



Research Article

SMALL CARDAMOM PRODUCTION TECHNOLOGY AND FUTURE PROSPECTS

VIJAYAN A.K.* , PRADIP KUMAR K. AND REMASHREE A.B.

Indian Cardamom Research Institute, Spices Board India (Ministry of Commerce and Industry, Govt. of India), Myladumpara, Idukki, 685 553, Kerala, India

*Corresponding Author: Email - drvijayannambiar@gmail.com

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Abstract: Small cardamom (*Elettaria cardamomum* Maton) the Queen of Spices enjoys a unique position in the international spices market, as one of the most sought after spices. In India, it is cultivated in the states of Kerala, Karnataka and Tami Nadu. The natural habitat of cardamom is the evergreen forests of Western Ghats. It is found to grow within an altitude ranging between 600 and 1200 meters above MSL. Various research institutions working on cardamom have released a number of elite location specific high yielding clones having yield potential of above 450 kg per hectare (rainfed) and superior capsule characters. Integrated pest and disease management is an important aspect of cardamom plantation management. Good quality of the produce can be achieved through timely harvest and adoption of scientific postharvest operations. Promising small cardamom varieties and improved selections coupled with optimum inputs and technologies can increase yield up to 2000 kg ha. Proper scientific management of plantation is the prime reason for successful cultivation. This production technology is recommended for commercial cultivation of small cardamom in the country.

Keywords: Cultivar, diseases, pest, production technology, small cardamom

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Introduction

Cardamom (*Elettaria cardamomum* Maton) the Queen of Spices is indigenous to the southern stretch of evergreen forests of Western Ghats. In India, small cardamom is cultivated in the states of Kerala, Karnataka and Tami Nadu. It is also cultivated in parts of Guatemala, Tanzania, Sri Lanka, EL Salvador, Vietnam, Laos, Cambodia and Papua New Guinea. Now Guatemala is offering stiff competition to Indian cardamom in the international market. Kerala is the largest producer of small cardamom and constitute lion share of Indian and world market. The cardamom of commerce is the dried fruit (capsule) of the plant. It is used as spice for various food preparations, in confectionaries, making perfumes and in several ayurvedic preparations. It possesses medicinal properties like carminative, stimulant, tonic, diuretic, digestive, expectorant, cardiogenic and used in several pharmaceutical preparations. It contains flavour compounds such as a-terpinyl acetate, 1-8 cineole, and linalool [1].

Climate and Soil

The natural habitat of cardamom is the evergreen forests of Western Ghats. It is found to grow within an altitude ranging between 600 and 1200 meters above MSL. Though considerable variations both in the total rainfall pattern and its distributions are noticed in the cardamom tracts (900- 4000mm), a well distributed rainfall of 1500-2500mm with not less than 200mm summer showers and mean temperature of 15 to 25°C would be ideal. Cardamom generally grows well in forest loamy soils that are acidic in nature, the preferable pH being 5.5-6.5. Cardamom soils are high in organic matter and nitrogen, low to medium in available phosphorous and medium to high in available potassium [2].

Crop botany

A mature cardamom plant may measure two to four meters in height. It is a shallow rooted shade loving (sciophyte) plant. Tiller production takes place throughout the year. Peak period is from January to March. Flowers are borne on panicles, which emerge directly from the swollen base of the aerial shoot. It is a cross-pollinated plant and pollination occurs by external agents like honeybees.

The panicles are erect in Cv.Mysore prostrate in Cv.Malabar and intermediate (pendent) in Cv.Vazhukka. Panicles may be branched or simple. The peak period of panicle emergence is from November to March. Flowering normally commences from February and extends to October; May-August being the peak flowering period. After fruit set, about 90-120 days are required for the fruits to attain maturity. The capsules are globose or ovoid or narrowly ellipsoid to elongate in shape, trilobular, containing 15-20 seeds. On maturity, seeds turn dark brown to black in colour and capsule is pale green to dark green [3]. They are better adapted to altitudes ranging from 900 to 1200 meters from sea level and thrive well under assured, well-distributed rainfall conditions. This type is mostly cultivated in Kerala in certain pockets of Tamil Nadu and Karnataka.

Cultivar Vazhukka

This is considered to be a natural hybrid of Malabar and Mysore types and consequently, the plants belonging to this group exhibit various characteristics intermediate to these two types. The plants are robust like Cv. Mysore. Its leaves are deep green, oblong to lanceolate or ovate, panicles are semi-erect (pendent) and capsules are bold, globose or ovoid in shape. It is extensively cultivated in Kerala and Tamil Nadu at elevations ranging from 900 ñ 1200 meters above sea level.

High yielding varieties and selections

Various research institutions working on the crop improvement aspects of cardamom have released a number of elite location specific high yielding clones having yield potential of above 450 kg per hectare (rainfed) and superior capsule characters. Prominent among them are detailed in [Table-1]. In addition to this, there are several high yielding clones selected by cardamom farmers. The most popular and widely cultivated farmer variety is Njallani green goldi which has very high yield potential and good quality characters. Others prominent selections are Palakkudy, Panikulangara -1, Vally green bold, Elarani, PNS Vaigai, cardamom vander, Kalarickal white cardamom etc.

Table-1 High yielding varieties and selections

No	Selections / Varieties	Cultivar	Special distinguishing characteristics	Area of adaptability	Yield Potential (Kg/ha)
1	ICRI - 1	Malabar	An early maturing profusely flowering variety, medium sized panicle with globose, extra bold, dark green coloured capsules. Performs well under irrigated conditions.	South Idukki zone of Kerala, where the rainfall is well distributed	660
2	ICRI -2	Mysore	Suitable for higher altitude. It has medium long and parrot green capsules.	Vandanmedu and Nelliampathy of Kerala and Anamalai and Meghamalai of Tamil Nadu	766
3	ICRI -3	Malabar	Early maturing type, non-pubescent leaves, oblong bold, parrot green capsules	Cardamom growing tract of Karnataka	600
4	ICRI -4 (TDK-4)	Malabar	An early maturing variety adaptable to low rainfall area. Medium size panicle, globose bold parrot green capsules. Non pubescent leaves.	Adapted to Lower Pulney hills of Tamil Nadu. Suitable for low rainfall area (1500 mm) and having similar agroecological conditions.	460
5	ICRI - 5	Malabar	Hybrid variety, early bearing, High yield, high oil content deep green a bold capsule, moderately tolerant to rot disease	Kerala and parts of Tamil Nadu	2000
6	ICRI - 6	Malabar	Regular yielder, high oil content, deep green long bold capsule, moderately tolerant to rot/pathogens thrips, borer and drought.	Kerala and parts of Tamil Nadu	1900
7	PV -2	Vazhukka	High yielder, deep green long bold capsule, high dry recovery percent	Kerala	1200
8	IISR Avinash	Malabar	Resistant to rhizome rot disease, Suited for hotspots of rhizome rot and leaf blight diseases. High quality elongated capsules	Kodagu, North Wayanad, Hassan and Chikmagalur	850
9	IISR Vijetha	Malabar	Tolerant to Katte disease	Kodagu, North Wayanad, Hassan and Chikmagalur	650

Propagation

Propagation of small cardamom is done through seeds and suckers. The propagation through seeds enables production of large number of seedlings. Virus diseases are not transmitted through seeds and therefore the seedlings are free from virus diseases, if adequate care is taken to isolate and protect the nursery from fresh infection. Plants raised from seeds need not necessarily be high yielders even if they are collected from very productive plants due to cross pollination. The major pollinator is honey bees. On the other hand, planting through suckers ensures true to the parents with a high productivity if they are collected from high yielding, disease free plants.

Land preparation

The land selected for planting is cleared of all under growth, weeds *etc.* Old cardamom plants, if any, may also be removed. Field operations are to be undertaken with the objective of preventing soil erosion and to conserve soil moisture. In sloppy areas, soil should be protected from soil erosion for which planting should be taken up in terraces. It should be prepared before commencement of monsoon, pits are left open for weathering for a fortnight and then about 1/3 of the pit should be filled with top soil and 1/3 should be filled with 1:3 mixture of organic manure and top soil.

Planting

Planting material of high yielding variety suitable for the areas may be selected for planting. They may be planted in the already prepared and filled pits and plants should be protected from wind by staking. For Mysore and Vazhukka cultivars, plants to plants distances can be 3x3 meters (1111 plants per hectare). A spacing of 2.4x2.4 meters (1736 plants/ha) is recommended for Tamilnadu 1.8x1.8 meters spacing (3086 plants per hectare) is suitable for Cv. Malabar in Karnataka. Immediately after planting, the plant base should be mulched well with available dried leaves to prevent soil erosion and conserve moisture. Planting should be done diagonally to the slope to reduce runoff.

Weed control

Weed control in the cardamom plantation is the important operation for maximum utilization of available soil moisture and nutrients by the plants. Use of spade for weeding is to be avoided as it will loosen the soil and cause soil erosion. The weeded materials may be used for mulching.

Irrigation

Irrigation is required generally during summer months and also during periods of prolonged dry spells, if it coincides with the critical periods of plant growth where development of young tillers and panicles takes place. Irrigation can be done at weekly intervals at the rate of 20- 30 liters per plant depending upon the clump size. Fogger/mist irrigation system is used widely in the cardamom plantations to create a suitable microclimate within the plant eco-system to create favorable environment for growth, flowering and seed setting. The frequency of operation of

the irrigation systems depends on the macroclimate in the plantation and hence has to be standardized for specific local weather situation. Irrigation is to be undertaken with utmost care to avoid excess wetness at the plant base for prolonged period to prevent occurrence of rot diseases.

Forking and mulching

As far as possible, the entire plantation and particularly the plant base are to be kept under mulch for reducing evaporation loss, suppress weed growth and to maintain optimum soil temperature. It is very essential to keep the plant base mulched (5-10 cm thick), except during periods of heavy monsoon (June to September). Through adopting the best soil management practices, the soils will remain loose and friable. However, in situations where soil has become compact and hard, forking the plant base to a distance up to 90cm and to a depth of 9-12 cm may be beneficial to enhance root proliferation, better infiltration of summer showers and for improving soil aeration. Forking could be done with the cessation of north east monsoon during November/December taking care to cause least damages to the root system.

Trashing and pruning

This operation may be carried out once in a year at any time after the receipt of the pre-monsoon showers, in May. Pruning is the operation undertaken with sharp sickles for removing the dead and hanging leaves from the pseudo-stem. Care should be taken not to peel off the leaf sheath from the pseudo-stem. This operation may be done during January and during September, which coincides with the peak thrips population. The resultant plant materials obtained through pruning can be used for mulching.

Earthing up

Whenever, the top soil covering the plant base is washed away and the rhizomes and roots are exposed, earthing-up of the plant base with top soil is recommended during November/December, before the withdrawal of north east monsoon.

Manures and fertilizer application

Cardamom responds to both manuring and fertilizer application. A soil test based judicious manuring schedule should be followed to achieve optimum production on sustainable basis. Application of mature farmyard manure/ Compost @ 5-10Kg per plant may be made during May/June along with rock phosphate (180 grams per plant) and murate of potash (90 grams/plant). Organic manures such as neemcake (one kg per plant), bone meal (one kg per plant) or vermicompost (one kg per plant) have beneficial effect on root proliferation and plant growth and also helps to reduce nematode and root grub infestation. Application of lime/dolomite is essential if pH of the soil is <5.5. Lime is to be applied in one or two splits during May and September. Fertilizer shall be applied only after 15-20 days of lime application. Zinc deficiency is widespread in cardamom soils and Boron deficiency is observed in certain areas.

Application of Zinc to the foliage is found to enhance not only cardamom growth and yield but also the quality of the produce. Hence, it is recommended that Zinc may be applied as a foliar spray as Zinc Sulphate @ 250 grams/100 litres of water during April/May and Sept./Oct. Under high production technology, where crop is harvested from 18 months onwards, fertilizer recommendation for full-grown plantation could be adopted from the second year onwards. Fertilisers would be applied in smaller doses in four or more splits after every harvest or combining both soil and foliar application of fertilisers. Whenever, the plant growth is affected due to root damage (root grub/fusarium diseases/soil compactness), foliar application of DAP (two percent) + MOP (two percent) could be adopted. Restrain fertilizer application on disease infected plants.

Schedule for the use of NPK fertilizers

Age of plants	Rainfed areas (Kg/ha)	Irrigated areas (Kg/ha)
First year of planting	Nitrogen -25 Phosphorus -25 Potassium -50 (2 split application)	Nitrogen -25 Phosphorus -25 Potassium -50 (2 split application)
Second year of planting	Nitrogen -40 Phosphorus -40 Potassium -80 (2 split application)	Nitrogen -60 Phosphorus -60 Potassium -80 (3split application)
Third year of planting	Nitrogen -75 Phosphorus -75 Potassium -150 (2 split application)	Nitrogen -125 Phosphorus -125 Potassium -250 (3 split application)

Shade management

Cardamom is a shade loving plant and trees provide suitable environment by maintaining humidity and prevent evaporation loss of moisture from the soil. Shade requirements of cardamom plants vary from place to place depending on the slope of land, soil type, rainfall patterns, crop combination etc. Climatic factors will adversely affect the growth, development and production. It is noticed heavy or less shade hinders crop growth and production. About 50 % shade is found ideal. Lopping of branches of shade trees is very important and should be done before onset of monsoon. But at the same time exposure to direct sunlight causes yellowing of leaves. Therefore, judicious shade management is very important for good growth, timely flowering and for better crop. The foraging behavior of honey bees commence in the morning and continue till evening. However peak forage is encountered from 9 am to 11 pm and this coincides with maximum capsules formation. Tree flowers act as pollen as well as nectar source to bees. The quality as well as the capsule set was related to the number of bee visits. A total of 19 tree species were listed in the cardamom plantations which not only supports the domestication of honey bees but also provides filtered shade, very much suited to the growth and development of cardamom plants. Some of the most ideal shade trees to be grown in the plantations are *Acrocarpus fraxinifolius*, *Actinodaphne malabarica*, *Bischofia javanica*, *Canarium strictum*, *Mesopsis eminii*, *Mesua ferrea*, *Myristica attenuata*, *Vateria indica*, *Vernonia arborea*, *Zedrella toona* etc.

Pests in small cardamom

Small cardamom is infested by many pests, right from the seedling stage to the cured cardamom in storage. Nearly 60 species of insect pests infests cardamom. Based on severity of infestation, these pests are categorized as major and minor pests, the former include thrips, panicle/capsule/shoot borer, root grub and root knot nematode and the latter, mid-rip caterpillar, whitefly, scales, red spider mites, lace wing bugs and aphid.

Major pests

Cardamom Thrips [*Sciothrips cardamomi* (Ramk.)]

Thrips is the most destructive and persistent pest of cardamom and found in all cardamom growing area. It colonize and breed in different parts of the plant such as unopened leaves, leaf sheaths, flower bracts and flower tubes. Adults and nymphs of the insect cause damage to panicle and capsules. Thrips lacerate the surface tissues with mandibles and suck the exuding plant sap. Affected capsules fetch a very low price in the market. Thrips infestation results in nearly 45-48 percent crop loss. Adult insect is greyish brown, 1.25 to 1.5 mm long and with two

pairs of fringed wings; females lay minute eggs below epidermis which hatch out into nymphs in 8-12 days. Nymphs grow by feeding on plant sap; after passing through three larval (nymph) and a non-feeding pupal stage they become adults, thus completing the life cycle in 27 to 33 days. Population of the pest is maximum in summer (February-May), minimum in rainy periods (June- July) and low in August-December.

Shoot/ Panicle/ Capsule borer [*Conogethes punctiferalis* (Guen.)]

Infestation of borer on capsule, panicle and shoot is a serious problem on cardamom in Kerala, Tamilnadu and Karnataka. The moths feed on nectar and do not cause direct damage to cardamom. A female moth lays about 20-35 eggs singly or in groups of two or three on leaf margin, leaf axils, panicles and racemes. Eggs hatch within five-six days. The seed and the capsules become empty. At a later stage the larvae bore into the shoots. They feed the central core of the pseudostem resulting in decaying of the central spindle and the characteristic dead heart symptom develops. A fully-grown larva is 30-35 mm long with pale purple body and black head. After a prepupal period of two-four days, it becomes a brown pupa. Adult emerges in about 11-15 days from pupa through the bore hole. The life cycle is completed within 41- 68 days during summer and prolongs upto 123 days in post monsoon period. Pest infestation is pronounced in three seasons: January- February, May- June and September-October. However, overlapping generation do occur in between. Insecticide sprays at late stages of the larvae which bore in pseudostem may not give adequate control of the pest. For an effective management, the insecticide has to be targeted on early stages of the larvae, which are usually present on panicles/ racemes within 15-20 days after adult emergence in the field. Injection of insecticide/Bacillus thuringiensis (Biological insecticide) solution through the bore hole is also a method for controlling larvae in pseudostems.

Root grub [*Basilepta fulvicorne* (Jacoby)]

Females are bigger than males. They are seen on cardamom leaves during morning and evening hours but do not feed on cardamom. The minute creamy white grubs hatch out from eggs, fall on the ground, reach root zone and start feeding the roots. Grubs have two periods of occurrence, the first during April-July and the second during September to January.

Nematodes (*Meloidogyne* spp.)

Root knot nematodes, (*Meloidogyne* spp) infest cardamom roots. Common symptoms of attack are narrowing of leaves, thickening of veins, reduction of internodes length and consequent appearance of rosette leaves. Roots branch heavily and galls appear on them. Plant growth becomes highly stunted. Egg, larva and adult are the different stages in the life cycle of the pest. Second stage larvae infect rootlets and induce formation of giant cells called galls. Larvae moult thrice and form adults. Female secretes a gelatinous matrix into which eggs are extruded. Frequent change of nursery beds will help to reduce nematode infection in nurseries. In case of infection in nurseries, application of carbofuran @ 80 grams per six square meter bed will control the pest. In plantation, carbofuran @ 60-80 grams per plant or 20-40 grams of phorate with 300- 500 grams of neem oil cake per plant in May-June and /or September bring down nematode infestation. Increasing the root biomass with application of compost/ vermicompost result in sustained management of the pest.

Integrated Pest Management (IPM)

Integrated Pest Management (IPM) is an important method for cardamom pest management. Following are the important pests that need clear understanding of their biology. Considering the vulnerable stages in their life cycle the following components of IPM are followed in cardamom.

- ✚ Cultural control
- ✚ Biological control
- ✚ Physical control
- ✚ Mechanical / manual removal
- ✚ Host plant resistance
- ✚ Chemical control

Table-2 Insecticides for control of pests in small cardamom.

Insecticides	Dosage (for 100 lit. of water)	Category/label	Target Pests
Acephate	100g	Blue	Thrips & borer
Quinalphos	200ml	Yellow	Thrips & borer
Fipronil 5 SC	100 ml	Yellow	Thrips & borer
Phenthoate 50 EC	150 ml	Yellow	Thrips & borer
Flubendiamide 480 SC	12 ml	Green	Borer
Dimethoate 30 EC	165 ml	Yellow	Thrips
Phosalone 35 EC	200 ml	Yellow	Thrips

Biological control of cardamom root grub

Entomo pathogenic nematodes (EPN) and Entomo pathogenic Fungi (EPF) such as *Metarhizium anisopliae* and *Beauveria bassiana* are effectively used for management of root grub in cardamom. Application of EPN infected Galleria larva (cadaver) at plant base has been found to reduce root grub infestation up to 95 percent. EPN survives in moist soil and hence they persist longer in soil resulting in sustainable management of root grub.

Diseases and their management

Cardamom is affected by a number of diseases caused by various pathogenic fungi, bacteria, viruses and nematodes, in main plantations as well as in nurseries. As many as twenty five fungal, bacterial, viral and nematode diseases have been reported till date.

Capsule rots (Azhukal disease)

Capsule rot or 'Azhukal' is the most serious fungal disease of cardamom. Disease symptoms develop mainly on the capsules, young leaves, panicles and tender shoots. The first visible symptom appears as discoloured water-soaked lesions on young leaves or capsules. Infected capsule show water soaked discoloured areas; they turn brownish and later such capsules decay and drop off. During favorable climatic conditions the diseases aggravate and infection extends to panicles and tender shoots. It has been shown that as high as 40 percent crop loss can occur in severely disease affected plantations. The disease severity is uniform in the three major cardamom types Mysore, Vazhukka and Malabar.

Disease management

Phytophthora meadii Mc Rae has been widely observed as causing capsule rot disease. As the outbreak of disease is during the monsoon season, disease management measures have to be initiated sufficiently in advance i.e. before the primary infection starts. Spraying and drenching of copper fungicides such as one percent Bordeaux mixture and 0.2 percent copper oxychloride is recommended as the control measure. Although a number of fungicides have been reported to control the disease, often disease control in the field has been a challenging experience. The factors responsible for the constraints in achieving satisfactory disease control include lack of phytosanitation, effective and timely application of schedule, and the continuous rain that makes any fungicidal application ineffective. Two to three rounds of sprays including one round of prophylactics spray with one percent Bordeaux mixture or 0.3 percent Aliette (Fosetyl – Aluminium) after proper phytosanitation effectively controlled the spread of the disease.

Biological control of capsule rot

Bioagents play an important role in an eco-friendly system of disease management to fight against the plant pathogens in a totally safe manner avoiding the use of expensive and hazardous chemical fungicides. Field control of capsule rot disease using *Trichoderma viride* and *Trichoderma harzianum* was achieved and has further developed a simple carrier come multiplication medium for *Trichoderma* application in the field. Today, field control of capsule rot (Azhukal) disease of small cardamom has become effective, environmentally safe and cost effective due to the biocontrol potential of *Trichoderma* sp.

Rhizome rot

Rhizome rot (Clump rot) is a common disease occurring in cardamom plantations

during the monsoon period. The disease is widely distributed throughout cardamom plantations in Kerala and Karnataka states and in heavy rainfall areas of Tamil Nadu such as the Anamalai hills. The symptoms of rotting develop at the collar region of the pseudo stem (tillers) which become soft and brown coloured. At this stage the affected tillers fall off emitting a foul smell. The panicles and young shoots attached to this are also affected by rot. The rotting extends to the rhizome and roots also. Falling of shoots resulting from rhizome rot infection becomes severe during July-August months. Rhizome rot is caused by *Pythium vexans* de Barry and or *Rhizoctonia solani* Kuhn.

Disease management

Dense shade increases rot disease infection despite regular fungicide application. On the other hand, regulated shade reduces disease incidence by making the microclimate unfavourable for the pathogen. The disease is usually observed in areas previously affected by rhizome rot disease. Therefore, phytosanitation plays a major role in disease management. Presence of inoculums in the soil and plant debris, overcrowding of plants, and thick shade are congenial conditions for disease development. Therefore, any disease management schedule has to be followed with these points in mind. One round pre-monsoon and two rounds post monsoon soil drenching with 0.25 percent Copper oxychloride is very effective for controlling the disease.

Biological control of Rhizome rot

Application of *Trichoderma viride* and *Trichoderma harzianum* is effective to reduce rhizome rot incidence in plantations. A formulation of *Trichoderma harzianum* in a carrier medium consisting of farmyard manure and coffee husk mixture has been developed for field application in the integrated disease management system.

Colletotrichum leaf blight

The leaf blight disease is caused by *Colletotrichum gloeosporioides* (Penz.) Penz and Sacc. The disease spread is faster in partially deforested areas and less shaded plantations. Though it was reported as a minor disease of limited spread, presently the situation is alarming as the disease is spreading to newer areas and is becoming a major problem.

Disease management

Three sprays at monthly intervals with Carbendazim (Bavistin-0.2 percent) or Mancozeb (0.2 percent) or Copper oxychloride (0.25 percent) effectively controlled the disease spread in the field.

Leaf blotch

The disease appears during monsoon season i.e., from June to August months, normally under heavily shaded conditions. Thick shade, continuous rainfall and high atmospheric humidity pre-disposed plants to infection. During rainy period, round, ovoid or irregular water-soaked lesions develop on middle leaves, usually near the leaf tips or at the midrib areas. These areas enlarge in size, become dark brown with a necrotic centre. In moist weather, a thick, grey colored fungal growth is seen under the side of these blotched areas. The periphery of the lesion shows a dark band of water-soaked zone as the lesions spread. However, the lesion spread is limited in size following a dry period.

Disease management

Leaf blotch is a fungal disease is caused by *Phaeodactylum alpiniae* (Sawada) (Ellis). Fungicidal spray with Copper oxychloride or Bordeaux mixture control leaf blotch infection in the field.

Fusarium infections of small cardamom

The cultivation of small cardamom and maintenance of healthy plants have become difficult tasks due to the incidence and spread of Fusarium infections in recent years. Fusarium infection in small cardamom have been reported in the form of capsule infection in the field, seed rot and seedling wilt in nurseries, stem rot & stem lodging in plantations, rhizome rot, root tip rot and foliar yellowing.

The disease incidence was observed to be severe in plantations 4-6 years of age during October – March months. The causal organism is identified as *Fusarium oxysporum* Sehlecht.

Pseudostem rot

This disease is generally seen during the post- monsoon period and may last up to summer months. Round to oval shaped brown lesions develop on the pseudostem. These later elongate and as infection proceeds deeper layer of the pseudostem gets discolored. The Pseudostem breaks at this point. The disease is caused by *Fusarium oxysporum*. Spraying with 0.2 percent Bavastin 0.2 percent or Hexaconazole 0.2 percent will control the disease.

Root tip rot

This disease also occurs during post monsoon period. The severity is more during summer. Spraying and soil drenching with 0.2 percent Bavistin or Contaf 0.2 percent (drenching only) are the recommended control measures and the applications may be repeated at 15 to 20 days intervals.

Viral diseases

The four viral diseases of small cardamom are mosaic virus or katte, Nilgiri necrosis virus, vein clearing virus (kokke kandu), and banana bract mosaic virus. Katte is widely distributed in all cardamom growing tracts and is a major production constraint for cardamom in India. Occurrence of these viral diseases is matters of concern to the cardamom industry. Use of virus free planting materials, removal of infected host plants, creating awareness among farmers, preventing the movement of diseased plant materials to check introduction of viruses to new areas regular phytosanitation, removal of virus sources, early detection through ELISA, use of resistant varieties are the methods/approaches required to manage the viral diseases in nurseries and plantations.

Management of viral diseases

Viral diseases of plants are cancerous in nature and are difficult to cure. Early identification of the diseased plants and reducing the spread are the easy ways to tackle the problem. Hence, from an environmentally safe and economically viable perspective the following measures would be adopted for effective management of the diseases.

- Monitor the plantation every month particularly during rainy season and carefully identify the diseased plants.
- The diseased plants may be uprooted and destroyed as and when they are seen. They should be taken to an isolated place, chopped into small pieces and buried in pits for quick decomposition. As an alternative, mass uprooting and burning of infected plants at the village / area level could be taken up for eradication of the disease.
- Never collect planting materials from an infected garden or apparently healthy plants from severely infected gardens.
- Establish nursery about 500 m away from main plantation in order to avoid aphid colonization
- Maintain clean clumps by removing old tillers with loosened leaf sheath so that aphids will not colonize.
- During plantation monitoring, especially prior to harvesting, the plantation must be inspected carefully for identification of diseased plants. These plants may be uprooted and destroyed on priority. The knife and other implements used for the purpose should not be used on healthy plants since disease could be transmitted through sap. Dip the implements in hot water for half an hour for killing the inoculum before going to the healthy plants for harvesting or cleaning.

Harvesting and Curing

Good quality of the produce can be achieved through timely harvest and adoption of scientific post harvest operations. Harvesting of capsules at correct maturity stage is a pre-requisite for improving the quality of the produce. The capsules

should be harvested when they attain physiological maturity (Karinkai) to fully ripened stage as to allow the capsules for the proper seed development and to obtain higher recovery. Recovery is highest (24 percent) in the fully ripened capsules. Cardamom curing may be defined as the process in which moisture of freshly harvested capsules is reduced from 80 percent to 10-12 percent through indirect heating. Drying is the most important unit operation that determines the colour of the end products. Apart from quality in terms of colour, flavour component such as 1-8 cineole, terpenyl acetate, linalool etc are also important. After keeping cardamom trays in the racks, curing room is closed and heating is done by burning firewood in the furnace. The hot air passed through the pipes placed a few centimeters above the floor enhances the room temperature to 45°C to 55°C and this temperature status should be maintained for three to four hours initially. At this stage the capsules sweat and with the enhanced temperature, give off moisture. The ventilators are opened for sweeping out water vapour from the drying fruits. After the complete removal of water vapour, ventilators are closed and the temperature inside the chamber should be maintained again at 45°C - 55°C for about 18 to 24 hours. The temperature is again raised to 60°C - 65°C for another one or two hours for completing the curing process. Efficient and largely automated cardamom dryers have been designed and manufactured by several private entrepreneurs using alternate source of fuel such as Kerosene, Liquid Petroleum Gas (LPG), and diesel cardamom or using combination of fuels. Dried capsules have to be polished either manually or with the help of machines before marketing. For efficient retention of green colour during storage, cardamom should be dried down to a moisture level of 10-12 percent. Use to 300-gauge black polythene lined gunny bags improves the storage efficiency.

Production trend and future prospects

Promising small cardamom varieties and improved selections coupled with optimum inputs and technologies can increase yield up to 2000 kg ha. Demand can be raised by adding by adding new value-added products from small cardamom. Income of the farmers can be doubled by using the healthy, good planting materials, application of farm yard manure, weed management, irrigation during dry period, diseases and pest's management. Proper scientific management of plantation is the prime reason for successful cultivation. The major causes of low productivity in some regions are lack of improved planting materials, pest and diseases, lack of proper shade management, moisture stress condition and climate change. However, there was a production of 14000 MT of small cardamom during 2012-13. That went up to 23890 MT in 2015-16. Small cardamom area under cultivation and production in India are given in Table 3. The increasing trend in cardamom production was observed over the years. A maximum prize of rupees 1420/kg of dried capsules of small cardamom was realized during 2017-18. If this trend continues the future of cardamom is bright and there are great opportunities for farming community.

Table-3 Small cardamom area under cultivation and year wise production

Year	Area(hectares)	Production(tonnes)
2012-13	69870	14000
2013-14	69970	16000
2014-15	69970	18000
2015-16	70008	23890
2016-17	69357	17990

Application of research: Study of cardamom cultivation and production

Research Category: Spices research

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***Principle Investigator or Chairperson of research: Dr A. K. Vijayan**
Institute: Indian Cardamom Research Institute, Spices Board India (Ministry of Commerce and Industry, Govt. of India), Myladumpara, Idukki, 685 553, Kerala
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