# Morphological Variability and Identification of Minimum Descriptors in Chilli Based on Principal Component Analysis

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Principal Component Analysis (PCA) was carried out in thirty three chilli accessions to assess the relative contribution of different morphological characters to the total variability and to establish a list of minimum descriptors. Eight principal components (PCs) accounting for 88.19% of the total variability among the accessions were extracted. The first PC accounted for 33.08% and the second PC accounted for 17.03% of the total variability and were mainly associated with seedling and fruit characters respectively. Vegetative characters were distributed mostly in the first four PCs. Scatter plot of the accessions drawn from the first two principal components revealed the characters which could discriminate among species and helped in grouping them into different clusters. Twenty eight minimum morphological descriptors were identified on the basis of their correlation with other characters and contribution to the total variability as revealed by PCA and were expected to be highly discriminating. These morphological descriptors would help in quick characterization of chilli germplasm.

**Key words: *Capsicum annuum*, *Capsicum chinense*, *Capsicum frutescens*, Principal component Analysis, Minimum descriptors**

The intra and interspecific variability in chilli is tremendous and many characters exhibit parallel variation across the species (Pickersgill, 1971) which often makes morphology based classification difficult. For the study of such morphologically complex populations, multivariate analysis combines the capacity to provide a synthetic summery of the most relevant traits and can help in assessing the relative importance of different characters to the total variability of the population (Camussi, 1979, Abadie *et al.*, 1998). Multivariate analysis of agronomic and morphological characters has been used for the characterization, evaluation and classification of germplasm in crops like beans, chickpeas, onion, peanuts, colocasia and maize (Costiñeiras, 1992, Fraga *et al.*, 1996; Shagarodsky *et al.*, 1996; Fundora *et al.*, 1997; Rodriquez Manzano *et al.*, 2001).

The Interenational Plant Genetic Resources Institute (IPGRI) has published the complete descriptors of capsicum which tremendously help in detail characterization and evaluation of capsicum germplasm. However, characterization of a large number of genotypes using numerous morphological traits is often tedious and a time consuming proposition, albeit, detail characterization of germplasm often requires considerably large number of morphological descriptors in view of the tremendous morphological variations apparent intra and interspecifically in chilli. However, for preliminary characterization and quick discrimination between genotypes, a basic set of descriptors having uniform expressivity across environments and easy visual scorability would be sufficient for all practical point of view.

In this work, Principal Component Analysis (PCA) was carried out using several morphological traits to determine the relative contribution of these characters towards the total variability in chilli and to establish a list of minimum descriptors for quick characterization and genotype identification.

## Materials and Methods

Thirty three chilli accessions representing a wide range of variation in chilli were included in the analysis (Fig. 1). Out of these, 21 accessions belonged to *C. annuum* L. (designated by 'A' within parenthesis in Fig. 1) 6 to *C. chinense* Jacq. (designated by 'C' within parenthesis) and 6 to *C. frutescens* L. (designated by 'F' within parenthesis). The experiment was conducted in the Experimental Farm of Assam Agricultural University, Jorhat, Assam during winter seasons of 2001-2002 and 2002-2003. Materials were evaluated in 5 x 2 $m^2$ plots and seedlings were transplanted in 50 x 40 cm spacing.

For morphological characterization forty characters (Table 1) were considered from the Capsicum Descriptors published by IPGRI (1995). Out of these, nine were considered useful primarily in separating species, while other characters included attributes which were helpful in morphological characterization within species. Nineteen of these characters were qualitative while the rest were quantitative in nature. The score or weightages as

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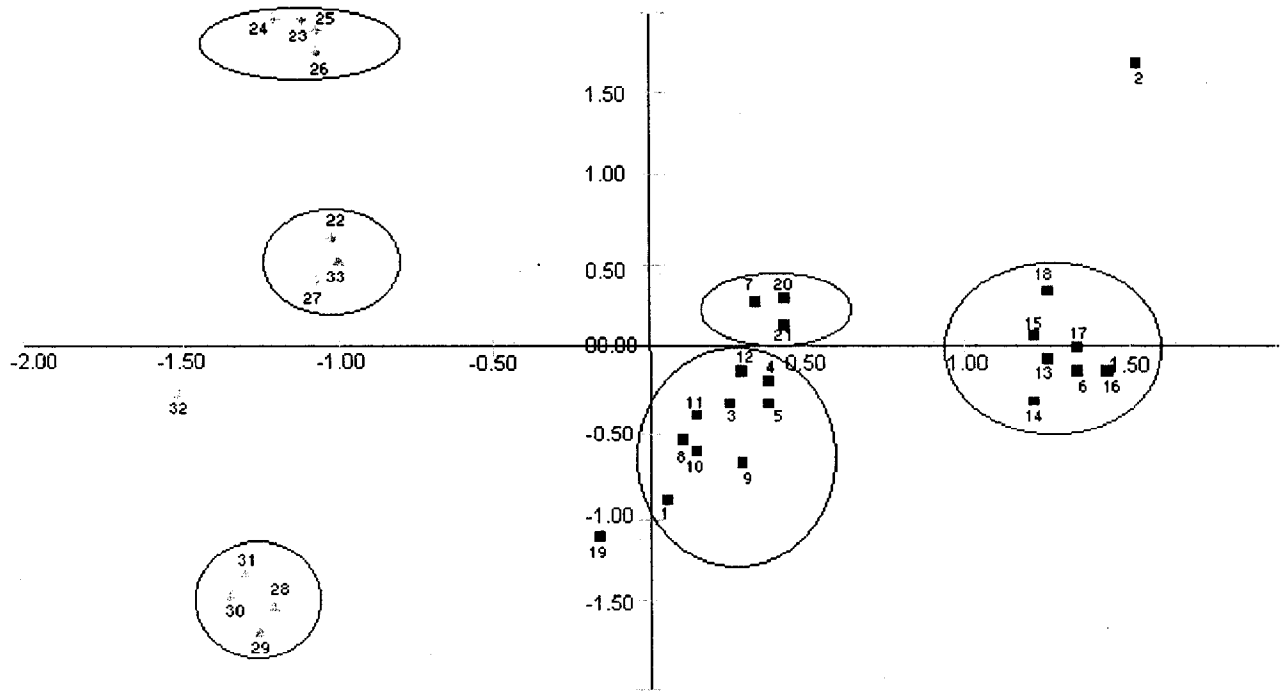


*Fig. 1: Plot of the cultivars representing C. annuum L., C. chinense Jacq. and C. frutescens L. on the first two components recognized by Pricipal Component Analysis. 1 = ACC(A)-01, 2 = ACC(A)-02, 3 = ACC(A)-03, 4 = ACC(A)-04, 5 = ACC(A)-05, 6 = ACC(A)-06, 7 = ACC(A)-07, 8 = ACC(A)-08, 9 = ACC(A)-09, 10 = ACC(A)-10, 11= ACC(A)-11, 12= ACC(A)-12, 13= ACC(A)-13, 4= ACC(A)-14, 15= ACC(A)-14-1, 16 = ACC(A)-14-2, 17 = ACC(A)-14-3, 18 = ACC(A)-15, 19 = ACC(A)-16, 20 = ACC(A)-17, 21= ACC(A)-18, 22 = ACC(C)-19, 23 = ACC(C)-20, 24 = ACC(C)-21, 25 = ACC(C)-22, 26 = ACC(C)-23, 27 = ACC(C)-24, 28 = ACC(F)-25, 29 = ACC(F)-26, 30 = ACC(F)-27, 31 = ACC(F)-28, 32 = ACC(F)-29, 33 = ACC(F)-30*

recommended for each of the qualitative characters in the Capsicum Descriptors and actual numerical data for the quantitative characters were used for numerical taxonomic study.

Principal Component Analysis (PCA) with the morphological data was carried out following method described by Sneath and Sokal (1973) and SAS Institute, Inc. (1985). In this procedure, first a standardized (mean = 0 and variance = 1) correlation matrix between the characters of all the test individuals was calculated to transform the original variables into a new set of independent variables. The principal components were then calculated from this standardized correlation matrix. The mean values from the highest and lowest eigenvectors were used as the threshold for selection of the characters contributing most to the total variability (Rodríquez Manzano *et al.*, 2001). The statistical computation of PCA was performed using statistical software package "SPSS for MS Windows Release 7.5".

**Results and Discussion**

The correlation coefficients among the forty morphological characters derived from standardization of original data were presented in Table 2. The large number of observation raised the test power, giving significance to most of the correlation; hence, only values above 0.6 are discussed. Several seedling characters viz., cotyledonous leaf colour, cotyledonous leaf length and width, cotyledonous leaf shape, hypocotyl colour and hypocotyl pubescence appeared highly correlated among themselves besides exhibiting positive association with several vegetative, inflorescence and fruit characters. Most of the vegetative characters viz., plant height, branching habit, growth habit, leaf colour, leaf pubescence type and density, leaf length and width were not associated among themselves and they mostly showed association with seedling characters only. Among the inflorescence characters, corolla length was found to be significantly associated with anther colour and calyx margin shape.

The matrix of eigenvectors and values of the principal components (PC) derived from the correlation matrix are presented in Table 3. Altogether eight (8) PCs were extracted accounting for 88.19% of the total variability of the chilli accessions. However, only the first four principal components are discussed as they explained 71.16% of the total variation.

**Table 1. Morphological characters of *Capsicum* species recorded for the study along with their scores/ weightage (as per IPGRI descriptor, 1995)**

| | | | |
|---|---|---|---|
| I. | **Seedling** | | |
| (i) | Hypocotyl colour | : | Green (1), ¼ purple from the base (2), ½ purple from the base (3), purple (4) |
| (ii) | Cotyledonous leaf length | : | (mm) |
| (iii) | Cotyledonous leaf width | : | (mm) |
| (iv) | Cotyledonous leaf shape | : | Deltoid (3), Ovate (5), Lanceolate (7) |
| (v) | Cotyledonous leaf colour | : | Light green (3), Green (5), Dark green (7), Other (9) |
| (vi) | Hypocotyl pubescence | : | Glabrous (0), Sparse (3), Intermediate (5), Abundant (7) |
| II. | **Vegetative** | | |
| (vii) | Plant growth habit | : | Prostrate (3), Compact (5), Erect (7) |
| (viii) | Plant height | : | (cm) |
| (ix) | Stem pubescence density (at 2 nodes below the shoot when first fruit turning red) | : | Glabrous (0), Sparse (3), Intermediate (5), Abundant (7) |
| (x) | Stem colour | : | Green (1), Green with few purple strip (2), Green with more purple strip (3), Purple (4), Others (5) |
| (xi) | Leaf pubescence density (the youngest mature leaves when first fruit turning red) | : | Glabrous (0), Sparse (3), Intermediate (5), Abundant (7) |
| (xii) | Leaf pubescence type | : | Short (3), Intermediate (5), Long (7) |
| (xiii) | Mature leaf length | : | (cm) |
| (xiv) | Mature leaf width | : | (cm) |
| (xv) | Leaf shape | : | Deltoid (3), Ovate (5), Lanceolate (7) |
| (xvi) | Leaf colour | : | Yellow (1), Light green (2), Green (3), Dark green (4) Others (5) |
| (xvii) | Branching habit | : | None (0), Sparse (3), Intermediate (5), Abundant (7) |
| III. | **Inflorescence and fruit** | | |
| (xviii) | Number of pedicels per axil | : | One per axil (1), Two pedicels per axil (2), Three or more pedicel per axil (3), Many pedicles in bunches but each in individual axil (4) |
| (xix) | Pedicel position at anthesis | : | Pendant (3), Intermediate (5), Erect (7) |
| (xx) | Angle between flower and pedicel | : | 0° (3), 45° (5), 90° (7), >90° (9) |
| (xxi) | Corolla colour | : | White (1), Light yellow (2), Yellow (3), Yellow- green (4), White with purple base (5), White with purple margin (6), Purple (7), Others (8) |
| (xxii) | Corolla length | : | (mm) |
| (xxiii) | Anther colour | : | Yellow (1), Pale blue (2), Blue (3), Purple (4), Others (5) |
| (xxiv) | Calyx margin shape | : | Smooth (3), Intermediate (5), Dentate (7) |
| (xxv) | Annular constriction at junction of calyx and peduncle | : | Absent (0), Not-clear (3), Clear (5), distinct and uniform in the whole plant (7) |
| (xxvi) | Fruit position | : | Declining (3), Intermediate (5), Erect (7) |
| (xxvii) | Fruit colour in immature stage | : | Green (1), Yellow (2), Orange (3), Red (4), Purple (5), Brown (6), Black (7), Others (8) |
| (xxviii) | Fruit colour in mature stage | : | Green (1), Yellow (2), Orange (3), Orange-red (4), Red (5), Purple (6), Brown (7), Black (8), Others (9) |
| (xxix) | Fruit length | : | (cm) |
| (xxx) | Fruit width | : | (cm) |
| (xxxi) | Fruit per plant | : | (Nos) |
| (xxxii) | Fruit weight (fresh) | : | (g) |
| (xxxiii) | Fruit weight (dry) | : | (g) |
| (xxxiv) | Fruit shape | : | Elongate (1), Oblate (2), Round (3), Conical (4), Campanulate (5), Bell or blocky (6), Others (7) |
| (xxxv) | Fruit cross-sectional corrugation | : | Smooth (0), Slightly corrugated (3), Intermediate (5), Corrugated (7) |
| (xxxvi) | Fruit pungency | : | Not pungent (0), Low (3), Intermediate High (7) |
| (xxxvii) | Fruit persistence | : | Deciduous (0), Slight (3), Intermediate (5), Persistent (7) |
| IV. | **Seed** | | |
| (xxxviii) | Seed colour | : | Straw colour (1), Black/brown (2), Others (3) |
| (xxxix) | 1000 seed weight | : | (g) |
| (xxxx) | Number of seeds/fruit | : | Nos. |

The first component accounting for 33.08% of the variation was mainly linked to all the seedling characters along with few vegetative, inflorescence and fruit characters. The characters showing greatest variability in this component were cotyledonous leaf length, cotyledonous leaf colour, cotyledonous leaf shape, cotyledonous leaf breadth, hypocotyl colour, hypocotyl pubescence, leaf colour, leaf shape, stem colour, calyx margin shape, corolla colour, anther colour, immature fruit colour and number of seeds/fruit. The association

**Table 2. Correlation co-efficients among 40 morphological characters of chilli**

| S.No. | Characters | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Anther colour | | -0.562 | -0.399 | 0.226 | -0.590 | 0.236 | 0.855 | 0.919 | 0.929 | 0.863 | 0.747 | 0.784 | 0.155 | -0.615 | 0.768 | 0.086 | -0.058 | -0.036 | -0.074 |
| 2 | Annular constriction[a] | -0.562** | | -0.108 | 0.313 | 0.538 | 0.144 | -0.439 | -0.488 | -0.611 | -0.630 | -0.251 | -0.333 | 0.104 | 0.868 | -0.243 | -0.003 | 0.319 | 0.175 | -0.117 |
| 3 | Angle between flower and pedicel | -0.399* | -0.108 | | -0.281 | 0.451 | -0.092 | -0.531 | -0.360 | -0.518 | -0.342 | -0.619 | -0.607 | -0.582 | -0.053 | -0.304 | -0.439 | -0.555 | -0.519 | 0.394 |
| 4 | Branching habit | 0.226 | 0.313 | -0.281 | | 0.044 | 0.153 | 0.144 | 0.099 | 0.119 | 0.147 | 0.168 | 0.441 | 0.125 | 0.307 | 0.199 | -0.039 | 0.121 | 0.229 | -0.309 |
| 5 | Fruit pungency | -0.590** | 0.538** | 0.451** | 0.044 | | 0.325 | -0.675 | -0.697 | -0.822 | -0.749 | -0.696 | -0.728 | -0.520 | 0.573 | -0.156 | 0.208 | -0.350 | -0.322 | 0.129 |
| 6 | Corolla colour | 0.236 | 0.144 | -0.092 | 0.153 | 0.325 | | 0.181 | 0.244 | 0.021 | -0.286 | 0.197 | -0.219 | -0.142 | 0.100 | 0.786 | 0.203 | -0.035 | -0.315 | -0.058 |
| 7 | Corolla length (mm) | 0.855** | -0.439* | -0.531** | 0.144 | -0.675** | 0.181 | | 0.848 | 0.878 | 0.752 | 0.789 | 0.750 | 0.276 | -0.444 | 0.621 | 0.179 | 0.108 | 0.136 | -0.105 |
| 8 | Cotyledonous leaf colour | 0.919** | -0.488** | -0.360* | 0.099 | -0.697** | 0.244 | 0.848** | | 0.921 | 0.778 | 0.816 | 0.689 | 0.319 | -0.566 | 0.724 | -0.026 | 0.138 | 0.054 | -0.121 |
| 9 | Cotyledonous leaf length (mm) | 0.929** | -0.611** | -0.518** | 0.119 | -0.822** | 0.021 | 0.878** | 0.921** | | 0.905 | 0.828 | 0.841 | 0.388 | -0.634 | 0.583 | 0.067 | 0.167 | 0.189 | -0.182 |
| 10 | Cotyledonous leaf shape | 0.863** | -0.630** | -0.342 | 0.147 | -0.749** | -0.286 | 0.752** | 0.778** | 0.905** | | 0.630 | 0.887 | 0.222 | -0.659 | 0.346 | -0.022 | -0.041 | 0.126 | -0.041 |
| 11 | Cotyledonous leaf breadth (mm) | 0.747** | -0.251 | -0.619** | 0.168 | -0.696** | 0.197 | 0.789** | 0.816** | 0.828** | 0.630** | | 0.658 | 0.576 | -0.250 | 0.575 | 0.095 | 0.444 | 0.291 | -0.309 |
| 12 | Calyx margin shape | 0.784** | -0.333 | -0.607** | 0.441** | -0.728** | -0.219 | 0.750** | 0.689** | 0.841** | 0.887** | 0.658** | | 0.369 | -0.390 | 0.337 | -0.021 | 0.155 | 0.295 | -0.185 |
| 13 | Dry fruit weight (g) | 0.155 | 0.104 | -0.582** | 0.125 | -0.520** | -0.142 | 0.276 | 0.319 | 0.388* | 0.222 | 0.576** | 0.369* | | 0.151 | -0.003 | 0.117 | 0.916 | 0.835 | -0.591 |
| 14 | Fruit cross-sectional corrugation | -0.615** | 0.868** | -0.053 | 0.307 | 0.573** | 0.100 | -0.444** | -0.566** | -0.634** | -0.659** | -0.250 | -0.390* | 0.151 | | -0.335 | 0.120 | 0.358 | 0.309 | -0.317 |
| 15 | Fruit colour (immature) | 0.768** | -0.243 | -0.304 | 0.199 | -0.156 | 0.786** | 0.621** | 0.724** | 0.583** | 0.346 | 0.575** | 0.337 | -0.003 | -0.335 | | 0.124 | -0.073 | -0.247 | -0.063 |
| 16 | Fruit colour (mature) | 0.086 | -0.003 | -0.439* | -0.039 | 0.208 | 0.203 | 0.179 | -0.026 | 0.067 | -0.022 | 0.095 | -0.021 | 0.117 | 0.120 | 0.124 | | 0.123 | 0.283 | -0.227 |
| 17 | Fresh fruit weight (g) | -0.058 | 0.319 | -0.555** | 0.121 | -0.350* | -0.035 | 0.108 | 0.138 | 0.167 | -0.041** | 0.444 | 0.155** | 0.916* | 0.358 | -0.073 | 0.123 | | 0.801 | -0.565 |
| 18 | Fruit length (cm) | -0.036 | 0.175 | -0.519** | 0.229 | -0.322 | -0.315 | 0.136 | 0.054 | 0.189 | 0.126 | 0.291 | 0.295 | 0.835** | 0.309 | -0.247 | 0.283 | 0.801** | | -0.700 |
| 19 | Fruit position | -0.074 | -0.117 | 0.394* | -0.309 | 0.129 | -0.058 | -0.105 | -0.121 | -0.182 | -0.041 | -0.309 | -0.185 | -0.591** | -0.317 | -0.063 | -0.227 | -0.565** | -0.700** | |
| 20 | Fruit/plant | -0.240 | -0.357* | 0.681** | -0.536** | 0.368* | 0.050 | -0.399* | -0.289 | -0.336 | -0.258 | -0.508** | -0.603** | -0.581** | -0.385* | -0.108 | 0.000 | -0.573** | -0.545** | 0.397* |
| 21 | Fruit persistence | 0.022 | -0.120 | -0.055* | -0.064 | 0.292 | 0.066 | -0.053 | -0.130 | -0.036 | -0.006 | -0.298 | -0.066 | -0.105 | -0.141 | 0.068 | 0.599** | -0.192 | 0.118 | -0.079 |
| 22 | Fruit shape | -0.074 | 0.414* | 0.019 | 0.363* | 0.129 | 0.336 | -0.055 | 0.005 | -0.137 | -0.266 | 0.193 | -0.069 | 0.150 | 0.471** | 0.164 | -0.269 | 0.255 | -0.008 | -0.143 |
| 23 | Fruit width (cm) | -0.176 | 0.647** | -0.438* | 0.365* | 0.033 | 0.253 | -0.024 | -0.074 | -0.130 | -0.311 | 0.206 | 0.028 | 0.537** | 0.647** | 0.054 | -0.038 | 0.717** | 0.433* | -0.288 |
| 24 | Hypocotyl colour | 0.762** | -0.267 | -0.235 | 0.294 | -0.136 | 0.752** | 0.634** | 0.716** | 0.583** | 0.372* | 0.529** | 0.361* | 0.001 | -0.326 | 0.938** | 0.172 | -0.074 | -0.191 | -0.102 |
| 25 | Hypocotyl pubescence | 0.689** | -0.435* | -0.130 | 0.104 | -0.536** | 0.012 | 0.383* | 0.704** | 0.684** | 0.677** | 0.558** | 0.530** | 0.267 | -0.563** | 0.467** | -0.291 | 0.102 | -0.010 | -0.061 |
| 26 | Leaf colour | 0.687** | -0.142 | -0.318 | 0.519** | -0.349* | 0.229 | 0.546** | 0.707** | 0.621** | 0.564** | 0.541** | 0.628** | 0.261 | -0.174 | 0.557** | -0.026 | 0.141 | 0.188 | -0.368* |
| 27 | Leaf pubescence density | 0.132 | 0.088 | 0.077 | 0.363* | -0.126 | -0.062 | -0.070 | 0.135 | 0.086 | 0.153 | 0.000 | 0.223 | 0.022 | -0.048 | 0.109 | -0.541** | -0.069 | -0.127 | 0.046 |
| 28 | Leaf pubescence type | 0.205 | -0.037 | 0.104 | 0.374* | -0.191 | -0.088 | -0.013 | 0.203 | 0.164 | 0.238 | 0.062 | 0.281 | 0.049 | -0.116 | 0.121 | -0.532** | -0.074 | -0.118 | 0.019 |
| 29 | Leaf shape | 0.734** | -0.681** | -0.403* | 0.009 | -0.588** | -0.127 | 0.633** | 0.610** | 0.763** | 0.790** | 0.378 | 0.689** | 0.063 | -0.740** | 0.390* | 0.178 | -0.180 | 0.059 | -0.061 |
| 30 | Mature leaf length (cm) | 0.133 | 0.302 | -0.091 | 0.507** | -0.052 | 0.192 | 0.186 | 0.151 | 0.061 | 0.047 | 0.057 | 0.310 | 0.092 | 0.240 | 0.181 | -0.346 | 0.157 | 0.098 | -0.127 |
| 31 | Mature leaf width (cm) | -0.288 | 0.653** | -0.007 | 0.280 | 0.251 | 0.275 | -0.115 | -0.192 | -0.343 | -0.416* | -0.131 | -0.137 | 0.102 | 0.571** | -0.015 | -0.231 | 0.291 | 0.101 | 0.012 |
| 32 | No. pedicels/axil | -0.505** | 0.352* | 0.110 | -0.306 | 0.169 | -0.054 | -0.162 | -0.356* | -0.422* | -0.469** | -0.367* | -0.381* | -0.112 | 0.287 | -0.326 | 0.032 | -0.018 | 0.033 | 0.192 |
| 33 | No. of seed/ fruit | 0.832** | -0.509** | -0.411* | 0.162 | -0.681** | 0.015 | 0.662** | 0.819** | 0.862** | 0.793** | 0.690** | 0.754** | 0.378* | -0.548** | 0.549** | -0.030 | 0.141 | 0.136 | -0.134 |
| 34 | Plant Growth habit | 0.363* | -0.432* | 0.200 | 0.028 | -0.247 | -0.081 | 0.115 | 0.335 | 0.320 | 0.395* | 0.180 | 0.183 | 0.065 | -0.546** | 0.198 | -0.200 | -0.071 | -0.021 | -0.052 |
| 35 | Plant height (cm) | 0.388* | -0.183 | -0.074 | -0.037 | -0.257 | 0.205 | 0.383* | 0.464** | 0.364* | 0.285 | 0.247 | 0.226 | 0.110 | -0.395* | 0.366* | 0.128 | 0.038 | 0.019 | 0.007 |
| 36 | Pedicel position at anthesis | -0.441** | -0.039 | 0.915** | -0.227 | 0.478** | -0.119 | -0.643** | -0.424* | -0.548** | -0.378* | -0.606** | -0.609** | -0.502** | 0.021 | -0.337 | -0.422* | -0.470 | -0.458** | 0.280 |
| 37 | Stem colour | 0.773** | -0.300 | -0.252 | 0.229 | -0.292 | 0.680** | 0.667** | 0.754** | 0.617** | 0.418* | 0.630** | 0.406* | -0.016* | -0.366** | 0.902** | -0.043 | -0.069 | -0.306 | 0.052 |
| 38 | Seed colour | -0.863** | 0.630** | 0.342 | -0.147 | 0.749** | 0.286 | -0.752** | -0.778** | -0.905** | -1.000** | -0.630** | -0.887** | -0.222** | 0.659** | -0.346** | 0.022 | 0.041 | -0.126 | 0.041 |
| 39 | Stem pubescence density | 0.158 | 0.068 | 0.355* | 0.022 | 0.064 | 0.243 | -0.127 | 0.237 | 0.016 | 0.027 | -0.005 | -0.069 | -0.155 | -0.164 | 0.334 | -0.549** | -0.207 | -0.381* | 0.245 |
| 40 | 1000 seed weight (g) | 0.058 | 0.013 | -0.262 | 0.076 | -0.311 | -0.148 | 0.110 | 0.206 | 0.225 | 0.141 | 0.289 | 0.232 | 0.482** | 0.121 | -0.059 | -0.043 | 0.381 | 0.462** | -0.478** |

Table 2. Contd.

| S.No. | Characters | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Anther colour | -0.240 | 0.022 | -0.074 | -0.176 | 0.762 | 0.689 | 0.687 | 0.132 | 0.205 | 0.734 | 0.133 | -0.288 | -0.505 | 0.832 | 0.363 | 0.388 | -0.441 | 0.773 | -0.863 | 0.158 | 0.058 |
| 2 | Annular constriction[a] | -0.357 | -0.120 | 0.414 | 0.647 | -0.267 | -0.435 | -0.142 | 0.088 | -0.037 | -0.681 | 0.302 | 0.653 | 0.352 | -0.509 | -0.432 | -0.183 | -0.039 | -0.300 | 0.630 | 0.068 | 0.013 |
| 3 | Angle between flower and pedicel | 0.681 | -0.055 | 0.019 | -0.438 | -0.235 | -0.130 | -0.318 | 0.077 | 0.104 | -0.403 | -0.091 | -0.007 | 0.110 | -0.411 | 0.200 | -0.074 | 0.915 | -0.252 | 0.342 | 0.355 | -0.262 |
| 4 | Branching habit | -0.536 | -0.064 | 0.363 | 0.365 | 0.294 | 0.104 | 0.519 | 0.363 | 0.374 | 0.009 | 0.507 | 0.280 | -0.306 | 0.162 | 0.028 | -0.037 | -0.227 | 0.229 | -0.147 | 0.022 | 0.076 |
| 5 | Fruit pungency | 0.368 | 0.292 | 0.129 | 0.033 | -0.136 | -0.536 | -0.349 | -0.126 | -0.191 | -0.588 | -0.052 | 0.251 | 0.169 | -0.681 | -0.247 | -0.257 | 0.478 | -0.292 | 0.749 | 0.064 | -0.311 |
| 6 | Corolla colour | 0.050 | 0.066 | 0.336 | 0.253 | 0.752 | 0.012 | 0.229 | -0.062 | -0.088 | -0.127 | 0.192 | 0.275 | -0.054 | 0.015 | -0.081 | 0.205 | -0.119 | 0.680 | 0.286 | 0.243 | -0.148 |
| 7 | Corolla length (mm) | -0.399 | -0.053 | -0.055 | -0.024 | 0.634 | 0.383 | 0.546 | -0.070 | -0.013 | 0.633 | 0.186 | -0.115 | -0.162 | 0.662 | 0.115 | 0.383 | -0.643 | 0.667 | -0.752 | -0.127 | 0.110 |
| 8 | Cotyledonous leaf colour | -0.289 | -0.130 | 0.005 | -0.074 | 0.716 | 0.704 | 0.707 | 0.135 | 0.203 | 0.610 | 0.151 | -0.192 | -0.356 | 0.819 | 0.335 | 0.464 | -0.424 | 0.754 | -0.778 | 0.237 | 0.206 |
| 9 | Cotyledonous leaf length (mm) | -0.336 | -0.036 | -0.137 | -0.130 | 0.583 | 0.684 | 0.621 | 0.086 | 0.164 | 0.763 | 0.061 | -0.343 | -0.422 | 0.862 | 0.320 | 0.364 | -0.548 | 0.617 | -0.905 | 0.016 | 0.225 |
| 10 | Cotyledonous leaf shape | -0.258 | -0.006 | -0.266 | -0.311 | 0.372 | 0.677 | 0.564 | 0.153 | 0.238 | 0.790 | 0.047 | -0.416 | -0.469 | 0.793 | 0.395 | 0.285 | -0.378 | 0.418 | -1.000 | 0.027 | 0.141 |
| 11 | Cotyledonous leaf breadth (mm) | -0.508 | -0.298 | 0.193 | 0.206 | 0.529 | 0.558 | 0.541 | 0.000 | 0.062 | 0.378 | 0.057 | -0.131 | -0.367 | 0.690 | 0.180 | 0.247 | -0.606 | 0.630 | -0.630 | -0.005 | 0.289 |
| 12 | Calyx margin shape | -0.603 | -0.066 | -0.069 | 0.028 | 0.361 | 0.530 | 0.628 | 0.223 | 0.281 | 0.689 | 0.310 | -0.137 | -0.381 | 0.754 | 0.183 | 0.226 | -0.609 | 0.406 | -0.887 | -0.069 | 0.232 |
| 13 | Dry fruit weight (g) | -0.581 | -0.105 | 0.150 | 0.537 | 0.001 | 0.267 | 0.261 | 0.022 | 0.049 | 0.063 | 0.092 | 0.102 | -0.112 | 0.378 | 0.065 | 0.110 | -0.502 | -0.016 | -0.222 | -0.155 | 0.482 |
| 14 | Fruit cross-sectional corrugation | -0.385 | -0.141 | 0.471 | 0.647 | -0.326 | -0.563 | -0.174 | -0.048 | -0.116 | -0.740 | 0.240 | 0.571 | 0.287 | -0.548 | -0.546 | -0.395 | 0.021 | -0.366 | 0.659 | -0.164 | 0.121 |
| 15 | Fruit colour (immature) | -0.108 | 0.068 | 0.164 | 0.054 | 0.938 | 0.467 | 0.557 | 0.109 | 0.121 | 0.390 | 0.181 | -0.015 | -0.326 | 0.549 | 0.198 | 0.366 | -0.337 | 0.902 | -0.346 | 0.334 | -0.059 |
| 16 | Fruit colour (mature) | 0.000 | 0.599 | -0.269 | -0.038 | 0.172 | -0.291 | -0.026 | -0.541 | -0.532 | 0.178 | -0.346 | -0.231 | 0.032 | -0.030 | -0.200 | 0.128 | -0.422 | -0.043 | 0.022 | -0.549 | -0.043 |
| 17 | Fresh fruit weight (g) | -0.573 | -0.192 | 0.255 | 0.717 | -0.074 | 0.102 | 0.141 | -0.069 | -0.074 | -0.180 | 0.157 | 0.291 | -0.018 | 0.141 | -0.071 | 0.038 | -0.470 | -0.069 | 0.041 | -0.207 | 0.381 |
| 18 | Fruit length (cm) | -0.545 | 0.118 | -0.008 | 0.433 | -0.191 | -0.010 | 0.188 | -0.127 | -0.118 | 0.059 | 0.098 | 0.101 | 0.033 | 0.136 | -0.021 | 0.019 | -0.458 | -0.306 | -0.126 | -0.381 | 0.462 |
| 19 | Fruit position | 0.397 | -0.079 | -0.143 | -0.288 | -0.102 | -0.061 | -0.368 | 0.046 | 0.019 | -0.061 | -0.127 | 0.012 | 0.192 | -0.134 | -0.052 | 0.007 | 0.280 | 0.052 | 0.041 | 0.245 | -0.478 |
| 20 | Fruit/plant | | 0.280 | -0.364 | -0.648 | -0.094 | -0.064 | -0.463 | -0.157 | -0.156 | -0.058 | -0.459 | -0.364 | 0.002 | -0.323 | 0.327 | 0.082 | 0.648 | -0.141 | 0.258 | 0.154 | -0.359 |
| 21 | Fruit persistence | 0.280 | | -0.525 | -0.339 | 0.173 | -0.096 | -0.021 | -0.160 | -0.208 | 0.314 | -0.271 | -0.244 | 0.154 | -0.048 | 0.120 | 0.374 | -0.108 | -0.207 | 0.006 | -0.101 | -0.012 |
| 22 | Fruit shape | -0.364* | -0.525** | | 0.605 | 0.085 | -0.165 | 0.122 | 0.249 | 0.284 | -0.591 | 0.377 | 0.522 | -0.019 | 0.119 | -0.194 | -0.180 | 0.097 | 0.161 | 0.266 | 0.087 | 0.025 |
| 23 | Fruit width ((cm) | -0.648** | -0.339 | 0.605** | | -0.007 | -0.187 | 0.051 | 0.094 | 0.043 | -0.483 | 0.497 | 0.723 | 0.118 | -0.042 | -0.351 | -0.120 | -0.348 | 0.070 | 0.311 | -0.060 | 0.150 |
| 24 | Hypocotyl colour | -0.094 | 0.173 | 0.085 | -0.007 | | 0.473 | 0.634 | 0.037 | 0.066 | 0.384 | 0.275 | 0.030 | -0.346 | 0.474 | 0.201 | 0.454 | -0.323 | 0.891 | -0.372 | 0.271 | -0.008 |
| 25 | Hypocotyl pubescence | -0.064 | -0.096 | -0.165 | -0.187 | 0.473** | | 0.568 | 0.350 | 0.385 | 0.530 | -0.011 | -0.355 | -0.671 | 0.662 | 0.583 | 0.253 | -0.109 | 0.519 | -0.677 | 0.529 | 0.130 |
| 26 | Leaf colour | -0.463** | -0.021 | 0.122 | 0.051 | 0.634** | 0.568** | | 0.243 | 0.294 | 0.441 | 0.314 | -0.074 | -0.440 | 0.606 | 0.206 | 0.246 | -0.288 | 0.555 | -0.564 | 0.206 | 0.242 |
| 27 | Leaf pubescence density | -0.157 | -0.160 | 0.249 | 0.094 | 0.037 | 0.350* | 0.243 | | 0.972 | 0.083 | 0.212 | 0.101 | -0.087 | 0.321 | 0.247 | -0.007 | 0.119 | 0.121 | -0.153 | 0.563 | 0.125 |
| 28 | Leaf pubescence type | -0.156 | -0.208 | 0.284 | 0.043 | 0.066 | 0.385* | 0.294 | 0.972** | | 0.119 | 0.211 | 0.035 | -0.184 | 0.406 | 0.317 | -0.001 | 0.144 | 0.164 | -0.238 | 0.502 | 0.158 |
| 29 | Leaf shape | -0.058 | 0.314 | -0.591** | -0.483** | 0.384* | 0.530** | 0.441** | 0.083 | 0.119 | | -0.121 | -0.585 | -0.310 | 0.625 | 0.301 | 0.252 | -0.435 | 0.352 | -0.790 | -0.016 | 0.027 |
| 30 | Mature leaf length (cm) | -0.459** | -0.271 | 0.377* | 0.497** | 0.275 | -0.011 | 0.314 | 0.212 | 0.211 | -0.121 | | 0.772 | 0.088 | 0.018 | -0.189 | 0.184 | -0.157 | 0.318 | -0.047 | 0.168 | 0.004 |
| 31 | Mature leaf width (cm) | -0.364* | -0.244 | 0.522** | 0.723** | 0.030 | -0.355* | -0.074 | 0.101 | 0.035 | -0.585** | 0.772** | | 0.405 | -0.327 | -0.351 | 0.104 | -0.083 | 0.070 | 0.416 | 0.102 | 0.005 |
| 32 | No. pedicels/axil | 0.002 | 0.154 | -0.019 | 0.118 | -0.346 | -0.671** | -0.440** | -0.087 | -0.184 | -0.310 | 0.088 | 0.405* | | -0.470 | -0.439 | 0.197 | -0.019 | -0.389 | 0.469 | -0.060 | 0.004 |
| 33 | No. of seed/ fruit | -0.323 | -0.048 | 0.119 | -0.042 | 0.474** | 0.662** | 0.606** | 0.321 | 0.406* | 0.625** | 0.018 | -0.327 | -0.470** | | 0.344 | 0.271 | -0.345 | 0.490 | -0.793 | 0.161 | 0.198 |
| 34 | Plant Growth habit | 0.327 | 0.120 | -0.194 | -0.351* | 0.201 | 0.583** | 0.206 | 0.247 | 0.317 | 0.301 | -0.189 | -0.351* | -0.439* | 0.344 | | 0.459 | 0.174 | 0.165 | -0.395 | 0.280 | 0.039 |
| 35 | Plant height (cm) | 0.082 | 0.374* | -0.180 | -0.120 | 0.454** | 0.253 | 0.246 | -0.007 | -0.001 | 0.252 | 0.184 | 0.104 | 0.197 | 0.271 | 0.459** | | -0.222 | 0.305 | -0.285 | 0.229 | 0.104 |
| 36 | Pedicel position at anthesis | 0.648** | -0.108 | 0.097 | -0.348* | -0.323 | -0.109 | -0.288 | 0.119 | 0.144 | -0.435* | -0.157 | -0.083 | -0.019 | -0.345 | 0.174 | -0.222 | | -0.321 | 0.378 | 0.379 | -0.323 |
| 37 | Stem colour | -0.141 | -0.207 | 0.161 | 0.070 | 0.891** | 0.519** | 0.555** | 0.121 | 0.164 | 0.352* | 0.318 | 0.070 | -0.389* | 0.490** | 0.165 | 0.305 | -0.321 | | -0.418 | 0.316 | -0.032 |
| 38 | Seed colour | 0.258 | 0.006 | 0.266 | 0.311 | -0.372* | -0.677** | -0.564** | -0.153 | -0.238 | -0.790** | -0.047 | 0.416* | 0.469** | -0.793** | -0.395* | -0.285 | 0.378* | -0.418* | | -0.027 | -0.141 |
| 39 | Stem pubescence density | 0.154 | -0.101 | 0.087 | -0.060 | 0.271 | 0.529** | 0.206 | 0.563** | 0.502** | -0.016 | 0.168 | 0.102 | -0.060 | 0.161 | 0.280 | 0.229 | 0.379* | 0.316 | -0.027 | | -0.098 |
| 40 | 1000 seed weight (g) | -0.359 | -0.012 | 0.025 | 0.150 | -0.008 | 0.130 | 0.242 | 0.125 | 0.158 | 0.027 | 0.004 | 0.005 | 0.004 | 0.198 | 0.039 | 0.104 | -0.323 | -0.032 | -0.141 | -0.098 | |

*a = Annular constriction at the junction of calyx and peduncle; * = significant at 5%; ** = Significant at 1%*

**Table 3. Matrix of eigenvectors and values of the principal components for 40 morphological characters of chilli**

| Characters | Principal components | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ | $C_8$ |
| Cotyledonous leaf length (mm) | 0.980 | -0.027 | -0.12 | 0.003 | -0.087 | -0.075 | 0.017 | -0.006 |
| Cotyledonous leaf width (mm) | 0.821 | 0.315 | -0.023 | 0.076 | -0.037 | -0.352 | -0.077 | -0.071 |
| Cotyledonous leaf colour | 0.932 | -0.025 | 0.146 | 0.085 | -0.026 | -0.183 | 0.113 | 0.010 |
| Cotyledonous leaf shape | 0.890 | -0.196 | -0.175 | -0.212 | -0.164 | 0.133 | -0.036 | 0.119 |
| Hypocotyl colour | 0.657 | -0.036 | 0.441 | 0.553 | 0.176 | 0.032 | 0.008 | 0.057 |
| Hypocotyl pubescence | 0.743 | -0.223 | 0.193 | -0.289 | 0.287 | -0.162 | -0.027 | 0.012 |
| Plant growth habit | 0.383 | -0.414 | 0.495 | -0.273 | 0.066 | -0.097 | 0.171 | 0.248 |
| Plant height | 0.392 | -0.113 | 0.744 | 0.259 | 0.197 | 0.063 | 0.064 | 0.187 |
| Leaf pubescence density | 0.179 | 0.010 | 0.527 | -0.596 | 0.138 | 0.304 | 0.099 | -0.407 |
| Leaf pubescence type | 0.253 | 0.022 | 0.507 | -0.628 | 0.139 | 0.258 | 0.037 | -0.324 |
| Leaf shape | 0.757 | -0.357 | -0.311 | 0.033 | -0.049 | 0.297 | 0.005 | -0.120 |
| Leaf colour | 0.716 | 0.188 | 0.254 | 0.002 | 0.209 | 0.223 | -0.145 | 0.171 |
| Branching habit | 0.237 | 0.455 | 0.354 | -0.09 | 0.556 | 0.116 | -0.300 | 0.204 |
| Mature leaf length | 0.128 | 0.509 | 0.472 | -0.025 | -0.285 | 0.273 | 0.238 | 0.431 |
| Mature leaf width | -0.296 | 0.613 | 0.478 | 0.095 | -0.231 | 0.061 | 0.360 | 0.212 |
| Stem colour | 0.682 | -0.03 | 0.530 | 0.392 | -0.080 | -0.160 | -0.062 | -0.014 |
| Stem pubescence density | 0.110 | -0.256 | 0.685 | -0.236 | 0.233 | -0.053 | 0.282 | -0.174 |
| Number of pedicels/axil | -0.488 | 0.645 | -0.107 | 0.150 | -0.311 | 0.099 | 0.149 | -0.219 |
| Pedicel position at anthesis | -0.545 | -0.519 | 0.330 | -0.306 | 0.179 | -0.148 | -0.103 | 0.246 |
| Angle between flower and pedicel | -0.519 | -0.584 | 0.340 | -0.221 | 0.083 | -0.119 | 0.078 | 0.305 |
| Corolla length | 0.101 | 0.112 | 0.576 | 0.723 | 0.220 | -0.154 | -0.043 | -0.134 |
| Corolla colour | 0.854 | 0.090 | -0.067 | 0.268 | -0.301 | -0.021 | 0.077 | 0.035 |
| Anther colour | 0.956 | -0.138 | 0.126 | 0.157 | -0.048 | 0.045 | -0.069 | 0.030 |
| Calyx margin shape | 0.857 | 0.182 | -0.112 | -0.198 | -0.239 | 0.305 | -0.051 | 0.078 |
| Annular constriction* | -0.542 | 0.642 | 0.253 | 0.040 | 0.060 | 0.169 | 0.039 | -0.103 |
| Fruit position | -0.204 | -0.546 | 0.241 | 0.027 | -0.528 | -0.027 | 0.142 | -0.187 |
| Fruit/plant | -0.368 | -0.809 | 0.009 | 0.137 | 0.221 | -0.190 | 0.078 | 0.072 |
| Immature fruit colour | 0.655 | -0.037 | 0.476 | 0.521 | 0.130 | -0.073 | -0.037 | -0.146 |
| Mature fruit colour | 0.035 | 0.109 | -0.533 | 0.677 | 0.209 | 0.185 | -0.145 | -0.112 |
| Fruit length | 0.168 | 0.670 | -0.541 | -0.187 | 0.287 | 0.042 | 0.106 | 0.154 |
| Fruit width | 0.090 | 0.888 | 0.239 | 0.016 | -0.04 | -0.138 | 0.036 | -0.056 |
| Fresh fruit weight | 0.156 | 0.790 | -0.254 | -0.127 | 0.238 | -0.346 | 0.134 | 0.002 |
| Dry fruit weight | 0.377 | 0.670 | -0.329 | -0.228 | 0.273 | -0.276 | 0.149 | -0.031 |
| Fruit shape | -0.096 | 0.522 | 0.568 | -0.088 | -0.068 | -0.245 | -0.213 | 0.008 |
| Fruit cross-sectional corrugation | -0.596 | 0.703 | 0.112 | 0.049 | 0.094 | 0.110 | -0.178 | -0.008 |
| Fruit pungency | -0.757 | -0.072 | 0.279 | 0.346 | 0.268 | 0.247 | -0.198 | 0.021 |
| Fruit persistance | -0.027 | -0.257 | -0.351 | 0.406 | 0.449 | 0.522 | 0.261 | -0.089 |
| Seed colour | -0.890 | 0.196 | 0.175 | 0.212 | 0.164 | -0.133 | 0.036 | -0.119 |
| No. of seeds/fruit | 0.872 | -0.020 | 0.042 | -0.172 | 0.035 | -0.049 | -0.061 | -0.161 |
| 1000 seed weight (g) | 0.225 | 0.371 | -0.219 | -0.253 | 0.280 | -0.050 | 0.179 | -0.109 |
| Total variance | 13.234 | 6.813 | 4.739 | 3.677 | 2.063 | 1.849 | 1.767 | 1.137 |
| % total contribution | 33.086 | 17.033 | 11.848 | 9.193 | 5.157 | 4.622 | 4.418 | 2.842 |
| Commulative % | 33.086 | 50.119 | 61.967 | 71.160 | 76.317 | 80.939 | 85.358 | 88.199 |

* Annular constriction at the junction of calyx and peduncle

of all the seedling characters to the first PC indicated their large contribution towards the total variability of the population.

Majority of these characters in the first PC are qualitative in nature and most of them are determined by one or few genes and have a discrete distribution. They can be easily identified and are little affected by environments, although, sometimes their expression may be altered by the action of modifying genes.

The second PC accounted for 17.03% of the total variability. This component was mainly linked with fruit characters as shown by its association with fruit width,

fresh and dry fruit weight, fruit length, fruit cross-sectional corrugation and fruit shape. The association of majority of the fruit characters to the second PC implied that fruit characters of chilli contribute considerably towards the variability and hence emphasis should be given to various fruit characters during germplasm characterization. Infect, the fruit character is so variable that the horticultural classification of chilli is solely based on it.

Plant height, stem pubescence density, corolla length, fruit shape, stem colour, leaf pubescence density and leaf pubescence type showed the greatest variability in third PC. Likewise, mature fruit colour, hypocotyl colour and immature fruit colour exhibited greater influence in fourth PC.

The vegetative characters were found to be distributed mostly in the first four PCs and their general lack of association among themselves and with most of the other plant characters except seedling characters indicated that they were independent set of characters. Therefore, in variability study, inclusion of as much as vegetative traits is important for correct assessment of variability. The inflorescence characters were mostly associated with the first and second PC indicating their significant contribution towards the total variability of the chilli cultivars.

The scatter plot of the cultivar drawn on the basis of the first two principal components is presented in Fig. 1. The differences in morphological characters contributing highly to the first PC (plotted in x-axis) which consisted mainly of seedling characters along with some vegetative, inflorescence and few fruit characters had clearly separated the *C. annuum* accessions from the *C. frutescens* and *C. chinense* accessions. On the other hand, characters contributing highly to the second PC (plotted in y-axis) consisted mainly of fruit characters had distinctly separated most of the *C. frutescens* and *C. chinense* accessions.

The scatter plot technique also allowed distinct grouping of the accessions belonging to each of the species. Three groups were observed in *C. annuum* accessions. Group I included the accessions having purple colouration either in the whole plant or in parts of the plant indicating that this group was distinct from the other groups of *C. annuum.* Group II included *C. annuum* accessions with white flower, conical and elongate medium sized fruits, while group III comprised of accessions with long pendent fruits. Group IV represented the *C. chinense* accessions with relatively smaller erect fruits. The *C. frutescens* accessions belonging to group VI were characterized by small and erect fruit except for accessions ACC (F)-29 which had fruits comparable to accessions belonging to group V. However, two *C. annuum* accessions viz., ACC(A)-02 and ACC(A)-16 were placed outside the groups of the *C. annuum* accessions primarily because of their fruit characteristics which were markedly different from the other cultivars of *C. annuum.*

The characters discussed above not only appeared to be important for characterization of chilli germplasm due to their high contribution towards the variability but were also equally capable of resolving the cultivars into species level. Therefore, special emphasis should be given on these characters during morphological characterization of chilli germplasm.

Twenty eight, minimum descriptors were identified in this study based on principal component analysis and correlation among different characters. For integrating the list of minimum descriptors (Table 4), all the seedling characters except cotyledonous leaf width were retained as they not only contributed highly to the total variability

**Table 4. Minimum descriptors for morphological characterization of chilli germplasm**

| **Seedling characters** | **Inflorescence and fruit characters** | **Seed characters** |
|---|---|---|
| Cotyledonous leaf length (mm) | Number of pedicels/axil | Seed colour |
| Cotyledonous leaf shape | Pedicel position at anthesis | No. of seeds/fruit |
| Cotyledonous leaf colour | Angle between flower and pedicel | |
| Hypocotyl pubescence | Corolla colour | |
| Hypocotyl colour | Calyx margin shape | |
| | Annular constriction at the junction of calyx and peduncle | |
| **Vegetative characters** | Fruit position | |
| Plant growth habit | Fruit/plant | |
| Plant height | Mature fruit colour | |
| Mature leaf length | Fruit length | |
| Leaf shape | Dry fruit weight | |
| Leaf colour | Fruit shape | |
| Branching habit | Fruit cross-sectional corrugation | |
| | Fruit pungency | |
| | Fruit persistence | |

but some of them also showed significant association among themselves and with some other important traits. Cotyledonous leaf breath was highly correlated with cotyledonous leaf length. Hence, scoring one of them would be sufficient. Similarly, leaf pubescences density, leaf pubescence type and stem pubescence density were also dropped from the list owing to their relatively low contribution towards total variability and their significant positive correlation with hypocotyl pubescence. Pubescence in hypocotyl in easier to score so retention of this character was felt sufficient.

Among the inflorescence characters, anther colour was omitted in the minimum descriptor list as it exhibited significant positive correlation with all the seedling characters and few other traits. Corolla length was rejected due to its non significant contribution to total variability.

The fruit characters of chilli are most important as some of them like fruit per plant, dry fruit weight, fruit shape and size, fruit colour and pungency, ultimately determine the economic value of the crop. Some of these characters like fruits per plant, fruit dry weight, fruit size etc. were found to be associated with fruit yield (Legg and Lippert, 1966; Gill *et al.*, 1977; Venkata Rao and Chhonkar, 1983). In the present study, dry and fresh fruit weight was found to be correlated and they contributed highly to the total variability. However, because of commercial importance and its correlation with fruits per plant and yield (Devi and Arumugam, 1999), dry fruit was retained. Among the seed characters, 1000 seed weight was rejected due to its low contribution to the total variability.

In the minimum descriptor list, some characters were however retained irrespective of their contribution to the total variability and correlation pattern primarily because these are considered species diagnostic traits. Moreover, many of the traits (pungency, fruit position, fruit shape, fruit colour, number of pedicels/axil, flower colour, leaf pubescence, plant colour, plant height etc.) included in the minimum descriptors are controlled by single or few genes (Legg and Lippert, 1966; Uzo, 1984; Loaiza-Figueroa and Tanksley, 1988; Shuh and Fontenot, 1990). Therefore, they are little effected by environment and can easily be identified. Thus, the set of minimum descriptors were supposed to be highly discriminating and expected to cover an important part of the existing diversity of chilli.

The Principal Component Analysis (PCA) allowed the dissection of various morphological characters contributing highly to the total variability in chilli and thus provided a direction towards the choice of characters in variability study and characterization of chilli germplasm. It also provided a quicker method for morphological based classification of various species of chilli which is often necessary for initial categorization of germplasm. Twenty eight characters comprising of seedling, vegetative, inflorescence and fruit characters have been included in the list of minimum descriptors for chilli. These descriptors have high heritability, uniform expressivity and high visual scorability and thus expected to be highly discriminating and would allow rapid characterization of chilli germplasm.

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