

Plant Protection Code for Large Cardamom

Policy on usage of Plant Protection Formulations in
Large Cardamom Plantations in India



Spices Board

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

Sugandha Bhavan, N.H. By Pass, Palarivattom P.O.,

Kochi 682025 Kerala, India

<http://www.indianspices.com>

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FOREWORD

Cultivated in the sub Himalayan tracts in the North Eastern India, Large Cardamom (*Amomum subulatum* Roxb) is one of the main cash crops of the region and has extensively been used by the food and beverage sector. Large Cardamom is also used for its medicinal properties such as 'hypnotic, appetizer, astringent to bowels, tonic to heart and liver 'in the Ayurvedic and Unani systems of medicine.

Traditionally cultivated as an agro-forestry crop mainly in Sikkim and Darjeeling district of West Bengal, there has been a shift in the recent years. Large Cardamom has made its way in to the nontraditional areas such as Arunachal Pradesh, Manipur and Nagaland using traditional practices. With the expansion of area under cultivation, it is important to have concrete guidelines for cultivation of Large Cardamom, for obtaining optimum productivity in the most sustainable way while addressing the safety and quality concerns of consumers and other stakeholders.

'The Plant Protection Code (PPC) for Large Cardamom' aims to achieve sustainability in the cardamom ecosystem through Integrated Pest Management (IPM), application and promotion of bio-control agents, and judicious application of plant protection formulations which are in alignment with the rich bio diversity of the Sub Himalayan region. Care has also been taken to ensure that 'the Plant Protection Code for Large Cardamom' addresses the concerns on adverse impact of chemicals on the environment as well as human beings in line with the quality and safety standards put forth by national and international regulators.

I hope, this document will be highly beneficial for the Large Cardamom Industry in reaching further heights through sustainable operations.

D. Sathiyan
Secretary, Spices Board

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PREAMBLE

Following are the guiding principles for Plant Protection Code:

- ◆ Plant Protection Formulations (PPFs) are essential pre-requisite for cultivation of large cardamom for achieving optimum productivity under prevailing conditions in India.
- ◆ Plant Protection Codes (PPCs) are aimed to achieve sustainability in agricultural system through an approach inclusive of 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.
- ◆ However, since Sikkim is declared as organic state in 2016, the usage of synthetic chemical has been totally banned. Hence thorough phytosanitation followed by application of bioagents is practiced for the management of various pests and diseases. But in other North Eastern states, synthetic chemicals can be used.
- ◆ 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 being 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, bio-pesticides etc.

INTRODUCTION

Large cardamom (*Amomum subulatum* Roxb.), a member of the family *Zingiberaceae*, is the main cash crop cultivated in the sub-Himalayan state of Sikkim and Darjeeling district of West Bengal. It is also cultivated in parts of Uttarakhand and in some other North Eastern Hill states like Arunachal Pradesh, Nagaland, Mizoram, Manipur, Meghalaya and Assam.

The large cardamom plant is a perennial herb with subterranean rhizomes with leafy shoots. The climatic conditions of the large cardamom growing regions of India are conducive for a large number of pests, diseases and weeds that needs to be managed below the economic injury levels to avoid huge crop loss. The usage of chemical pesticides is banned in large cardamom cultivation in Sikkim since the state is declared as organic in January 2016 by Govt. of India. But in other North East states synthetic chemicals can be used after following phyto-sanitation for effective control of pests and diseases.

The crop loss is estimated to be approximately 20-40% of production due to various pests, diseases and weeds. Being an export oriented spice crop, the responsibility of large cardamom growers and PPFs manufacturers is to maintain the sustainable yield and quality of the spice produce.

In recent years, there have been continuous efforts to reduce the use of chemicals in agricultural system and adopt integrated management system for control of the pests, diseases and weeds affecting large cardamom cultivation. The large-scale 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 large cardamom plantation the farmers have to be very careful in using pesticides.

Under IPM, instead of sole approach, PPFs are used **only as a component**. It is always emphasized that pesticides should be used in a judicious way rather than as blanket sprays in the fields during flowering season, since large cardamom being a cross pollinated crop, it will affect the visit of bumble bees and consequent pollination. A very effective pest monitoring system is required at the grass-root level to minimize the indiscriminate use of pesticides in other North East states where large cardamom is cultivated.

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, Government of India, with label claim on cardamom. It is not applicable to Sikkim which is declared as organic state.
 - 1.1 Only Spices Board in India is authorized to undertake efficacy and residue trials of new PPFs that have to be cleared by CIB for use in large cardamom.
 - 1.2 Indian Cardamom Research Institute (ICRI), Spices Board is authorized to visit spices gardens and to take the inventory of PPFs used in each garden for compliance with the approved list mentioned in this document.
 - 1.3 The planters as and when PPFs like Copper oxychloride (COC) is purchased, may send to ICRI for checking its purity.
 - 1.4 The scientists of ICRI and development officers of Spices Board will ensure that only such PPFs (as per Annexure 1) are used for the plant protection in large cardamom plantations. The decision with regard to purchase and application of the PPFs would be made by the panel of experts, development officials and farmers.
2. All the large cardamom plantations shall keep the records of usage of PPFs.
3. All large cardamom plantations should follow IPM for sustainable production.
4. 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.
5. There should be designated area 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.
6. 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.
7. Storage area 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 present and the safety precautions to be observed.
8. There should be provisions for training for plantation workers on safe and appropriate usage of PPFs.
9. The large cardamom plantation unit must regularly maintain and calibrate agrochemical application equipment and keep records of maintenance of such equipment and calibration.
10. 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.
11. During transportation of plant protection products, the plantation unit should ensure prevention of spilling and other accidents.
 12. Safe interval of application of PPFs should be ensured as per recommendations of the authorized institutes.
 13. The spraying procedure and maintenance of spraying equipment should be done as per the advice of ICRI, Spices Board.

Annexure 1

List of approved Plant Protection Formulations for use in large cardamom plantations

| SI. No | Type of PPFs | Name of PPFs |
|--------|--------------|---------------------------|
| 1 | Insecticides | Quinalphos 25% EC |
| 2 | Fungicides | Copper oxychloride 50% WP |

The above list is dynamic and may change from time to time based on the CIB approved list of pesticides for use in large cardamom and this may be seen from the website of Spices Board.

Annexure 2

List of approved Plant Protection Formulations with MRLs fixed by FSSAI for use in large cardamom plantations

| SI No | Name of PPFs | MRL (mg/kg) |
|-------|--------------------|-------------|
| 1 | Quinalphos | 0.02 |
| 2 | Copper oxychloride | ---- |

CHAPTER 2

INTEGRATED PEST AND DISEASE MANAGEMENT IN LARGE 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 on the possible adverse effects of pesticides on non target living organisms, environment and human health.

There are various non-chemical strategies established against various pests of large cardamom including cultural, biological, physical and mechanical and have been recommended for incorporation with chemical control measures in North Eastern States except Sikkim which is declared as organic state and use of chemical plant protection formulations is banned. These approaches not only control pests effectively but also provide a way for judicious use of chemical pesticides, reduces 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 and time of occurrence
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 large cardamom plantations is in existence since 1985 in North East region 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. Incidence of certain sucking pests and diseases in several crops are known to be reduced by applying higher dosage of potassium fertilizers.

1.1. Shade management:

Large cardamom is shade loving plant. In open areas hail storm causes severe damage to the foliage of large cardamom in Sikkim during February to May leading to the blight incidence and crop loss. Maintaining the pandals with agro shade net can help to eliminate the damage to some extent. There will be the chance of incidence of blight disease and sun scorching in open conditions. Hence, 50% shade has to be maintained.

1.2. Field sanitation:

Chirke and *foorkey* are the major viral diseases in large cardamom and the corn aphid *Rophalosiphum maidis* is one of the prevalent insect vectors for transmitting the *chirke* disease and *Pentalonia nigronervosa* and *Micromyzus kalimpongensis* for *foorkey*. Most

of the weeds in the large cardamom plantation are alternate hosts for the aphids. An effective weed management system can reduce the spread of these diseases and attack of insect-pest to considerable extent. In the case of large cardamom, 3-4 times weeding in an year is recommended.

1.3. Fertilizer application:

Application of higher levels of potassium fertilizers is known to reduce the incidence of pests and diseases in several crops. However, Sikkim being an organic state, the alternate organic fertilizers should be applied to compensate the potassium requirements. 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. Research on clonal selection and breeding of large cardamom should be primarily aimed at the production of high yielding and superior quality plants with high emphasis on resistance to pests and diseases. This approach is highly effective in bringing down the use of chemical insecticides / pesticides etc.

3. Physical control:

Manual removal and soil solarization in the nursery are some most common approaches of physical control, to manage 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. Biopesticides and other methods of control:

Plant products such as Azadirachtin, Karanj 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. Growing a row of marigold in the border areas of large cardamom plantations reduces the root knot nematodes attack effectively.

5. Indigenous Technical Knowledge (ITK) for Pest Control in Large Cardamom

Since long back, farmers in Sikkim have been using various indigenous techniques to control a wide range of pests in large cardamom. It includes use of ash, juice of different medicinal plants, leaf extracts etc.

The ants pose a serious threat to large cardamom cultivation by burrowing around plant base. In such conditions, farmers use warm ash around plant base to control attack of ants. Use of tobacco leaf juice is very common practice for controlling white grub and soil insects. Monkeys have been causing serious damage in large cardamom plantations. To keep the monkeys away and frighten them, farmers use to hang a bell and rang it in between. Timur fruit grind have been used widely to control sucking pests in large cardamom. Application of rotten eggs at plant base is a regular practice for controlling mammalian pests. The leaf extract of *titepati*, *indreni* and *chillowney* are quite common to control chewing, sucking and soil borne pests of large cardamom.

6. Traps: Different traps are followed for collection of insects

6.1 Yellow / blue pan water / sticky traps:

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

6.2 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 operated around the dusk time (6 pm to 10 pm).

7. Ecological engineering for pest management

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

7.1 Ecological Engineering for pest management – Below Ground:

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

- ◆ Crop rotations with leguminous plants which will 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 will enhance below ground biodiversity of beneficial microbes and insects.
- ◆ Application of balanced dose of nutrients using biofertilizers based on soil test report.
- ◆ Application of biofertilizers with special focus on mycorrhiza and Plant Growth Promoting Rhizobacteria (PGPR)

- ◆ Application of *Trichoderma harzianum* / *T. viride* and *Pseudomonas fluorescens* for treatment of seed / seedling / planting materials in the nurseries and field application (if commercial products are used, check for label claim. However, no registration is required for biopesticides produced by farmers for own use in their fields.

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.

7.3 In order to attract natural enemies following activities can be practiced:

- ◆ Raise 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.
- ◆ Do not uproot weed plants those are growing naturally such as *Tridax procumbens*, *Ageratum* sp, *Alternanthera* sp etc. which act as nectar source for natural enemies.
- ◆ Do not apply broad spectrum chemical pesticides, when the P: D ratio is favourable.

The plant compensation ability should also be considered before applying chemical pesticides.

- ◆ Reduce tillage intensity so that hibernating natural enemies can be saved.
- ◆ Select and plant appropriate companion plants which are trap crops and pest repellent crops. The trap crops and pest repellent crops will also recruit natural enemies as their flowers provide nectar and provide suitable microclimate.

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

PEST MANAGEMENT IN LARGE CARDAMOM

There are as many as 23 insect pests found associated with large cardamom. But all of them are not causing economic damage to the plant. Among the insect pests that attack large cardamom, leaf caterpillar (*Artona chorista* Jordon), stem borer (*Glyphipterix* spp.) Shootfly, (*Merochlorops dimorphus* Cherian) and White grub (*Holotrichia* sp.) are considered as important pests. Aphids are responsible for transmitting viral diseases viz., *chirke* and *foorkey*.

Large cardamom plant health management is an important key to manage pests at below economic injury level. Nutrient, shade and irrigation management plays vital role to maintain plant health. Replenishment of nutrients is very essential for sustained good yield and to compensate the nutrient loss from the soil. Application of well decomposed cattle manure / compost or organic products @ 5kg/plant at least twice a year in April-May and August-September is beneficial. Vermicompost, have favourable impact on soil physical properties

and good source of nutrients, particularly in the beds, is now gradually becoming popular organic manure. It may be applied @ 1 kg/clump in two equal doses in combination with FYM. Soil base with gentle slope from the plant is beneficial for application of inputs to the plants viz., FYM, vermicompost, etc.

It is noticed that dense shade or less shade hinders optimum crop growth and production. About 50% shade is found ideal. Therefore, judicious shade management is very important for good growth, timely flowering and for better yield. *Alnus nepalensis* (Utis in Nepali) / (Taram in Nyishi) is the most common shade tree and *Alnus*-large cardamom is a most appropriate agro-forestry system for sustainable production in the region. The other species of shade trees are *Terminalia myriocarpa* (Panisaj), *Bucklandia* spp. (Pipli), *Macaranga denticulata* (Malato), *Edgeworthia gardneri* (Argeli), *Viburnum erubescens* (Asare), *Maesa chisia* (Bilaune), *Symplocos theifolia* (Kharane), *Albizzia lebeck* (Siris), *Erythrina indica* (Phaledo), *Schima wallichii* (Chilaune) etc.

Due consideration should be given towards conservation of pollinators while taking up pest management operations. The bumble bees, *Bombus breviceps* and *B. haemorrhoidalis* have been recorded as important pollinators of large cardamom in all the altitudes.

Decline of bumble bee population throughout the world is a cause of concern now. Care should be taken during farm operations to keep the nests in the soil undisturbed to conserve the pollinators in their natural habitat. Maintenance of natural vegetation as well as micro-climate of the bumble bee nests in the plantation bears significant importance. Flowering plants need to be grown in the plantation throughout the year to maintain continuous supply of their food.

Integrated Pest Management (IPM) is an important method for large 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 life cycle of the pests the following components of IPM are followed in large cardamom.

1. Cultural practices such as Plucking, Pruning, Shade regulation, Infilling the vacancies in field etc.
2. Biological and other methods of control
3. Physical control
4. Mechanical / manual removal
5. Use of Light traps and
6. Host plant resistance

The important pests and their management are given below.

1. Leaf eating caterpillar

The leaf eating caterpillar (*Artona chorista* Jordon) is the only major pest presently causing economic loss in all over the region.

Seasonal occurrence:

The pest occurs sporadically in epidemic form every year in all the cardamom growing area of NE region and Darjeeling District of West Bengal. Usually the incidence of the pest is observed from June to July and October to March in the field.

Nature and extent of damage:

The leaf caterpillar is monophagous and is highly host specific. The larvae are gregarious in nature and feed on chlorophyll contents

underneath the leaf, leaving transparent epidermis and veins (skeletonization). The mature larvae completely defoliate the plant leaving the mid rib of the leaves. Indirectly, defoliation of the plant by the pest affects the yield. There are two generations per year in the field first generation from May to August and second generation from September to April.

Management

Cultural Control:

1. The larvae are gregarious in nature and feed underneath the cardamom leaf; the infested leaf can easily be identified from a distance and these may be collected along with larvae and destroyed in June-July and October-December.
2. Light traps should be arranged to attract and collect the moths. For an area of 10 ha one light trap (Actinic BL light or NCIPM, ICAR designed light trap) should be arranged. The light trap should be placed during early evening as soon as it is dark for 3-4 hours on road, vacant patches.

Chemical Control:

1. Quinalphos 25 EC (0.05%) is effective against this pest and may be applied in areas not declared as organic.

| Insecticide | Dilution | |
|------------------|----------|--------|
| | HV | LV |
| Quinalphos 25 EC | 1: 400 | 1: 200 |

2.STEM BORER:

Stem Borer, *Glyphepterix* sp. (Glyphiperidae:Lepidoptera), also cause damage to large cardamom in all the cardamom growing tract.

Seasonal occurrence:

Stem borer incidence is noticed throughout the year. They are most abundant during four

periods mainly December-January, March-April, May-June and September-October

Nature and extent of damage:

The larvae feed on the central portion of the shoot, hence passage of food material to growing tip is blocked. The central leaf of the plant gets dried up and this symptom is known as dead heart. Infestation of this pest is also indicated by the presence of entry holes plugged with excreta.

Management:

This pest can be controlled by removing infested shoots along with caterpillar.

Chemical Control:

1. Spraying of 3000 ppm neem oil @ 3.0 ml/lit of water during July-October (at 21-day intervals) is effective.

| Insecticides | Dilution | |
|--------------------------------|----------|--------|
| | HV | LV |
| Neem Oil (azadirachtin 5% W/W) | 1: 1500 | 1: 750 |

3. Shoot fly

Shoot fly, *Merchlorops dimorphus* Cherian (Chloropidae: Diptera), was recorded as a major pest of large cardamom damaging young shoots. Low to moderate damage of shoot fly is recorded.

Seasonal occurrence:

It is present throughout the year in large cardamom growing tract. The high incidence is recorded in new plantations within 1-3 year.

Nature and extent of damage:

The tip of the shoot becomes brown and later whole shoot dries up. Larva bores the young shoot and feeds on the core of the pseudostem from top to bottom resulting in damage of central leaf ultimately leads to death of the tiller.

Management:

1. Infested young shoots should be removed at ground level and destroyed.
2. Adult shoot fly can be trapped using fish bait and then killed.
3. Application of neem seed kernel extract (5%) also reduces the pest problem.

| Insecticides | Dilution | |
|------------------------------------|----------|--------|
| | HV | LV |
| Neem Extract (azadirachtin 5% W/W) | 1: 1500 | 1: 750 |

4. White Grubs

White Grubs, *Holotrichia* sp. (Melolonthidae: Coleoptera), is a polyphagous white grub infesting the roots and rhizomes of large cardamom in some of the places.

Seasonal occurrence:

The newly-hatched grubs emerge during June-August and continue to develop up to October / November. Adult beetles emerge by March-April and lay their eggs in the soil.

Nature and extent of damage:

The grubs are white and 'C' shaped with brown head. The grub feeds on the feeder root of the plants and the infested plant shows withering symptoms.

Management:

1. Collect the beetles using hand nets during peak period of emergence *i.e.*, during April-May and kill them.
2. Light raking of soil before the insecticide application is essential for effective control of root grubs.

5. Aphids

The aphids cause more damage as a vector

rather than a pest. The aphids are associated with the transmission of viral diseases (*Foorkey* and *Chirke*) of large cardamom.

Seasonal occurrence: The aphid population is recorded high during summer months at lower altitudes. The major species are:

1. *Pentalonia nigronervosa* f. *Caladii* (van der Goot) (Aphididae: Hemiptera).
2. *Micromyzus kalimpongensis* Basu (Aphididae: Hemiptera)
3. *Rophalosiphum maidis* Fitch (Aphididae: Hemiptera).
4. *Rophalosiphum padii* (Lin.) (Aphididae: Hemiptera)

Management:

1. The removal and destruction of diseased plants is helpful in controlling the further spread of the disease and in reduction of aphid population.
2. During some occasions, minor pest like Hairy caterpillar (*Eupterote* sp.) cause considerable loss in cardamom plantation. Other minor pests are mealy bug (*Planococcus* spp) and thrips (*Heliothrips haemorrhoidalis*).

DISEASES MANAGEMENT

1. Leaf Blight

The disease incidence is assessed by counting the infected tillers / total tillers and infected leaves / total leaves in randomly selected clumps. *Colletotrichum* blight is found to devastate the large cardamom plantation and is the cause of concern for severe crop loss and decline in plant population in recent years. The disease appears generally with the advent of the pre-monsoon showers in April – May and progresses rapidly during the rainy season. However, in some areas the incidence starts during winter months (January – March).

Management:

Cultural Control

1. The infected leaf and tillers and mature and bearing tillers after harvest must be cut and composted.
2. Leaves and left over portions of spikes may also be used for composting. Compost pits may be made for the purpose at convenient places in each plantation prior to harvest.
3. Regulate and maintain 50% shade. Proper mulching should followed during summer months.
4. Regular irrigation should be provided during summer months.
5. Recommended dose of organic / inorganic fertilizers should be applied at proper intervals.

Biological Control

1. Treat the suckers with *Pseudomonas fluorescence* @ 5 litres in 100 litres of water at the time of planting.
2. Spraying and drenching of *Pseudomonas fluorescence* @ 4 liter / plant (3 to 5 liter / 100 litres of water) during May and August – September.

Chemical Control

1. Three times spray and drench with 0.3% Copper oxychloride (COC) (3g / litre of water) will drastically reduce the blight incidence.

Control Measures

| Fungicide | Dosage in 100 liters of water | Spray interval (days) |
|--------------------|-------------------------------|-----------------------|
| Copper oxychloride | 300 g | 20-25 |

2. Phoma leaf spot disease

Leaf spot caused by *Phoma* was found to be a

severe concern in seedling nurseries in all the large cardamom growing states. Fast spread during continuous rain and consequent damage indicate its potential to devastate. In Sikkim, the disease was found to occur during late winter and peak rainy periods. Numerous water soaked lesions, round in shape appear on the lamina which coalesce and become yellowish and dry out. The following steps may be adopted for controlling the disease. **Cultural Control** Severely infected and dead leaves may be cut and destroyed.

Chemical Control

Spraying 0.3% Copper oxychloride (COC) two times can control the disease.

Control Measures

| Fungicides | Dosages in 100 liters of water | Spray interval (days) |
|--------------------|--------------------------------|-----------------------|
| Copper oxychloride | 300 g | 20-25 |

3. Leaf streak disease

It is caused by *Pestalotiopsis r oyenae* and

results in considerable damage to foliage in variety Golsey. It is prevalent round the year. The disease symptom is the formation of numerous translucent streaks on young leaves along the veins. The infection starts from emerging folded leaves. Three rounds of 0.2% Copper oxychloride (COC) can control the disease.

Cultural Control

1. Severely infected and dead leaves may be cut and destroyed.
2. The infected leaves and tillers and mature and bearing tillers may be cut during harvest and composted.

Chemical Control

Spray one round of @ 0.2% Copper oxychloride (200 g / 100 litres of water) at 15-25 days interval based on severity of the disease.

Control Measures

| Fungicide | Dosage in 100 litres of water | Spray interval (days) |
|--------------------|-------------------------------|-----------------------|
| Copper oxychloride | 200 g | 15-25 |

VIRAL DISEASES OF LARGE CARDAMOM

| Aspect | Chirke disease | Foorkey disease |
|-----------------------------|--|---|
| Identification by symptoms | Mosaic appearance on leaves | Stunted and bushy growth of newly emerging tillers with small pale green leaves. Sometimes produce broadened pan like leaves. |
| Causal agent | It is caused by virus. Primary spread by infected planting materials. Transmitted through sap and aphid, <i>Rophalosiphum maidis</i> . Knife used for farm operations and harvesting can carry sap of infected plant to healthy ones. In most situations this is the major mode of spread. | It is caused by virus. Primary spread by infected planting materials. Transmitted through aphids, <i>Pentalonia nigronervosa</i> and <i>Micromyzus kalimpongensis</i> . |
| Survival of infected plants | Plants continue to survive for few more years gradually reducing the yield. | Rapid reduction in yield. |

| | | |
|--|--|--|
| Transmission through seeds & seedlings | Not transmitted through seeds, hence seedlings are disease free. | Not transmitted through seeds, hence seedlings are disease free. |
| Resistance / tolerance | No resistant cultivars / sources known | No resistant cultivars / sources known |

Management of viral diseases

Viral diseases of plants are difficult to cure. Early identification of the diseased plants and reducing the spread are the easy ways to tackle the problem. Hence, from an environmentally safe and economically viable perspective the following measures would 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.
5. Maintain clean clumps by removing old tillers with loosened leaf sheaths so that aphids will not colonize.
6. During plantation monitoring, especially prior to harvest, the plantation must be inspected carefully for identification of diseased plants. These plants may be uprooted and destroyed on priority. The knife and other implements used for the purpose should not be used on healthy plants since disease could be transmitted through sap. Dip the implements in hot water for half an hour for killing the inoculum before going to the healthy plants for harvesting or cleaning.

CHAPTER 3

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 coloured 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 1).

Table 1 Hazard categorization of PPFs

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



Plate I: 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 Association-s Nationales des Fabricants de Produits agrochimiques).

CHAPTER 4

DO'S AND DON'T S IN LARGE CARDAMOM PEST MANAGEMENT

- ❖ Monitor the incidence of pests by assessing their populations in the field.
- ❖ Mark the areas from where the pest attack starts.
- ❖ Start appropriate control measures in the beginning of the season.
- ❖ Integrate cultural control methods with biological control measures.
- ❖ Use bio-formulations (botanical formulations and entomopathogens) wherever possible.
- ❖ Do not allow the growth of weeds in ravines, along drains, foot-paths and vacant patches. Since these weeds may be alternate host of these large cardamom pests.
- ❖ Do not allow cattle inside the large cardamom field.
- ❖ Use only the recommended pesticide from authorized supplier.
- ❖ Apply pesticides at the correct dosage and by the recommended method.
- ❖ Never blow out clogged nozzles with mouth.
- ❖ Do not use leaking sprayers. Avoid contamination of skin, mouth and eyes.
- ❖ Do not inhale the pesticide while mixing.
- ❖ Never spray against the wind.
- ❖ Do not wash pesticide containers near wells or running streams.
- ❖ Keep clean water, soaps and towels ready for use.
- ❖ Keep the pesticides locked in store room and out of reach of children and other unauthorized persons.

Guidelines for safe and effective use of pesticides

- ❖ Read carefully the label on the pesticide container.
- ❖ Use the pesticide only when it is essential.

Dispose the containers safely after thoroughly emptying and washing. They may be buried in a place away from wells or water sources.

CHAPTER 5

SAFE DISPOSAL OF PESTICIDE CONTAINERS

1. Unwanted pesticides and containers are serious hazards in the large cardamom plantations if not disposed of properly, due to be contaminations.
2. Pesticide containers should not be used for any other purposes like storage tanks, livestock 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 unless the container label warns against 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. They have to be disposed by burying them in the soil.
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.

CHAPTER 6

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 taking 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 guideline will 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. If 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 labour 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 (TREM CARD) 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 7

STORAGE OF PLANT PROTECTION FORMULATIONS

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

- 1) Never store 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 fires.
- 4) Store in a locked cupboard or box meant exclusively for pesticides. There should be designated in-charge for keys to storage of PPFs.
- 5) Store in shaded area.
- 6) Keep storage quantity to a minimum and maintain the temperature.
- 7) Buy only when needed and consume quickly.
- 8) Store in a ventilated area.
- 9) Do not store animal feed or other food stuff with 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.

CHAPTER 8

APPLICATION OF PLANT PROTECTION FORMULATIONS

Spraying equipment and tips for successful spraying:

Spraying is an important operation in large 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 large cardamom plantation.

Knapsack sprayer for pesticide, fungicide and nutrient spraying:

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

CHAPTER 9

PRE-HARVEST INTERVAL

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

| PPFs | Dosage (MI / Ha or dilutions) | Pre harvest interval (Days)* |
|--------------------|----------------------------------|---------------------------------|
| Quinalphos | 1:400 dilution | 8-21 |
| Copper oxychloride | 1:400 dilution | 7-15 |

*Depending on the location

CHAPTER 10

SPRAYING INSTRUCTIONS AND PROPER MAINTENANCE OF SPRAYING EQUIPMENT

- 1) Read carefully the label on the pesticide containers.
 - 2) Wear personal protective equipment as recommended.
 - 3) Spray crops with the wind and 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.
- ❖ Ascertain that all components are clean, especially filling and suction strainer, sprayer tank, cut-off device and nozzle.
 - ❖ Test the sprayer and ascertain whether it pumps the required output at rated pressure.
 - ❖ Check the nozzle spray pattern and discharge rate.
 - ❖ Calibrate the sprayer, by set spraying speed and nozzle swath by adjusting spray height and nozzle spacing.

During Spraying

Before spraying

- ❖ Identify the pest and ascertain the damage. Use only recommended pesticide which is least toxic, if the pest populations exceed the economic injury Level.
 - ❖ Read instructions manual of the pesticide and equipment.
 - ❖ Check the spraying equipment and accessories which are to be used.
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 other containers.
 3. Recheck the use instructions of pesticide and equipment.
 4. Wear appropriate clothing. Avoid contamination of the skin especially eyes and mouth. Liquid for formulation should be poured carefully to avoid splashing.
 5. Do not spray in high wind, high temperature and rain.
 6. Never eat or 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 the 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 as it is of paramount importance.

CHAPTER 11

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 as far as possible for spray applications. Test water for turbidity, hardness, pH and EC.

Poor quality water can:

- ❖ Reduce activity of agricultural chemicals.
- ❖ Block spray lines or nozzles, reducing the uniform distribution of the chemicals.
- ❖ Increase wear of nozzles causing reduced distribution of chemicals.
- ❖ Increase we spray rigs.
- ❖ 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 as far as 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 water quality; check the specific instructions on pesticide labels.

Guideline to minimize spray failure Turbidity

Dam or river water often contains suspended particles of 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 formulations of 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 well 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 <6, can affect spray mixes. pH >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, the 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 solution 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 get 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 filters 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, ppm). This can cause blockages in equipment such as pressure gauges. Iron is soluble in water where there is little or no oxygen, as 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 oxidises iron, which makes it to 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 temperatures extremes can increase / accentuate the effects of other water quality factors. Avoid mixing sprays during extreme weather. On a hot day let the water flow through the hose for time enough to become cool.

CHAPTER 12

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 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 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 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:

The large gum boots offer the best protection. 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 a 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. A properly fitting set of goggles might be 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 instead of goggles

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 13

MEASURES TO KEEP THE RESIDUES IN LARGE 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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