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Sadashiv Nadukeri
Department of Plantation, Spices, Medicinal and Aromatic Crops College of Horticulture, Mudigere, Karnataka, India

Umesha K
Emeritus Professor, Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Bengaluru, Karnataka, India

MK Naik
Vice Chancellor, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Srinivasa V
Professor and Head Department of Vegetable Science, College of Horticulture, Mudigere, Karnataka, India

SJ Ankegowda
Principal Scientist and Head, ICAR-Indian Institute of Spice Research, Regional Station, Appangala, Madikeri, Karnataka, India

Hanumantharaya L
Professor and Head Department of Agricultural Entomology, College of Horticulture, Mudigere, Karnataka, India

Shankarappa KS
Assistant professor, Department of Plant Pathology, College of Horticulture, Bengaluru, Karnataka, India

Anilkumar GS
Ph.D. Scholar, College of Horticulture, Bengaluru, Karnataka, India

Corresponding Author:
Sadashiv Nadukeri
Department of Plantation, Spices, Medicinal and Aromatic Crops College of Horticulture, Mudigere, Karnataka, India

Variability studies in small cardamom (*Elettaria cardamomum*) genotypes for growth characters

Sadashiv Nadukeri, Umesha K, MK Naik, Srinivasa V, SJ Ankegowda, Hanumantharaya L, Shankarappa KS and Anilkumar GS

Abstract
The name cardamom is most commonly used for the dry capsules of *Elettaria cardamomum* Maton which is herbaceous, perennial monocotyledonous plant belongs to the family Zingiberaceae. It is cross pollinated crop and propagated through both vegetative and seed method, hence, variability is present among the genotypes. The result of the present investigation from the ANOVA showed that, all the growth characters shown significant difference at1 and 5 per cent level except for the trait leaf breadth. Phenotypic coefficient of variation is slight higher than genotypic coefficient of variation for all the growth characters. Highest GCV (23.5%) and PCV (24.3%) were recorded for the trait number of leaves per tiller. High heritability (99.0%) and genetic advance over mean (48.2%) was noticed for the trait number of vegetative buds per clump.

Keywords: *Elettaria cardamomum*, GCV, PCV and heritability

Introduction
Cardamom (*Elettaria cardamomum* Maton) is herbaceous, perennial monocotyledonous plant belongs to the family Zingiberaceae of the natural order Scitamineae. It is an ancient spice mentioned in ancient Indian Ayurvedic texts, *Charaka Samhita* and *Sushruta samhita*, written in the post-epic period 1400-600 BC (Ravindran, 2002) [11]. The ancient Greeks and Romans also used it in food, medicines and perfumes (Korikanthimath *et al*., 2001) [5]. The cardamom of commerce is a dried fruit (capsule) known for its sweet delicate aroma, Hence, it is considered as "Queen of spice". Small cardamom is a perennial bushy herb with mauve-marked, orchid-like white flowers and very long, lance-shaped leaves. Indian cardamom is unique in terms of aroma, flavour, size and colour (green) due to warm humid climate, loamy soils rich in organic matter, well distributed rainfall and special cultivation and processing methods (Parthasarathy and Prasath, 2012) [9]. Cardamom is a major flavouring agent in food products, beverages such as tea, cocoa and coffee, baked foods and in confectionaries (Jebur *et al*., 2014 and Vijayan *et al*., 2018) [4, 15].
Cardamom is cross-pollinated crop and propagated through seedlings and suckers, occasionally selfing also occurs. Considerable variation is noticed in seedling progenies of cardamom (Padmini *et al*., 2000) [8]. Collection and evaluation of germplasm, quantification of the magnitude of variability existing in different characters and classification into groups helps in identifying productive genotypes. Therefore, it is necessary to partition the observed variability into heritable and non-heritable components by calculating genetic parameters such as genotypic and phenotypic coefficient of variation, heritability and genetic advance.

Material and methods
Genetic variability studies in cardamom (*Elettaria cardamomum*) genotypes under the hill zone of Karnataka was carried out during 2016-2017 at Zonal Agricultural and Horticultural Research Station, University of Agricultural and Horticultural Sciences campus Mudigere. The experimental site is situated in the Western Ghats and represents the typical hill zone (Zone-9 and Region-V) of Karnataka and located at 13º25' North latitude and 75º25' East longitude at an altitude of 980 m above mean sea level.

Experimental material
The details of the experimental materials used and techniques adopted in the present investigation are described below.

Table 1: List of small cardamom (*Elettaria cardamomum* Maton) working collections used for morphological study

S. No.	Genotypes	Origin of genotypes	Unique characteristics
1.	CL-692	ZAHRS Mudigere	Oval/oblong in shape, bold, good yield
2.	M-1	ZAHRS, Mudigere (Local check)	Tolerant to thrips and shoot borer pubescent leaves
3.	M-2	ZAHRS, Mudigere (Local check)	Clonal selection from CL-683
4.	Wayanad	Wayanad, Kerala	Thick stem from the base
5.	CL-671	ZAHRS Mudigere	Prostrate panicle
6.	CL-622	ZAHRS Mudigere	Medium bold capsules with pale green colour
7.	D-751	Mudigere, Karnataka	Medium bold capsules with pale green colour
8.	PV-4	Pampadumpara	Malabar type from Walayar collection
9.	D-168	Mudigere, Karnataka	Semi erect panicle
10.	PDP-4	Pampadumpara	Erect panicle and medium plant height
11.	PDP-14	Pampadumpara	Erect panicle and medium plant height
12.	Pink Pseudostem	Myladumpara	Pink coloured pseudo stem
13.	NCL-1	ZAHRS, Mudigere	Semi erect Mysore type, long petiole
14.	CL-73	ZAHRS, Mudigere	Prostrate panicle, short span of flowering
15.	Dharmada	Sri Lanka	Erect panicle, green colour capsule
16.	Ceylone-5	Periyar Tiger reserve, Kerala	Erect panicle and good plant height
17.	P-10	Pampadumpara	Round capsules with medium plant height
18.	Ceylon-2	Periyar Tiger reserve, Kerala	Erect panicle and good plant height
19.	PDP-12	Pampadumpara	Semi erect, late and long flowering span
20.	K-5	Kalmane, Mudigere, Karnataka	Semi erect, late flowering
21.	D-516	Mudigere, Karnataka	Semi erect, round oblong capsules
22.	KMRD-2	Kammardi, Koppa Taluk, Karnataka	Semi erect, green colour capsules with good plant height
23.	D-11	Mudigere, Karnataka	Semi erect, green capsules
24.	D-140	Mudigere, Karnataka	Prostrate, Malabar type
25.	D-163	Mudigere, Karnataka	Prostrate, Malabar type
26.	KMRD-10	Kammardi, Koppa Taluk, Karnataka	Semi erect, green colour capsules with good plant height
27.	P 1	Pampadumpara	Early maturing variety with slightly ribbed light green capsules. Short panicle
28.	Kallar	Adimali, Idukki	Prostrate type
29.	CL-679	ZAHRS Mudigere	Bold capsules, Panicle length is good.
30.	Green Gold	Vandanmedu, Idukki	Dark green coloured bold capsules, robust in nature, perform well under intensive cultivation
31.	HS-1	Handi selection, Mudigere	Drought tolerant and good yield, round capsules
32.	MCC-61	Myladumpara	Bold capsules and produce more tillers
33.	SKP-5	ICRI, Sakleshpur	Prostrate type, early and short span of flowering
34.	MCC-12	Myladumpara	Terminal flowering
35.	MCC-21	Myladumpara	Bold capsules and produce more tillers
36.	CSS-800	IISR, Appangala	Bold capsules, Semi erect panicles and dark deep green capsule
37.	ICRI-2	Myladumpara	Mysore type, clonal selection from MCC-61
38.	SKP21	ICRI, Sakleshpur	Prostrate type, early and short span of flowering
39.	SKP-72	ICRI, Sakleshpur	Prostrate type, early and short span of flowering, good plant height
40.	CL-698	ZAHRS, Mudigere	Bold capsules, Panicle length is good.
41.	MCC-18	Myladumpara	Bold capsules, number of bearing suckers are more
42.	CL-668	ZAHRS Mudigere	Medium bold capsules with green in colour
43.	CCS-800	IISR, Appangala	High yielding and dark green capsules
44.	Sel-98	ZAHRS, Mudigere	Bold capsules, Panicle length is good.
45.	10-6-D10	ZAHRS, Mudigere	Superior for number of bearing suckers and high yielding
46.	2-5-D11	ZAHRS, Mudigere	Superior for number of bearing suckers, high yield and medium bold capsules
47.	12-7-D11	ZAHRS, Mudigere	Good plant height with more number of bearing suckers
48.	26-16-D11	ZAHRS, Mudigere	Medium oval shape capsules
49.	8-4-D11	ZAHRS, Mudigere	Pale or golden yellow capsules
50.	29-9-D11	ZAHRS, Mudigere	Medium bold oval shape capsules
51.	S-1	Pampadumpara	Semi erect
52.	MHC-73	Myladumpara	Medium plant height, with pale yellow capsules
53.	MHC-26	Myladumpara	Semi erect, Mysore type, oval shape capsules
54.	MCC-309	Myladumpara	Erect to semi erect, oval shape capsules
55.	APG-284	IISR, Appangala	Good yield, bold capsule and dark green colour leaves
56.	APG-293	IISR, Appangala	Good yield and bold capsule

57.	MHC-10	Myladumpara	Medium plant height with pale yellow capsules
58.	SKP-170	ICRI, Sakleshpur	prostrate type, with round to oblong capsules
59.	MHC-18	Myladumpara	A hybrid of the germplasm collections, It has characteristic deep green, angular bold capsules. Performance is fairly good even under rainfed conditions
60.	MHC-13	Myladumpara	Medium plant height, with green to pale yellow capsules
61.	SKP-165	ICRI, Sakleshpur	Good plant height with more number of bearing suckers
62.	PS-44	Pampadumpara	Bold capsules, good panicle length.
63.	MCC-200	Myladumpara	Early flowering type
64.	CSS-872	IISR, Appangala	High yielding and dark green capsules
65.	RR1	IISR, Appangala	Plants of 4th generation of clone 37 collection from ZAHRS Mudigere
66.	CCS-1	IISR, Appangala	Maximum bearing and bold capsules
67.	CL-688	ZAHRS Mudigere	Panicle is prostrate type, bold capsules

Statistical analysis of the experimental data

The statistical analysis of the data was carried out using GENSTAT programmes at Department of Crop improvement and Biotechnology, College of Horticulture, Mudigere.

Results and discussion

Analysis of variance

All the variances among entries, checks, varieties and checks *vs.* varieties were found to be significant for all the characters *viz.*, number of tillers per clump, tiller height (cm), number of leaves per tiller, leaf length (cm), number of vegetative buds per clump. The results of analysis of variance for all the growth characters are presented in Table 2. The variation in all the growth characters is due to difference in the genetic constitution of the genotypes and these results are in accordance with the findings of Kuruvilla *et al.* (2000) [6] and Prasath *et al*. (2009) [10] and Senthilkumar *et al*. (2017) [13] in cardamom. Thus, it can be deduced that, there was recognisably sufficient variability in the material used for the study, which provides ample scope for selecting superior and desired genotypes by the plant breeders for further improvement in cardamom.

Table 2: Analysis of variance for different characters in cardamom (*Elettaria cardamomum*) genotypes

Characters	Mean sum of squares 2016-17					
	Block	Entries	Checks	Varieties	Checks vs. Varieties	Error
	Degrees of freedom					
	7	66	2	63	1	14
Number of tillers/clump	10.23	41.85**	42.20	37.67**	304.27*	12.13
Tiller height (cm)	42.58	2171.98**	20947.71**	1037.67**	36081.61**	90.99
Number of leaves/tiller	1.40	20.39**	30.27**	16.36**	254.07**	0.89
Leaf length (cm)	6.15	77.96**	265.65**	63.81**	594.14**	19.77
Leaf breadth (cm)	0.53	3.72	4.09	3.59	11.14	0.26
Number of vegetative buds/clump	0.24*	3.33**	8.41**	3.18	2.68**	0.04

*Significant @5% and **Significant @ 1% level

Genetic variability, heritability and genetic advance

Genetic variability, heritability and genetic advance for the growth character in cardamom are presented in table 3.

Number of tillers per clump recorded a phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) of 21.9 and 17.3 per cent, respectively. Magnitude of heritability estimated was high (62.4%) accompanied with low estimates of GA (7.3) and high expected genetic advance of 28.2 as per cent mean was observed among the genotypes during 2016-17. The tiller height showed moderate PCV (12.3%) and GCV (11.6%). The trait had a high heritability of 89.1 per cent accompanied with high estimates of GA (53.1) and GAM (22.7%). The phenotypic and genotypic coefficients of variability for number of leaves per tiller were 24.3 and 23.5 per cent, respectively. It had a high heritability of 93.2 per cent coupled with low genetic advance (6.9) and high genetic advance over mean of 46.7 per cent for number of leaves per tillers for the trait number of leaves per tillers. Leaf length recorded moderate PCV (13.4%) and GCV (10.7%). The magnitude of heritability estimates was high (63.7%) accompanied with low estimate of GA (9.7) and moderate GAM of 17.6 per cent of mean was observed among the genotypes. Similarly, the genotypic and phenotypic coefficients of variations were 14.6 and 15.3 per cent respectively for leaf breadth, high heritability of 90.9 per cent accompanied with low estimates of genetic advance (3.2) and high genetic advance of 28.7 per cent over mean. Number of vegetative buds per clump manifested high PCV (23.7%) and GCV (23.6%). The magnitude of heritability estimated was high (99.0%) with low GA (3.2) and high GAM of 48.2 as per cent mean.

High phenotypic and genotypic coefficients of variability, heritability and genetic advance over the mean were observed for number of leaves per tiller indicating existence of broad genetic base for the trait which could be exploited by further selection and it indicates the additive gene action as it has shown high heritability and high genetic advance over mean. Gupta *et al.* (2016) [2] in large cardamom, Verma *et al.* (2014) [14] and Salimath *et al.* (2017) [12] in turmeric recorded low to moderate variability accompanied with high heritability and genetic advance over percent mean for the trait. Leaf length recorded moderate PCV and low GCV for the trait accompanied with high heritability and moderate GAM, while leaf breadth revealed moderate genotypic and phenotypic coefficients of variations with high heritability and genetic advance over mean. Similar results were recorded by Nirmalbabu *et al.* (1993) [7] in turmeric, while Gupta *et al.* (2016) [2] in large cardamom recorded moderate variability with high heritability and high GAM. Number of vegetative buds per clump exhibited moderate GCV, PCV as well as GAM with high heritability. Hrideek *et al.* (2015) [3] in cardamom recorded non-significant association for the trait.

High PCV and GCV accompanied with high heritability and high GAM were observed for the traits which suggest existence of additive gene action and is amenable for direct selection. The results of the present investigation are in accordance with Hrideek *et al.* (2015) [3] in cardamom, Fukrei *et al.* (2011) [1] in rice.

Table 3: Coefficient of variation, heritability, genetic advance and genetic advance as per cent mean for growth characters in cardamom (*Elettaria cardamomum)* genotypes

Characters	PCV (%)	GCV (%)	h^2	GA	GAM (%)
Number of tillers/clump	21.9	17.3	62.4	7.3	28.2
Tiller height (cm)	12.3	11.6	89.1	53.1	22.7
Number of leaves/tiller	24.3	23.5	93.2	6.9	46.7
Leaf length (cm)	13.4	10.7	63.7	9.7	17.6
Leaf breadth (cm)	15.3	14.6	90.9	3.2	28.7
Number of vegetative buds/clump	23.7	23.6	99.0	3.2	48.2

GCV & PCV: 0-10%-low; 10.1-20%-Moderate; >20.1%-High. Heritability: 0-30%-Low; 30-60%-Moderate; 60% & above-High. GA and GAM: 0-10%-low; 10.1-20%-Moderate; >20.1%-High.

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