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Factor analysis in cardamom (*Elettaria cardamomum* Maton)

V V Radhakrishnan, Priya P Menon, K J Madhusoodanan, K M Kuruvilla & J Thomas

Indian Cardamom Research Institute
Myladumpara - 685 553, Idukki District, Kerala, India
E-mail: icrimyla@eth.net

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Abstract

A pooled factor analysis of 17 variables representing morphological, yield contributing and qualitative characters of 90 genotypes of cardamom (*Elettaria cardamomum*) was carried out at Myladumpara (Kerala), for identifying marker characters which accommodate the inheritance of associated characters. Among the 17 characters subjected to the analysis, 6 factors were identified as having maximum influence on growth, yield and quality of cardamom. Among the six factors identified, three factors controlled yield and yield contributing characters, two factors controlled qualitative characters and one factor controlled growth characters. The characters identified with maximum factor loadings in each group include bearing tillers clump^{-1}, seeds capsule^{-1}, internodal length, racemes panicle^{-1}, leaf breadth and capsules (dry) kg^{-1}. The six principal components or factors accounted for 78.09% of the total variance.

Key words: cardamom, *Elettaria cardamomum*, factor analysis, germplasm.

Cardamom economy in the Western Ghat region of India supports a sizeable proportion of small farm sector and agricultural labour and hence there is an urgent need to improve and sustain the production and productivity of this crop. One of the constraints in the successful utilization of germplasm in breeding programmes is the delay in its characterization, evaluation and cataloguing. In the genetic evaluation of germplasm of cardamom (*Elettaria cardamomum* Maton), a large number of morphological, yield contributing and qualitative traits are to be recorded for estimation of genetic variance and correlations among these characters. The recording of data on such large number of characters is time consuming, especially when large number of genotypes are evaluated. Application of multivariate data analysis has become a popular method mainly because it can provide information not otherwise accessible. In the present study, a factor analysis by means of principal component analysis method was carried out to reveal such underlined factors in groups of related variables. Factor analysis is a useful statistical tool to reduce the total number of variables to be studied by identifying marker variables, which will accommodate the inheritance of a set of variables associated with it. The present study is the first of its kind to be undertaken in cardamom.

The study was undertaken at Indian Cardamom Research Institute, Myladumpara

(Kerala), utilizing 90 genotypes of cardamom planted in a field evaluation trial in 1996. The genotypes were planted in a randomized block design at a spacing of 2.4 m x 2.4 m. The plants were maintained adopting the package of practices recommended by Spices Board. Data on tillers clump^{-1}, tiller height, leaves tiller^{-1}, vegetative buds clump^{-1}, leaf length, leaf breadth, bearing tillers clump^{-1}, panicles clump^{-1}, panicle length, internodal length, racemes panicle^{-1}, capsules raceme^{-1}, seeds capsule^{-1}, recovery percentage, percentage of capsules having size ≥ 7 mm, number of dry capsules kg^{-1} and volatile oil content were recorded for three consecutive seasons. Factor analysis was done using the principal component analysis method as described by Harman (1976).

Analysis of the 17 morphological, yield contributing and qualitative characters in the cardamom germplasm enabled to get a set of reduced number of new orthogonal variables. Further, the above set of variables identified 6 factors, which accounted for 78.09% variability in these 17 variables (Table 1). It is to be noted that this method estimated only mathematical associations among the multivariates. Hence the results should be supplemented with biological interpretations of these associations based on logics. All the variables were grouped with respect to various factors identified and marker variables were identified based on the factor loadings for each character (Tables 2 and 3).

Table 1. Percentage variability observed in factor analysis of cardamom genotypes

Factor	Eigen value	Percentage variance	Cumulative percentage
F_1	4.260	27.178	27.178
F_2	2.142	12.600	39.778
F_3	2.105	12.381	52.159
F_4	1.563	9.192	61.351
F_5	1.443	8.489	69.840
F_6	1.402	8.247	78.088

In the present study, the first factor was found to be associated with bearing tillers clump^{-1}, total tillers clump^{-1}, panicles clump^{-1}, percentage of capsules having size ≥ 7 mm and capsules raceme^{-1} with factor loadings 0.944, 0.939, 0.938, 0.801 and 0.708, respectively. Bearing tillers clump^{-1}, total tillers clump^{-1}, panicles clump^{-1}, percentage of capsules having size ≥ 7 mm and capsules raceme^{-1} may be considered as five independent traits as the factor seems to have more or less equal control in their inheritance. All these five variables can be expected to behave alike in

Table 2. Factor loadings of the pooled characters of cardamom genotypes

Sl. No.	Character	F_1	F_2	F_3	F_4	F_5	F_6
1	Total tillers clump^{-1}	**0.939**	0.101	0.103	0.215	-0.108	-0.007
2	Tiller height	0.563	-0.133	0.462	-0.031	0.079	0.420
3	Leaves tiller^{-1}	0.417	0.065	0.308	-0.152	**0.474**	0.421
4	Vegetative buds clump^{-1}	-0.129	-0.213	0.032	-0.027	**0.526**	-0.045
5	Leaf length	0.054	0.067	-0.039	-0.594	-0.475	0.143
6	Leaf breadth	-0.010	0.252	-0.108	0.019	**0.717**	-0.096
7	Bearing tillers clump^{-1}	**0.944**	0.113	0.109	0.188	-0.110	0.006
8	Panicles clump^{-1}	**0.938**	0.104	0.106	0.179	-0.117	0.002
9	Panicle length	0.294	0.042	**0.880**	0.207	-0.079	0.007
10	Internodal length	0.017	0.027	**0.939**	-0.271	0.039	-0.007
11	Racemes panicle^{-1}	0.363	0.090	-0.102	**0.818**	-0.139	-0.067
12	Capsules raceme^{-1}	**0.708**	0.087	0.160	-0.467	0.273	-0.014
13	Seeds capsule^{-1}	0.093	**0.942**	-0.009	-0.014	0.028	-0.003
14	Recovery percentage	0.085	**0.936**	0.018	-0.001	-0.004	-0.002
15	Percentage of capsules having size ≥ 7 mm	**0.801**	0.087	0.044	-0.069	-0.004	-0.358
16	Number of dry capsules kg^{-1}	-0.117	0.033	0.034	-0.057	-0.217	**0.827**
17	Volatile oil content	0.256	**0.428**	0.232	0.242	0.100	-0.448

Values in bold indicate maximum factor loading

Table 3. Distribution of various characters among the six factors identified

Factor	Characters associated
F_1	Bearing tillers clump^{-1}, tillers clump^{-1}, panicles clump^{-1}, Percentage of capsules having size ≥ 7 mm, capsules raceme^{-1}
F_2	Seeds capsule^{-1}, recovery percentage, volatile oil content
F_3	Internodal length, panicle length
F_4	Racemes panicle^{-1}
F_5	Leaf breadth, vegetative buds clump^{-1}
F_6	Number of dry capsules kg^{-1}

their inheritance as a single factor and it is believed to control the inheritance of these variables. The second factor was found to be associated with a set of qualitative characters namely, seeds capsule^{-1}, recovery percentage and volatile oil content with factor loadings 0.942, 0.936 and 0.428, respectively. Among the variables, seeds capsule^{-1} and recovery percentage are the most important indicators of quality in cardamom and these may be considered as two independent traits. Factor three was also associated with yield characters namely, internodal length and panicle length. Here internodal length was found to have the maximum factor loading of 0.939 and it could be identified as the marker character. Factor four was associated with only one yield character namely, racemes panicle^{-1} (0.818). Factor five was associated with growth characters namely, leaf breadth (0.717), vegetative buds clump^{-1} (0.526) and leaves tiller^{-1} (0.474); here, the maximum factor loading was for leaf breadth, identifying it as the prominent character among the three variables. Factor six was associated with a single character namely, dry capsules kg^{-1}, which can be considered as an independent triat. Thus the dimension of the data could be reduced to 10 variables, controlled by 6 factors, which can thus very well present the structure of the whole data from the complete set of variables. This assumes importance in the context of evaluating large number of germplasm accessions. Factor analysis has also been used for analysis of interrelationships of variables and grouping of characters by earlier workers in other crops (Rao *et al.* 1981; Saji *et al.* 2002).

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