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A Study on Variability of Elite Landraces of Small Cardamom (*Elettaria cardamomum* Maton)

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Even though over one dozen improved varieties of small cardamom are made available to farmers, many farmers still depend on promising landraces for cultivation. Being a crop that is mainly propagated clonally by suckers, evaluation of such landraces in order to select promising genotypes from them has immense scope in the crop improvement of cardamom. With this objective, a field experiment for the evaluation of ten elite landraces of cardamom based on genetic variability, heritability and genetic advance was undertaken. Sixty-three characters including seven growth characters, nine yield characters, sixteen quality characters and thirty-one biophysical/ chemical characters were recorded. Among the growth characters, highest GCV and PCV were shown by tillers per clump; highest heritability was shown by leaf length and highest genetic advance by tillers per clump. This shows that number of tillers per clump is the most important growth character. Among the yield characters highest GCV and genetic advance were shown by internodal length, PCV by panicles per clump and heritability by racemes per panicle. In quality characters, GCV and PCV were the highest in dry seed weight and heritability in percentage of 7 mm and above sized capsules which is a very desirable phenomenon. With regard to the biophysical/biochemical characters, acid insoluble ash showed the highest GCV; PCV was shown by chlorophyll b content of leaf; heritability by acid insoluble ash in capsule. The characters analyzed showed genetic advance ranging from 0.006 to 0.58. Characters with high genetic advance could be utilized for selection.

Key Words: Cardamom, *Elettaria cardamomum*, Landraces, Variability

Introduction

Small cardamom, often referred to as the 'queen of spices' is the commercial product obtained from the zingiberaceous, perennial, rhizomatous plant species *Elettaria cardamomum* Maton. It is grown on plantation scale in the Western Ghat region of South India at an elevation of 800-1300 m as an undercrop in forest lands. It is also grown in countries like Guatemala, Sri Lanka, Papua New Guinea and Tanzania. Cardamom is native to the moist evergreen forests of Western Ghats of South India (Ravindran, 2002).

Till date only a few hybrids have been released in cardamom and hence hybridization and selection of promising genotypes from the resultant segregating populations also can be used as an important tool in cardamom improvement. Cardamom genotypes are highly niche specific and hence evaluation of suitable genotypes adaptable to different growing regions is also necessary.

Materials and Methods

The experiments consist of analysis of ten elite landraces of cardamom collected from the Idukki district of Kerala, India in comparison with a released variety ICRI-2 based on genetic variability, heritability and genetic divergence. The experiment was designed to study the variability of promising landraces identified by farmers. The investigations were carried out in the experimental farm of Indian Cardamom Research Institute, Myladumpara, Idukki, Kerala, during 2002-2006. The experimental farm is located at an altitude of 1,068 m above MSL at 9° 53'N latitude and 77° 09' E longitude. The location enjoyed humid tropical climate. The soil is forest loam with a pH of 5-6. The experiment was laid out in randomized block design with three replications and 12 plants per plot at a spacing of 3 m × 3 m. The materials used for the study included ten landraces and ICRI-2, a released variety as control. Package of practices recommendation of the Spices Board, India was followed for cultivation.

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The details of the landraces studied and the control are furnished in Table 1.

Sixty-three characters including seven growth characters, nine yield characters, sixteen quality characters and thirty one biophysical/chemical characters of the landraces studied and control were observed consecutively for three years starting from the fourth year of planting onwards and subjected to analysis of variance (ANOVA) to test the significance of variations between the accessions with reference to standard F table (Fisher and Yates, 1963). Phenotypic variance, genotypic variance, phenotypic coefficient of variation, genotypic coefficient of variation, heritability (broad sense) and genetic advance were analyzed to study the extent of variation in the case of each character. Phenotypic and genotypic coefficients of variation were estimated following Burton and Devane (1953). Heritability (broad sense), the fraction of the total variance that is heritable was estimated as the percentage of genotypic variance over phenotypic variance (Jain, 1982). Genetic advance under selection was calculated using the formula proposed by Abraham (2000).

Results and Discussion

Among the growth characters, highest GCV and PCV were shown by tillers per clump; highest heritability was shown by leaf length and highest genetic advance by tillers per clump. This shows that tillers per clump is the most important growth character with the highest GCV, PCV and genetic advance. This character shows 75.42 percentage of heritability (broad sense) also. Among the yield characters studied, the highest GCV and genetic advance were shown by internodal length, highest PCV by panicles per clump and the highest heritability by racemes per panicle. Among the quality characters, GCV and PCV were the highest in dry seed weight, highest heritability was in the case of percentage of 7 mm and above sized capsules and highest genetic advance in the case of percentage of 7 mm and above capsules, seed weight-dry and husk weight-fresh (Table 2).

Among the biophysical/biochemical characters, acid insoluble ash content showed the highest GCV. Highest PCV was shown by chlorophyll b content of leaf. Highest heritability was shown by acid insoluble ash content in capsule followed by soluble protein in leaf, crude protein in capsule, tannin in capsule and reducing sugar in capsule. In all the characters that were statistically significant, PCV was found to be higher than GCV indicating polygenic control of characters and additive gene action. Differential variability of quantitative characters has been reported by earlier workers in cardamom (Prasath and Venugopal, 2002; 2004; Radhakrishnan *et al.*, 2006; Prasath *et al.*, 2009; Prasath and Venugopal, 2009), rice (Mini, 2006), coffee (Nikhila *et al.*, 2002; Raghu *et al.*, 2003), medicinal plants (Misra *et al.*, 1998; Jayasree *et al.*, 2006) and vanilla (Umamaheswari and Mohanan, 2004). Study of variability of the genetic resources of a crop is the first step towards the understanding of the genetic diversity of the genetic stock so as to use them in crop improvement programmes.

Most of the agronomic characters of the crop plants are polygenic and cardamom is no exemption. Polygenic characters show different levels of heritability based on their response to environmental factors. Among the growth characters heritability (broad sense) was found to be the highest in the case of leaf length followed by tillers per clump (Table 2). Among the yield characters, racemes per panicle showed the highest heritability. In case of quality characters the highest heritability was shown by percentage of 7 mm and above sized capsules which is a very desirable phenomenon. In case of biochemical characters, the highest heritability was shown by acid insoluble ash, soluble protein- leaf, crude protein-capsule and reducing sugar-capsule in that order.

Highest heritability of characters indicates the limited influence of environment on these characters. Characters like panicles per clump, panicle length, fruit set percentage, fresh seed weight, litre weight of fresh capsules, oleoresin content, chlorophyll b content of leaf and chlorophyll a/b ratio of leaf and capsules show heritability below 50%, where as all other statistically significant characters showed above 50% of heritability. The reason for low heritability in the case of some characters is the influence of environment on them as suggested by earlier workers (Tripathy *et al.*, 2000; Radhakrishnan, 2003).

Genetic advance of characters in percentage of mean is a very effective indicator of the characters that could be utilized in selection programmes. It is a measure derived from heritability. Statistically significant characters analyzed presently showed genetic advance ranging from 0.006 to 0.58. Total chlorophyll content-fresh capsule showed the maximum genetic advance and this is a very desirable condition since green colour of capsules is determined by their chlorophyll content and green dry capsules are preferred highly in the internal and

Table 1. Description of the landraces and control used for the study of variability of landraces.

Landrace	Description
Panikulangara-1	It is a *Vazhukka* type cardamom with oval shaped and green coloured capsules. This plant performs well under rainfed conditions.
Panikulangara-2	The plants are bushy in nature with vigorous growth. Branched panicles are also seen in this type. The capsules are oblong and deep green in colour.
Njallani Green Gold	It is a *Vazhukka* type cardamom. The plants are robust in nature with tall tillers with purple coloured swollen base. It has simple unbranched inflorescence. Capsules are extra bold, dark green and thick skinned.
Vali Green Bold	It is a *Vazhukka* type cardamom. The plants are robust in nature and the rhizome is fleshy and very stout with the nodes and internodes crowded. Panicles are unbranched and capsules are extra bold and dark green.
Palakkudi	It is a *Malabar* type cardamom. Plants are robust in nature and rhizomes stout and fleshy. Each tiller has 2-3 unbranched panicles. Capsules are round bold and deep green in colour.
PNS Vaigai	Plants are robust in nature with tall tillers. The dark green coloured non-pubescent leaves and the prominent ligules with light pale green colour are the striking features of this landrace. It has simple unbranched inflorescence. Capsules are extra bold with parrot green colour and thick skin.
Vander Cardamom	It is a *Vazhukka* type cardamom. Plants are robust and bushy in nature with very long shoots and deep green foliage. Branched panicles are also seen in this plant. The capsules are extrabold in size and deep green in colour.
Ela Rani -1	It is a *Vazhukka* type cardamom. Plants are robust and bushy in nature with very stout pseudostem base. Capsules are round oblong and pale green in colour.
Ela Rani -2	It is a *Vazhukka* type cardamom. Plants show only average growth and size with average sized tiller base. Capsules are round, slightly oblong and pale green in colour.
Ela Rani-3	It is a *Vazhukka* type cardamom. Plants are robust and bushy in nature with vigorous growth and strong tiller base. Capsules are medium sized, round oblong in shape with light green colour.
ICRI-2 (control)	This variety was released by the Indian Cardamom Research Institute (ICRI), Myladumpara, Idukki, Kerala. It is a *Mysore* type cardamom. Plants are robust in nature. Capsules are oblong and bold with parrot green colour.

Table 2. Genotypic variance, phenotypic variance, GCV, PCV, heritability (broad sense) and genetic advance of the characters studied in the case of the landraces of cardamom

Characters	Mean	Genotypic variance	Phenotypic variance	GCV	PCV	Heritability (broad sense) (%)	Genetic advance
Growth characters							
Tillers/ clump**	82.31	139.2	182.14	14.33	16.38	75.42	0.19
Tiller height **	341.58 cm	565.77	981.87	7.00	9.17	57.80	0.11
Leaves/ tiller^{NS}	20.44	0.23	2.40	–	–	–	–
Leaf length **	61.74 cm	20.64	24.17	7.30	7.91	85.00	0.14
Leaf breadth **	11.55 cm	1.19	2.07	9.71	12.81	57.00	0.15
Number of vegetative buds^{NS}	3.83	0.08	1.19	–	–	–	–
Number of bearing tillers^{NS}	47.74	18.56	76.17	–	–	–	–
Yield characters							
Panicles per clump*	89.35	118.31	361.25	12.17	21.30	32.75	0.14
Panicle length *	80.45 cm	117.64	279.4	13.48	20.77	42.10	0.18
Racemes per panicle**	25.51	7.79	10.96	10.93	12.95	71.00	0.19
Capsules per raceme**	8.04	0.30	0.59	6.58	9.57	50.85	0.10
Fruit set % **	69.30	30.76	70.59	8.01	12.12	43.58	0.11
Seeds/ capsule^{NS}	19.03	1.67	5.82	–	–	–	–
Internodal length **	4.36 cm	0.39	0.68	14.19	18.76	57.00	0.22
Yield per plant fresh ^{NS}	4.19 kg	0.02	0.91	–	–	–	–
Yield per plant dry ^{NS}	0.88 kg	0.01	0.04	–	–	–	–

Characters	Mean	Genotypic variance	Phenotypic variance	GCV	PCV	Heritability (broad sense) (%)	Genetic advance
Quality characters							
Recovery %*	20.95	0.47	1.12	3.29	5.05	51.09	0.05
% of 7 mm and above capsules**	73.43	47.29	47.81	9.38	9.43	98.93	0.19
Seed wt.– fresh**	0.43 g	0.0001	0.0043	7.18	14.90	2.32	0.006
Seed wt.– dry**	0.21 g	0.0008	0.0015	12.85	17.60	53.3	0.19
Husk wt.–fresh*	0.92 g	0.013	0.022	12..39	16.12	59.09	0.19
Husk wt–dry *	0.06 g	0.0543	0.0544	–	–	–	–
Seed : Husk ratio fresh^{NS}	48.78:1	31.64	111.76	–	–	–	–
Litre wt. of fresh capsules *	560.78 g	54.07	130.31	1.306	2.03	41.49	0.017
Number of fresh capsules per litre**	558.24	1226.57	1913.60	6.27	7.83	64.09	0.103
100 capsule wt.– fresh**	130.16 g	60.6	76.03	5.98	6.69	79.71	0.11
Litre wt of dry capsules**	344.33 g	124.26	131.81	3.23	3.33	94..27	0.064
Number of dry capsules/litre**	2158.03	20610.24	38543.54	6.65	9.09	53.47	0.10
100 capsule wt dry**	21.52 g	5.12	9.12	10.5	14.04	56.14	0.16
Volatile oil content (%)^{NS}	8.89	0.083	0.28	–	–	–	–
Oleoresin content (%)**	6.80	0.23	0.50	7.05	10.30	46.00	0.10
Moisture content (%)**	10.88	0.81	0.92	8.24	8.78	88.04	0.14
Biochemical characters							
Chlorophyll a content– leaf **	2.06 mg/g fresh tissue	0.25	0.29	24.27	26.14	86.21	0.46
Chlorophyll b content– leaf *	0.42 mg/g fresh tissue	0.007	0.019	19.05	33.33	36.84	0.23
Total chlorophyll– leaf*	1.83 mg/g fresh tissue	0.32	0.37	30.76	33.23	85.67	0.58
Chlorophyll a/ b ratio Leaf*	4.73	0.63	1.46	16.67	25.53	43.15	0.23
Chlorophyll a content fresh capsule^{NS}	1.30 mg/g fresh tissue	0.027	0.089	–	–	–	–
Chlorophyll b– fresh capsule**	0.94 mg/g fresh tissue	0.07	0.09	30.68	34.1	77.78	0.05
Total chlorophyll fresh capsule**	0.97 mg/g fresh tissue	0.08	0.09	31.1	33.3	88.00	0.61
Chlorophyll a/ b ratio–fresh capsule**	1.57	0.25	0.8	31.21	56.69	31.25	0.36
Chlorophyll a –dry capsule**	2.84 mg/g	0.053	0.123	8.07	12.30	43.00	0.11
Chlorophyll b– dry capsule**	2.66 mg/g	0.14	0.20	14.16	16.66	72.00	0.24
Total chlorophyll– dry capsule**	2.39 mg/g	0.10	0.20	12.92	18.75	50.00	0.19
Chlorophyll a/ b ratio– dry capsule**	1.43	0.01	0.01	6.48	9.26	50.00	0.01
Relative water content– leaf**	71.26%	54.94	103.20	10.39	14.25	53.24	0.16
Stomatal frequency**	26.85%	5.59	11.04	8.80	12.37	50.63	0.47
Stomatal index^{NS}	5.00	0.16	0.45	–	–	–	–
Leaf proline**	1.98 µmoles/g	0.20	0.23	22.73	24.24	86.96	0.43
Epicuticular wax**	9.39 µg/cm^2	0.91	1.13	10.11	11.28	80.53	0.19
Reducing sugar– leaf**	4.49 g 100/g fresh tissue	0.68	1.09	18.26	23.16	62.39	0.30

Characters	Mean	Genotypic variance	Phenotypic variance	GCV	PCV	Heritability (broad sense) (%)	Genetic advance
Soluble protein– leaf**	7.58 g 100/g fresh tissue	3.80	3.87	25.69	25.96	98.19	0.52
Insoluble protein– leaf**	17.11 g 100/g fresh tissue	7.63	9.18	16.13	17.71	83.12	0.30
Crude protein– capsule**	11.55 g 100/g capsule flour	0.94	0.97	8.39	8.48	96.91	0.17
Crude lipid– capsule^{NS}	3.05 g 100/g capsule flour	0.06	0.53	–	–	–	–
Crude fibre(%)– capsule**	23.72	5.12	6.19	9.54	11.08	74.10	0.17
Ash– capsule (%)**	8.80	0.39	0.50	7.79	8.82	78.00	0.14
Acid insoluble ash– capsule**	0.34g 100/g capsule flour	0.02	0.02	48.76	48.76	100.00	0.14
Carbohydrate– capsule**	53.93g 100/g capsule flour	7.30	10.74	5.0	6.07	67.97	0.08
Calorific value of capsule^{NS}	288.42Kcal 100/g DM	12.29	312.99	–	–	–	–
Phenol– capsule**	0.26 g 100/g capsule flour	0.0020	0.0023	17.2	18.44	86.86	0.32
Tannins– capsule**	0.19 g 100/g capsule flour	0.0023	0.0024	23.97	24.49	95.83	0.46
Amino acids– capsule**	0.23 g 100/g capsule flour	0.0008	0.001	11.78	13.18	80.00	0.21
Reducing sugar– capsule**	5.40 g 100/g capsule flour	2.27	2.38	27.9	28.6	92.43	0.54

**: significant at 1% level; *: significant at 5% level.

international markets. Total chlorophyll content in leaf showed high genetic advance also. Among the growth characters, total tillers per clump showed the highest genetic advance and among the yield characters internodal length of panicles and racemes per panicle showed the highest genetic advance in that order. Among the quality characters percentage of 7 mm and above sized capsules, dry seed weight and fresh husk weight showed the highest genetic advance. Characters with highest genetic advance could be utilized for selection programmes as reported by earlier workers in cardamom (George *et al*., 1981; Radhakrishnan *et al.*, 2006) and other crops (Jayasree *et al.* 2006). Studies by Korikanthimath *et al.* (1998) and Korikanthimath *et al*. (2000) showed significant treatment differences for yield and morphological characters.

References

Abraham ST (2000) Genetic parameters and divergence in certain wild genotypes of *Hevea brasiliensis* (Willd. ex Adr. De. Juss.) Muell. Arg. *Ph.D. Thesis*. MG University, Kerala, India.

Burton GW and EH Davane (1953) Estimating heritability in tall fescue from replicated clonal material. *Agronomy J.* **45**: 478-481.

Fisher RA and F Yates (1963) *Statistical Tables for Biological, Agricultural and Medical Research*. Longman, England.

George KV, SB Dandin, KJ Madhusoodanan and K John (1981) Natural variations in the yield parameters of cardamom (*Elettaria cardamomum*). *In:* S.Vishveshwara (ed.). *Genetics, Pl. Breed. Hort.*. Proc. of the Fourth Annual Symposium on Plantation Crops (PLACROSYM IV), pp 216-224.

Jain JP (1982) *Statistical Techniques in Quantitative Genetics*. Tata Mc Grew Hill, New Delhi.

Jayasree M, KV Mohanan and R Umamaheswari (2006) Genetic variability of mango ginger (*Curcuma amada* Roxb.) in Kerala. *J. Plantation Crops* **34**: 164-166.

Korikanthimath VS and Ravindra Mulge (1998) Assessment of elite cardamom lines for dry matter distribution and harvest index. *J. Medicinal Aromatic Plant Sci.* **20**: 28-31.

Korikanthimath VS, D Prasath and AA Mohammed Sayed (2000) Evaluation of cardamom accessions in relation to yield, recovery and oil content. *Indian J. Hort*. **57**: 273-275.

Mini CB (2006) Studies on Variability and Conservation of Some Native Rices of Kerala. *Ph.D. Thesis*. Department of Botany, University of Calicut, Kerala, India

Misra HO, JR Sharma, RK Lal and S Sharma (1998) Genetic variability and path analysis in *Withania somnifera*. *J. Medicinal and Aromatic Plant Sci*. **20**: 753-756.

Nikhila KR, AGS Reddy, VB Sureshkumar and KV Mohanan (2002) Consequences of sib mating in C × R (*Coffea congensis* × *Coffea canephora*) coffee. Proc. of the Plantation Crops Symposium XV (PLACROXYM XV). pp. 83-87.

Prasath D and MN Venugopal (2002) Genetic analysis for quantitative characters in cardamom (*Elettaria cardamomum* Maton). *Indian J. Genet. Pl. Breed.* **62**: 179-180.

Prasath D and MN Venugopal (2004) Genetic diversity and conservation of cardamom (*Elettaria cardamomum* Maton) in India. *Plant Genet. Resour. Newslet.* **138**: 55-60.

Prasath D, MN Venugopal and R Senthil Kumar (2009) Evaluation of high yielding cardamom selection in Karnataka for yield and quality. *Indian J. Agric. Sci.* **79**(3): 207-209.

Prasath D and MN Venugopal (2009) Compound inflorescence cardamom (*Elettaria cardamomum* Maton) in India. *Genet. Resour. Crop Evol.* **56**: 749-753.

Radhakrishnan VV, KV Mohanan and PM Priya (2006) Genetic divergence in cardamom (*Elettaria cardamomum* Maton). *J. Plantation Crops* **34**: 149-151.

Radhakrishnan VV (2003) *Studies on Variability, Genetic Divergence and Crop Improvement in Cardamom* (*Elettaria cardamomum* Maton). *Ph.D. Thesis*. Department of Botany, University of Calicut, Kerala, India.

Raghu AV, KV Mohanan, AGS Reddy and VB Sureshkumar (2003) Variability in a sibmated progeny of C × R (*Coffea congensis* × *Coffea canephora*) coffee. *Indian J. Agric. Res.* **37**: 110-114.

Ravindran PN (2002) *Introduction. In:* PN Ravendran and KJ Madhusoodanan (eds), Cardamom – the genus *Elettaria*. Taylor and Francis Inc., London, pp 1-10.

Tripathi SM, Kamaluddin, SBL Srivastava and JP Srivastava (2000) Variability, heritability and correlation studies in coriander (*Coriandrum sativum* L.). *In:* KV Ramana, SJ Eapen, KN Babu, KS Krishnamoorthi and A Kumar (eds), *Spices and Aromatic Plants — Challenges and Opportunities in the New Century*. Indian Society for Spices, Calicut, India, pp 30-34.

Umamaheswari R and KV Mohanan (2004) A study of field level variability of *Vanilla planifolia* in Kerala. *J. Plantation Crops* **32** (Suppl.): 98-99.