Planting material production technology in small cardamom

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Introduction

Cardamom (*Elettaria cardamomum* Maton), the "Queen of Spices" is the true cardamom belonging to the *Zingiberaceae*. The area under cardamom (small) was 69,670 ha with a production of 16,000 MT during the year 2013-14. Till late seventies, India was enjoying a near monopoly position in the world trade of cardamom. But situation since then has changed as the share of India in the world trade has declined. The main competitor is Guatemala. Hence, as the International market for cardamom is increasingly competitive, there is no other go except to increase the production of domestic cardamom and to bring down cost of cultivation. There are mainly three types/ cultivars in cardamom viz., Mysore, Malabar and Vazukka. Generally, Mysore and Vazukka types are cultivated in Kerala and Tamil Nadu, whereas, Malabar type is cultivated in Karnataka.

Cardamom selections

Variety	Parentage	Year of release	Released from Institute	Yield kg/ha (Dry)	Salient Features	Recommended for
Mudigere 1	Clonal selection from Malabar type	1984	Regional Research Station, UAS, Mudigere, Karnataka	300	Erect and compact panicle suitable for high density planting, moderately tolerant to thrips,hairy caterpillar and white grubs	Karnataka
Mudigere 2	Clonal selection from Malabar type	1996	Regional Research Station, UAS, Mudigere, Karnataka	476	Early maturing variety, suitable for high density planting	Karnataka
PV 1	A selection from Walayar collection	1991	Cardamom Research Station, KAU, Pampadumpara, Kerala	260	Long, bold capsule, suitable for all cardamom growing tracts of Kerala and Karnataka	Kerala and Karnataka
PV 2	Selection from OP Seedlings of PV-1	2000	Cardamom Research Station, KAU, Pampadumpara, Kerala	982	Long bold capsules, high dry recovery percentage, field tolerant to stem borer and thrips	Kerala

ICRI 1	Selection from Chakkupallam	1992	ICRI (Spices Board), Myladumpara, Kerala	325	Profusely flowering , early maturing type, round and bold capsule	Kerala
ICRI 2	Clonal selection from Germplasm collection	1992	ICRI (Spices Board), Myladumpara, Kerala	375	Performs well under high altitude and irrigated condition	Kerala and TamilNadu
ICRI 3	Selection from Malabar type	1993	ICRI (Spices Board) Sakleshpur, Karnataka	440	Oblong capsule, suitable for hill zone of Karnataka	Karnataka
ICRI 4	Clonal selection from Vadagaraparai area of Lower Pulneys	1997	ICRI (Spices Board), Kerala Tadiyankudisai, Tamil Nadu	455	Suitable for low rainfall areas relatively tolerant to rhizome rot and capsule borer	Karnataka
ICRI 5	Mhc 26 a cross between MCC 260 x MCC 49	2005	ICRI (Spices Board), Myladumpara, Kerala	—	—	Kerala
IISR Kodagu Suvasini	OP progeny of CL-37		Indian Institute of Spices Research Calicut Kerala	745	Small plant type, suitable for high density planting and low inputs	Kamtaka
IISR Avinash	OP progeny of CCS-1		Indian Institute of Spices Research Calicut Kerala	847	Tolerant to rhizome rot.	Karnataka
IISR Vijetha	A selection from field resistant plants		Indian Institute of Spices Research, Calicut, Kerala	643	Resistant to Katte	Karnataka
ICRI – 6 (MCC-73)	Selection from the germplasm acc. MCC-73	2005	ICRI (Spices Board), Myladumpara, Kerala	-	-	Kerala

* Yield Kg/ha (Dry)

About 24 clonal selections have been developed by cardamom growers themselves in their respective plantations through constant observations of yield and other important traits, resistant to biotic and abiotic stresses. Njallani Green Gold farmer's selection from local Vazukka from Kerala has high yield potential. It has long panicles, wide adaptability and responds to high inputs.

Large Cardamom (*Amomum subulatum*), is another member of *Zingiberaceae* cultivated in the sub-Himalayan State of Sikkim and Darjeeling District of West Bengal covering an area of about 23,500 ha. The annual production varies from 4500-5000 metric tonnes. It is also cultivated in parts of Uttaranchal and in some other North-eastern States. Nepal & Bhutan are the other countries where large cardamom is cultivated. There are mainly five popular cultivars in large cardamom *viz., Ramsey*, *Sawney*, *Golsey*, *Ramla* and *Varlanga*. *Seremma* which resembles *Golsey* is gaining importance in lower altitudes. *Bebo* is another cultivar from Arunachal Pradesh.

Several varieties with superior quality traits for high yield, resistant to pests and diseases have been evolved through selection and hybridization process and being widely accepted among the farming community across the cardamom growing regions.

Both cardamom (small) and large cardamom can be propagated by seeds (seedlings) as well as clonal propagation (rhizome) and micro propagation (tissue culture). As cardamom is highly a cross pollinated crop, propagation by seeds result in seedling progeny with mixed character and it will not be true to type. The vegetative propagation can overcome this defect. Vegetative propagation can be resorted both by macro *i.e.,* rhizome (sucker) propagation through clonal multiplication under intensive care and micro propagation by tissue culture. Raising of seedlings by tissue culture has gained an impetus in recent years and has been taken up by commercial organizations in India to mass multiply high yielding selections. In order to raise a cardamom plantation, seedlings or suckers of high yielding varieties are to be used (Korikanthimath, 1995, Ravindran and Madhusoodanan, 2002, Ankegowda, *et al*., 2012).

One of the most important reasons for low productivity in Cardamom is the use of poor planting materials. However, in recent years elite clonal materials has been adopted for enhancing productivity and production. Scientific nursery management needs careful consideration selection of suitable site for nursery, seed selection, preparation of seeds, viability of seeds, optimum time of sowing, pre-sowing treatments of seeds, seed rate and sowing, mulching, transplanting to secondary nursery, irrigation, provision of pandal, fertilizer application, weeding and regular plant protection measures. Details of raising quality planting materials both by using seeds and vegetative means both in Cardamom (*Elettaria cardamomum* Maton) and large cardamom (*Amomum subutatum* Roxburgh) is presented and discussed in this paper.

SMALL CARDAMOM

In order to get quality seedlings, the nursery has to be managed carefully and scientifically. The most developed system of nursery management involves the germination of seed in prepared beds from which they are transplanted into nursery beds and finally into the field. Two stages of nursery–primary and secondary are involved in raising seedlings.

I. Primary Nursery

1. Nursery Site

It is always advantageous to select the nursery site on gentle slope, having an easy access to a perennial source of water (John 1968 ; Ponnurangam 1946; Siddaramaiah 1967). The nursery area should be cleared of all existing vegetation, stumps, roots, stones etc. Raised beds are prepared after cultivating the land to a depth of about 30 to 45 cm. Usually the beds of one meter width and convenient length up to 5-6 M raised to a height of about 30 cm are formed for sowing the seeds. A fine layer of humus rich forest soil to a thickness of 2-3 cm is spread over the beds. Soaking the soil in the seed bed to a depth of 15 cm with 1:50 formaldehyde solution is found to be effective in controlling the damping off disease of cardamom seedlings (Anonymous, 1985). Beds are to be covered with moist gunny bags or ploythene sheets for one or two days to allow the fumes to act and the seeds are to be sown one week after treatment.

2. Seed selection

Selection of seed material needs considerable attention while raising seedlings. High yield and bold size of cardamom capsules are associated with superior genetical traits of the plants. It is always desirable to watch the continued performance of selected, individual mother plants, before the final selection. (Cherian, 1979). Seed capsules should be collected from high yielding plants, with well ripened capsules, vigorous, fully matured, well formed compact panicles of plants free from infestation of pest and disease. Number of flowering branches formed on the panicles, number of fruit set and number of seeds per capsule should be given due consideration while selecting the material (Anonymous, 1979 ; John 1968 ; Ponnurangam 1946 ; Siddaramaiah 1967). Apart from these desirable attributes – the mother clump should have more number of tillers (shoots) per plant, leaves with dark green colour, high percentage of fruit set. Colour of capsules should be dark green (Krishna, 1968). On an average one kg of seed capsules contain

900-1000 capsules with 10-15 seeds per capsules. Taking into consideration the percentages of germination, mortality due to diseases etc., on an average one kg of seed capsules are required to get about 5000 plantable seedlings.

3. Preparation of Seeds

Seeds for sowing are collected from fully ripe capsules preferably from 2 to 3 round of harvest in September and is then either washed in water and sown immediately or mixed with wood ash and dried for two to three days in the room temperature. The first method gives best results and is almost universal in most of cardamom estates now. After picking, seed capsules should be immersed in water and gently pressed for ejecting the seeds, which should then be washed well in cold water for removing the mucilaginous coating of the seed (Pattanshetti and Prasad, 1973) stated that after. Immediate sowing of fresh seeds is obviously only possible when seed collection is done on the estate where it is required. If seeds have to be transported to far off any distance, some drying is essential to prevent mould development. Treating seeds with organo-mercurials would ensure better germination.

4. Viability of Seeds

Storing seeds for a longer time result in considerable loss of viability and great delay in germination. The study on viability of seeds was conducted by using seeds of Mysore and Malabar types of cardamom at Cardamom Research Centre, Appangala, with treatments comprising of sowing of seeds immediately after harvest (fresh seeds) and after storing for 30, 60 and 90 days. The maximum percentage of germination was in fresh seeds. *i.e.,* 58.86 and 50.63 in Mysore and Malabar types respectively. The germination was reduced when there was a delay in sowing after storing the seeds for a long time. Storage of seeds results in loss of viability and delay in germination. Germination reduced when there is a delay in sowing. Seeds treated with organo-mercurials and stored in bottles maintain viability up to a period of four months. Germination was highest (71.8 per cent) when sown in September (Pattanshetti and Prasad, 1973; Pattanashetty *et al.,* 1978). Seeds treated with organo mercurials and stored in open bottles maintained vigour up to a period of four months. The germination of treated seeds was considerably reduces when they were stored in air tight bottles. Besides the length and type of storage, the weather conditions that follow the sowing had a profound influence on germination (Pattanshetti, *et al.,* 1978). Study conducted to find out if capsules/ seeds stored in polythene bags for a period of 8 months (till subsequent sowing) could be used for raising seedlings by Krishnamurthy *et al.,* (1989) indicated very low percentage of germination in untreated seeds irrespective of their storage in the form of capsules (10%) or extracted seeds (0.6%). Since, seeds lose their viability quite early, they have to be sown immediately for better germination (Abraham, 1958) from natural capsules.

5. Time of Sowing

The time of sowing cardamom seeds varies according to places. When cardamom seeds were sown at monthly interval from September to January best germination was obtained in September (71.8%) and least *i.e.,* 8.0% January (Pattanshetti and Prasad, 1973). Korikanthimath (1981) started that in case of Malabar type of cardamom commonly cultivated in Karnataka, there was a gradual decline in germination percentage *i.e.,* 56.76,51.07,46.44, 34.14, 32.51 and 29.64 when observed after 60 days of sowing in case of seeds sown on 1st August, 15th August, 30th August, 14th September, 29th September and 14th October, respectively. Cardamom seeds sown during September germinated uniformly, early and satisfactorily. The seedlings from these grew fast and healthy and were ready for transplanting at the end of 10 months. If they were further retained in the nursery beds for the next planting season either by proper thinning or by providing wider

spacing in the secondary nursery beds, they developed rhizome with large number of tillers and this was particularly useful in the initial establishment of plantation (Pattanshetti and Prasad, 1972). It is also seen that the seeds sown early (August-September) will put up sufficient growth and can withstand incidence of leaf spot diseases. Late sowing of seeds beyond October will drastically bring down germination as it would coincide with cold temperature. So, the early sowing is always beneficial for better growth and enhancing tillering of seedlings before taking up transplanting in main field. *ie.*, plantation. In the northern areas, Kodagu, Mysore and North Canara, seeds are usually sown in September and germinate in about a month. In the southern areas, the seeds are rarely put down before November and germination is more irregular and takes considerably longer time. Both air and soil temperature show a marked drop in November and December and low temperature at this time may account for some of the difficulties experienced with seed sown in southern districts. The ideal sowing season is the dry period from November to January in Kerala and Tamil Nadu and September to October in Karnataka (Anonymous, 1970; Anonymous, 1979).

6. Pre Sowing Treatment of Seeds

Cardamom seeds possess a hard seed coat which delays its germination. Various studies have been undertaken on the effect of pre sowing treatment of seeds to overcome the delay in germination. Treatment of freshly extracted seeds with concentrated nitric and hydrolic acids for five minutes significantly improved the germination of cardamom seeds sown during November (Prasad *et al.,* 1974). Treatments with Nitric acid, acetic acid (25%) and hydrolic acid (50%) for 10 minutes each were found to be the best for all treatments with 97.6%, 98.6% and 91.5% germination, respectively (Suryanarayana Redyy, *et al.,* 1973). Studies conducted at Cardamom Research Centre, Appangala during late sowing revealed that out of four acids *viz.,* Acetic acid, Hydrochloric acid, Sulphuric acid and Nitric acid with five concentrations *ie.,* 20%, 40%, 60%, 80% and control (untreated), seeds treated with nitric acid recorded maximum germination (49.23%) at 20% concentration, almost double the germination obtained in untreated control (23.30%). Maximum germination was observed in the lower concentration (20%) of all the acids tried for treating the seeds. In the highest concentration (80%) both in case of sulphuric acid and nitric acid, there was no germination at all. It would be quite beneficial to treat cardamom seeds with acids as mentioned above if sowing of seeds is delayed beyond September for ensuring better germination. Overall effect of acid treatment on seed germination of cardamom is presented here below.

Effect of acid treatment on seed germination of cardamom

Acid	Mode of treatment	Treatment duration	Germination percentage(%)	Reference
Con. Nitric acid	Soaking	5minutes	9% increase	Kololgi *et al.*, 1973
			Increased germination	Prasad *et al.*, 1974, Govindaraju and Chandrasekharan, 1982
Conc. Hydrochloric acid	Soaking	5minutes germination	Increased	Chendrasekharan, 1982 Prasad *et al.*, 1974; Govindaraju and
25% Nitric acid	Soaking	10minutes	55% increase (fresh seeds) 25% increase (6-8 months old seeds)	Sulikeri and Kololgi, 1977
25% Acetic acid 25% Hydrochloric acid 25% Nitric acid	Soaking	10minutes	90 per cent germination	Reddy *et al.*, 1973 Korikanthimath and Ravindra Mulge, 1998
Acetone	Soaking	10minutes	Increased germination	Govindaraju and Chandrasekharan, 1982

It is seen from the above table that in general, soaking cardamom seeds in dilute or concentrated acids for 5-10 minutes increases the germination percentage. In addition, soaking seeds with GA_3 and ethrel solutions was found to enhance germination while kinetin did not (Rajashekaran *et al.*, 1992). Korikanthimath and Ravindra Mulge (1998) reported increased germination by treating seeds with GA_3 100ppm and planofix 75 ppm. Effect of mutagen on seed germination of cardamom has also been reported by Mohamed Sayeed and Subba Rao (1982).

7. Effect of temperature on germination

The harvest of cardamom normally commences by middle of August and continues upto end of January. The germination of seeds is high when sown fresh and decreases with time. Germination is maximum when seeds are sown during August-September and least when sown in January. Seeds collected from capsules harvested in winter *i.e.,* December to February may not be used for sowing either immediately because of the prevailing very low temperature or after long storage because of poor viability. Hence, studies were conducted to find out the causes of low germination in winter and the remedies to overcome the same (Krishnamurthy *et al.,* 1989). The cause of low germination were studies by sowing cardamom seeds in January in the geographically distinct locations (coastal area and hill areas). Results indicated that the germination of cardamom seeds was significantly affected by locations. There was a significant positive correlation between minimum temperature V/s maximum temperature (0.975). Apart from other factors, ambient temperature also plays a role in germination. The low temperature also influences germination. The low temperature in the cardamom growing area reduces as well as delays germination it Gurumurthy and Hegde (1987) found that germination is significantly correlated with maximum and minimum temperature prevalent in the area. The cardamom seeds fail to germinate at temperature less than 15°C and greater than 35°C at constant temperature in incubator. Germination of 70.9-73.0% was considered optimum which was achieved at 30°C. The highest percentage germination was observed under ambient temperature for September-October (Siddagangaiah *et al.*, 1993). Studies conducted on influence of ploythene structure and polythene cover (covering the seed bed) on percentage of germination indicated significant difference in germination among polythene structure consisting of spreading of polythene sheet on a frame placed 6 inches above materials (situations) could be attributed to increment in minimum and maximum temperature beneath polythene structure (4.5/ 3.7°C) compared to polythene cover (3.2/ 3.0°C) and control. Hence, it is always advantageous to take up sowing of seeds in early August-September for enhancing germination. Late sowing which would synchronize with winter temperature should be avoided.

8. Seed rate and Sowing

The seed rate commonly adopted is 2-5 g per square meter of germination bed for raising 10 months old seedlings and 10 g for raising 18 months old seedlings (Anonymous 1976; Anonymous 1986). Seeds are either broadcasted or sown in lines, usually not more than 1 cm deep. Rows are spaced 15 cm apart and seeds are sown 1-2 cm apart within row. Deep sowing of seeds should be avoided for better and quick germination. Seed beds are to be dusted with any suitable insecticides to prevent termite attack. Line sowing is always preferable as against broadcasting of seeds where there is a chance for the overcrowding of seedlings after sprouting which lead to heavy mortality when damping off disease appears. After sowing the seeds, beds are covered with a thin layer of fine sand or soil and pressed gently with wooden plank. Beds are watered daily. Germination will commence in about 30 days and may continue for a month or two. The mulch materials are removed soon after the commencement of germination. The young seedlings are to be protected against exposure to sun and rain by providing shade pandals over the germination beds (Anonymous, 2003).

9. Mulching of nursery beds

Use of mulches on the nursery beds has a profound influence on germination (Abraham 1958). The beds covered with paddy straw recorded highest germination (40.82%) when seed were sown in September (Korikanthimath 1981). Treatment of seeds with concentrated nitric acid increased the percentage of germination 60 days after sowing from 8-16% and this further increased to about 60% by the mulch treatment with coconut coir dust, paddy straw or goose berry (*Phyllanthus emblica*) leaves (Mayne, 1951 ; Sulikeri and Kololgi, 1978 ; Korikanthimath, 1983). Among the various mulches, paddy straw is most desirable as it is economical and locally available. Potagrass (*Granotia stricta*) is commonly used in Kerala.

Germination will commence in about 30 days and may continue for a month or two even later. The nursery beds should not be covered with *pandal* till the commencement of germination. Exposure of beds to sun after mulching followed by irrigation would enhance germination due to local build up of increased (higher) temperature. The emphasis placed on leaving the beds exposed to the sun in the early stages suggests that the temperature is probably a vital factor in satisfactory seed germination (Mayne, 1951). The mulch materials are removed soon after the commencement of germination. The young seedlings are to be protected against exposure to sun and rain by providing shade *pandals*.

10. Major pests and diseases in nursery and management

Major diseases observed in the nursery are - leaf spots, damping off/seedling rot and leaf rot.

A. Diseases

a. Primary nursery - leaf spots

Primary nursery leaf spot caused by, *Phyllosticta elettariae* is a destructive disease in nurseries. The disease makes its appearance during the months of February- April with the receipt of pre-monsoon showers. The disease initially manifests as small dull white round to oval spots, which later turn necrotic and leave a hole (shot hole) in the center of necrotic area. The spots may be surrounded by water soaked area. The disease is more severe in open nurseries exposed to direct sunlight. However, the seedlings develop tolerance as they pickup growth.

The disease can be contained by undertaking the following management measures:

- Sowing of the seeds may be undertaken during August – September to ensure sufficient growth of seedlings so that they develop tolerance to the disease.
- Provide adequate shade by providing overhead *pandals* with coir mat/agro- shade nets/ thatched coconut fronds etc.
- Prophylactic spraying with fungicides such as mancozeb (0.2 %) may be resorted on the leaves. First spray is to be given during March-April, depending on the receipt of summer showers and subsequent sprays at fortnightly intervals. Two to three rounds of spraying may be given.
- Clipping and destructing of severely affected leaves after spraying is to be done to arrest further spread to the remaining healthy plants.
- Avoid raising nursery continuously in the same site.

b. Secondary nursery leaf spot

In secondary nurseries, another type of leaf spot incited by *Cercospora zingiberi* is of common occurrence. The disease is characterized with the formation of yellowish to reddish brown coloured rectangular patches on the lamina which run parallel to the veins. In the advanced stages, the lesions assume muddy red colour. Prophylactic spraying with mancozeb (0.2 %) on the foliage effectively prevents the incidence and subsequent spread of the disease.

c. Nursery leaf rot

Normally seedlings of three to four months old are more vulnerable to this disease. The disease, which is of limited occurrence in the nurseries, is caused by *Fusarium* sp. and *Alternaria* sp. The symptoms include formation of water soaked lesions on the leaves which later becomes necrotic patches leading to decay of affected areas. Usually the damage is more pronounced on the leaf tips and distal portions of the foliage. Under favourable conditions, rotting extends to petiole and leaf sheaths also. Avoiding excessive watering in the nurseries prevents initiation and further proliferation of the disease. When the disease is noticed in the nurseries, spray the seedlings with carbendazim (0.2%) twice at 15 days interval after destroying the affected plant parts.

d. Damping off or seedling rot

The disease appears usually in the nurseries during rainy season and accentuated excess soil moisture due to inadequate drainage facilities. The disease is caused by soil-borne fungi such as *Pythium vexans* and *Rhizoctonia solani*. *Fusarium oxysporum* also causes similar seedling rot, resulting in the wilting and withering of entire seedlings. In the initial stages of disease development, the leaves turn pale with yellowish tips. Gradually, the symptoms spread over the entire leaf lamina, extending to leaf sheath and result in wilting of seedlings. The collar portion decays and the entire seedlings collapse. In mature seedlings, rotting extends from the collar region to the rhizomes resulting in decay and ultimate death of the plant. To contain/ control the disease resort to following operations

- In primary nurseries, practice thin sowing to avoid overcrowding of the seedlings.
- Prevent water stagnation by providing adequate drainage facilities.
- Remove affected seedlings and maintain proper phyto sanitary measures in the nursery.
- When infection is noticed, drench the nursery beds with copper oxychloride (0.2 %).
- Pre-sowing treatment of seeds with antagonistic bio control agents such as *Trichoderma* or *Pseudomonas* protect the seedlings in the early stages of growth. Application of *Trichoderma* at 100 grams per square meter of the bed also helps in reducing the disease spread.

B. Pests

a. Pest Management in nurseries

In nursery stage seedlings are affected by cut worm, shoot borer, root grub, leaf thrips and root knot nematode. Root grubs and root not nematode pose more problem in two season nurseries. To manage whole pest complex the following measures are to be followed at various stages of nursery.

b. Cultural Practices

Raise nurseries away from main plantations to reduce possibilities of infestation and reinfestation from the nearby infested plantations.

Provide sufficient organic manures to encourage better vegetative growth.

- Shift nurseries repeatedly to overcome soil- borne pest problems like root knot nematodes and root grubs.
- Catch and destroy the beetles of root grubs using insect nets especially in two season nurseries.
- Collect the cut worms hiding in the mulch in the affected area and destroy.

c. Chemical control

Insecticides like quinalphos (0.05%), fenthion (0.075%) or dimethoate (0.05%) may be used to tackle the pest problem. The sprays may be undertaken at monthly intervals starting from rapid tillering stage. In the old nursery sites, exposed sandy loam areas and two season nurseries root knot nematode assume severe proportion. Apply one round of carbofuran or phorate at 30-40 g/ m^2 in one season nursery at rapidly tillering stage and apply two rounds of granular insecticides to two season nurseries at three monthly intervals. Application of granular insecticides at three monthly intervals is highly essential to protect the underground and sub-aerial parts in clonal nurseries (Gopakumar and Chandrasekar, 2002)

II. Secondary Nursery

There are two methods of raising seedlings in secondary nursery. They are bed and poly bag nurseries. In Kerala and Tamil Nadu region, the seedlings are transplanted to secondary nursery beds when they are about 6 months old, where raising of seedlings both in primary and secondary nursery are commonly followed. Whereas in Karnataka, the old practice of sowing seeds in the primary nursery and thinning out excess (crowded) seedlings and allowing seedlings to grow right in the same nursery is followed. Where seedlings were not transplanted into fresh beds, there was a considerable complaint of nursery losses from disease. This obviously suggests that overcrowding is an important factor, damaged by nursery leaf spot and damping off disease (Mayne, 1951). The experiment conducted by Korikanthimath (1982) have clearly revealed that following of both primary and secondary nursery practices would be more ideal to get vigorous seedlings attaining a minimum of 4-5 strong tillers within a span of 10 months itself.

1. Preparation of seed beds

Prepare beds as in primary nursery. A layer of powdered cattle manure and wood ash may be spread on the bed and mixed with soil before transplanting.

On an average, 10 secondary beds are required for transplanting the seedlings from one germination bed. A mixture of powdered cow dung and wood ash is spread over the secondary beds before transplanting. Beds for transplanting are prepared in the same way as for primary nursery seed beds although there is frequently the adoption of more compost or pulverized cattle manure.

2. Leaf stage and spacing

The time at which transplanting takes place depends very largely on the time at which seeds are sown. In Karnataka, where seeds are sown during August-September, transplanting takes place in November-January. In Kerala and Tamil Nadu states, the seedlings from primary beds (4-5 leaf

stage) are transplanted to secondary nursery beds during June-July at a spacing of 20 x 20 cm. Studies conducted Cardamom Research Centre, Appangala, Kodagu, Karnataka on the optimum spacing and size (leaf stage) of seedlings for transplanting in secondary nursery revealed that, rate of mortality was found to be maximum when transplanting was done in the 2nd leaf stage (25.4%) as against 5th leaf stage (1.09%). Transplanting seedlings at 5-6th leaf stage is more ideal as the seedlings in the primary nursery would put up strong, sturdy and adequate growth and could withstand transplanting shock. Korikanthimath (1982) reported that the number of tillers produced per seedling was significantly more in wider spacing (11.92) by following 30 x 30 cm spacing followed by 22.5 x 22.5 cm (9.24) and 15.0 x 15.0 cm (7.29) respectively. Rate of mortality was higher when transplanting was done in second leaf stage. It can be minimized by transplanting at four-five leaf stage. However, taking into consideration that vast area and expenditure involved in raising nursery by transplanting seedlings at 5-6 leaf stage at a spacing of 15 x 15 cm may be followed.

3. Fertilizer

The broad uptake ratio worked out for pre potent plants was 9:1:17::N:P:K, respectively. Based on the above observation it is quite evident that cardamom plant requires more of potassium. Nitrogen and phosphorous are needed in comparatively lesser extent (Korikanthimath *et al.*, 2001). A well decomposed compost, cattle manure and fertilizer top jungle soil may be used for application to each nursery bed @ 8-10 kg (2.5 x 1.0 m) both in the primary and secondary nursery. Since considerable amount of nutrients are removed by the seedlings, it will be necessary to apply fertilizers in secondary nursery. It is found that as much as 120 g nitrogen, 20 g phosphoric acid and 300 g potash, 50 g magnesium and 75 g calcium are removed on an average from a bed of 100 seedlings. To promote uniform growth 250 g mixture made of 92 parts of 17:17:17 and 8 parts of Zinc sulphate dissolved in 10 litres for 1000 plants may be sprayed once in 15-20 days starting after one month of transplanting (Anonymous, 1990). Regional Research Station, Mudigere, recommends NPK mixture at the rate of 160 g per bed one month after planting. This is to be increased by 160 g every month until a maximum of 960 g per bed is reached. The proportion of NPK is one part urea, two parts superphosphate and one part murate of potash, (Anonymous, 1979). At Cardamom Research Centre, Appangala, Korikanthimath (1982) observed that application of 45 g N, 30 g P_2O_5 and 60 g K_2O per bed of 2.5 x 1 M size three equal splits at an interval of 45 days would result in better growth and higher number of tillers. The first dose of fertilizer may be applied after 30 days of transplanting in the secondary nursery. Application of Diammonium phosphate (DAP) along with murriate of potash is found to be beneficial for tiller and root production (Anonymous, 1989). Sufficient mulch should be applied after planting as in the case of primary nursery.

4. Erection of *pandal*

Once the seeds germinate which normally under most favourable circumstances is after about a month, the beds must be shaded from the sun. To protect the seedlings from sun, shade has to be provided by erecting a pandal. Overhead *pandal* is preferred to an individual bed *pandal* as it provides uniform filtered sun light and facilitate watering, spraying and other cultural operations. Overhead *pandal* should be erected at least at a height of 2 m for easy movements. Locally available wooden poles bamboo or granite poles may be used for erecting the *pandal*. Normally nursery poles are placed at 3-3.5 m apart. The top of the *pandal* is either covered with network of G.I. wire or with jungle wooden reeper/ rafters. Covering overhead *pandal* with coirmat is most preferable as it allows sufficient filtered sun light which enables adequate growth and production of tillers per plant. Coir mats with half an inch is recommended (Anonymous, 1986). The coirmat may be sprayed with 1% Bodeaux mixture before placing on top of *pandal* to minimize the

damage due to fungal infection. However, locally available covering materials like tree twings (foliage) of Jackate (*Birucaspus longue Roxb*) which will not shed its leaves, knetted coconut fronds and arecanut leaves may be used economically. It is important to avoid dripping from the *pandal* in wet weather as the young plants are tender and easily damaged. Slant pandals are most ideal in cardamom nursery. On the slant *pandals* there is no scope for rain water to accumulate and drop on the leaves of young plants as the rain water flows down the *pandal* and away from the seedlings. This kind of slant *pandals* can be erected both in small (farmer estates) and large commercial nurseries and either for individual beds or for two or three beds together. It is advisable to erect slant *pandals* of 45° angle on the nursery beds to save plants from severe attack of fungal diseases and to obtain healthy cardamom seedlings for planting in estate (Parameshwara *et al.*, 1979). The cover material on *pandal* may be removed immediately after onset of regular monsoon to avoid falling of *pandal* due to over weight on account of absorption of moisture and to allow sunlight during cloudy rainy weather.

5. Irrigation and Drainage

The nursery beds should be irrigated twice a day immediately after planting upto 8-10 days, thereafter once a day upto 30 days. Once the seedlings establish and putforth new growth, watering may be resorted on alternate day till the receipt of monsoon showers. Flood and flash irrigation should be avoided as it may accentuate the problem of damping off and leaf spot diseases.Adequate drainage should be provided to avoid stagnation of water particularly in the low lying areas during monsoon by providing central and lateral drains.

6. Weeding

Hand weeding may be resorted once in 20-25 days to keep the nursery beds free from weeds. The weed growth will be smothered once the seedlings attain sufficient growth.

7. Earthing up

The top soil between the rows of cardamom seedlings would normally get washed out and deposited in the pathways provided between the nursery beds. Scraping of the soil deposited from pathways and application in a thin layer upto collar region may be taken up two months after transplanting seedlings in secondary nursery. Application of the fertile soil collected from jungle along with cattle manure would be much more beneficial. Earthing up may be takenup immediately after split application of fertilizer as mentioned above. This should help in replenishment of fertile soil, strong anchorage enhanced tillering and vigorous growth of seedlings.

8. Rotation and fallow of nursery site

Normally it would be ideal to change or shift the nursery site once in 2-3 years to avoid the buildup of insect/ pests by using the same site repeatedly over a period of time. Where the shifting of nursery site is not possible due to non availability of alternate site, as it normally happens in case of departmental nurseries it would be better to follow the rotation of land with green manure crops like Daincha, Sesbania or Sunhemp and raising of cardamom seedlings. Green manure crops should be ploughed back and incorporated in the soil once in two years and then the cardamom seedlings may be raised. The practice of leaving part of the area fallow after deep digging/ ploughing for a year would help in exposing of insect/ pests to sun and bringing down the inoculums built up in the nursery site during the previous years.

By following the cultural practices regularly, the seedlings would be ready for transplanting in the main field (plantation) after 10 months of sowing the seeds. Raising of seedlings in the primary

nursery and later transplanting them to the secondary nursery is found to be more advantageous as it facilitates better establishment and initiation of adequate number of suckers per plant.

III. Raising of seedlings in paddy fields

The survey conducted in Coorg, Hassan and Chickamagalur district of Karnataka revealed that most of the small and marginal farmers raise cardamom nursery in paddy fields (wet lands) as water is easily and abundantly accessible. Sufficient drainage needs to be provided both in and around the nursery to avoid water stagnation during monsoon. Beds are separated by deep channels into which naturally available water is run. This ensures moisture supply but as soils are frequently heavy, there is some risk of excessive moisture in the soil (Mayne, 1951). These areas which normally possess sandy loam soils facilitate better root development and adequate growth of seedlings.

IV. Dry nursery

Dry nursery is followed in plot system of cardamom cultivation. This is popularly known as "*Malai* Cultivation" of cardamom in Kodagu district of Karnataka. The protection offered by the forest belt is also congenial it is possible to raise cardamom nursery in small plots without erecting any overhead *pandal* and watering. As no watering involved the nursery is known as "Dry Nursery". The nursery operations are very limited. The maintenance of dry nursery is very cheap as there is no need for watering or overhead pandal. The leaf litter is heaped up and seeds of cardamom are broadcasted after the first or second showers of summer rain in March or April (Mayne, 1951). The seeds are raked into the soil and the surface is covered with leaf mould and thin layer of leaves. The branches of shade trees are cut to regulate shade. The hand weeding is carried out after the germination. Before the end of monsoon, jungle soil is applied as a thin layer and the beds are adequately mulched with leaf litter. The seedlings withstand the drought while growing. Seedling are planted in the field after attaining sufficient growth as is the case with other conventional and common methods of raising seedlings.

V. Poly bag nursery

Transplanting seedlings at 4-5 leaf stage from primary nursery to the poly bag nursery is more suitable (Ankegowda, 2008). Black polythene bags of 20 x 20 cm size and thickness of 100 gauge provided with 3-4 holes at the bottom can be used for raising cardamom seedlings. Bags may be filled with nursery (pot) mixture in the ratio of 3:1:1 of jungle top soil, farm yard manure and sand. The bags are arranged in rows of convenient length and breadth for easy management. At later stage in between the bags adequate space may be provided for better tillering. The advantage of raising seedlings in polythene bags are – seedlings of uniform growth and tillering can be obtained, nursery period can be reduced to five to six months after transplanting seedlings as against 10 to 12 months in secondary nursery and better establishment and growth of seedlings in the main field. Cardamom plants from secondary nursery or poly bags can be transplanted to the main field during last week of May after receipt of pre-monsoon showers or the first week of June soon after commencement of south west monsoon.

9. Age of Seedlings for Field Planting

Generally comparative success of establishment in the estate (plantation) and the raising the seedlings should be given due consideration while recommending one season (10 months old) or two season (18-22 months) old seedlings. One year old seedlings can profitability be planted in estates, when vigorous seedlings are raised in nurseries (Kasi and Iyengar, 1961). However, it is generally observed felt that 10 months old seedlings may be suited for new planting with a well

developed rhizome perform well in Karnataka would be more suitable for gap filling which can withstand the competition. Seedlings of 18-22 months old are usually preferred for planting in Kerala, Tamil Nadu region where the Mysore and Vazhukka which are robust in growth are cultivated.

VI. Vegetative Propagation

The vegetative propagation method is simple, reliable and facilitates easy multiplication of selected clump or type. Plants raised from rhizome come to bearing earlier than the seedlings raised from seeds. Vegetative propagation is advantageous in areas where 'Katte' disease is not a problem. Variability in cardamom being very high a study to evaluate the yield and the cropping behavior of cardamom in the field trials over a population of 764 plants obtained from 78 selections was conducted during 1962-64 (Krishnamurthy, *et al.,* 1989). As it was found that nearly 36 per cent of the plants in a plantation only bear heavy yield it was possible to step up production of cardamom by stocking plantation with high yielders and by roguing out medium and poor yielders. The high degree of variability in yield high percentage of plants of poor yielders in the seedling population necessitates selection of clone for getting uniform and increased yield in cardamom. In this background the vegetative propagation assumes a greater significance in multiplication (generation) of high yielding plant material for planting on a larger areas. The vegetative propagation can be resorted to both by macro *i.e.,,,* rhizome propagation through rapid clonal multiplication with intensive care and micro propagation by tissue culture. Though cardamom can be propagated both vegetative (micropropagation and clonal) and through seeds, large scale propagation of cardamom was mostly through seeds during earlier years. Since production of heterogenous progeny is an inherent problem, an attempt was made on selection of elite clones, evaluation both in clonal nursery and main field. A simple and reliable rapid clonal multiplication technique was developed.

A. Clonal (Macro/Rhizome/Sucker) Propatation

Vegetative propagation can be resorted by macro propagation i.e.; using rhizomes for propagation under intensive care in the field and micro propagation by tissue culture which deals with meristem and callus under asceptic conditions. Mass multiplication of high yielding cardamom plants (micro propagation) through tissue culture, has been commercialized by several firms. However, the cost of these plants is high and not within the reach of small and marginal growers who constitute nearly 70 per cent of the cardamom farming community. Moreover cardamom is highly location specific. In view of these practical problems, development of a rapid clonal multiplication technique is felt most necessary. Suckers from elite clones can be used for establishing plantations capable of high productivity. Suckers should not be used in areas where katte and other virus diseases (such as Kokke kandu and Niligiir necrosis) are common.

a. Rapid of clonal propagation in cardamom

High yielding varieties/selections are generally multiplied in isolated clonal nurseries. Virus free high yielding plants are selected and subcloned for further multiplication. For rapid multiplication following timely agro techniques has to be followed

1. High yielding plants free from pest and diseases, with characters like bold capsules and retentivity of green colour are to be selected from plantations and part of the clump has to be uprooted for clonal multiplication leaving the mother clump in its original place to induce subsequent suckers for further use.

2. The minimum planting unit consists of one grown up sucker (rhizome) and a growing young shoot.

3. Trenches having width and depth of 45 cm and convenient length have to be opened filled with jungle soil, compost and topsoil.

4. The rhizomes (planting unit) are placed at a spacing of 1.8 m x 0.6 m in trenches, thus accommodating 9259 plants per hectare of clonal nursery area.

5. Pandal protection, regular watering (once in a week during November to May) and chemical manure @ 48:48:96 g. NPK per plant in two splits have to be applied.

6. On an average 32 - 42 suckers will be produced after 12 months of planting per one planting unit. Taking the barely minimum of 50% of these suckers/clump one can get 16-21 planting units (one grown up sucker along with a growing young shoot *i.e.*,sucker) from one mother-planting unit after 12 months.

7. In an area of 1-hectare clonal nursery 1,48,144 to 1,94,439 planting units can be produced after 12 months.

8. Clones thus produced should be free from virus, rhizome rot and root knot nematodes.

(Korikanthimath, 1999 a).

b. Multiplication technique

Rapid clonal multiplication of elite cardamom clones consisted of selection of elite clones, multiplication in trench method of planting with high density (1.8 m x 1.6 m), monitoring of mother clumps from plantation, adoption of precision farming practices *viz.,* selection of suitable site, land preparation, planting the trenches, providing over head shade by locally available shade tree twigs which do not shed leaves, timely plant protection, adoption of appropriate timely cultural operations, uprooting of clumps at the end of 10 months and separating each planting unit (containing the grown up sucker along with a growing young shoot) for further planting in the field for large scale cultivation with genetically elite planting material and economic analysis.

The rate of multiplication of planting material *i.e.* ,rhizome containing a grown up sucker along with a growing shoot, was 1:20 (as against 1:9 in the plantation where suckers are normally used for gap filling, under overhead shade trees) within a short span of 10 months as 9,260 planting units were obtained from 463 mother clonal units in an area of 0.05 ha. The pseudostem with swollen base along with its food storage organ *i.e.,* rhizome serves as a new planting unit under macro propagation. This technique is simple, reliable and economically feasible technique for production of quality planting material. It can be easily adopted by farmers right on their own plantations as most of the estates are still inaccessible and spread over in far flung interior ever green forests (Korikanthimath, 1995 ; Korikanthimath, 1997). At the end of 20 months, a total of 14,816 planting units (each planting unit consisting of a grown up sucker along with a growing young shoot) were produced from an area of 0.05 ha, starting from 463 mother planting units accommodated in the clonal nursery. The rate of multiplication of planting material was 1:32 at the end of 20 months besides resulting in early bearing and contributing to substantial yield. A remarkable yield of 90.29 kg dry cardamom per 0.05 ha was obtained within a short span of 20 months in the high density planting (1.80 x 0.6 m) in clonal nursery. This worked out to be 183.14 g dry cardamom per plant besides generating 32 planting units per mother rhizome.

B. Micro Propagation (Tissue Culture)

Although cardamom is one, of the important plantation crops no work reported on Tissue Culture upto 1980. Only one report on callus induction and organ differentiation from seedlings (Srinivasa Rao *et al.,* 1982) was brought out in 1982 but this did not contain details on transfer of plants to field. Tissue Culture work in cardamom was initiated and technique perfected at ICAR-Central Plantation Crops Research Institute, Kasargod and ICAR-Indian Institute of Spices Research, Calicut, Kerala and Cardamom Research Centre, Appangala, Madikeri, Karnataka. Multiplication of virus resistant and high yielding plants at a faster rate can be achieved by Tissue Culture than can be done by the conventionally used methods.

Three types of explants are found to be economical for culture. They are tender vegetative buds, tender inflorescence and floral raceme. Detailed protocol for multiplication of cardamom by using vegetative buds, immature panicles and floral recemes has been standardized. Quite a number of private Bio technology laboratories in India have taken up the micro propagation of cardamom by resorting to tissue culture with high yielding lines/ selections.Extremely efficient methods for in vitro clonal propagation of cardamom are available (Nadagauda et al., 1983; Priyadarsan and Zachariah, 1986; Vatsy et al., 1987; Regunath and Gopalakrishnan, 1991). Kumar *et al.,* (1985) reported the successful conversion of immature floral buds to vegetative buds and subsequently to plantlets.

a. Plant Regeneration from callus cultures

Plant regeneration from callus cultures of cardamom was reported (Rao *et al.,* 1982, Priyadarsan and Zachariah 1986, Nirmal Babu *et al.,* 1997). Variability could be noticed among the somaclones for the morphological characters in the culture vessels itself. A few somaclones tolerant to 'Katte Virus' were identified (Peter *et al.,* 2002).

b. Raising Tissue Culture Seedlings before planting in the field

On a commercial scale the hardened rooted tissue culture plantlets of 4-5 leaf stage with a well developed root system from Tissue Culture Laboratories are supplied to growers in egg trays or in individual plastic cubicles (pots). On an average 5-6 thousand such seedlings can be transported in a Jeep. After transporting to the site of planting *i.e.,* estates, these plantlets are further transferred to polythene bags (perforated) of 20 x 20 cm containing nursery pot mixture of jungle top fertile soil, sand and cattle manure in 1:1:1 proportion or directly transplanted in the raised bed nursery at 21 x 21 cm apart for better establishment and inducing of suckers (tillers). It would take about 6-9 months to get these seedlings ready for planting in the main field.

Large Cardamom

Propagation of large cardamom is done through seeds, rhizomes (sucker multiplication) and tissue culture techniques. Cultivars suitable for specific areas, altitudes, agro climatic conditions and mother plant/clump of known performance are selected for collection of seed, rhizome and vegetative bud.

A. Propagation through seeds

Healthy plantations free from viral disease with high yield are selected for seed capsules. Spikes are harvested at maturity and seed capsules collected from the lowest two circles in the spike. After dehusking, the seeds are washed well with water to remove mucilage covering of seeds, mixed with wood ash and dried under shade. The dried seeds are treated with 25 % nitric acid for 10 min for early and higher percentage of germination (Gupta, 1989). The acid treated seeds are

washed thoroughly in running water to remove the acid residue and are surface dried under shade. The seeds are sown immediately after acid treatment. Once the seedlings in the primary seed bed reach 3-4 leaf stage (in February/March) if the seeds are sown in September /October or April/May if the seeds are sown in (February/March) they are transplanted either to poly bags or into secondary nursery beds in February/March or April/May respectively (Gupta, 1989). Raising of primary nursery and secondary nursery /poly bag nursery are similar to small cardamom.

B. Propagation through suckers

1. Selection of planting material

High yielding disease free plantations are to be selected. The plantation should have high yield record *i.e.*, more than 800 kg/ha for at least three consecutive years. One mature tiller with two immature tillers or vegetative buds is used as planting unit.

2. Nursery site selection

The nursery should be about 500 meters away from the main plantation to avoid occurrence of pests and diseases. The irrigation facility should be available in the nursery. It should be easily accessible by road. Sloppy land is not suitable for nursery establishment.

3. Preparation of trenches

The trenches should be of 45 cm width and 30 cm depth with convenient length and may be made across the slopes of the field. Top soil (15 cm depth) to be kept separately from the trench in the upside. Below side (15cm depth) soil to be forked thoroughly. Dried leaves to be applied as layer in the trench first. Then the trench to be filled by top soil mixed with cow dung compost. Spacing of 30 cm is required in between two trenches. The planting units to be planted at a spacing of 45 cm in proper staking (Gudade *et al.*, 2013).

4. Pre treatment with bio- agents

Sikkim being an organic state, only eco friendly and non chemical measures should be adopted. Suckers may be treated by dipping in 5% solution of *Trichoderma* sp. /*Pseudomonas fluorescens* and *Bacillus subtilis* for 30 minutes before planting in trenches as a prophylactic measure.

5. Time of planting

Planting can be done during last week of May to June. It should be done as early as possible so that maximum number of planting units could be generated for the subsequent season.

6. Maintenance

Thick mulching with dry leaf / grass may be applied at the base of plant and watering may be done during November to March depending on the soil moisture condition. Well decomposed cattle manure may be applied. The plot may be maintained with 50% shade under shade trees or using agro shade net. The disease and pest incidence to be looked from time to time. Disease affected plants to be uprooted and to be destroyed outside the sucker nursery. Spraying and drenching with 5% solution of *Trichoderma* sp./ *Pseudomonas fluorescens* and *Bacillus subtilis* in sucker nursery may be carried out once in three months starting from May-June, August- September, December-January. With proper management, a minimum of 5 planting units could be obtained from a single plant. Monitor the nursery once in a month and ensure water drainage. Weeding may be done, if necessary (Battarai *et al.*, 2013).

C. Micro propagation

Large cardamom can be multiplied on a large scale through micropropagation. Protocols for micro propagation were developed at Indian Institute of Spices Research (Sajina *et al.*, 1997 and Nirmal Babu *et al.*,1997) Auxiliary buds of 0.5-2cm lengths from promising, virus disease free mother plants are used as explants. The explants were thoroughly washed in clean running water and then in a detergent solution and treated in 0.15 per cent $HgCl_2$ for 2 min and then passed through absolute alcohol for 30 sec. These are cultured using the modified MS Medium, solidified with agar and with different adjuvant. Nirmal Babu *et al.*, (1997) and Sajina *et al.*, (1997) accomplished both multiplication of shoots and rooting in the same medium, in MS basal+BAP (1mg/l) and IBA (0.5mg/l) with 3% sucrose and gelled with 0.7 percent agar at pH 5.8 and 12 h photoperiod at a light intensity of 2500 lux. This combination produced 8-12 shoots per culture and roots per shoots. Sushen Pradhan *et al.*, (2014) reported that the shoot tip as explants of Ramsay responded well and it was found to be the best explants for the production of disease free planting materials. They tried 52 different hormone concentrations using MS medium. The shooting and the rooting of the explants were better and faster with more number of healthy shoots, leaves and proper growth regulator on different concentration. The best medium was modified MS medium fortified with BAP 3 mg/l +NAA 0.5 mg/l and sucrose 40g and for the formation of both multiple shoots and roots and successfully 100 % acclimatised plantlets were transferred into fields.

Conclusion

There is not much of area expansion both in cardamom(small) and large cardamom, in fact the area under cardamom has come down from 1,00,000 ha. to 73,000 ha. in the recent years due to disturbing natural evergreen forest eco system and the traditional cardamom area being replaced with other high value crops like pepper mix cropped with coffee, etc. in South India. Hence, it is imperative to enhance productivity by using quality planting material (QPM) and bring down cost of production of cardamoms so as to remain competitive in the International market besides meeting the growing demand in India itself. One of the reasons for low productivity in cardamoms is the propagation through seeds. The inherent drawback of this method is the production of heterogeneous progeny which is genetically not uniform due to natural cross pollination. Cardamom can be propagated both vegetatively by macro-clonal or rhizome multiplication, micro propagation (tissue culture) and through seeds. Large scale propagation of cardamom was mostly through seeds during earlier years. Over three decades of research, it is amply proved that it is possible to step up productivity and production by stocking the plantation with high yielders through clonal propagation.

Clonal multiplication ensures genetically uniform planting material true to the parent. Vegetative propagation can be resorted by macro propagation i.e. using rhizomes of elite clones with not only high yield but also resistant/ tolerant to biotic and abiotic stress, under intensive care in the field (clonal nursery) and micro propagation by tissue culture which deals with meristem and callus under asceptic conditions. Mass multiplication of high yielding cardamom plants (micro propagation) through tissue culture, has been commercialized by several firms. However, the cost of these plants is high and not within the reach of small and marginal growers who constitute merely 70 per cent of cardamom farming community. Moreover cardamom is highly location specific. In view of these practical problems, development of a Rapid Clonal Multiplication Technique is felt most necessary to select the high yielders in the farmers plantations/ estates itself to generate the quality plant material for further expansion of the area and also replanting with genetically superior line.

Scientific and systematic nursery practices both in primary and secondary would ensure healthy and vigorous cardamom seedlings. In case of large cardamom, raising of primary nursery and secondary nursery/ poly bag nursery are similar to small cardamom. Both cardamom and large cardamom can be multiplied on a large scale through micro propagation (tissue culture) by using elite clonal materials. A large number of cardamom farmers in Kerala have taken up cultivation of cardamom by clonal propagation of superior selections in almost over 90% of the plantations with a record yield of 2500 kg (dry/ha). The rapid clonal multiplication is thus most reliable, cost effective and can be easily followed by farmers right in their cardamom plantations. The efforts made by several cardamom growers in making their own selections of elite lines and multiplying them for further planting on a large scale is most commendable.

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