***Original Research Article***

**Comparative Evaluation of Growth Attributes in Three Major Cultivars of Small Cardamom [*Elettaria cardamomum* (L.) Maton] during the Early Growth Stage**

 **Abstract**

An evaluation of three natural cultivars of small cardamom [*Elettaria cardamomum* (L.) Maton], namely *Malabar*, *Mysore*, and *Vazhukka*, was conducted during the secondary nursery stage at the Cardamamom Research Station, Pampadumpara, to assess variations in growth attributes. Observations on tiller height, tiller thickness, tiller number, number of leaves per clump, leaf length and width, emerging bud number, and dry matter content of leaves and pseudostems were recorded at 4, 8, and 12 months after planting (MAP). Tiller height, tiller thickness, and the number of tillers increased progressively with growth across all cultivars. *Mysore* consistently recorded the highest tiller height and dry matter accumulation, followed by *Vazhukka*, while *Malabar* exhibited the greatest number of tillers and emerging buds. Significant differences were observed among cultivars for tiller thickness at early stages and for dry matter content of leaves and pseudostems. The study highlights the importance of nursery stage evaluation in understanding early growth dynamics of these cultivars in guiding the selection of suitable cultivars for field establishment and productivity optimization.

Keywords: Cardamamom, clump, cultivars, tiller thickness

**Introduction**

*Elettaria cardamomum* (L.) Maton, commonly known as small cardamom or Indian cardamom, is highly significant spice crop and is primarily cultivated in southern India (Govindarajan *et* *al*., 1982). It is herbaceous, perennial monocotyledonous plant belongs to the family Zingiberaceae (Nayar, 1987). It is considered as “Queen of spice”. The plant part used as a spice is the dried fruit capsule, which contains seeds rich in aromatic volatile oils (Ashokkumar *et al*., 2020).

Small cardamom is renowned for its distinct aroma, flavor, vibrant green color, and well defined capsule size and qualities that stem from the unique agroclimatic conditions of its growing regions. These include a warm and humid climate, organically rich loamy soils, evenly distributed rainfall, and specialized cultivation and post harvest practices (Parthasarathy and Prasath, 2012). As a high value spice crop, small cardamom plays a crucial role in India’s export economy. Its trade performance has notably improved in the post-WTO era, despite earlier challenges. However, fluctuations in export unit prices continue to influence its market value, with recent export trends showing increased concentration toward Middle Eastern countries (Indhushree and Kuruvila, 2019).

Selection of appropriate cultivars based on their early growth stage is essential for ensuring successful establishment and robust development under field conditions. Nursery phase evaluation allows early identification of vigour and adaptability, which are critical for plant survival in challenging environments. Franco *et al*. (2006) reported that proper selection strategies and nursery conditioning significantly enhanced seedling quality and post transplant survival. Similarly, Sharma *et al*. (2014) observed considerable variation in growth traits among poplar clones, emphasizing the importance of cultivar screening for superior nursery performance. These findings highlight the vital role of nursery stage selection and management in optimizing subsequent field growth and productivity.

Traditionally, small cardamom is categorized into three main cultivated types or natural varieties viz. *Malabar*, *Mysore* and *Vazhukka* based upon the nature of panicles, such as prostrate, erect and semi erect respectively (Madhusoodanan *et al*., 2002).The present study aims to compare the vegetative growth and vigor of these three major cultivated types during their secondary nursery phase.

**Materials and Methods**

The field experiment was carried out at the Cardamom Research Station, Pampadumpara, Idukki, Kerala located at a latitude of 9o 45’ North and longitude of 77o 10’ East at an altitude of 1100 m above MSL. Three cultivated types of small cardamom typically *Malabar, Mysore* and *Vazhukka* were the experimental study materials.

Planting materials were procured from the Cardamom Research Station, Pampadumpara. The suckers were separated carefully by trimming the roots, ensuring that each planting unit comprised of a rhizome with one mature tiller and one emerging tiller (KAU, 2016). These planting units were established in pots for the study. The experiment was laid out in Completely Randomised Design (CRD) consisting of 3 treatments (cultivated types) with 5 replications. The three treatments were as follows: T1 (Sucker unit of *Malabar*), T2 (Sucker unit of *Vazhukka*) and T3 (Sucker unit of *Mysore*).

The sucker units were transplanted to grow bags (24 cm × 24 cm × 40 cm) filled with a growing medium composed of well decomposed cattle manure, sand, and topsoil in a 1:1:1 volumetric ratio, with each component contributing approximately 7,680 cm³, making a total volume of 23,040 cm³ per grow bag. Each planting unit was provided with staking for support and overhead shade net pandal was installed prior to transplanting. Irrigation was given fortnightly, and plant protection measures were followed (KAU, 2011). Fertilizers were applied at the rate of 100:50:200 kg ha⁻¹ (N:P₂O₅:K₂O) in six split doses at two-month intervals. This corresponded to 30 g Urea, 38.5 g Rajphos, and 46.3 g Muriate of potash (MOP) per plant per application. Mulching was done adequately during summer months., sickle weeding was performed frequently, and annual trashing of old shoots, leaves, and panicles was undertaken (KAU, 2016).

The study was conducted over a period of one year, from November 2023 to November 2024, with observations recorded at four month intervals. Tiller height (cm), tiller number, tiller thickness (cm), number of leaves per clump, leaf length & width (cm), number of emerging buds, drymatter content of leaves and pseudostems were the parameters studied. Observations were subjected to statistical analysis adopting analysis of variance (ANOVA) and the significance of treatment effects was evaluated at the 5% level.

**Results and Discussion**

Table 1. Variability in tiller characteristics of small cardamom cultivars

|  |  |  |  |
| --- | --- | --- | --- |
| Treatment | Tiller height (cm) | Tiller thickness (cm) | Tiller number |
| Period | 4 MAP | 8 MAP | 12 MAP | 4 MAP | 8 MAP | 12 MAP | 4 MAP | 8 MAP | 12 MAP |
| T1 (*Malabar*) | 44.80 | 89.12 | 141.10 | 2.25b | 2.64 | 3.00 | 3.20 | 6.60 | 9.80 |
| T2 (*Vazhukka*) | 56.00 | 92.46 | 143.06 | 2.94a | 3.15 | 3.36 | 2.80 | 4.80 | 8.60 |
| T3 (*Mysore*) | 63.40 | 101.98 | 144.12 | 3.01a | 3.07 | 3.37 | 2.20 | 5.80 | 8.40 |
| SE±(m) | 11.413 | 10.044 | 12.645 | 0.210 | 0.224 | 0.147 | 0.583 | 0.693 | 0.698 |
| CD (0.05) | NS | NS | NS | 0.647 | NS | NS | NS | NS | NS |

Table 2. Variability in leaf characteristics of small cardamom cultivars

|  |  |  |  |
| --- | --- | --- | --- |
| Treatment | No. of leaves per clump | Leaf length | Leaf width |
| Period | 4 MAP | 8 MAP | 12 MAP | 4 MAP | 8 MAP | 12 MAP | 4 MAP | 8 MAP | 12 MAP |
| T1 (*Malabar*) | 16.20 | 38.00 | 59.80 | 47.60 | 52.70 | 55.96 | 6.90 | 7.66 | 8.80 |
| T2 (*Vazhukka*) | 13.00 | 27.80 | 54.20 | 49.54 | 52.56 | 60.80 | 7.72 | 8.26 | 9.42 |
| T3 (*Mysore*) | 11.60 | 30.80 | 57.40 | 49.80 | 54.88 | 62.22 | 7.98 | 8.86 | 10.02 |
| SE±(m) | 3.502 | 4.102 | 3.383 | 3.389 | 3.102 | 1.731 | 0.515 | 0.446 | 0.613 |
| CD (0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Table 3. Variability in emerging bud count and dry matter content of leaves and pseudostems in small cardamom cultivars

|  |  |  |  |
| --- | --- | --- | --- |
| Treatment | Number of emerging buds | Drymatter content of leaves | Drymatter content of pseudostem |
| Period | 4 MAP | 8 MAP | 12 MAP | 4 MAP | 8 MAP | 12 MAP | 4 MAP | 8 MAP | 12 MAP |
| T1 (*Malabar*) | 2.40 | 3.80 | 6.40 | 18.33b | 20.78b | 21.80b | 21.48b | 26.36b | 28.70 |
| T2 (*Vazhukka*) | 1.80 | 2.80 | 6.20 | 18.60a | 21.44a | 22.44a | 21.79b | 26.50b | 29.08 |
| T3 (*Mysore*) | 2.00 | 3.40 | 6.00 | 18.70a | 21.59a | 22.60a | 23.05a | 27.87a | 28.92 |
| SE±(m) | 0.365 | 0.383 | 0.707 | 0.052 | 0.123 | 0.190 | 0.262 | 0.333 | 0.164 |
| CD (0.05) | NS | NS | NS | 0.161 | 0.378 | 0.586 | 0.808 | 1.027 | NS |

Means followed by the same letter are not significantly different at p < 0.05 based on CD. NS = Not Significant

Variability of small cardamom cultivars with respect to tiller height, tiller thickness, and tiller number was recorded at 4, 8, and 12 MAP (Table 1). Tiller height increased progressively across all cultivars during the observation period. Among the three cultivars, *Mysore* recorded the highest tiller height at all stages (63.40 cm, 101.98 cm and 144.12 cm at 4, 8 and 12 MAP, correspondingly), followed by *Vazhukka* (56.00 cm, 92.46 cm and 143.06 cm at 4, 8 and 12 MAP accordingly) and *Malabar* (44.80 cm, 89.12 cm and 141.10 cm at 4, 8 and 12 MAP respectively). However, the differences in tiller height were not significant. These findings align with previous studies reporting plant height variability. Senthil Kumar *et al*. (2018) and Sharon *et al*. (2020) observed height ranges from 110-310 cm and 100-350 cm, in that order, among cardamom accessions, while Chukwudi *et al*. (2020) and Jan *et al*. (2012) noted shorter heights in ginger and turmeric.

Tiller thickness showed significant variation among cultivars at 4 MAP. *Mysore* (3.01 cm) and *Vazhukka* (2.94 cm) had significantly thicker tillers compared to *Malabar* (2.25 cm). Although tiller thickness increased in all cultivars over time, the differences were not significant at 8 and 12 MAP. By 12 MAP, *Mysore* recorded the highest tiller thickness (3.37 cm) among the treatments. These results correspond with Trimanto *et al*. (2021), who recorded a tiller thickness of 2 cm in *Alpinia galanga*, although slightly lower than the 4-5.74 cm range reported in small cardamom seedlings by Divyabharathi *et al*. (2023). Comparatively moderate tiller thickness observed in this study could be attributed to the pot culture environment compared to field grown, mature plants reported in the previous studies.

Number of tillers per plant increased progressively with growth across all cultivars. *Malabar* consistently recorded the highest number of tillers at each observation stage (3.20, 6.60, and 9.80 at 4, 8, and 12 MAP, respectively), while *Mysore* showed the lowest tiller count by 12 MAP (8.40). However, the differences in tiller number were nonsignificant. The results are comparable with previous reports in ginger (2-9 tillers; Chukwudi *et al*., 2020) and turmeric (5-10 tillers; Nair *et al*., 2010).

Observations on leaf morphological traits such as number of leaves per clump, leaf length, and leaf width were registered at 4, 8, and 12 months after planting (MAP) across the three cardamom cultivars (Table 2). The number of leaves per clump showed a progressive increase over time in all cultivars. *Malabar* consistently reported the highest number of leaves (16.20, 38.00 and 59.80 at 4, 8 and 12 MAP, respectively) followed by *Mysore* (11.60, 30.80 and 57.40 at 4,8 and 12 MAP, accordingly) and *Vazhukka* (13.00, 27.80, 54.20 at 4,8 and 12 MAP respectively). However, the differences were not significant. The results agree with previous findings in turmeric (7–17 leaves; Jan *et al*., 2012) and ginger (31.2 leaves; Ilyas *et al*., 2016).

Leaf length also increased with plant age across all treatments. *Mysore* produced longest leaves (49.80 cm, 54.88 cm and 62.22 cm at 4,8 and 12 MAP correspondingly) followed by *Vazhukka* (13.00 cm, 27.80 cm and 54.20 cm at 4, 8 and 12 MAP, respectively), while *Malabar* had the shortest leaves (47.60 cm, 52.70 cm and 55.96 cm at 4,8 and 12 MAP, respectively) at all stages. Despite numerical differences, no significant variation was observed among the cultivars. The results were consistent with leaf lengths reported by Jan *et al*. (2012) (35–57 cm) and Sharon *et al*. (2020) (32.40–66.20 cm) in turmeric and cardamom, accordingly.

A similar increasing trend was noted in leaf width. *Mysore* exhibited the widest leaves throughout the observation period (7.98 cm, 8.86 cm and 10.02 cm at 4, 8 and 12 MAP, respectively) chased by *Vazhukka* showing broader leaves (7.72 cm, 8.26 cm and 9.42 cm at 4, 8 and 12 MAP, accordingly) than *Malabar* (6.90, 7.66 and 8.80 cm at 4, 8 and 12 MAP, appropriately) at all stages. The results falls within the variation observed by Sharon *et al*. (2020) (7.36-11.32 cm).

The number of emerging buds per clump increased progressively with growth across all cultivars (Table 3). The highest number of emerging buds was observed in *Malabar* throughout the study (2.40, 3.80 and 6.40 at 4, 8 and 12 MAP, respectively) and the least was noted for *Vazhukka* during 4 and 8 MAP (1.80 and 2.80) while *Mysore* during 12 MAP (6.00). However, the differences among the treatments at all stages were not significant. The results are aligning with earlier reports of 3.83 buds per plant in small cardamom (Hrideek *et al*., 2015) and 4.8-8.8 buds in small cardamom (Nadukeri *et al*., 2020). The relatively moderate number of emerging buds recorded in this study may be due to the pot culture conditions and the younger developmental stage of the plants, as compared to the mature field grown plants documented in earlier reports.

 Dry matter content in leaves rose progressively with age for all cultivars. *Mysore* showed significantly highest leaf dry matter content at 4, 8, and 12 MAP (18.70 %, 21.59 %, and 22.60 %, respectively), followed by *Vazhukka* (18.60 %, 21.44 % and 22.44 % at 4, 8 and 12 MAP, correspondingly). *Malabar* consistently recorded the lowest leaf dry matter content (18.33 %, 20.78 % and 21.80 % at 4, 8 and 12 MAP, in the same way). The differences were significant at all three stages.

In the case of pseudostem dry matter content, *Mysore* again recorded the highest values, particularly at 4 and 8 MAP (23.05 % and 27.87%), which was significantly higher than *Malabar* (21.48 % and 26.36 % at 4 and 8 MAP, respectively) and *Vazhukka* (21.79 % and 26.50 % at 4 and 8 MAP, accordingly). However, by 12 MAP, the differences became non significant. The higher dry matter content reported in the *Mysore* and *Vazhukka* cultivar indicated better biomass accumulation efficiency, possibly due to its comparatively robust growth habit and physiological vigor. In contrast, the relatively lower dry matter content in *Malabar* could be due to slower structural development or higher moisture retention at the sampled stages.

****

**Fig 1. Field view of small cardamom cultivars at the time of planting**

**A**

**C**

**B**

**Fig 2. Samples collected from A) *Malabar*, B) *Vazhukka*, and C) *Mysore* cultivars at 12 MAP**

Fig 3. Tiller thickness (cm) of cardamom cultivars at different growth stages

Fig 4. Drymatter content of leaves (%) of cardamom cultivars at different growth stages

Fig 5. Drymatter content of pseudostem of cardamom cultivars at different growth stages

**Conclusion**

The comparative evaluation of three major small cardamom cultivars *Malabar, Mysore*, and *Vazhukka* during the secondary nursery stage revealed significant variations in certain growth parameters, particularly in tiller thickness and dry matter content of leaves and pseudostems at early growth stages. While all cultivars showed progressive improvement in vegetative growth attributes over time, *Mysore* and *Vazhukka* generally exhibited superior performance in terms of tiller height, thickness, and dry matter accumulation, indicating greater biomass potential. *Malabar*, on the other hand, recorded higher tiller numbers and emerging bud counts, suggesting vigorous vegetative proliferation as well as capsule yield. Although all differences were not statistically significant, the observed trends provide valuable insights into the early stage growth behavior of these cultivars. These findings underscore the importance of nursery stage characterization in guiding the selection of suitable cultivars for field establishment and productivity optimization.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

**References**

1. Ashokkumar, K., Murugan, M., Dhanya, M.K. and Warkentin, T.D. 2020. Botany, traditional uses, phytochemistry and biological activities of cardamom [*Elettaria cardamomum* (L.) Maton] – A critical review. *J. Ethnopharmacol.* 246: 112244.
2. Chukwudi, U.P., Agbo, C.U., Echezona, B.C., Eze, E.I., Kutu, F.R. and Mavengahama, S. 2020. Variability in morphological, yield and nutritional attributes of ginger (*Zingiber officinale*) germplasm in Nigeria. *Res. Crops* 21(3): 634-642.
3. Divyabharathi, D., Ravi, C.S., Nandish, M.S., Ganapathi, M. and Raviraja Shetty, G. 2023. Enhancement of seedling quality in small cardamom (*Elettaria cardamomum* Maton.) through inoculation of VAM fungi and liquid microbial inoculants as PGPR. *Ecol. Environ. Cons.* 29(4): 1891-1895.
4. Franco, J.A., Martínez-Sánchez, J.J., Fernández, J.A. and Bañón, S. 2006. Selection and nursery production of ornamental plants for landscaping and xerogardening in semi-arid environments. *J. Hort. Sci. Biotechnol.* 81(1): 3-17.
5. Govindarajan, V.S., Narasimhan, S., Raghuveer, K.G., Lewis, Y.S. and Stahl, W.H. 1982. Cardamom—Production, technology, chemistry, and quality. *Crit. Rev. Food Sci. Nutr.* 16(3): 229–326.
6. Hrideek, T.K., Radhakrishnan, V.V., Kuruvilla, K.M. and Mohanan, K.V. 2015. A study on variability of elite landraces of small cardamom (*Elettaria cardamomum* Maton). *Indian J. Plant Genet. Resour.* 28(3): 311-316.
7. Ilyas, S., Palupi, E.R. and Susila, A.D. 2016. Growth, yield and quality of ginger produced through early senescence. *Int. J. Appl. Sci. Technol.* 6(1): 21-28.
8. Indhushree, A. and Kuruvila, A. 2019. Performance of small cardamom export from India. *J. Trop. Agric.* 57(2).
9. Jan, H.U., Rabbani, M.A. and Shinwari, Z.K. 2012. Estimation of genetic variability in turmeric (*Curcuma longa* L.) germplasm using agro-morphological traits. *Pak. J. Bot.* 44: 231-238.
10. KAU (Kerala Agricultural University) 2011. *Package of Practices Recommendations: Crops* (14th Ed.). Kerala Agricultural University, Thrissur, 360p.
11. KAU (Kerala Agricultural University) 2016. *Package of Practices Recommendations: Crops* (15th Ed.). Kerala Agricultural University, Thrissur, 392p.
12. Madhusoodanan, K.J., Kumar, K.P., and Ravindran, P.N. 2002. Botany, crop improvement and biotechnology of cardamom. In: Ravindran, P.N. and Madhusoodanan, K.J. (eds), Cardamom- The Genus Elettaria (Medicinal and Aromatic Plants Industrial Series). Taylor and Francis, *Lond. N.Y*., pp. 11- 68.
13. Nadukeri, S., Umesha, K., Naik, M.K., Srinivasa, V., Ankegowda, S.J., Hanumantharaya, L. and Shankarappa, K.S. 2020. Evaluation of working collections of cardamom (*Elettaria cardamomum* Maton) for morphological attributes under hill zone of Karnataka. *Int. J. Chem. Stud.* 8(6): 2215-2219.
14. Nair, R.R., Shiva, K.N., Anchu, S. and Zachariah, T.J. 2010. Characterization of open-pollinated seedling progenies of turmeric (*Curcuma longa* L.) based on chromosome number, plant morphology, rhizome yield and rhizome quality. *Cytologia* 75(4): 443-449.
15. Nayar, K. G. 1987 Problems and prospects of marketing Indian cardamom at home and abroad. PhD. Thesis, Cochin University of Science and Technology, Cochin.
16. Parthasarathy, V.A. and Prashath. 2012. Cardamom. In: Peter, K.V. (eds.), Handbook of Herbs and Spices (Second Edition), Woodhead Publishing Series, *J. Food Sci. Technol*., pp. 131-170.
17. Senthil Kumar, R., Aravind, S., Biju, C.N. and Ankegowda, S.J. 2018. Characterization of genotypes of small cardamom (*Elettaria cardamomum* Maton) for yield parameters and disease resistance. *J. Plantation Crops* 46(2): 143-146.
18. Sharma, J.P., Singh, N.B. and Thakur, S. 2014. Nursery growth performance of newly developed superior clones of Poplar (*Populus deltoides* Bartr. Ex Marsh). *J. Tree Sci.* 33(2): 7-16.
19. Sharon, A., Biju, C.N., Ankegowda, S.J., Shivakumar, M.S., Kumar, R.S. and Peeran, M.F. 2020. Screening small cardamom (*Elettaria cardamomum* Maton) field gene bank accessions for phenotypic characters, yield potential and disease resistance. *J. Spices Aromat. Crops* 29(2).
20. Trimanto, T., Hapsari, L. and Dwiyanti, D. 2021. *Alpinia galanga* (L.) willd: Plant morphological characteristic, histochemical analysis and review on pharmacological. In *AIP Conference Proceedings* (Vol. 2353, No. 1). AIP Publishing.