भाकृअनुप
ICAR

Good Agricultural Practices (GAP) for

LARGE CARDAMOM

(*Amomum subulatum* Roxb.)

A Practical Guide for Sustainable, Safe and Quality Large Cardamom Production



Indian Cardamom Research Institute, Regional Station,
Spices Board, Gangtok – 737102, India
&
ICAR–All India Coordinated Research Project on Spices,
Kozhikode – 673012, India
2026

Good Agricultural Practices (GAP) for large cardamom

(*Amomum subulatum* Roxb.)

2026/05
EXTENSION FOLDER

Citation:
Bora S S, John Jo Varghese, Deka T N, Mukesh Sankar S and Lijo Thomas (2026). Good Agricultural Practices (GAP) for large cardamom (*Amomum subulatum Roxb*.). Spices Board–Indian Cardamom Research Institute, Regional Station, Gangtok and ICAR-All India Coordinated Research Project on Spices. **36p.**

Published by

Project Coordinator
ICAR–All India Coordinated Research Project on Spices
Kozhikode – 673012, Keralam, India

Photographs
Spices Board–Indian Cardamom Research Institute, Regional Station, Gangtok Photo Archive

ACKNOWLEDGMENT
We place our sincere gratitude to all our officials who have contributed for the research and development of large cardamom since inception. The whole hearted support rendered by the Government functionaries, farming fraternity, cardamom traders, exporters and other stakeholders is gratefully acknowledged.

© ICAR–All India Coordinated Research Project on Spices
All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form without prior permission of the publisher, except for educational and non-commercial purposes with due acknowledgement.

Foreword

Large cardamom (*Amomum subulatum Roxb*.) is an important high-value spice crop of the Eastern Himalayas, particularly in Sikkim, the Darjeeling and Kalimpong hills of West Bengal, and parts of the North-Eastern region of India. The crop plays a vital role in sustaining the livelihoods of farming communities in these ecologically fragile regions. Its cultivation is closely intertwined with the traditional agricultural systems, biodiversity and socio-economic fabric of the region. Strengthening the sustainability, productivity and quality of large cardamom production is therefore important not only from an agricultural perspective but also for promoting resilient rural livelihoods. However, large cardamom cultivation is increasingly confronted with several challenges. Addressing these challenges calls for a holistic approach that goes beyond individual crop management interventions and integrates good agricultural practices across the entire production and post-production value chain. The adoption of scientifically validated and location-specific Good Agricultural Practices (GAP) is essential for improving resource-use efficiency, reducing production risks and ensuring food safety.

This guide brings together important research findings, technological recommendations and field-level practices developed through the sustained efforts of the Indian Cardamom Research Institute (ICRI), Regional Station, Gangtok, under the Spices Board, and the ICAR–AICRP on Spices. It provides comprehensive and practical guidance covering all major aspects of large cardamom cultivation. There is a clear emphasis on integrating productivity enhancement with environmental sustainability and safe production. The recommendations are especially relevant to the unique agro-ecological conditions of large cardamom-growing regions.

I am confident that this publication will serve as a valuable technical resource for large cardamom growers, scientists, extension professionals and field functionaries. I congratulate the scientists and technical contributors from the Spices Board–ICRI, Regional Station, Gangtok, and ICAR–AICRP on Spices for bringing out this useful publication. I hope this guide will translate scientific knowledge into improved field practices and contribute meaningfully to the sustainable development and future growth of the large cardamom sector in India.

D Prasath
Project Coordinator, ICAR–AICRP on Spices
Kozhikode, Keralam

Preface

Large cardamom (*Amomum subulatum Roxb.*) cultivation in India is undergoing significant transformation due to several challenges, including changing climatic conditions, increasing pest and disease pressures, fluctuations in productivity, declining soil health and the need for improved post-harvest management. These developments necessitate the adoption of scientifically sound, locally appropriate and environmentally sustainable production practices.

This manual presents Good Agricultural Practices (GAP) for large cardamom cultivation and incorporates recommendations generated through research, field validation and practical experiences. It covers the major aspects of production, including selection of suitable varieties and quality planting material, propagation, land preparation and planting, shade management, soil and nutrient management, moisture conservation, weed management, integrated pest and disease management, pollinator conservation, harvesting and post-harvest handling. Particular attention is given to the safe and judicious use of agricultural inputs, improved curing, grading and storage practices, and measures to maintain product quality and food safety.

The objective of this manual is to provide a practical reference for farmers, extension personnel and other stakeholders involved in the large cardamom value chain. Adoption of the recommended practices will help improve productivity, enhance produce quality, promote efficient use of natural resources, ensure safe production and strengthen the sustainability and resilience of large cardamom-based farming systems.

The recommendations presented draw upon the research and field experiences of the Indian Cardamom Research Institute, Regional Station, Gangtok, under the Spices Board, and the ICAR–All India Coordinated Research Project on Spices, Kozhikode. Their application may be suitably adapted to local agroclimatic conditions and prevailing field situations.

The authors gratefully acknowledge the contributions and institutional support of scientists, technical personnel, farmers and other stakeholders whose efforts have facilitated the development of these recommendations and the preparation of this manual.

Authors

Disclaimer

The crop production, plant protection and post-harvest management recommendations presented in this publication are based on research findings, field evaluations and technical expertise available at the time of publication. Certain products, active ingredients and management practices included in this document may be based on their demonstrated efficacy under experimental, field or validation studies.

Users are advised to adopt only those pesticides and plant protection products that are approved and registered by the Central Insecticides Board and Registration Committee (CIB&RC), Government of India, for the respective crop and target pest or disease. The latest label claims, recommended dosages, waiting periods, safety precautions and statutory regulations should always be followed.

The inclusion of any product, active ingredient or trade name in this publication does not constitute endorsement by the Indian Cardamom Research Institute (ICRI), or ICAR–All India Coordinated Research Project on Spices. Pesticide registrations and recommendations are subject to change, and users are encouraged to consult the latest notifications and recommendations issued by ICAR, State Agricultural Universities, State Departments of Agriculture and CIB&RC before adopting plant protection measures.

The publisher shall not be responsible for any consequences arising from the use of products or practices that are inconsistent with prevailing regulatory approvals and guidelines.

Table of contents

1. Introduction 10
2. Climate and Soil Requirements 10
3. Soil Health and Moisture Management 11
4. Crop Cultivars and Varieties 11
5. Propagation and Planting Material 13
6. Field preparation and planting 14
7. Mulching 14
8. Shade Management 14
9. Irrigation Management 15
10. Nutrient Management 15
11. Soil Testing 16
12. Weed Management 16
13. Intercultural Operations 16
14. Insect Pests and their Management 16
15. Diseases and their Management 21
16. Abiotic Disorders and Management 26
17. Pollinator Management 27
18. Integrated Pest Management (IPM) 27
19. Harvesting 29
20. Post-Harvest Handling and Processing 29
21. Storage and Quality standard 30
Annexure I. Soil sampling procedure 31
Annexure II. Preparation of 1% Bordeaux Mixture 32
Annexure III. Preparation of Fish Meal Trap 32
Annexure IV. Preparation of Neem Seed Kernel Extract (NSKE) 33
Annexure V. Worker Safety, Hygiene and Safe Use of Agrochemicals 33
Annexure VI. Crop Calendar 34

1. Introduction

Large cardamom *(Amomum subulatum Roxb.)*, belonging to the family *Zingiberaceae*, is a perennial herbaceous spice crop cultivated in the sub-Himalayan region. It is popularly known as the "*Badi Elaichi*" in the Eastern Himalayas. India is the largest producer, importer and consumer of large cardamom globally. It is also the leading exporter of the commodity. During 2024-25, the crop was cultivated in 46617 ha with an output of 9552 MT. The crop is primarily cultivated across the Sikkim Himalayan region- v*iz*., Sikkim, West Bengal (Darjeeling and Kalimpong hills) and North Eastern Hill region, with, Arunachal Pradesh and Nagaland contributing major share of the national output. Large cardamom holds significant economic importance by driving rural farm livelihoods and also generating foreign exchange.

The crop is valued mainly for its dried capsules and seeds. The capsules contain about 1.5- 3.0 per cent essential oil and the capsules are used as a spice and flavouring material in rice preparations, meat and meat-based foods, sweets, beverages and masala preparations. The crop also has uses in traditional medicine and other value-added products.

The adoption of Good Agricultural Practices (GAP) is essential for ensuring sustainable, hazard-free, and high-quality large cardamom production. GAP framework coordinates precise soil, water, variety, and input regimes to mitigate biotic stress while preserving biodiversity and enhancing food safety and the value chain.

2. Climate and Soil Requirements

Climate

Large cardamom thrives optimally under the cool, humid sub-tropical mountain ecosystems typical of the sub-Himalayan range. It can be grown successfully from an altitude of 600 m up to 2000 m above mean sea level. The crop grows best at temperature limits ranging between 6–30°C and prefers an annual well-distributed rainfall of 2000–3500 mm. Persistent high relative humidity across the year is ideal. Continuous moisture availability during winter months support vegetative tillering, while clear dry breaks during autumn accelerate uniform capsule maturation.

Soil

The crop grows best in deep, well-aerated soils exceptionally rich in organic matter and humus. It can establish successfully across forest loamy soils ranging from sandy and sandy loam to silty loam and clay, provided exceptional drainage gradients are present. An acidic to nearly neutral soil pH between 5.5–6.0 rich in organic matter and nitrogen, with medium phosphorus and potassium and micronutrient availability is desirable for optimal growth and development of the plant. Water stagnation or waterlogged basins severely degrade root vitality and trigger lethal soil-borne fungal pathogens.

3. Soil Health and Moisture Management

Sustaining soil health across steep, sloping sub-Himalayan contours requires continuous organic replenishment. To maintain the proper pH level, the required amount of liming material must be applied based on regular soil testing. To meet nutrient requirements effectively, apply well decomposed farmyard manure (FYM), vermicompost, and forest leaf mold compost into the soil. Additionally, incorporate permitted organic materials and bio-fertilizers, such as *Azospirillum*, Vesicular-Arbuscular Mycorrhiza (VAM), and Phosphate Solubilizing Bacteria (PSB).

Soil and moisture conservation measures are structurally vital on hilly topography to minimize soil erosion and regulate surface runoff. Adoption of contour terracing, construction of catch pits filled with biomass, and establishment of continuous drainage trenches along slopes can effectively reduce runoff velocity and soil loss. These measures also facilitate proper drainage during intense sub-Himalayan monsoon rainfall, thereby reducing the risk of waterlogging and root-zone saturation. Preservation of natural ground-cover vegetation and application of adequate leaf-mould mulch helps in protecting topsoil, improve moisture infiltration and retention, and maintain soil moisture during the dry winter period.

4. Crop Cultivars and Varieties

The selection of suitable cultivars or varieties forms a fundamental component of Good Agricultural Practices (GAP). Cultivar selection should be based on agro-ecological suitability, particularly elevation, moisture availability, and the prevailing disease-pressure profile of the locality. Large cardamom comprises six prominent traditional cultivars, several less common types, and two released varieties.

Cultivar	General altitude suitability (m amsl)	Salient features
Ramsey	>1515	1.5–2.0 m tall; robust; maroon tillers; narrow leaves; 25–40 seeds/capsule
Ramla	>1515	1.5–2.0 m tall; vigorous; broad, long leaves; dark pinkish capsules with 30–40 seeds
Sawney	975–1515	Widely adapted; robust; bold capsules with 35–50 seeds
Varlangey	>1515 m	1.5–2.5 m tall; robust; 2–3 spikes/productive tiller; bold capsules with 50–70 seeds
Seremna	<975 m	1.5–2.0 m tall; green drooping tillers; 2–3 spikes/productive tiller; 65–70 seeds/capsule
Dzongu Golsey	<975 m	1.0–1.5 m tall; green tillers; narrow erect leaves; bold capsules with 50–70 seeds

High-yielding varieties released by ICRI RRS, Tadong in 2004

Variety	Suitability	Characteristics and yield
ICRI Sikkim 1	1500–1650 m	Selected from Sawney; robust, maroon tillers; bold maroon capsules; 35–50 seeds; average yield -840 kg/ha
ICRI Sikkim 2	975–1500 m	Selected from Sawney; robust; deep maroon tillers; bold maroon capsules; about 45 seeds per capsule; average yield 898 kg/ha



Ramsey



Ramla



Sawney



Varlanegy



Seremna



Dzongu Golsey




ICRI Sikkim 1




ICRI Sikkim 2

5. Propagation and Planting Material

Large cardamom is propagated primarily through vegetative suckers or through virus-free seedlings grown carefully from seed following strict nursery protocols. Vegetative multiplication uses mature, active suckers comprising an established pseudostem with an adjacent young growing tiller and a section of healthy underground rhizome. Suckers must be carefully sourced from verified, disease-free high-yielding elite mother plantations.

Sucker / Seedling rate

The planting material requirement depends upon the Cultivar/ variety, field topography and spacing architecture.

- Standard spacing:1.5 m × 1.5 m
  (Approximately 4,440 suckers ha^{-1})
- For Robust type cultivar like *Ramla, Ramsey, Sawney and Varlangey*: 1.8 m × 1.8 m
  (Approximately 3,086 suckers ha^{-1})
- For non-robust cultivars like *Dzongu Golsey* and *Seremna*: 1.2m x 1.2 m
  (Approximately 6940 suckers ha^{-1})

Sucker and Seed Rhizome Treatment

Before open field planting, suckers must be dipped in 3–5% solution of *Pseudomonas fluorescens* and *Bacillus subtilis* for half an hour.

Transplanting Using Nursery Seedlings

Producing planting material through seed-derived block nurseries ensure virus-free, vigorous planting stocks. Clean, true-to-type seeds are extracted from premium healthy capsules, and sown inprimary raised nursery beds. Upon reaching the 3–4 leaf stage, seedlings are gently uprooted and shifted into perforated poly-bags filled using a mixture of Forest Soil: FYM: Vermi compost in the ratio 1:1:1 and enriched with *Arbuscular mychorrhiza*@ 5g kg^{-1}mixture.

Seedlings are protected under 50% agro-net shade structures with irrigation as and when necessary to ensure sufficient moisture. Poly-bed seedlings become ready for field planting in 10–12 months, developing uniform, robust root-mass networks that minimize field mortality compared to conventional vegetative suckers.

6. Field Preparation and Planting

Field clearing must be selective, ensuring that the beneficial, deep-rooted primary shade trees remain completely undisturbed. Clear the undergrowth and perform 2–3 shallow hoeing rounds across contours to establish a clean tilth without disturbing vulnerable topsoil. Dig standard planting basins measuring 30 cm × 30 cm × 30 cm dimension at least 15–30 days prior to planting. Fill each pit with a rich blend of topsoil mixed with 2 kg of fully decomposed farmyard manure with 0.5 kg of Rock Phosphate and 100 g of decomposed neem cake.

Under rainfed sub-Himalayan situation, field planting operations are carried out during the monsoon showers spanning June – July. For areas where early pre-monsoon showers are received as well as in irrigated valley zones, early spring planting during May is highly recommended. Plant the suckers/seedlings ensuring that soil covers the collar region. Avoid deep planting as it can delay emergence of tillers. Stake the newly planted suckers to prevent lodging under heavy rain and wind.

7. Mulching

Mulching is an important agronomic practice. Mulching at the plant base with easily degradable organic materials is good for conserving both moisture and soil. Mulching can be done during November to March as dry spells are usually experienced during winter period. Dried organic matter, leaves, weeds etc, can be used as mulching materials. Among different moisture conservation practices, surface mulching is effective for retaining higher soil moisture content. Applications of leaf mould as mulching material @ 2.5 kg per clump significantly enhances large cardamom production.

8. Shade Management

Large cardamom is a shade-loving sciophyte that requires a permanent canopy providing 40-50% percent filtered sun light. Cultivation under open condition triggers leaf scorching and affects capsule development while excess shade reduce growth and production. Excessive shade can also make the plant vulnerable to fungal diseases due to excess humidity build up . Establish or maintain shade canopies utilizing indigenous species such as Uttis *(Alnus nepalensis)*, Panisaj *(Terminalia myriocarpa)*, Pipli *(Exbucklandia populnea)*, and Chillouni *(Schima wallichii)*. *Alnus nepalensis* with age upto 15 years is the ideal shade tree due to two major factors. Its symbiotic root nodules fix atmospheric nitrogen and the tree's rapid winter leaf-shed cycle automatically deposits massive volumes of high-quality nutrient-rich organic mulch in the field. Regulate the forest canopy by selective lopping of overhanging branches just before the onset of the monsoon season to optimize sub-canopy air circulation and to prevent excess humidity build-up.

9. Irrigation Management

Large cardamom is predominantly cultivated under rainfed conditions in the sub-Himalayan region; however, maintaining an adequate and consistent soil-moisture regime is essential for optimum growth, flowering and capsule set. Prolonged moisture stress, particularly during the dry period from November to April, can adversely affect flowering and yield. Supplementary irrigation should therefore be provided during moisture-deficit periods at approximately 10–14 day intervals, depending on soil-moisture status, rainfall and water availability. Irrigation may be provided through hoses, sprinklers or small field channels, while avoiding excessive irrigation and water stagnation. In water-scarce areas, rainwater harvesting structures such as *JalKunds*, farm ponds and water-harvesting pits should be established to collect and store monsoon runoff for use during dry periods.

10. Nutrient Management

Large cardamom is a highly exhaustive crop that requires regular nutrient replenishment to sustain long-term economic yields. Nutrient management is essential for sustained growth, flowering and productivity of large cardamom. Nutrient removal varies among cultivars; robust cultivars may remove approximately 10.33 kg N, 1.95 kg P, 26.24 kg K, 19.10 kg Ca and 11.90 kg Mg per 100 kg of dry capsules, whereas *Dzongu Golsey* removes comparatively lower quantities of nutrients. Under organic production, disease-free crop residues should be recycled within the plantation, supplemented with well-decomposed cattle manure/FYM, compost and other permitted organic inputs @ 5 kg plant^{-1} at least twice a year, preferably during April–May and October–November. Vermicompost may be applied @ 1 kg clump^{-1} year^{-1} in two equal doses along with FYM, while mustard cake @ 500 g plant^{-1} once in two years during April–May can also be applied. Before manure application, mulch should be temporarily removed from the plant base and the soil lightly forked in a 15-cm-wide circular band at 30–45 cm from the base of the clump. Manure should be applied along the band, mixed with soil and subsequently covered with mulch to minimize nutrient loss.

Micronutrient Management

For long-term soil health and sustainable production, a dual approach of soil and foliar nutrient application should be adopted to address micronutrient requirements, particularly Zn, B, Mn and Mg, based on soil and plant nutrient status. Soil application of the combined micronutrient treatment with a mixture of $ZnSO_4$ + $MnSO_4$ + $MgSO_4$ (in equal quantities) @ 10 kg ha^{-1} is recommended. For rapid correction of micronutrient deficiencies, a combined foliar spray of $ZnSO_4$ + $MnSO_4$ + $MgSO_4$, each @ 0.5 g L^{-1}may be adopted for proper growth and development. In soils where deficiency of Boron is confirmed, borax @ 2.5 kg ha^{-1} as soil application combined with foliar application of borax 0.5% (5 g L^{-1}) is recommended.

Integrated management through organic nutrient recycling, soil application and need-based foliar supplementation of micronutrients helps maintain soil fertility, improve plant nutrient status and support sustainable productivity of large cardamom.

11. Soil Testing

Regular soil testing is a foundational element of large cardamom GAP. It enables correction of soil pH, nutrient management scheduling for enhancing nutrient use efficiency, prevents from over-application, and reduces production costs. Growers should sample soil every alternate year. Samples should be collected from the active root-zone depth (0–20 cm) following a systematic zig-zag pattern across the plantation. Samples can be submitted to accredited testing laboratories operated by State Departments of Agriculture, ICAR institutes, or Regional Spices Board Research Stations. Detailed sampling guidelines are provided in Annexure I.

12. Weed Management

Effective weed control is critical during the first two years of crop establishment to minimize intense competition for nutrients, light, and root space. Execute 2–3 hand-weeding operations annually depending on weed density. Weeding rounds should be carefully scheduled just prior to manure application and basin mulching. Clean weeding should be done only around the plant bases, while weeds between the rows should be slashed or cut. This selective weed management maintains soil binding protection and minimizes erosion across steep mountain slopes.

13. Intercultural Operations

Intercultural management directly impacts plantation lifespan and annual productivity. Thrashing, removal of old/dry plant parts and phytosanitation should be undertaken regularly as part of plantation maintenance. Aged, diseased and unproductive plants may be removed and gaps replanted where appropriate.

Carry out earthing-up when the roots are exposed, preferably during post-harvest field cleaning. This involves placing loose, fertile topsoil mixed with organic compost around the base of developing clumps, which protects exposed rhizomes, improves root aeration, and accelerates new vegetative tiller formation.

14. Insect Pests of Large Cardamom

There are as many as 23 insect pests found associated with large cardamom. Among them, only a few cause severe economic damage to the plant.

14.1 Leaf-eating caterpillar – *Artona chorista* Jordon

The pest is a major defoliator. Infestation is commonly observed during June–July and October–March. Gregarious larvae feed underneath leaves, causing skeletonization; severe feeding may leave only the midrib. If no management adopted, then it may cause damage up to 30-40 per cent of the crop.



Leaf caterpillar & its infestation

Management

- Collect infested leaves with larvae during June–July and October–December and destroy them.
- Where outbreaks occur, community-level manual collection and destruction can help suppress the pest.
- Natural enemies reported include *Cotesia* sp., *Dolichogenedea* sp., *Medina* sp. and *Bactromyra* sp.
- Neem Kernal Aqueous Extract (NKAE) at 5% + 1% surfactant can deter the pest from feeding. The NKAE has to be applied on both sides of the leaves at 15 days interval during September to November and last week of May to July.
- Application of Spinosad 45% SC at 0.3 ml/l three times in cropping year February–March, June-July and October-November was found to be most effective to manage this pest.
- Application of Neem based oil (Azadirachtin. 0.15% EC) 1500 ppm at 3 ml/l three times in cropping year February–March, June-July and October-November also provides control.
- Alternatively, entomopathogenic fungi viz. *Beauveria bassiana* (1×10^8 CFU/g) at 5.0 ml/l or *Metarhizium anisopliae* (1×10^8 CFU/g) at 5.0 ml/l or beneficial bacteria *Bacillus thuringiensis* var. kurstaki WG (1×10^8 CFU/g) at 2.0 g/l three times in cropping year February–March, June-July and October-November also provides control of this pest.

14.2 Shoot fly – *Merochlorops dimorphus* and *Bradysia sp.*

Severe incidence is generally noted during February–August, especially in 1–3-year-old plantations. Larvae bores into the young shoots and produce a dead-heart symptom. Shoot fly damage may go up to 30-45 percent in nursery stage, mostly in seedling nursery.



Shoot fly larvae & dead heart symptom

Management

- Infested young shoots should be removed at ground level and destroyed.
- Adult shoot-fly can be trapped using fish meal bait and then destroyed (Procedure for preparation of fish meal bait is given in annexure)
- Application of Neem Seed Kernel Extract 5% during new shoot emergence at monthly interval reduces the pest problem. (Procedure for preparation of NSKE is given in annexure)
- Application of Spinosad 45 % SC at 0.3 ml/l three times during February–March, June-July and October- November was found to be most effective to manage this pest.
- Application of Neem based oil (Azadirachtin 0.15% EC) 1500 ppm at 3 ml/l three times February–March, June-July and October-November also provides control.
- Application of entomopathogenic fungi viz. *Beauveria bassiana* at 5.0 ml/l/ or *Metarhizium anisopliae* (1×10^8 CFU/g) at 5.0 ml/l/ or beneficial bacteria, *Bacillus thuringiensis* var. Kurstaki WG (1×10^8 CFU/g) at 2 g/l three times in cropping year February–March, June-July and October- November can also control this pest.

14.3 Stem borer – *Glyphepterix* sp.

Incidence occurs throughout the year, with higher abundance during December–January, March–April, May–June and September–October. Larvae feed on the central shoot and produce dead-heart symptoms. The damage may reach up to 10-15 percent, however recently it is noticed that infestation level reduced drastically.



Stem borer & its infestation

Management

- Infested shoots are to be removed at ground level and destroyed.
- Spraying of 1500 ppm neem oil at 3.0 ml/ lit of water during July-October (at 21 day intervals) is effective.
- Application of Spinosad 45 % SC at 0.3 ml/l three times February – March, June-July and October-November found to be most effective to manage this pest.

14.4 White grub – *Holotrichia* spp.

Holotrichia spp. feed on feeder roots and newly formed rhizomes. Adults emerge following summer showers, while damaging larval stages are active mainly during the rainy season.



White grub and its infestation

Management

- Community-wise collection and destruction of adult beetles during dusk to night (about 6:00–7:30 pm) from May to early July is recommended.
- Light traps @ 1 trap/ha during May to early July may reduce adult beetles to some extent.
- Neem Seed Kernel Extract @ 5 ml/L as drenching during monthly intervals may reduce infestation.
- *Metarhizium anisopliae* (1×10^8 CFU/g) @ 10 g/L or *Beauveria bassiana* (1×10^8 CFU/g) @ 10 g/L at monthly intervals are also effective options; Use only where permitted and according to current product instructions.

14.5 Aphids

Aphids are particularly important as vectors of *Foorkey* and *Chirke* viruses. Species listed include *Pentalonia nigronervosa* f. *caladii*, *Micromyzus kalimpongensis, Rhopalosiphum maidis* and *R. padi.*



Aphids and its infestation

Management

- Remove and destroy virus-infected plants to reduce further spread and aphid sources.
- Monitor alternate hosts, including banana and canna for *P. nigronervosa* and maize for *R. maidis* and *R. padi*; remove and destroy infested alternate hosts where appropriate.
- Neem oil (Azadirachtin 0.15% EC, 1500 ppm) @ 3 ml/L at 15–20 day intervals is recommended.

14.6 Capsule borer – *Jamides alecto* / *Jamides sp.*

Capsule borer is described as an emerging pest whose larvae bore into developing capsules and feed on seeds. Capsule borer may cause damage up to 33.9% and a larva may feed on about 7–9 capsules during its complete development of larval phase.



Capsule borer & its infestation

Management

- Maintain good plantation sanitation and avoid neglected plantations.
- Application of Neem oil (Azadirachtin 0.15% EC, 1500 ppm) @ 3 ml/L at 30 days intervals from flowering to capsule development.
- Application of Spinosad 45 % SC at 0.25 ml/l three times at 30 days intervals from flowering to capsule development.

- Entomopathogenic fungi viz. *Beauveria bassiana* (1×10^8 CFU/g) at 5.0 ml/l or *Metarhizium anisopliae* (1×10^8 CFU/g) at 5.0 ml/l at 30 days intervals from flowering to capsule development.

15. Diseases and their Management

Disease management should emphasize healthy planting material, phytosanitation, appropriate shade, drainage, soil health, moisture management and biological measures, with chemical measures used only as permitted and needed. *Colletotrichum* blight, Phoma leaf spot, leaf streak, leaf rust, *Fusarium* wilt/stem lodging, *Chirke* and *Foorkey* are the major diseases in large cardamom.

15.1 Colletotrichum blight – *Colletotrichum gloeosporioides*

The disease generally appears with pre-monsoon showers during April–May and progresses rapidly during the rainy season, although incidence may begin in winter in some locations. Water-soaked leaf lesions enlarge and coalesce, while sheath and pseudostem lesions may lead to brittleness, lodging and drying of clumps. Diseased spikes may show poor fruit setting or immature seeds.



Blight disease

Management

- Remove diseased leaves, tillers and other plant parts and dispose of them safely away from the plantation. Burial or composting is recommended to destroy inoculum.
- Remove alternate hosts including marigold, *Amomum dealbatum*, canna, wild colocasia and ornamental basil.
- Correct highly acidic soils by liming, maintain organic manure application and provide winter irrigation to reduce plant stress.
- Shade regulation should be carried out in a such a way that at least 50% of direct sunlight reaches the ground in areas where the disease is common
- Pre-treatment of suckers with bioagents like *Pseudomonas fluorescens* and *Bacillus subtilis* at 3-5 litres liquid formulation in 100 litres water

- Application of bioagents like *Pseudomonas fluorescens* or *Bacillus subtilis* as foliar spray and as soil drench after harvest, before onset of monsoon and during monsoon months. Mix 3-5 litres of bioagents in 100 litres of water and apply at 3-4 litres/clump.
- Apply FYM enriched with *Trichoderma* spp. (1-2 kg/100 kg) and neem cake (1 kg/ 100 kg) in soil at the rate of 2 kg/clump. This will reduce soil inoculum of pathogen.
- Apply 1% Bordeaux mixture as foliar spray three times; after harvest, before monsoon (April/May) and after monsoon (September/October), to reduce the disease load.
- Copper oxychloride 50 WP @ 0.3% as spray and soil drench during monsoon at 20–25 day intervals reduce the disease incidence.
- Severely infected gardens may be temporarily converted to other crops for 3–4 years where feasible.

15.2 *Phoma* leaf spot -*Phoma* sp.

Phoma leaf spot has been reported in seedling nurseries in Arunachal Pradesh and on field plants in Sikkim. Water-soaked round lesions coalesce and become yellowish to dark brown and dry out.



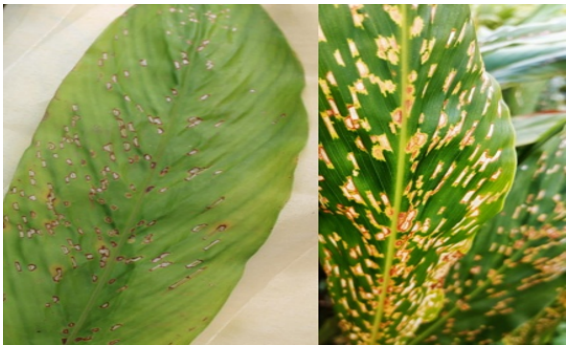
Phoma disease

Management

- Field phyto-sanitation by removal and destruction of disease affected plants or plant parts.
- Provide adequate drainage.
- Spray 1% Bordeaux mixture at 20-25 days interval during rainy season based on disease severity.
- Spray *Pseudomonas fluorescens* or *Bacillus subtilis* liquid formulation at the rate of 3 Litre/100 Litre water.

15.3 Leaf streak – *Pestalotiopsis royenae*

Leaf streak is prevalent throughout the year and can damage foliage, particularly in *Dzongu Golsey*. Translucent streaks occur along veins of young leaves.



Leaf streak disease

Management

- Management includes removal and destruction of severely affected parts and three rounds of 1% Bordeaux mixture at 15-day intervals.

15.4 Leaf rust – *Phakospora elettariae*

Leaf rust mainly affects older leaves and is more prevalent during rainy months. Whitish to brown powdery uredosori occur on the lower leaf surface with chlorotic halo.



Leaf rust disease

Management

- One or two rounds of 1% Bordeaux mixture at 15-day intervals during rainy season.
- Avoid overhead sprinkler irrigation in order to reduce the chance of dispersal of disease causing organism.

15.5 *Fusarium* wilt / dry rot- *Fusarium oxysporum*

Fusarium wilt has been reported from large cardamom nurseries and plantations. Symptoms include wilting, chlorosis, collapse of leaves, vascular discoloration, rhizome and root damage and eventual drying of the clump. Acidic soil, poor fertility and poor plantation management act as predisposing factors.



***Fusarium* wilt disease**

Management

- Correction of soil acidity by applying lime.
- Diseased materials to be properly disposed.
- Provide adequate shade in the plantation.
- Maintain plantation by providing irrigation and apply recommended organic manures.
- Apply *Trichoderma* mixed with FYM (1-2 kg/100 kg) and neem cake (1 kg/100 kg) in soil at 2 kg/clump. This will reduce soil inoculum of pathogen.

15.6 *Chirke* disease

Chirke is a viral disease. The disease is transmitted from infected plants by aphids. Mosaic symptoms with pale-green to yellow longitudinal stripes on young leaves, reduced flowering and progressive yield reduction are the major symptoms.



***Chirke* disease**

15.7 *Foorkey* disease

Foorkey is a viral disease transmitted by *Pentalonia nigronervosa* and *Micromyzus kalimpongensis* and through infected rhizomes. Affected plants produce many stunted shoots, small pale-green leaves and stunted inflorescences with little or no fruiting.



***Foorkey* disease**

Management of viral diseases

- Monitor plantations regularly, particularly during the rainy season, and identify diseased plants early.
- Uproot and destroy diseased plants; chopping and burying infected material in pits or area-level eradication measures where appropriate.
- Never collect planting material from infected gardens or apparently healthy plants from severely infected gardens.
- Establish nurseries approximately 500 m away from the main plantation to reduce aphid colonization.
- Maintain clean clumps by removing old tillers with loosened leaf sheaths where aphids may colonize.
- Inspect plantations before harvest. Implements used to cut diseased plants should not be used on healthy plants without appropriate sanitation; hot-water treatment of implements is recommended before moving to healthy plants.

16. Nematode Pests

Plant-parasitic nematodes have been reported in association with large cardamom in the Sikkim Himalaya. The recorded nematodes include *Meloidogyne incognita*, *Pratylenchus* sp., *Helicotylenchus* spp., *Hoplolaimus* sp., *Tylenchorhynchus annulatus* and *Macroposthonia* spp., with *Helicotylenchus* spp. reported as the predominant group.

Nematode infestation may cause stunted growth, reduced leaf development, chlorosis or yellowing, rosette-like growth, and poor root development with galling or lesions, depending on the nematode species involved. These symptoms may resemble nutrient deficiencies or other soil-borne disorders and should therefore be confirmed through soil and root examination.



Foliar symptoms of nematode infestation

Management:

- Healthy and nematode-free planting material should be used, and nursery beds should be regularly monitored for nematode infestation.
- Well-decomposed FYM, compost and other organic amendments should be incorporated to improve soil health and support beneficial soil microorganisms.
- Where nematode infestation is suspected, soil and root samples should be collected and examined before adopting control measures.
- Biological control agents like *Pochonia chlamydosporia* or *Purpureocillium lilacinum* @ 25 g powder formulation per clump in pre and post monsoon application and organic amendments like neem cake @ 1.5–2.0 t ha^{-1} may be integrated as part of an eco-friendly management programme.

17. Abiotic Disorders and Management

17.1 Frost injury

At high altitudes, particularly above 1500 m, frost injury may occur during December–February when temperatures fall below about 4°C. Symptoms include yellowing, pale-brown discoloration, water-soaked spots, browning and drying of leaves. Damage is more severe in exposed areas.

17.2 Hail damage

Hail during summer showers, particularly March–April, can tear leaf lamina parallel to veins, reduce photosynthesis and create wounds that may be colonized by fungi.

17.3 Sun scorch

Sun scorch occurs particularly in open areas and during summer. Newly unfurled leaves may show yellowing, browning, drying, chlorosis and bleaching.

Management of abiotic stress

- Maintain approximately 50% shade to reduce frost, hail and sun-scorch injury.
- Provide about 50% agro-shade net in sucker and seedling nurseries.
- After damaging weather conditions pass, selectively remove severely damaged tissues.
- Provide irrigation and light manuring to promote recovery.
- Use bioagents where appropriate to prevent fungal colonization through wounds, consistent with product and certification requirements.

18. Pollinator conservation

Bombus breviceps and B. *haemorrhoidalis* are identified as important pollinators at different altitudes, while *Apis dorsata* also contributes to capsule setting. Bumble bees nest in soil and their nests and surrounding habitat should not be disturbed during farm operations.

- Maintain natural vegetation and the microclimate around bumble-bee nesting sites.
- Maintain flowering plants in and around plantations to provide a continuous food supply.
- Undertake weeding in a manner that facilitates movement of pollinators without disturbing nests.
- Avoid unnecessary pesticide applications during periods of intense pollinator activity, particularly during flowering.

19. Integrated Pest Management

Integrated Pest Management (IPM) in large cardamom combines cultural and mechanical and biological tools to control pests while protecting mountain ecosystem health. Key components include planting certified virus-free suckers, executing rigorous field sanitation, conducting soil solarization across nursery beds, lopping canopy shade to regulate sub-canopy relative humidity, and deploying biological control agents like *Trichoderma harzianum* and *Pseudomonas fluorescens* and permissible pest management products based on systematic field scouting and economic injury levels.

Month/ Period	Crop stage / Major concern	Recommended IPM practices
January–February	Winter dormancy; dry-period stress; rhizome/root-zone problems	Maintain soil moisture through need-based irrigation and retain organic mulch. Remove and destroy severely diseased/dried plant parts. Inspect clumps for blight, dry rot and other soil-borne diseases. Maintain drainage and avoid water stagnation. Apply permitted *Trichoderma*-enriched compost/FYM where required.
March	New vegetative growth; emergence of pests and diseases with increasing temperature	Conduct plantation sanitation and remove infected leaves, shoots and debris. Monitor for shoot fly, leaf-eating caterpillars and stem borer. Apply *Trichoderma/Bacillus/Pseudomonas* through recommended organic formulations where appropriate. Maintain optimum shade and avoid excessive canopy humidity.
April–May	Active vegetative growth; pest multiplication; nutrient and moisture stress	Intensify scouting for shoot fly, leaf-eating caterpillars, aphids and capsule borer. Collect and destroy infested shoots and caterpillars where feasible. Apply biological agents such as *Beauveria bassiana/Metarhizium* spp**.** against susceptible insect pests as per approved recommendations. Application of Neem Kernal Aqueous Extract (NKAE) and Spinosad against insect pest. Apply *Bacillus/Pseudomonas* and *Trichoderma* for disease suppression. Provide organic manure/compost and correct confirmed micronutrient deficiencies.
June–July	Monsoon; vigorous growth; high disease pressure. capsule development	Maintain effective drainage and prevent prolonged waterlogging. Regularly inspect for leaf blight, leaf streakand monitor flowering and developing capsules for capsule borer. Remove severely infected plant parts and dispose of them safely. Apply biological antagonists, particularly *Trichoderma*, *Bacillus* and *Pseudomonas*, as appropriate. Monitor for shoot fly, capsule borer and caterpillars; use need-based biocontrol measures and Application of Neem Kernal Aqueous Extract (NKAE) and Spinosad. Avoid unnecessary pesticide applications during periods of heavy rainfall.
August–September	high humidity; pests and diseases; Capsule maturation	Continue surveillance for capsule borer, viral and foliar diseases Remove and destroy infested capsules and severely affected plant parts. Maintain field sanitation and adequate aeration. Use biological control agents and permitted botanicals on the basis of pest/disease surveillance. Avoid excessive irrigation and maintain drainage.
October	Capsule maturation; post-monsoon pest and disease management	Continue surveillance for capsule borer and foliar diseases. Harvest mature capsules promptly and avoid leaving over-ripe or diseased capsules in the plantation. Remove diseased plant residues and maintain sanitation before the dry season. Apply organic manure/compost as recommended and replenish mulch.

November	Post-harvest; onset of dry period	Complete sanitation after harvest. Remove severely diseased clumps and plant residues. Maintain mulching and soil-moisture conservation. Begin supplementary irrigation where required. Monitor rhizomes and roots for soil-borne pathogens and nematodes. Apply permitted biological soil amendments where necessary.
December	Dry/winter period; post-harvest crop maintenance	Continue need-based irrigation at approximately 10–14-day intervals depending on soil moisture and water availability. Maintain mulch and shade regulation. Inspect plants for symptoms of diseases, nematodes and nutrient deficiencies. Avoid unnecessary disturbance of the crop during dry conditions.

20. Harvesting

Large cardamom reaches harvest maturity approximately 210–240 days after flowering. Harvest maturity is indicated when seeds of the topmost capsules in a spike turn brown. Bearing tillers are cut at about 30–40 cm from the ground and left for another 10–15 days for capsules to attain full maturity. Spikes are harvested with a cardamom knife (*Elaichi chhuri*)cutting close to the rhizome base. Harvested spikes should be heaped and capsules separated manually preferably on the same day; separation should not be delayed beyond two days because capsules may become blackish. Based on management practices average fresh yield ranges between 500-2000 kg/ha across different large cardamom growing tract, whereas, with adoption of proper cultivation approaches it reaches up to 4000-5000kg/ha fresh.

Cultivar	**General harvesting period**
Ramsey	October–November
Ramla	October–November
Sawney	August–October; November at high altitude
Varlangey	October–December
Seremna	August–October
Dzongu Golsey	September–October

20. Post-Harvest Handling and Processing

20.1 Cleaning

In order to get good coloured cured produce it is suggested to thoroughly wash harvested capsule in clean running water to remove adhering soil, dirt, and plant debris.

20.2 Curing and Drying (Bhatti Processing)

Fresh large cardamom capsules contain approximately 80- 85% moisture, which must be reduced to 10–12% for safe, long-term storage. Traditional curing uses direct-smoke *bhattis*, which often scorches capsules and diminishes their essential oil quality. GAP strongly recommends adopting modified, indirect-heating ICRI *bhattis* or other modern curing/drying systems. These modern curing systems circulate clean, hot air at a regulated temperature of 45–55°C, preserving the natural pink-purple capsule color and protecting the delicate volatile oil profile from smoke contamination. Curing is completed within 24–36 hours, based on the drying system adopted. Average dry recovery ranges from 18–20% of fresh capsule weight.

20.3 Tail cutting and Polishing

Gently rub dried capsules against mesh screens or process them through mechanical polishing drums to remove loose skin, grit, and calyx remains, enhancing their visual appearance. Complete removal of tail or calyx is an important part of post harvest processing using specialized trimming tools (*Kainchi*) which is specialized scissors.

20.4 Grading

Grading is a foundational pillar of Good Agricultural Practices that transforms highly variable harvests into a standardized, high-value commodity. While traditional trading relies on informal sorting—namely *Badadana* (bold) and *Chhotadana* (small)—GAP mandates systematic separation using precise sieve sizes standardized by Indian Cardamom Research Institute(ICRI)- Spices Board. Capsules are sorted into Extra Bold/*Bada – Dana*(Grade I) retained on >1.5 cm sieves, *Bada Dana* (Grade II) retained on 1.4-1.5 cm sieve, Medium *Dana* (Grade III)retained on 1.3 to 1.4 cm sieve, and *Chotadana* (Grade IV-retained under 1.2 -1.3cm) and Pan grade (Grade V-less than 1.2 cm). Additional distinctions are made based on processing, specifically separating tail-cut (*Kainchi*-cut) pods from non-tail-cut varieties.

21. Storage and Quality Standards

Storage Guidelines

- Fresh Capsules: Freshly harvested capsules can be held temporarily in cold storage at 4–5°C and 75–80% relative humidity for up to 60 days. Capsules should be packed in clean, ventilated crates to avoid moisture condensation and sweating damage.

- Dried Large Cardamom: Pack fully dried, cooled capsules into moisture-proof multi-layer high-density polyethylene (HDPE) bags or laminate-lined gunny sacks. Store packages in clean, dry, well-ventilated storage rooms placed over elevated wooden pallets. Maintain a safe moisture level below 12% to prevent cigarette beetle (*Lasioderma serricorne*) infestations and mold growth. Avoid mixing old and new crops to maintain quality and flavor profiles.

Quality Standards (FSSAI Regulations)

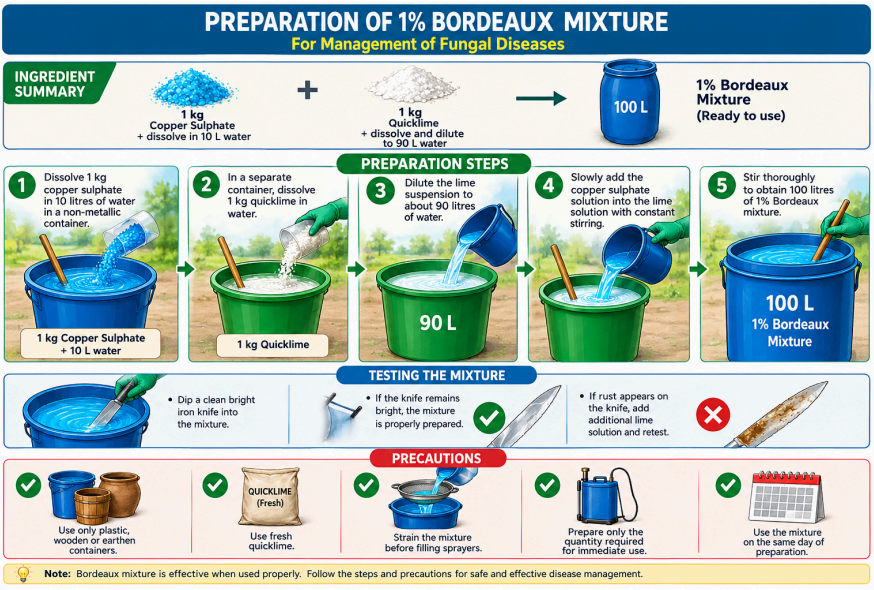
Dried whole large cardamom and derived seed powder must comply with quality benchmarks established by the Food Safety and Standards Authority of India (FSSAI) to ensure safety and market compliance.

S.No.	Quality Parameter / Description	FSSAI Prescribed Value (% by weight)
1	Extraneous Organic Matter	Not more than 1.0%
2	Empty and malformed capsules by count	Not more than 2.0% by count
3	Immature and shriveled capsules	Not more than 2.0 %
4	Moisture Content	Not more than 12.0%
5	Total Ash on Dry Basis	Not more than 8.0%
6	Ash insoluble in dilute HCL on dry basis	Not more than 2.0 %
7	Volatile Essential Oil Content on dry basis	Not less than 1.0 % v/w
8	Insect-Damaged Matter	Not more than 1.0% by count

Annexure I. Soil Sampling Procedure

1. Field Demarcation: Divide the plantation into homogenous blocks based on altitude, slope gradient, management history, and visible soil characteristics
2. Avoid Contaminated Sites: Never collect samples from compost pits, recently fertilized basins, animal shelter tracks, waterlogged channels, or right next to trunk lines.
3. Method of Collection: Clear surface organic litter and forest mulch without removing topsoil. Dig a V-shaped pit exactly 15 cm deep using a clean spade. Slice a uniform 2 cm thick layer of soil from the exposed face of the pit.
4. Composite Preparation: Collect 10–15 similar sub-samples across a zig-zag pattern from each block. Mix the sub-samples thoroughly in a clean plastic bucket. Use the quartering method (flatten the core, divide into four quarters, discard opposite halves) repeatedly until the composite sample is reduced to approximately 500 g.
5. Packing and Submission: Shade-dry the final 500 g composite sample completely. Pack it into a clean, dry cloth or polythene bag. Clearly label the bag with the farmer's name, village location, block/field number, altitude, and crop age, and submit it to an accredited regional soil testing facility.

Annexure II. Preparation of 1% Bordeaux Mixture



Annexure III. Preparation of Fish Meal Trap



Annexure IV. Preparation of 100 litres of 5% Neem Seed Kernel Extract (NSKE)



Annexure V. Worker Safety, Hygiene and Safe Use of Agrochemicals

1. Operational Training: Ensure all plantation workers are properly trained in safe handling of agrochemicals, personal hygiene protocols, and emergency first-aid measures for chemical exposure.
2. Personal Protective Equipment (PPE): Workers must wear appropriate PPE, including rubber gloves, protective overalls, face masks, and rubber boots, during pesticide preparation and application.
3. Secure Storage: Store all chemical inputs in their original labeled containers within a secure, locked storehouse. Keep chemicals far away from food, animal feed, and domestic water sources.
4. Triple Rinsing: Triple-rinse empty pesticide containers, puncture or crush them to prevent reuse, and dispose of them safely at designated collection points away from mountain streams and habitation.

Annexure VI. Crop calendar

Period	Major activities
January–February	**Nursery:** regular watering according to moisture; remove mulch when about 25% germination is observed and erect shade; control nursery pests/diseases promptly; weed as needed. **Plantation:** after harvest, compost dried leaves/shoots rather than using infected material as mulch; mulch plant bases with forest leaves; remove virus-infected plants; collect/destroy leaf caterpillar and stem-borer infested parts; irrigate according to soil moisture.
March–April	**Nursery:** water as required; apply decomposed/powdered cattle manure or organic manure; remove pest/disease affected suckers; weed and fork soil at plant base. **Plantation:** irrigate according to moisture; remove and destroy *Colletotrichum* and viral disease affected plants; prophylactic *Pseudomonas fluorescens* treatment after phytosanitation as specified in the source guide; inspect shoot fly/stem borer; weed to facilitate pollinator movement.
May–June	**Nursery:** prepare new secondary/sucker nursery sites and complete planting; remove affected plant parts. **Plantation:** apply decomposed organic manure if not applied earlier; remove diseased plants; undertake recommended biological/copper/Bordeaux measures as appropriate; remove aged, diseased and unproductive plants; prepare pits for gap filling; plant shade-tree saplings where shade is inadequate and regulate excess shade.
July–August	**Nursery:** mulch with dry forest leaves; remove affected suckers; weed as required. **Plantation:** complete replanting/gap filling in the first fortnight of July; remove virus and blight affected plants; undertake recommended biological/copper measures; inspect caterpillar/stem borer/shoot fly; prepare/repair improved Bhatti; harvest lower-altitude capsules according to maturity.
September–October	**Nursery:** raise overhead shade; mulch; remove affected suckers; weed; prepare primary seed beds and sow seed. **Plantation:** remove disease affected plants; apply recommended bioagents if not already done; inspect pests; capsules mature at higher elevations; repair Bhatti; harvest mature capsules and cure immediately; apply second round of organic manure where appropriate.
November–December	**Nursery:** mulch with forest leaves; irrigate according to soil moisture; remove pest/disease affected material; complete seed sowing and mulching early where applicable. **Plantation:** complete harvest at higher elevations and cure immediately; compost dried leaves and shoots; mulch plant bases; remove virus-infected plants and caterpillar/stem-borer infested parts; irrigate according to moisture.

For Further Information

Project Coordinating Cell
ICAR-All India Coordinated Research Project on Spices (ICAR-AICRPS)
ICAR – Indian Institute of Spices Research
Kozhikode – 673012, Keralam, India
Phone: 0495-2731410
Email: aicrpspices@gmail.com
Website: www.aicrps.res.in