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**A Study of Character Association in Small Cardamom
(*Elettaria cardamomum* Maton)***

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Abstract: Factor analysis has been carried out in the case of growth, yield and quality characters of small cardamom presently based on a study of eleven genotypes grown under typical humid tropical climate in the cardamom hill reserve area of Kerala State of India to analyze the association between them. The seven growth characters studied could be grouped in to two based on factor loading with number of bearing tillers showing maximum factor loading in the first group and leaves per tiller showing maximum factor loading in the second group. Out of the two factors identified among the growth characters the first factor with four characters contributed 33.79% of variance exhibited by the growth characters studied and the second factor with three characters contributed 31.08% of variance. Characters with the highest factor loadings can be considered as lead characters and the present analysis showed that number of bearing tillers and leaves per tiller are the most important characters of cardamom based on which selection could be carried out. The yield characters also could be grouped into two factors and the two factors together contributed 58.57% of cumulative variance contributed by the yield characters. Yield per plant and inter nodal length of panicles were found to be the lead characters among them. In the case of quality characters nine out of eleven characters studied could be grouped into three factor groups with moisture content, volatile oil and 100 capsule weight- dry as the lead characters.

Key words: *Elettaria cardamomum*, cardamom, character association

INTRODUCTION

Small cardamom (*Elettaria cardamomum* Maton, Zingiberaceae) often referred to as the queen of spices is a very important spice crop that originated in the Western Ghats of India (Ravindran, 2002). It is grown extensively in India at an elevation of 800-1300 m as an under crop in forest lands. It is also grown in countries like Guatemala, Sri Lanka, Papua New Guinea and Tanzania. In India the cardamom growing region lies within 8° and 30° N latitudes and 75° and 78° 30' E longitudes. The cardamom tracts of India cover an area of 73000 ha producing about 12540 mt annually. *Elettaria cardamomum* Maton is a perennial rhizomatous tall herb. It is represented in nature by three natural varieties. Variety Malabar is characterized by prostrate panicles; var. Mysore by erect panicles and var. Vazhukka by semi erect panicles (Thomas, 2006). Cardamom is a major flavouring agent used in food products, beverages and medicines. It is used in Indian systems of medicine like Ayurveda, Siddha and Unani. Cardamom is carminative, diuretic and stomachic. Mature capsules under dried condition form the cardamom of commerce. The agronomic characters of cardamom are quantitative in nature and they show continuous distribution. Such characters show different levels of inter

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relationship due to gene sharing. (Radhakrishnan *et al.*, 2006). Study of character association helps to identify this relationship and groups the characters accordingly and also to select lead characters from each group. The lead characters can be used as characters based on which selection for superior genotypes can be practiced so that other characters associated with them get automatically selected. Hence, an attempt was made presently to group the agronomic characters of cardamom based on factor analysis and also to identify the lead characters among them.

MATERIALS AND METHODS

The experiment was carried out in the experimental farm of Indian Cardamom Research Institute (ICRI), Myladumpara, Idukki, Kerala, India during 2002-2006. The farm is located at an altitude of 1,068 m above MSL at 9° 53N latitude and 77° 09 E longitude and it enjoys humid tropical monsoon climate. The soil is forest loam with 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 3×3 m. Eleven genotypes consisting of ten elite native landraces and one released variety were used for the study (Table 1). Package of practices recommendation of the Spices Board, India was followed for cultivation. Observations on seven growth characters, nine yield attributes and eleven quality parameters were recorded and analyzed.

Biometric study of growth, yield and quality characters of the eleven genotypes has been used to analyze character association in cardamom. Factor analysis by means of principal component analysis (Sneath and Sokal, 1973) was carried out for the purpose with the help of the software STATISTICA.

Table 1: Cardamom genotypes used for the study

Genotypes	Description
Panikulangara-1	Vazhukka type cardamom with oval shaped and green coloured capsules. This plant performs well under rain fed conditions.
Panikulangara-2	Vazhukka type cardamom with bushy nature and vigorous growth. Branched panicles are also seen in this type. The capsules are oblong and deep green in colour.
Njallani Green Gold	Vazhukka type cardamom with robust plants and tall tillers with purple coloured swollen base. It has simple unbranched inflorescences. Capsules are extra bold, dark green and thick skinned.
Vali Green Gold	Vazhukka type cardamom with robust nature. 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	Malabar type cardamom with robust nature and stout and fleshy rhizomes. Each tiller has 2-3 unbranched panicles. Capsules are round bold and deep green in colour.
PNS Vaigai	Vazhukka type cardamom, 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	Vazhukka type cardamom, 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	Vazhukka type cardamom, robust and bushy in nature with very stout pseudostem base. Capsules are round oblong and pale green in colour.
Ela Rani 2	Vazhukka type cardamom, with average growth and size and average sized tiller base. Capsules are round, slightly oblong and pale green in colour.
Ela Rani 3	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	A variety released by Indian Cardamom Research Institute (ICRI), Myladumpara, Idukki, Kerala, India. It is a Mysore type cardamom. Plants are robust in nature. Capsule is oblong and bold with parrot green colour.

RESULTS AND DISCUSSION

The seven growth characters of cardamom studied presently could be grouped in to two based on factor loading with number of bearing tillers showing maximum factor loading in the first group and leaves per tiller showing maximum factor loading in the second group (Table 2-4). Out of the two factors identified among the growth characters the first factor with four characters contributed 33.79% of variance exhibited by the growth characters studied and the second factor consisting of three characters contributed 31.08% of variance. Characters with the highest factor loadings can be considered as lead characters based on which selection could be practiced. This analysis has shown that number of bearing tillers and leaves per tiller are the most important characters to be considered when

Table 2: Factor analysis of growth characters in the eleven cultivars of cardamom studied- percentage of variance contributed by each factor and cumulative percentage of variance

Factors	Eigen value	Variance (%)	Cumulative Eigen value	Cumulative variance (%)
1	2.365475	33.79250	2.365475	33.79250
2	2.175556	31.07937	4.541031	64.87187

Table 3: Factor analysis of growth characters in the eleven cultivars of cardamom studied- factor loadings

Characters	F ₁	F ₂
Tillers per clump	0.809195	-0.288217
Tiller height	0.628600	0.635518
Leaves per tiller	0.237894	0.857640
Leaf length	0.554993	-0.476761
Leaf breadth	0.322677	-0.700081
Number of vegetative buds	0.434252	0.473839
Number of bearing tillers	0.811317	-0.105454

Table 4: Factor analysis of growth characters in the eleven cultivars of cardamom studied- factor groups and the characters in each group

Factors	Characters
1	No. of bearing tillers, tillers per clump, leaf length, leaf breadth
2	Leaves per tiller, tiller height, number of vegetative buds

Table 5: Factor analysis of yield characters in the eleven cultivars of cardamom studied- percentage of variance contributed by each factor and cumulative percentage of variance

Factors	Eigen value	Variance (%)	Cumulative eigen value	Cumulative variance (%)
1	3.140609	34.89566	3.140609	34.89566
2	2.130817	23.67574	5.271426	58.57140

Table 6: Factor analysis of yield characters in the eleven cultivars of cardamom studied- factor loadings

Characters	F ₁	F ₂
Panicles/clump	0.367683	0.433825
Panicle length	0.752460	0.608896
Racemes/panicle	0.786796	0.064932
Capsules/raceme	0.337043	-0.819825
Fruit set (%)	-0.320631	0.096428
Seeds per capsule	-0.204170	-0.505149
Internodal length of panicles	0.127113	0.654656
Yield/plant-fresh	0.854444	-0.369032
Yield/plant-dry	0.903247	-0.257480

Table 7: Factor analysis of yield characters in the eleven cultivars of cardamom studied- factor groups and the characters in each group

Factors	Characters
1	Yield/plant dry, yield/plant fresh, racemes/panicle, panicle length, capsules per raceme
2	Internodal length of panicles, panicles/clump, fruit set (%)

Table 8: Factor analysis of quality characters in the eleven cultivars of cardamom studied- percentage of variance contributed by each factor and cumulative percentage of variance

Factors	Eigen value	Variance (%)	Cumulative eigen value	Cumulative variance (%)
1	4.477351	40.70865	4.477951	40.70865
2	2.269908	20.63553	6.747859	61.34418
3	1.480318	13.45744	8.228178	74.80162

Table 9: Factor analysis of quality characters in the eleven cultivars of cardamom studied- factor loadings

Characters	F ₁	F ₂	F ₃
Recovery (%)	0.522628	-0.530923	-0.581043
(%) of 7 mm and above capsules	0.872938	0.037928	-0.353847
Litre wt. of fresh capsules	-0.593038	-0.534259	-0.021103
No. of fresh capsules L ⁻¹	-0.730373	0.228948	-0.274044
Litre wt. of dry capsules	-0.219835	-0.815976	-0.164549
No. of dry capsules L ⁻¹	-0.688611	0.345673	-0.500525
100 capsule wt.-fresh	0.693381	-0.108926	0.283440
100 capsule wt.-dry	-0.268909	-0.568193	0.685706
Volatile oil content	0.299027	0.672405	0.216237
Oleoresin content	0.755718	-0.264196	-0.226625
Moisture content-capsule	0.906379	0.082447	0.125215

Table 10: Factor analysis of quality characters in the eleven cultivars of cardamom studied- factor groups and the characters in each group

Factor	Characters
1	Moisture content- capsule, % of 7 mm and above sized capsules, oleoresin content, 100 capsule wt.-fresh, recovery %
2	Volatile oil content, number of dry capsule per litre, number of fresh capsule/litre
3	100 capsule wt.-dry

selection is practiced for growth characters of cardamom. It also indicated that if selection is carried out based on the above two characters, the other characters will automatically get selected favorably.

The yield characters under study could be grouped into two factors based on factor loading and the first group consists of five characters and the second group consists of four characters (Table 5, 6 and 7). Seeds per capsule could not be grouped in any of these groups. The first factor contributed 34.9% of variation contributed by yield characters and second factor contributed 23.68% of variability. Dry yield per plant was found to be the lead character in the case of the first group of variables and internodal length was found to be the lead character in the second group of variables.

Factor analysis of eleven quality characters resulted in the grouping of the characters in to three groups based on factor loading (Table 8-10). The first group consisted of five characters, second group consisted of three characters and the third group consisted of one character. However, the rest of the variables could not be grouped in to any of these factor groups. The three factors together contributed 74.80% of cumulative variance. The percentage of variance contributed by the first factor is 40.71, that contributed by second factor is 20.64 and that contributed by the third factor is 13.46. The lead character in the case of the first group is moisture content followed by percentage of bold (7 mm and above) capsules. In the second factor group, volatile oil content is the lead character and in the third factor group 100 capsule weight-dry is the only character involved.

Factor analysis is a very efficient tool used to find out character association and to group the variables in to different groups and also to effect data reduction by identifying the lead variables of each group and the technique has been utilized by earlier workers in crops like rubber (Abraham *et al.*, 2002), coconut (Abdul Kadher *et al.*, 2007) and chillies (Hrideek *et al.*, 2006). A study of character association in cardamom by Sritharan *et al.* (1993) revealed that number of pseudostems per plant, leaf length, number of panicles per plant, panicle length and number of capsules in a panicle had higher association with yield than other parameters. Pooled factor analysis resulted in the grouping of 17 characters of cardamom in to six factors in an experiment carried out by Radhakrishnan *et al.* (2006).

The present study has revealed that the quantitative agronomic characters of small cardamom can be grouped in to three groups based on factor analysis. Moisture content in capsules, percentage of bold capsules, volatile oil content and weight of capsules have been identified as the lead characters in small cardamom based on which further improvement programmes can be designed.

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