Large cardamom (*Amomum subulatum* Roxb.)-a review

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ABSTRACT

Large cardamom (*Amomum subulatum*) is the most important cash crop of Sikkim and also in parts of North Eastern States and West Bengal in India. The information available on various aspects of the crop viz., improvement, management, pests and diseases and end products are discussed in the review.

Key words : *Amomum subulatum*, crop improvement,crop management, diseases, end products, large cardamom, pests.

Introduction

Large cardamom commonly known as 'bada elachi' in Hindi(*Amomum subulatum* Roxburg) (Scitaminae : Zingiberaceae) is indigenous to moist deciduous and evergreen forests of sub-Himalayan tracts. The presence of wild species locally known as 'churumpa' viz., *A. delbatum, A. aromaticum, A. kingir, A. lingriformi, A. corynostachum* etc. and the tremendous variability within the cultivated species support the view of its origin in Sikkim (Subba 1984). It is the most important cash crop of Sikkim from where it spread to North Eastern States and parts of West Bengal and neighbouring countries; Nepal and Bhutan (Singh 1978; Gupta 1983). Sikkim has the largest area under cultivation (91%) with the highest production(87.5%) in India (John 1984). Large cardamom is a shade loving crop and is better established under humid and cold conditions at an altitude of 900 to 2000 m above MSL and within a temperature range of 10 to 30°C under uniformly distributed annual rainfall of 2000 to 3500 mm (Biswas, Bhutia & Gupta 1988). The information available on various aspects of the crop is discussed in this review.

Crop improvement

The distribution of the genus *Amomum* along with its individual species was described elsewhere (Anonymous 1950;

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Upadhyaya & Ghosh 1983). The following 18 species of *Amomum* were described and a key was also developed for their identification (Anonymous 1950).

1. *A. spiceum*
2. *A. xanthophlebium*
3. *A. macranthum*
4. *A. macrodeus*
5. *A. hastilabium*
6. *A. cylindraceum*
7. *A. vivale*
8. *A. testaceum*
9. *A. squarrosum*
10. *A. biflorum*
11. *A. macroglossa*
12. *A. citrinum*
13. *A. uticolosum*
14. *A. ochreum*
15. *A. uphalotes*
16. *A. leppaceum*
17. *A. aculeatum*
18. *A. uliginosum*

Morphology

The plant morphology was described by several authors (Mukherjee 1968, 1972; John & Mathew 1979; Gyatso, Tshering & Basnet 1980; Gupta 1987; Roy 1988). The plant is a perennial herb having subterranean rhizomes which gives rise to leafy shoots and spikes. Mature plant height ranges from 1.5 to 3.0 m. Leafy shoots are formed by long sheath like stalks encircling one another. The leaves are green or dark green, glabrous on both surfaces with accuminate apex. Inflorescence is a dense spike on a short peduncle bearing 40 to 50 flower buds in an acropetal sequence. The fruit is a trilocular many seeded capsule. The capsule wall is echinated and is reddish brown to dark pink. The capsule morphology was studied in detail by Gupta (1986a). The structure of the seed was described by Berger (1958). A method for non destructive determination of leaf area was reported by Karibasappa & Dhiman (1987).

Varieties

There are three popular varieties (cultivars) in Sikkim viz., Ramsey, Golsey and Sawney. The varietal differences were described by Gyatso, Tshering & Basnet (1980) and Subba (1984) (Table 1). In addition to these popular varieties, there are several other varieties such as Ramla, Chivey Ramsey, Garday Seto Ramsey , Ramnag, Madhusay, Seto Golsey, Slant Golsey, Red Sawney, Green Sawney and Mingney (Gupta 1986). Rao *et al* . (1990) reported a promising variety Barlanga from higher altitudes with desirable high yielding characters like maximum ratio of mature tillers to productive spikes (1:3.6) and bold size capsules (with 50 to 80 seeds). Surveys carried out by Biswas, Gupta & Bhutia (1986b) revealed that Ramsey and Ramla are well suited to higher altitudes, Golsey for lower altitudes and Sawney widely adaptable to different elevations.

Cytology

Studies on cytology of *Amomum* made by Venkatasubbu (1946) and Sharma & Bhattacharya (1959) indicated that the diploid chromosome number of *A. subulatum* was 48. However, variability was also reported with 2n = 26, 34,

Table 1. Characteristics of different varieties of large cardamom

Character	Variety		
	Ramsey	Golsey	Sawney
Altitude	High	Low to middle	Middle
Extent of cultivation	60%	30%	7%
Status	Tall, vigorous wide clump growth	Less vigorous with erect leafy stems bearing stout upright leaves. Clumps medium	Tall, vigorous bent downwards
Stem colour	Maroonish with dense foliage	Greenish to maroonish	Pinkish with dark green foliage
Flowers	Yellowish and small; corolla tip with pink tinge at base	Yellowish orange	Yellowish with pink tinge at base of corolla
Capsules	Smaller (16 to 30 seeds)	Bold to round (40 to 50 seeds)	Medium bold (30 to 40 seeds)
Essential oil	1 to 1.8%	2.3 to 5%	1.8 to 2.5%
Shade requirement	Deep shade	Less shade	Moderate to deep shade
Susceptibility to diseases	Susceptible to Chirkey and Foorkey at lower altitudes	Tolerant to Chirkey and Foorkey but susceptible to leaf spots	Susceptible to viral diseases

42 and 44 in *A. subulatum* (Sharma & Bhattacharya 1959). In *A. magnificum* Benth. *et* Hook. 2n was reported to be 48 or 52. The diploid number (2n) of 48 was also reported in *A. hypoleucum* Thw., *A. involucratum* Benth. and *A. microstemphanum* Baker by Ramachandran (1969).

Flowering and pollination

Large cardamom is essentially a cross pollinated crop due to its heterostylic (pin type) nature of flowers, though they are self fertile. Flowering is completed in 75 to 125 days from April to June at lower altitudes and May to July at higher altitudes depending on weather conditions and type of cultivar. Though each spike bears 40 to 50 flowers, which open in an acropetal sequence, only 10 to 15 capsules are formed per spike. The flowers remain viable for about 14 h after opening. Gupta & John (1987) studied the floral biology and reported that anthesis starts at 8.00 am and ends at 8.30 am on sunny days and from 9.15

to 9.30 am on cloudy and rainy days. The stigma is receptive for 24 h on rainy and cloudy days and is limited to 2 h on sunny days i.e. from 1.00 to 3.00 pm only.

Bumble bees (*Bumbos* sp.) are effective pollinators due to their compatible size. Foraging activity of bumble bees was maximum during 5.00 to 6.00 am during clear days and their activity becomes less or even nil during rains. However, studies of Gupta & John (1987) reveal that the time of bee visit was from 9.00 am in the morning and between 12.30 to 4.00 pm in the evening. Preliminary studies on the role of honey bees (*Apis dorsata*) on productivity of large cardamom showed that increase in production was directly related to increase in honey bee colonies (Verma 1987).

Breeding

A high genotypic coefficient of variation for mature tillers per clump, panicles per clump and capsule : panicle ratio in five year old plants of five varieties i.e. Sawney, Pink Golsey, Ramsey, Ramnag and Madhusey were recorded (Karibasappa *et al* .1987). All the varieties showed high heritability coupled with high genetic advance characters for mature tillers, panicles per clump, panicle weight and capsule yield. Capsule yield was directly correlated with clump girth, panicle weight, panicles per clump, mature tillers and capsule: panicle ratio. Correlation studies by Karibasappa, Dhiman & Rai (1989) indicated that mature seed index, TSS (Total Soluble Sugars) of seed mucilage and 1000 seed weight were associated positively with oleoresin and negatively with cineole contents.

Crop management

The agronomic and cultural practices were discussed in detail by Singh (1978), John & Mathew (1979), Gyatso, Tshering & Basnet (1980), Subba (1984) and Singh (1985).

Preplanting practices

Shade development: Shade acts as a vital factor in determining productivity of large cardamom. Robust varieties viz., Ramsey, Sawney and Ramla require thick shade while non robust variety like Golsey grows in sparse shade conditions. The characteristics of ideal shade trees required for large cardamom cultivation were reported by Gupta (1986) and 'Utis' *(Alnus nepalensis)* was recommended as an ideal shade tree.

Planting systems(Propagation): The common methods of planting in practice were discussed by Gyatso, Tshering & Basnet (1980).

a) Rhizome (sucker) planting - The rhizome transplantation method of propagation is easy and common in practice since transportation of seedlings and their maintenance are difficult in hilly areas. This method is advantageous for having uniformity and true to parent characters in the plant population. However, a drawback is the possibility of transmission of viral diseases.

b) Seedling planting - In this method three steps are involved:

Primary seed beds (sowing during November to December)

↓ Germination (March to April)

↓ Transplantation (August to September)

Secondary seed beds

↓ Transplantation (Next year June to July)

Main field

The method was discussed in detail by Anonymous (1984). Karibasappa (1987a; 1988) and Gupta (1988; 1989) reported that seed germination starts only after 30 days if the seeds are sown during August to September and the germination percentage was better if the seeds are selected from middle and bottom capsules of healthy mother clumps. Seeds remain dormant for 7 to 8 months till May and germination reaches a peak in mid June (Bhowmick & Chattopadhyay 1960). Singh (1985) pointed out that old age of the plantation is one of the important factors in determining the yield and suggested replanting of old plantations with seedlings to increase productivity.

Post planting practices

Weed control: Large cardamom plantations require regular weeding during the first and second years of planting and thereafter the problem gets lessened as foliage covers the entire field (Subba 1984). The intensity and frequency of weeding depends upon the weed species population and diversity which depend upon climatic factors, ground preparation methods and vigour or growth of young seedlings. Both manual weeding and use of herbicides can be resorted to. Manual weeding by scraping the soil surface is a common practice which should be discouraged because it adversely affects the soil physical conditions and exposes bare soil to destructive forces of the climate (Gyatso, Tshering & Basnet 1980; Subba 1984).

Mulching and earthing up: Though several advantages of mulching are evident, many planters have not recognised its importance (Subba 1984). Another practice akin to mulching is earthing up. As the plants become old, the underground rhizomes rise above the soil surface and give out roots. It becomes necessary to spread some soil around such suckers to stimulate growth of vegetative buds. The earthing up operation should be followed by usual mulching (Gyatso, Tshering & Basnet 1980; Subba 1984).

Soil analysis: Analysis of 400 soil samples collected from 27 VLW (Village Level Worker) centres from different districts of Sikkim and 5 blocks of Darjeeling District of West Bengal showed that fertility status of large cardamom growing soils was high in nitrogen and medium in phosphorous and potassium (Bhutia, Gupta & Biswas 1985; Biswas,Gupta & Bhutia 1986a; Biswas, Bhutia & Gupta 1988). In a majority of samples, pH values ranged from 5.0 to 5.5 and the percentage of organic carbon was higher than 1.0.

Insect pests

Large cardamom is attacked by several insect pests which adversely affects production. Although 21 insect species are associated with the crop, only a few of them cause severe damage (Bhowmick 1962; Azad Thakur 1982; Pangtey & Azad Thakur 1986). Variations in intensity of pest incidence are also noticed in different regions. Some insect pests also cause indirect loss by infesting shade trees grown in large cardamom fields.

Leaf eating caterpillars

Clelea plumbiola Hampson (Lepidoptera : Zygonidae): The moth was described by Hampson (1892) from Burma. The caterpillars feed gregariously on the chlorophyll of leaves leaving only the veins and midribs (Pangtey & Azad Thakur 1986). An epidemic of the pest was reported in Assam Linzey, Dugalakha, Sotak, Sorung, Dzongu and Rayong in which about 2000 acres of plantations were defoliated in 1978 (Subba 1980a).

Eupterote fabia Crammer (Lepidoptera : Eupterodidae) : It is a sporadic polyphagous pest causing severe damage to the crop. The larvae feed voraciously on leaves causing complete defoliation and affecting the yield (Azad Thakur 1982). Fenitrothion 50 E C (0.05%), Aldrin 30 EC (0.02%), Dichlorvos 40 EC (0.0.3%) and Carbaryl (Sevin 50 WP 0.2%) were effective in controlling the pest (Subba 1979; 1980).

Borers

Glyphepterix sp. (Lepidoptera : Glyphiperidae) : This pest is specific to large cardamom. The young larvae bore into the shoot and feed on the central leaf core causing dead heart symptoms resulting eventually in the death of the shoot (Bhowmick 1962; Azad Thakkur 1982).

Scolytid beetle (Coleoptera) : Scolytid beetles are serious pests of immature capsules. They feed on the soft seed mass and make the capsule hollow (Azad Thakur 1982).

Leaf eating beetles and weevils

Several species of beetles are reported of which *Chrysomela chlorine* and *Basiolepta femoratum* (Chrysomelidae) are major pests. These pests scrape the green matter of leaves resulting in the formation of numerous perforations on the leaf surface (Azad Thakur 1980; Pangtey & Azad Thakur 1986). These pests also severely attack 'Utis' which is the most common shade tree in large cardamom plantations.

Aphids

Most of the aphids are associated with transmission of virus diseases; hence the loss due to them are mostly indirect. However some of them cause direct effect by colonising the base of clumps. Among the aphids, banana aphid (*Pentalonia nigronervosa* Cock.), cardamom aphid (*P. caladi* Goot) pink aphid *(Micromyzus kalimpongensis)* and corn aphids (*Ropholosiphum maidis* Fitch and *R. padi* Linn.) are important (Pangtey & Azad Thakur 1986).

Storage pests

Storages pests like cardamom moth (Lepidoptera) and psocids (Psocoptera) damage stored cardamom (Azad Thakur 1982).

Root grubs

Polyphagous white grubs which are'C' shaped infest roots and rhizomes (Pangtey & Azad Thakur 1986).

Minor pests

The leaf hoppers *Kolla mimica* and *K. opponens;* thrips *Rhipiphorothrips cruentatus* Hood and mealy bugs are considered as minor pests of the crop (Pangtey & Azad Thakur 1986).

Nematodes

Root knot nematodes such as *Meloidogyne* sp. infest large cardamom affecting its productivity. The affected seedlings are stunted with numerous thin grassy shoots. Drenching nursery beds with 2% formaldehyde and covering them with polythene sheets for 72 h and treating the beds with granular nematicides like Carbofuran or Aldicarb was effective in controlling nematode infestations (Subba 1984; Pangtey & Azad Thakur 1986).

Mammals

Rodents, monkeys and wild cats are also serious pests attacking plantations during the period of harvest and it was

suggested that poison baits and traps were the best methods to control these pests (Subba 1980a).

Diseases

Large cardamom is affected by several fungal disease and by the two well known viral diseases viz., Foorkey and Chirkey.

Viral diseases

Chirkey : This is a major disease of large cardamom. The corn aphid *Ropholosiphum maidis* is the vector for the disease (Raychowdhury & Chatterjee 1958; 1961; 1965a). Besides this species, aphids collected on peach and an unidentified species collected on squash also transmit the virus (Raychowdhury & Chatterjee 1964; Raychowdhury & Ganguly 1965; Sharma, Raychowdhury & Capoor 1972).

This disease spreads rapidly and the symptoms cannot be identified unless closely observed (Ganguly 1966). The symptoms of the disease are very much similar to that of small cardamom 'katte' disease. In young leaves, discrete pale green to yellow longitudinal stripes running parallel to each other can be seen, but in mature leaves the above symptoms are masked. In advanced stages, flecks measuring about 2.5 mm and the characteristic mosaic symptoms are also seen. The affected plants produce flowers and spikes but without capsules (Raychowdhury & Chatterjee 1964; Ganguly 1966).

Foorkey : The foorkey disease which was first reported by Vasudeva (1956) causes severe damage in Darjeeling District of West Bengal. It is transmitted through banana aphid *Pentalonia nigronervosa* Coquillet (Anonymous 1964; Verma & Capoor 1964). The symptoms of the disease are production of bushy growth of stunted shoots which are sterile (Capoor 1967; Basu & Ganguly 1968). Diseased plants survive for a few years but remain sterile and unproductive.

As sanitary measures, infected plants should be uprooted and the surrounding area drenched with systemic insecticides to control movement of aphids on the main host as well as collateral hosts such as corn, banana, peach and squash. The plantations should be regularly sprayed once in three weeks with a suitable aphidicide such as Metasystotox to check the movement of aphids (Anonymous 1964; Verma & Capoor 1964; Chattopadhyay & Bhowmick 1965; Raychowdhury & Chatterjee 1965b; Capoor 1967; Gyatso, Tshering & Basnet 1980).

Fungal diseases

Seedling rot and Collar rot : Collar rot caused by *Fusarium oxysporum* is very much destructive to productivity of large cardamom (Srivastva 1989). At nursery stage, it is called as seedling rot and at maturity stage, it is called as collar rot, clump rot or spike rot. The primary symptoms include paleness of leaves followed by yellowing and decaying of collar which gradually extends towards the base. Normally, the flowers also remain unopened; if some open, they do not bear fruit and ultimately the spike rots or wilts. This disease is locally called as 'agulta'. Continuous rainfall during flowering period, water stagnation and old plantations with degenerated clumps are favourable for the spread of the disease.

Leaf spot : This is also widespread in occurence and is cause by two species of *Pestalotiopsis*. *P. versicolor* (Speg.) Steyaert produces angular irregular

spots with reddish brown margins surrounded by chlorotic holes and the central portion becomes necrotic. *P. royenae* causes leaf streak disease and is characterised by numerous elongated trasluscent streaks appearing on young leaves along the veins (Srivastava & Verma 1989). The streaks turn reddish brown within 3 to 4 days with a central straw coloured nercotic area surrounded by prominent dark brown margins.

Leaf rust : Rust disease caused by *Phakospora elettaria* (Racib.) was reported by Srivastava & Varma (1987). It was mainly observed in May and June on the ventral surface of lower leaves in the form of numerous minute brown uredosori. In early stages of development, the uredosori were surrounded by chlorotic holes. In the advanced stage, the whole leaf was covered by uredosori causing premature drying of leaves.

Leaf blight : Prasad *et al* .(1984) reported that blight was caused by *Colletotrichum* sp. in large cardamom.

Capsule rot : Capsule rot is caused by *Pestalotiopsis* sp. The affected capsules become slimy, water soaked and have discoloured appearance. The seeds produce a foul smell (Subba 1984).

Cultural practices such as roguing of plants, field sanitation by providing drainage in nurseries and plantations, removal of diseased debris and weeds are effective in controlling the diseases. Drenching/spraying once or twice before onset of monsoon and just after flowering with Bavistin (0.3%), Rovral (0.5%), Captafol (0.2%), Bordeaux Mixture (1%) or Dithane M 45 (0.25%); drenching the soil with Thiram (0.2%) or Dithane M 45 (0.25%) during February - March in and around the clumps are some of the general control measures suggested by Srivastava and Verma (1987 ; 1989).

End products

Curing of large cardamom is traditionally done in 'bhattis' (direct heating type smoke kilns). The 'bhatti' consists of a platform made of bamboo mats erected on stone or mud walls. Three sides of the kilns are covered by these walls. From the open end, wood is burnt below the platfrom. Fresh cardamom is spread on the platform to a thickness of 20-25 cm. The hot air with smoke passes through the capsules and removes the moisture.

Recently, Spices Board has introduced a scientific method of curing known as 'flue pipe system' of curing. In this method flue pipes are laid inside a room and is connected to a furnace installed outside. Fresh cardamom is spread over wire mesh fixed above the flue pipes. This is an indirect system of drying and smoke does not come in contact with the produce at any stage.

Under the auspices of Spices Board, a low cost dryer developed by Central Plantation Crops Research Institute, Kasargod was introduced in a limited scale. An improved 'bhatti' system wherein it is made of mud and stone walls provided with enclosed furnace with chimney is also adopted.

The advantages and disadvantages of diffrent systems explained above were discussed in detail by Anonymous (1987), Karibasappa (1987b) and Annamalai, Patil & John (1988) (Table 2). It is necessary to adopt appropriate curing techniques which involve indirect heat i.e. flue pipe system, optimum temperature (50-55°C), rapid air circulation

Table 2. Comparison of curing systems in large cardamom

Attribute	Local 'bhatti'	Flue pipe	Portable curing	Improved 'bhatti'
Cost per unit (Rs)	100 to 200	10,000 to 20,000	3,000 to 4,000	300 to 500
Capacity (kg)	100 to 200	100	50 to 100	100
Adaptability	Constructed without external dependence for material and easy to operate	Suitable for community curing centres	Suitable for medium and rich farmers	Suitable for poor and medium farmers
Drying time (h) (200 kg raw capsules)	48 to 56	30 to 40	44 to 48	46 to 50
Raw capsule: firewood requirement	1 : 2.0	1 : 1.0	1 : 0.8	1 : 1.0
Quality of cured capsules	Dark smoky appearance and burnt smell with uneven drying. About 25% of essential oil is lost and cineole content reduced by 10%	Natural colour and aroma retained. Drying is uniform with occasional stirring. Essential oil contents remain intact	Same as flue pipe system	Same as flue pipe system

within and exhaustion of moist air from from the drying unit; otherwise flavour constituents which are highly volatile may easily be lost by direct heat and high temperature.

The quality of large cardamom depends mainly on a) external appearance, which provides visual perception of quality as influenced by colour, uniformity of size, shape, consistency and texture, and b) flavour, which determines taste and odour and is influenced by composition of aromatic compounds. Cineole contributes to pungency while terpinyl acetate towards pleasant aroma(Karibasappa 1987b). He has also reported that the cultivar Ramnag followed by Golsey has uniform sized capsules with maximum values for capsule weight, capsule size, seeds per capsules, oleoresin content and volatile oil content.

Table 3. Comparison of chemical analysis of large and small cardamom seeds

Character	Large cardamom	Small cardamom
	Average %	Average %
Moisture	8.49	8.30
Volatile oil	2.80	8.30
Protein	8.00	10.30
Crude fibre	22.00	9.20
Total ether extract	43.21	45.40
Alcohol extract	7.02	—
Total ash	4.01	5.00

The fruit on an average comprises of 70% seeds and 30% skin. The seeds possess similar properties of small cardamom. An analysis of large cardamom seeds in comparison with small cardamom was reported by Singh (1978) (Table 3). Essential oil is obtained on steam distillation of crushed seeds which yield 2.5% of mobile liquid having a characteristic smell of cineole with the following physical and chemical properties (Nigam & Purohit 1960; Singh 1978):

1. Specific gravity at 29°C - 0.9142
2. Refractive index at 29°C - 1.46
3. Optical rotation in chloroform - 18.3"
4. Acid value - 2.9%
5. Saponification value - 14.53
6. Saponification value after acetylation - 40.2
7. Cineole - 64.9%
8. Terpinine - 10.7%
9. Sabinine - 6.6%
10. Terpinly acetate - 5.1%
11. Bisabolene - 3.6%
12. Polymazid oil - 3.6%
13. Terpineol - 7.1%

In the analysis of terpinoids, 15 compounds were reported in *A. korarima* while 25 compounds in *A. cardamom* and *A. glabosum* (Lawrence 1970; Lawrence *et al* . 1972). Out of 13 compounds in *A. subulatum,* 11 compounds were similar as in *A. korarima* while 2 were different (Lawrence 1970).

Composition of large cardamom seeds indicate that they can be put to a variety of industrial uses (Pruthi 1977; Singh 1978; Gupta *et al* .1984). Arora (1985) reported diversified uses of different species of *Amomum* (Table 4). The possibility of its use in ayurvedic medicines and in fish and meat processing provide better prospects (Gupta 1983). Chandrasekhar (1987) suggested that globus fruit stalks which are usually

Table 4. Distribution and diversified uses of different species of *Amomum*

Species	Common name	Country	Use
A. aromaticum Roxb.	Bengal cardamom or Nepal cardamom	Eastern India Pakistan	Rhizomes are used as condiment and flowering shoots are used in curries
A. *compactum* Soland	Round cardamom	Malaysia Java	Fruits are used as condiment and spice
A. glabosum Cour	Round Chinese cardamom	China	Seeds are used as cardamom
A. krervanw Pierre	—	Cambodia Indochina	Fruits are used as condiment and to flavour curries, sausages and cordials
A. maximum Roxb.	Java cardamom	Malaysia	Condiment
A. xanthioides Wall.	Wild bastard Siamese cardamom	Burma India	Condiment

discarded by farmers have a good scope after drying and powdering, to use them as a base for agarbattis. He further suggested that the silver coated large cardamom seeds can be used as *supari*. The capsules are fleshy while harvesting with 72 to 85% of moisture content and the outer layer of the capsules is also echinated that can be removed by rubbing after curing. The normal conversion ratio of green to dry capsules is 4:1 to 5:1 which varies according to size and method of curing (Roy 1988). Retention of maroon colour of capsules is a positive index of quality (Karibasappa 1987b).

Thrust areas

The present review highlights the following thrust areas of research in large cardamom:

1. Development of high yielding superior varieties adaptable to different argo-climatic conditions.
2. Sustainable production through better resource management such as vermiculture and bio-technology.
3. Integrated pest and disease management strategies including biotechnology.
4. Improving quality of end products.

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