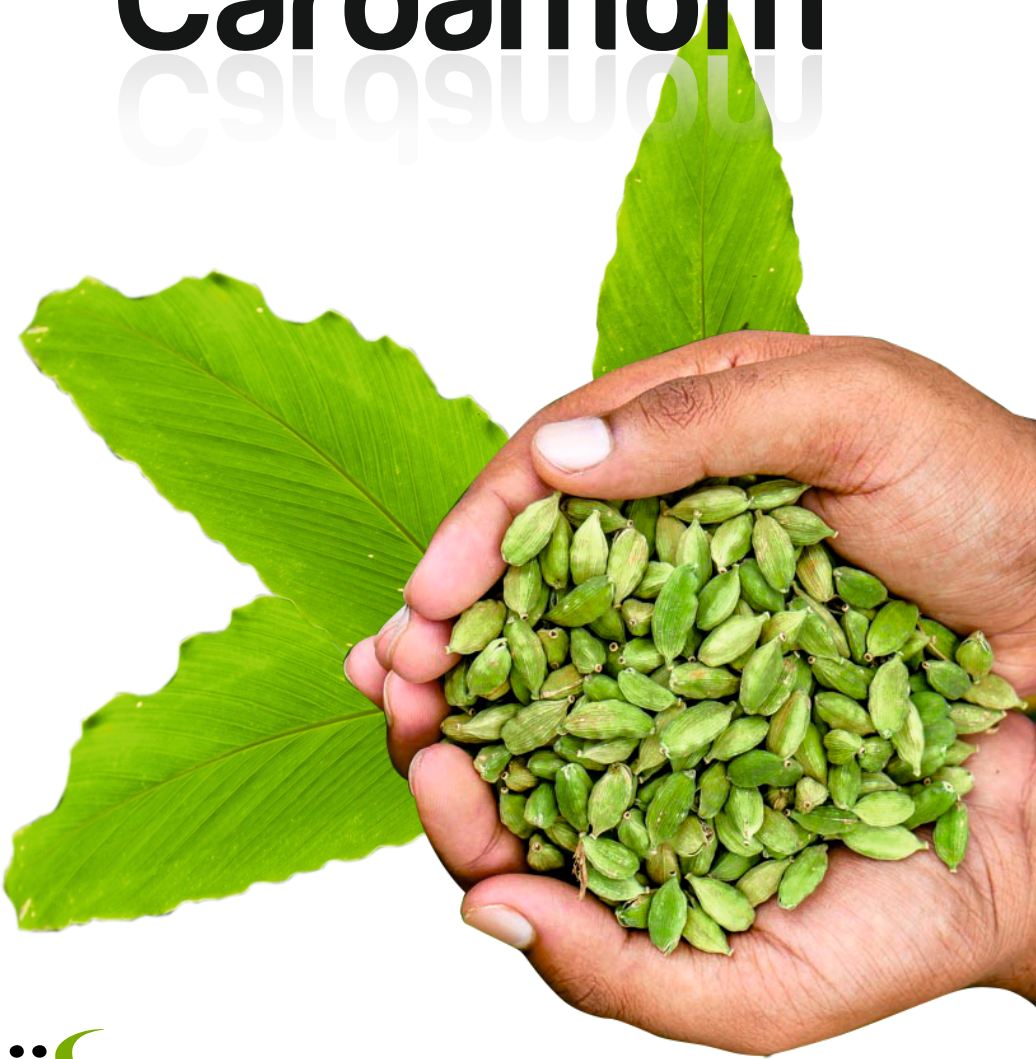




Cardamom



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SMALL CARDAMOM

Small Cardamom (*Elettaria cardamomum* Maton) is one of the oldest known spices in the world. Evergreen forests of Western Ghats of South India are considered as the centre of origin as well as the natural habitat of cardamom. Cardamom is commercially cultivated for its dried fruits (capsules), which is also referred as cardamom of commerce. Small Cardamom is commonly cultivated in evergreen Western Ghats region of South India, mainly in Kerala (56.71 per cent), Karnataka (35.91 per cent) and Tamil Nadu (7.31 per cent). During 2020-21, the crop was cultivated in an area of 69190 ha with an estimated production of 11235 tonnes of cardamom. During 2020-21, India exported 6486 tonnes of small cardamom valued at Rs 1104 crores. The country also exported 16.9 tonnes of cardamom oleoresins worth Rs 16 crores during the same period.

Types/cultivars

Based on adaptability, nature of panicle, shape and size of capsules, the cultivars are categorized into Malabar, Mysore and *Vazhukka*. The Malabar cultivar, with prostrate panicles (panicles spreading on ground), is widely grown in Karnataka, while the Mysore cultivar, characterized with erect panicles, is cultivated in Kerala and parts of Tamil Nadu. The cultivar *Vazhukka*, which is a natural hybrid between Malabar and Mysore types, with a distinct semi-erect (pendent) panicle, is the most popular cultivar in Kerala.

Climate and soil

The crop thrives well in regions which receive a well-distributed annual rainfall of 1500-2500 mm with a mean temperature of 15°C to 35°C and elevation of 600-1200 m above mean sea level. Cardamom grows luxuriously in forest loam soils, which are generally acidic in nature with a pH range of 5.5-6.5. Growth of cardamom is enhanced when planted in humus rich soils with low to medium available phosphorus and medium to high available potassium.

Varieties

Several varieties and improved selections of small cardamom with high yield potential and superior capsule characters, suitable to different cardamom growing regions have been developed by various research organizations. The details of the released varieties/selections are given in table 1.

Table 1. Released cardamom varieties / selections

Selection/ Variety	Cultivar	Important features	Area of adaptability	Average yield (Kg/ha)
ICAR-Indian Institute of Spices Research, Regional Station, Appangala, Kodagu, Karnataka				
Appangala-1	Malabar	Suitable for intensive cultivation both under monocrop and mixed crop conditions. Early maturing variety, highly adaptive and produces 89% bold capsules. (Potential yield 1322 kg dry capsules/ha).	All cardamom growing tracts of Karnataka and Wayanad district of Kerala	745
Appangala-2	Malabar	High yielding variety resistant to <i>cardamom mosaic virus</i> causing <i>kattedisease</i>	All cardamom growing tracts of Karnataka and Wayanad of Kerala	927
IISR Avinash	Malabar	Rhizome rot resistant, high yielding variety suitable for planting in valleys. Produces 51% bold, dark green capsules. (Potential yield 1483 kg dry capsules/ha).	Suited for rhizome rot and leaf blight prone areas.	847 (with protective irrigation)
IISR Vijetha	Malabar	A selection resistant to Cardamom mosaic virus causing <i>katte</i> disease. Recommended for mosaic disease prone areas and for planting under moderate to high shade (Potential yield 979 kg dry capsules per ha).	Suitable for Kodagu, Hassan, Chikmagalur and North Wayanad. Suitable for <i>katte</i> prone areas. Adapted to moderate rainfall	643
Indian Cardamom Research Institute (ICRI), Myladumpara, Idukki, Kerala				
ICRI 1	Malabar	Early maturing, dark green bold capsules.	South zone of Idukki, Kerala	656
ICRI 2	Mysore	Performs well under high altitude and irrigated conditions. Tolerant to <i>azhukal</i> disease.	Vandanmedu and Nelliampathy of Kerala and Anamalai, Meghamalai of Tamil Nadu	766
ICRI 4	Malabar	Early maturing, medium sized panicle with globose, bold capsules. Suitable for low rainfall regions.	Adapted to Lower Palani hills	961
ICRI 5	Malabar	Early maturing, moderately tolerant to drought, high yield under intensive management, 68% bold capsules (> 7 mm).	Kerala and parts of Tamil Nadu	1543

ICRI 6	Malabar	High percentage of bold capsules (>7 mm) tolerant to rot, thrips, borer and drought	Moderately	Kerala and parts of Tamil Nadu	1900
ICRI 7	Vazhukka	Angular bold pale green capsules.		Kerala	1000
ICRI Regional Station (Spices Board), Donigal Post, Sakaleshapura, Hassan, Karnataka					
ICRI 3	Malabar	Oblong, bold, parrot green capsules. Tolerant to rhizome rot.	Cardamom growing tracts of Karnataka	599	
ICRI 8	Malabar	Ovoid bold, pale green capsules. Higher recovery of bold capsules (70.1% of capsules > 7.5mm in diameter)	Cardamom growing tracts of Karnataka	706	
Cardamom Research Station (Kerala Agricultural University), Pampadumpara, Idukki, Kerala					
PV 1	Malabar	Early maturing variety with elongated capsules	All cardamom growing tracts of Kerala and parts of Tamil Nadu	500	
PV 2	Vazhukka	Green bold capsules	Cardamom hill reserves of Kerala	982	
PV 3	Malabar	Parrot green bold capsules. Cured capsules have ellipsoid shape and maintain attractive green colour. Moderately tolerant to thrips and capsule borer.	Cardamom hill reserves of Kerala	1120	
Regional Horticultural Research & Extension Centre, University of Agricultural and Horticultural Sciences, Mudigere, Chikkamagaluru, Karnataka					
Mudigere 1	Malabar	Pale green, oval bold capsules. Moderately tolerant to shoot borer and thrips. Suitable for rainfed conditions	Traditional cardamom growing Malanad areas of Karnataka.	275	
Mudigere 2	Malabar	Early maturing, round/oval and bold capsules. Suitable for high density planting.	Cardamom growing tracts of Karnataka	475	
Mudigere 3	Malabar	Oval/ oblong light green capsules.	Cardamom growing tracts of Karnataka	400	



Appangala 1



Appangala 2

Table 2: Important farmers varieties in cardamom

Variety	Name and address of farmer	Type	Salient features
Njallani Green Gold	Mr. Sebastian Joseph and Mr. Rejimon Joseph Njallaniyil House Idukki, Kerala	Vazhukka	High yielding variety. 80 % of the capsules will be > 7 mm
Thiruthali	Mr. T. P. Joseph Idukki, Kerala	Vazhukka	Medium bold, parrot green colour capsules. Good yielder under rainfed conditions. Suited for areas with less shade (< 40 %). 4-6 kg dry yield per plant.
Wonder Cardamom	Mr. Sabu Varghese Idukki, Kerala	Vazhukka	Panicles are branched and very long ranging from 1.5 to 2.0 meters with short internodes. Capsules are extra bold in size with deep green colour. 3 to 4 kg dry yield / plant.

Panikulangara Green Bold 1	Mr. Joy Peter Idukki, Kerala	Vazhukka	Capsules retain attractive green colour after drying. Can be cultivated in less shaded (40 %) areas.
Panikulangara Green Bold 2	Mr. Joy Peter Idukki, Kerala	Vazhukka	Resistant to <i>Azhukkal</i> disease
White flower	Mr. K. J. Baby Puliyanmala, Idukki, Kerala	Vazhukka	Flowers will be pure white in colour. 4-5 kg dry cardamom per plant.
PNS Vaigai	Mr. P. N. Surulivel Theni, Tamil Nadu	Mysore	High and consistent yielder - 900-1400 kg/acre. 60-70 percent of the produce is 7 mm and above.
Elarajan	Mr. K. J. Benny Kerala	Vazhukka	80-90 % of capsules will be 8-9 mm. High yielding 2500 kg/ha
Pappalu	Mr. KV Paulose Idukki, Kerala	Vazhukka	Average yield 2000-2500 kg/ha. 25 % dry recovery. Long panicle (130-147 cm), ovoid capsules
Arjun	Mr. Menuwin Thomas Idukki, Kerala	Vazhukka	Suitable to higher elevation (3000 ft from sea level). 2000 - 3000 kg dry yield/ha.
Pachaikkai	Mr. L. Ramaiah and Mr. R. Murugan Theni, Tamil Nadu	Vazhukka	High yielding 2000 kg/ha dry yield. Bright green coloured bold capsules. Drought tolerant and suitable for lower elevation areas of Tamil Nadu.
Thadathil Gold	Mr. C. M. Mathew Idukki, Kerala	Vazhukka	Ovoid and pale green capsules. High yielding variety.

Propagation

Propagation by vegetative means through suckers is the most preferred method. Production of planting materials from seeds and through tissue culture are alternative methods of propagation. It should be noted that seedling propagated plants may not be true to its parent.

Clonal nursery

Establishment of clonal nursery is essential for large-scale multiplication of high yielding varieties/selections. The planting unit consists of a grown-up tiller with a portion of the rhizome and a developing shoot. Sucker multiplication can be taken up from the first week of June to September. The site selected should be in open, well-drained areas adjacent to a perennial water source.

Trenches with a width and depth of 45 cm and convenient length are prepared. The planting units are planted at a spacing of 1.8 m × 0.6 m in the trenches or 0.9 × 0.9 m in pits. The trenches (or pits) should be filled with a mixture of humus rich top soil, sand and well decomposed compost. Provide shade to protect the planting units from direct sunlight and desiccation. For

better establishment of the suckers, irrigation may be given once in a fortnight. Apply fertilizers @ 48:48:96 g NPK per sucker in 2-3 splits starting from two months after planting. Neem cake @ 100-150 g/plant may also be applied during planting. About 15-20 good quality planting units could be produced from a mother clump within ten months of planting.



Trench for clonal multiplication of cardamom



Filling up of trench with compost and manures



Planting in trenches



Clonal nursery

Nursery

Cardamom seedlings are raised in two stages. First the seedlings are raised in the primary nursery. Subsequently they are transplanted to the secondary nurseries before they are ready for planting in the main field.

Primary nursery

The nursery site is selected in open, well-drained areas, near a water source. Prepare the area by removing existing vegetation, stumps and stubbles. Stones are removed after

ploughing the field to a depth of about 30 cm. After this, beds of size $6 \times 1 \times 0.2$ m are made and a thin layer of humus rich forest soil is uniformly spread over the beds.

Fully ripened bold capsules from high yielding, disease-free mother clumps are collected from second and third harvests during the month of September. Seeds from one kg fresh capsules comprising of about 500-800 fruits is sufficient to produce 3000-5000 seedlings. The seeds are extracted by gently pressing the capsules and then washed 3-4 times in cold water to remove the mucilage adhering to the seeds. The washed seeds are drained, mixed with wood ash and dried under shade. To ensure early and uniform germination, seeds should be sown immediately after extraction, preferably within 15 days since viability of the seed is lost during storage. The ideal season for sowing is September in Karnataka and November-January in Kerala and Tamil Nadu.

Acid scarification with 25% nitric acid increases the germination percentage. For this, wrap the extracted seeds in nylon net, tie it loosely and then immerse in 25% nitric acid for 10 minutes. After treatment, the seeds are removed and washed repeatedly in cold water to remove traces of acid.

Sow the seeds in rows spaced at 10 cm and 1-2 cm apart within the row. The seed rate for 6×1 m sized bed is 30-50 g. After sowing, the beds are covered with a thin layer of sand and mulched with paddy straw or similar material to a thickness of 2 cm over which tree twigs are laid. Water the beds regularly to maintain sufficient moisture and to promote germination. Germination commences in about 20-25 days and may continue for a month or two. Once sprouting is observed, remove existing mulch and maintain thin mulch material between the rows. Protect the seedlings by providing overhead shade. Transplant the seedlings at 3-4 leaf stage to the secondary nursery.



Nursery beds for sowing seeds



Line sowing of cardamom seeds

Secondary nursery

Seedlings are raised in the secondary nursery by two methods.

Bed nursery

The beds are prepared as in the case of primary nursery. Spread a layer of compost on the bed and mix thoroughly with soil. Seedlings with 3-4 leaves are transplanted at a distance of 20 to 25 cm. Mulching and watering should be done immediately after transplanting.

In Kerala and Tamil Nadu, transplanting is carried out during June-July, whereas in Karnataka it is undertaken during the months of November - January. Apply 90:60:120 g NPK/per bed of 6 × 1 m size, in three equal splits at an Interval of 45 days. First dose of fertilizer may be applied at 30 days after transplanting. Earthing up need to be undertaken after each fertilizer application and hand weeding is done once in 20-25 days. One month before uprooting, the shade should be removed to encourage better tillering. The seedlings will be ready for transplanting after 8-10 months of planting.

Polybag nursery

Polythene bags of size 20 × 20 cm and 100-gauge thickness are filled with potting mixture consisting of fertile top soil, cow dung and sand (ratio 3:1:1). Provide sufficient holes at the base of poly bags to ensure good drainage. Seedlings at 3-4 leaf stages are transplanted into each bag (one seedling/bag). Seedlings raised in the poly bags have a uniform growth and nursery period could be reduced by 5-6 months.



Polybag nursery

Planting and cultural practices

Planting

Planting unit consisting of grown up tiller with portion of rhizome and developing shoot are generally planted during rainy season. Whereas in case of seedlings, in Karnataka, 10 month old seedlings are preferred for planting in the main field, while in Kerala and Tamil Nadu 18 month old seedlings are commonly used.

On slopes, prepare the land by contour terracing and in open areas like valleys and grasslands, raise shade trees before planting cardamom seedlings. Plant fast growing shade trees like Dadap (*Erythrina lithosperma*), Albizia, Karuna (*Vernonia arborea*), Corangati (*Acrocarpus fraxinifolius*), Chandana Viambu (*Toona ciliata*), Njaval (*Syzygium cumini*), Jack tree (*Atrocarpus heterophyllus*) etc. to protect the seedlings from direct sunlight. Clear the ground for planting in new areas and for replanting areas, remove the old plants.

Shade regulation, terracing and preparation of planting pits should be done during summer months in the areas identified for fresh planting.

In newly planted areas, shade regulation is undertaken during the months of March-April by pruning branches of shade tree to provide 40 to 60% filtered light. To ensure a balanced canopy, lopping of branches is carried out on all sides of the shade trees. Preferably, South-Western slopes should be provided with more shade than North-Eastern slopes.

For planting, pits of required size are prepared before commencement of the monsoon season (April-May). For planting Malabar types, pits of size 45 × 45 × 45 cm are prepared and for Mysore and *Vazhukka* types, pits of 90 × 90 × 45 cm or 90 × 90 × 90 cm are recommended. The pits are filled to one third with top soil. Application of well decomposed farmyard manure or compost or leaf litter and 50 g of rock phosphate along with the top soil will help in proper establishment and quick growth of suckers.

Planting is normally done during June-July with the commencement of monsoon. Ideal time for planting in the low-lying areas would be after the cessation of heavy monsoon showers.

While planting, 15 g of carbofuran (banned in Kerala) or 50 g neem cake and rock phosphate (50 g) are applied to the pit. Deep planting should be avoided, as it results in suppression of the growth of new shoots and might result in death of the plants. Stakes may be provided to avoid the damage caused by wind and the plant base need to be covered with suitable mulching material.

Planting diagonally to the slopes helps to reduce run off. Trench system of planting (60 × 30 cm) with a spacing of 2 × 1 m is generally preferred over pit system, as it results in better establishment of the plants, higher yield and greater moisture retention. In sloppy lands, contour terraces need to be prepared and pits are taken along the contours at 2 × 1m spacing. Based on slope, terraces are made at 2-3 m between the contours.

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Cultivars	Spacing (m)	Plants/hectare
Malabar	1.8 × 1.8 or 2.0 × 2.0	2500-3000
Mysore	3 × 3	1111
<i>Vazhukka</i>	2.4 × 2.4	1736

Irrigation

It is essential to irrigate the crop during January to May. Plants may be irrigated at an interval of 10-15 days till the onset of monsoon, by adopting a convenient method of irrigation either by hose/sprinkler/mini-sprinkler/drip. In case of drip irrigation, it needs to be supplemented with sprinkler irrigation once in a month. Sprinkler irrigation of 25 mm of

rain once in 12-15 days or drip irrigation of 4-9 litre per day based on size of clump can be given. Mini sprinkler daily two hours in summer months will help in maintaining the moisture status.

On fields with gentle slopes, opening of rectangular silt pits (1.0 × 0.5 × 0.6m) between four plants will help in soil and water conservation. If the slope is steep, construct stone pitching walls at 10 to 20 m interval across the slope. Additionally, digging of water collecting trenches along drainage channels would strengthen the soil and water conservation measures in such fields.

Weeding

Cardamom is considered as a surface feeder. Therefore weeding is important for plant establishment. In the first year of planting, weeding at frequent intervals is necessary. Later, depending on the intensity of weed growth, 2-3 rounds of hand weeding at the plant base during May, September and December/January and slash weeding in the interspace are recommended. Mechanical weed cutters can be used for weeding.

Mulching

Entire plantation and particularly the plant bases should be mulched at 5-10 cm thickness using fallen leaves of the shade trees, except during periods of heavy monsoon (June-September). To facilitate honey bee movement, remove mulch during May-June after the receipt of pre-monsoon showers. Areas where soil has become compact and hard, forking the plant base with garden fork to a distance up to 90 cm and to a depth of 9-12 cm promotes better root penetration. Forking could be done with the cessation of northeast monsoon during November/December with least damage to the root system.

Trashing

Trashing is removing of old, drying shoots and leaves. Trashing may be carried out once in a year with the onset of monsoon under rain fed conditions and 2-3 times in high-density plantation provided with irrigation facilities. Trashing from November onwards may be avoided, due to summer. Trashing facilitates better sunlight penetration and aeration, thereby promoting tiller initiation and growth as well as reduction in thrips and aphids population.

Earthing up

Earthing up of the plant base and root zone with topsoil is recommended during October-December. In valleys and high rainfall areas with medium slopes, suitable drains (45 cm depth and 30 cm width) are provided in between two rows of cardamom.

Shade regulation

To provide adequate light during monsoon, shade regulation may be taken up before the commencement of rainy season (May). Regulation of excess shade and maintaining shade at 50 per cent level helps in getting more reproductive tillers and higher capsule yield. The quality of capsules with respect to its aroma also improves under such conditions.

Pollination

The principal pollinating agent in cardamom is honey bee (*Apis cerana indica*). Maintaining

four honey bee colonies per hectare during the flowering season is recommended to increase pollination and consequently promoting fruit set and production of a greater number of capsules.

Replanting

To maintain higher productivity, undertake replanting once in 8-10 years. Replanting may also be taken up, once the yield starts declining below the economic level.

Manuring and fertilizer application

Apply one-third of the recommended dose of fertilizers during the first year of planting both under rain-fed and irrigated conditions (Table 3). During the second year, increase the dose to one-half and apply full dose of fertilizers from third year onwards.

Table 3. Fertilizer recommendation for cardamom

NPK (kg/ha)		Soil	Foliar
75:75:150 (rainfed - two splits)	Half of the recommended dose to be applied in soil and the remaining to be given through foliar application. NPK 37.5:37.5:75 kg/ha may be given through soil application The strength of the solution to be used for foliar application: Urea (2.5%), Single super phosphate (0.75%)Muriate of Potash (1.0%)	May/June/ September/ October/ December/ January	September/ November/ January
125:125:250 (irrigated-three splits)			

As the soil fertility will be varying with the agro-ecological conditions or management systems, site specific nutrient management for yielding gardens based on their soil test results for major nutrient is advocated. The recommended dose of nutrients for varying soil test values of N, P and K is given in Table 4.

Before applying fertilizer, the mulching material is removed from the plant basin and the panicles are coiled. Fertilizer is applied in a circular band of width 15 cm, leaving 30 cm from the plant basin and thoroughly mixed with top 5-7 cm of surface soil. After fertilizer application, the basin is mulched.

For yielding plants, soil-cum-foliar application will be an effective method of fertilizer application. Spray the solution containing fertilizers to the foliage covering both sides of the leaves.

Apply agricultural lime @ 1 kg/plant/year for soils with pH below 5.0 in one or two splits during May and September. Fertilizers shall be applied only after 15-20 days of lime application.

Table 4: Site specific nutrient management for targeted yield in cardamom

Soil test value for available nutrients (kg/ha)	Fertilizer nutrient recommended (kg/ha) for yield targets	
	6.50 q/ha	11.00 q/ha
Nitrogen (N)		
< 150	255	400
150-250	200	370
250-400	100	320
>400	50	150
Phosphorus (P ₂ O ₅)		
<25	225	275
25-50	175	225
>50	100	175
Potassium (K ₂ O)		
<250	350	550
250-500	280	500
500-800	180	450
>800	50	250

Organic manures like farm yard manure/compost @ 5 kg/plant may be applied during May/June along with rock phosphate and muriate of potash. Application of neem cake, bone meal or vermicompost @1 kg/plant improves root proliferation and plant growth.

Foliar spray of zinc (Zinc sulphate @ 250 g/100 litres of water) during April/May and September/October enhance growth, yield and quality of the produce. Zinc should be applied alone and not to be mixed with any insecticide/fungicide. Soil application of boron in two splits along with NPK fertilizers (Borax @ 7.5 kg/ha) is also recommended. Foliar application of micro nutrient mixture developed by IISR specific to cardamom is also recommended (dosage @ 5 g/L) twice, in May – June and September-October, for higher yield.

Diseases

Nursery diseases

Nursery leaf spot

Nursery leaf spot Leaf spot caused by the fungus *Phyllosticta elettariae* is a destructive disease in primary nurseries. It appears mostly during February-April with the receipt of summer showers. The disease manifests as small round or oval spots, which are dull white in colour. These spots later become necrotic and in the advanced stages, the central portion of the spot withers off leading to the formation of shot hole. In secondary nurseries, another type of leaf spot caused by *Cercospora zingiberi* is also observed. Symptoms are yellowish to reddish brown coloured rectangular patches on the lamina which are almost parallel to the side veins.



Nursery leaf spot

Management

- Sow the seeds in August-September, to ensure sufficient growth of seedlings, so that they develop tolerance to the disease.
- Avoid exposure to direct sunlight from top or sides.
- The practice of raising nurseries continuously on the same site may be avoided.
- Prophylactic spraying with fungicides such as mancozeb (0.2%) may be given. First spray is to be given during March-April, depending on the receipt of summer showers and subsequent sprays may be undertaken at fortnightly intervals. Depending on the severity of the disease, two to three rounds of spraying may be given. Alternatively spray of tebuconazole 2ml/L at fortnightly interval can also be given
- Spraying mancozeb (0.2%) effectively controls secondary leaf spot disease.

Nursery leafrot

Nursery leaf rot is caused by fungi such as *Fusarium* and *Alternaria*. This disease commonly appears on three to four months old young seedlings. The symptoms develop as water-soaked lesions on the foliage, which later turns to necrotic patches leading to the decay of affected areas. Usually the leaf tip and distal portions are damaged. In severe cases, rotting extends to the petiole and leaf sheaths also.

Management

- Avoid excessive watering to the seedlings.
- Spraying Carbendazim (0.2%) twice at 15 days interval after removal of the infected leaf portions controls the disease effectively.



Damping off

Damping off or seedling rot

The disease appears in primary nurseries during rainy season and when there is excessive soil moisture due to inadequate drainage. As a result, the infected seedlings die and collapse in masses. The disease is caused by soil-borne fungi such as *Pythium vexans* and *Rhizoctonia solani*. *Fusarium oxysporum* also

causes similar seedling rot resulting in wilting of the entire seedlings.

Management

- In primary nurseries, thin sowing may be practiced to avoid overcrowding of seedlings.
- Adequate drainage facilities may be provided to prevent water stagnation.
- Maintain proper phytosanitary measures in the nurseries by removing infected and dead seedlings.
- When the initial symptoms are noticed, drench nursery beds with 0.2% copper oxychloride (COC) @ 3-5 L/m². Two to three rounds of drenching may be adopted at an interval of 15 days.
- Pre-treatment of seeds with 10 g/kg (*Trichoderma* or *Pseudomonas*) before sowing reduces the chance of early incidence of the disease in nurseries. Further, application of *Trichoderma* to the nursery bed @ 100 g /m² reduces subsequent disease spread.

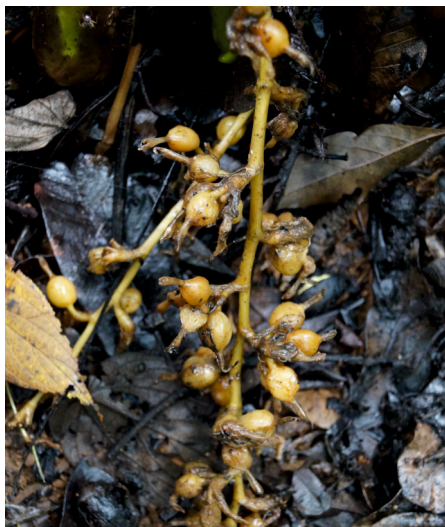
Diseases in plantation

'Azhukal' or capsule rot

'Azhukal' (*Phytophthora nicotianae* var. *nicotianae* and *P. meadii*) is a serious problem and a major constraint in the successful cultivation of cardamom. During heavy and continuous rainfall, the crop loss arising from *azhukal* can be as high as 40 per cent.

Symptoms

The disease appears after the onset of South-West monsoon in the form of water-soaked lesions on tender leaves and capsules, which later form dead areas surrounded by yellow halo. As a result, the leaves rot and shred along the veins. In the advanced stages, the affected leaves break at the base of the petiole and remain hanging. On the immature capsules, the symptoms develop as water soaked discoloured areas, which later turn brownish. Upon decay such capsules emit a foul smell and subsequently drop off. Mature capsules when infected become shrivelled upon drying. Plants of all ages are susceptible to the disease; however, under field conditions, disease incidence is noticed mainly on the bearing plants. High incidence of the disease is usually noticed during July-August with heavy rainfall and high relative humidity. All the varieties are susceptible to the disease; however, the cultivar Malabar is more severely affected.



Capsule rot

Management

- Trashing and cleaning of the plant basin should be carried out before the onset of monsoon.

- Thick shade may be regulated by adequate lopping of tree branches.
- Provide drainage in low lying areas.
- Destroy disease affected portions and plant debris.
- Prophylactic sprays with Bordeaux mixture (1%) should be given during May-June and subsequent sprays may be repeated during July-August. If the monsoon prolongs, a third spray may be given in September.
- Alternatively, fungicides like fosetyl-aluminium (0.2 %) or potassium phosphonate (0.3 %) can be sprayed @ 500-750 mL per plant. A waiting period of 90 days should be given in case of fosetyl-aluminium before harvesting.
- Drenching plant basin with copper oxychloride (0.2%) also reduces the soil inoculum and further spread of the disease.
- *Trichoderma viride* or *T. harzianum* mass multiplied on suitable carrier media may be applied to plant basins @ 1 kg during May and September-October. If the soil is drenched with copper oxychloride or other fungicides, *Trichoderma* should be applied only after 15 days.

Rhizome rot

Rhizome rot is also called as clump rot. Soil-borne pathogenic fungi, *Pythium vexans*, *Rhizoctonia solani* and *Fusarium* spp. are the causal organisms of rhizome rot disease in mature plants.

Symptoms

The disease appears as yellowing of foliage, followed by drooping of leaves; collar region becomes brittle which breaks off at slight disturbance. As the disease advances, rotting extends to the rhizomes and roots. Severely affected tillers eventually fall off. Rotten rhizomes become soft, dark brown in colour and emit a foul smell. Rhizome rot and lodging of shoots are severe during monsoon season.



Rhizome rot

Management

- Trashing and cleaning of the plant base should be undertaken before the onset of monsoon.
- Regulate shade in the plantation with the onset of pre-monsoon showers.
- Prevent water logging by providing adequate drainage in the plantation.
- Uproot and destroy severely affected clumps from the plantation.
- Drench the plant basins with copper oxychloride 0.25% and spray the plants with Bordeaux mixture 1% with the onset of pre-monsoon showers during May-June;

repeat drenching and spraying during August-September and also during October if the monsoon is prolonged.

- Alternatively, drench and spray potassium phosphonate 0.3% or metalaxyl-mancozeb 0.125% with the onset of pre-monsoon showers during May-June; Repeat drenching and spraying during August-September and also during October if the monsoon is prolonged.
- *Trichoderma harzianum* mass multiplied on suitable carrier media may be applied to plant basins @ 1 kg during May and September-October. If the soil is drenched with copper oxychloride or other fungicides, *Trichoderma* should be applied only after 15 days.
- Cultivate rhizome rot resistant variety IISR-Avinash in areas prone to the disease

Leaf Blight

Symptoms

Leaf blight (*Chenthai*) is caused by the fungus *Colletotrichum gloeosporioides*. The disease assumes severity during the post-monsoon period. The disease initially manifests on the leaves as water-soaked lesions which later coalesce to form yellowish-brown to reddish-brown patches and subsequently withers off. In the advanced stages, several such lesions develop on young and older leaves, which eventually dries up and gives a burnt appearance to the plants.



Leaf blight initial symptoms



Leaf blight severity



Leaf blight severity

Management

- Destroy leaf blight affected portions and plant debris during May, before the onset of monsoon.
- Maintain optimum shade levels of 40-60% filtered light. Undertake shade management before the onset of South-West monsoon season. As prophylactic measure, spray Bordeaux mixture (1%) @ 0.5-1 L/plant during May-June before the onset of monsoon season and repeat sprays in August-September.
- Once the disease appears, spray combination product of carbendazim and mancozeb (0.1%) or carbendazim (0.2%) @ 500-750 mL/plant during August-September and repeat the sprays at 30 days interval for 2-3 times depending on the severity and extent of disease spread.

Minor diseases

Leaf blotch (*Phaeodactylum alpiniae*), stem lodging (*Fusarium oxysporum*), and capsule tip rot (*Rhizoctonia solani*) are some of the minor diseases affecting cardamom. Spraying two rounds of carbendazim (0.2%) at 30 days interval can effectively manage leaf blight, while spraying Bordeaux mixture (1%), copper oxychloride (0.2%) or mancozeb (0.3%) is recommended to manage leaf blotch. Stem lodging and capsule tip rot diseases can be controlled by spraying carbendazim (0.2%) or hexaconazole (0.2%).

Viral diseases

Mosaic or *Katte* disease

Mosaic disease is locally known as *katte* meaning a disorder. When plants are infected during the early stages, the loss will be almost total while, late infection results in gradual decline in productivity. Total decline of plants occurs after 3-5 years of infection with a yield reduction up to 70 per cent.

Symptoms

The infected plant is diagnosed by the presence of interveinal mosaic or stripe mosaic originating from the midrib and running towards the margin of leaves. In the advanced stage size of the leaves gets reduced leading to stunting of the plant. Leaf-sheath of infected plant show mottling symptoms. From the infected plant, the disease spreads to all the tillers in the clump leading to the reduced number of small tillers with few and short panicles. Plants of all stages are susceptible to the infection and in the advanced stages, the affected plants produce shorter and slender tillers with few shorter panicles and degenerate gradually. The disease is caused by cardamom mosaic virus (CdMV).

The disease is not transmitted through seed, soil, contact between roots, or through manual operations. The primary spread of the virus occurs through infected plants, while the secondary spread within the field is through the aphid, *Pentalonia caladii*.



Katte symptoms on leaf

Cardamom vein clearing disease or *Kokke kandu*

This disease first reported during 1993 has become a threat to cardamom cultivation in a few pockets of Hassan and Uttara Kannada districts of Karnataka, where the disease is endemic. Because of its characteristic symptom, it is locally referred as *kokke kandu*, meaning hook-like tiller. Unlike mosaic disease, the plants affected with vein clearing disease decline rapidly with yield reduction up to 62-84% in the first year of peak crop. The affected plants become stunted and perish within 1-2 years of infection. The *kokke kandu* disease occurs either singly or in mixed infection with mosaic disease.

Symptoms

The first visible symptoms of the disease include, chlorosis of the veins followed by rosetting, loosening of leaf sheath and shredding of leaves. Newly emerging leaves get entangled in the older leaves and form hook-like tillers and hence the disease is locally known by the name *kokke kandu*. Leaf sheaths of the infected plants exhibit mottling symptoms. Light green patches with shallow grooves are also seen on the immature capsules. Cracking of fruits and partial sterility of seeds are other associated deformities. Plants of all stages from seedlings to bearing stage exhibit these symptoms. The disease is caused by cardamom vein clearing virus (CdVVCV).

The virus is not transmitted through seed, soil, mechanical means, contact between roots, and farm implements. The primary source for infection includes infected clones while the secondary spread within the plantations is through the cardamom aphid, *P. caladii*.



Kokke kandhu symptoms

Chlorotic streak disease

This disease was first reported in the year 2012. This viral disease is a new threat to cardamom cultivation both in Kerala and Karnataka. The virus causing this disease is identified as a strain of banana bract mosaic virus (BBrMV)

Symptoms

Most characteristic symptom of the disease is continuous or discontinuous spindle shaped yellow or light green streaks on leaves intravenously and along the midrib, which later coalesces so that the veins turn yellow or light green in colour. Discontinuous spindle shaped mottling appears on the pseudostem and also on the petioles. In severe cases, tillering in infected plant is suppressed. The distinguishing feature of



Chlorotic streak symptoms on leaf

the the disease is the formation of intravenous chlorotic streaks; hence the disease was named as chlorotic streak. The infected cardamom plants serve as the primary source for the spread of the virus. The secondary spread of the disease occurs through aphids.

Integrated management of viral diseases of cardamom

- The variety IISR-Vijetha, resistant to CdMV is recommended for cultivation in areas where the mosaic disease is prevalent.
- Production and use of virus-free planting material is an important component in the integrated disease management package.
- To produce virus-free planting material, the nurseries should be established using indexed virus-free suckers in isolated locations.
- Laboratory based diagnostics such as RT-PCR would help to identify virus-free mother genotypes for subsequent propagation.
- In the plantations, regular monitoring, removal of infected plants including collateral hosts such as *Colocasia* and *Caladium* that serve as breeding sites of aphids are important.
- Trashing of old and senile leaves followed by spraying with recommended insecticides or biopesticides would reduce aphid population.
- Neem based products at 0.1% concentration significantly reduces settlement of aphids on the cardamom leaves and are also lethal to the aphids at higher concentrations.

Pests

Cardamom thrips (*Sciothrips cardamomi*)

Cardamom thrips is the most destructive and persistent pest of cardamom. It is found in almost all the cardamom growing areas. Thrips breed inside the unopened leaf spindles, leaf sheaths, flower bracts and flower tubes. Adults as well as the larvae lacerate and feed on leaves, shoots, inflorescences and capsules. Infestation on the panicles results in shedding of flowers and immature capsules. Feeding activity on tender capsules leads to the formation of corky, scab-like encrustations. The extent of damage may be as high as 80 per cent in certain areas. The thrips infested capsules fetch lower price in the market. Population of thrips is generally high during the summer months (February- May) and declines with the onset of monsoon. The Mysore and *Vazhukka* types are highly susceptible to thrips infestation.



Thrips infestation on cardamom capsules

Management

- Regulate shade in the plantation by pruning branches of shade trees.
- Trashing operation should be undertaken thrice a year i.e., during early monsoon, mid-monsoon and late monsoon periods to remove breeding sites of the pests.
- Spray insecticides like quinalphos (0.025%), during March, April, May, August and September.
- Under Karnataka conditions, spraying of fipronil 0.005% or spinosad 0.0135% during Feb-March, March-April, April-May, September and October is also effective.
- Avoid spraying operations during peak periods of honey bee activity.

Shoot and capsule borer (*Conogethes punctiferalis*)

The shoot and capsule borer is a serious pest in nurseries as well as in the main plantations. The larvae bore into pseudostems and feed on the internal contents leading to the formation of 'dead heart' symptom. When panicles are attacked, the portion ahead of point of entry dries off. The larvae also bores into the capsules and feed on the seeds resulting in empty capsules. The pest is prevalent throughout the year but higher incidence is noticed during the months of January-February, May-June, and September-October.



Shoot borer infestation on cardamom pseudostem



Shoot & capsule borer larvae



Shoot & capsule borer adult moth



Bore hole on the capsule

Management

- Remove infested suckers as indicated by extrusion of frass, during September-October when the infestation is less than 10%.
- Collect and destroy adults which are generally observed on the undersurface of leaves.
- Spray quinalphos (0.075%) twice, during February-March and September-October coinciding with emergence of panicles and new shoots.

Root grub (*Basilepta fulvicorne*)

Root grubs are major pests of cardamom in nurseries and main fields. The grubs damage the roots and rhizomes by feeding, sometimes resulting in the death of entire root system. As a result, the plants turn yellow and remain stunted; severely infested plants die. The peak periods of adult emergence are during April and September. Grubs have two periods of occurrence, first during April-July and January.



Cardamom root grubs



Root grub infested cardamom plant



Root grub beetle

Management

- Collect and destroy adult beetles during peak periods of emergence i.e. April-May and September – October.
- Apply chlorpyrifos (0.075%) twice a year during May-June and August-September synchronizing with emergence of adults and egg laying periods of the pest.
- Light raking of soil before the insecticide application is essential for effective control of root grubs.

Minor Pests

Capsule borers

The caterpillars bore and feed on flowers and capsules. The affected capsule become empty, decay and ultimately drops off. The pest is generally serious during the monsoon period.

Management

- Regulate shade in thickly shaded areas.
- Spray insecticides like quinalphos (0.025%) during March, April, May, August and September.

Root and rhizome borers

The larvae of root and rhizome borers bore into the roots by making tunnels filled with frass. The roots die due to the infestation and in the case of severe infestation, the affected clump dries off. The pest infestation is generally serious in the secondary nursery.

Management

- Destruction of infected rhizomes with immature stages of the pest and basal application concentration will control the pest.

Hairy caterpillars

Hairy caterpillars appear sporadically in large numbers and cause severe damage to cardamom by defoliating the plants. The caterpillars are gregarious in habit and they congregate on trunks of shade trees during the daytime. During early stages of the life cycle, they feed on shade trees and become a pest of cardamom during the later stages.

Management

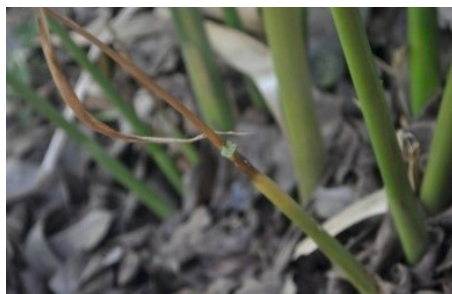
- Swarms of hairy caterpillars congregating on the trunk of shade trees during daytime should be collected and killed mechanically.
- The adults of hairy caterpillars can be attracted and trapped by operating light traps at night. The trapped insects can be collected and killed.
- Spray insecticide like quinalphos (0.05%) to control larval stages.

Shoot fly

The larvae of shoot fly feed on the growing shoot of young cardamom plants resulting in formation of dead hearts. The pest incidence is generally severe during October-November and March-April. In general, young plants in the new plantations, which are grown under inadequate shade conditions, are severely affected.



Shoot fly larvae



Shoot fly damage on young shoots

Management

- Remove the affected shoots at ground level and destroy them.
- Spray quinalphos 0.05%.

Nematodes

Nematodes, especially, root knot nematodes (*Meloidogyne incognita* and *M.javanica*) are major problems in nurseries as well as in main plantations. They cause considerable damage by attacking the feeder roots of cardamom and reduce the yield by 32-47 per cent. Aerial symptoms manifested on heavily infested plants include stunting, yellowing, reduced tillering, premature drying of leaf tips and margins and reduced leaf size. Flowering is normally delayed in the affected plants and immature fruits drop resulting in yield reduction. Availability of collateral hosts like *Erythrina indica* and *E. lithosperma*, exposed areas and sandy soils favours population buildup of nematodes

Management

Nursery

Disinfest the nursery beds under polythene cover using biocide methyl bromide (to be used only by pest control operators under the supervision of Govt. experts or experts approved by the Plant Protection Advisor to Govt. of India) for 3-7 days or by application of any granular insecticides [Carbofuran (banned in Kerala)].

Plantation

- Ensure planting of nematode free seedlings.
- Provide mulching, particularly in the exposed areas.
- Regular application of organic manures such as neem cake twice a year @ 250-1000 g depending on the clump size reduces nematode infestation.
- Apply granular insecticide like carbofuran @ 15-50 g (banned in Kerala) depending on the size of the plant twice a year in May/June and September.
- Application of nematicides during pre-monsoon period followed by neem cake application in mid-monsoon period is the safest approach to reduce residue problem in the capsules.

Harvesting and processing

Cardamom plants start bearing two to three years after planting suckers or seedlings, respectively. The capsules ripen within a period of 120-135 days after its formation. Harvesting period commences from June-July and continues till January-February in Kerala and Tamil Nadu. While in Karnataka, harvesting begins in August and prolongs till December-January. Usually harvesting is done at an interval of 15 -30 days.

The capsules are harvested when they attain physiological maturity, which is indicated by dark green colour of rind and black coloured seeds. Harvesting of ripened capsules is avoided as it leads to the loss of green colour and also causes splitting of capsules during curing process. Immature capsules on processing yields uneven sized, shriveled and undesirably coloured produce. Freshly harvested capsules are washed in water to remove the soil particles and other dirt adhering to it and to get good quality commodity. Storage of capsules after harvest for longer duration adversely affects quality of the end product.

Curing of cardamom is the process by which moisture of freshly harvested capsules is reduced from 80 to 10-12 per cent through indirect heating. Maturity of capsules and curing temperature influences the colour and quality of processed cardamom. During curing a temperature range of 40-45°C is maintained during all the stages of drying which helps in good retention of green colour. Gradual increase of drying temperature to 50-55°C in the last two hours of curing enables easy removal of floral remnants during polishing. During curing, if temperature exceeds the threshold levels, capsules develop brownish streaks due to heat injury. An increase in drying temperature also results in loss of oil from the seeds

Cardamom is dried by adopting two methods:

1. Natural (Sun drying)
2. Flue curing

Natural (Sun drying)

Freshly harvested capsules are directly dried under sun for a period of five to six days or more depending on the availability and duration of sunlight. Natural drying does not retain green colour of capsules and also leads to splitting of the capsules. During cloudy and rainy weather conditions, proper drying of capsules cannot be accomplished and hence the quality of the capsules deteriorates. In general, sun dried capsules are not preferred for export. Sun drying is commonly practiced in some parts of Karnataka.

Flue curing

It is one of the best methods of drying by which high quality green cardamom can be obtained. A traditional firewood based curing house consists of a furnace for burning the wood, flue pipes for conveying the hot air and drying racks for stacking the trays. A drying chamber with dimensions of 4.5 m in length and breadth is sufficient for a plantation, which has a production capacity of 2 tonnes of fresh cardamom. In general, 3-4 kg of firewood is consumed for drying 1 kg of fresh cardamom.

The capsules are spread evenly in thin layers on the trays. After staking the trays on the racks in the drying chamber, the curing room is closed. Hot air generated by burning firewood in the furnace is circulated through the flue pipes, which are placed few centimeters above the floor. This process enhances the room temperature to 45-55°C, which is maintained for a period of 3-4 hours. During this period, the capsules sweat and give off the moisture. The drying process is facilitated by opening the ventilators for sweeping out the water vapour generated from the drying capsules. Exhaust fans are also used for the speedy removal of moisture. After complete removal of watervapor, the ventilators are closed and the temperature inside the chamber is again maintained at 45-55°C for a period of 18-24 hours. In the final stage of curing process, the temperature is maintained at 50-55°C for another 1-2 hours. The temperature is raised to hasten the cleaning process by which debris like stalks attached to the capsules can be removed easily. Temperature inside the curing chamber is maintained around 55°C to avoid splitting of the capsules and also to prevent the loss of volatile oil. Under these conditions, it is possible to obtain high quality green cardamom in about 24-30 hours.

Efficient and highly automated cardamom dryers have been developed and being widely used with alternative sources of fuels such as kerosene, Liquid Petroleum Gas (LPG) and diesel or with combination of fuels. Such kind of improved systems has the advantage of retaining high quality of produce with respect to colour and duration of curing is also substantially reduced to 16-18 hours.

Dried capsules are polished either manually or with the help of machines. Polishing is carried out by rubbing the dried capsules in hot state against a hard surface. The polished produce is subsequently graded based on the quality parameters such as colour, weight per volume, size and percentage of empties, malformed, shrivelled and immature capsules (Table 5).

After grading cardamom capsules are stored. The capsules are stored at a moisture content of less than 10 percent to retain the original parrot green colour and to prevent mould growth. Use of 300-gauge black polythene lined gunny bags

improves efficiency of storage. It is advisable to store the dried cardamom in wooden boxes at room temperature.

Other products of cardamom

Cardamom seeds: Cardamom seeds are obtained by decorticating the capsules. Decortication is achieved by using a plate mill, which is also called as disc mill.

Cardamom powder: Cardamom in its powder form gives maximum flavour to the food products. But the disadvantage with powder is that it loses aroma quality due to rapid loss of volatile constituents.

Cardamom oil: Cardamom oil is obtained by distillation of powdered seeds of cardamom. Steam distillation is the common method employed for the production of oil. Cardamom capsules with good flavour, which do not fetch higher value because of defective appearance, are suitable for distillation. The flavour of cardamom is mainly due to 1,8 cineole, terpinyl acetate, linalyl acetate and linalool.

Table 5: AgMark Grade designations and quality of cardamom whole capsules

Grade designation	Quality								
	Special Characteristics (percent by mass)								
	Organic extraneous matter (Maximum)	Inorganic extraneous matter (Maximum)	Empty and malformed capsules per cent by count (Maximum)	Immature & shriveled capsules (Maximum)	Insect damaged matter* (Maximum)	Mass in gm/L (Minimum)	Moisture (Maximum)	Total ash on dry basis (Maximum)	Volatile oil on dry basis % (v/w) (Minimum)
Special	0.2	0.1	2.0	2.0	0.20	435	11.0	8.0	4.0
Standard	0.7	0.3	3.0	3.0	0.50	385	13.0	9.5	3.5

* Thrips marks alone should not lead to the conclusion that the capsules have been infested with insects

Table 6: FSSAI regulatory requirements for whole cardamom

Sl No	Parameter	Value
(i)	Extraneous matter	Not more than 1.0 percent by weight
(ii)	Empty and malformed capsules by count	Not more than 3.0 percent by count
(iii)	Immature and shriveled capsules	Not more than 3.0 percent by weight
(iv)	Moisture	Not more than 13.0 percent by weight
(v)	Total ash on dry basis	Not more than 9.5 percent by weight
(vi)	Volatile oil content on dry basis	Not less than 3.5 percent by v/w
(vii)	Insect damaged matter	Not more than 1.0 percent by weight

Table 7. Grades and specifications for Indian cardamom

Grade	Description	Size (mm)	Weight (g/l)	Colour	General characteristics
AGB	Extra Bold	7	435		
AGS	Superior	5	385	Green	Kiln dried, 3 cornered and with ribbed appearance
AGS 1	Shipment	4	320-350		
AGL	Light	3.5	260	Light green	
CGEB	Extra Bold	8	450		
CGB	Bold	7.5	435	Golden to light green	
CG-1	Superior	6.5	415	Light green	
CG-2	Mota, Green	6	385	Green	Round, ribbed or smooth skin
CG-3	Shipment	5.5	350	Cream	
CG-4	Light	3.5	280	Brown	
BL-1		8.5	340	Pale	
BL-2		7	340	Creamy	Fully developed round, 3 cornered ribbed or smooth skin
BL-3		5	300	Dull white	
AG -Alleppey Green, CG -Coorg Green, BL -Bleached					

Disease management schedule

Chemical	Method of application	May-June	July-August	Aug-Sep
Bordeaux mixture (1%)	Spray	1. 'Azhukal' or capsule rot 2. Rhizome rot 3. Leaf blight	1. 'Azhukal' or capsule rot 2. Rhizome rot	1. Leaf blight
Copper oxy chloride (0.25 %)	Drench	Rhizome rot		Rhizome rot
Carbendazim and mancozeb (0.1%) or carbendazim (0.2%)	Spray			Leaf blight

Insect pest management in cardamom

Chemical	Method of application	Feb-Mar	Mar-Apr	Apr-May	May-June	Aug-Sep	Sep-Oct	Oct-Nov
Fipronil 0.005% or Spinosad 0.0135% alternatively	Spray	1.Thrips 2.Shoot and capsule borer	Thrips	Thrips			1. Thrips 2.Shoot and capsule borer	
Quinalphos (0.075%)	Spray	Shoot and capsule borer	Shoot fly				Shoot and capsule borer	Shoot fly
Chlorpyrifos (0.075%)	Drench				Root grub	Root grub		



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