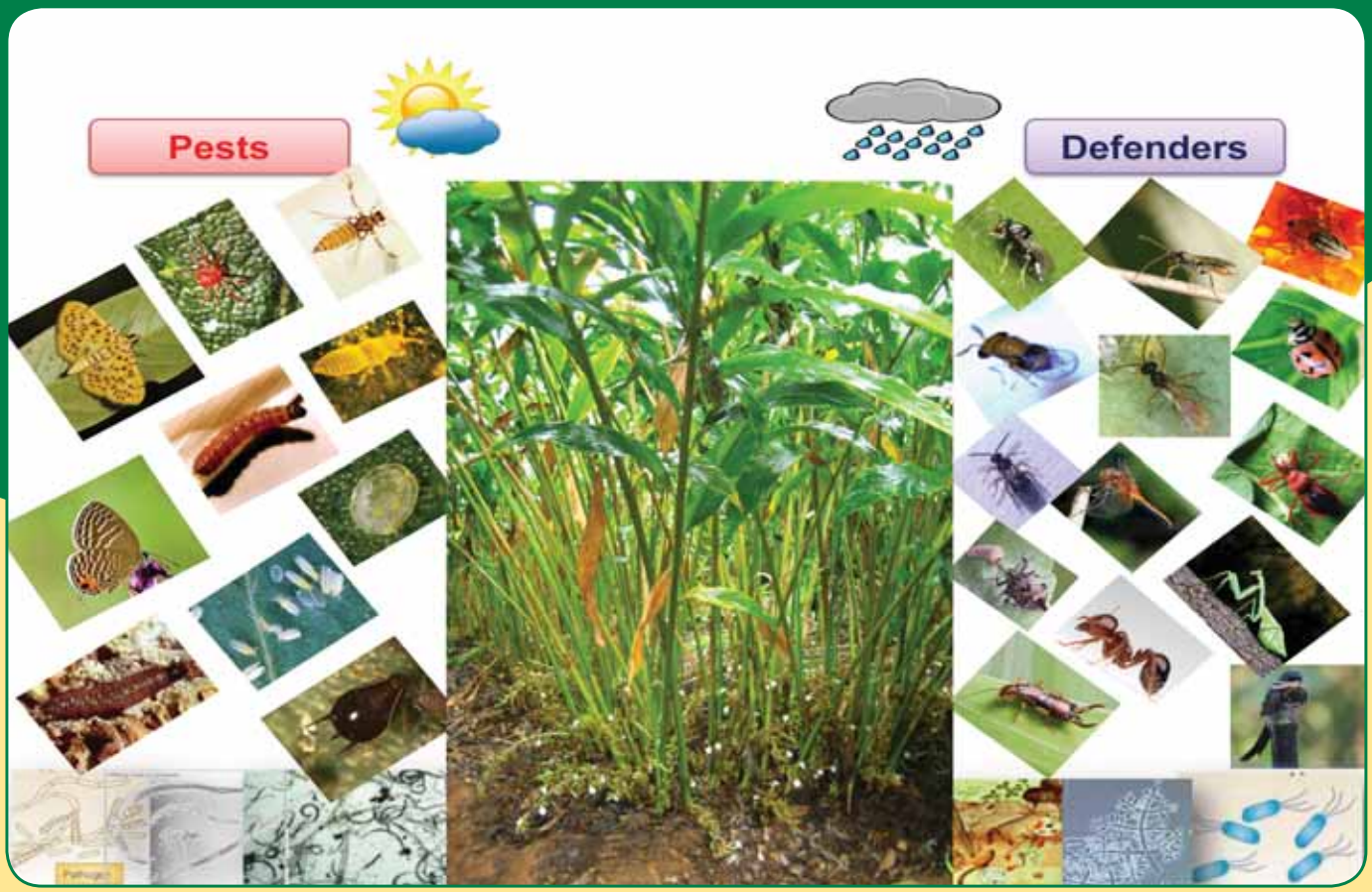
AESA BASED IPM PACKAGE

AESA based IPM – Small cardamom



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

National Institute of
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Rajendranagar, Hyderabad, Telangana

Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

Important Natural Enemies of Small cardamom Insect Pests

Parasitoids

***Trichogramma* spp.**

***Tetrastichus* spp.**

Chrysocharis pentheus

***Bracon* spp.**

Encarsia formosa

***Aphidius* sp**

Predators

Robber fly

Earwig

Pentatomid bug

Reduviid bug

Ground beetle

Black drongo

The AESA based IPM–Small cardamom, 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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Citation Satyagopal, K., S.N. Sushil, P. Jeyakumar, G. Shankar, O.P. Sharma, D.R. Boina, S.K. Sain, M.N. Reddy, N.S. Rao, B.S. Sunanda**,** Ram Asre, K.S. Kapoor, Sanjay Arya, Subhash Kumar, C.S. Patni, T.K. Jacob, Santhosh J. E., C.N. Biju, K. Dhanapal, H. Ravindra, Linga Raju, S., Ramesh Babu, B.C. Hanumanthaswamy. 2014. AESA based IPM package for Small cardamom. pp 43.

Front cover picture Model AESA chart for Small cardamom

Back cover picture Small cardamom field

Published by National Institute of Plant Health Management, Rajendranagar, Hyderabad – 500 030

Copies: 1,000, September 2014

For internal circulation only. Not for sale.

Contact APPA - IPM, Directorate of Plant Protection, Quarantine & Storage, CGO Complex, NH IV, Faridabad, Haryana - 121 001.

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Printed at **Balaji Scan Pvt. Ltd.,**
A.C. Guards, Hyderabad.
Tel : 040-23303424
e-mail: bsplpress@gmail.com
www.balajiscan.com

अपर सचिव
भारत सरकार
कृषि मंत्रालय
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FOREWORD

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

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

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

Date : 6.3.2014

(Avinash K. Srivastava)

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FOREWORD

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

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

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

(Utpal Kumar Singh)

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PREFACE

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

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

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

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

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

(K. SATYAGOPAL)

CONTENTS

AESA BASED IPM PACKAGE FOR SMALL CARDAMOM

Small cardamom plant description:

Small cardamom (*Elettaria cardamomum* (L.); Family: Zingiberaceae). It is popularly known as **queen of spices**. Small cardamom, which is used as spice, is in fact a dried fruit of a tall perennial herbaceous plant. India is a major producer, consumer and exporter of small cardamom. In India, small cardamom is mainly cultivated in Kerala (60%), Karnataka (30%) and Tamil Nadu (10%). Small cardamom is one of the most expensive spices in the world.

Both seed propagation and vegetative propagation are practiced in small cardamom. Vegetative propagation is favored over seed propagation as the latter ensures large scale commercial production of true-to-type planting materials of high-yielding lines. The suckers free from pests and diseases are generally used for vegetative propagation. Micropropagation using tissue culture technique is also practiced for commercial propagation. As in case of suckers, tissue-cultured plantlets also behave like that of the parents ensuring high productivity, if original tissue is selected from high-yielding lines. Seedlings are raised in nursery beds and they become ready for planting in the main field within 10 -18 months.

Ideal time for planting cardamom is at the onset of South-West monsoons (June-July). Cloudy days with light drizzles are ideal for planting. While planting suckers, one mature sucker along with a young growing shoot is planted in a pit. After planting, pits are filled and base is covered with mulch. While planting seedlings, care is taken to avoid deep planting. Seedlings are planted up to collar region in the pit. The seedlings should be supported by stakes and mulched. In case of tissue culture seedlings, hardened plants are planted in the main field.

I. PESTS

A. Pests of National Significance

1. Insect pests

1.1 Cardamom thrips: *Sciothrips cardamomi* Ramakrishna (Thysanoptera: Thripidae)
1.2 Shoot/panicle/capsule borer: *Conogethes punctiferalis* Guenée (Lepidoptera: Pyralidae)
1.3 Early capsule borer: *Jamides alecto* felder (Lepidoptera: Lycaenidae)
1.4 Rootgrub: *Basilepta fulvicornis* Jacoby (Coleoptera: Chrysomelidae)

2. Diseases

2.1 'Katte' or mosaic or marble disease: *Cardamom mosaic virus*
2.2 Primary nursery leaf spot: *Phyllosticta elettariae* Chowdhury
2.3 Capsule rot/azhukal disease: *Phytophthora nicotianae* var. *nicotianae* Breda de Haan, *P. meadii* McRae
2.4 Nursery leaf rot: *Fusarium* spp., *Alternaria* spp.
2.5 Damping off or seedling rot: *Pythium vexans* de Bary and *Rhizoctonia solani* J.G. Kühn, *Fusarium oxysporum* Schlecht
2.6 Clump rot or rhizome rot: *Pythium vexans* de Bary, *Rhizoctonia solani* Kühn and *Fusarium* sp.

3. Nematode

3.1 Root-knot nematode: *Meloidogyne* spp.

4. Weeds

Broadleaf

4.1 Goat weed: *Ageratum conyzoides* L. (Asteraceae)
4.2 Spanish needles: *Bidens pilosa* L. (Asteraceae)
4.3 Creeping wood sorrel: *Oxalis corniculata* L. (Oxalidaceae)
4.4 *Neanotis wightiana* Wallich ex Wight & Arnott) *N. indica* (Rubiaceae)
4.5 Soft blumea: *Blumea wightiana* D. (Asteraceae)
4.6 Little ironweed: *Vernonia cineria* (L.) Less. (Asteraceae)
4.7 Asiatic pennywort: *Centella asiatica* L. (Apiaceae)

Grasses

4.8 Bermuda grass: *Cynodon dactylon* (L) (Poaceae)
4.9 Crowfoot grass: *Dactyloctenium aegyptium* (L.) Willd. (Poaceae)
4.10 Wrinkled duck-beak: *Ischaemum rugosum* Salisb. (Poaceae)
4.11 Buffalo grass: *Paspalum conjugatum* Bergius (Poaceae)
4.12 Bunch grass: *Eragrostis tanella* (L.) Roem.& Schult. (Poaceae)
4.13 Wavy leaf basket grass: *Oplimenus undulatifolius* (Ard.) (Poaceae)

Sedges

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

5. Rodents

5.1 Three stripped squirrel: *Funambulus palmarum* (Linnaeus)
5.2 Lesser bandicoot: *Bandicota bengalensis* (Gray)

B. Pests of Regional Significance

1. Insect and mite pests

1.1 Cardamom whitefly: *Kanakarajiella cardamomi* David and Subramaniam (Hemiptera: Aleyrodidae)
1.2 Hairy caterpillars: *Eupterote undata*, *E. fabia*, *E. cardamomi*, *E. canaraica*, *E. mollis* and *E. blanda* (Lepidoptera: Eupterotidae)
1.3 Shoot fly: *Formosina flavipes,* Malloch (Diptera: Chlopidae)
1.4 Lacewing bug: *Stephanitis typicus* Distant (Hemiptera: Tingidae)

1.5 Cardamom aphid: *Pentalonia caladii* van der Goot (Hemiptera: Aphididae)
1.6 Cutworm: *Acrilasisa plagiata* M (Lepidoptera: Noctuidae)
1.7 Mid rib caterpillar: *Metapodistis polychrysa* Meyrick (Lepidoptera: Glyphipterigidae)
1.8 Rhizome weevil: *Prodioctes haematicus* Chevrolat L.A.A. (Coleoptera: Curculionidae))
1.9 Red spider mite: *Tetranychus* spp. (Acarina: Tetranychidae)

2. Diseases

2.1 Secondary nursery leaf spot/*Cercospora* leaf spot: *Cercospora zingiberi*
2.2 Chenthal disease/ capsule brown spots: *Colletotrichum gloeosporioides* (Penz.) Penz.and Sacc
2.3 Leaf blotch disease: *Phaeodactylium alpiniae* (Sawada) M. B. Ellis
2.4 Leaf spot: *Sphaceloma cardamomi*
2.5 Leaf rust: *Phakospora elettariae* (Racib.) comb. nov.
2.6 Leaf blight: *Phytophthora meadii* McRae
2.7 Root tip rot/leaf yellowing/pseudostem rot/stem lodging: *Fusarium oxysporum* Schlech
2.8 Panicle wilt: *Fusarium* spp.
2.9 Chlorotic streak disease: *Banana bract mosaic virus*
2.10 Cardamom necrosis/Nilgiri necrosis; *Cardamom necrosis virus*
2.11 Cardamom vein clearing or Kokke kandu: *Cardamom vein clearing virus*

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

A. AESA:

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

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

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

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

Principles of AESA based IPM:

Grow a healthy crop:

- Select a variety resistant/tolerant to major pests
- Select healthy seeds/seedlings/planting material
- Treat the seed/seedlings/planting material with recommended pesticides especially biopesticides

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

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

Farmers should:

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

Plant compensation ability:

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

Understand and conserve defenders:

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

Insect zoo:

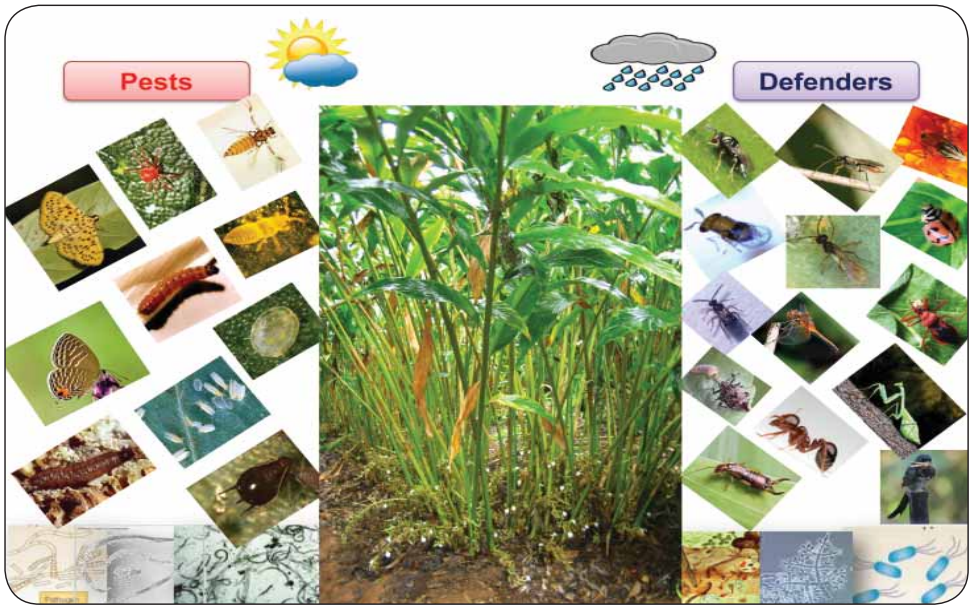
In field various types of insects are present. Some are beneficial and some may be harmful. Generally farmers are not aware about it. Predators (friends of the farmers) which feed on pests are not easy to observe in crop field. Insect zoo concept can be helpful to enhance farmers' skill to identify beneficial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

Pest: Defender ratio (P: D ratio):

Identifying the number of pests and beneficial insects helps the farmers to make appropriate pest management decisions. Sweep net, visual counts etc. can be adopted to arrive at the numbers of pests and defenders. The P: D ratio can vary depending on the feeding potential of natural enemy as well as the type of pest. The natural enemies of small 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 leaves, crop stage, deficiency symptoms etc.
    - Insect pests: Observe and count insect pests at different places on the plant.
    - Defenders (natural enemies): Observe and count parasitoids and predators.
    - Diseases: Observe leaves and stems and identify any visible disease symptoms and severity.
    - 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. Collect plant parts with disease symptoms.
- Find a shady place to sit as a group in a small circle for drawing and discussion.
- If needed, kill the insects with some chloroform (if available) on a piece of cotton.
- Each group will first identify the pests, defenders and diseases collected.
- Each group will then analyze the field situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on another side. Write the number next to each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a crop management recommendation.
- The small groups then join each other and a member of each group will now present their analysis in front of all participants.
- The facilitator will facilitate the discussion by asking guiding questions and makes sure that all participants (also shy or illiterate persons) are actively involved in this process.
- Formulate a common conclusion. The whole group should support the decision on what field management is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purpose in the following weeks.

Data recording:

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

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

Data to be recorded:

- **Plant growth (weekly):** Length 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.

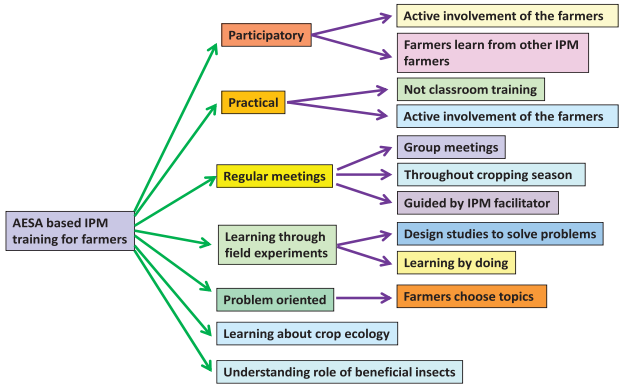
AESA and farmer field school (FFS):

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 in the field should commence soon after crop establishment at weekly intervals thereafter. In each field, select five spots randomly. Select five random clumps at each spot for recording counts of insects as per procedure finalized for individual insects.

For insect pests:

Aphid, whitefly and mite: Count and record the number of both nymphs and adults on five randomly selected tillers per clump.

Thrips: Count and record the number of nymphs and adults of thrips present on five tillers/panicles per clump (tapping method also can be used to count thrips).

Conogethes, Jamides: Total number of plant capsules, damaged parts and capsules due to *Conogethes* and *Jamides* and number of larvae on individual plants should be counted and recorded.

For diseases:

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

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

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

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

C. Yellow/blue pan water/sticky traps:

Set up yellow pan water/sticky traps 15 cm above the canopy for monitoring whitefly and 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.

D. 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).

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

III. ECOLOGICAL ENGINEERING FOR PEST MANAGEMENT

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

Natural enemies may require:

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

Ecological engineering for pest management – Above ground:

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

Ecological engineering for pest management – Below ground:

- Crop rotations with leguminous plants which enhance nitrogen content.
- Keep soils covered year-round with living vegetation and/or crop residue.
- Add organic matter in the form of farm yard manure (FYM), vermicompost, crop residue which enhance below ground biodiversity.
- Reduce tillage intensity so that hibernating natural enemies can be saved.
- Apply balanced dose of nutrients using biofertilizers.
- Apply mycorrhiza and plant growth promoting rhizobacteria (PGPR)
- Apply *Trichoderma* spp. and *Pseudomonas fluorescens* as seed/seedling/planting material, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).

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

Ecological Engineering Plants

Attractant plants


Cluster bean


Cowpea


Carrot


Sunflower


Buckwheat


French bean


Alfalfa


Maize


Mustard


***Coreopsis* spp.**


Cosmos


Dandelion


Anise


Caraway


Dill


Parsely

Repellent plant


Peppermint


***Ocimum* spp.**

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

A. Resistant/tolerant varieties:

Pest/disease	Tolerant/resistant variety*
Rhizome rot	IISR Avinash, ICRI 3
Katte disease	IISR Vijetha
Azhukal disease	ICRI 2
Rot, thrips, borer and drought	ICRI 6
Shoot borer and thrips	Mudigere 1
Thrips and borer	Mudigere 3

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

IV. CROP STAGE-WISE IPM

Management	Activity
Pre-sowing*	
	Common cultural practices: • Deep summer ploughing of fields to control resting stages of insect pests. • Follow crop rotation with non-host crops • Field sanitation, rogueing • Destroy the alternate host plants • Sow the ecological engineering plants • Sow/plant sorghum/maize/bajra in 4 rows all around cumin crop as a guard/barrier crop • Removal and destruction of alternate host weeds
Soil borne pathogens nematodes and resting stages of insects	**Cultural control:** • Practice green manuring and intercropping with redgram for the control of root rot. **Biological control:** • Apply neem cake @ 100 Kg/acre at the time of transplanting for reducing capsule borer damage
Seedling/nursery*	
	Common cultural practices: • Grow resistant/tolerant varieties • Use healthy, certified and weed seed free seeds/suckers/planting material. • Destruction of infested plants • Do not use the same site repeatedly for raising the seedlings • Raise nurseries away from main plantations to reduce possibilities of infestation and re infestation from the nearby infested plantations. • Provide adequate drainage facilities.
I. Primary nursery	• Seed treatment with acid or similar chemicals improves germination. Acid scarification with 25 per cent nitric acid for 10 minutes to break the seed coat will enhance germination. • Fumigate the beds with 2% formalin (10 liters per bed) 10 days before sowing • After extraction of seeds wash through water to avoiding mucilage and mix with wood ash for shade drying. • Bed size should be 6 m in length, 1 m width and 20 cm height after timely sowing and planting. • 30-50 g seeds should be recommended per bed. • Select the suckers of high yielding varieties suiting to the location. • Select the virus free planting material, vegetative propagation through suckers is the best method.
Weeds	• Use vegetative mulches to avoid weed growth in nursery. • Weeds should be removed manually as and when required

II. Secondary nursery	• Prepare beds as in primary nursery • Fumigate the beds with 2% formalin (10 l per bed) 10 days before sowing • Mixing of well decomposed cattle manure and wood ash with the top layer of the soil will help the seedlings to establish well and to grow vigorously • Shade pandals should be provided before transplanting. • Mulching the bed with dry leaves will help to conserve soil moisture. • Regular watering during dry months, weeding, application of fertilizers, control of pests and diseases.
Weeds	• Mulching should be done to check the growth of weeds. • Weeds should be removed by using hand tools/hoeing during May, September and December months.
Rhizome weevil**	**Cultural control:** • Provide sufficient organic manures to encourage better vegetative growth.
Shoot fly**	**Cultural control:** • Provide sufficient shade to the plants.
Shoot borer	**Cultural control:** • Rogueing and destruction of infested tillers during September-October.
Root-knot nematode	**Cultural control:** • Nursery should be raised in nematode free sites or fumigated or solarized beds. • The roots should be pruned prior to distribution or transplanting. • Avoiding planting of alternate hosts such as banana, colocasia and jackfruit **Biological control:** • Soil application of neem cake @ 500 g/plant.
Damping off or seedling rot	**Cultural control:** • In the primary nursery, practice thin sowing for avoiding overcrowding of seedlings. **Chemical control**: • Spray/drench the soil with fosetyl-AL 80% WP @ 900-1200 g in 300-400 l of water/acre
Primary nursery leaf spot	**Cultural control:** • Raise nursery in fertile soil. • Avoid direct sunlight on nursery beds. Use agro shade net. • Early sowing of seeds in August-September will ensure mature seedlings which are less prone to diseases during south west monsoon. **Chemical control:** • Spray/drench the soil after germination of seedlings with copper oxy-chloride @ 1 g in 300-400 l of water/acre
Secondary nursery leaf spot/ ***Cercospora* leaf spot**	**Cultural control:** • Cardamom seeds should be sown in the month of August – September, to ensure sufficient growth of seedlings, so that seedlings develop sufficient tolerance to the disease. **Chemical control:** • Spray/drench the soil with copper oxy-chloride 50% WP @ 1 Kg in 300-400 l of water/acre
'Katte' or mosaic or marble disease	**Cultural control:** • Fill the gaps with healthy disease free materials.
* Apply *Trichoderma viride/harzianum* and *Pseudomonas fluorescens* as seed/seedling/planting material, nursery treatment and soil application (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own consumption in their fields, registration is not required).	
Plantation stage	
	Common cultural practices: • Collect and destroy crop debris.

	• Provide irrigation at critical stages of the crop. • Avoid water logging. • Regulate shade in thickly shaded areas. • Avoid water stress during flowering stage. • Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed. • Remove and destroy collateral/alternate hosts such as castor, ginger, turmeric in the immediate vicinity. • Maintain optimum plant density. • Ensure adequate shade of 65-70% in endemic areas and irrigate the crop before attaining critical period. • Fill gaps with healthy disease free materials. • Mulching the plant basins with green leaves and other organic materials during summer months conserves and maintains the population of native beneficial microflora. **Common mechanical practices:** • Collect and destroy disease infected and insect infested plant parts. • Collection and destruction of eggs and early stage larvae. • Handpick the older larvae during early stages of crop. • The infested shoots may be collected and destroyed. • Handpick the gregarious caterpillars and the cocoons which are found on stem and destroy them in kerosene mixed water. • Use yellow sticky traps @ 4-5 trap/acre. • Use light trap @ 1/acre and operate between 6 pm and 10 pm. • Install pheromone traps @ 4-5/acre for monitoring adult moths activity (replace the lures with fresh lures after every 2-3 weeks). • Encouragement of golden backed woodpecker and crow-pheasant in the plantation and erect of bird perches @ 20/acre to attract birds of economic importance in biological control. **Common biological practices:** • Conserve natural enemies through ecological engineering. • Augmentative release of natural enemies.
Nutrients	• Application of organic manures such as FYM, cow dung or compost @ 5 Kg/plant or neem cake @ 1-2 Kg / plant may be done during June-July. • The present recommendation of nutrients for cardamom is N:P_2O_5:K_2O @ 30:30:60 Kg/ acre. • The fertilizers may be applied in two split doses, before and after the southwest monsoon, in a circular band of 20 cm wide and 30-40 cm away from the base of the clumps, and mixed with soil.
Weeds	• Three rounds of hand tool weeding during May, September and December/January • Slash weeding by use of power mower in the inter row space. • Use of spade for weeding is to be avoided as it will loosen the soil and cause soil erosion. • The weeded materials may be used for mulching.
Cardamom thrips	• Follow the common cultural, mechanical and biological practices **Cultural control:** • Removal of dry drooping leaves as well as dry leaf sheath (trashing) during January-February. • Destruction of collateral host plants. • Detrashing and weeding reduce thrips infestation. **Biological control:** • Release *Chrysoperla zastrowi sillemi* @ 2 larvae/plant in early stage of the plant and 4 larvae/plant in later stage.

	Chemical control: • Spray quinalphos 25% EC @ 240-480 ml in 200-400 l of water/acre or phenthoate 50% EC @ 200 ml in 200-400 l of water/acre or diafenthiuron 50% WP @ 320 g in 400 l of water/acre or monocrotophos 36% SL @ 374.8 ml in 200-400 l of water/acre
Shoot borer	• Follow the common cultural, mechanical and biological practices **Cultural control:** • Castor seeds 0.4-0.8 Kg/acre may be sown as trap crop in open areas/ boundary. • Rogueing and destruction of infested tillers during September-October. **Mechanical control:** • Castor inflorescence with capsules infested by shoots and capsule may be collected and destroyed. • Use of pheromones in the monitoring of the pest and therefore correct timing of application of biorationals shall be recommended. **Biological control:** • Application of *Bacillus thuringiensis* when early-instar larvae are found in capsule or panicle or unopened lead buds i.e., within 20 days of adult moth emergence.
Early capsule borer	• Follow the common cultural, mechanical and biological practices **Mechanical control:** • Clipping the inflorescence/flower parts of alternate hosts viz., *Alpinia speciosa, A.mutica, Amomum ghaticum, A. pterocarpum, Curcuma heilyherrensis, Hedydium ceranarium* during off season (December to May). **Chemical control:** • Diafenthiuron 50% WP @ 320 g in 400 l of water/acre
White grub/root grub	• Follow the common cultural, mechanical and biological practices **Cultural control:** • Avoid planting of jack, mango, fig etc. as shade trees as these trees are alternate hosts of the pest. • Mulching of plant base with leaves of wild *Helianthus* sp. to prevent egg laying of adult beetles. • Earthing up and detrashing. • Irrigation @15–20 l per plant reduces root grub population. **Mechanical control:** • Set up light trap @ 1/acre. **Biological control:** • Local strain of EPN (*Heterorhabditis indica*) application @ 1,00,000 nematodes (IJS) / plant
Whitefly**	• Follow the common cultural, mechanical and biological practices **Biological control:** • Release *Chrysoperla zastrowi sillemi* @ 2 larvae/plant in early stage of the plant and 4 larvae/plant in later stage. • Spraying of neem oil @ 50 ml with soap solution in 500 ml in 100 l of water (lower surface of leaf)
Hairy caterpillars**	• Follow the common cultural, mechanical and biological practices
Shoot fly**	• Follow the common cultural, mechanical and biological practices
Lacewing bug**	• Follow the common cultural, mechanical and biological practices
Midrib caterpillar**	• Follow the common cultural, mechanical and biological practices **Cultural control** • Prune dried leaves in January end (before first spray), and also in September.
Cardamom aphid**	• Follow the common cultural, mechanical and biological practices

	Cultural control: • Remove partly dried and decayed pseudostems which harbour the colonies of aphids to reduce aphid population.
Red spider mite**	• Follow the common cultural, mechanical and biological practices
'Katte' or mosaic or marble disease	• Follow the common cultural, mechanical and biological practices
Capsule rot/ Azhukal disease	• Follow the common cultural, mechanical and biological practices **Biological control:** • *Trichoderma harzianum* 0.50% WS @ 100 g/plant (soil treatment): Apply 100 g product/ plant along with neem cake (0.5 Kg/plant) and 5 Kg FYM/plant **Chemical control:** • Spray/drench the soil with fosetyl-AL 80% WP @ 900-1200 g in 300-400 l of water/acre
Clump rot or rhizome rot	• Follow the common cultural, mechanical and biological practices **Chemical control:** • Spray/drench the soil with copper oxy-chloride 50% WP @ 1 Kg in 300-400 l of water/acre
Leaf spot and leaf rust****	• Follow the common cultural, mechanical and biological practices **Chemical control:** • Spray/drench the soil after germination of seedlings with copper oxy chloride 50% WP @ 1 Kg in 300-400 l of water/acre
Root tip rot/ pseudostem rot/ stem lodging	• Follow the common cultural, mechanical and biological practices
Chlorotic streak disease, *Banana bract mosaic virus* **	• Follow the common cultural, mechanical and biological practices

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

** Pests of regional significance

Method of spraying (proper foliar application of insecticides)

1) For effective management of thrips and shoot borer, panicles and 1/3 portion of the plants from base of the clumps, covering panicles and young tillers may be sprayed with spray fluid.
2) Total quantity of 800-1200 ml spray fluid is sufficient per clump (depending on the size of the clump).
3) The first application of insecticide coincides with the panicle initiation, and it may be either in February or March. The insecticide imposition has to be done only with high volume sprayer (manual or mechanized) and care should be taken to avoid spray run off.
4) Insecticide spray can be avoided during heavy rain (Monsoon season-June to Sept.).

Excess use of insecticides kills not only pests but also the natural enemies of cardamom, which leads to out-break of minor pests like whiteflies, red-spider mite, etc. Certain stages of pest's *viz*., late stages of shoot borer/hairy caterpillars cannot be controlled by application of insecticides which are controlled only by their natural enemies. Under such condition, the natural enemies should be conserved and augmented to have the natural regulation of pests of cardamom by their natural enemies.

V. RODENT PEST MANAGEMENT

Three striped squirrel and lesser bandicoot:

The rodent problem exist in southern states of India especially Karnakata, Tamil Nadu, Kerala. The yield losses in cardamom due to rodents estimated around 10-12% in Karnataka. The rodent damage is occurring at mature stage particularly squirrels cause severe damage at the fruiting stage. The mature capsule (seed) emits odour containing mucilaginous matter that's attract the rodents.

Management practices :

Cultural control:

- Disturb and destroy the habitat (burrows) of the rodents by practicing clean cultivation
- Minimize the alternate food sources and secured habitation by removing the weeds and crop residues in/ around the fields and timely harvest of seeds will reduce the rodent damage.

Mechanical control:

- Practice burrow smoking using paddy straw or other natural smoking materials in 'ANGRAU/NIPHM burrow fumigator' for 2-3 minutes for each Bandicoot burrow.

Biological control:

- Encourage the establishment of natural predator like barn owls by establishing barn owl perches/ wooden boxes in and around the crop fields.

Chemical control:

- Application of 0.005% bromadiolone in ready to use form (wax blocks) or loose bait in packets near rodent burrows.
- In cases of high level of infestation (>50 live burrows/ac) practice poison baiting with zinc phosphide @ 2.0% on community approach. PRACTICE PRE-BAITING TO AVOID BAIT SHYNESS

VI. INSECTICIDE RESISTANCE AND ITS MANAGEMENT

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

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

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

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

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

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

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

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

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

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

VII. COMMON WEEDS

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

2) Crowfoot grass: *Dactyloctenium aegyptium*(L.) Wild (Poaceae)

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

4) Buffalo grass: *Paspalum conjugatum* Bergius (Poaceae)

5) Wavy leaf basket grass: *Oplimenus undulatifolius* (Ard.) (Poaceae)

6) Bunch grass: *Eragrostis tanella* (L.) Roem. & Schult. (Poaceae)

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

8) Spanish needles: *Bidens pilosa* L . (Asteraceae)

9) Creeping wood sorrel: *Oxalis corniculata* L. (Oxalidaceae)

10) *Neanotis wightiana*, Wallich ex Wight & Arnott) *N. indica* (Rubiaceae)

11) Soft blumea: *Blumea wightiana*. D. (Asteraceae)

12) Little ironweed: *Vernonia cineria* . (L.) Less. (Asteraceae)

13) Asiatic pennywort: *Centella asiatica* .L. (Apiaceae)

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

VIII. DESCRIPTION OF INSECT, MITE AND NEMATODE PESTS

1) Cardamom thrips:

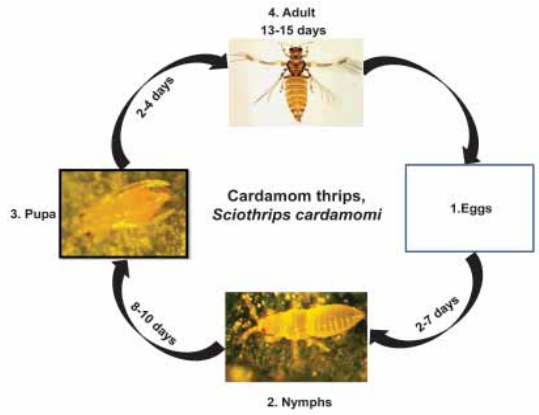
Biology:

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.

Life cycle:



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.

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

Thrips affected capsules

Thrips damage in cardamom capsules

Natural enemies of cardamom thrips:

Predators: Lacewing, big-eyed bug, *Orius laevigatus, Thripoctenus americensi* etc.

*For management refer to page number 14

2) Shoot, panicle and capsule borer:

Biology:

Egg: Eggs are pink, oval, flat and laid singly or in groups on the tender part of the plant

Larva: Long, pale greenish with a pinkish colour dorsally, head and pro-thoracic shield brown in colour and body covered with minute hairs.

Pupa: Pupation takes place in lose silken cocoon in larval tunnel.

Adult: Medium sized moth (22-24mm); the wings are pale yellowish with black spots on the wings.

Damage symptoms:

- Early stage of the larva bores the unopened leaf buds and feeds on the leaf tissue.
- They also bore the panicles leading to drying up of the portion from the affected spot
- Feed on immature capsules and the young seeds inside rendering the capsules empty.
- Late stage larvae bore the pseudostem and feed on the central core of the stem resulting in drying of the terminal leaf and thus produce characteristic 'dead heart' symptom.
- Oozing out of frass material at the point of tunnelling is the indication for the presence of larva inside the plant parts.
- The incidence of this pest is noticed throughout the year but they occur in enormous number in four periods, December-January, March-April, May-June and September-October and their abundance synchronizes with the panicle production, fruit formation and new tiller production.

Shoot borer damage

Early stage borer larvae

Shoot borer larvae in cardamom

http://agritech.tnau.ac.in/crop_protection/crop_prot_crop_insect_spi_card_pest&disease.html#2

Natural enemies of shoot, panicle and capsule borer:

Parasitoids: *Trichogramma chiloni, Tetrastichus* spp., *Apanteles* sp, *Eriborus* sp, *Friona* sp, braconid wasp, *Telenomus* spp., *Xanthopimpla australicus, Agrypon* sp etc.

Predators: Lacewing, ladybird beetle, King crow, dragonfly, spider, robber fly, reduviid bug, praying mantis, earwig, red ant etc.

*For management refer to page numbers 13, 15

3) Early capsule borer:

Biology:

Egg: Eggs are spherical, greenish white laid on the panicled flower.

Larva: Larvae are flat, trowel shaped covered with dense hairs covering all over the body.

Pupa: Small and brownish in colour and pupates in the debris near the panicle.

Adult: The wings of moth are bluish with metallic lustier on the upper surface and bordered with a white thin line and black shade

Damage symptoms:

- Caterpillars bore and feed on the inflorescence, flower buds, flowers and capsules.
- Affected capsules become empty with a big circular hole, turn yellowish – brown which decay and drop off in the rainy season.

Natural enemies of early capsule borer:

Parasitoids: *Trichogramma* spp., *Tetrastichus* spp., *Apanteles* spp., Braconid wasp etc.

Predators: Lacewing, ladybird beetle, King crow, dragonfly, spider, robber fly, reduviid bug, praying mantis, earwig, red ant etc.

*For management refer to page number 15

4) White grub/root grub:

Biology:

Among the three species *B. fulvicorne* is found to cause more damage in cardamom tracts.

Egg: Eggs are pale yellow in colour.

Grub: Grubs are short, stout, 'C' shaped, pale white in colour.

Adult: Beetles are shiny, metallic blue, bluish green, greenish brown or brown in colour.

Damage symptoms:

- The grubs feed on the roots in the form of irregular scraping.
- In advanced stages entire root system is found damaged resulting in drying and rotting depending on the season of attack.
- In the severely infested plants, leaves turn yellow and dry.

Cardamom plant infected by root grub

http://iisr.agropedia.in/content/root-grub-cardamom

Natural enemies of white grub/root grub:

Predators: Lacewing, ladybird beetle, King crow, dragonfly, spider, robber fly, reduviid bug, praying mantis, earwig, red ant etc.

*For management refer to page number 15

5) Cardamom whitefly:

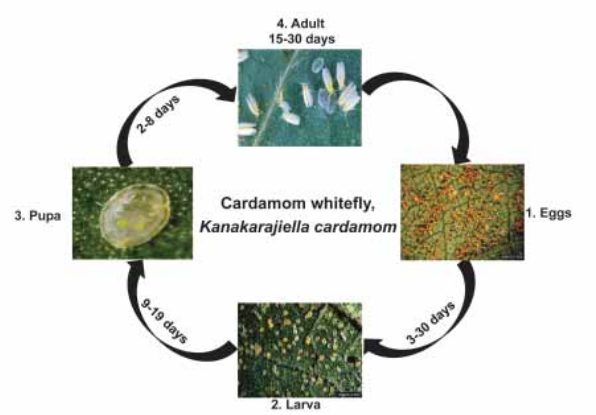
Biology:

Egg: Eggs are cylindrical, pale yellow in colour when freshly laid and gradually turn brown.

Nymph: Nymphs are elliptical and pale green in colour. There are four nymphal stages.

Adult: Adults are small soft bodied insect, about 2 mm long and having two pairs of white wings. The life cycle is completed within two-three week.

Life cycle:



Damage symptoms:

- Damage to the plant is caused by the depletion of sap from leaves.
- In severe infestation the leaves turn yellow and the vigour and growth of the plant get considerably reduced.
- The nymphs secrete sticky honeydew, which drops on to lower leaves. On these, black sooty mould develops, which interrupts photosynthesis of the leaves.

1. http://m.animal.memozee.com/m.view.php?q=%EB%8B%B4%EB%B0%B0%EA% B0%80%EB%A3%A8%EC%9D%B4&p=3
2. http://www.forestryimages.org/browse/detail.cfm?imgnum=2511050
3 http://www.fera.defra.gov.uk/plants/publications/documents/factsheets/bemisia.pdf
4. http://www.entomology.umn.edu/cues/inter/inmine/Whitefg.html

Favourable conditions:

Warm weather conditions are favourable for multiplication

Natural enemies of whitefly:

Parasitoids: *Encarsia* spp., *Eretmocerus* spp., *Chrysocharis* spp. etc.

Predators: Lacewing (*Mallada boninensis)*, big-eyed bug, ladybird beetle, dragonfly, spider, predatory mites etc.

*For management refer to page number 15

6) Hairy caterpillars:

Biology:

Egg: Eggs are dome shaped and laid on undersurface of the leaves of shade trees.

Larva: Larvae are robust, bluish black with pale brown head, white hairs and dorsal conical tuft of hairs.

Pupa: Pupation takes place in soil/plant debris.

Adult: Large moths, pale yellow with wavy lines and a series of spots near the outer margin of wings

Damage symptoms:

- Caterpillars are gregarious in habit and they congregate on the trunks of shaded trees during day time and drop down on the cardamom plants during night time.
- They fed voraciously on leaves and defoliate the whole cardamom plants.
- Usually the damage is observed during October-December.
- These appear sporadically in enormous populations at intervals of several years and cause heavy damage to the foliage.

Natural enemies of hairy caterpillars:

Predators: Lacewing, ladybird beetle, King crow, dragonfly, spider, robber fly, reduviid bug, praying mantis, earwig, red ant etc.

*For management refer to page number 15

7) Shoot fly:

Biology:

Egg: Eggs are cigar shaped and white colour and are laid in between leaf sheath and pseudostem on the whorl.

Damage symptoms:

- Larvae feed on the growing shoot of the young cardamom suckers.
- Emerging maggots (larvae) enter the pseudostem reach down the base by feeding the core tissue resulting in drying of the terminal leaf.
- Infestation is more on plants in open area; the pest activity starts during November and is at its peak in March-April.

Natural enemies of shoot fly:

Parasitoid: *Opius mudigerensis* (larval)

Predators: Lacewing, ladybird beetle, King crow, dragonfly, spider, robber fly, reduviid bug, praying mantis, earwig, red ant etc.

*For management refer to page number 15

8) Mid rib caterpillar:

Biology:

Egg: Eggs are spherical in shape.

Larva: Larvae are pale green in colour and 1 cm long when fully grown. Large black dots are present dorsally on head and the last abdominal segment.

Pupa: Pupae are silken cocoon

Adult: Adults are black brown in colour moths having two golden stripes on their wings.

Damage symptoms:

- Caterpillars of this insect feed on unopened leaves of cardamom.
- Larva make a hole almost at the middle of an unopened leaf, enter through the hole and feed on one half of the lamina as well as part of the mid rib from its point of entry.

Natural enemies of mid rib caterpillar:

Predators: Lacewing, ladybird beetle, King crow, dragonfly, spider, robber fly, reduviid bug, praying mantis, earwig, red ant etc.

*For management refer to page number 15

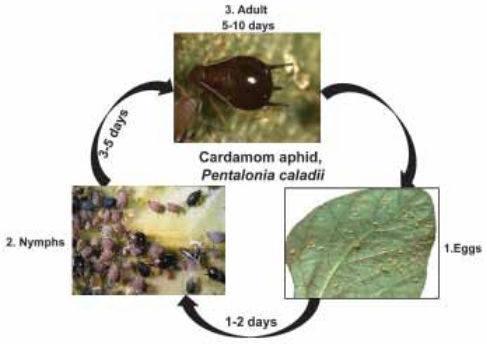
9) Cardamom aphid:

Biology:

Nymph: Nymphs are dark in colour.

Adult: Adults are brown in colour and has black veined wings. They reproduce by viviparous and partheno-genetically

Life cycle:



Damage symptoms:

- Both nymphs and adults suck up plant sap.
- Colonies of aphids are seen under concealed conditions inside leaf sheaths of the older pseudostems.

Natural enemies of aphid:

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

Predators: Ladybird beetle, lacewing, spiders, hover fly etc.

*For management refer to page number 15

10) Rhizome weevil:

Biology:

Egg: Adult weevil lays eggs in punctures made by it on the exposed portion of the rhizome.

Adult: Adults are brown in colour in 12 mm length with 3 black lines on the pronotum, one mid dorsally and other 2 on either sidel elytra 3 black dots, two anteriorly and one posteriorly. Adults emerge immediately after the summer rains in April. Adults live for 7-8months

Damage symptoms:

- The grubs feed on the rhizome and basal portion of the stem, which results in the drying of the leaves and breaking up of the stem at the base.
- The pest becomes a serious menace in secondary nursery during November-January.

Natural enemies of rhizome weevil:

Predators: Earwig, King crow, dragonfly, spider, reduviid bug, praying mantis, red ant etc.

*For management refer to page number 13

11) Red spider mites:

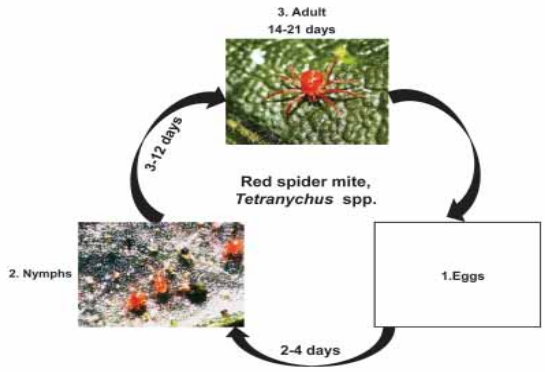
Biology:

Egg: Eggs are hyaline , globular laid in mass

Nymphs: Nymphs are yellowish in colour

Adult: Adults are red coloured small size

Life cycle:



Damage symptoms:

- Affected leaves become reddish brown and bronzy.
- Severe infestation, silken webbing on the leaves.
- Leaves wither and dry.
- Flower and fruit formation affected.

1. http://www.simplepestcontrol.com/spider-mite-control.htm
2. http://entomology.k-state.edu/extension/insect-photo-gallery/Corn-Insects.html
3. http://www.al.gov.bc.ca/cropprot/grapeipm/spidermites.htm.http://www.simplepestcontrol.com/spider-mite-control.htm

Favourable condition:

Warm weather conditions are favourable for multiplication.

Natural enemies of red spider mite:

Predators: Predatory mites (*Phytoseiulis persimilis*, *Neoseiulis cucumeris)*, predatory beetles such as small staphilinidae (*Oligota* spp.) and ladybird beetles, lacewings, predatory thrips, anthocorid bugs (*Orius* spp.), mirid bugs, predatory flies (hover flies) etc.

*For management refer to page number 16

12) Root-knot nematode:

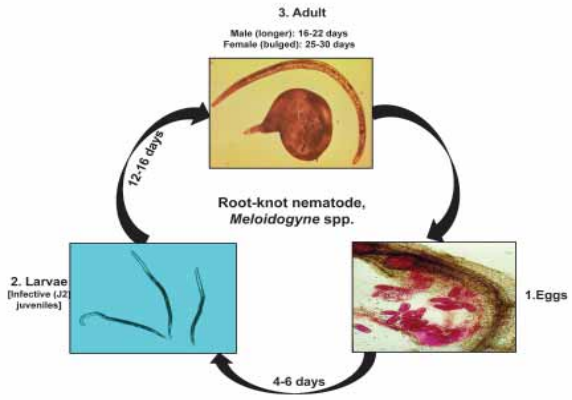
Biology:

- 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. Second stage larvae hatch from eggs to find and infect plant roots or in some cases foliar tissues.

- 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:

Life stages are microscopic in size



Damage symptoms:

- Root-knot nematode infests cardamom roots.
- Common symptoms of attack are narrowing of leaves, thickening of veins, reduction of internodes length and consequent appearance of rosette leaves.
- Roots branch heavily and galls appear on them.
- Plant growth becomes highly stunted

1. http://keys.lucidcentral.org/keys/sweetpotato/key/Sweetpotato%20Diagnotes/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

Survival and spread:

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

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

Favourable conditions:

- Loamy light soils

*For management refer to page number 12

Natural Enemies of Small cardamom Insect and Mite Pests

Parasitoids

Egg parasitoids

1. *Trichogramma* spp.

2. *Tetrastichus* spp.

3. *Telenomus* spp.

Larval parasitoids

4. *Agrypon* spp.

5. *Apanteles* spp.

6. *Eriborus* spp.

7. *Bracon* spp.

Nymphal, pupal and adult parasitoids

8. *Encarsia formosa*

9. *Eretmocerus* spp.

10. *Chrysocharis pentheus*

11. *Aphidius colemani*

12. *Aphelinus* spp.

1. http://www.nbaii.res.in/Featured_insects/Trichogrammatids.php; 2. http://www.pbase.com/image/135529248; 3. http://baba-insects.blogspot.in/2012/02/telenomus.html; 4. http://www.commanster.eu/commanster/Insects/Bees/SpBeesAgrypon.anxium.html; 5. http://www.waspweb.org/Ichneumonoidea/Braconidae/Microgastrinae/Apanteles/Apanteles_bordagei.htm; 6. http://www.commanster.eu/commanster/Insects/Bees/SpBees/Eriborus.braccatus.html; 8. http://www.buglogical.comwhitefly-control/encarsia-formosa/ 9. http://www.dongbufarmceres.com/main/mboard.asp?strBoardID=c_product01en; 10.http://baba-insects.blogspot.in/2012/05/blog-post_21.html;11.http://www.goodbugs.org.au/Good%20bugs%20available/Resources/aphidius254a.jpeg; 12.http://australianmuseum.net.au/Uploads/Images/23077/Pro%20019_big.jpg;

Preda tors


1. Lacewing


2. Ladybird beetle


3. Reduviid bug


4. Spider


5. Robber fly


6. Red ant


7. Black drongo


8. Common mynah


9. Big-eyed bug


10. Earwig


11. Ground beetle


12. Pentatomid bug


13. Preying mantis


14. *Dicyphus hesperus*


15. Predatory mite


16. Predatory thrips


17. *Oligota* spp.


18. *Orius* spp.


19. Hover fly


20. Mirid bug

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

IX. DESCRIPTION OF DISEASES

1) 'Katte disease' (mosaic or marble disease):

Disease symptoms:

- The first visible symptom appears on the youngest leaf of the affected tiller as spindle shaped slender chlorotic flecks measuring 2-5 mm in length.
- Later these flecks develop into pale green discontinuous stripes. The stripes run parallel to the vein from the midrib to leaf margin.
- All the subsequently emerging new leaves show characteristic mosaic symptoms with chlorotic and green stripes. As the leaf matures, the mosaic symptoms are more or less masked.
- Disease is systemic in nature and it gradually spreads to all the tillers in a clump.
- Younger plants express symptoms earlier than grown up clumps. Infected clumps are stunted and smaller in size with a few slender tillers and shorter panicles.
- Katte infected plants continue to survive for many years and serve as sources of inoculum.
- If the plants are infected in the seedling stage or the same year of planting the loss will be total. In bearing clumps, the loss will be upto 68% in three years after infection (the loss will be even more at later stages).

http://www.celkau.in/Crops/Spices/Cardamom/plant_protection_mainfield.aspx#d1

Survival and spread:

It spreads through aphid vector *Pentalonia caladii*.

*For management refer to page numbers 13, 16

2) Primary nursery leaf spot:

Disease symptoms:

- Disease appears as small round or oval spots, which are dull, white in colour.
- These spots later become necrotic and leave a hole (shot hole) in the center.
- The spots may be surrounded by water soaked area. High intensity of disease is noticed in open nurseries exposed to direct sunlight.

In such cases, numerous spots develop on the leaves. Appears mostly during February to April with receipt of summer rains.

http://spicespromo.blogspot.in/2012/12/strategies-to-curtail-fungal-diseases.html

Survival and spread:

- High intensity of disease is noticed in open nurseries exposed to direct sunlight.

Favorable conditions:

High humidity or persistent dew.

*For management refer to page number 13

3) Capsule rot/azhukal disease:

Disease symptoms:

- The disease appears during the rainy season.
- On the infected leaves, water soaked lesions appear first followed by rotting and shredding of leaves along the veins.

- The infected capsules become dull greenish brown and decay. This emits a foul smell and subsequently shed.
- Infection spreads to the panicles and tillers resulting in their decay.

http://spicespromo.blogspot.in/2012/12/strategies-to-curtail-fungal-diseases.html

Survival and spread:

- The disease spreads through soil, water and wind.

Favourable conditions:

- Continuous rain fall and high relative humidity.

*For management refer to page number 16

4) Nursery leaf rot:

Disease symptoms:

- Development of water soaked lesions on the leaves, which later become necrotic patches leading to decay of affected areas. Usually the leaf tip and distal portions are damaged.
- In severe cases rotting extends to petiole and leaf sheaths also

Survival and spread:

- This disease is seen in young seedlings of three to four months old. It is not wide spread in occurrence; but seen only in a few nurseries.

Favourable conditions:

- Excessive soil moisture, high humidity or overcrowding of seedlings.

5) Damping off/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 management refer to page number 13

6) Clump rot or rhizome rot:

Disease symptoms:

- Decay of the tillers starting from the collar region and toppling of tillers.
- Affected tillers can be pulled out with little force and the discoloration of the basal portion of clump can be seen.

- Early symptoms on leaves appear as pale yellow colour, partial of leaf margins and withering. Rotting or decay starts at the collar region and it spreads to rhizomes and roots.
- In severe cases, the collar region breaks off and the seedling collapse.

Survival and spread:

- Below 24° C for few days are ideal for infection and development of disease.

Favourable conditions:

- High humidity, high soil moisture, cloudiness and low tempera-tures.

*For management refer to page number 16

1. http://spicespromo.blogspot.in/2012/12/strategies-to-curtail-fungal-diseases.html
2. http://agritech.tnau.ac.in/crop_protection/crop_prot_crop%20diseases_spices_cardamom.html

7) Cardamom necrosis/nilgiri necrosis:

Disease symptoms:

- Young leaves exhibit whitish to yellowish continuous or broken streaks proceeding from the midrib to the leaf margins and later turn reddish brown. Often leaf shredding is noticed.
- The affected plants are stunted and fail to bear the panicles and capsules.

1. 2. 3.

1.Irregular yellowish patches on younger leaves;

2. Necrotic patches on the leaves;

3. Stunted appearance of Nilgiri necrosis affected plant

1,2,3 http://iisr.agropedia.in/content/cardamom-necrosis-disease-nilgiri-necrosis-diseasg

Survival and spread:

- The disease spreads mainly through infected planting material.

8) Cardamom vein clearing or Kokke kandu:

Disease symptoms:

Its characteristic symptom "hook- like tiller" it is locally called as "*Kokke Kandu*".

- The characteristic symptoms are continuous or discontinuous intraveinal clearing, stunting, rosetting, loosening of leaf sheath, shredding of leaves and clear mottling on stem.
- Clear light green patches with three shallow grooves are seen on the immature capsules.
- Cracking of fruits and partial sterility of seeds are other associated symptoms.

1. 2. 3.

1. Hook like tiller
2. Mottling symptoms on leaf sheath
3. Light green patches with shallow grooves on immature capsules

http://iisr.agropedia.in/content/cardamom-vein-clearing-disease-or-kokke-kandu

Survival and spread:

- Transmitted through cardamom aphid, *P. caladii* in a semi persistent manner.
- **Primary**: Alate viruliferous vectors and infected plant materials.

Secondary: Alate forms of aphid

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

9) Secondary nursery leaf spot/*Cercospora* leaf spot:

Disease symptoms:

- The *Cercospora* leaf spots are found in the nursery and plantations in the form of rectangular muddy red stripes running along the veins.
- The *Sphaceloma* leaf spot is seen in main plantation as scattered spherical blotches on the leaves. These start as small spots measuring a few mm and later several spots coalesce to from larger areas.
- Leaf rust is often seen on mature leaves as whitish powdery pustules on the under surface of the leaves with corresponding yellow necrotic patches
- On the upper surface. Diseased leaves show a rusty appearance.

Survival and spread:

Disease appears mostly during February- April months with the receipt of summer showers

*For management refer to page number 13

http://iisr.agropedia.in/content/nursery-leaf-spot-cardamom

10) Chenthal disease/capsule brown spot:

Disease symptoms:

- Initially the symptoms appear as small water soaked rectangular lesions on the leaves which, later elongate to form parallelly arranged streaks and turn to yellowish brown to orange red in colour.
- The central portions become necrotic.

Survival and spread:

- The disease intensity is found to be severe in open areas where shade is inadequate
- The disease which appears during mid- monsoon, becomes severe during late monsoon periods.

Favourable conditions:

Intermittent rains and prevalence of misty conditions

*For management refer to page number

11) Leaf blotch disease:

Disease symptoms:

- The disease is characterized by the appearance of large blotches of irregular lesions with alternating shades of light and dark brown necrotic leaves. This is mainly observed on mature leaves.
- Later, on the underside of these blotches, the fungal mycelium and spores develop as grey brown masses

Survival and spread:

- During monsoon season very active and during dry weather conditions infection is restricted

Favourable conditions:

- High rainfall and humidity

*For management refer to page number

12) Leaf blight:

Disease symptoms:

- The infection starts on the young middle aged leaves in the form of elongate or ovoid, large, brown coloured patches which soon become necrotic and dry.
- These necrotic dry patches are seen mostly on leaf margins and in severe cases the entire leaf area on one side of the midrib is found affected.
- Leaf blight or drying of leaves in patches is observed during October to February months

Survival and spread:

- The disease which appears during mid- monsoon, becomes severe during late monsoon periods.

Favourable conditions:

- Intermittent rains and prevalence of misty conditions.

http://iisr.agropedia.in

Cardamom plant affected by leaf blight

*For management refer to page number

13) Root tip rot:

Disease symptoms:

- The symptoms are development of rotting of the root tips followed by die back of roots.
- The lower leaves of affected tillers become yellowish and gradually dry off.
- The tiller is weakened at this portion and leads to partial breakage.
- The partially broken tillers bend downwards and hang from the point of infection.
- These diseases occur during post monsoon period

http://iisr.agropedia.in

Survival and spread:

- Soil and implements.

Favourable conditions:

- Relatively high soil moisture and soil temperature

*For management refer to page number 16

14) Chlorotic streak disease:

Disease symptoms:

- The formation of continuous or discontinuous spindle shaped yellow or light green intravenous streaks along the veins and midrib.
- These streaks later coalesced together and imparted yellow or light green colour to the veins.
- In the advanced stages of disease progression, size of the leaves gets reduced and production of new tillers is suppressed.

(1) Spindle shaped yellow or light green intravenous streaks along the midrib and veins; (2) Advanced stage showing light green or yellowveins; (3) Spindle-shaped mottling along the pseudostem; (4) Reduced tillering in an affected clump.

Survival and spread:

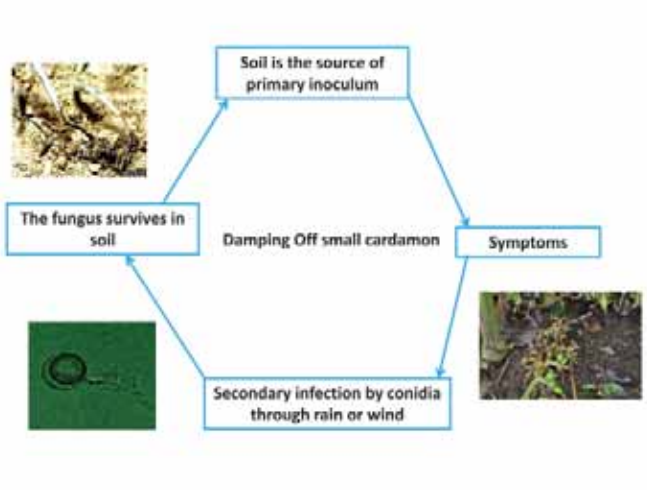
- The disease spreads mainly through infected planting material.

1,2,3 http://iisr.agropedia.in/content/chlorotic-streak-disease-cardamom

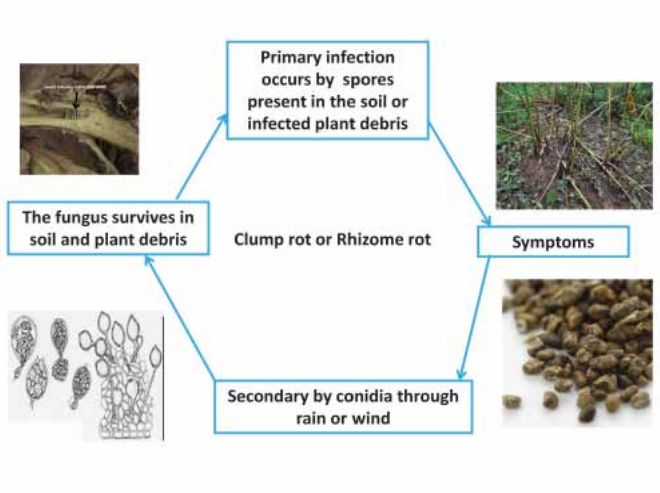
*For management refer to page number 16

Disease cycles:

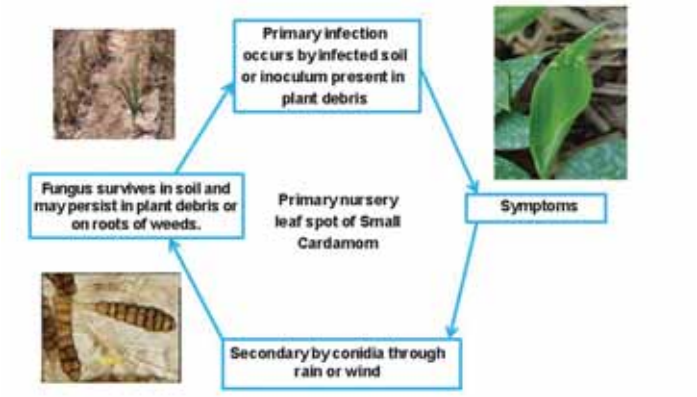
1. Damping off/seedling rot:



2. Clump rot or rhizome rot:



3. Primary nursery leaf spot:



X. DESCRIPTION OF RODENT PESTS

1) Lesser bandicoot:

- Distributed throughout India and infests almost all crops.
- It is a robust rodent (200 to 300 g body weight) with a rounded head and a broad muzzle. Dorsum covered with grey-brownish rough hairs. Tail is naked, shorter than head and body. Breeds throughout the season and litter size 6-8 in normal conditions.
- Nocturnal and fossorial
- Burrows are characterized by the presence of scooped soil at the entrance and mostly burrow openings are closed with soil.
- It is also a major pest in irrigated crops

Nature of damage: The rodent problem exist in southern states of India especially Karnakata, Tamil Nadu, Kerala. The yield losses in cardamom due to rodents estimated around 10-12% in Karnataka. The mature capsule (seed) emits odour contains mucilaginous matter attract the rodents.

2) Southern palm squirrel:

- It has bushy tail with dorsal surface having three distinct white stripes.
- It is a diurnal rodent and lives in the trunks of trees/rocks and orchards.
- It distributed southern parts of India.
- It breeds from March to September with a litter size ranging from 1-5.
- It is a serious pest in Horticultural crops.

Nature of damage: The rodent problem exist in southern states of India especially Karnakata, Tamil Nadu, Kerala. The yield losses in cardamom due to rodents estimated around 10-12% in Karnataka. The rodent damage is occurring at mature stage particularly squirrels cause severe damage at the fruiting stage. The mature capsule (seed) emit odour contain mucilaginous matter it attract the rodents.

XI. SAFETY MEASURES

A. At the time of harvesting:

Plants start bearing in the second or third year of planting. The fruits mature at 30–40 days intervals, necessitating 5–6 pickings. Harvesting season is October– November. In Kerala and Tamil Nadu, harvesting starts from August–September and continues till February–March, whereas in Karnataka, it starts in July–August and continues up to December–January. Capsules are harvested just short of full ripeness. Over mature fruits split on drying floor, whereas the unripe fruits shrivel on drying. An average yield of dry capsules from a well-maintained plantation comes to 400 - 500 Kg/ha.

B. During post-harvest storage:

Both sun drying and machine drying are practiced. After harvesting, capsules are dried either in fuel kiln or electrical drier or in the sun. Soaking freshly harvested green cardamom capsules in 2% washing soda solution for 10 minutes prior to drying help retain original green colour during drying. Under flue pipe drier, it should be dried at 45°–50° C for 14–18 hr, while overnight drying at 50°–60° C is required under an electric drier. The capsules are spread thinly and stirred frequently to ensure uniform drying. The dried capsules are rubbed with hands or agitated to ensure uniform drying.

Cleaning, sorting and grading:

Dried capsules are winnowed to remove any foreign matter. Sorting and grading is done based on the size and

colour of the dried capsules. Graded capsules are stored in black polythene lined gunny bags to retain the green colour during storage. These bags are kept in wooden chambers and sent to market as and when required.

http://agrihortico.com/tutorialsview.php?id=102

XII. DO'S AND DON'TS IN IPM

S. No.	Do's	Don'ts
1	Clean the area from all existing vegetation, stumps, roots and stones	Don't select plain area for nursery bed.
2	Prepare bed with 1 meter width, 20 cm height and of required length	Don't make too wide nursery bed
3	Fumigate the beds with 2% formalin (2 l/100 l of water) under polythene cover for 48 hrs (10 l/bed) or do solarization.	Don't sow seed within week of fumigation
4	Grow only recommended varieties.	Do not grow varieties not suitable for the season or the region.
5	Collect ripened bold capsules from disease free mother clumps from 2nd and 3rdharvests for seed extraction.	Don't collect unripened capsules for seed
6	Sow the seed in September preferably	Avoid sowing before September
7	Always treat the seeds with approved biopesticides/ chemicals for the control of seed borne diseases/ pests.	Do not use seeds without seed treatment with biopesticides/chemicals.
9	Cover the bed with mulch material either with pot grass or paddy straw	Don't throw away the topsoil
10	Once sprouting is observed, remove the mulch and cover the bed with thinly sliced mulch materials.	Avoid the contact of mulch materials with the soil by supporting twigs laid across the bed.
11	Keep plant base mulched (5-10 meter thick) except during June-Sept.	Don't use spade for weeding, as it will cause soil erosion
12	Apply proper manure, fertilizer and irrigation	Avoid imbalance fertilizer.
13	Do hand weeding during May, Sept. and Dec./Jan..	Avoid too much shade and too much openness.
14	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.
15	Use NPK fertilizers as per the soil test recommendation.	Avoid imbalanced use of fertilizers.
16	Use micronutrient mixture after sowing based on test recommendations.	Do not apply any micronutrient mixture after sowing without test recommendations.
17	Conduct weekly AESA in the morning preferably before 9 a.m. Take decision on management practice based on AESA and P: D ratio only.	Do not take any management decision without considering AESA and P: D ratio
18	Install pheromone traps at appropriate period.	Do not store the pheromone lures at normal room temperature (keep them in refrigerator).
19	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.

21	Apply pesticides on need basis	Avoid calendar based application of pesticides and avoid dust formulation
22	Spray pesticides in afternoon only.	Spray should not be done in morning hours especially between 7 to 11 am to protect bees.
23	Spray pesticides thoroughly to treat the undersurface of the leaves, particularly for sucking pests.	Do not spray pesticides only on the upper surface of leaves.
24	Apply short persistent pesticides to avoid pesticide residue in the soil and produce.	Do not apply pesticides during preceding 7 days before harvest.
25	Follow the recommended procedure of trap crop technology.	Do not apply long persistent pesticides on trap crop, otherwise it may not attract the pests and natural enemies.

XIII. SAFETY PARAMETERS IN PESTICIDE USAGE

S. No	Pesticide Classification as per insecticide rules 1971 Colour of toxicity triangle	WHO classification of hazard	Symptoms of poisoning	First aid measures and treatment of poisoning	Harvesting interval (days)
1.	Monocrotophos Extremely toxic 	Class I a-Extremely hazardous	Mild-anorexia, headache, dizziness, weakness, anxiety, tremors of tongue and eyelids, miosis, impairment of visual acuity	**First aid measures:** Remove the person from the contaminated environment. In case of (a) Skin contact - Remove all contaminated clothings and immediately wash with lot of water and soap (b) Eye contamination - Wash the eyes with plenty of cool and clean water; (c) Inhalation - Carry the person to the open fresh air, loosen the clothings around neck and chest, and (d) Ingestion - If the Victim is fully conscious, induce vomiting by tickling back of the throat. Do not administer milk, alcohol and fatty substances. In case the person is unconscious make sure the breathing passage is kept clear without any obstruction. Victim's head should be little lowered and face should be turned to one side in the lying down position. In case of breathing difficulty, give mouth to mouth or mouth to nose breathing. Medical aid: Take the patient to the doctor / Primary Health Centre immediately along with the original container, leaflet and label. **Treatment of poisoning:** For extreme symptoms of O.P poisoning, injection of atropine (2·4 mg., for adults, 0..5·1.0 mg for children) is recommended, repeated at 5·10 minute intervals until signs atropinization occur.	--

2.	Quinalphos Highly toxic 	Class II Slightly hazardous	Moderate - nausea, salivation, lacrimation, abdominal cramp, vomiting, sweating, slow pulse, muscular tremors, miosis.	**-do-**	3 days
3.	Diafenthiuron Highly toxic 	Class II Moderately hazardous	Severe- diarrhoea, pinpoint and nonreactive pupils, respiratory difficulty, pulmonary edema, cyanosis, loss of sphincter control, convulsions, coma and heart block.	**First aid measures:** Remove the person from the contaminated environment. In case of (a) Skin contact - Remove all contaminated clothings and immediately wash with lot of water and soap (b) Eye contamination - Wash the eyes with plenty of cool and clean water; (c) Inhalation - Carry the person to the open fresh air, loosen the clothings around neck and chest, and (d) Ingestion - If the Victim is fully conscious, induce vomiting by tickling back of the throat. Do not administer milk, alcohol and fatty substances. In case the person is unconscious make sure the breathing passage is kept clear without any obstruction. Victim's head should be little lowered and face should be turned to one side in the lying down position. In case of breathing difficulty, give mouth to mouth or mouth to nose breathing. Medical aid: Take the patient to the doctor / Primary Health Centre immediately along with the original container, leaflet and label. **Treatment of poisoning:** Speed is imperative -Atropine injection -1 to 4 mg. Repeat 2 mg. when toxic symptoms begin to recur (15-l6 minute interval), Excessive salivation- good sign. more atropine needed.	--

				-Keep airways open, Aspirate, use oxygen, insert endotracheal tube. Do tracheotomy and give artificial respiration as needed. -For ingestion lavage stomach with 5% sodium bicarbonate, if not vomiting. For skin contact, wash with soap and water (eyes- wash with isotonic saline). Wear rubber gloves while washing contact areas. In addition to atropine give 2-PAM (2-pyridine aldoxime methiodide). 1g and 0.25 g for infants intravenously at a slow rate over period of 5 minutes and administer again periodically as indicated. More than one injection may be required. Avoid morphine, theophyllin, aminophyllin, barbiturates or phenothiazines. Do not give atropine to a cyanotic patient. Give artificial respiration first then administer atropine.	
4.	Phenthoate Highly toxic 	Class II Moderately hazardous	Severe- diarrhoea, pinpoint and nonreactive pupils, respiratory difficulty, pulmooary edema, cyanosis, loss of sphincter control, convulsions, coma and heart block	-do-	--
FUNGICIDES					
1.	Fosetyl Moderately toxic 	Table 5 – Unlikely to present acute hazard in normal use	Headache, palpitation, nausea, vomiting, flushed face, irritation of nose, throat, eyes and skin etc.	**Treatment of poisoning:** No specific antidote, Treatment is essentially symptomatic.	
2.	Copper oxychloride	Class III - Slightly Hazardous			

XIV. BASIC PRECAUTIONS IN PESTICIDE USAGE

A. Purchase

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

B. Storage

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

C. Handling

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

D. Precautions for preparing spray solution

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

E. Equipments

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

F. Precautions for applying pesticides

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

G. Disposal

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

XV. PESTICIDE APPLICATION TECHNIQUES

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

XVI. OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

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

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Ecological Engineering Plants for Small cardamom

Cluster bean

Sunflower

***Ocimum* spp.**

***Coreopsis* spp.**

Spearmint

Mustard

Parsley

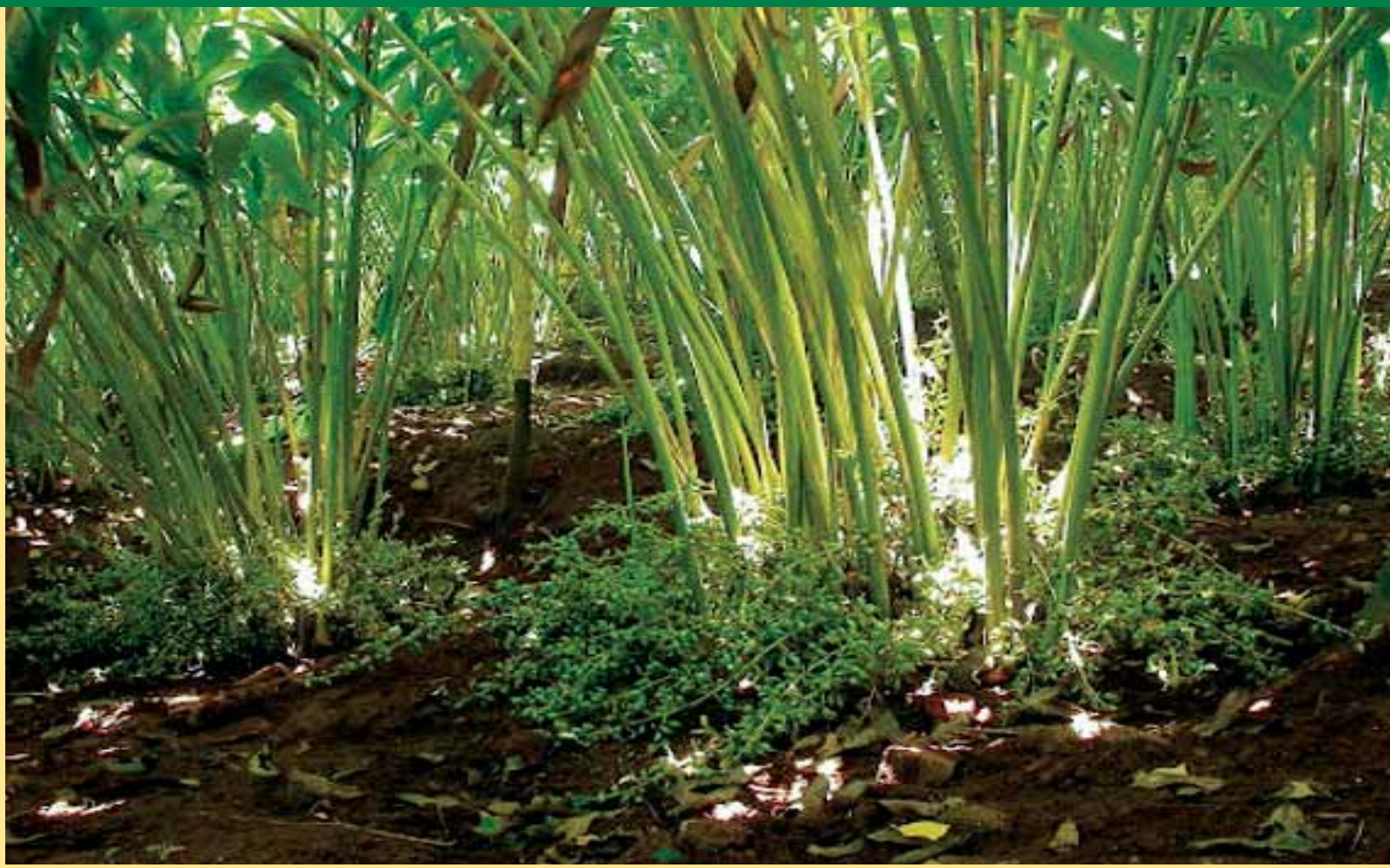
Dandelion

French bean

Cowpea

Buckwheat

Maize



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