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Multivariate analysis in large cardamom (*Amomum subulatum* Roxb.)

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Abstract

The variability in large cardamom (*Amomum subulatum*) germplasm was studied by application of multivariate methods such as principal component analysis, discriminant function analysis and Hotelling's T^2 statistic. Variables such as girth of the clump, number of bearing tillers, number of spikes clump^{-1}, number of capsules spike^{-1}, capsule length, capsule diameter and capsule weight recorded in 40 accessions belonging to two cultivars of large cardamom namely, *Ramsey* and *Sawney* were used in the study. Principal component analysis resulted in the identification of three components, which could explain 73% of variability in large cardamom. Discriminant function analysis brought about a discriminant function to distinguish between the two cultivars of large cardamom. Among the variables, capsule weight, girth of the clump, capsules spike^{-1} and number of bearing tillers contributed maximum towards yield and hence such characters can be effectively exploited in crop improvement programmes.

Keywords: *Amomum subulatum*, large cardamom, multivariate analysis, variability.

Large cardamom (*Amomum subulatum* Roxb.) also referred as 'Nepal cardamom' is an important cash crop of Sikkim. Its cultivation is mainly confined to elevations ranging from 900 to 2000 m above MSL at a temperature regime varying between 10^{0}C and 30^{0}C and rainfall of 2000 to 3000 mm per annum. Though a large number of cultivars have been identified in large cardamom, few studies have been carried out on character association and documentation of capsule characters in the crop (Gupta 2000). Hence, the present study was undertaken with an objective of employing multivariate analysis to examine the morphological variation and to identify the most important variables contributing to variability in large cardamom germplasm.

The study was undertaken at Indian Cardamom Research Institute, Regional Station, Gangtok, Sikkim (5000′, 27^0.00′N and 88^0.00′E). Forty accessions of yielding large cardamom (4 years old) belonging to cultivars *Sawney* and *Ramsey* were used for the study. The accessions were planted in a randomized block design, replicated thrice with 12 plants per plot. Plant growth characters such as girth of the clump (X_1), number of bearing tillers (X_2), number of spikes clump^{-1}

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(X_3), number of capsules spike^{-1} (X_4), capsule length (X_5), capsule diameter (X_6) and capsule weight (X_7) were recorded. The data were subjected to analysis using various statistical methods such as principal component analysis (PCA) (Sneath & Sokal 1973), Hotelling's T^2 statistic test and discriminant function analysis (Fisher 1938). Correlation analysis of the discriminant function with the variables identified the traits which contributed to the cultivar differentiation (absolute value of correlation coefficients > 0.5) as suggested by Jayaraman (2001).

The results of the PCA are presented in Table-1. The characters were recorded in different scales of measurement, the extraction of the eigen roots and vectors of correlation matrix were found to be appropriate in the PCA analysis. Three components in the study altogether contributed 73% divergence among the large cardamom accessions. The first component contributed 32.67% of the total variation. The second and third components contributed 21.84% and 18.34% variation, respectively. The latent vectors in descending order are presented in Table 2. The main contributors towards the majority of variations were capsule weight, girth of clump, number of capsules spike^{-1} and number of productive tillers plant^{-1}. Similar studies have been undertaken earlier in small cardamom to isolate most important variables contributing towards variability (Kuruvilla *et al.* 2003).

The genuineness of the data was tested using Q-Q plot and the data was found to be in order. Hotelling's T^2 statistic was employed to differentiate the germplasm at cultivar levels. The results revealed that there is significant difference between the cultivars with respect to the characters studied. Discriminant function analysis brought about a discriminant function to distinguish between the two cultivars. The function is:

$$Z = -0.039 X_1 - 0.015 X_2 + 0.020 X_3 - 0.058 X_4 + 24.5 X_5 - 8.378 X_6 + 10.11 X_7$$

The centroids of the discriminant scores for the two cultivars *Sawney* and *Ramsey* are 88.44 and 83.98 and thus a genotype with a discriminant score above 86.21 can be grouped under cultivar *Sawney* and that with a score below 86.21 can be placed under *Ramsey*.

Correlation analysis of the discriminant function with the variables revealed that among the variables, capsule length and capsule weight contributed maximum discrimination between *Ramsey* and *Sawney* cultivars (Table 3).

The application of Hotelling's T^2 statistic for highlighting the significant difference between accessions belonging to two large cardamom cultivars based on growth charac-

Table 1. Latent roots, percentage of variance and cumulative variance observed in principal component analysis of large cardamom germplasm

Principal component	Latent roots	Percentage variance	Cumulative variance
PRIN 1	2.257	32.672	32.672
PRIN 2	1.529	21.836	54.509
PRIN 3	1.284	18.341	72.850

Table 2. Latent vectors in descending order in large cardamom germplasm

Character	Principal component 1	Principal component 2	Principal component 3
Capsule weight	0.595	-0.097	0.054
Capsule length	0.570	0.003	-0.044
Capsule diameter	0.449	-0.298	0.214
Number of spikes	0.209	0.614	0.195
Girth of clump at base	0.120	0.690	-0.177
Capsules spike^{-1}	0.119	0.069	-0.739
Productive tillers	-0.076	0.212	0.578

Table 3. Correlation of discriminant function using variables studied in large cardamom germplasm

Variable	Correlation with Z
Girth of clump at base	-0.064
Productive tillers	-0.154
Number of spikes	0.220
Capsules spike^{-1}	0.083
Capsule length	0.914
Capsule diameter	0.457
Weight of capsule	0.843

ters revealed that the application of discriminant function could be employed for distinguishing between the two cultivars and also for identifying the variables that contribute towards the discrimination. Further, characters contributing maximum to the discrimination also explained wide variability as revealed by principal component analysis. These yield contributing characters can be utilized in crop improvement programmes in the crop.

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