# Plant Protection Code for Small Cardamom

***Policy on usage of Plant Protection Formulations in Small Cardamom Plantations in India***

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**Spices Board India**

**(Ministry of Commerce & Industry, Govt of India)**

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*Policy on usage of Plant Protection Formulations in Small Cardamom Plantations in India*

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## FOREWORD

Small Cardamom, the tiny, parrot green capsules that are grown under the thick ever green forest cover of the Western Ghats, has always been in much demand by the globe to flavor food and aid health. Though cardamom was one among the major spices that were traded from India, it remained a forest good for long and until the late 1800, there were no commercial cultivation. The warm flavour and its enticing aroma have made cardamom an inevitable ingredient in many of the sweet delicacies and now it enjoys patronage as a premium spice around the world, especially in the Middle East.

The estimated production of small cardamom in India during 2017-18 is 12,940 MT and the production is concentrated in the southern states of Kerala, Karnataka and Tamil Nadu. Cardamom requires unique climatic conditions and skilled care for better yield and this makes it the third most expensive spice in the world after Saffron and Vanilla. Since, cardamom cultivation is intrinsically entwined to the vibrant ecosystem of the Western Ghats, sustainable operations are essential for preserving the crop and biodiversity alike. Moreover, quality has become the chosen USP by the consumers, as the world is looking for more sustainable and healthy products.

The focus has been steadily shifting to ecofriendly production practices which are safe to the nature, laborers and consumers; at the same time, it has to support the productivity and profitability also. This calls for judicious cultural operations, integrated pest and disease management and post-harvest operations. There is a resolution that, the Spices Board shall recommend only such Plant Protection Formulations (PPFs) - that have been cleared and registered by the Central Insecticides Board and Registration Committee (CIB & RC), Government of India, with label claim on small cardamom, which comply with the standards and norms stipulated by both the Indian and International regulators such as Food Safety and Standards Authority of India (FSSAI), FAO/WHO, Codex etc.

Plant Protection Code on Small Cardamom is a complete guide on the judicious management of small cardamom plantations which addresses all concerns in the production process. I believe, this would help the Cardamom farmers to augment their good agricultural practices to strive further adhering to good agricultural practices and sustainable operations at the farm level leading to availability of quality and safe cardamom for domestic as well as external markets.

**(D. Sathiyan IFS)**
**Secretary, Spices Board**

## List of abbreviations and acronyms used in the text and their full forms

AESA: Agro Ecosystem Analysis

CIBRC: Central Insecticides Board and Registration Committee

EC: Emulsifiable Concentrate

ELISA: Enzyme-Linked Immunosorbent Assay

EPN: Entomopathogenic Nematode

FAO: Food and Agriculture Organization

FYM: Farm Yard Manure

GIFAP: Groupment International des Associations Nationales des Fabricants de Produits agrochimiques

Ha: Hectare

HCN: Hand Compression Nozzle

ICRI: Indian Cardamom Research Institute

IISR: Indian Institute of Spices Research

INM: Integrated Nutrition Management

IPM: Integrated Pest Management

MSDS: Material Safety Data Sheet

NMD: Number Median Diameter

NPK: Nitrogen, Phosphorus and Potash

P: D ratio: Pest Defender ratio

PCR: Polymerase Chain Reaction

PGPR: Plant Growth Promoting Rhizobacteria

PPC: Plant Protection Code

PPFS: Plant Protection Formulations

PPM: Parts Per Million

SL: Suspension Liquid

TREMCARD: Transport Emergency Card

ULV: Ultra Low Volume

WP: Wettable Powder

# PREAMBLE

**Following are the guiding principles for Plant Protection Code (PPC):**

- Plant Protection Formulations (PPFs) are essential pre-requisite of cultivation of small cardamom for achieving optimum productivity under prevailing conditions in India.

- Plant Protection Code (PPC) for small cardamom are aimed to achieve sustainability in agricultural system through an approach inclusive Integrated Pest Management (IPM), application and promotion of bio-control agents and judicious application of plant protection formulations in agriculture thus gradually reducing the dependence on chemicals in India.

- PPC shall focus on scientific and responsible approaches of chemical management *viz*., proper selection, judicious usage, safe storage and proper disposal, occupational health and safety and green chemistry.

- PPC is committed to reduce the anticipated adverse impact of pesticides on human beings and the environment to as low as possible. This can be achieved through a coordinated approach including effective governance, review and monitoring.

*In this document the term "PPF" includes all Plant Protection Formulations covering insecticides, fungicides, nematicides, weedicides, bio-pesticides etc.*

# INTRODUCTION

Small cardamom [*Elettaria cardamomum* (L.) Maton], the "Queen of Spices" enjoys a unique position in the International spices market, as one of the most sought after spices. It is indigenous to the southern stretch of evergreen forests of Western Ghats. In India, small cardamom is cultivated in the Southern States of Kerala, Karnataka and Tamil Nadu. Kerala accounts for 87 percent of the cultivation followed by Karnataka (8 percent) and Tamil Nadu (5 percent). The total area under small cardamom in India is estimated to be around 69,000 hectares (www.indianspices.com).

Small cardamom is used for flavoring various food preparations, confectionery and beverages. It is also used for medicinal purpose, both in modern and indigenous systems of medicine.

The small cardamom of commerce is the dried fruit (capsule) of the plant, *Elettaria cardamomum* Maton. The genus belongs to the natural order *Scitamineae*, family *Zingiberaceae* under monocotyledons. It is basically a sciophytic plant/shade loving plant growing under shade in evergreen forests. Small cardamom plants mature in about 20 to 22 months after planting. Economic yield starts from third year of planting and it continues up to 8 to 12 years for high yielding varieties depending upon the level of management. Mysore, Malabar and Vazhukka are the three types of cultivars of small cardamom varieties and are highly location specific. In order to raise a small cardamom plantation, suckers or seedlings of high yielding varieties suitable to respective locations are to be used. If virus free production of planting material could be ensured, vegetative propagation through suckers is the best method. However, vegetative propagation has the inherent disadvantage of reducing genetic base of small cardamom. Traditionally, small cardamom plantations were raised from seeds.

Small cardamom is susceptible to diseases and pests. The crop loss is estimated to be approximately 20-40% of production due to various pests, diseases and weeds. Diseases alone can cause up to 50 percent of total loss if not managed properly. Small cardamom being an export-oriented spice crop, the responsibility of spices growers is to maintain sustainable yield and quality of produce.

In the recent years, there have been continuous efforts to reduce the use of chemicals in agricultural system by adopting integrated management for the control of pests, diseases and weeds. A massive adoption of the recommended integrated pest management (IPM) approach from the very beginning of the season will be most crucial in ensuring food safety and adequate crop protection. Looking critically at the practical aspects of IPM adoption in small cardamom plantation, the farmers have to be very careful in using pesticides.

Instead of adopting as a single approach, PPFs are to be used ***only as a component*** in IPM. It is always emphasized that pesticides should be used in a judicious way rather than blanket sprays in the fields during flowering season since small cardamom being a cross pollinated crop, it will affect the visit of bees and the pollination. A very effective pest monitoring system is required to put in place at the grass-root level to minimize the indiscriminate use of pesticides in small cardamom production in India.

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# CHAPTER 1

## PLANT PROTECTION FORMULATIONS USAGE POLICY

1. Spices Board India shall recommend only such Plant Protection Formulations (PPFs) - that have been cleared and registered by the Central Insecticides Board and Registration Committee (CIB & RC), Government of India, with label claim on small cardamom.
2. The Spices Board may recommend only such PPFs as per Annexure 1 for plant protection in small cardamom plantations.
3. All the small cardamom plantations shall keep the record of usage of PPFs.
4. All small cardamom plantations should follow IPM for sustainable production.
5. The PPFs should not be used near the water bodies, wildlife habitats and human dwelling to ensure that there is no contamination beyond the application area.
6. There should be designated areas for preparation of spray fluids with clear signage for the workers. These areas must be away from any natural water bodies, drinking water sources, children's play areas, food stores, clinics and fish ponds.
7. The PPFs must be stored safely and correctly in facilities which are dry, well ventilated and should not be accessible to children and unauthorized people. The storage facility should be away from food and animal feed.
8. Storage areas should display information on hazardous chemicals in a way which is easily understandable for the workers (in a language they can understand or in pictorial formats), including information regarding their classification, the hazards they cause and the safety precautions to be observed.
9. There should be provisions for training of plantation workers on safe and appropriate usage of PPFs.
10. The small cardamom plantation unit must regularly maintain and calibrate agrochemical application equipment and keep records of such equipment maintenance and calibration.
11. The plantation unit must have emergency facilities and procedures available in the vicinity of PPFs storage to deal with spillage of PPFs (*i.e.* sand or sawdust) and with operator contamination (*i.e.* clean water). The procedure must indicate basic accident care instructions as well as contain the contact details of the ambulance, nearest hospital

and the person trained in first aid.

12. During transportation of plant protection products, the plantation unit should ensure prevention of spilling and other accidents.
13. Safe interval of application of PPFs should be ensured as per recommendations of the authorized institutes.
14. The spraying procedure and maintenance of spraying equipment should be done as per the advice of Indian Cardamom Research Institute, Spices Board.

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**Annexure 1**

**Table 1** LIST OF APPROVED FUNGICIDE FORMULATIONS FOR USE IN SMALL CARDAMOM PLANTATIONS

| **Sl No** | **Name of PPFs** | **Target diseases** | **Dosage (g)** | **Dilution in water (lit)** |
|---|---|---|---|---|
| 1 | Copper oxychloride 50% WP | *Azhukal* (Capsule rot), Leaf rot, Leaf spot, Leaf rust, Leaf blotch, Damping off, Clump rot | 200 | 100 |
| 2 | Fosetyl-Aluminium 80% WP | *Azhukal* (Capsule rot), Leaf rot, Leaf blight | 200 | 100 |

(Source**:** ppqs.gov.in/divisions/cib-rc/registered-products, ppqs.gov.in/ipm-packages/spices)

**Annexure 2**

**TABLE 2** LIST OF INSECTICIDES APPROVED FOR USE IN SMALL CARDAMOM PLANTATIONS

| Sl No | Insecticides | Target pests | Dosage (gm / ml) | Dilution in water (lit) | Waiting period (Days) |
|---|---|---|---|---|---|
| 1 | Diafenthiuron 50%WP | Thrips and capsule borer | 800 | 1000 | 7 |
| 2 | Lambda-cyhalothrin 04.9 CS | Thrips and shoot & capsule borer | 400 | 1000 | 34 |

# CHAPTER 2

## INTEGRATED PEST AND DISEASE MANAGEMENT IN SMALL CARDAMOM PLANTATIONS

**The concept of IPM**

Integrated Pest Management (IPM) is a system where all suitable methods and techniques are utilized in a compatible manner to maintain pest incidence at levels below those causing economic loss of crop. For formulating an effective IPM strategy one needs to have knowledge of bio-ecology of pests and pathogens, economics of control measures and the possible adverse effects of pesticides on non target living organisms and environment & human health.

There are various non-chemical strategies established against pests of small cardamom including cultural, biological, physical and mechanical and have been recommended for incorporation with chemical control measures. These approaches not only control pests effectively but also provide a way for judicious use of chemical pesticides, thereby reducing the harmful effects of chemicals on the environment. To impart a successful IPM programme, it needs the knowledge on:

1. Identification of pests and diseases, time of occurrence and extent of loss
2. Life cycle and biology of the causal organism
3. Site of attack
4. Damage symptoms and sign of pest attack
5. Mode of migration/dispersal
6. Alternate hosts

The concept of integrated pest management (IPM) in small cardamom plantations is in existence since 1985, in India and this has resulted in minimizing the use of toxic agrochemicals.

**Elements of IPM**

1. **Cultural practices**

The incidence of pests and diseases can be reduced to some extent by collecting and destroying the different pests and affected plant parts, maintenance of shade and weed control.

1.1 **Shade management**

Shade regulation is one of the important practices that should be attended during summer (March - April) in the new planting areas and during May - June after the receipt of summer showers in the existing plantation. If there is thick shade, chopping of branches should be done to provide filtered sun light of 40-60 percent of the open area. Below 50% shade, accelerates vegetative growth and adversely affects the flowering and yield. The shade management possesses a vital role for lowering the incidence of pests like thrips, shoot fly etc.

1.2 **Field sanitation**

Viral diseases are responsible for rapid degeneration of production potential in early stages of plantation establishment and cause constant threat to sustainable production. Some weeds including *Alpinia, Amomum, Curcuma, Colocasia etc.* found in the small cardamom plantation are alternate hosts for the aphids which transmit the viruses. An effective weed management system can reduce the spread of these diseases and attack of insect-pest to a considerable extent. Weeds are also potential competitors to small cardamom for water and nutrients. Two or three rounds of hand weeding around the plant base during May, September and December/January and slash weeding in the inter-space are advisable. Pruning operation may be carried out during January and September, which avoid increasing thrips population. Pruning is the operation undertaken with sharp sickles for removing the dead and hanging leaves from the pseudostem and care should be taken not to peel off the leaf sheath from the pseudostem. Trashing may be carried out once a year after the receipt of the pre monsoon showers. It consists of removing of old tillers, dead rhizome, dry leaves and leaf sheaths. The resultant plant material obtained through pruning and trashing can be used for mulching.

1.3 **Application of fertilizers & organic manures**

Small cardamom responds well to both organic manuring and chemical fertilizer applications. A soil test based judicious manuring schedule is to be arrived at to achieve optimum production on sustainable basis. Application of 5-10 kg of decomposed farmyard manure/compost per plant may be done during May/June. Chemical fertilizers may be applied based on soil test results. The manure should be gently mixed with surface soil after application. Manuring can be done in two splits, one in May and the subsequent application during September. Organic manures such as neem cake (1 kg per plant), bone meal (1 kg per plant) or vermicompost (1 kg per plant) have beneficial effect on root proliferation and plant growth and also helps to reduce nematode infestation. The period of application and quality of organic inputs are very important. Sufficient moisture should be maintained and the organic inputs must be composted well before application.

2. **Host plant resistance**

Use of pest and disease tolerant varieties has been one of the most important ways to reduce the incidence of pests and diseases. Small cardamom being a perennial crop, research on clonal selection and breeding should be primarily aimed at the production of high yielding and superior quality plants with high emphasis on resistance to pests and diseases (Table 3). This approach would be highly effective in bringing down the use of chemical pesticides.

**Table 3** Disease and pest tolerant varieties in small cardamom

| **Sl No** | **Variety** | **Tolerance to pest / disease** |
|---|---|---|
| 1 | IISR-Vijetha | Cardamom mosaic virus |
| 2 | IISR-Avinash | Rhizome rot |
| 3 | Appangala 2 | *Katte* |
| 4 | ICRI 2 | *Azhukal* / Capsule rot |
| 5 | ICRI 3 | Rhizome rot |
| 6 | ICRI 6 | Moderately tolerant to rot, thrips, borer and drought |
| 7 | Mudigere 1 and 3 | Thrips and borer |

## 3. Physical control

Manual removal and soil solarization in the nursery are some of the most common approach to control certain types of insect-pest populations in spices. For example, in case of large caterpillars, their pupae can be collected manually and destroyed. Soil solarization can be effectively employed to eliminate root knot nematodes in the nursery.

## 4. Biological control of small cardamom pest

ICRI has carried out studies on biological control of small cardamom root grub with Entomopathogenic Nematodes (EPN) and Entomopathogenic Fungi (EPF) like *Metarhizium anisopliae and Beauveria bassiana.* These fungi can be used along with compost at the plant base for management of root grub. Application of EPN infected *Galleria* larva (cadaver) at the plant base has been found to reduce root grub infestation up to 95 percent. EPN survives in moist soil resulting in sustainable management of root grub.

## 5. Biopesticides and other methods of control

Plant products such as neem oil, *Pongamia* oil and extracts of several herbs having pesticidal properties are also found to be effective against several pests and pathogens. Sex pheromones form an important component of IPM which has been used successfully for controlling populations of moths and flush worms.

## 6. Traps

Different traps are followed for collection of insects

### 6.1 Yellow sticky traps

Set up yellow pan water / sticky traps 15 cm above the canopy for monitoring aphids and yellow sticky traps for whitefly @ 4-5 traps/acre. Locally available empty tins p a i n t e d yellow / blue and coated with grease / Vaseline / castor oil on outer surface, also can be used.

### 6.2 Light traps

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

### 6.3 **Fish meal traps**

Fish meal traps helps to collect adults of shoot fly infesting small cardamom. It must be installed during Oct-Nov or towards the end of the monsoon. Six to seven traps are required per acre. Traps are to be cleaned and re-installed once in 45-60 days till May.

## 7. Ecological engineering for pest management

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

### 7.1 Ecological Engineering for Pest Management – Below Ground

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

- Add organic matter in the form of Farm Yard Manure (FYM), vermicompost, crop residue which enhance below ground biodiversity of beneficial microbes and insects.
- Application of balanced dose of nutrients based on soil test report and INM.
- Application of biofertilizers with special focus on mycorrhiza and Plant Growth Promoting Rhizobacteria (PGPR).
- Application of *Trichoderma harzianum / T. viride* and *Pseudomonas fluorescens* for treatment of seed / seedling / planting materials in the nurseries and field (if commercial products are used, check for label claim. However, biopesticides produced by farmers for own use in their fields, need not be registered).

7.2 **Ecological Engineering for Pest Management – Above Ground:**

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

Natural enemies may require:

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

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

## PEST MANAGEMENT IN SMALL CARDAMOM

Small cardamom is infested by many pests, right from the seedling stage to the cured small cardamom in storage. Nearly 60 species of insect pests infest on small cardamom. Based on severity of infestation, these pests are categorized as major and minor, the former include thrips, panicle/capsule/shoot borer, root grub and root knot nematode and the latter include mid-rib caterpillar, whitefly, scales, red spider mites, lace wing bugs and aphid.

**Integrated Pest Management (IPM)** is an important method for small cardamom pest management. IPM includes careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes on the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms (FAO). Considering the vulnerable stages

in the life cycle of the pests, the following components of IPM are followed in small cardamom:

1. Cultural control
2. Biological control
3. Physical control
4. Mechanical / manual removal
5. Host plant resistance
6. Chemical control

The major pests and their management are given below.

## PESTS OF SMALL CARDAMOM

**Small cardamom Thrips [*Sciothrips cardamomi* (Ramk.)]:**

**Biology:**

**Egg:** Kidney shaped, laid singly in the tender part of the leaf sheath, racemes

**Larva**: Tiny, slender, fragile and straw yellow in color

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

**Damage symptoms:**

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

**Management:**

Follow the common cultural, mechanical and biological practices

**Cultural control:**

- Removal of dry drooping leaves as well as dry leaf sheath (trashing / pruning) during January, May and September.

- Removal of collateral host plants from small cardamom field and may be used for composting.
- Detrashing and weeding reduce thrips infestation.

**Chemical control:**

Spray Diafenthiuron 50% WP @ 800g/ha and Lambda-cyhalothrin 04.9 CS @ 400ml/ha

**Shoot, panicle and capsule borer [*Conogethes* sp] Biology:**

**Egg:** Pink, oval, flat and laid singly on the tender part of the plant
**Larva:** Long, pale pinkish and body covered with minute hairs.

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

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

**Damage symptoms:**

- Early stage of the larvae 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.
- Bore into the immature capsules and feed on the young seeds inside rendering the capsules empty.
- Late stage larvae bore the pseudostem and feed the central core resulting in drying of the terminal leaf and thus produce characteristic 'dead heart' symptom.
- Extrusion of frass material at the point of tunneling is the indication for the presence of larva inside the plant parts (pseudostem / panicle / capsule).
- The incidence of this pest is noticed throughout the year but they occur in enormous number in three seasons, January-February, May-June and September-October and their abundance synchronize with the panicle production, fruit formation and new tiller production.

**Management:**

Follow the common cultural, mechanical and biological practices

**Cultural control:**

- Roguing and destruction of infested tillers during September-October.

**Mechanical control:**

- Castor inflorescence along with capsules infested by borer may be collected and destroyed.

**Biological control:**

- Releasing and conserving of predators and parasitoids *viz*., *Agrypon* sp., and *Apanteles* sp.,

**Chemical control:**

Spray Diafenthiuron 50% WP @ 800g/ha and Lambda-cyhalothrin 04.9 CS @ 400ml/ha.

**Root grub [*Basilepta fulvicorne* (Jacoby)]:**

**Biology:**

Among the three species of root grubs, *B. fulvicorne* is found to cause more damage in small cardamom.

**Egg:** Pale yellow in colour.

**Grub:** Short, stout, 'C' shaped, pale white in colour.

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

**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.

**Management:**

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 de-trashing.

- Irrigation during summer @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 @ 4 cadavers /plant

**Early capsule borer [*Jamides alecto* Feld]:**

**Biology:**

**Egg**: Spherical, greenish white, laid on the panicle/ flower.

**Larva:** Flat, trowel shaped covered with dense hairs all over the body.

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

**Adult:** The wings of moth are bluish with metallic luster 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.

**Management:**

Clipping the inflorescence/ flower parts of alternate hosts *viz*., *Alpinia speciosa, A. mutica, Amomum ghaticum, A. pterocarpum, Curcuma heilyherrensis, Hedychium coronarium* during off season (December to May).

**Small cardamom whitefly [*Singhiella cardamomi* (David & Subramaniam)]:**

**Biology:**

**Egg**: Cylindrical, pale yellow when freshly laid and gradually turn brown.

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

**Adult**: Small soft bodied insect, about 2 mm long and having two pairs of white wings. The life cycle is completed within two-three weeks

**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 mold develops, which interrupts photosynthesis of the leaves.

**Favorable conditions:**
Warm weather conditions are favorable for multiplication.

**Management:**

- Release *Chrysoperla zastrowi sillemi* @ 2 larvae/plant in early stage of the plant and 4 larvae /plant in the later stage.
- Placing yellow sticky trap @ 4-5 / acre

**Hairy caterpillar (*Eupterote* spp): Biology:**

**Egg:** Dome shaped and laid on undersurface of the leaves of shade trees.

**Larva:** Robust, bluish black with pale brown head, white hairs and dorsal conical tuft of hairs.

**Pupa:** Pupation takes place in soil

**Adult**: Large moth, 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 shade trees during day time and drop down on the small cardamom plants during night time.
- They feed voraciously on leaves and defoliate the whole small cardamom plants.
- Usually the damage is observed during October-December
- Appear sporadically in enormous populations at intervals of several years and cause heavy damage to the foliage.

**Shoot fly (*Formosina flavipes* Malloch*)***

**Biology:**

**Egg:** Cigar shaped and white in color and laid in between leaf sheath and pseudostem on the whorl.

**Damage symptoms:**

- Larvae feed on the growing shoot of the young small cardamom suckers

- Emerging maggots (larvae) enter the pseudostem reach down the base by feeding the core tissue resulting in drying of the terminal leaf (Dead Heart Symptom).
- Infestation is more on plants in open area; severe during first and second year of planting. The pest activity starts during October and continues till March-April.

**Management:**

Follow the common cultural, mechanical and biological practices

Placing fish meal trap in the infested small cardamom plantations to trap the adult flies.

**Mid rib caterpillar [*Metapodistis polychrysa* Meyrick]:**

**Biology:**

**Egg:** Spherical in shape.

**Larva:** Pale green and 1 cm long when fully grown. Large black dots are present dorsally on head and the last abdominal segment.

**Pupa:** Pupa is a silken cocoon

**Adult:** Black brown moths having two golden stripes on their wings.

**Damage symptoms:**

- Caterpillars of this insect feed on unopened leaves of small cardamom.
- First larvae 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.

**Small cardamom aphid [*Pentalonia caladii* van der Goot]:**

**Biology:**

**Nymph:** Dark in color.

**Adult:** Brownish and has black veined wings. Reproduction is by vivipary and parthenogenesis.

**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.
- Transmit the viral diseases.

**Management:**

Release of *Chrysoperla* in the small cardamom plantations.

**Red spider mite (*Tetranychus s*p.) Biology:**

**Egg:** Hyaline, globular laid in mass

**Nymphs:** Yellowish in colour.

**Adult:** Red coloured small size.

**Damage symptoms:**

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

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

**Lace wing bug [*Stephanitis typicus* Distant]**

Nymphs and adults are found on lower surface of leaves. They suck the cell sap from leaves, resulting in grayish spots on leaves. Adult is small dull coloured bug with transparent lace wings. Damage is very severe in summer months in certain isolated pockets in open areas.

**Scales (*Aulacaspis* sp.)**

Infestation of this pest is noticed during summer months. Capsules, panicles and pseudostems are the usual sites of infestation. As a result of infestation, capsules are shriveled.

**NEMATODES**

**Root-knot nematode (*Meloidogyne incognita* Kofoid and White)**

**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.

**Damage symptoms:**

- Root knot nematode, infest small 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.

**Management:**

Avoid shade tree such as dadaps and intercrop like banana in cardamom cultivation.

**RODENT PESTS**

**A. Lesser bandicoot [*Bandicota bengalensis* Gray]:**

- 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 are 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 exists in Karnataka, Tamil Nadu and Kerala.
- The yield loss in small cardamom due to rodents is estimated to be around 10-12% in Karnataka. The rodent damage occurs at mature stage particularly during the fruiting period.

**Management:**

Placing traps in the small cardamom plantations.

**B. Southern palm squirrel [*Funambulus palmarum* L.]**

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

**Nature of damage:**

This rodent problem exists in southern states of India especially Karnakata, Tamil Nadu and Kerala. The yield loss in small cardamom due to this pest is estimated to be around 10-12% in Karnataka. The damage occurs at mature stage particularly during the fruiting period.

**Management:**

- Placing snap traps
- Placing panicles in an overlapped manner, timely harvest, clean cultivation and covering panicles with dried leaf mulch.

**Mammalian Pests**

Monkey, wild boar and porcupine cause damage to small cardamom in some areas.

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## SMALL CARDAMOM DISEASE MANAGEMENT

Small cardamom is affected by a number of diseases caused by various pathogenic fungi and viruses in main plantations as well as in nurseries. As many as twenty-five fungal and viral diseases have been reported till date. Among them four rot diseases in plantations and two diseases in nurseries seriously affect the plant and cause considerable crop damage. Diseases alone can cause up to 50 percent crop loss if not managed properly.

Diseases affecting small cardamom

1. Capsule rot (*Azhukal* disease)

Capsule rot or *Azhukal* is the most serious fungal disease of small cardamom. Disease symptoms develop mainly on the capsules, young leaves, panicles and tender shoots. Infected capsule show water-soaked discolored areas; they turn brownish and later such capsules decay and drop off. During favorable climatic conditions the disease aggravates and infection extends to panicles and tender shoots. It has been shown that as high as 40 percent crop loss can occur in severely affected plantations.

1.1 Management of capsule rot

*Phytophthora meadii* McRae and *P. nicotianae* Breda de Haan has been widely observed as causing capsule rot disease. As the outbreak of disease is during the monsoon season, disease management measures have to be initiated sufficiently in advance *i.e.*, before the primary infection starts. Spraying 1.0 percent Bordeaux mixture and drenching 0.2 percent Copper oxychloride respectively is recommended as prophylactic measure. Although a number of fungicides have been reported to control the disease, often disease control in the field is a challenging experience. The factors responsible for the constraints in achieving satisfactory disease control include lack of phytosanitation, effective and timely application schedule, and the continuous rain that makes any fungicidal application ineffective. Two to three rounds of sprays with 1.0 percent Bordeaux mixture or 0.2 percent Fosetyl-Aluminium 80% WP after thorough phytosanitation can effectively control the spread of the disease.

1.2 Biological control of capsule rot

Bioagents play an important role in an ecofriendly management of soil borne pathogens in a totally safe manner avoidingthe use of expensive and hazardous chemical fungicides. Control of capsule rot diseaseusing *Trichoderma viride* and *T. harzianum* is successful and for this purpose a simple carriercum multiplication medium was developed by ICRI. Today, control of capsule rot disease of small cardamom has become effective, environmentally safe and cost effective due to the biocontrol potential of *Trichoderma* spp.

2. Rhizome rot

Rhizome rot (Clump rot) is a common disease occurring in small cardamom plantations during the monsoon period. The disease is widely distributed throughout small cardamom plantations in Kerala and Karnataka states and in heavy rainfall areas of Tamil Nadu such as the Anamalai hills. The symptoms of rotting develop at the collar region of the pseudostem (tillers) which become soft and brown coloured. At this stage the affected tillers fall off emitting a foul smell. The panicles and young shoots attached to this are also affected by rot. The rotting extends to the rhizome and roots also. Falling of shoots resulting from rhizome rot infection becomes severe during July-August. Rhizome rot is caused by *Pythium vexans* de Bary and/or *Rhizoctonia solani* Kuhn.

2.1 Management of rhizome rot

Dense shade increases rot disease infection despite regular fungicide application. On the other hand, regulated shade reduces disease incidence by making the microclimate unfavorable for the pathogen. The disease is usually observed in areas previously affected by rhizome rot disease. Therefore, phytosanitation plays a major role in disease management. Presence of inoculum in the soil and plant debris, overcrowding of plants, and thick shade are congenial conditions for disease development. Therefore, any disease management schedule has to be followed keeping these points in mind. Need based one round pre monsoon and two rounds post monsoon soil drenching with 0.2 percent Copper oxychloride is very effective in controlling the disease.

2.2 Biological control of rhizome rot

Application of *T. viride* and *T. harzianum* is effective to reduce rhizome rot incidence in plantations. A formulation of *T. harzianum* in a carrier medium consisting of farmyard manure and coffee husk mixture has been developed by ICRI for filed application in the integrated disease management system.

3. *Colletotrichum* leaf blight

The leaf blight disease is caused by *Colletotrichum gloeosporioides* (Penz.) Penz. and Sacc. Initially the symptoms appear as small water soaked rectangular lesions on the leaves which,

later elongate to form parallel streaks and turn to yellowish brown to orange red in colour. The central portions become necrotic. The disease spread is faster in partially deforested areas and less shaded plantations. Though it was reported as a minor disease of limited spread, presently the situation is alarming as the disease is spreading to newer areas and is becoming a major problem.

### 3.1 Management of *Colletotrichum* leaf blight

Three sprays at monthly intervals with 1.0 percent Bordeaux mixture effectively controlled the disease spread in the field.

## 4. Leaf blotch

The disease appears during monsoon season i.e. from June to August, normally under heavily shaded conditions. Thick shade, continuous rainfall and high atmospheric humidity pre dispose plants to infection. During rainy period, round, ovoid or irregular water soaked lesions develop on leaves, usually near the leaf tips or at the midrib areas. These areas enlarge in size, become dark brown with necrotic areas. In moist weather, a thick, grey colored fungal growth is seen under side of these blotched areas. The periphery of the lesion shows a dark band of water soaked zone as the lesions spread. However, the lesion spread is limited in size following a dry period.

### 4.1 Management of leaf blotch

Leaf blotch is a fungal disease caused by *Phaeodactylium alpiniae* (Sawada) Ellis. Fungicidal spray with Bordeaux mixture (1%) can control leaf blotch infection in the field.

## 5. *Phytophthora* leaf blight

Leaf blight incidence is observed in small cardamom plantations during the post monsoon season. The infection starts on the young- middle aged leaves as brown coloured patches which soon become necrotic and dry off. The disease appears during October-November and may extend up to January – February. Thick shade, low night temperature and fog prevailing in isolated pockets in the plantation pre- dispose the plants to leaf blight infection.

5.1 Management of *Phytophthora* leaf blight

The causal organism is *Phytophthora meadii* McRae. Disease symptoms are seen only on leaves. The leaf blight infection can be controlled at the initial stage itself with one round of foliar spray of Bordeaux mixture (1.0 percent) or Fosetyl-Aluminium (0.2 percent).

6. Leaf rust

The disease appears after monsoon during October-May. The disease symptoms appear on leaves in the form of numerous yellowish rusty coloured pustules distributed on the leaf surface in several patches, mostly seen on the underside of leaves. These areas later dry off as the disease advances.

6.1 Management of leaf rust

The disease is caused by the rust fungus *Phakospora elettariae* (Racib.) Cummins. The spread of leaf rust infection can be managed by spraying Bordeaux mixture (1.0 percent) immediately after post monsoon showers.

7. Leaf spot diseases

Small cardamom foliage is affected by a number of leaf spot diseases caused by a variety of fungi. They occur both at the seedling stage and in mature plants in the plantations. These diseases occur as minor diseases and as such do not cause considerable damage to plants.

7.1.1 *Sphaceloma* leaf spot

This disease is caused by *Sphaceloma cardamomi* Muthappa. Although the disease is present throughout the year, its abundance and severity are more during the post monsoon period. Symptoms of the disease appear on leaves in the form of scattered spherical blotches measuring a few millimeters in diameter and the adjacent lesions coalesce to form large necrotic patches.

7.1.2 *Cercospora* leaf spot

The disease is caused by *Cercospora zingiberi* Togashi Katsaki. The symptoms originate on the leaf blade as water soaked linear lesions which are rectangular and parallely arranged alongside veins. In advanced stages, lesion become grayish- brown in colour and later these areas dry off.

### 7.1.3 *Glomerella* leaf spot

The disease is caused by *Glomerella cingulata* (Stoneman) Spaulding & Schrenk. The symptoms of the disease are characterized by the presence of circular-ovoid dark brown concentric spots on the middle leaves. The disease is generally seen only in cultivar Malabar.

## 7.2 Management of leaf spot diseases

The spread of leaf spot diseases can be managed by spraying one or two rounds of Bordeaux mixture (1 percent).

## 8. *Fusarium* infections of small cardamom

The cultivation of small cardamom and maintenance of healthy plants have become difficult tasks due to the incidence and spread of Fusarium infections in recent years. *Fusarium* infection in small cardamom have been reported in the form of seedling wilt in nurseries, capsule infection, stem rot & stem lodging in plantations, rhizome rot, root tip rot and foliar yellowing. The disease incidence was observed to be severe in plantations of 4-6 years of age during October –March. The causal organism is identified as *Fusarium oxysporum* Schlecht. The pathogen causes root rot, leaf yellowing, pseudostem rot & lodging, panicle blight and rhizome rot.

### 8.1 Disease management

Provide adequate shade, irrigation and mulching.

### 8.2 Biocontrol

Soil application with biocontrol agents *T. harzianum* and *P. fluorescens* (1 - 2 %) can control the Fusarium infections.

## 9. Capsule ring spot

The symptoms of the disease are development of reddish-brown concentric rings or zonation on capsule rind. These areas turn necrotic and later dry off. The infection is caused by *Marasmius* sp. The disease can be controlled by spraying 0.2 percent Copper oxychloride.

10. Capsule tip rot

The symptom of the disease is a characteristic type of rotting of the tip of capsules in plantations. The disease makes its appearance as small water-soaked lesions at the distal end of the capsule, which later spreads downwards. In advanced stages, the rotting extends to the entire capsule. The disease is caused by *Rhizoctonia solani* Kuhn. Spraying 1.0 percent Bordeaux mixture can control the disease spread.

11. Sooty mold

A sooty mold infection on leaves of small cardamom growing under the shade trees appears generally during January-February when the trees are in blossom. Infection starts as minute scattered dark mycelial growth on the upper leaf surface and later spreads to the entire leaf lamina, the petioles and leafy stems. In advanced stages, foliage tear-off along the veins and dry out. The disease is caused by the fungus *Trichosporiopsis* sp.

12. Seedling diseases

Major diseases occurring on small cardamom seedlings are damping off caused by *Rhizoctonia solani* Kuhn and or *Pythium vexans* de Bary. The pathogens cause seedling rot or clump rot also. The association of root knot nematode, *Meloidogyne incognita* (Kofoid & White), along with *R. solani* and *P. vexans* has been observed in small cardamom nurseries. Diseases such as wilting of seedlings caused by *Fusarium oxysporum*, rotting of leaves, leaf sheath and leafy stem caused by *Sclerotium rolfsii* Sacc. were also recorded. Leaf spots caused by *Phyllosticta elettariae* Chowdhary and leaf blight caused by *Colletotrichum gloeosporioides* (Penz.) Sacc. are the major foliar diseases affecting seedlings.

12.1 Disease management

Seedling rot and damping off in small cardamom nursery can be controlled by soil drenching with 0.2 percent Copper oxychloride. Spraying the foliage with 1.0 percent Bordeaux mixture is effective in reducing the disease spread.

All the chemicals mentioned / recommendations are based on bio-efficacy study.

13. Viral diseases

The four viral diseases of small cardamom are mosaic virus or *katte* (caused by cardamom mosaic virus), Nilgiri necrosis disease (caused by Nilgiri necrosis virus), *kokke kandu* disease (caused by cardamom vein clearing virus) and chlorotic streak (caused by banana bract mosaic virus). *Katte* disease is widely distributed in all the small cardamom growing tracts and is a major production constraint for small cardamom in India while chlorotic streak is prevalent where banana is growing nearby. Occurrence of these viral diseases is a matter of concern to the small cardamom industry. Use of virus free planting materials, removal of infected host plants, creating awareness among farmers, preventing the movement of diseased plant materials to check introduction of viruses to new areas, regular phytosanitation, removal of virus sources, early detection through ELISA or PCR, use of resistant varieties are the methods / approaches required to manage the viral diseases in nurseries and plantations.

13.1 Management of viral diseases

Viral diseases of plants are difficult to control. Early identification of diseased plants and reducing its spread are the easy ways to tackle the problem. Hence, from an environmentally safe and economically viable perspective the following measures should be adopted for effective management of the diseases.

1. Monitor the plantation every month particularly during rainy season and carefully identify the diseased plants.
2. The diseased plants may be uprooted and destroyed as and when they are seen. They should be taken to an isolated place, chopped into small pieces and buried in pits for quick decomposition. As an alternative, mass uprooting and burning of infected plants at the village / area level could be taken up for eradication of the disease.
3. Never collect planting materials from an infected garden or apparently healthy plants from severely infected gardens.
4. Establish nursery about 500 m away from main plantation in order to avoid aphid colonization. Maintain clean clumps by removing old tillers with loosened leaf sheath so that aphids do not colonize.

5. During plantation monitoring, especially prior to harvesting, the plantation must of diseased plants. These plants may be uprooted and destroyed on priority.
6. Grow mosaic virus resistant variety, IISR Vijetha in hot spot areas.

## WEED MANAGEMENT

Cardamom being a surface feeder, frequent weeding is necessary to avoid competition between young cardamom plants and weeds. Weeds are mainly controlled by hand weeding in the plant base and slash weeding in the inter space areas. Two to three rounds of weeding need to be carried out in the first year of planting to remove the regenerating undergrowth. Generally, first hand weeding is done in May-June, the second in August-September and third in December-January. The weed intensity comes down as plant gets established in the later years and the number of weeding can be reduced accordingly. Mechanical weed cutters can also be used for weeding in the interspaces for initial years of plantation establishment while hand weeding is to be done around the plant base. Use of spade for weeding is to be avoided as it will loosen the soil and cause erosion. The biomass collected through weeding may be used for mulching. Though 50 to 60 weed species have been identified in cardamom plantations, only 10 to 15 species are predominant. The major weed flora identified in cardamom ecosystem are discussed below.

1. Broadleaved weeds

Goat weed: *Ageratum conyzoides* L. (family: *Asteraceae*)
Spanish needles: *Bidens pilosa* L. (family: *Asteraceae*)
Creeping wood sorrel: *Oxalis corniculata* L. (family: *Oxalidaceae*), *Neanotis wightiana* and *N. indica* (DC) Lewis (family: *Rubiaceae*)
Soft blumea: *Blumea wightiana* D. (family: *Asteraceae*)
Little ironweed: *Vernonia cineriea* (L.) Less. (family: *Asteraceae*)
Asiatic pennywort: *Centella asiatica* L. (family: *Apiaceae*)

2. Grasses

Bermuda grass: *Cynodon dactylon* (L.) (famly: *Poaceae*)

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

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

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

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

Wavy leaf basket grass: *Oplimenus undulatifolius* (family: *Poaceae)*

3. Sedges

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

## CHAPTER 3

## DO'S AND DON'TS IN IPM

| Sl No | DO'S | DON'TS |
|---|---|---|
| 1 | Clean the area from all existing vegetation, stumps, roots and stones | Don't select plain area for nursery beds |
| 2 | Prepare beds with 1 m width, 20 cm height and of required length | Don't make too wide nursery beds |
| 3 | Grow only recommended varieties | Do not grow varieties not suitable for the season or the region |
| 4 | Pick ripened bold capsules from the second and third harvest of disease-free mother clumps for seed extraction | Don't collect un-ripened capsules for extraction of seeds |
| 5 | Sow the seeds preferably in September | Avoid sowing before September |
| 6 | Always treat the seeds with approved biopesticides or chemicals for the control of seed borne diseases and pests | Do not sow seeds without seed treatment with biopesticides or chemicals |
| 7 | Cover the beds with mulch material like pot grass or paddy straw | Don't expose the top soil |
| 8 | Once sprouting is observed, remove the old mulch and cover the beds with thinly sliced mulch materials | Avoid the contact of mulch materials with the soil by supporting twigs laid across the bed |
| 9 | Keep plant base mulched in the plantation (5-10 cm thick) except during June-September. | Don't use spade for weeding, as it will cause soil erosion |
| 10 | Follow application of manures, fertilizers and irrigation judiciously | Avoid imbalanced application of fertilizers |
| 11 | Do hand weeding during May, September, December-January | Avoid too much shade and too much open conditions |
| 12 | Maintain optimum and healthy crop | Crops should not be exposed to moisture |

| | | |
|---|---|---|
| | stand which would be capable of competing with weeds at a critical stage of crop-weed competition | deficit stress at their critical growth stages |
| 13 | Use NPK fertilizers as per the soil test recommendation | Avoid imbalanced application of fertilizers |
| 14 | Use micronutrient mixture based on test recommendations | Do not apply any micronutrient mixture without soil test recommendations |
| 15 | Conduct AESA weekly in the morning preferably before 9.00 AM. Take decision on management practices based on AESA and P:D ration only | Do not take any management decision without considering AESA and P:D ratio |
| 16 | Install traps at appropriate period | Do not install without insecticides in the attractant |
| 17 | Release parasitoids only after noticing adult moth catches in the trap | Do not apply chemical pesticides within seven days of release of parasitoids |
| 18 | Apply pesticides on need basis | Avoid calendar based application of pesticides and avoid dust formulation |
| 19 | Spray pesticides in the afternoon only | Spray should not be done in morning hours especially between 7.00 AM to 11.00 AM when there is honey bee foraging |
| 20 | Spray pesticides thoroughly to treat the under surface of the leaves, particularly for sucking pests | Do not spray pesticides only on the upper surface of leaves |
| 21 | Apply short persistent pesticides to avoid pesticide residue in the soil and produce | Do not apply pesticides preceding 30 days of harvest |
| 22 | Follow the recommended procedure to trap crop technology | Do not apply long persistent pesticides on trap crop, otherwise it may not attract the pests and natural enemies |

# BASIC PRECAUTIONS IN PESTICIDE USAGE

## Purchase

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

## Storage

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

## Handling

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

## 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 spray solution.
8. Avoid drift / spillage while opening sealed containers of concentrated pesticides. Do not

smell pesticides.

9. Avoid spilling of pesticides while filling the spray tank.

10. The operator should protect his bare feet and hands with polythene bags.

**Equipment**

1. Select right kind of equipment.

2. Do not use leaky and defective equipment.

3. Select right kind of nozzles.

4. Don’t blow / clean clogged nozzle with mouth. Use old tooth brush tied with the sprayer and clean with water.

5. Do not use same sprayer for weedicide and insecticide.

**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 wind direction.

3. Emulsifiable concentrate (EC) 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.

**Disposal**

1. Left over spray solution should not be drained in ponds or water lines etc. Throw it in barren isolated area.

2. The used / empty containers should be crushed with a stone / stick and buried deep into soil away from water source.

3. Never re -use empty pesticide containers for any other purpose.

## PESTICIDE APPLICATION TECHNIQUES AND EQUIPMENTS

| | |
|---|---|
| **Category A: Stationary, crawling pests or diseases** | |
| Vegetative stage<br>1. For crawling pests and soil borne diseases. | Lever operated knapsack sprayer (droplets of big size), hollow cone nozzle @ 35 to 40 psi. Lever operating speed = 15 to 20 strokes per minute. |
| 2. For small sucking pests and leaf borne diseases. | Motorized knapsack sprayer or mist blower (droplets of small size), air blast nozzle, operating speed = 2/3$^{rd}$ throttle |
| Reproductive stage | Lever operated knapsack sprayer (droplets of big size), hollow cone nozzle @ 35 to 40 psi. Lever operating speed = 15 to 20 strokes per minute |
| **Category B: Field flying / airborne pest** | |
| Vegetative and reproductive stage | Motorized knapsack sprayer or mist blower (droplets of small size), air blast nozzle Operating speed: 2/3rd throttle<br>OR<br>Battery operated low volume sprayer (droplets of small size), spinning disc nozzle |

## OPERATIONAL, CALIBRATION AND MAINTENANCE GUIDELINES IN BRIEF

1. For application rate and dosage see the label and leaflet of the particular pesticide.

2. It is advisable to check the output of the sprayer (calibration) before commencement of spraying under guidance of trained person.

3. Clean and wash the machines and nozzles and store in dry place after use.

4. It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides.

5. Do not apply pesticides without protective clothing and wash clothes immediately after spray application.

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

# CHAPTER 4
# HAZARD CATEGORIZATION OF PESTICIDES

Pesticides are poisonous substances and they are to be handled with extreme care. On the basis of 'acute toxicity', pesticides are grouped into four 'hazard categories'. The hazard categorization of the pesticide should be indicated in the label on the pesticide container. The label shows a square (set at an angle of 45°) divided into two triangles. The lower triangle will be colored according to the hazard category and the upper triangle will show the symbols of toxicity (Plate I). Following table gives the details of hazard categorization of pesticides in India (Table 4).

Table 4: Hazard categorization of PPFs

| Classification of pesticides | Colour of the lower triangle | Symbol and signal word on the upper triangle |
|---|---|---|
| Extremely toxic | Bright Red | Skull and cross bones, 'POISON' in red |
| Highly toxic | Bright Yellow | 'POISON' in red |
| Moderately toxic | Bright Blue | 'DANGER' in red |
| Slightly toxic | Bright Green | 'CAUTION' in green |

Plate 1: Hazard categorization of pesticides

## SAFETY PRECAUTIONS

The responsibility for the safe and effective use of pesticides rests with the government, industry, extension agencies, farmers and workers themselves (**GIFAP, 1983). The improper use of pesticides is a major cause of concern in all the developing countries and this highlights the need for educating the people engaged in the storage, handling and application of these poisonous chemicals. It is the responsibility of all concerned with the use of pesticides to ensure that the workers involved in the application are properly educated and trained.

** Groupment International des Associations Nationales des Fabricants de Produits agrochimiques.

## CHAPTER 5

## GUIDELINES FOR SAFE AND EFFECTIVE USE OF PESTICIDES

1. Read the label on the pesticide container carefully.
2. Use the pesticide only when it is essential.
3. Use only the recommended pesticide from authorized supplier.
4. Apply pesticides at the correct dosage and by the recommended method.
5. Never blow out clogged nozzles with mouth.
6. Do not use leaking sprayers. Avoid contamination of skin, mouth and eyes.
7. Do not inhale the pesticide fumes while mixing.
8. Never spray against the wind.
9. Do not wash pesticide containers near wells or running streams.
10. Keep clean water, soaps and towels ready for use.
11. Keep the pesticides locked in store room and out of reach of children and other unauthorized persons.
12. Dispose the containers safely after thoroughly emptying and washing. They may be buried in a place away from wells or water sources.

## CHAPTER 6

## SAFE DISPOSAL OF PESTICIDE CONTAINERS

1. Unwanted pesticides and containers are serious hazards in the small cardamom plantation area, if not disposed properly, due to contaminations and resulting environmental toxicity.
2. Pesticide containers should not be used for any other purposes like storage tanks, lives tock feeding trough etc.
3. Pesticide containers can never be properly cleaned or decontaminated at garden level.
4. It is hazardous to leave the empty containers as such. These should be appropriately disposed off.
5. Combustible containers can be burnt if the container labels permit burning. Containers made of paper, cardboard & plant materials can be disposed off by burning.
6. Noncombustible containers should be broken or deformed by punching holes at several places to prevent reuse.
7. The excess or left over pesticide spray fluid should also be disposed off in the designated pesticide disposal area.
8. The pesticide waste disposal area in the garden should be away from any water source. The soil should be deep.

## CHAPTER 7

## TRANSPORTATION OF PLANT PROTECTION FORMULATIONS

Pesticides are toxic materials and accidents can occur at any time. The person undertaking transportation of the materials is responsible for adopting necessary preventive measures to reduce hazards during transportation. Several precautions need to be taken to ensure safe transportation. Safety of the labourers loading and unloading the material, and safety of transporter, is equally important. The following guidelines would be helpful in the safe handling and transportation of pesticides.

1. The safest means of transporting pesticides by road is an open-type truck. Closed trucks do not offer good ventilation, hence materials which give off noxious fumes can be hazardous.
2. Ensure that the goods are protected against rain during transportation.
3. Load and unload the materials with care.
4. Do not throw pesticide packages, or allow them to drop from a height.
5. Do not use hooks in loading bags.
6. Never place pesticide packages under heavy loads of other items.
7. Whenever possible, do not load pesticides in passenger vehicles.
8. Do not carry foodstuff, animal feed etc., on the same truck of pesticides.
9. Do not transport livestock or domestic animals with pesticides.
10. Avoid puncturing paper containers when handling them.
11. Load only tightly closed and sealed containers.
12. When loading, check that the outside of the package is not contaminated with pesticide.
13. Load the pesticides on the vehicles in such a way that it does not roll or slide from place to place.
14. Do not transport herbicides with other pesticides and fertilizers.
15. Do not allow children to ride on the vehicle.
16. Place boxes with the right side up.
17. Load one container or package at a time.
18. Do not permit handling labor to smoke or prepare and chew tobacco during loading and unloading.
19. Load carefully within the weight limitation of the vehicle. Ensure that containers do not fall

on the vehicle.

20. Inform the truck driver of the potential hazards of the pesticide.
21. When transporting any hazardous substance, it is desirable that the carrier should have a Transport Emergency Card (TREMCARD) inside the vehicle.
22. Material Safety Data Sheet (MSDS) should be made available.
23. Do not leave a loaded vehicle unattended. Such vehicles may attract the attention of inquisitive children or livestock.
24. Always send a detailed inventory of the material loaded in the truck with the driver.
25. After unloading the truck inspect the body of the vehicle, the tarpaulin used to cover the material and other parts of the truck for evidence of leaks or spills. If found, treat spill properly.
26. Before loading check the truck body for protruding nails, metal strips or other sharp objects which could puncture containers. Hammer them flat if found.
27. Do not permit passengers to ride in the back of the truck, or sleep on top of the loaded truck.
28. Clean the vehicle after unloading.

# CHAPTER 8

# STORAGE OF PLANT PROTECTION FORMULATIONS

The farmer or consumer normally handles much smaller quantities compared to the retailers. However, the fundamental principles of good storage practice remain the same.

1. Never store bio pesticides in living quarters, or in the kitchen.
2. Always keep pesticides in their original containers. Do not transfer to food or water containers.
3. Store away from children and fire.
4. Store in a locked cupboard or box meant exclusively for pesticides. There should be designated in-charge for keys to stored PPFs.
5. Store in shaded area.
6. Keep storage quantity to a minimum and maintain the temperature.
7. Buy only when needed and utilize quickly.
8. Store in a ventilated area.
9. Do not store animal feed or other food stuff with bio pesticides.
10. Inform all family members of the location of the store and warn them.
11. Inspect periodically for signs of damage or leaks. The storage areas should have sand pits and the floor should be concrete.
12. Use the oldest stock first.

## Waiting period of approved fungicides and insecticides for small cardamom

The following pesticides were approved for use in small cardamom. The waiting period of these pesticides are given below (Table 5).

**Table 5:** Waiting period of approved fungicides and insecticides for use in small cardamom

| Sl No | Name of pesticide | Waiting period (days) |
|---|---|---|
| 1 | Copper oxychloride 50% WP | 21 |
| 2 | Fosetyl-Aluminium 80% WP | 20 |
| 2 | Diafenthiuron 50% WP | 7 |
| 4 | Lambda-Cyhalothrin 0.4.9CS | 34 |

# CHAPTER 9

# APPLICATION OF PLANT PROTECTION FORMULATIONS

## Spraying equipment and tips for successful spraying

Spraying is an important operation in small cardamom agro-practices and considerable manpower and financial inputs are involved in the operation. The main difference in application of all these materials lies in the variable requirement of droplet sizes, accompanying spray pressure and targeting the spray towards different parts of the plant body.

## Knapsack sprayers & backpack sprayers (Hand sprayers)

Hand sprayers are generally high-volume sprayers used for spraying of pesticides in small cardamom plantation.

## Knapsack sprayer for pesticide, fungicide and nutrient spraying

For spraying pesticides and fungicides, the spraying machine needs to be fitted with Hollow cone nozzle which normally discharges 450 cc fluid per minute under an operating pressure of 40 psi. Recommended nozzles are NMD 60/450, NMD 80/450, HCN 100/700, BAN 75/450. For efficient operation of hand sprayers, continuous pumping is necessary.

## CHAPTER 10

## PRE-HARVEST INTERVAL

The safe pre-harvest intervals for the commonly used PPFs are shown below.

| PPFs | Dosage (ml / ha or dilutions) | Pre-harvest interval (days) |
|---|---|---|
| Copper oxychloride | 1:400 dilution | 7-15 |

# CHAPTER 11

# SPRAYING INSTRUCTIONS AND PROPER MAINTENANCE OF SPRAYING EQUIPMENT

1. Read carefully the label on the bio pesticide containers.
2. Wear personal protective equipment as recommended.
3. Spray crops with the wind and its gradient. In other words, spray with the wind coming from the back.
4. Ensure that there are no animals, people, food or animal feed downwind, *i.e*. in the direction in which the wind is blowing.
5. Check sprayer and equipment for leaks. Leaking spray equipment can seriously contaminate the person. Avoid contamination of the skin, mouth and eyes.
6. Do not walk with running sprayer on roads, pathways.
7. Apply at the correct dosage and by the recommended method.
8. Never blow out clogged nozzles with mouth.
9. Do not wash pesticide containers near a well or running stream.

**Before spraying**

1. Identify the pest and ascertain the damage done. Use only recommended pesticide which is least toxic, if the pest populations exceed the economic injury Level.
2. Read instructions manual of the pesticide and equipment.
3. Check the spraying equipment and accessories which are to be used.
4. Ascertain that all components are clean, especially filing and suction strainer, sprayer tank, cut-off device and nozzle.
5. Test the sprayer and ascertain whether it pumps the required output at rated pressure.
6. Check the nozzle spray pattern and discharge rate.
7. Calibrate the sprayer, by the set spraying speed and nozzle swath by adjusting spray height and nozzle spacing.

**During Spraying**

1. Take only sufficient pesticide for the day's application from the store to the site.

2. Do not transfer pesticides from original container and packing into the other containers. Recheck the use instructions of pesticide and equipment.

3. Wear appropriate clothing. Avoid contamination of the skin especially eyes and mouth.

4. Liquid formulation should be poured carefully to avoid splashing.

5. Do not spray during high wind, high temperature and rain.

6. Never eat, drink when mixing or applying pesticides.

7. Never blow out clogged nozzles or hose with your mouth.

8. Follow correct spray technique. Spray the crop thoroughly by operating sprayer at correct speed and correct pressure.

**Maintenance**

1. Checking and preparation should commence well before the beginning of the season. Sprayer should be well maintained during the spraying season.

2. Clean both inside and outside of sprayer after each day's work, even if the same chemical is being used next day**.**

3. Sprayer should be lubricated thoroughly and regularly, especially all moving parts, before starting the work.

4. While inspecting the parts of sprayer, worn out, broken and damaged parts should be replaced.

5. Filters and nozzles should be cleaned thoroughly and it is of paramount importance**.**

# CHAPTER 12
# QUALITY OF WATER FOR SPRAYING

The quality of water used to mix with agricultural chemicals can reduce the effectiveness of the chemical applications.

Poor quality water can reduce spray efficacy. Use cleanest water possible for spray applications. Test water for turbidity, hardness, pH and EC.

**Consequences of poor-quality water**

1. It reduces activity of agricultural chemicals.
2. It blocks spray lines or nozzles, reducing chemical application uniformly.
3. It Increases wear of nozzles causing reduced chemical application uniformly a n d increase wear on spray rigs.
4. Water quality is variable and is dependent on the source of the water (*e.g*. rainwater, farm dams, river, bore, town reservoir). Water quality can also vary throughout the year and after periods of high rainfall or drought. Use the cleanest water possible when preparing agricultural chemicals for application. Where clean rain water is not available use the following guidelines to minimize spray failure due to poor quality water. Note that some agricultural chemicals are more sensitive than others to poor quality; check the specific instructions on pesticide labels.

The following are the guidelines to minimize the spray failure.

**Turbidity**

Dam or river water often contains suspended particle or clay, silt and fine organic matter, giving the water a ‘muddy’ appearance. Transfer muddy water to a settling tank where heavier particles will sink to bottom. Use a ‘flocculent’ such as Alum (Aluminium sulphate) to settle out the very light particles. However, DO NOT use water treated with Alum to spray amine formulation chemicals. Filter the water before filling the spray tank. Alum is most effective at pH 6.8 – 7.5 and should not be used if water pH is less than 5.5.

**Hardness**

Water hardness is caused by high levels of calcium and or magnesium and is common for bore water. Chemicals with amine formulations, which include the herbicides: glyphosate, 2, 4-D amine, and dicamba are adversely affected by hard water. Hard water can cause some chemicals to precipitate and can affect the properties of surfactants, emulsifiers and wetting agents. Precipitates can block nozzles and pre-filters and cause additional wear of spray rigs. To "soften" hard water use softening agents, adjust pH and use water that is neither very hot nor very cold. Add Ammonium sulphate to hard water in spray tank before adding amine formulation herbicides. This will improve efficacy.

**pH**

The pH of water indicates its acidity or alkalinity and is measured on a scale of 1 to 14. The neutral pH is 7. Most water has a pH between 6.5 and 8. Water above 8 is alkaline and water below 6.5 is acidic. pH >8.5 or 8 can cause deposits in pipes and blockage of equipment. pH <6 can cause corrosion of metal pipes and fittings. Alkaline water (pH >8) can break down some chemicals through a process called alkali hydrolysis. In the case of some herbicides this actually improves efficacy, but it is likely to reduce the efficacy of many other agricultural chemicals. The longer a mixed chemical is left in the tank prior to spraying, th greater the breakdown; it is not recommended to leave spray mixes overnight. Acidic water can affect the stability and physical properties of some chemical formulations. Critical pH levels at which chemical efficacy is compromised, should be included on pesticide labels. Water pH can be changed by adding an acid or alkali to the water tank. Using an acid such as sulphuric or phosphoric acid will lower pH while addition of an alkali such as potassium hydroxide will increase pH. This has to be done precisely using calculated amounts depending on the pH change required. Do not guess.

**Salinity**

Salinity is the concentration of all soluble salts in water. The amount of mineral salts dissolved in water is measured by its electrical conductivity (EC). The type of local rock and soil can influence the saltiness of water, but high EC is usually caused by runoff containing fertilizer

salts getting into the water source. Salty water can cause blockages and corrode the metal parts of spray rigs. High salt levels, particularly chloride, can lead to burning of crop foliage. Sensitivity to salts varies between crops. It is important to know the concentration of chloride that will cause foliar damage to crops grown. Most agricultural chemicals are not adversely affected by low to moderate salt levels. Salty water can be mixed with fresh water to reduce EC levels to more suitable levels for spraying.

**Organic matter**

Water containing a lot of organic matter (*e.g*. algae or leaves) can block nozzles and pre- filters. High levels of algae can also increase the alkalinity of water and will reduce the efficacy of some agricultural chemicals. Filter water before filling spray tanks. The best filters to remove organic matter are media filers with 1 mm crushed basalt. Disc filters with 60-micron openings can also be used.

**Iron**

Iron-loving bacteria can grow in water where the concentration of iron is 0.3 to 1.5 mg/L (0.3 to 1.5 parts per million). This can cause blockages in equipment such as pressure gauges. Iron is soluble in water where there is little or no oxygen, and can occur in deep bores and dams. Iron concentrations above 1.5 mg/L (1.5 ppm) can cause iron deposits in water, pipes and equipment. Aeration oxidizes iron, which makes it form solid particles that can be filtered or settled out of solution. Procedures used include aeration, settling, chlorination and use of Potassium permanganate.

**Temperature**

Very cold water can cause some chemicals to gel and reduces the solubility of wettable granule formulations. Hot water can reduce the stability of chemical mixtures. Water temperature extremes can increase / accentuate the effects of other water quality factors. Avoid mixing sprays during extreme weather. On hot days let the hose flow for time enough to become cool.

# CHAPTER 13
# SAFETY MEASURES FOR SPRAYING SQUAD

The following type of protective equipment can be used:

**Overalls**

Usually in most of the conditions a light cotton overall is the best and it must cover as much of the body as possible. A high collar with the upper-most button closed offers good protection of most of the body areas while the long sleeves with cuff-buttons, trouser buttons which are laceable at the bottom offer good protection. Pockets and any such parts/areas which are supposed to accumulate pesticides dust/ residue must be avoided.

In no case should a pesticide be applied or mixed without adequate protective gear. There must always be a separate set of clothes for above said purpose, this should be chosen in such a way that it covers body as much as possible.

**Aprons**

Water proof aprons made of rubber or plastic are very effective while mixing bio- pesticides and/or spraying them in uncertain wind conditions and it should reach from the top of the chest to below the knees. However, the locally available apron is a large sized plastic bag with three holes cut on its seamed bottom for the head and two hands can also be used but such apron does not protect the sleeves and shoulder but offers good protection to the body.

**Gloves**

Gloves are one of the most important accessories helpful to avoid dermal exposure while mixing or spraying pesticides. The gloves used should have a length up to 2-3" below the elbow and should be worn outside the shirt sleeves so that any liquid does not wet the shirt. Rubber gloves are clean and easily available but other durable gloves like cloth- backed PVC gloves which are also quite effective. Continued use of gloves may cause stiffness and slight loss of dexterity so such works which include use of gloves should be done patiently and with due gap of time. Gloves should be cleaned regularly and changed after recommended period or

if damage is seen.

**Shoes**

Large gum boots offer the best protection. However even ordinary shoes offer good protection. Shoes should be regularly inspected for damage and possible leaks. Using shoes greatly reduces chances of dermal exposure.

**Head Protection**

Hair presents an excellent place for dust or liquid mist to accumulate. It is also difficult to wash. It is therefore important to protect this area. A rain coat cap or hat with a wide brim offers reasonable amount of protection. In many areas, turbans are used. This long piece of cloth can be effectively used to cover the head. It is preferable to identify one such turban for pesticide application and decontaminate it like other pieces of clothing. A cotton balaclava cap is cheap and offers a reasonable degree of protection. Pesticides should never be handled without proper head gear.

**Goggles**

Goggles, face shields and spectacles primarily protect the eyes and the face. Apart from protecting against splashes and spills, tight fitting goggles offer good protection against irritating fumes on the eyes. Goggles, however do not protect the face. Further a properly fitting set of goggles might be found uncomfortable.

A cheap and fairly efficient method of protection against mists, small droplets and splashes reaching the eye is achieved by wearing ordinary spectacles. These are quite comfortable to use and can be used for prolonged time. A face shield is a piece of transparent acetate or acrylic sheet which covers the whole face. It is good to prevent a spill or splash from reaching the face. However, it does not protect against fumes irritating the eyes.

## CHAPTER 14

## MEASURES TO KEEP THE RESIDUES IN SMALL CARDAMOM BELOW THE MAXIMUM LIMIT

1. There should be regular monitoring for early detection of pests.
2. Adopt integrated pest management techniques.
3. Use only recommended safer botanicals and bioagents.
4. Avoid repeated spraying of same pesticides.
5. Sufficient waiting period should be allowed between spraying and plucking.
6. Blanket sprays must be avoided as far as possible.
7. Resort to spot treatment.
8. Pesticides should be used as per recommendations.
9. Check pesticide formulations for active ingredient and impurities.
10. Regular monitoring should be done for inputs used in the plantations.

11 Hygienic conditions must be maintained both in field and factory.

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