LARGE CARDAMOM GUIDE

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LARGE CARDAMOM
(*Amomum subulatum* Roxb.)

INTRODUCTION

Large cardamom (*Amomum subulatum* Roxb.), a member of the family, *Zingiberaceae* under the order *Scitaminae* is the main cash crop cultivated in the sub-Himalayan state of Sikkim and Darjeeling District of West Bengal. Large cardamom is known to be amongst the oldest spice used by the mankind. In India, it has references of use in Ayurvedic preparations as early as 6th Century BC as mentioned by Susruta. It is used in Ayurvedic and Unani medicines. The seeds contain about 2-3% essential oil, a powerful flavouring agent and are used mainly as spice and for food flavouring. Demand for natural products of flavour and fragrance has been on the rise in food industry, perfumeries, medicines etc., where large cardamom has tremendous potential. It possesses carminative, stomachic, diuretic and cardiac stimulant properties and is also a remedy for throat and respiratory trouble. It is used as a flavouring agent in fried rice, meat and meat based preparations. It has applications in flavouring ice creams, colas, biscuits and liquors.

Area and Distribution

Apart from Sikkim and Darjeeling, large cardamom is also cultivated in some other North Eastern Hill states like Arunachal Pradesh, Nagaland and parts of Uttarakhand. Nepal, Bhutan and Myanmar are the other Himalayan countries where large cardamom is cultivated. Sikkim is the largest producer of large cardamom and constitutes the major share of Indian and world market followed by Arunachal Pradesh, Nagaland and Darjeeling District of West Bengal.

Botany

This semi perennial rhizomatous herb has subterranean rhizomes bearing about 11-15 circular scales along the cross section which are formed after shedding of the leaves. At maturity each rhizome shows a leafy stem with about 13-15 leaves on the apex, whereas the lower or basal scales form the roots. The leafy stem is formed by long sheath like structure encircling one another. Many such rhizomatous leafy sheaths range from 30 to 70 and form a *tussock* or the clump which actually is called a "single plant". The rhizomes mature in about 10-12 months of their emergence where vegetative buds are formed on the middle scales. While on the middle and upper scales, the flower buds differentiate. Usually each rhizome bears one pseudostem and 1-3 flower buds or spikes. The rhizomes usually become dry after bearing the fruits or capsules. The height of the robust leafy stem (pseudostem) ranges between 1.0 and 2.5 m. The leaves are arranged distichously (slightly alternate) and are simple, linear and lanceolate in shape and dark green leaf blade, glabrous on both sides with prominent midrib. The inflorescence is a dense spike on a short peduncle (3-5 cm) with axis (3-6 cm) bearing about 45-50 flower buds appear in an acro-petal sequence. The flowers are medianly zygomorphic, bisexual, epigynous, bracteates and cuspinated. The yellowish perianth (3+3) differentiated in to calyx, corolla and anther crest. All the commercial varieties of large cardamom belong to species, *Amomum subulatum* Roxburgh. Out of the total 150 species of *Amomum* that occur in the tropics of old world only about 8 species are considered native of Eastern sub-Himalayan region *viz*., *A. subulatum* Roxb., *A. costatum* Benth., *A. linguiformae* Benth., *A. paucifloram* Baker., *A. corynostachyum* Baker., *A. dealbatum* Roxb. (*A.sericeum* Roxb.), *A. kingii* Roxb. and *A. aromaticum* Roxb. Cultivated large cardamom (*Amomum subulatum* Roxb.) along with the occurrence of seven wild species makes this plant native to Sikkim.

The flowering season begins early in the lower altitudes with peak flowering during March-April, while it is late in the higher altitudes with a peak period during June-July. The fruit is a trilocular,

many seeded capsule. The capsule wall is echinated having reddish-brown to dark-pinkish to maroon colour. The seeds are di-angular, whitish when immature and become dark-greyish towards maturity. Usually the capsules which are formed at the basal portion of the spike are bigger and bolder than others.

Climate

Large cardamom, a shade loving plant (sciophyte), has its natural habitat in the humid subtropical semi-evergreen forests of mountainous sub-Himalayan region. It grows well in the altitudes of 600-2000 m MSL receiving annual rainfall of 2000-3500 mm apportioned over 200 days. Cloudy conditions prevail for most of the monsoon period. The lower altitudes of cooler zones (proximal to the snow-line) and higher reaches of the warmer zones are best suited for its growth. Large cardamom belts experience mean annual ambient temperature range of 6°C (December-January) and 30°C (June-July) accompanied by constant high relative humidity. Continuous rain during flowering is detrimental, as it hampers the foraging activity of pollinating bees, thus affecting the flowers and resulting in poor capsule setting and barren spikes. Plants remain dormant during severe winter and can withstand up to 2°C but frost and hailstorm are injurious to large cardamom.

Soil

Large cardamom is generally grown in forest loamy soil having depth of few centimeters to several inches. Colour of large cardamom soil ranges from brownish yellow to very dark greyish brown. Texture varies from sandy, sandy loam, silty loam to clay. In general, large cardamom soils are acidic in nature and majority of soils have pH ranges from 5.0 to 5.5 and more than 1% organic carbon content. On an average, these soils have high available Nitrogen and medium Phosphorus and Potassium. Steepness of the terrain reduces chances of water logging and water-logged conditions are not suitable for the plants hence, adequate drainage is quite essential for the better stand of the crop.

CROP CULTIVARS AND VARIETIES

There are mainly six popular cultivars of large cardamom viz., Ramsey, Ramla, Sawney, Varlangey, Seremna and Dzongu Golsey. Several others which are not so popular include Chivey, Gardo Seto Ramnag, Madhusey, Seto Golsey, Slant Golsey, Red Sawney, Green Sawney and Mingney.

1. **Ramsey:** It is well suited to high altitudes (1515 m MSL) and can be cultivated even in steep slopes. The cultivar is identified by the maroonish colour of the tiller and narrow leaves. Plants are 1.5 to 2.0 m tall, robust with large number of tillers. Flowering starts in May and crop is ready for harvest by October – November. Capsules are smaller in size with 25 - 40 seeds.

2. **Ramla:** Plants are 1.5 to 2 m tall and vigorous like Ramsey. Colour of tillers resembles that of Ramsey and the leaves are broad and long, capsules are dark pinkish in colour with 30 - 40 seeds. Cultivation is restricted to few high altitude areas in North Sikkim. Flowering commences in May and the crop is generally ready for harvest in October.

3. **Sawney:** It is a widely adapted cultivar, which is most suited to medium (975 – 1515 m MSL) and high (> 1515 m MSL) altitude areas. Plants are 1.5 to 2.0 m tall, robust in nature, leaves are ovate and broad and the colour of tiller is similar to Ramsey. Capsules are bigger and bold with 35 - 50 seeds. Flowering starts from March to May and harvest begins in September – October, sometimes extends up to November in high altitude areas.

4. Varlangey: It is found to grow in mid and high altitude (> 1515 m MSL) areas. Its yield performance is exceptionally high at high altitudes. Plant height is 1.5 - 2.5 m, robust type and resembles Ramsey with narrow leaves having wavy margins. The productive tiller and spike ratio is relatively high in this cultivar. Capsules are bold with 50 - 70 seeds. Flowering starts in May at medium altitudes and during June - July at high altitudes. Consequently, harvesting is delayed up to the end of November in high altitudes.

5. Seremna: The cultivar is grown in a small pocket of the Hee-Gaon, West Sikkim at low altitude (< 975 m MSL) and is known for its high yield potential. Plants are 1.5 to 2.0 m tall, tillers are green and leaves are mostly drooping type, hence named as 'Seremna'. On an average 2 - 3 spikes in each productive tiller with average 10 capsules in each spike and 65 - 70 seeds per capsules are recorded.

6. Dzongu Golsey: It is suitable to areas below 975 m MSL and is very specific in Dzongu area of North Sikkim. The plant height is 1.0 to 1.5 m and not as robust like other cultivars. Unlike Ramsey and Sawney, the tillers are green in colour and the leaves are narrow and erect. Capsules are big and bold and contain 50 - 70 seeds. Flowering starts in March and harvesting is done in September – October.

High yielding Varieties: Indian Cardamom Research Institute, Regional Station, Spices Board Tadong released two high yielding varieties in the year 2004 for cultivation in Sikkim and Darjeeling. These two varieties *viz.* ICRI Sikkim 1 and ICRI Sikkim 2 are selection from the cultivar Sawney.

(1) **ICRI Sikkim 1:** This variety is well suited to medium (1500 m MSL) to high (1650 m MSL) altitudes. Plants are robust in nature and leaves are ovate and broad. Tillers are maroon in colour. 60% of spike bears 14 capsules in a 5 years old plant. Capsules are maroon in colour, bold and 80% capsules are more than 2.2 cm in length and 2.0 cm in diameter and with 35-50 nos. of seeds. Average yield is around 840 kg/ha.

(2) **ICRI Sikkim 2:** This variety suited to medium (1500 m MSL) altitude. Plants are robust in nature and leaves are ovate and broad. Tillers are deep maroon in colour. 60% of spike bears 15 capsules in a 5 years old plant. Capsules are also maroon in colour, bold and 70% capsules are more than 2.7 cm in length and 2.2 cm in diameter and with an average 45 nos. of seeds. Average yield is around 898 kg/ha.

PROPAGATION

Propagation of large cardamom is mainly done through seeds and suckers in field level. However, tissue culture techniques also used for propagation now a days.

The propagation through seeds enables production of large number of seedlings. Virus diseases are not transmitted through seeds and therefore, the seedlings are free from viral diseases, if adequate care is taken to isolate and protect the nursery from fresh infection. Plants raised from seeds are necessarily not high yielders even if they are collected from very productive plants due to cross-pollination.

On the other hand, producing planting material through suckers ensures true to the type/parents with a high productivity if they are collected from high yielding, disease free plants. This techniques produce sucker ready for field planting in next season itself. But there are chances of transmission of viral diseases if suckers are taken from diseased plantation.

Tissue culture technique though produces true to type and large number of plants it require high expertise and investment so this is not so popular till date.

Propagation through seeds

Seeds are collected from high yielding and well-maintained plantation free from diseases. Well matured capsules from bottom and middle position of the spikes are selected for extraction of seeds. After de-husking, seeds are mixed and rubbed with fine sand and then washed with water to remove the mucilage completely. Once the water is completely drained, the seeds are mixed with wood ash, dried in shade and sown in the primary nursery.

Mature capsules & seeds

PRIMARY NURSERY

Seeds are generally sown in September - October. Seed beds are prepared in well-drained soil dug to a depth of 30 cm and left for weathering. Raised beds with 15 to 25 cm height, 1 m width and convenient length, preferably 6 m, are prepared. Well decomposed cattle manure is mixed with the soil and the surface of the bed is made to fine tilth. About 80 – 100 g of seeds per bed is sown in lines across the bed at a distance of 10 cm. Seeds are covered with fine soil and mulch with rice straw / dry grass (10 – 15 cm thick). Watering is done at regular intervals to keep the surface of the bed moist. Germination of acid treated seeds commences after 25 to 30 days of sowing. When average germination is noticed the mulch materials are removed. The inter space between rows is then re-mulched with chopped rice straw. Shades are immediately erected by using bamboo mats / reed mats or agro-shade nets. The beds are watered regularly and weeding is done as and when required. When the seedlings attain 3 to 4 leaf stage, they are transplanted to secondary beds / nursery.

Seed bed

Seeds covered with rice straw

Watering the seed bed

Germination in the bed

SECONDARY NURSERY

Secondary nurseries can be prepared in poly bags or in raised secondary beds.

Poly bag nursery: polythene bags of size 15 X 15 cm with perforations at the base are used for planting the seedlings from the primary nursery beds. The bags are filled with potting mixture of soil, sand and cow dung in the ratio of 4:1:1. The bags filled with the mixture are arranged in row of one metre width and in convenient length under shade. Seedlings with 3 - 4 leaves are planted in the poly bags in April - May and watered regularly. They become ready for field planting in 10 to 12 months.

Poly bag nursery

Raised secondary beds: Beds of size 15 cm in height and 10 m width with convenient length are prepared and well decomposed cattle manure is mixed with the soil and an even surface is formed. Seedlings with 3-4 leaves are transplanted to the beds in May - June at spacing of 15 cm between them. The inter space is mulched with chopped rice straw or dry leaves. Overhead shade is erected for providing cover and the soil is kept moist with irrigation. The seedlings on attaining height of 45-60 cm with 2-3 tillers are planted in the main field during June - July of the subsequent year.

Secondary nursery

Propagation through suckers

The suckers collected from high yielding disease-free, elite plantations having one mature tiller with one or two immature tillers or vegetative buds is used as planting units.

Selection of planting material

- High yielding disease free plantations to be selected.
- The plantation should be have high yield record *i.e.* more than 800 kg / ha for at least 3 consecutive years.
- One mature tiller with two immature tillers or vegetative buds is used as planting unit.

Site of nursery

- The nursery should be about 500 metres away from the main plantation to avoid occurrence of pests and diseases due to vector movement.
- The irrigation facility should be available.
- It should be easily accessible by road.

Preparation of trenches

- The trenches should be of 45 cm (1½ ft.) width and 30 cm (1 ft.) depth with convenient length and may be made across the slopes of the field.
- Top soil 15 cm (½ ft.) to be kept separately from the trench on the upside.
- Lower side 15cm soil to be forked thoroughly.
- Dried leaves to be first applied as layer in the trench.
- Then the trench to be filled with top soil mixed with cow dung compost.
- Spacing of 30 cm is required in between two trenches.
- The planting units to be planted at spacing of 45 cm (1½ ft.) in between with proper staking.

Preparation of trenches

Planting in trenches

Planting season

- Last week of May to June.

Maintenance

- Thick mulching with dry leaf/grass may be applied at the base of plant and watering may be done during November to March depending on the soil moisture condition.
- Well decomposed cattle manure may be applied.
- The plot may be maintained with 50% shade under shade trees or using agro shade net.
- The disease and pest incidence to be monitored from time to time. Disease affected plants to be uprooted and destroyed outside the sucker nursery.
- Minimum of five planting units could be obtained from a single plant with proper management.

Large cardamom sucker nursery

PLANTATION ESTABLISHMENT AND MANAGEMENT

Selection of site

Large cardamom grows well in forest loamy soils with gentle to medium slopes. Luxuriant growth is observed in nearby perennial water sources. However, water logged condition is detrimental to the plants. It performs well under partial shade (50%). *Alnus nepalensis* (*Utis* in Nepali) is the most common shade tree. *Alnus nepalensis* (Himalayan alder) - large cardamom is very good agro-forestry system for sustainable production in the region.

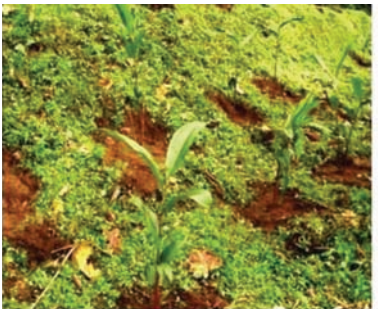
Soil type: Deep, well-drained soils with loamy texture, medium availability of phosphorus and potash, and pH 5.0-5.5 are best suited. Usually the soil is rich in organic matter and nitrogen as the plants are cultivated under older trees and other local varieties of trees.

Land preparation

The land selected for planting is cleared of all the under growth, weeds etc. before on set of monsoon. Old large cardamom plants, if any may also be removed Pits of size 30 cm x 30 cm x 30 cm are prepared on contours at a spacing of 1.5 m x 1.5 m from the centre of the pits. Wider spacing of 1.8 m x 1.8 m is recommended for robust cultivars like Ramla, Ramsey, Sawney, and Varlangey etc. while closer spacing 1.2 m x 1.2 m is advised for non-robust cultivators like Dzongu Golsey, Seremna etc. Pits are left open for weathering for a fortnight and then filled with topsoil mixed with cow dung compost/FYM @ 2-3 kg per pit. Pit making and filling operation should be completed in the third week of May before the onset of pre-monsoon showers.

Planting

Planting is done in June-July in Sikkim and Darjeeling. In Arunachal Pradesh planting is done in the month of May when there is enough moisture in the soil. A mature tiller with 2-3 immature tillers/ vegetative buds is used as planting unit. Quality planting material is to be raised in the nurseries or collected from certified nurseries for better production. Suckers/seedlings are planted by scooping a little soil from the centre of the pits and planted up to collar zone. Deep planting should be avoided. Staking is needed to avoid lodging from heavy rain and wind and mulching is done at the plant base.



Planting

Staking the plants

Organic nutrient management

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 @ 5 kg/plant at least twice a year in April-May and August-September is beneficial. Vermicompost, having favourable impact on soil physical properties and good source of nutrients, particularly in the beds is gradually becoming popular organic manure and 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.

Plant base cleaned before application of organic inputs / bioagents

Application of manure at plant base

Mulching and soil management

If the land is not terraced the soil base may be made by cutting the top soil from the upper half and placed on the lower half followed by mulching. Mulching at the plant base with easily degradable organic materials is good for conserving both moisture and soil. Mulch is well-

known to improve the soil physical condition and fertility. Dried organic matter, leaves, weeds etc. can be used as much.

Mulching at plant base

Weed management

Weed control in the plantations is the important operation for maximum utilization of available soil moisture and nutrients by the plants. Three rounds of weeding are required for effective control of weed growth in initial two to three years. Weeding is generally done by using a sickle or by hand depending upon the intensity of weed growth. From around the plant base weeds are pulled out by hand and in inter-space needs only slash weeding with sickle. Clean weeding is not advised as the crop is found to be a good colonizer. While weeding dried shoots and other thrashed materials are used as mulch around the plant base which will help to conserve moisture in the ensuing dry months, cover the exposed roots and prevent weed growth around the plant base. During flowering period, the thrashed materials should not cover the inflorescences.

Plant base weeding

Slash weeding in plantation

Water management

Large cardamom plants cannot thrive well under water stress. In the first year of planting irrigation is required at least once in 10 days during dry months in October to March for better growth thereafter. It is observed that plant growth and productivity is higher in plantations where irrigation is provided. Depending on the availability of water sources hose/sprinkler/flood irrigation through small channels is advised. Water harvesting pits made in between four plants of nearby rows during rainy season can to some extent support the water requirement of the crop in the dry season and is a cost-effective option.

Jalkund

Pit between four plants

Shade management

It is noticed that dense shade or less shade hinders optimum crop growth and production. About 50% shade is found ideal. The lopping of branches of the shade trees to remove excess shade is very important and should be done before the onset of the monsoon during May - June. But simultaneously over-exposure to direct sunlight causes yellowing of leaves. 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 lebbeck* (Siris), *Erythrina indica* (Phaledo), *Eurja tapanica* (Jhingani), *Schima wallichii* (Chilaune) etc.

However, presently in Sikkim, Darjeeling of West Bengal and other areas there is an increasing trend of planting large cardamom in open field without any shade with varying response.

Pollinators of large cardamom

The bumble bees, *Bombus breviceps* and *B. haemorrhoidalis* have been recorded as important pollinators of large cardamom in all the altitudes. These bumble bees are called locally as *Bhomora* (Nepali*)*, *Boom boom Taka* (Bhutia), *Tungboom* (Lepcha) in Sikkim and Tai-Taga (Galo), Ngonia, Tong, Taga (Nyishi) in Arunachal Pradesh.

Bombus haemorrhoidalis

Bombus breviceps

Nest of Bumble bee in soil

Foraging activity of bumble bees is maximum during morning hours on clear days and their activity becomes less or even nil when it is rainy. It is known that *Apis dorsata* plays a positive role on productivity of large cardamom capsule. However, reports suggest that *A. cerana* works as the pollen robber. It is observed that for optimum capsule and seed set a minimum 50 visits by pollinators are required. A well-set spike gives a small pineapple look. When the capsules get mature, the seeds are turned into blackish colour.

Decline of bumble bee population throughout the world is a cause of concern now. There is practice of consuming the adult, brood and also hive of bumble bees by local communities in Arunachal Pradesh. It causes adverse effect in the augmentation of bumble bee population. 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.

PESTS AND THEIR MANAGEMENT

There are as many as 23 insect pests are found associated with large cardamom. But all of them are not causing the 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.

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 lower layer of 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.

Leaf caterpillar damaged on large cardamom & leaf caterpillars

Management:

i) 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.

ii) There are some natural enemies which kill the larvae and pupae of leaf caterpillars. These natural enemies reduce the pest population considerably in the field. Pentatomid bug and syrphid fly larvae are recorded as predators on leaf caterpillars. Two dipteran, *Nedina* sp. and *Bactromyra* sp. and two hymenopteran (*Venturia* sp. and *Nesochorus* sp.) parasitoids are recorded as natural enemies of leaf caterpillars.

2. Stem Borer: *Glyphepterix* sp. (Glyphiperidae: Lepidoptera) is also associated to large cardamom in all the cardamom growing tract.

Seasonal occurrence: Stem borer incidence is noticed throughout the year. But in four periods, December-January, March-April, May-June and September-October their abundance is more.

Nature and extent of damage: The larvae feed on the central portion of the shoot. 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.

Stem borer infestation symptoms

Management:

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

3. Shootfly: Shootfly, *Merochlorops dimorphus* Cherian (Chlororpidae: Diptera), was recorded as a major pest of large cardamom damaging young shoots. Low to moderate damage of shootfly is recorded in large cardamom plantation in all the four districts of Sikkim and Darjeeling District of West Bengal.

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 the top to the bottom resulting in damage of central leaf ultimately leads to death of the tiller.

Shoot fly infestation symptoms

Management:

i) Infested young shoots should be removed at ground level and destroyed.

ii) Adult shoot fly can be trapped using fish bait and then kill.

iii) Application of neem seed kernel extract also reduces the pest problem.

4. 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 away the feeder root of the plants and the infested plant shows yellowing and withering symptoms.

White grub damage symptoms on plant and root

White grub larvae

White grub adult

Management:

i) Collect the beetles using hand nets during peak period of emergence *i.e.,* during April- May and kill them.

ii) 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.

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

I. *Pentalonia nigronervosa* f. *caladii* (Goot) (Aphididae:Hemiptera).

II. *Micromyzus kalimpongensis* (Aphididae:Hemiptera)

III. *Rophalosiphum maidis* Fitch (Aphididae: Hemiptera).

IV. *Rophalosiphum padi* (Lin.) (Aphidadae:Hemiptera)

P. nigronervosa f. *caladii* and *M. Kalimpongensis* are known to be as vectors of '*foorkey*' or virus yellow disease. The aphids colonize at the base (rhizome) of the clump and if population is more, they move to aerial portion of the clump. They remain mostly to exposed rhizomes and dried leaf sheaths suck the sap from the pseudostem.

Maize aphids, *Rophalosiphum maidis* and *R. padi* are used to be on the lower surface of the leaves of large cardamom, congregating near the mid-rib and veins. These aphids are known to be the vector of another viral disease, mosaic streak or '*chirke*'.

Management:

The removal and destruction of diseased plants is helpful in control of the disease and in reduction of aphid population.

In some occasion minor pest like hairy caterpillar (*Eupterote* sp) cause considerable loss in cardamom plantation. Other minor pests are mealy bugs (*Planococcus* spp) and thrips (*Heliothrips haemorrhoidalis).*

DISEASES AND THEIR MANAGEMENT

Major threat to large cardamom is the widespread occurrence of fungal and viral diseases causing considerable damage and consequent crop loss in devastating proportions. Diseases affecting large cardamom and their management are dealt herewith in detail.

1. Blight (*Colletotrichum gloeosporioides*)

Colletotrichum blight has devastated the large cardamom plantation and is the cause of concern for severe crop loss and decline in plant population in the recent past.

Causal organism:

Blight is caused by *Colletotrichum gloeosporioides* and its perfect state *Glomerella cingulata*. Lesions on leaf and sheath carry black dots and are rough in its texture. These dots are identified as perithecia of the pathogen.

Epidemiology

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).

Symptoms

Water-soaked lesions appear either at margins or tips or any other point on the leaves which rapidly enlarge, coalesce and cover major portion or the entire leaf lamina giving a blighted appearance. The advancing lesions are blackish brown in color and margins give a yellow halo. In some cases, the entire lamina becomes yellowish and blighted. The affected area becomes necrotic and dry up.

Blight affected plant in the field

Blight symptoms on leaves

Lesion on pseudostem

Pseudostem lodging symptom

Leaf sheath covering the pseudostem show blackish brown discoloration which extends up to rhizomes and subsequently turn into greyish or blackish patches with brown margins. Gradually the pseudostem becomes brittle and breaks in the middle or at the collar regions. In most cases, the lesions on the pseudostem become necrotic as a result the entire leaves dry out giving a burnt appearance. Later, the pseudostem lodges at the point of necrotic lesion. As a whole, the affected clumps and hence, the entire plantation look dried up.

The disease mostly affects the bearing tillers of the clump while the new tillers remain apparently healthy. However, later in the season, in some cases the young emerging leaves of the new tillers in the diseased clump show pale yellow discoloration in the inter-veinal areas. Sometimes the emerging leaves are whitish in colour and droop without opening properly. Slight yellowing and narrowing of emerging leaves are also noticed and in some cases the pseudostem break open longitudinally in the middle and the young leaves emerge through the opening. Examination of the rhizomes of such tillers showed brown lesion with air space in the middle.

The spike from the diseased clump exhibit elongated appearance in comparison to the spike from the healthy clump and this is mainly due to lack of fruit setting. However, in other cases, flowering and seed-setting takes place but the seeds do not mature and remains whitish or light brown instead of natural black. Generally the roots are not infected. In the cultivar Varlangey the newly formed tillers in the diseased clump show pale yellowing and rosetting of leaves giving a stunted appearance as compared to the healthy plants.

Collateral hosts:

14 species of plants belonging to various families showed symptoms similar to *Colletotrichum* blight. Some of them are marigold, *Amomum dealbatum* (*Churumpa*), canna, wild colocasia, ornamental basil, *Alnus nepalensis* etc.

Blight Management:

It must be kept in mind that high disease pressure exists in the large cardamom ecosystems which has developed over the last few years in the absolute absence of management practices either developed or followed. Moreover, Sikkim being an organic state, only

eco-friendly and non-chemical measures can be adopted. It is observed that, generally, the bearing and old tillers are cut and spread around the plant base during the harvesting time. Since bearing tillers (old tillers) are the infected ones with plenty of lesions and sporulation all over, they serve as the inoculum in the next season. Hence, the disease perpetuates in the subsequent season resulting in greater devastation and crop loss. In this context, reducing the initial disease pressure is an unconditional pre-requisite before undertaking any management practice.

Considering this aspect, the following approach is suggested that would help tackle the problem systematically. The mature and bearing tillers cut during harvesting must be composted. Even the leaves and residue of spikes must also be composted. During the composting process, temperature increase and most pathogens are killed. Compost pits for the purpose may be made at convenient places in each plantation prior to harvest. Use of EM (Effective Microorganisms) solution or cow dung slurry may be encouraged for easy composting. If this is followed at least for 2-3 years, the adoption of other management practices such as application of bio-control agents or permissible chemicals etc. would give better results. The tillers cut during harvest and other plant debris can also be burnt, wherever possible for safe disposal. However, burning is not permitted under organic norms. As a third alternative, the plant debris generated during harvest can be chopped into small pieces and buried in pits for quick decomposition.

Most of the cultivars were found susceptible to the disease under natural conditions. The disease can be managed by the following methods.

- Proper phyto-sanitation by removal and destruction of disease affected plants/plant parts in the plantation and nursery.
- Pre treatment of suckers with bio- agent *Pseudomonas fluorescens* @ 5 lit in 100 lit water or Copper oxychloride @ 0.3% (*i.e.* 300gm in 100 lit water) at the time of planting in nursery/ field.
- Destroy the collateral host plants such as Marigold, *Amomum dealbatum* (*Churumpa*), Canna, wild Colocasia, ornamental Basil etc.
- Regulate shade in thickly shaded areas and also ensure proper shade in open conditions.
- Apply bio-control agent *Trichoderma* mixed with FYM (1:100) @ 2kg /clump at plant soil basin.

- Prophylactic spraying and drenching of *Pseudomonas fluorescens* @ 3-4 litre per clump during April last week or May 1st week. Repeat the application again in August & September (mix 3-5 litres of the bioagent in100 litres of water).

Or

Application of 1% Bordeaux mixture as prophylactic spray before onset of monsoon and after monsoon. Spray and drench 0.3% (*i.e.* 300 gm in 100 litre water) Copper oxychloride (50% WP). Three sprays at 20 - 25 days interval may be given based on disease intensity. If the soil is drenched with Copper oxychloride or spray Bordeaux mixture, bioagents should be applied only after15 days interval. Avoid mixing Copper fungicides with biocontrol agents.

2. *Phoma* leaf spot disease

Leaf spot caused by *Phoma* was found to be of serious concern in the seedling nurseries in Arunachal Pradesh and field plants in Sikkim.

Symptoms

Numerous water-soaked lesions, round in shape appear on the lamina which coalesce and become yellowish and dry out.

Initial symptoms on leaves

Phoma leaf spots affected plant in the field

Epidemiology

Rapid 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.

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 days based on disease severity.

3. Leaf streak disease (*Pestalotiopsis royenae*)

It is prevalent round the year and results in considerable damage to foliage in variety Golsey.

Symptoms

The disease symptom is the formation of numerous translucent streaks on young leaves along the veins. The infection starts from emerging folded leaves .

Leaf streak disease

Management

- Three rounds of 0.2% Copper oxychloride (i.e, 200 g in100 lit water) or 1% Bordeaux mixture at 15 days interval can control the disease.

4. *Chirke* disease

The corn aphid *Rophalosiphum maidis* is one of the prevalent insect-vectors of the disease. Primary spread of the disease from one area to another is through infected rhizome and further spread within the field takes place by contaminated farm implements and aphids.

Symptoms

- The disease is characterized by mosaic appearance on leaves.
- The symptom is more prominent on young emerged leaves where discrete pale green to yellow longitudinal stripes running parallel to each other can be seen.
- The above symptoms are masked on mature leaves.
- The flowering is greatly reduced, gradually reducing the yield over the years. The disease is caused by virus and transmitted through insect vector and mechanically through sap.

Symptoms of *chirke* on new leaves

5. *Foorkey* disease

The causal agent of the disease is virus which is not transmitted mechanically through sap but through vector, *viz*., banana black aphid, *Pentalonia nigronervosa* and *Micromyzus kalimpongensis*. It is transmitted in a persistent manner, means the virus can survive inside

the aphid for a long time after acquisition feeding on infected plants. The virus also spread primarily through infected rhizomes.

Symptoms

- The affected plants produce many stunted shoots which fail to produce flowers.
- The leaves become small, lightly curled and pale green in colour. Sometimes, slightly broadened leaves resembling pan is also seen.
- The inflorescence becomes stunted, thereby producing no flowers and fruits.

Symptoms of *Foorkey* affected large cardamom

Management of viral diseases

Viral diseases affected 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 sheath so that aphids will not colonize.

6. During plantation monitoring, especially prior to harvesting, 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.

INTEGRATED PEST AND DISEASE MANAGEMENT (IPM) SCHEDULE FOR ORGANIC LARGE CARDAMOM PRODUCTION

Month	Operation	Target pests / pollinators
January–December (Through out the year)	• Monitoring of plantations at 15 days interval to identify *chirke* and *foorkey* infected plants for removal and destruction by burning/deep burring outside the plantation. • Thrashing and phyto-sanitation. (Depending on pest incidence)	• Aphids and viral diseases (*chirke* and *foorkey*) (To make large cardamom plantation virus and pest free)
March – May	• Weeding in large cardamom plantations during flowering period will facilitate foraging of pollinators. • Phyto-sanitation by collecting blight infected leaves, caterpillar infested leaves and destroy them by burning/deep burring outside the plantation. • Application of copper oxychloride (0.3%) as spraying and drenching in plantations after phyto- sanitation. • Application of bio-control agents and botanicals as basal drenching and foliar spray (Two to three applications at monthly intervals)	• Pollination by bumble bees/ honey bees and conservation of bumble bee nests in the soil. • *Colletotrichum* blight • Leaf caterpillar(*A. chorista*),
June – July	• Phyto-sanitation by collecting blight infected leaves, caterpillar infested leaves, uprooting of viral infected plants and destroy them by burning/ deep burring outside the plantation.	• *Colletotrichum* blight • Leaf caterpillar (*A. chorista*), • Viral diseases (chirke and *foorkey)*
August – December	• Weeding, covering of spike with dried leaves and small branches of trees • Trashing and phyto-sanitation. Application of bio-control agents and botanicals as basal drenching and foliar spray.	• Mammalian pests • Colletotrichum blight, • Leaf caterpillar (*A. chorista*), • Viral diseases (*chirke* and *foorkey*)

HARVESTING AND CURING

The indication of time of harvest is when the seeds of top most capsules turn brown. As soon as the said colour appears and to enhance maturity bearing tillers are cut at a height of 30 – 40 cm from ground and left for another 10 – 15 days for full maturity. The spikes are harvested by using special knives known as "Cardamom-knife" (*Elaichi chhuri*).

Cutting of bearing tillers

Elaichi chhuri

Harvesting begins early in the lower altitudes, during August-September and is as late as November-December at higher altitudes. The average yields range from 100 to 400 kg/ha.

Mature spikes

Mature capsules

Cultivar	**Harvesting time (in general)**
Ramsey	October
Ramla	October
Sawney	September – October (November in high altitude)
Varlangey	October - November
Seremna	October
Dzongu Golsey	September – October

CURING OF LARGE CARDAMOM

The quality of large cardamom is governed by its external appearance, which is influenced by colour, uniformity of size, shape, consistency and texture and flavour, which ascertains taste and odour and is affected by composition of aromatic compounds. Appearance provides a visual perception of co-uniformity in size, shape, consistency. The essential oil contains the volatile principles such as 1:8 cineole (75-85%), a-bisabolene (3-6%), r-terpinene (4-8%), a-terpineol + a – terpinyl acetate (3-6%) also the B-myrcene, nerolidol, pinene, thujene etc., are known in traces. Cineole contributes to the pungency while a-terpinyl acetate towards pleasant aroma.

The harvested spikes are heaped and capsules separated and dried. The cured capsules are rubbed on wire mesh for cleaning and removal of calyx (tail).

The fresh capsules are fleshy with almost 85% moisture. Their keeping quality is poor and is highly perishable. They are cured or dried to about 10-12% moisture on dry weight basis to prolong its shelf life.

Cardamom is cured (i.e., dehydration of the fruits over low sustained heat) in a curing furnace, the heat invariably coming from burning of wood fuel. Traditionally, locally made furnace, the "*Bhatti*", crude and primitive in operation, is a stone-mud structure, cheap to erect and moderately efficient where capsules are dried by direct heating. Considerable loss of quality characteristics is seen with the *bhatties*, yet, they are common in the entire cardamom belt. The colour of the capsules turned to black due to direct heating and smoke.

Local Bhatti

Local bhatti cured cardamom

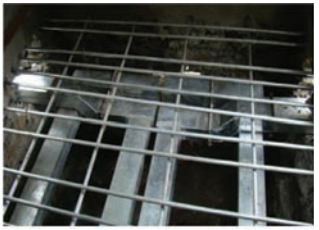
For good market value, the retention of natural colour and flavor constituents is very important. The highly volatile flavor constituents are easily lost because of direct heat and/or high temperature. This necessitates adoption of an appropriate curing method/ system involving indirect heating with an optimum temperature range of 50-55°C, rapid air circulation within an exhaustion of moist air from the drying unit. The unit must be easily maintained and convenient in operation near or in the vicinity of the remote plantations.

Spices Board, Ministry of Commerce, Government of India has attempted for quite some time with improved and scientific "curing unit" based on hot-air flue indirect heating system but the traditional *Bhatti* still used to some extent.

ICRI improved Bhatti:

Improved curing techniques are presently available in which cardamom is processed to give quality and appearance. One such method is ICRI *Bhatti* curing system developed by Indian Cardamom Research Institute, Regional Research Station, Tadong where cardamom is dried through indirect heating. The system is available in 200 and 400 kg (fresh capsules capacities), cost is estimated as Rs. 48,000/- and 70,000/-, respectively. This Bhatti has been popularized by the Spices Board Regional Office at Gangtok and Zonal Offices in Sikkim and Kalimpong in West Bengal through subsidized development scheme. In this cardamom is dried by indirect heating at 50-55°C. Curing is done till moisture content of the produce is brought down to 10 -12% and gives metallic sound while shuffling.

ICRI Improved bhatti



ICRI bhatti flue pipes

Drying

ICRI bhatti cured cardamom

GRADING, PACKAGING AND MARKETING

Grading

Farmers are not used to do any grading but in practice there are two grades used to mention *chota dana* and *bada dana*. Grading is mainly done by the trader for their marketing purpose. Trader use different sieves to grade their produce which is not having any uniformity. Indian Cardamom Research Institute, Regional Station, Tadong, Spices Board developed four sieve standardizing the grades for large cardamom. Accordingly five grades of large cardamom based on sieves size standardized.

Sl. No.	Grade Name	Specifications	Grade Name	Specifications ICRI,RS Tadong
1	Badadana	>1.5cm	Extra Bold Hand pick	>1.5cm
2.	Medium Badadana or Goldana	1.3-1.5cm	Medium Bold tailcut	>1.4 but<1.5cm
3.	Chhotadana	1.2-1.3cm	Medium tail cut	>1.3 but<1.4cm
4.	Pan grade or Pan variety	<1.2cm	Chotta tailcut	>1.2 but<1.3cm
5.	-	-	Pan variety or Pan dana tail cut	<1.2cm

Grading Sieves developed by ICRI, Tadong

Packaging and Storage

The properly dried capsules should be allowed to cool and then packed in polythene lined jute bags. The bags may be stored on wooden platform away from sidewall to avoid absorption of moisture and thereby to avoid fungal growth on the stored produce.

Packaging in polythene lined gunny bag

Storage in godown

Tail cutting and Polishing

At farmers' level no one is involved in tail cutting and polishing but to increase the market price trader are doing both tail cutting and polishing of cardamom capsule. Tail cutting is done manually and polishing by machineries.

Tail cutting

Cardamom polishing machine

Marketing of large cardamom

The marketing of large cardamom is controlled by traders and is exclusively in the unorganized sector. It involves a number of intermediaries right from the production centre at the village level to the final consumer – the house hold sector, industry and export clients. In fact, there is an average of three to five intermediaries between the producer and the final consumer.

In order to streamlining the large cardamom market Spices Board India made it mandatory to trader of large cardamom to obtain cardamom trader license from Spices Board and made it mandatory to submit trade details to the Board. Spices Board also initiated large cardamom auction centre at Singtam and Kalimpong by authorizing auctioneer for organized system of sales.

At present, in Sikkim and Darjeeling 45 nos. of large cardamom dealers are available in different local market. Among them important market centre are Singtam, Gangtok, Rongli, Mangan, Jorethang, Naya Bazar, Gyalshing, Rabangla, Sukhiapokhri, Bijanbari & Simana. But large cardamom market in Arunachal Pradesh and Nagaland is controlled from Siliguri which is the major trade centre of large cardamom not only for Indian produce but also for Nepal and Bhutan produce.

Principal marketing centres for large cardamom are Delhi, Amritsar, Kanpur, Mumbai, Calcutta and Hyderabad.

Amritsar, Mumbai and Siliguri besides catering to the local demand, are also the principal exporting centre for large cardamom. Around 10% of the large cardamom is exported. Major importing countries include Pakistan and several countries of Middle East Asia.

CROP CALENDAR

Month	Activities
January **February**	**Nursery** • Regular watering may be done in secondary/ sucker nursery based on available soil moisture in nursery. • In primary nursery if 25% germination is observed, the mulch has to remove immediately and shade pandal has to erect. • If any symptoms of disease/pest infestation noticed it may be controlled immediately. • Need based weeding. **Plantation** • After harvest of the crop, the dried leaves and shoot may be dumped in pit instead of using as mulching material. • The base of the plants may be mulched with forest leaves. • Viral disease (chirke and foorkey) infected plants may be destroyed by uprooting/burial at regular intervals. • Leaf caterpillar/stem borer infested plant parts may be collected and destroyed mechanically. • Regular watering may be done based on available soil moisture in plantation.
March – April	**Nursery** • Regular watering may be done in secondary/ sucker nursery based on available soil moisture in nursery. • Decomposed or powdered cattle manure/ organic manure may be applied in the nurseries for healthy growth of suckers. • Disease/pest infested suckers may be removed and destroyed. • One round of weeding followed by forking of soil at plant base.

	Plantation • Irrigation may be done based on available soil moisture in plantation. • Colletotrichum blight and viral disease (chirke and foorkey) infected plants may be destroyed by uprooting and burial at regular intervals. • Prophylactic spray and drench of Pseudomonas fluorescens (3-5 litre in100 litre water) during April last week after removing blight infected plants (Phytosanitation). • Regular inspections may be carried out to observe shoot fly/stem borer incidence if any, may be hand picked and destroyed mechanically. • One round of weeding may be done for easy movement of bumble bee and honey bee for pollination.
May - June	**Nursery** • Disease & pest affected plant parts may be removed and destroyed. • New site for secondary/sucker nursery has to prepare and planting may be completed. • One year old sucker nursery seedlings ready for planting in main field. **Plantation** • Decomposed cattle manure/organic manure may be applied in the plantation if not applied earlier for sustained production. • Colletotrichum blight and viral disease (chirke and foorkey) infected plants may be destroyed by uprooting/burial at regular intervals. • Prophylactic spray and drench of Pseudomonas fluorescens 3-5 litre in100 litre water – 1st week of May after removing blight infected plants if not applied in earlier. • Spray and drench the plants with copper oxychloride 50% WP @ 1 Kg in 300-400 litre of water/acre.

	• Regular inspections may be carried out to observe caterpillar/stem borer/shoot fly incidence if any, may be hand picked and destroyed mechanically. • All the aged/diseased/un-productive cardamom plants may be uprooted and removed. Line marking, opening pits and filled with top soil/ compost/cow dung so that timely replanting/ gap filling operation can be taken soon after getting rains. • Suitable native shade tree saplings may be used for planting where shade is less and where shade is more it may be regulated by loping the excess shade. • Bordeaux mixture1% as prophylactic spray during onset of monsoon.
July - August	**Nursery** • Nursery bed may be mulched properly with dried forest leaves. • Disease/pest affected suckers may be removed and destroyed. • Weeding may be carried out if necessary. **Plantation** • Replanting/gap filling operation may be completed within 1st fortnight of July if not done earlier. • Colletotrichum blight and viral disease (chirke and foorkey) infected plants may be uprooted and destroyed by burial at regular intervals. • Spray and drench of Pseudomonas fluorescens 3-5 litre in 100 litre water in August after removing the blight affected plants. • Spray and drench the soil with copper oxychloride 50% WP @ 1 Kg in 300-400 litre of water/acre. • Regular inspections may be carried out to observe caterpillar/stem borer/shoot fly incidence if any, may be hand picked and destroyed mechanically.

	• Farmers who are not having bhatti for curing cardamom have to start constructing ICRI improve bhatti before starting of harvest. • In lower elevation capsule start maturing and one round of weeding and threshing may be done. • Harvesting may be carried out based on maturity in August last.
September - October	**Nursery** • Over head pandal may be raised for the nursery opened during May-June. • Nursery bed may be mulched properly with dried forest leaves. • Disease/pest infested suckers may be removed and destroyed. • Necessary weeding may be carried out. • Seed bed/primary nursery bed may be prepared for raising nursery and seed may be sown. **Plantation** • Colletotrichum blight and viral disease (chirke and foorkey) infected plants may be destroyed by uprooting and burial at regular intervals. • Spray/ drench of Pseudomonas fluorescens 3-5 litre in 100 litre water in September if not applied in August after removing the blight affected plants/plant parts. • Regular inspections may be carried out to observe caterpillar/stem borer/shoot fly incidence if any, may be hand picked and destroyed mechanically. • Capsule start maturing in higher elevation and one round of weeding and threshing may be done if not carried out earlier. • Farmers may repair their bhatti for curing cardamom. • Harvesting may be done when capsules are fully matured and curing can be carried out immediately.

	• Second round of application of dried or powdered cattle manure/organic manure may be carried out in the plantation to boost up the production.
November-December	**Nursery** • Nursery bed may be mulched properly with dried forest leaves. • Irrigate the nursery based on available soil moisture. • Disease/pest infested suckers/plant parts may be removed and destroyed. • Seed sowing and mulching has to complete immediately within 1st week of November in the seed bed/primary nursery bed and regular watering may be done based on soil moisture. **Plantation** • Harvesting has to be completed in higher elevation based on maturity and curing may be carried out immediately. • After harvest of the crop, the dried leaves and shoot may be dumped in pit for composting instead of using as mulching material. • The base of the plants may be mulched with forest leaves. • Viral disease (chirke and foorkey) infected plants may be destroyed by uprooting and burial at regular intervals. • Leaf caterpillar/stem borer infestation may be collected and destroyed mechanically. • Regular watering may be done based on available soil moisture in plantation.

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