

SMALL CARDAMOM

Scientific Name: *Elettaria cardamomum* Maton.

Family : *Zingiberaceae*

English name : Small cardamom, Lesser cardamom, Malabar cardamom.

Indian name : *Chhoti Elaichi*(Hindi), *Yelakki*(Kannada), *Elathari* (Malayalam), *Ela* (Sanskrit), *Yelakkai*, *Elakkai* (Tamil), *Yealakkayulu*, *Elakkayi* (Telugu)



The small cardamom, popularly known as ‘Queen of Spices’ is a tall perennial herbaceous plant in the family *Zingiberaceae*. Cardamom of commerce is the dried capsule of this shade loving plant indigenous to the evergreen forests of Western Ghats of South India.

Origin and distribution:

Cardamom is indigenous to the evergreen rainforests of Western Ghats of southern India from where it spread to some other tropical countries such as Sri Lanka, Tanzania and a few Central American countries. Presently, it is being cultivated in not less than twelve countries from three continents lying between 20° latitude north and south. Cardamom was an article of Greek trade during the 4th century B.C. It was listed among the Indian spices liable to duty at Alexandria in A.D. 176. The cultivation of cardamom in India was actively taken up by the erstwhile Travancore Government in 1823 A.D.

The major cardamom-producing countries besides India are Guatemala, Sri Lanka, Thailand, Tanzania and Cambodia. Cardamom is also produced on a smaller scale in Laos, Vietnam, Costa Rica and El Salvador. In India the Cardamom is cultivated in Kerala, Karnataka and Tamilnadu. In Kerala the major cardamom growing area are Travancore, in the Idukky district, Wayanad and Kottayam region. In Karnataka Coorg, Chikmaglore, Hassan and Uttara Kannada district, Palany, Nilagiris and Kodai hills of Tamilnadu.

Area and production:

India has been the world’s largest cardamom producer until 1979-80, when Guatemala came to the scene as a major rival. At present, Guatemala is the world leader in production. Cost of production in Guatemala is reported to be only half of that in India and India finds it difficult to compete with Guatemala in the international market.

In India, small cardamom cultivation is restricted to the Western Ghats region of

Kerala, Karnataka and Tamil Nadu. The Indian cardamom has higher oil content and aroma. Kerala occupies the first place, contributing to about 60% of the total area and Karnataka covers about **31%** of the area, followed by Tamil Nadu (**9%**), with a production of 58.5, 34 and **7.5%**, respectively during the year 2009-10.

The average annual production of cardamom is reported to be around 15,000 tonnes obtained from 90,200 hectares in **2009-10**. India still meets about 60-65% of the world's demand through the export of cardamom to about 50 countries. During 2010-11, 11.75 tonnes of cardamom was exported earning a foreign exchange of Rs.13,216 lakhs. The important countries importing cardamom from India are Kuwait, Qatar, Saudi Arabia, the erstwhile USSR and Japan.

Botany:

Cardamom is a tall growing, cross-pollinated, herbaceous perennial, with branched subterranean rhizomes. The real stem is the rhizome, which is subterranean in habit. Cardamom is a shallow-rooted plant. The leaves are 35 cm long and 1-10 cm wide, distichous, linear and lanceolate in shape, with short petioles. The inflorescence or the long panicles with racemose clusters arise from the underground rhizome. The flowers open in succession from the base to the top and develop into fruits. The calyx is cylindrical and persistent and the corolla tube is shortly exerted. The fruit is a trilocular capsule; the capsules are globose and rounded. The seeds are black when fully ripe in a capsule and embedded or covered with a white mucilagenous coat. There are 15-20 seeds in each capsule with a hard seed-coat.

Scope and Importance:

Cardamom is indigenous to Western Ghats in south India, the hilly region of the country in Kerala, Karnataka and Tamilnadu are having more favourable agro-climatic conditions for cultivation of cardamom. The heavy rainfall, higher elevation and low temperature are congenial for cultivation of cardamom. Similarly the prevailing soil types, red sandyloam and forests soil rich in humus are ideal for cultivation of this crop. Cardamom is shade loving crop and suitable for cultivation as inter/mixed cropping system in arecanut and coffee plantations. The lower valleys of coffee and tea plantations having suitable micro-climate which is more favourable for cultivation of this crop. Cardamom is a high valued crop and good income generating crop. There is a lot of export demand because of high quality and also maximum internal consumption need expansion of area and more production.

Cardamom is used as a spice and flavouring of various preparations of food, confectionary, beverages and liquors. It is also used in flavouring of curries, cakes, bread and other culinary preparations. Cardamom is used in three forms viz., whole, decorticated seeds and ground. It is used for the extraction of essential oil and oleoresin. In Arab countries the coffee is prepared using cardamom is popularly known as Gahwa' it is a prestigious drink for them. Cardamom is used in flavouring of soft drinks, payasa, ghee rice etc., Oils and oleoresins are used in flavoring of cordials and preparation of chewing gums, perfumery and

cosmetics. It is also used in flavouring of medicines. Cardamom is a good stimulator for heart and liver. Cardamom tea is used to prevent dysentery, scanty urination, exhaustion due to over work. Cardamom with honey is reported to improve eyesight, strengthen nervous system. Cardamom is an essential ingredient of digestive stimulants and is used in medicinal preparations for indigestion and flatulence. The new products of cardamom are cardamom cola, instant gahwa, chewing gum, biscuits, encapsulated cardamom oil etc.,

Climate

The crop thrives well in evergreen tropical forests at an altitude of 600 m to 1500 m. above MSL. Cardamom is found to grow well even in areas where the annual rainfall ranges from 150-400 cm, provided the rainfall is well distributed. The better distribution of rain rather than high annual rainfall is the most important factor for a good crop. It grows well in a temperature range of 10° to 35°C. Valleys and gentle slopes facing the North or North-eastern direction, protected from strong winds, form an ideal situation for cardamom plantation. Cardamom requires filtered light for better growth.

Soil

Well-drained soils rich in organic matter, forest loams rich in phosphorus and potassium and deep light-textured lateritic soils with a pH range of 4.6 to 6.5 and plenty of humus are good for the crop. It is mostly grown as a pure crop in the lower portion of undulating valleys.

Varieties

Based on the size of the fruit, two varieties viz, *Elettaria* cardamom Maton variety *major*, made up of the wild indigenous types and the variety *minor* Watt (Syn.var. *miniscula* Burkill) comprising of the cultivated types are recognized. Among the various cultivated types, three major races viz., "Mysore", "Malabar" and "Vazhukka" are most popular and can be identified on the basis of certain specific morphological characteristics.

Malabar or prostrate type

This is the most common race cultivated on the Travancore hills and the southern Western Ghats. The plants are of medium size and grow 2-3 m in height. The leaves are either pubescent on the dorsal side, or sometimes glabrous. The panicles are prostrate and the fruit is roundish. This type is suited to the 600-1000 m elevational zone. The plants are early, short span of flowering, more drought resistant. The Malabar cardamom is considered to be more tolerant to the attack of thrips. This variety is mostly suitable for lower elevations.

Mysore or erect type

The plants are robust and grow to 3 to 5 m in height. The leaves are lanceolate or oblong, glabrous on both surfaces, large and dark green, petiole long. The panicles are erect, late bearing long flowering span, the capsules bold, and more productive. This variety is suited to high elevations (900-1,200 m MSL) and withstands exposure to wind.

Vazhukka or semi-erect type

This is a hybrid of the "Mysore" and "Malabar" types and consequently the plants exhibit various characteristics which are intermediate between the two types. They are also adaptable to a fairly wide range of environmental conditions. The plants are robust (3 to 5 m height) like the "Mysore" types and have deep green leaves, semi-erect panicles and bold capsules. Late long flowering span suitable for higher elevation.



Malabar Type



Vazhukka type



Mysore Type

Improved cardamom varieties released from different research stations/institutes for cultivations.

Variety! year of release	Pedigree / parentage and plant type	Institution! University	Av. Yield kg/ha (dry)	Salient features
Mudigere 1 1984	Clonal selection from Malabar type	Regional Research Station, UAS Mudigere- 577 132, Chikmagalur (Dist.) Karnataka	275 (potl. yield 1000)	Erect and compact plant, short panicle, pale green, oval capsules, suitable for high density planting, moderately thrips, hairy caterpillar and white grubs, pubescent 8.0% oil, 36.0% 1,8 cineol, 42.0% α -terpenyl acetate, recovery 20.0%
Mudigere 2 1996	Clonal selection from open pollinated in Malabar type	-do-	475 (potl. yield 1000)	Early maturing, suitable for high density planting, bold capsules, oil 8.0% ¹⁰ , 1,8 cineol 45.0%, α -terpenyl 38.0%
PV1 1991	A selection from Walayar collection, a Malabar type	Cardamom Research Station, RAU, Pampadumpara, Idukki, Kerala PIN 685 553	260 (potl. yield 500)	An early maturing type, short panicle, elongated slightly light green capsules, essential oil 6.8%, 1,8 cineol terpenyl acetate 46.0% ¹⁰ , dry recovery 19.9%
PV2 2001	A selection from OP seedlings of PV-1, Vazhukka type	-do-	982 (potl. Yield 1250)	Early maturing, unbranched lengthy panicle, long bold high dry recovery percentage (23.8%), essential oil 6.6%, tolerant to stem borer and thrips. Suitable for elevation 1000 to 1200 meters above MSL
ICR11 1992	Selection from Chakkupallam collection, a Malabar type	ICRI (Spices Board), Myladumpara, Kailas anadu, Idukki (Dist.), Kerala - 685 535	325 (656 kg under irrigated condition)	An early maturing variety, medium sized panicle with round and extra bold dark green capsules contains oil cineol 29.0% ¹⁰ , α -terpenyl acetate 38.0% ¹⁰ and dry
ICR12 1992	Clonal selection from germplasm collection, Mysore type	-do-	375 (766 kg under irrigated condition)	Performs well under high altitude and irrigated long panicles, oblong bold and parrot green capsules, <i>aeukkal</i> disease. Dry recovery 22.5%
ICR13 1993	Selection from Malabar type	ICRI (Spices Board). Sakleshpur, Donigalpost 573 134, Karnataka	440 (790 kg under irrigated condition)	Early maturing, non-pubescent leaves, tolerant to disease, oblong, bold parrot green capsules, suitable for Karnataka, oil 6.6%, 1,8 cineol 54.0%, α -terpenyl dry recovery 22.0%
TKD4 1997	Clonal selection from Vadagaraparai area of lower puleyns, a Malabar type	ICRI (Spice Board) Thdyankudisai - 624212 TamilNadu	455 (960 kg under irrigated condition)	Early maturity, medium sized panicle, globose bold 6.4%. Suitable for low rainfall areas, relatively tolerant rot and capsule borer
IISR Suvasini (CCS-1) 1997	Selection from OP progeny of CL 37 from RRS Mudigere. Malabar type	Indian Institute of Spices Research, Cardamom Research Centre (ICAR), Madikeri-571201, Appangal, Karnataka	745 (1322 kg under condition)	Early maturing, suitable for high density planting, long high % of bold parrot green capsule (89), tolerant to thrips, shoot/panicle capsule borer, essential oil 8.7%, 42.0%, α -terpenyl acetate 37.0%, dry recovery 22.0%

IISR	Clonal selection from field	-do-	643 (pot! Yield 979 kg)	Virus resistant selection with high percentage of bold
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Vijetha (NKE-12) 2001	resistant plant for katte, a Mala bar type			(77.0%) oil 17.9%, 1,8 cineol 45. <i>CPIo</i> , α -terpenyl acetate dry recovery 22.0%. Recommended to moderate moderate high shaded and mosaic infected areas, field thrips and borer as well as mosaic
IISR Avinash (RR-J) 2001	A selection from OP seedlings of CCS-1. a Malabar type	-do-	847 (pot! yield 1483)	Has extended flowering period, dark green capsules colour even after processing. Tolerant to rhizome rot, capsule borer, oil 6.7%, 1,8 cineol 30.4%, α - terpenyl 35.5%, dry recovery 20.8%. Highly suitable for planting and rhizome rot prone areas and intensive cultivation
Njallani Green Gold	A clonal selection from Vazhukka type	Farmers selection from Idukki district of Kerala	1600 (pot! yield > 3000)	A higher yielding clonal selection by a cardamom district. Capsules bold, over 70% of the cured mm. Reported to be of high quality. Currently the cultivar. Yield up to 5000 kg/ha has been recorded

Propagation

Cardamom is propagated both asexually (through suckers) and sexually (through seeds). Seed propagation is recommended in areas affected by 'Katte' disease (a disease transmitted through suckers) as well as when large number of planting material is to be produced. Vegetative propagation gives earlier bearing and true to type plants. Micro propagation technique has also been standardised and commercialized in cardamom.

Seed propagation

Fully ripe seeds are extracted from ripe capsules from high yielding vigorous plants preferably from 2nd and 3rd round of harvest. Best time for seed capsule collection is September-October. Immediately after picking, capsules are immersed in water and seeds are extracted by gently pressing capsules. Seeds are then washed in water to remove mucilage. Scarification seed with 25 % nitric acid for 10 minutes followed by washing in water before sowing assures 80 % germination. Seeds are then smeared with wood and dried under shade. September sowing is ideal as seedlings are ready transplanting during ensuring planting season.

Primary nursery

Nursery site should be preferably on moderately sloppy land, in open and well drained location near source of water. Raised seed beds (20 cm) of one meter width and of convenient length are prepared. Spread a layer of forest soil over the bed. Soil solarisation of seed beds enhances germination by 25 %, reduces weed growth by 82 % and suppress pests and diseases. Seeds can be broadcasted or live sown 1-2 cm apart in rows 8-10 cm apart. Seed rate is 10 g/m². On an average, one kg of seed capsules are required to get about 5000 plantable seedlings. Beds are mulched to a thickness of about 2 cm with paddy straw and watered regularly in morning and evening. Sprouting commences in about 25-30 days. After germination is completed, mulch is removed and an over head 'pandal' at a height of 2 m is erected for providing shade. Regular

watering, weeding and plant protection are attended. Thinning of seedlings is done at six-seven leaf state, followed by earthing up.

Secondary nursery

Nursery beds are prepared in same manner as for primary nursery. Shade is to be provided by erecting overhead pandal. Seedlings are transplanted when they are 4-6 months old (4 to 5 leaf stage) at a distance of 20 cm x 20 cm. Beds are mulched and watered regularly. Weeding, manuring and plant protection practices have to be attended whenever needed. One month before transplanting, the overhead shade is removed to enhance tillering. In Kerala 18-22 months old seedlings are used for transplanting while in Karnataka 10 months old seedlings are used. Two year old seedlings is the best for getting more tillers and higher yields. The secondary nursery can also be raised in polybags. Polybags of 20 x 20 cm filled with a mixture of humus rich top soil, cow dung and sand (3:1:1) is an excellent medium for filling polybags. Raising seedlings in polybags has many advantages like uniform growth, more tillering and good establishment in field.

Vegetative propagation

Clonal propagation is advantageous in places where 'Katte' disease is not a menace. Also plants raised from rhizomes come to bear early compared to seedlings. Cardamom is propagated vegetatively by division of rhizomes. A portion of the rhizome with one old and one young shoot consists a planting unit. The main disadvantage with clonal propagation is limited availability of planting material.

Rapid clonal multiplication technique

A rapid multiplication technique for production of vegetative planting material was standardised at IISR research centre at Appangala, Karnataka. Suckers are collected from high yielding plants and planted at a spacing of 1.8 m x 0.6 m, thus accommodating approximately 6800 plants/ha of clonal nursery area. Overhead shade is provided and nursery is irrigated. Fertilizers at the rate of 48: 48: 96g NPK plant⁻¹ is given in two splits. After 12 months of planting, each planting unit produces on an

average 32-42 suckers. In an area of 1 ha clonal nursery, 1 to 1.4 lakhs planting units can be produced after one year. A crop of 190 g/plant of dry cardamom (1759 kg/ha) also could be harvested within just 19 months of planting. This system is easy and cheap and can be adopted by farmers.

Micropropagation

First commercial level production of plantlets in spice crops through tissue culture was achieved in Cardamom. Micropropagation technique in cardamom was standardised by many scientists. The approaches used were (1) through callusing, (2) through adventitious bud formation and (3) through enhanced axillary branching. Cost effective commercial micro propagation technology developed at ICRI, Spices Board.

Young sprouting tillers of eight to 10 cm length were found as the best explants for tissue culture of small cardamom. Time of collection of the explants is also very important for success of tissue culture of small cardamom. Collection of explants between March to May is ideal. Various media formulations were tested such as LS (1965), Gamborg *et al.* (B5) (1968), MS (1962), KC (1946) and SH (1972). Media were supplemented with various growth regulators such as BAP, KN, IAA etc. Coconut milk was added to every combination tested. Growth factors D-Biotin and calcium pantothenate also were added @ 0.1 mg/l. Hardening of tissue-cultured plantlets was done in sand filled cups under a mist chamber with 80 % relative humidity at a temperature not exceeding 33°C.

Among various media formulations tried, SH was more effective for cardamom shoot induction supplemented with BAP, KN and coconut milk each 0.5 mg/l and IAA at 2 mg/L. Growth factors D-Biotin and calcium pantothenate also were added @ 0.1 mg/l. The buds elongated on M I medium 6-8 weeks, grew to a height of 30-40 mm within 12 weeks. (M I = SH basal + BAP 0.5 mg/l + KN 0.5 mg/l + IAA 2 mg/l + CW(5 per cent V/V) + D-biotin 0.1 mg/l +- Ca. pant 0.1 mg/l).

Transfer of shoots to fresh medium could be done every five weeks, although well established cultures of cardamom appeared to hardly remain in the same medium for up to two months without any deterioration.

When primary cultures were about 30-40 mm long, they were individually transferred to shoot multiplication medium M II (M II = MS basal + BAP 0.5 mg/l +

KN 0.5 mg/l + IAA 2 mg/l + CW 5 pr cent V/V + D-biotin 0.1 mg/l + Ca. pan 0.1 mg/l).

Rate of multiplication ranged from 1:1 to 1:13 with an average of 1:3 per month and the rapidly growing cultures were normally subcultured at an interval of 27-35 days. Although subcultures *could* often be continued over many months and even years without adverse effects apparent in culture, genetically variant shoots could arise through somaclonal variation. To prevent this it was found desirable to initiate fresh cultures from new explants after every 12th subculture. White's rooting medium without any hormones was found more effective than any other media in promoting shoot elongation and subsequent rooting in cardamom. White roots appeared from 4 to 14 days after transferring to rooting medium. The shoots grew rapidly to a length of 50-60 mm during this period. The rooting percentage was 86-93 %.

Rooted shoots that were 4 to 5 cm high and having well-ramified roots were transferred for hardening and acclimatization. Topsoil or a composted soil mixture preferably sterilized or pasteurized was found satisfactory as planting medium. Dipping plantlets in fungicidal solution prior to soil transplanting reduced the risk of damage by fungal attack.

Plantlets were generally allowed to acclimatize in nursery for two to three months till they reached a height of 20-30 cm before transplanting either to polybags or directly to field. Field preparation, planting and culture management were performed according to recommended practices to achieve successful field establishment and subsequent vigorous growth.

Cultivation:

Selection of land, preparation and system of cultivation

The land selected for cultivation of cardamom should be cleared with wild growth and prepare the soil with adequate soil conservation techniques adopted. Normally gentle slope lands or valleys are preferred for cultivation of the crop. Terraces made across the slope at suitable planting distances. Planting distance should be more in high rainfall areas or irrigated condition and less in low rainfall areas. Spacing depends on soil fertility, type of cultivars and terrain. Spacing adopted is more in Kerala while in Karnataka, closer spacing is followed. Spacing of 1.8 m x 1.8 m or 2

m x 2 m is recommended for Malabar variety. 3 m x 3 m for Mysore and Vazhukka. However, in fields of low fertility, plant density can go up to 1600/ha for Mysore and Vazhukka and up to 3000/ha for Malabar. For Karnataka, a general spacing of 1.8 m x 1.8 m is suggested. A spacing of 1.8 m x 1.8 m (3025 plants/ha) and 2.7 m x 2.7 m (1371 plants/ha) is recommended in Malabar and Mysore types respectively in Tamil Nadu. Pits of size 45 cm x 45 cm x 30 cm are dug during April-May, filled with a mixture of surface soil and compost or well-rotten farm yard manure + 100 of rockphosphate. This has to be done two months in advance of planting of seedling for better establishment and good growth. Best season for planting is with commencement of South West monsoon before heavy rains. Cloudy days with light drizzles would be ideal for planting and result in early and maximum percentage of establishment. Avoid deep planting. A small mound may be formed inside pit to cover the rhizome and immediately after planting mulching should be done. Plants should be supported by stakes. In Karnataka 10-12 months old and 18-24 months old seedlings in Kerala are used for planting in the field.

High density planting

Studies have proved that Malabar varieties perform well under high density planting. Planting of cardamom (Malabar type) with a high density of 5000 plants/ha under rainfed condition in trench system with a fertilizer dose of 120:120:240 kg NPK/ha is recommended for Karnataka state. Studies on high density planting with a spacing of 1.8 x 1.8 m (3025 plants/ha) indicated early and high yields in initial three-four years. However, removal of alternate plants after five to six years is inevitable for facilitating easy cultural operations. Variety Mudigere-I (Malabar type) is the best suited for high density planting (1 m x 1 m spacing). A closer spacing of 1 m x 1 m for Malabar types gave higher yields closely followed by 1.5 m x 1.5 m spacing under the rainfall conditions of Shevroy hills in Tamil Nadu. Planting of suckers at a spacing of 1.8 m x 0.9 m gave considerable high yields in initial stage. Mysore and Vazhukka varieties are not suitable for high density planting.

Shade management

Cardamom is a pseophyte, it requires filtered light of 50-60 percent for better growth and yield. Shade management is an important operation in cardamom plantation. Shade trees having distributed branching pattern and small leaves are ideal for cardamom. The ideal shade tree in cardamom plantation should have the characteristics of Wide canopy so that number of shade trees in unit area is minimum, No shedding of leaves during flowering phase so that pollination is not affected, Medium size and evergreen in nature retaining their foliage throughout the year, Should have small leaves and well spread branching system, Should have deep root system to avoid competition with cardamom and to resist wind and Should be fast growing to provide necessary immediate shade.

It is desirable to maintain a mixed population of medium sized trees that facilitate shade regulation and maintain more or less optimum conditions throughout the year.

Some of the good shade trees suited are *Vernonia arborea* (Karana), *Cedrella toona* (Red cedar), *Cassia fistula* (Kanikonna), *Diospyros malabaricum* (Vellakil), *Terminalia tomentosa* (fhempavu), *Hopea pannflora* (Thambakam), *Acrocarpus [raxinifolius* (Balangi), *Mesopsis eminii* (Elangi) and *Artocarpus integrifolia* (jack), Shade trees like red cedar, which shed their leaves in monsoon, provide natural shade regulation. Protection from sunlight by maintaining an overhead tree shade is essential for cardamom in the initial stages of growth to enhance tillering. In newly established plantations, where shade is inadequate, fast growing species of *Eruihrina* may be planted along with other trees. After the establishment of shade trees, erytrina may be removed. Similarly, shade should be thinned during monsoon and premonsoon period. In order to provide adequate sunlight during rainy season (when light intensity is less), excess shade should be regulated before onset of monsoon. Shade regulation studies on cardamom productivity revealed that one third of-incident sunlight (15.20 K Lux) in the form of filtered light is optimum for growth and production. Studies at RRS Mudigere (University of Agricultural Sciences, Bangalore) revealed that shade trees in cardamom plantation play an important role in nutrient recycling through leaf fall. *Theoeiia nerifolia*, *Terminalia catapa* and *Artocarpus integrifoia*, produced more biomass around 950 g/m²/year. Jack tree is found to recycle maximum NPK (63.9kg/10 tonnes

biomass). A study conducted at Cardamom Research Station, Pampadumpara to assess organic carbon content of CHR dominated by different tree species was given by Miniraj and Murugan (2000). In the undisturbed ecosystem, organic carbon content of soil was high (Table 14). Comparatively higher organic carbon content was recorded in cardamom production systems as compared to that black pepper. This is clearly attributed to lack of native tree species and low biomass production of dominant tree - *Erythrina*. Besides, warmer soil environment experienced in pepper production system due to shadeless condition directly and indirectly affect decomposition of organic matter. Cultivation of cardamom under artificial shade (coir mat) is economical and feasible.

Manures and Fertilizers

Cardamom requires regular manuring and fertilizers for better growth and yield. Organic manures like compost or cattle manure may be given @ 5-10 kg/ clump. Neem oil cake may also be applied @ one kg/ clump. Nutrient uptake studies indicated the uptake of N, P, K, Ca and Mg in the ratio of 6:1:12:3:0.8 respectively. Cardamom is a heavy feeder of potash. For crop yielding 100 kg dry capsules/ha, an optimum fertilizer dose of 75:75:150 kg NPK/ha (half the dose for one year old plant) in two split doses is recommended for Karnataka. Cardamom is a surface feeder. Roots are generally confined to surface soil and nearly 70% of roots are within 5 cm depth. Therefore fertilizer is to be applied in circular bands of 15 cm width leaving a distance of 30 cm from plant base. First application during May-June helps production of suckers and development of capsules and second application during September-October helps initiation of panicles and suckers. In irrigated plantation, application of fertilizers in 4 split doses at quarterly interval is beneficial. Higher levels of fertilizer viz., 150:150:225 kg NPK/ha resulted in significant higher capsule yields at Mudigere (Karnataka). Evaluation of optimum fertilizer levels for high density cropping studies conducted at Mudigere confirmed that cardamom grown under natural shade responded positively for fertilizer application and significantly influenced yield. Mudigere (Karnataka) and Pampadumpara (Kerala) have come out with independent fertilizer recommendations viz. 75:75:150 kg NPK/ha and 100:100:175 kg NPK/ha respectively. While the fertilizer recommended for Tamil Nadu is 40:80:40 kg NPK/ha during June, August and November. For low rainfall areas of Tamil Nadu,

recommendation is 20:40:20 kg NPK/ha in two splits during September and November. Fertilizer dose of 120:120:240 kg NPK/ha is recommended in high density planting of (5000 plants/ha) Karnataka. At Mudigere, studies on integrated nutrient management using organic and inorganic manures on yield of cardamom confirmed that 100% inorganic manure alone recorded maximum green capsule yield (707 kg/ha). Studies also confirmed that boron and molybdenum play an important role along with other management practices in increasing yield. Application of boron in the form of disodium tetraborate @ 20 kg/ha and molybdenum in the form of sodium molybdate @ 0.25 kg/ha mixed with appropriate quantity of FYM @ 1 kg/plant applied with onset of monsoon increased cardamom yield by 20%.

Deficiency Symptoms:

Nitrogen: Yellowing of older leaves, reduction in leaf size and sucker production and drying of new suckers.

Phosphorous: Perish spots, premature falling of older leaves, stunted plant growth, reduced number of suckers and roots.

Potash: Browning of leaf tips, whole leaf turned dark brown, no new sucker production, reduction in root and shoot growth.

Calcium: Leaves become brittle, reduction in size, no new growth of aerial shoots, root and shoot growth restricted, bulky appearance.

Magnesium: Tip drying, twisting of stunts, root and shoot growth affected, vein clearing and Yellowing of leaves.

Mulching: It is an important operation to conserve soil and moisture, fallen leaves of the shade trees are utilized for mulching around the space of the plant. Five centimeter thickness of mulching is advisable. Mulching should be done during the month of November-December to overcome the ill effects of drought, which is prevailing during summer. Mulching helps in conservation of moisture and helps for better growth of the plant. Any locally available mulch materials (Dry leaves, grass, phoenix leaves etc.) and polythene sheets can also be used as mulch materials.

Liming:

Cardamom is cultivated in heavy rain fall areas of hilly region, top soil along with nutrients or eroded as a result soils are becoming acidic. Before application of fertilizers soil pH as to be corrected by adding lime based on the soil test results. However, every two years

once 2 to 3 tonnes of lime per hecters is recommended and this as to be applied during April-May. Agricultural lime and dolomite lime are commonly used liming materials to correct the soil acidity.

Irrigation

Cardamom is sensitive to moisture stress and needs irrigation during summer. Irrigation at an interval of 10-15 days from December till commencement of monsoon is required. Analysis of rainfall pattern of 50 years in cardamom growing tracts by ICRI, Spices Board recommended that judicious irrigation during peak dry months (February to April) ensures increased yield. This is the period when development of young tillers and elongation of panicle take place. Water stress during this period of growth result L11 reduced yield. Anyone of the methods viz. sprinkler, drip or hose irrigation could be adopted. Taking into account the crops consumptive use and climatic condition, it is recommended that irrigation is given at an interval of 10-12 days to get the equivalent of 25 mm rain in each round. Cardamom plants are also sensitive to water logging. Hence, excessive irrigation is also detrimental, Combination of irrigation at 75 % available soil moisture level and high light intensity (65 to 70% lux) resulted in sustained increase in yield. Irrigation through drip method four litter per plant per day is recommended.

Use of growth regulators

Exogenous application of NAA (40 ppm) or 2,4-D (4 ppm) increased plant height and panicle production. Similarly, spraying of NAA (25 ppm) twice (June and July) reduced fruit drop and increased fruit set. Application of ethrel (250 ppm) under high light intensity (15 K lux) doubled sucker production.

Bee-keeping

Pollination in cardamom is entomophilous mainly by two species of honey bees viz. *Apis cerana* and *Apis dorsata*. Honey bees contribute over 90% pollination, lack of pollination causes fruit drop and fruit set in cardamom. Number of visits of bees is directly correlated with the number of seed formed in capsules. Five to six visits by bees are required for getting full seed set. At least four bee colonies (hives) / ha to are needed to enhance pollination and fruit set. Increase in yield up to nine % could be obtained by keeping bee

hives. Soil and moisture conservation, the economic life span of cardamom crop is 10-15 years under good growth condition without severe pests and diseases. Conservation of soil and water should be taken care in hill slopes. Measures like contour trenching, bunding, bench terracing, drain channels, check dams and afford station are recommended. Intensive tillage of soil leads to soil erosion.

Weeding :

Two to three weeding are required in a year depending on the weed growth. First weeding may be done in May-June before the fertilizers of application. Second weeding is done in August-September before the post monsoon application of fertilizers. It is very important to carry out the third round of weeding in November-December soon after the North-East monsoon is over for avoiding the competition of weeds for moisture and nutrients. Weedcides like paraquat (Gramoxone) 1.25 liters per hectore could be used to overcome the weeds.

Exposing of panicales :

From first week of June onwards exposed panicales by lifting them above the layer of mulch to facilitate the visiting of bees for pollination. This operation has to be followed 2 to 3 times in a cropping period.

Earthing up operation:

After the monsoon is over a thin layer of top soil is earthened up to the base of the clump covering upto the collar region by scrapping between the rows or obtaining the soil from the trenches or check pits, which encourages the new growth and sucker production.

Trashing :

Clean the plant by removing old suckers, dry leaves etc., once in a year in May-June It helps for better production of suckers and to reduce pests and diseases.

Harvesting and processing

Cardamom plants start bearing fruits (capsules) from 2-3 years after planting and satisfactory yield is obtained from 5th year. It takes 110 days from flowering to fruit maturity. Harvesting season is in August-December; peak harvest is during October-November. Capsules are harvested at an interval of 15-20 days at Karnataka and 30 days in Kerala and harvesting will be completed in seven-eight rounds. Fruits that are just ripened or physiologically mature (at the black seeded stage) are picked by experienced

workers. If capsules are immature, they will have a wrinkled appearance on curing and if they are fully ripe they will split on curing and will develop an yellow colour. Essential oil content will be more at physiologically mature stage and dry recovery more at ripened stage. At physiologically mature stage, recovery is 24 %.

Two types of pickings are adopted - light picking and hard picking. In light picking, only mature capsules are harvested whereas in hard picking semi-mature crop is also removed. Choice depend on availability of labour. Cardamom harvesting is mainly done by women labourers. The average yield of dry capsules is ranged between 200-500 kg/ha.

Quality parameters of cardamom

Boldness and colour of cured capsules, content and organoleptic character of volatile oil are important quality parameters of cardamom. They are primarily dependent on cultivar and time of harvest. Malabar is superior with regard to flavour and quality whereas Mysore dominated in production of bold green capsules.

Green Cardamom

Colour of cured cardamom is an important factor in consumer market. The highest quality cardamom traditionally was Aleppy Green, which is still regarded as the best. Different chemical treatments were tried to retain green colour of harvested capsules. Among such treatments, soaking green (wet) capsules immediately after harvest in two per cent sodium carbonate solution for 10 minutes fixes green colour during subsequent drying and storage. Except sun drying, all other methods are found to protect the green colour.



Post harvest operations

Post harvest operations consist of washing, curing (drying), cleaning, polishing, sorting, grading and packing. The capsules immediately after harvest are washed in water to remove adhering soil. Sometimes, capsules are treated with 2% washing soda (sodium carbonate) for 10 minutes to stabilize chlorophyll and this treatment imparts better green colour.

Curing

Cardamom curing may be defined as process in which moisture content of freshly harvested cardamom capsules is reduced from 80 % to 11-12 % at an optimum temperature of 45-55°C to retain its green colour and volatile oil to a maximum extent (Vadiraj, 2004). There are mainly two types of drying in cardamom viz. natural (sun drying) and artificial (firewood, electricity, kerosene or LPG as fuel).

Sun drying

Harvested capsules are directly dried under sun for a period of five to six days. Sun dried capsules will be bleached in appearance. Splitting of capsules will be more. This method is prevalent in some parts of Karnataka.

Flue pipe curing

It is one of the best methods of drying by which high quality green cardamom can be obtained. Hand picked fruits are dried in special curing chambers under controlled temperature to retain delicate flavour and green colour. Heat required for drying is produced by burning fire wood in iron Kiln, the heat thus produced is passed through pipes made of galvanized iron sheet. Capsules left for drying are spread thinly on wire net trays arranged one above the other on racks in the upper chamber of the curing house. They are stirred frequently to ensure uniform drying and also help to retain green colour of capsule. Drying temperature is kept at 50°C for first 4 hours and subsequently reduced to 45-50°C by opening ventilators and using exhaust fan. Finally temperature is raised to 60°C for one hour. The process of drying takes about 36-48 h.

Dried capsules are rubbed with coir mat! gunny cloth/ steel mesh and sieved to remove other plant debris. This process is called polishing. Polishing is also done in machines. The polished capsules are then graded according to size by passing through sieves of size 7, 6 and 5 mm. They are sorted according to size and colour. The percentage recovery is 24. The graded produce is packed in polythene lined gunny bags. Bin drier designed by UAS, Bangalore (electricity based), Melccard drier used in Bodinaikkenur region in Tamil Nadu (firewood operated), Solar drier developed by CPCRI, Kasaragod (solar energy as fuel), Mechanical cardamom drier developed by RRL, Trivandrum (electricity as energy), and thorough flow drier fabricated by CFTRI (electricity as energy source) are some of the new generation driers available. Kerosene, LPG gas and biogas were successfully used as an alternate fuel source in cardamom curing especially in the fire wood deficient areas and also by small and marginal growers. The kerosene and LPG based system were standardised for small quantity of 50-100 kg capacity (Vadiraj, 2004). These systems are not only ecofriendly but economical also.

Bleached cardamom

Bleached cardamom is manufactured in some parts of Karnataka. It is creamy white or golden yellow in colour. Bleaching can be done either with dried capsules or fresh capsules. Fresh capsules are soaked in 20 % potassium metabisulphite solution containing one % hydrogen peroxide for one hour. Drying of these capsules yield golden yellow colour. For dry capsules, bleaching agents used are bleaching powder, sulphur dioxide, potassium metabisulphite and hydrogen peroxide. In the conventional method prevalent still in Karnataka, bleaching of cardamom is carried out by steeping dried capsules in soap nut water (*Sapindus saponaria*). Bleached cardamom is inferior in quality (low volatile oil content) but its keeping quality is slightly better.

Cardamom seed and powder

Cardamom seeds are obtained by decorticating capsules. Cardamom powder is obtained by grinding seeds.

Value added products

Cardamom oil

Produced commercially by steam distillation of crushed fruits or powdered seeds of cardamom. Oil percentage is 8-11. Main flavour components of the oil are 1,8-cineole, α -terpinylacetate, linalyl acetate and linalool. Relative proportions of these constituents have a direct bearing on cardamom quality. Cineole is responsible for camphoraceous odour while other esters and alcohols give pleasant fruity odour.



Cardamom oleoresin

Oleoresin is obtained by solvent extraction. Of late, super critical fluid extraction is also adopted (SCFE). Oleoresin is produced in a relatively small scale only.

Fixed oil of cardamom seeds : Obtained from seeds. Major constituents of oil are oleic and palmitic acids.

Grading of cardamom Specifications for Indian cardamoms are given below:

Grade	Description	Size	Weight (g/l) min	Colour	General characteristics
AGAlleppe Green					
AGB	Extra bold	7	435	Green	Kiln dried 3 cornered and with ribbed appearance
AGS	Superior	5	385	Green	
AGSI	Shipment	4	320-350	Light green	~
AGL	Light	3.5	260	Light green	
CG Coorg Green					
CGEB	Extra bold	8	450	Golden to light green	Round, ribbed or smooth
CGB	Bold	7.5	435		

CG-1	Superior	6.5	415	Light Green	Fully developed round/3 cornered ribbed
CG-2	Mota, green	6	385	Green	
CG-3	Shipment	5	350	Cream	
CG-4	Light	3.5	280	Brown	
Bleached bleached)					
BL-1		8.5	340	Pale	
BL-2		7	340	Creamy	
BL-3		5	300	or smooth Dull white	

Agmark grades are also available for Coorg Cardamom and Bleached Cardamom.