

# **LARGE CARDAMOM (*Amomum subulatum* Roxb.)**

## **Introduction**

Large cardamom (*Amomum subulatum* Roxb.), a member of the family, Zingiberaceae is the main cash crop cultivated in the sub-Himalayan state of Sikkim and Darjeeling district of West Bengal. Large cardamom is known to be amongst the oldest spice used by the mankind. Sikkim is the largest producer of large cardamom and contributes lion's share to the Indian and world market. Recently large cardamom cultivation has also started in Nagaland, Meghalaya and Arunachal Pradesh.

## **Climate**

Large cardamom, a shade loving plant (sciophyte), has its natural habitat in the humid subtropical semi-evergreen forests of mountainous sub-Himalayan region. The areas under large cardamom cultivation receive annual rainfall of 2000-3500 mm apportioned over 200 days. 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 hailstorms are injurious to large cardamom.

## **Soils**

Large cardamom is generally grown in forest loamy soils having soil depth of few centimetres 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 one per cent 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.

## **Cultivars/varieties**

There are mainly six popular cultivars of large cardamom viz., Ramsey, Ramla, Sawney, Varlangey, Seremna and Dzongu Golsey. Several others include Chivey, Ramsey, Gardo Seto Ramnag, Madhusey, Seto Golsey, Slant Golsey, Red Sawney, Green Sawney and Mingney.

1. **Ramsey:** It is well-suited to high altitude (1515 m amsl ) and can be cultivated even on steep slopes. The cultivar is identified by 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 amsl) and high (> 1515 m amsl) 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 amsl) 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 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.



**Photo – Large cardamom cultivars Sawney (left), Seremna (middle), Verlangey (left)**

6. **Dzongu Golsey:** It is suitable to areas below 975 m amsl 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.
7. **High yielding released varieties:** There are two high yielding varieties released by Indian Cardamom Research Institute in the year 2004 for cultivation in Sikkim and Darjeeling. The various features of these varieties are given in Table 1.

Table 1. Features of high yielding varieties released by Indian Cardamom Research Institute

| Characters               | ICRI SIKKIM 1  | ICRI SIKKIM 2                                   |
|--------------------------|--|---|
| 1. Cultivar              | Selection from Sawney                                | Selection from Sawney                           |
| 2. Morphology            | Robust in nature and leaves are ovate and broad      | Robust in nature and leaves are ovate and broad |
| 3. Tiller / stem colour  | Maroon   | Deep maroon to red                              |
| 4. Capsules / spike      | 10-14 (10.9)   | 10-15 (10.7)                                    |
| 5. Capsule length (cm)   | 1.5-2.4 (2.2)  | 1.6-2.8 (2.7)                                   |
| 6. Capsule diameter (cm) | 1.4-2.4 (2.0)  | 1.6-2.6 (2.2)                                   |
| 7. Seeds / capsule       | 35-50 (42)   | 36-55 (45)                                      |
| 8. Dry yield (kg /ha)    | 800-900  | 800-900   |
| 9. Suitability           | Medium (1500 m amsl) to high (1650 m amsl) altitudes | Medium (1500 m amsl) altitude                   |

*Values in parentheses are means*

## **Field preparation**

Large cardamom grows well in forest loamy soils with gentle to medium slopes. Luxuriant growth is observed close to perennial water sources. However, water-logged condition is detrimental to the plants. It performs well under partial shade (50 %). *Alnus nepalensis (utis)* is the most common shade tree and *Alnus*-large cardamom is the 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)*, *Schima wallichii (chilaune)* etc.

The land selected for planting is cleared of all the under growth, weeds etc. 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, Varlangey etc. While closer spacing 1.45 m x 1.45 m is advised for non-robust cultivators like Dzongu Golsay, Seremna etc. Pits are left open for weathering for a fortnight and then filled with topsoil mixed with cow dung compost/FYM @ 1-2 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 is done in June-July 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 materials are to be raised in the nurseries or to be 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 under heavy rain and wind and mulching is done at the plant base.

## **Propagation**

Propagation of large cardamom is done through seeds and suckers. 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. The major pollinator is bumble bee, even though honey bees also play a role in pollination. On the other hand, planting through suckers ensures true to the type/parents with high productivity if they are collected from high yielding, disease-free plants.

### **(i) Propagation through seeds**

Seeds are collected from high yielding and well-maintained plantations free from diseases. Well matured capsules from the bottom and middle position of the spikes are selected for extraction of seeds. After de-husking seeds are mixed and rubbed with 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.

### ***Primary nursery***

Seeds are generally sown in September-October. Seed beds are prepared in well-drained soils 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 material is 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.

### ***Secondary nursery***

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

***Poly bag nursery:*** polythene bags of size 15 cm 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 meter width and at convenient length under the shades. 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.

***Raised secondary beds:*** Beds of size 15 cm height and 10 cm 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.

## **(ii) Propagation through suckers**

The suckers collected from high yielding (*i.e.*, more than 800 kg/ha for at least three consecutive years) disease-free, elite plantations having minimum of one mature tiller with 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 have high yield record *i.e.*, more than 800 kg/ha for at least three consecutive years.
- One mature tiller with two immature tiller or vegetative buds is used as planting units.

### **Site of nursery**

- The nursery should be about 500 m away from the main plantation to avoid occurrence of pests and diseases.
- 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 15 cm soil to be forked thoroughly.
- Dried leaves to be first applied as layer in the trench.
- Then the trench is 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.

### **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 per cent shade under shade trees or using agro shade net.
- The disease and pest incidence to be looked 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.

### **Selection of site**

Large cardamom grows well in forest loamy soils with gentle to medium slopes. Luxuriant growth is observed nearby perennial water sources. However, water logged condition is detrimental to the plants. It performs well under partial shade (50 %). *Alnus nepalensis (utis)* is the most common shade tree and *Alnus nepalensis* (Himalayan alder)-large cardamom is very good agro-forestry system for sustainable production in the region. The other species of shade trees are *Terminalia myriocarpa (panisāj)*, *Bucklandia* spp. (*pipli*), *Macaranga denticulata (malato)*, *Edgeworthia gardneri (argeli)*, *Viburnum erubescens (asare)*, *Maesa chisia (bilaune)*, *Symplocos* spp. (*kharane*), *Albizia lebbeck (siris)*, *Erythrina indica (phaledo)*, *Eurja tapanica (jhingani)*, *Schima wallichii (chilaune)* etc.

### **Planting**

Planting is done in June-July 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.

Soil base making and mulching: 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 *Alnus nepalensis* (Himalayan alder) and other local varieties of trees. Soil base with gentle slope from the plant is beneficial for application of inputs to the plants viz., FYM, vermicompost, etc. If the land is not terraced, soil base may be made by cutting top soil from the upper half and be 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 improves the soil condition and the soil fertility. Dried organic matter, leaves, weeds etc. can be used as mulching materials.

### **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.

### **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 mulch.

### **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 the dry months of September 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.

### **Shade management**

It is noticed that dense shade or less shade hinders optimum crop growth and production. About 50 per cent shade is found ideal. The lopping of branches of the shade trees is very important and should be done before the onset of the monsoon during June-July. 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. However, presently in Sikkim and other areas there is an increasing trend planting large cardamom in terraces and open fields without any shade with varying response. This is an area of interest for the researchers' *vis-à-vis* crop longevity.

### **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 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.

### **Pollinators of large cardamom**

The bumble bee, *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*) and Tungboom (*Lepcha*). Flowering in large cardamom spikes will complete within 60 days. It is observed that during the initial flowering period (about 20 days from the starting of flowering) in all the altitudes; frequency of visit of *B. breviceps* is more. Later on, in mid and peak flowering period (21-60 days) visit of *B. haemorrhoidalis* is predominant. Each spike bears 40 to 50 flowers and only 10 to 15 capsules set per spike. The flowers remain viable for about 14 hours after opening. Anthesis starts at 8.00 am and ends at 8.30 am on sunny days and from 9.15 to 9.30 am on cloudy and rainy days. The stigma remains receptive for 24 hours on rainy and cloudy days and is limited to 2 hours on sunny days from 1.00 to 3.00 pm only.

Foraging activity of bumble bees is the highest 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. The speculated reason is that the flower adaptations for pollination are the length of the nectar tube and narrow passage in the fresh flower between the anther-stigma column and the labellum which is not accessible to short-tongued bees in large cardamom flowers. The passage does not allow the *Apis cerana indica* to push the anther-stigma column, while entering into the flower. As a result, the small size pollinators fail to touch the anther and stigma, thus are unable to bring about effective pollination. 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. It is known that pathogens infecting honey bees have started spreading to the wild pollinators also. 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.

### **Biodiversity angle**

The discussion will not be complete without a mention of the relationship large cardamom has with the forests. The growth of large cardamom as an undergrowth ensures the maintenance of a good forest cover. In the presence of cardamom, it has been noted that the middle tier is occupied by it in the three-tier forest constitution. In the present context, forests comprise the biodiversity and biologically diverse systems are known to possess greater sustainability. Cultivated large cardamom (*Amomum subulatum* Roxb.) along with the occurrence of five wild species (*A. linguiforme*, *A. kingii*, *A. aromaticum*, *A. carynostachyum* and *A. dealbatum*) makes this plant native to Sikkim. Large cardamom is a cultivated mono culture crop where the issue of agrobiodiversity is a non-issue. Nevertheless, cultivation of this crop has encouraged and supported highly diverse tree components as shade trees (Avasthe *et al.*, 2011). This AFS supported as many as 31 tree species, the diversity index was high (Table 2).

Table 2. Trees species' diversity in the large cardamom-based agroforestry

| System                            | Tree species number | Tree diversity index | Prominent tree species  |
|-----------------------------------|---------------------|----------------------|---|
| Large cardamom-based agroforestry | 31                  | 5.20                 | <i>Alnus nepalensis</i> , <i>Schima wallichii</i> , <i>Toona ciliata</i> , <i>Brassiopsis mitis</i> , <i>Actinodaphne</i> spp., <i>Prunus nepalensis</i> , <i>Ficus nemoralis</i> , <i>Ficus hookeri</i> , <i>Saurauia nepalensis</i> , <i>Casearia glomerata</i> , <i>Juglans regia</i> <i>Castonopsis tribuloides</i> , <i>Engelhardtia acerifoila</i> , <i>Leucosceptrum canum</i> , <i>Lyonia ovalifolia</i> , <i>Maesa chisia</i> , <i>Nyssa sessiliflora</i> , <i>Eurya acuminate</i> , <i>Symplocos theifolia</i> , <i>Acer oblongum</i> , <i>Osbeckia paniculata</i> , <i>Viburnum cordifolium</i> , <i>Litsaea polyantha</i> , <i>Macaranga postulata</i> , <i>Prunus cerasoides</i> , <i>Albizzia lebbeck</i> , <i>Dendrocalamus</i> spp., <i>Bambusa</i> spp., <i>Phyllostachys</i> spp., <i>Grewia optiva</i> , <i>Daphne cannabina</i> |

Source: Avasthe *et al.*, 2011

Many of the tree species mentioned in the Table 2 qualify as multiple use trees for the farmers as fodder, fuel, timber, material for making farm implements, and importantly

the leaf litter is used as bedding for the livestock. These trees species support a variety of avifauna and other wildlife, which professes another dimension in this ecosystem. The diversity index was expectedly higher in the large cardamom AFS.

Further, studies by Spices Board, Regional Research Centre, Gangtok, resulted in enlisting 36 species of herbaceous flora that constituted the ground flora. Some of them like *Dioscorea fibrifuga*, *Artemisia vulgaris*, *Eupatorium* sp., *Lycopodium clavatum* were potential medicinal plants. The ground flora comprised *Dennstaedtia scabra*, *Lysimachia japonica*, *Lecanthus peduncularis*, *Gnaphalium* spp., *Persicaria runcinata*, *P. pubescens* var. *acuminata*, *Dioscorea fibrifuga*, *Viola distans*, *Yongia japonica*, *Selaginella* spp., *Equisetum diffusum*, *Gymnogramme aurita*, *Davallia immersa*, *Angiopteris erecta*, *Gleichenia longissima*, *Ageratum conysoides*, *Artemisia vulgaris*, *Eupatorium* spp., *Cynoglossum wallichii*, *Elstozia strobilifera*, *Rubus ellipticus*, *Chenopodium umbrosum*, *Lycopodium clavatum*, *Aspidium macrocarpum*, *Polypodium wallichiana*, *Pilea glaberrimum*, *Melastoma melabathricum*, *Adenostemma lavenia*, *Selatostema hookerianum*, *Carex indica*, *Diplazium* spp., *Sarcopyramis nepalensis*, *Oplismensus compositus*, *Blumea lacera*, *Cautteya gracilis*, and *Myriactis nepalensis*. The plantations of large cardamom though have the nomenclature of a monoculture, do function in a small way as a refuge for biodiversity also.

## **Pest Management**

### **Insects**

Among the insect pests that attack large cardamom, leaf caterpillar (*Artona chorista* Jordon), tea mosquito bug, shoot fly and stem borer (*Glyphipterix* spp.) are considered as important pests. Aphids are responsible for transmitting viral diseases viz., *chirke* and *foorkey*. White grub is also becoming an important pest and needs attention for their management.

#### **1. Leaf caterpillar (*Artona chorista* Jordon.)**

**Symptoms** It is a major pest of large cardamom in Sikkim and West Bengal. Caterpillars are gregarious in nature (60-200 caterpillars/leaf) and feed on chlorophyll contents on leaf lamina underneath the leaf, leaving transparent epidermis and veins (skeletonization). The damaged portion of the leaf becomes brownish and which can be identified easily. The mature larvae completely defoliate the plant leaving the midrib of the leaves. Defoliation of the plant by the pest affects the yield indirectly.

#### **Management**

- I. Infested leaf can easily be identified from a distance and can be collected along with larvae and destroyed in June-July and October-December. This method is effective

because, caterpillars remain in congregation in clusters; therefore, large numbers of caterpillars can be collected from a single colony, infested leaves can be identified easily by their transparent epidermis and caterpillars are sluggish in nature.

- II. Natural enemies like species of predatory pentatomid bug which can kill 1-3 larvae/day by sucking body fluid or larval parasitoids like *Medina* spp., *Bactromyza* spp., *Venturia* spp., *Mesochorus* spp., *Apanteles* spp. and *Dolichogenedea* spp. have been helpful in naturally controlling the population of leaf caterpillar.



**Photo – Leaf caterpillar**

## 2. **Stem borer** (*Glyphipterix* spp.)

**Symptoms** It is a minor pest but specific to large cardamom. The larvae bore into pseudo stem above collar region and feed on the central portion of the shoot and as a result the terminal 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. The intensity of infestation has been found higher at lower altitudes (about 5 per cent) in Sikkim on seedlings and main plantations

### **Management**

It is a minor pest and can be controlled by removing infested shoots along with caterpillars.

## 3. **Shoot Fly** (*Merchlorops dimorph*)

**Symptoms** - It has been recorded as a major pest of large cardamom damaging young shoots recorded throughout the year in growing tracts. The tip of the shoot becomes brown and later whole shoot dries up causing 'dead heart' symptom. Single, pale glossy white larva bores the young shoot and feeds on the central core

of pseudostem from the top to the bottom resulting in its death. The mature larva measures 8-10 mm long and pupates inside the infested stem. The pupal period lasts for 20-24 days and adult survives for 4-6 days in the laboratory condition.

### **Management**

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

#### **4. Tea Mosquito Bug (*Helopeltis theivora*)**

**Symptoms** - It has become a major pest in recent years damaging large cardamom plants by sucking the sap from the leaves. The affected parts of the plant develop a streak stain that is dark brown. The young shoots become curled, dried and black, thus, slowing down the growth of the plant and ultimately affecting the yield. Badly damaged plants produce less shoots and thus, the plant loses vigour and becomes stunted.

The female lays eggs inside the tender stem, petiole and midrib. After hatching, nymphs complete their nymphal period through four instars. The size of spots increases gradually with the development of instars. First or second instar nymphs can produce more than 140 spots in a day. The fully mature nymph or adult can produce at least 100 spots/day. The first and second instar nymphs prefer mostly the shoots and younger leaves, whereas the later instars and adults prefer comparatively mature leaves. The abundance of the pest is seen from April to November; but in Sikkim it causes major damage during June–September. Initially the damage starts from a small area and then spreads to the entire area. It causes 30-35% damage in the leaves with symptoms resembling the leaf streak disease.

### **Management**

Regular monitoring of field and collection of nymphs and adults by using hand nets at twilight hours. Removal of weeds/wild hosts in and around tea fields will reduce the incidence of tea mosquito bug. It can be killed or mass trapped with the help of pheromone based sticky trap @ 10-12 traps/ha. Deployment of entomopathogen like *B. bassiana*, predatory ant *O. smaragdina*, egg parasitoid *Telenomus* spp., nymphal adult parasitoid *Leiophron* spp. and predators like spiders, reduviids, mantids under natural conditions are also effective in controlling the tea mosquito bug population.

#### **5. Aphids**

**Symptoms** - The aphids cause more damage as a vector rather than as a pest. The aphids are associated with the transmission of viral diseases (*Foorkey and Chirke*)

of large cardamom. The aphid population has been recorded to be high during summer months at lower altitudes. The major species are:

- a. *Pentalonia nigronervosa f. caladii* (Goot) (Hemiptera: Aphididae).
- b. *Micromyzus kalimpongensis* (Hemiptera: Aphididae)
- c. *Raphalosiphum maidis* (Hemiptera: Aphididae)
- d. *Raphalosiphum padi* (Hemiptera: Aphididae)

*P. nigronervosa* and *M. kalimpongensis* are known as vectors of Foorkey or virus yellow disease. The aphids colonize at the base (rhizome) of clump and if population is more, they move to aerial portion of clump. The aphids are dark brown in colour, small and measure 1-1.5 mm in length. They remain mostly inside the soil close to rhizomes and suck the sap from the pseudostem.

### **Management**

The removal and destruction of diseased plants is helpful in control of further spread of disease and in reduction of aphid population. Use neem oil or NSKE @ 0.3 per cent and 5 per cent, respectively to control aphids.

### **Integrated pest management**

- ❖ Proper sanitation at the field and phyto-sanitation of damaged leaves, shoots and plants must be emphasized to limit the source of primary inoculum.
- ❖ Regular monitoring of the field, collection and destruction of eggs, larvae, pupae and adults of different insects should be adopted.
- ❖ Pest infested plants/plant parts should be destroyed immediately so that it does not act as the breeding ground for the pests.
- ❖ Infested planting material should be completely avoided for new plantation.
- ❖ Greater benefits are obtained if all the management measures are adopted at the community level.
- ❖ It is beneficial to protect bumble bees, honey bees or wild bees as they are the pollinators of large cardamom.
- ❖ Spraying schedule should be followed to reduce the insect populations to economic threshold level:
  1. Four sprays of neem oil 0.15EC @ 3 ml/l at 20 days interval from June onwards has been found to be effective against shoot borer.
  2. Drenching of the clumps and rhizomes of the plants with petroleum agro-spray @ 15 ml/l for mealy bug at 15 days interval.
  3. Application of local strains of *Beauveria bassiana* or *Metarhizium anisopliae* mixed with vermicompost @ 5 g/kg or drenching the soil with these entomopathogenic fungi @ 5 g/l gives effective results against white grub.

## Diseases

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.

### 6. Blight (*Colletotrichum gloeosporioides*)

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

**Symptoms** - The disease is cause of concern for severe crop loss and decline in plant population in the recent past. 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 dries up. 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. The disease mostly affects the bearing tillers of the clump while the new tillers remain apparently healthy. 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. As a whole, the affected clumps and hence, the entire plantation look dried up.

### Survival and spread

The fungus survives in soil as well as crop debris.

The disease appears generally with the advent of pre-monsoon showers followed by clear sunny days during March-May and progresses rapidly during the rainy season. However, in some areas the incidence starts during winter months (January-March) due to moisture stress.

### Management

- Practice of field sanitation is the most important management strategy against the disease spread. The infected tillers from the current season must be collected and buried or composted because this serves as inoculum for the next season.

- Proper nutrient and moisture management for the crop should be ensured throughout the year especially during the winter season when the crop experiences tremendous moisture stress and dry weather.
- Proper mulching of plantation and provision of shade also restricts the spread of disease.
- Spraying of copper oxychloride @ 0.25-0.3% upon initiation of disease.
- Soil application of *Trichoderma viride* @ 2.5 kg mixed with 25 kg well-decomposed FYM.

### 7. *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. 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**

Severely infected and dead leaves may be cut and burned.

Application of sanitation and phyto-sanitation measures and bio-agents.

### 8. Leaf streak disease (*Pestalotiopsis royenae*)

**Symptoms** - It is prevalent round the year and results in considerable damage to foliage in variety Golsey. The disease symptom is the formation of numerous translucent streaks on the young leaves along the veins. The infection starts from the emerging folded leaves.





**Photo – Leaf streak**

### **Management**

Three rounds of copper oxychloride @ 0.2 per cent or Bordeaux mixture @ 1 per cent at 15 days interval can control the disease.

### **9. Stem lodging and capsule rot (*Fusarium oxysporum*)**

**Symptoms** - The symptoms initially appeared as small brownish lesions on the stem especially on the leaf sheath attached to the stem. Later, the lesions increased in size and turned black. The infected tillers broke at the point of infection before attaining actual maturity and the partially broken tillers bent downwards and hung from the point of breakage. The leaves and leaf sheaths of affected tillers dried up eventually giving blighted appearance. The infected flowers and capsules appeared black in colour and emitted unpleasant smell due to rotting.

No effective management solution is available

### **10. Chirke disease (Large Cardamom Chirke Virus)**

**Symptoms** - This disease is characterized by mosaic appearance with pale streaks on leaves. The symptom is more prominent on young emerged leaves where discrete pale green to yellow longitudinal streaks running parallel to each other can be seen. The above symptoms are masked on mature leaves. The streaks turn pale brown resulting in drying, withering of leaves and finally death of the plants

The flowering is greatly reduced, gradually reducing the yield over the years. In the rigorously affected plant, the mosaic streaks coalesce and the leaf gradually turns brown and dries up subsequently. The disease is caused by virus and transmitted through insect vector and mechanically through sap.

### **Transmission**

The corn aphid *Raphalosiphum 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.

### **Management**

- Insect vector can be managed by spraying neem oil or NSKE @ 0.3 per cent or 5 per cent, respectively.
- Practice of field and tool sanitation to prevent the spread of disease.
- Removal of severely infected plant to prevent spread of infection to healthy plants.



**Photo – Chirkey disease (left), Furkey disease (right)**

### **11. Foorkey disease (Cardamom Bushy dwarf Virus)**

**Symptoms** - Pronounced stunting and formation of numerous minute tillers which fail to form inflorescence. The leaves become small, lightly curled and pale green in colour. Sometimes slightly broadened leaves resembling pan is also seen. The tillers do not grow beyond a few inches in height and appear bushy.

### Transmission

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

### Management

- Insect vector can be managed by spray of neem oil or NSKE @ 0.3 per cent or 5 per cent, respectively.
- Removal of severely infected plant to prevent infection to healthy plants.

### Few important aspects of *Chirke* and *Foorkey* diseases

| Aspect                      | <i>Chirke</i> disease  | <i>Foorkey</i> disease   |
|-----------------------------|--|--|
| Identification by symptoms  | Mosaic appearance on leaves.   | Stunted and bushy growth of newly emerging tillers with small pale green leaves. Sometimes produce broadened pan like leaves.  |
| Causal agent                | It is caused by virus. Primary spread by infected planting materials. Transmitted through sap and aphid, <i>Raphalosiphum maidis</i> . Knife used for farm operations and harvesting can carry sap of infected plant to healthy ones. In most situations this is the major mode of spread. | It is caused by virus. Primary spread by the use of infected planting materials. Transmitted through aphids, <i>Pentalonia nigronervosa</i> and <i>Micromyzus kalimpongensis</i> . |
| Survival of infected plants | Plants continue to survive for few more years with gradual reduction in yield.   | Rapid reduction in yield.  |
| Transmission                | Not transmitted through seeds,   | Not transmitted through  |

|                             |                                       |  |
|-----------------------------|---------------------------------------|--|
| through seeds and seedlings | hence seedlings are disease-free.     | seeds, hence seedlings are disease-free. |
| Resistance / tolerance      | No resistant cultivars/sources known. | No resistant cultivars/sources known.    |

### Management of viral diseases

Viral diseases of plants are cancerous in nature and 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 are recommended for effective management of the diseases.

1. Monitor the plantation every month particularly during the 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 500m 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 harvesting of healthy plants or cleaning.

### Integrated disease management

- ❖ Adoption of proper sanitation in the field and phyto-sanitation of infected leaves/shoots/clumps are unconditional pre-requisites before undertaking any other management practice against the pathogens infecting the crop.
- ❖ Mature and bearing tillers cut during harvesting must be composted and treated with local strains of bio-control agent *Trichoderma viride* @ 4 ml/l of water before use.
- ❖ Four sprays of copper oxychloride @ 2.5 g/l at 20 days interval from June onwards or 1 per cent Bordeaux mixture at 15 days interval can manage the foliar diseases.

- ❖ Viral diseases can be managed by uprooting and destroying diseased plants 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 undertaken for eradication of the disease.
- ❖ Apply bio-control enriched manure (vermicompost 100g + poultry manure 400 g + 1 kg FYM + 10 g bio-fertilizer) per plant after harvest for the management of soil-borne diseases.
- ❖ Life saving irrigation to be applied at 15 days interval during November to March.
- ❖ Proper shade management to reduce blight disease in plantation.
- ❖ Avoid planting in such areas where the incidence of blight and other diseases is severe.

### **Harvesting and threshing**

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*).

### **Yield, storage and post-harvest operations**

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. The fruit is a tri-locular, many seeded capsule. The capsule wall is echinated having reddish-brown to dark-pinkish in 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 are bigger and bolder than others.

### **Curing**

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 flavour of large cardamom very much resembles that of *Elettaria* cardamom. The essential oil contains the volatile principles such as 1:8 cineole (75-85%),  $\alpha$ -bisabolene (3-6%),  $r$ -terpinene (4-8%),  $\alpha$ -terpineol +  $\alpha$  – terpinyl acetate (3-6%) also the B-myrcene, nerolidol, pinene, thujene etc., are known in traces. Cineole contributes to the pungency while  $\alpha$ -terpinyl acetate towards pleasant aroma (Karibasappa, 1991). 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 per cent moisture. Their keeping quality is poor and is highly perishable. They are cured or dried to about 10-13 per cent 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 place in the entire cardamom belt.

For good market value, the retention of natural colour and flavour constituents is very important. On one hand, the highly volatile flavour constituents are easily lost because of direct heat and/or high temperature, while on the other conditions of the traditional curing chambers result in colour loss and oozing capsules. 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 and exhaustion of moist air from the drying unit. The unit must be easily maintained and portable to be 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 now with improved and scientific "curing centres" based on hot-air flue indirect heating system but the traditional *bhatti* still survives.

ICRI improved *bhatti*: Improved curing techniques are presently available in which cardamom is processed to give quality and appearance. One such method is ICRI Improved *Bhatti* curing system developed by Indian Cardamom Research Institute, Regional 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. 12,000/- and Rs. 21,000/-, respectively. This *bhatti* has been popularized by the Spices Board Regional Office at Gangtok and Zonal Offices at Tadong, Mangan, Jorethang and Kalimpong through subsidized development scheme. In this cardamom is dried by indirect heating at 45-50°C. Curing is done till moisture content of the produce is brought down to 10 per cent and gives metallic sound while shuffling.

### **Packaging and marketing**

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 the sidewall to avoid absorption of moisture and thereby, avoid fungal growth on the stored produce.

## Crop calendar

| Month               | Activities  |
|---------------------|---|
| January - February  | Provide shade in the nurseries at higher altitude to reduce the damage due to low temperature. Sprinkler or drip irrigation can be carried out during this period at weekly intervals. Slashed pseudo-stem, weeds or leftover fodder residue should be mulched with dung to provide additional nutrients to the plants after decomposition as well as protect the base of the clumps from frost or snow.  |
| March               | Monitor the plantation for incidence of <i>Colletotrichum</i> blight, <i>Phoma</i> leaf spot disease. Sprinkler or drip irrigation can be applied during this period depending on the rain interval.  |
| April - May         | Monitor the plantation for incidence of chirke, foorkey and fungal diseases. Appropriate doses of organic fertilizer should be applied to improve soil health. Application of well-decomposed cattle manure/compost or organic products @ 5 kg/plant along with vermicompost is beneficial. Planting of leguminous trees or shrubs can serve as live fences, hedge plants, insect repellents and also provide nitrogen to plant. The collected seed/s during the previous season can be sown for establishing seedling nursery. |
| June - July         | Monitor the plantation for incidence of <i>Colletotrichum</i> blight and <i>Phoma</i> leaf spot disease. Gap filling can be carried out to maintain an adequate number of cardamom clumps in the field. Diseased plants, old and unproductive tillers, and dried suckers should be uprooted or slashed without disturbing the adjoining healthy tillers.  |
| August              | Monitor the plantation for incidence of <i>Colletotrichum</i> blight and <i>Phoma</i> leaf spot disease. Weeding should be done before flowering and harvest. Weeds can be used as mulch around the clumps. Gap filling can be undertaken to maintain an adequate number of cardamom clumps in the field. Harvesting starts in the lower altitude. Follow the sanitary and phyto-sanitary measures to reduce the disease inoculum levels.   |
| September - October | Harvesting in the low and mid altitudes. Follow the sanitary and phyto-sanitary measures to reduce the disease inoculum levels. Weeding should be done and mulched around the clumps to maintain proper soil moisture.  |
| November - December | Harvesting in the high altitude. Sprinkler or drip irrigation can be undertaken during this period at weekly intervals. Follow the sanitary and phyto-sanitary measures to reduce the disease inoculum levels.  |