 five plants randomly at each spot for recording counts of insects as per procedure finalized for individual insects.

For sucking pests:

For aphids: Count and record the number of both nymphs and adults on five randomly selected per aerial tiller per clump/plant.

For borers: Count the number of young and grown up larvae on each plant and record.

For diseases:

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

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

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

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

C. Surveillance through pheromone trap catches:

Pheromone traps for @ 4-5/acre field have to be installed, if available. Install the traps for each species separated by a distance of >75 feet in the vicinity of the selected fixed field. Change of lures should be made at 2-3 week interval (regular interval). Total number of moths/trap/week should be recorded year round. The trapped moths should be removed and destroyed after each recording.

D. Yellow/blue pan water/sticky traps:

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

E. Light traps

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

F. Nematode extraction

Collect 100 to 300 cm³ (200-300 g) representative soil sample. Mix soil sample and pass through a coarse sieve to remove rocks, roots, etc. Take a 600 cc subsample of soil, pack lightly into a beaker uniformly. Place soil in one of the buckets or pans half filled with water. Mix soil and water by stirring with paddle; allow to stand until water almost stops swirling. Pour all but heavy sediment through 20-mesh sieve into

second bucket; discard residue in first bucket; discard material caught on sieve. Stir material in second bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 200-mesh sieve into first bucket; discard residue in second bucket. Backwash material caught on 200-mesh sieve (which includes large nematodes) into 250-ml beaker. Stir material in first bucket; allow to stand until water almost stops swirling. Pour all but heavy sediment through 325-mesh sieve into second bucket; discard residue in first bucket. Backwash material caught on 325-mesh sieve (which includes small to mid-sized nematodes and silty material) into 250-ml beaker. More than 90% of the live nematodes are recovered in the first 5-8 mm of water drawn from the rubber tubing and the sample is placed in a shallow dish for examination.

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

Ecological Engineering for Pest Management – Below Ground:

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

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

Ecological Engineering for Pest Management – Above Ground:

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

Natural enemies may require

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

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

- Raise the flowering plants / compatible cash crops along the field border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population

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

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

Plants suitable for Ecological Engineering for Pest Management

Attractant plants



Cowpea



Carrot



Sunflower



Buckwheat



French bean



Alfaalfa



Mustard



Cosmos



Anise



Caraway



Dill



Parsley

Repellent plants



***Ocimum* sp**



Peppermint/Spearmint

Border plants



Maize



Sorghum

Biodiversity of natural enemies observed in Ecological Engineering field at NIPHM

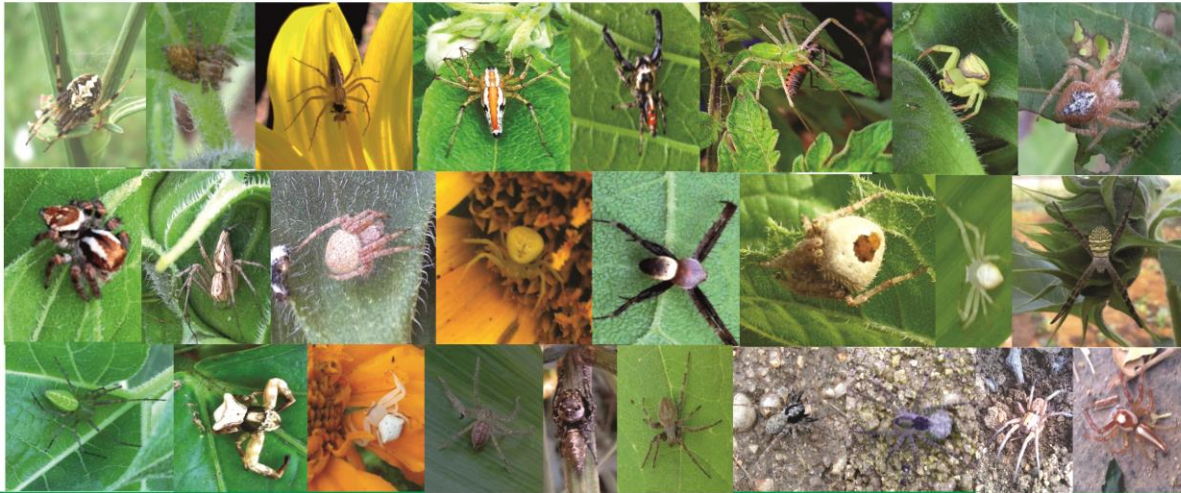
Biodiversity of natural enemies: Parasitoids



Biodiversity of natural enemies: Predators



Biodiversity of natural enemies: Spiders



IV. CROP STAGE-WISE IPM

Management	Activity
Pre-sowing*	
	<p><u>Common cultural practices:</u></p> <ul style="list-style-type: none"> • Deep ploughing of fields during summer to control nematodes population and weeds. • Soil solarization • Timely sowing should be done. • Field sanitation, rogueing. • Destroy the alternate host plants • Apply manures and fertilizers as per soil test recommendations. • Plant tall border crops like maize, sorghum or millet to reduce pests population. • Crop rotation with graminaceous crops • Adopt ecological engineering by growing the attractant, repellent, and trap crops around the field bunds. <p><u>Common biological control:</u></p> <ul style="list-style-type: none"> • Apply neem cake @ 100 Kg/acre at the time of transplanting for reducing capsule borer damage
Nursery stage	
Nematode	<ul style="list-style-type: none"> • Change the nursery site every year to avoid nematode infestation. • Soil solarization may be practiced • Apply well rotten farm yard manure.
Seed selection	<ul style="list-style-type: none"> • Use only seeds from certified nurseries/plantations with a productivity of 400 kg/acre for three consecutive years • Select the seeds or clumps from disease free healthy plants. • Select variety which suits to particular altitude area and locality
Chirkey & foorkey viral diseases	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Regular survey of the plantation to trace out diseased plants. • Remove diseased plants completely along with rhizome & roots and destroy as soon as they are traced. • Use healthy disease free planting material preferably seedlings. • Do not raise nurseries in the vicinity of infected plantations. • Destroy all the collateral host plants of the aphids in and near the plantation.
Leaf thrips**	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Its incidence is more in cardamom seedling at lower altitude during April to November. • Collect and destroy the infested leaves.

	<p><u>Biological control:</u></p> <p>Predators: <i>Anthocoris</i> and <i>Orius</i> spp., predatory thrips (<i>Aeolothripsintermedius</i>, <i>Mymarothripsgaruda</i>), <i>Chrysoperlacarnea</i>, <i>Malladasp</i>, praying mantids, lady bird beetles, syrphid flies, spiders etc.</p>
Weeds	<ul style="list-style-type: none"> • Line sowing of seeds in 15-25 cm raised primary nursery at 10 cm distance and use mulch with local plant materials upto germination of the seeds that is 25-30 days. After that remove the mulch. • Remulch the primary nursery interole space with chopped paddy straw and leaves. • Remove weeds manually from time to time. • When seeding attain 3-4 leaf stage, they are transplanted to secondary nursery beds of 15 cm height and 100 cm width in May- June at 15 cm row spacing. • The inter row space in secondary nursery is also mulched with chopped paddy straw or dried leaf for 12 to 13 months. • Alternatively, sucker multiplication nursery may be established under the shade of forest trees/ pandals in tranches of 30x30 cm during May - June by planting the suckers from healthy plantation. Remove weeds in this nursery from time to time. The grown up tillers from buds are ready for planting in the main fields in June- July.
Watering	<ul style="list-style-type: none"> • Over watering may be avoided.
Nutrients	<ul style="list-style-type: none"> • Nutrients should be applied on the basis of soil test report and recommendation for the particular agro-climatic zone. • For rhizome multiplication in nursery, use organic matter rich top soil or add organic manures.
Plantation stage	
Shade	<ul style="list-style-type: none"> • Large cardamom is a shade loving crop, maintain optimum shade
Nutrients	<ul style="list-style-type: none"> • Apply well decomposed farm yard manure. • Apply chemical fertilizers based on soil test @ 40:60 :40 kg N₂P₂O₅ and K₂O per kg in two splits - once in April-May on receipt of 1 summer-shower and '2nd split in September- October before monsoon is over • Dig pits of 30 cm x 30 cm x 30cm size and fill with organic manure and top soil. Contour planting may be done in sloppy areas. • Application of well decomposed FYM or compost and 100 g of rock phosphate with the topsoil in the pit will help in proper establishment and quick growth of plants. • If the selected site is a hill slope, terraces may be formed before digging pits.
Weed	<ul style="list-style-type: none"> • Maintain weed free plantation. • Destroy all the weeds from planting area by ploughing during summer and remove all the perennial weeds and their rhizomes/suckers before onset of monsoon.

Mulching and Earthing up	<ul style="list-style-type: none"> • Thick mulching with dry leaves/grass may be done on the base of the rhizome to keep the soil moist • In old plantations, earthing up is necessary to cover exposed roots and rhizomes of the plants
Leaf eating caterpillar	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Collect and destroy infested leaves along with larvae in June-July and October-December months. • Community approach of mechanical control may be adopted in the locality when the outbreak is observed. It may totally suppress this pest in the course of 2-3 years. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Follow common cultural practices.
Aphids*	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • The removal and destruction of diseased plants are helpful in control of further spread of disease and in reduction of aphid population. • Destroy wild <i>Amomum</i>, <i>Colocasia</i>; <i>Curcuma</i> and other , collateral host plants of the aphid vector in and near the plantations
Shoot fly	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Its damage is more in first 2-3 years after planting. Therefore, regularly monitor the new plantations. • Remove infested young shoots at ground level and destroy
Stem borer**	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Remove and destroy the infested shoots based on 'dead heart' symptoms
White grub**	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Mechanical collection of adult beetles during the emergence period is an effective method in managing the pest. <p><u>Biological control:</u></p> <ul style="list-style-type: none"> • Entomogenous fungus, <i>Metarhizium</i> is also effective
Chirkey & foorkey disease	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Regular survey of the plantation to trace out diseased plants. • Remove completely diseased plants along with rhizome & roots and destroy as soon as they are traced. • Use healthy disease free planting material preferably seedlings. • Do not raise nurseries in the vicinity of infected plantations. • Destroy all the collateral host plants of the aphids in and near the plantation.
Wilt disease	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Planting in swampy or dry areas may be avoided. • Collect and destroy (by burning or burying) the affected plants .
Flower rot**	<p><u>Cultural control:</u></p> <ul style="list-style-type: none"> • Avoid the accumulation of leaf mass or waste plant parts over the inflorescence/spike during rainy season. • Spills of soil over 1hc spike may be avoided at the time of base making by pouring soil to the plant base. • Collect and bury affected flowers/spikes

Vegetative	
Weeds	<ul style="list-style-type: none"> • Around the base of pits, weeds should be removed with the help of sickles. • Hand tool weeding should be carried out 3 times in during March, July and August in a year for effective control of weeds or • Slash weeding may be done by using power mover/weeder. • After establishment of plantation, inter crops with regional recommended crop like turmeric may be grown to utilize the inter space of 1.5 to 1.8 meter between 2 rows during intial years.
Flowering	
	<ul style="list-style-type: none"> • Encourage the population of bumble bees which are the main pollinators and also help to increase the yield. • Remove mulch from inflorescences/spikes during rainy season • Spraying should be taken during afternoon when the pollinators activities arc minimum
Weeds	<ul style="list-style-type: none"> • Hand tool weeding should be carried out or slash weeding may be done by using power mover/weeder.
Harvesting	
	<ul style="list-style-type: none"> • Harvest at the right maturity of the capsules at different altitudes to avoid the damage by rats and wild cats etc.
Weeds	<ul style="list-style-type: none"> • Left over weeds may be remove before shedding of seeds to check their spread in subsequent years.

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

** Pests of miner significance

V. INSECTICIDE RESISTANCDE 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. NUTRIENT DEFICIENCY

Potassium: Older leaves show chlorosis. The symptoms start from margins and become necrotic brown colour. Drying starts from leaf tip towards base. Leaf become pale green and turns yellow with scorching appearance.

Correction Measure: Foliar spray of K_2SO_4 @1% at fortnightly intervals.



VII. COMMON WEEDS



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



2 *Panicum* sp. (Poaceae)



3 Crowfoot
grass: *Dactyloctenium*
aegyptium (L.) Willd,
(Poaceae)



4. Large crabgrass (L): *Digiteria*
sanguinalis (Poaceae)



5. Common barnyardgras:
Echinochloa crusgalli (L.), *E.*
colona



6. Goosegrass: *Eleusine*
indica (L.) Gaertner.
(Poaceae)



7. Wrinkled duck-beak:
Ischaemum rugosum Salisb.
(Poaceae)



8. Signal grass: *Brachiaria* sp:
(Poaceae)



9 Torpedograss: *Panicum*
repens, (Poaceae)



10 Southern cutgrass: *Leersia hexandra*, Swartz, (Poaceae)



11 Pigweed: *Amaranthus viridis* Hook. F. (Amaranthaceae)



12 Lesser swine-cress: *Coronopus didymus* (L.) Sm. (Brassicaceae)



13 Black nightshade: *Solanum nigrum* L. (Solanaceae)



14 False amaranth: *Digera arvensis* Forssk. (Amaranthaceae)



15 Common purslane: *Portulaca oleracea* L. (Portulacaceae)



16 Goat weed: *Ageratum conyzoides* L. (Asteraceae)



17 Broadleaf woodsorrel: *Oxalis latifolia* Kunth, (Oxalidaceae)



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



19 Cock's comb: *Celosia argentea* L. (Amaranthaceae)



20 Asthma herb/Spurge: *Euphorbia hirta* L. (Euphorbiaceae)



21 Yellow spider flower: *Cleome viscosa* L. (Capparidaceae)



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



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



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

VIII. DESCRIPTION OF INSECT PESTS

1. Leaf thrips

Biology:

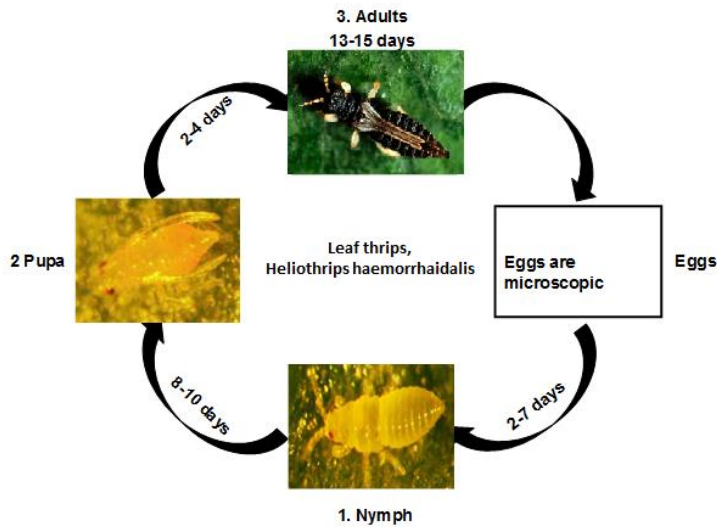
Egg: The adult female lays eggs on the leaf or fruit surface. Just before hatching the egg blisters. The eggs are white and banana-shaped and are inserted singly in plant tissue

Larva: The early larval stage is whitish with red eyes. Larvae become yellowish after feeding. Mature larvae average about 1 mm in length. There are two larval instars and then it moults to the prepupal stage which is light yellow with red eyes and short wing pads

Pupa: The pupal stage is slightly larger, with longer wing pads and larger eyes. It is yellowish and then darkens with age. The antennae are bent backward over the head in the pupal stage. The prepupal and pupal stages do not feed.

Adult: As it matures into an adult, the greenhouse thrips' head and thorax darken to black while the abdomen changes from yellow, yellow-red, brown, and black. Cool temperatures retard the color changes. The legs remain a light yellow, and the antenna has eight segments. The greenhouse thrips is parthenogenic, in that it reproduces without mating, and males are seldom seen. It is a poor flier and remains in the shaded areas on the plant almost all the time.

Life cycle:



http://entnemdept.ufl.edu/creatures/orn/thrips/greenhouse_thrips.htm

Damage symptoms:

- This pest feeds primarily on the foliage of ornamental plants.
- It attacks the lower surface first and, as feeding progresses and the population increases, the thrips move to the upper surface.
- The leaves become discoloured and develop distortion between the lateral veins.
- Severely damaged leaves turn yellow

Natural enemies of leaf thrips:

Parasitoid: *Megaphragma mymaripenne*,

Predators: Predatory thrips (*Franklinothrips orizabensis*, *F. vespiformis*, *Leptothrips mali*)

2. Rhizome weevil

Biology

Egg: Eggs are laid in cavities made on rhizome. Egg period 8 -10 days

Grub: Larvae feed inside the rhizome, larval period 21 days. Pupate in the feeding tunnels

Pupa: pupal period 21 days. Adult is a brown weevil, 12 mm in length

Adult: is a brown weevil, live for 7 – 8 months. Only one generation in a year.

Damage symptoms:

- Grubs tunnel and feed on the rhizome causing death of entire clumps of cardamom.

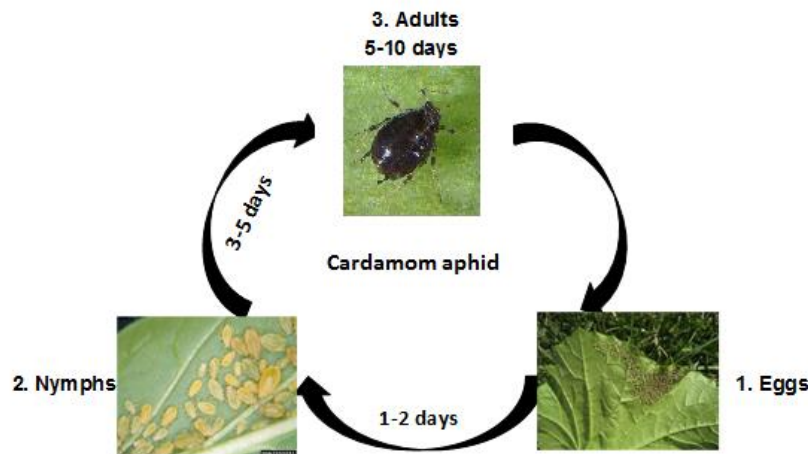
3. Aphid

Biology

Egg: Eggs are kidney shaped laid singly in the tender part of the leaf sheath, racemes

Nymph: Nymphs tiny, slender, fragile and straw yellow in colour

Adult: Minute, dark greyish brown, 1.25 to 1.5 mm long and with fringed wings.



Damage symptoms:

- Panicles become stunted
- Shedding of flowers and immature capsules thus reducing the total number of capsules formed.
- Infestation causes formation of corky encrustations on capsule resulting in their malformed and shriveled condition.
- Such pods lack their fine aroma and the seeds within are also poorly developed.

Natural enemies of aphid:

Parasitoids: *Aphidius colemani*, *Aphelinus* spp.

Predators: Lacewing, ladybird beetle, spider, syrphid larva

4. Hairy caterpillar

Biology

Egg: 300 – 800 eggs are laid on the under surface of leaves of shade trees. Egg period 13 – 20 days.

Larva: Larva is hairy and has a dark – grey body, pale brown head. Larva undergoes 10 instars in 5 months.

Pupa: Pupate in soil at a depth of 2 – 2.5 inch, pupa is cocoon, pupal period 7 – 8 months.

Adult: The adult is a large moth measuring 70 -80 mm, ochrus in colour with post medial lines on the wings.

Damage symptoms:

- The caterpillars congregate on the trunks of shade trees and then descend to the cardamom plants.
- They feed voraciously the leaves of cardamom plants, defoliating within a short time.

5. White grub

Biology

Eggs: Adult beetles emerge by March-April and lay their eggs in the soil. The eggs are soft, ellipsoid, off-white, and about 1 mm long on the longest axis.

Grubs: The larvae are fat, whitish or cream coloured grubs, and generally about 38 mm long when fully grown. The newly-hatched grubs emerge during June-August and continue to develop up to

October/November. During this period, the feeding grubs are found in the top 6 inches of the soil but may move deeper when the soil is very dry. The larvae feed on plant roots and organic matter in the soil.

Adults: The adults are typical chafer beetles, mostly brown, and 19-20 mm long.

Damage symptoms:

- Affected plants show yellowing of the foliage, scorching of leaves, defoliation and dieback.
- Inspection of the root system will reveal that the roots have been chewed off leaving calloused stumps. *H. disparilis* also feeds on the at soil level, causing of the stem followed by death of the plants

Natural enemies of white grub:

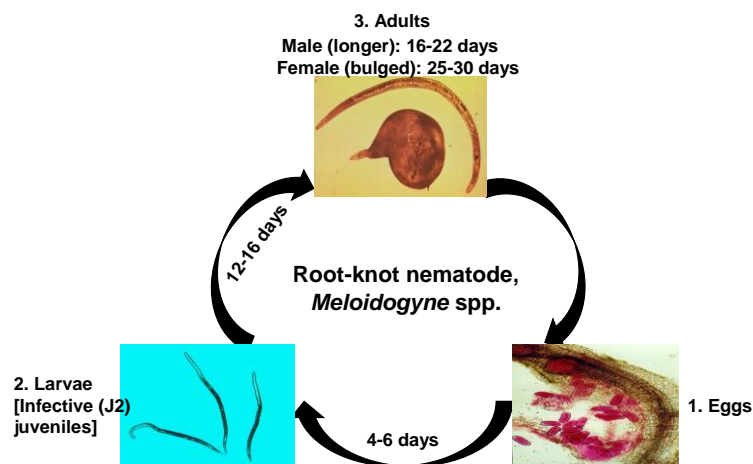
Nematode: *Heterorabditis* nematode

6. Root knot nematode

Biology:

- Most species of plant parasitic nematodes have a relatively simple life cycle consisting of the egg, four larval stages and the adult male and female. They are microscopic in size.
- Development of the first stage larvae occurs within the egg where the first moult occurs. Under suitable environmental conditions, the eggs hatch and new larvae emerge to complete the life cycle within 4 to 8 weeks depending on temperature.
- Nematode development is generally most rapid within an optimal soil temperature range of 70 to 80°F.

Life cycle:



1. <http://keys.lucidcentral.org/keys/sweetpotato/key/Sweetpotato%20Diagnoses/Media/Html/TheProblems/Nematodes/RootKnotNematode/Root-knot.htm>

2. <http://nematology.umd.edu/rootknot.html>

3. http://www.cals.ncsu.edu/pgg/dan_webpage/Introduction/Images/pyroform.htm

Damage symptoms:

- Poor germination of seeds in the primary nurseries.
- Poor establishment after transplanting to secondary nurseries or main field.
- Yellowing and drying of leaf tips and margins.

- Stunting and poor growth of the plants.
- Heavy galling and abnormal branching of roots.

Survival and spread:

Primary: Egg masses in infected plant debris and soil or collateral and other hosts like Solonaceous, Malvaceous and Leguminaceous plants act as sources of inoculum

Secondary: Autonomous second stage juveniles that may also be water dispersed

Natural Enemies of Large Cardamom Pests

Parasitoids

Egg parasite



Megaphragma mymaripenne

<http://unnamedharald.hubpages.com/hub/A-Wasp-Smaller-Than-an-Amoeba>

Nymphal and adult parasitoids



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. *Franklinothrips orizabensis*



2 *F. vespiformis*,



3. *Leptothrips mali*,



4. Lacewing



5. Ladybird beetle



6. Spider



7. Syrphid larva

1. http://anic.ento.csiro.au/thrips/identifying_thrips/Aeolothripidae.htm

2. <http://en.wikipedia.org/wiki/Franklinothrips>

3. http://calphotos.berkeley.edu/cgi/img_query?enlarge=0000+0000+1008+0696

4. http://www.macro-world.cz/image.php?id_foto=514&gal=29

7. <http://en.wikipedia.org/wiki/Aphid>

IX. DESCRIPTION OF DISEASES

1. Seedling rot:

Disease symptoms:

- Leaves turn pale and their tips become yellow. Gradually, these symptoms spread over the entire leaf extending to leaf sheath resulting in wilting of seedlings.
- The collar portion decays and the entire seedlings die. Infection spreads in the nursery beds resulting in death of seedlings in small patches.
- In grown up seedlings, rotting extends from the collar region to the rhizomes resulting in their decay and ultimate death of the plant.

Survival and spread:

- Seed, Soil and Water

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.

*For the management refer page no.....

2.Chirkey disease:

Disease symptoms:

- The disease is characterized by mosaic appearance on leaves. The symptom is more prominent on young emerged leaves where discrete pale green to yellow longitudinal strips running parallel to each other can be seen. The flowering is greatly reduced thereby reducing the yield with time

Survival and spread:

- The fungus survives in soil as well as crop debris.

Favourable condition

- Lack of phyto-sanitation to destroy the insect vector, presence of infected old plants in garden

*For the management refer page no.....

3.Foorkey disease:

Disease symptoms:

- The affected plants produce profuse stunted shoots which fail to produce flowers. The leaves become small, lightly curled and pale green in colour. The inflorescence becomes stunted, thereby producing no flowers and fruits. The capsule size reduced and chaffy without seeds

Survival and spread:

- The fungus survives in soil as well as crop debris.

Favourable condition:

- Lack of phyto-sanitation to destroy the insect vector, presence of infected old plants in garden

*For the management refer page no.....

4. Leaf blight:

Disease symptoms:

- Water-soaked lesions appear on the leaf margin or on the tips of the leaves which rapidly enlarges, coalesce and cover the entire leaf lamina giving blighted appearance. The advancing lesions are blackish-brown in colour and margins have a yellow halo around it. The affected leaves become necrotic and dry. Leaf sheath covering the pseudostem shows blackish-brown discolouration which progress down to the rhizome and gradually the pseudostem becomes brittle and breaks in the middle or at the collar region. Eventually, the affected clump dries up completely giving the entire plant a burnt appearance

Survival and spread:

- The fungus survives in soil as well as crop debris.

Favourable condition:

- Inadequate shade level, lack of field sanitation and nutrient management. The cardamom crop is grown as monoculture crop ever since its introduction which has provided favourable condition for building up of the pests and pathogen in the long run

*For the management refer page no.....

X. SAFETY MEASURES

A. Pre-harvest: The first crop comes to harvest in about 2-3 years after planting suckers or seedlings. Stabilized yields are realized only from the 4th year and may sustain up to 10-12 years depending on the management practices adopted. Harvesting season commences during August/September at low altitudes and continues until December at higher altitudes. Harvesting is done in one round when, the seeds of capsules at the top in the spike attain dark gray colour. The spikes are harvested with a special type of knife, locally known as *Elaichi chhuri*. The stalk of the spikes is cut near to the leafy shoot and later, individual capsules are separated manually. Later the, capsules are cured to reduce the moisture level up to 10-12 per cent. The traditional curing is called *Bhatti* curing system or direct heat drying. However, other systems like flue pipe curing system (indirect heat drying), portable curing chamber, natural convection dryer system

and gasifier system are also have been developed and employed for the curing purpose.

Bhatti system: The *Bhatti*, a locally made kiln comprises of a platform made of bamboo mats or wire mesh, laid over a four-walled structure made of stone pieces, with a 'V' shaped opening in the front for loading fire wood. The capsules are uniformly spread over the platform and are dried by direct heat generated from the firewood. Depending on thickness of the capsule layer, 60-72 h are required for curing. The colour of cured capsules under this system is dark brown or black. However, if the smoke percolates through the capsules, it loses original colour, gets smoky smell and fetches low price. The disadvantages of this system include:

- (a) Loss of volatile oil
- (b) Exposure to smoke imparts a smoked-smell to the volatile oil.
- (c) Charring of capsules due to localized overheating.

Portable curing chamber: This is a prototype of 'Copra dryer' developed at ICAR - Central Plantation Crops Research Institute (CPCRI), Kasaragod, Kerala. Under this system, fresh capsules are spread on the platform made of wire mesh of size 3-5 mm to a thickness of about 15-20 cm. Firewood is burnt inside the furnace cylinder. Consequently, air around the furnace gets heated up converted upwards and passes through the produce there by drying it. The temperature of the heating chamber is regulated by adjusting the rate of burning of firewood and also by regulating the chimney valves. It takes about 20 h for curing about 50 kg raw capsules.

Flue pipe curing system: In order to overcome the drawbacks of *Bhatti* curing, a system known as "flue pipe system" has been developed. The capsules are spread over the wire mesh floor and shelves in one or two layers after the chamber is maintained at 40°C. As soon as capsules are spread, the curing room is closed and hot air is passed through the furnace into the flue pipes, bringing the room temperature around 45-50°C and maintained for about 3-4 h. At this stage, sweating of capsules occurs, thereby releasing the moisture. Ventilators are then opened for sweeping out the entire accumulated moisture from the chamber. Further, the ventilators are closed and temperature is maintained at 40-45°C. To attain uniform drying, capsules are stirred one or two times. The whole process of curing takes about 28 to 29 h. The capsules thus cured are immediately collected and rubbed in trays or processed in cardamom polishing machine for removing the tail. Cleaned produce is then packed in polythene lined gunny bags and stored in wooden boxes. Cured cardamom on an average gives 25 per cent by weight of fresh cardamom.

Cardamom dried by employing this method has following advantages compared to the Bhatti system:

- (i) Original colour (pink) and flavour (sweet camphor aroma) is retained.
- (ii) Fetches better market price.
- (iii) Curing expenses are comparatively low and firewood consumption is less.
- (iv) Total curing process is completed within 28-29 h.
- (v) Uniform dryage is ensured.

Natural convection dryer: The dryer designed by Central Food Technology Research Institute (CFTRI) is similar to Flue pipe curing system. This dryer with a thermal efficiency of about 5.6 is better than the conventional flue curing kilns. It can dry 300 kg large cardamom at a time and for drying to a level of 10 per cent moisture the time required is 24 h.

Gasifier system of curing. It is an upgradation of the *Bhatti* curing system, developed by TATA Energy Research Institute, New Delhi. This system helps to get improved quality large cardamom with better appearance and more volatile oil content. The controlled burning in a gasifier system helps in (1) retention of more volatile oil (2) better quality of volatile oil without any burnt or smoking smells due to clean burning of gaseous fuel and (3) retention of the natural pink colour of processed produce.

XI. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1.	Grow only recommended varieties for the particular altitude and area	Don't grow varieties which are not suitable for the particular altitude and region
2	Use only certified seeds	Don't collect seeds from unknown source and diseases prone areas
3	Use acid treated seeds for early and high germination	Without seed treatment germination will be delayed
4	Treat the seeds with approved chemical / bio products for the control of seed borne disease/pests	Don't use seeds without seed treatment with biocide/ chemicals
5	Use NPK fertilizer as per the soil test recommendation	Avoid imbalance use of fertilizers
6	Use only recommended pesticides at the recommended dosages for control of various pests	Do not use recommended pesticides or mixture of various pesticides.
7	Apply pesticide as a last resort when pest incidence is above economic threshold level (ETL)	Do not apply on calendar basis

XII. BASIC PRECAUTIONS IN PESTICIDES USAGE

A. Purchase

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

B. Storage

1. Avoid storage of pesticides in house premises.
2. Keep only in original container with intact seal.
3. **Do not** transfer pesticides to other containers; **Do not** 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. Equipment

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






F. Precautions for applying pesticides


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

G. Disposal



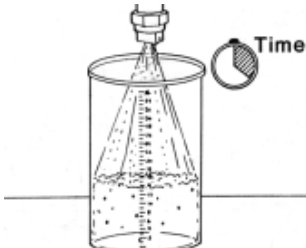

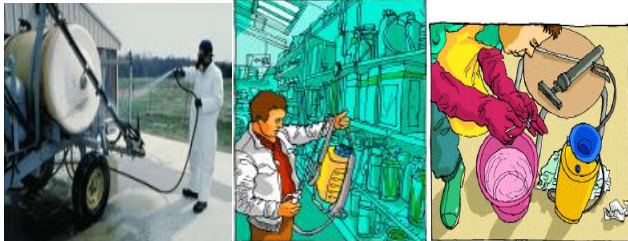

1. Left over spray solution should not be drained in ponds or water lines etc. throw it in barren isolated area if possible
2. The used/empty containers should be crushed with a stone/stick and buried deep into soil away from water source.
3. Never reuse empty pesticides container for any other purpose.










XIII. PESTICIDE APPLICATION TECHNIQUES

Equipment			
Category A: Stationary, crawling pest/disease			
Vegetative stage i) for crawling and soil borne pests ii) for small sucking leaf borne pests	Insecticides and fungicides	<ul style="list-style-type: none"> • Lever operated knapsack sprayer (droplets of big size) • Hollow cone nozzle @ 35 to 40 psi • Lever operating speed = 15 to 20 strokes/min <li style="text-align: center;">or • Motorized knapsack sprayer or mist blower (droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle 	
Reproductive stage	Insecticides and fungicides	<ul style="list-style-type: none"> • 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 <i>(Field Pests)</i>	Insecticides and fungicides	<ul style="list-style-type: none"> • Motorized knapsack sprayer or mist blower (droplets of small size) • Airblast nozzle • Operating speed: 2/3rd throttle <li style="text-align: center;">Or • Battery operated low volume sprayer (droplets of small size) • Spinning disc nozzle 	
Mosquito/ locust and spatial application <i>(migratory Pests)</i>	Insecticides and fungicides	<ul style="list-style-type: none"> • Fogging machine and ENV (exhaust nozzle vehicle) (droplets of very small size) • Hot tube nozzle 	
Category C: Weeds			
Post-emergence application	Weedicide	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Trolley mounted low volume sprayer (droplets of small size) • Battery operated low volume sprayer (droplets of small size) 	
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XIV. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

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

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.	

XV. REFERENCES

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