**Morphological characterization of *Capsicum* spp. accessions from the germoplasm collection of Corpoica C.I. Palmira, Colombia**

**Caracterización morfológica de introducciones de *Capsicum* spp.existentes en el Banco de Germoplasma activo de Corpoica C.I. Palmira, Colombia**

*Diana Villota-Cerón*, *Martha Liliana Bonilla-Betancourt*2\*, *Horacio Carmen-Carrillo*3, *Juan**Jaramillo-Vásquez*4, and *Mario Augusto García-Dávila*5

Universidad de Nariño, Pasto, Nariño, Colombia. 2,3,4Colombian Corporation for Agricultural Research, Corpoica Palmira, Valle del Cauca, Colombia. 5Universidad Nacional de Colombia - Palmira, Department of Agricultural Sciences, Palmira, Valle del Cauca, Colombia.

\*Corresponding author: mbonilla@corpoica.org.co, mlbonillab@gmail.com

Rec.: 12.10.11 Acept.: 04.03.12

**Abstract**

68 accessions from the *Capsicum* collection of the Colombian Corporation for Agricultural Research CORPOICA, Palmira were morphologically characterized by using 12 quantitative and 10 qualitative descriptors. The variables with highest contribution in the principal components analysis were associated to plant architecture and fruit descriptors that explained 70.8% of the total variability. Classification analysis, based on quantitative data, showed 5 groups but it did not allow discrimination between species. For the multiple correspondence analyses, 83.4% of the variability was explained by variables related with flower and fruit traits. The classification analyses, using qualitative descriptors, showed 4 groups and allowed discrimination of *C. baccatum* species. The discriminant analysis showed that *C. annuum*, *C. frutescens*, and *C*. *chinense* are close phylogenetically.

**Key words:** Accessions, *Capsicum*, morphological characterization.

**Resumen**

Se caracterizaron morfológicamente 68 introducciones del género *Capsicum* existentes en el Banco de Germoplasma activo del Centro de Investigaciones Agropecuarias (Corpoica) Palmira, utilizando 12 descriptores cuantitativos y 10 cualitativos. En el análisis de componentes principales las características de mayor contribución fueron las relacionadas con el fruto y arquitectura de planta, que explicaron el 70.8% de la variabilidad. El análisis de clasificación permitió conformar cinco grupos con base en características cuantitativas, pero no permitió discriminar entre especies. En el análisis de correspondencia múltiple el 83.4% de la variabilidad fue explicada por los descriptores de flor y fruto. El análisis de agrupamiento para las variables cualitativas generó cuatro grupos y discriminó la especies *C. baccatum.* El análisis discriminante mostró que las especies *C. annuum*, *C. frutescens*, y *C*. *chinense* son cercanas filogenéticamente.

**Palabras clave:** *Capsicum*, caracterización morfológica, introducciones.

**Introducción**

The genus *Capsicum* is native to the Americas continent (Bolivia, Peru, south of Mexico and Colombia). However, its natural range ex­tends from southern United States to Argenti­na (Arias and Melgarejo, 2000). It comprises about 25 species from which *C. annuum L., C. chinense Jacq., C. pubescens* Ruiz & Pav., *C. frutescens* L. and *C. baccatum* L. have been domesticated and cultivated primarily for its high content of vitamins A and C, and the content of capsaicinoids and alkaloid respon­sible for the pungency (Nuez *et al.*, 1996). The diversity available within the domesti­cated taxa has been little exploited, and the use of this variability is relatively easy compa­red to the problems of interspecific transfer of genes to other genera (Pickersgill, 1997). Their breeding depends on the availability and strategic use of genetic diversity. Genetic variation of wild species, compared to domes­ticated, provides novel gene complexes for strategic breeding to tolerance of biotic and abiotic factors (Votaba *et al.*, 2002).

From this research, it is expected to con­tribute to the study of morphological variabi­lity of 68 accessions of *Capsicum* from the active Germplasm Bank that is settled in the Research Center Corpoica-Palmira, and also to the selection of promising accessions to increase the supply of varieties of this genus.

**Materials and Methods**

Morphological characterization was performed at the Research Center Corpoica-Palmira, Valle del Cauca, Colombia, located at 1001 MASL, average temperature of 24°C and ave­rage rainfall of 1022 mm/year.

**Plant material**

68 accessions of *Capsicum* genus were carac­terized. Those belonged to *C. annuum, C. fru­tescens, C. chinense, C. pubescens* and *C. ba­ccatum* species from the Germoplasm Bank at the Colombian Corporation of Agricultural Research (Corpoica) C.I Palmira. It was also included commercial genotypes in Colombia represented by *C. chinense* (Habanero Ama­rillo), *C. annuum* (Jalapeño Telica and Cayene Durke) and *C. frutescens* (Tabasco Costa) (Ta­ble 1). A completely randomized design was used with 18 plants per introduction, without replicates. Plants of each Introduction were planted in double rows at a distance of 40cm between plants and 1.20cm between rows.

**Morphological characterization**

12 quantitative and 10 qualitative descriptors of plant, flower, fruit and seed were selected according to IPGRI *et al.* (1995). Those were identified as discriminating in previous cha­racterization studies (Pardey *et al.*, 2006) (Ta­ble 2). Each descriptor was evaluated in nine plants to obtain the average value of the re­sults.

**Analysis of results**

Descriptive analysis, simple correlation and principal components (PCA) were performed for quantitative variables. Principal compo­nents were selected with eigenvalues >1.0, which explain the greater variability in the studied population. From PCA, the classifi­cation analysis was performed following the ranking aggregation method of Lebart *et al.* (1998).

Multiple correspondence analysis (MCA) was performed for qualitative variables to ob­tain a three-dimensional representation of the grouping of genotypes based on genetic dis­tances. The statistical package NTSYS-pc version 1.80 (Rohlf, 1994) was used to get data of genetic similarity. Then, a grouping matrix and subsequently, the dendrogram were generated by the UPGMA arithmetic ave­rage, non-weighted method. Discriminant relatioships between species and group of analysis was performed to establish relationships between species and group of individuals.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Table 1.** *Capsicum* accessions evaluated from the existing collection in C.I Corpoica-Palmira. | | | | | | |
| **Consecutive** | **Accession** | **Species** | **Consecutive** | **Accession** | **Species** | |
| 1 | Yellow habanero | *C. chinense* | 35 | 2762 | *C. annuum* | |
| 2 | Jalapeño Telica | *C. annuum* | 36 | 1371 | *C. frutescens* | |
| 3 | Tabasco Costa | *C. frutescens* | 37 | 486 | *C. baccatum* | |
| 4 | Cayene Durke | *C. annuum* | 38 | 2606 | *C. baccatum* | |
| 5 | 820 | *C. annuum.* | 39 | 2577 | *C. frutescens* | |
| 6 | 593 | *C. baccatum* | 40 | 535 | *C. chinense* | |
| 7 | 1312 | *C. frutescens* | 41 | 820(1) | *C. annuum* | |
| 8 | 1391(1)a | *C. frutescens* | 42 | 1404 | *C. chinense* | |
| 9 | 1391 | *C. frutescens* | 43 | 1406 | *C. chinense* | |
| 10 | 1390 | *C. chinense* | 44 | 590 | *C. annuum* | |
| 11 | 346 | *C. baccatum* | 45 | 1360 | *C. chinense* | |
| 12 | 1353(3) | *C. chinense* | 46 | 612 | *C. chinense* | |
| 13 | 2608 | *C. baccatum* | 47 | 2570(1) | *C. annuum* | |
| 14 | 1353 | *C. chinense* | 48 | 1409 | *C. annuum* | |
| 15 | 1414 | *C. chinense* | 49 | 1378 | *C. pubescens* | |
| 16 | 597 | *C. chinense* | 50 | 2579(3) | *C. chinense* | |
| 17 | 1306 | *C. chinense* | 51 | 1319(1) | *C. annuum* | |
| 18 | 529 | *C. chinense* | 52 | 002 | *C. annuum* | |
| 19 | 1374 | *C. annuum* | 53 | 2550 | *C. annuum* | |
| 20 | 1324 | *C. chinense* | 54 | 2761 | *C. anuum* | |
| 21 | 2547 | *C. annuum* | 55 | 1381 | *C. frutescens* | |
| 22 | 1367 | *C. frutescens* | 56 | 456 | *C. chinense* | |
| 23 | 1334 | *C. chinense* | 57 | 333 | *C. baccatum* | |
| 24 | 1353(4) | *C. chinense* | 58 | 1353(2) | *C. chinense* | |
| 25 | 2659 | *C. chinense* | 59 | 1420 | *C. annuum* | |
| 26 | 536 | *C. annuum* | 60 | 2570 | *C. annuum* | |
| 27 | 039P | *C. annuum* | 61 | 1327 | *C. annuum* | |
| 28 | 036P | *C. annuum* | 62 | 1372 | *C. annuum* | |
| 29 | 038Pv | *C. annuum* | 63 | 1307 | *C. frutescens* | |
| 30 | 591 | *C. baccatum* | 64 | 037P | *C. annuum* | |
| 31 | 1390(1) | *C. chinense* | 65 | 1375(1) | *C. annuum* | |
| 32 | 063 | *C. baccatum* | 66 | 1421 | *C. baccatum* | |
| 33 | 2544 | *C. baccatum* | 67 | 2579(2) | *C. chinense* | |
| 34 | 1423 | *C. annuum* | 68 | 536(1) | *C. annuum* | |
| a. Accessions coded with a number in parentheses are identified plants from accessions with segregation, that were also independently evaluated for this study.. | | | | | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Table 2.** Quantitative and qualitative descriptors assessment of the existing *Capsicum* collection in C.I. Corpoica-Palmira. | | | | | | |
| **Qualitative variables** | **Identification** | | **Qualitative variables** | | **Identification** | |
| Flower position | | PF | | Plant height | | ALP |
| Corolla color | | CC | | Plant width | | ANP |
| Presence/ absence of stains | | PM | | Leaf width | | ANH |
| Stigma erection | | EE | | Blade length | | LH |
| Anthers opening | | AA | | Pedicel length | | LP |
| Calyx anular constriction | | CAC | | Number of flowers \* axilla | | NFA |
| Fruit shape | | FF | | Corolla length | | LC |
| Apex fruit shape | | FAF | | Fruit length | | LF |
| Fruit epidermis type | | TEF | | Fruit width | | AF |
| Seed color | | CS | | Fruit weight | | PF |
| ― | | ― | | Wall thickness of the fruit | | EPF |
| ― | | ― | | Number of locules | | NL |

**Results and discussion**

**Qualitative descriptors**

*Capsicum* species share common features, but some have their own characteristics highligh­ting: *C. baccatum* by the stain on the corolla, *C. chinense* by constriction ring in the cup, *C. frutescens* by the erect position of the fruit, and *C. annuum* the slope position of the fruit (Table 3).

**Multiple correspondence analysis**

The 10 qualitative variables in the MCA allo­wed identifying four dimensions that explain more than 80% of the total variability (Table 4). The first dimension is defined by the va­riables anther opening (AA) with a contribu­tion of 35%, fruit epidermis type (EF) with 27%, and flower position (PF) with 16%. The second dimension is defined by the descriptor corolla color (CC) with a contribution of 29%. The third dimension is defined by apex shape of the fruit (FAF). The fourth dimension is defined by the calyx ring block (CAC) in 15.2%. Photo 1 shows the great variation in flower and fruit descriptors for the evaluated accessions.

**Clustering analysis**

Four groups were identified in the classifica­tion analysis based on the MCA, which showed a clustering tendency by species characteristics (Figure 1).

The first group consists of accessions be­longing to the species *C. baccatum*. These accessions had spots on the corolla, exserted stigma and anthers separated from the stigma. These characteristics are representa­tive of this species and used as taxonomic classification criteria. The opening descriptor of the anther was added to the list of des­criptors proposed by IPGRI *et al.* (1995), and was characteristic of these species accessions.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Table 3.** Qualitative descriptors used in 68 accessions of Capsicum in the existing collection of C.I. Corpoica-Palmira. | | | | | | |
| **Descriptor** | **Category** | ***C. annuum*** | ***C. baccatum*** | ***C. chinense*** | ***C. frutescens*** | ***C. pubescens*** |
| Flower position | Pendula  Intermediate  Erect | 21  35  42 | ―  ―  100 | ―  15  85 | ―  15  85 | ―  ―  100 |
| Corolla color | White  Light yellow  Yellow Green  Purple | 57  36  7  0  ― | ―  100  ―  ―  ― | ―  40  60  ―  ― | ―  ―  100  ―  ― | ―  ―  ―  ―  100 |
| Presence/ absence of stains | Present  Absent | ―  100 | 100  ― | ―  100 | ―  100 | 100  ― |
| Stigma exsertion | Insert  At the same level  Exsertedo | ―  11  89 | 80  10  10 | ―  ―  100 | ―  ―  100 | ―  100  ― |
| Anthers opening | Open  Closed | 7  93 | 100  0 | 5  95 | ―  100 | 100  ― |
| Calyx constriction ring | Present  Absent | ―  100 | ―  100 | 100  ― | ―  100 | ―  100 |
| Fruit shape | Elongated  Triangle-shaped  Bell-shaped | 25  71  4 | 100  ―  ― | ―  28  72 | 25  75  ― | ―  100  ― |
| Apex fruit shape | Pointy  Romo  Sunked | 82  17  ― | 100  ―  ― | 71  ―  28 | 38  62  ― | ―  100  ― |
| Fruit epidermis type | Smooth  Semi-rough  Rough | 68  29  3 | ―  80  20 | 0  62  38 | 12  75  13 | 100  -  - |
| Seed color | Yellor  Black | 100  ― | 100  ― | 100  ― | 100  ― | ―  100 |
| The values indicate the percentage of accessions presenting the respective category | | | | | | |

**Figure 1.** Hierarchical classification of 68 accessions of *Capsicum* in the existing germplasm bank in Corpoica Palmira. Obtained from multiple correspondence analysis (MCA).



The second group consists of two acce­ssions 002 belonging to the species *C. annuum* and the 1378 introduction belonging to *C. pubescens* specie. The species *C. pubescens* is considered unique among domesticated cap­sicum by adaptation (Bosland, 1996). This introduction is characterized by purple corolla and triangular fruit, and this should have

The third group consists of 17 accessions, all belonging to the *C. annuum* Specie. These accessions were characterized by a white co­rolla and exserted stigma.

The fourth group comprises 57.3% of the studied accessions. The following accessions species met in this group: *C. chinense, C. fru­tescens*, and some accessions of *C. annuum*. These materials presented exserted stigma, yellow seed color and upright flower position, a typical characteristic of the species *C. fru­tescens* and *C. chinense*. To these belong the most accessions of this group.

**Picture 1.** Morphological variability of *Capsicum* in the existing germplasm bank in Corpoica Palmira. **A-E**, corolla color and anther aperture. F-I, fruit variability: color, shape and size. **J-L**, flower position (pendula, erect and intermediate, respectively). **M-N**, seed color.



Vallejo *et al.* (2006) and Palacios-Castro and Garcia-Davila (2008) were able to dis­criminate the species *C. pubescens* and *C. bacccatum*, but not between the species *C. annuum, C. frutescens* and *C. chinense*. The results of this study confirmed the hypothesis that these three species are a culti group in differentiation pathway (Pickersgill, 1997). The cophenetic coefficient (0.82) also indi­cated a high degree of correspondence bet­ween the similarity matrix and the dendro­gram obtained as a measure of dispersion.

**Relationships between species**

Mahalanobis distance indicated that *C. annuum, C. frutescens* and *C. chinense* spe­cies are phylogenetically close (Table 5). The results of this study support the observations made by Garcia (2006) about the species *C. annuum, C. frutescens* and *C. chinense* becau­se they form a group that is in the process of differentiation. This statement is attributed to the phylogenetic distances between groups and within groups based on morphological, isozyme and crossability studies among wild and domesticated species.

|  |  |  |  |
| --- | --- | --- | --- |
| **Table 4.** Multiple correspondence analysis for qualitative variables of 68 *Capsicum* accessions in the existing collection of C.I. Corpoica-Palmira. | | | |
| **Number** | **Eigenvalue** | **Percentage** | **Accumulated percentage** |
| 1 | 0.0311 | 36.71 | 36.71 |
| 2 | 0.0198 | 23.35 | 60.06 |
| 3 | 0.0118 | 13.94 | 74.00 |
| 4 | 0.0080 | 9.45 | 83.45 |
| 5 | 0.0063 | 7.45 | 90.90 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 5.** Square genetic distance between *Capsicum* species in the existing collection of C.I. Corpoica-Palmira. | | | | | |
| **Variables** | *C. annuum* | *C. baccatum* | *C. chinense* | *C. frutescnes* | *C.pubescens* |
| *C. annuum* | 1.77 |  |  |  |  |
| *C. baccatum* | **83.71** | 3.83 |  |  |  |
| *C. chinense* | 14.58 | **90.32** | 2.34 |  |  |
| *C. frutescens* | 6.22 | **88.45** | 4.558 | 4.28 |  |
| *C. pubescens* | **74.05** | **215.2** | **146.34** | **114.89** | 8.43 |

**Quantitative descriptors**

Quantitative descriptors presented a wide range of variation, which is deduced from scattering and the intervals measurements in each of the attributes (Table 6). The coeffi­cient of variation (CV) was > 25% for 75% of the descriptors considered, confirming the importance of these descriptors to discrimi­nate variability in active genebanks or germplasm banks of chile. The leaf length and number of cores were the descriptors that contributed the least to variability, which confirms the results of Pardey *et al.* (2006).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 6.** Simple statistical for 12 quantitative traits of *Capsicum* species in the existing collection of C.I. Corpoica-Palmira. | | | | | |
| **Variable** | **Media** | **Max. Value.** | **Min. Value** | **S.D** | **C.V. (%)** |
| Plant height | 111.160 | 179 | 34 | 33.76 | 30.38 |
| Plant width | 93.237 | 154 | 40 | 23.97 | 25.71 |
| Leaf width | 4.625 | 7.4 | 1.9 | 1.1609 | 25.10 |
| Leaf length | 8.803 | 12.5 | 3.5 | 1.914 | 21.74 |
| Corolla length | 1.828 | 3 | 0.9 | 0.4462 | 24.41 |
| Number of flowers per axill | 1.338 | 2 | 1 | 0.4766 | 35.62 |
| Pedicel lenght | 3.450 | 10 | 0.7 | 1.4356 | 41.61 |
| Fruit lenght | 5.235 | 10.9 | 0.4 | 2.8433 | 54.31 |
| Fruit width | 1.986 | 3.81 | 0.76 | 0.8085 | 40.70 |
| Fruit weight | 5.913 | 18.6 | 0.18 | 4.840 | 81.85 |
| Wall fruit tickness | 0.200 | 0.4 | 0.02 | 0.0937 | 46.65 |
| Number of cores | 2.529 | 4.0 | 2.0 | 0.5591 | 22.10 |

The highest correlations were observed between leaf length and leaf width variables, with a coefficient (r) of 0.76. Width of the plant and plant height was r = 0.65. Wall thickness of the fruit, and width and weight of the fruit were r = 0.60 and 0.68, respectively (Table 7).

**Principal component analysis**

PCA showed that the first four components are eigenvalues > 1, with a cumulative varia­bility of 70.8% (Table 8). The contribution of each quantitative variable to the formation of the axes is shown in Table 9. The represen­tation of three-dimensional space of the 12 quantitative variables in the first three princi­pal components is presented also in Figure 1, where the major variable contribution is rela­ted to the characteristics of fruit and vegeta­bles.

Variables with the highest contribution to the first CP construction are related to fruit variables like: fruit weight (PF), wall thickness of the fruit (EPF), fruit width (AF) and fruit length (LF).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 7.** Coefficient matrix of Pearson correlations between 12 quantitative variables of *Capsicum* species in the existing collection of I.C. Corpoica-Palmira. | | | | | | | | | | | | |
| **Variables** | **ALP** | **ANP** | **ANH** | **LH** | **LC** | **NFA** | **LP** | **LF** | **AF** | **PF** | **EPF** | **NL** |
| Plant height | 1.00 |  |  |  |  |  |  |  |  |  |  |  |
| Plant width | **0.65\*** | 1.00 |  |  |  |  |  |  |  |  |  |  |
| Leaf width | 0.25 | 0.32 | 1.00 |  |  |  |  |  |  |  |  |  |
| Leaf length | 0.43 | 0.34 | **0.76** | 1.00 |  |  |  |  |  |  |  |  |
| Corolla length | -0.27 | -0.35 | -0.30 | -0.23 | 1.00 |  |  |  |  |  |  |  |
| Number of flowers / axil | -0.13 | 0.36 | 0.27 | 0.29 | -0.39 | 1.00 |  |  |  |  |  |  |
| Pedicel length | -0.17 | -0.09 | 0.03 | -0.10 | 0.26 | -0.11 | 1.00 |  |  |  |  |  |
| Fruit length | -0.18 | -0.04 | -0.007 | 0.04 | 0.46 | -0.19 | 0.18 | 1.00 |  |  |  |  |
| Fruit width | -0.30 | -0.22 | 0.18 | -0.01 | 0.33 | -0.02 | 0.41 | 0.08 | 1.00 |  |  |  |
| Fruit weight | -0.39 | -0.34 | -0.02 | -0.07 | 0.47 | -0.21 | 0.27 | **0.60** | **0.56** | 1.00 |  |  |
| Fruit wall tickness | -0.38 | -0.41 | -0.16 | -0.23 | 0.43 | -0.25 | 0.32 | 0.32 | **0.60** | **0.68** | 1.00 |  |
| Number of cores | -0.06 | -0.01 | 0.17 | 0.08 | -0.07 | 0.01 | 0.04 | 0.38 | 0.21 | 0.43 | 0.29 | 1.00 |
|  | **ALP** | **ANP** | **ANH** | **LH** | **LC** | **NFA** | **LP** | **LF** | **AF** | **PF** | **EPF** | **NL** |
| \* Values in bold are significant (P < 0.001). | | | | | | | | | | | | |

|  |  |  |  |
| --- | --- | --- | --- |
| **Table 8.** Principal component analysis (PCA) for quantitative variables of *Capsicum* species in the existing collection of C.I. Corpoica-Palmira. | | | |
| **Number** | **Eigenvalue** | **Percentage** | **Accumulated percentage** |
| 1 | 3.9641 | 33.03 | 33.03 |
| 2 | 2.2364 | 18.64 | 51.67 |
| 3 | 1.2338 | 10.28 | 61.95 |
| 4 | 1.0619 | 0.090 | 70.80 |
| 5 | 0.8686 | 0.072 | 78.04 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Table 9.** Quantitative variables contribution to the formation of the first four principal components (PC) of *Capsicum* species in the existing collection of C.I. Corpoica-Palmira. | | | | |
| **Variable** | **CP1** | **CP2** | **CP3** | **CP4** |
| Plant height | -0.3287 | 0.1517 | 0.2795 | 0.3400 |
| Plant width | -0.3257 | 0.2307 | 0.1847 | 0.2301 |
| Leaf width | -0.1763 | 0.5207 | -0.1707 | 0.0300 |
| Leaf length | -0.2233 | 0.4698 | 0.0445 | 0.1247 |
| Number of flowers/axil | -0.2298 | 0.2053 | -0.3552 | -0.2044 |
| Corolla length | 0.3446 | -0.0526 | 0.2114 | 0.4539 |
| Pedicel length | 0.2112 | 0.1462 | -0.2989 | 0.4964 |
| Fruit length | 0.2520a | 0.2530 | 0.5579 | 0.0458 |
| Fruit width | 0.2921 | 0.2860 | -0.4553 | 0.1111 |
| Fruit weight | 0.3999 | 0.2676 | 0.1097 | -0.1037 |
| Wall fruit tickness | 0.4007 | 0.1289 | -0.1076 | -0.3990 |
| Number of cores | 0.1384 | 0.3622 | 0.2323 | -0.5419 |
| a. Underlined variables are the ones with the highest contribution to each component | | | | |

The second CP is determined by the des­criptors of plant: leaf width (ANH), leaf length (LH) and width of the plant (ANP). Pardey *et al.* (2006) found similar results when studying characteristics of fruit and plant, which had the highest contribution to the formation of the first two components, respectively, dis­criminating the variability between and among species.

The variable plant height (ALP) makes the largest contribution to the third component, while the fourth CP was defined by floral structures like the length of the corolla (LC) and the length of the pedicel (LP).

Results from this study confirm that the variability of the genus *Capsicum* is defined first, by the characteristics of the fruit, follo­wed by the architecture of the plant and flower descriptors (Pardey *et al.*, 2006; Vallejo *et al.*, 2006).

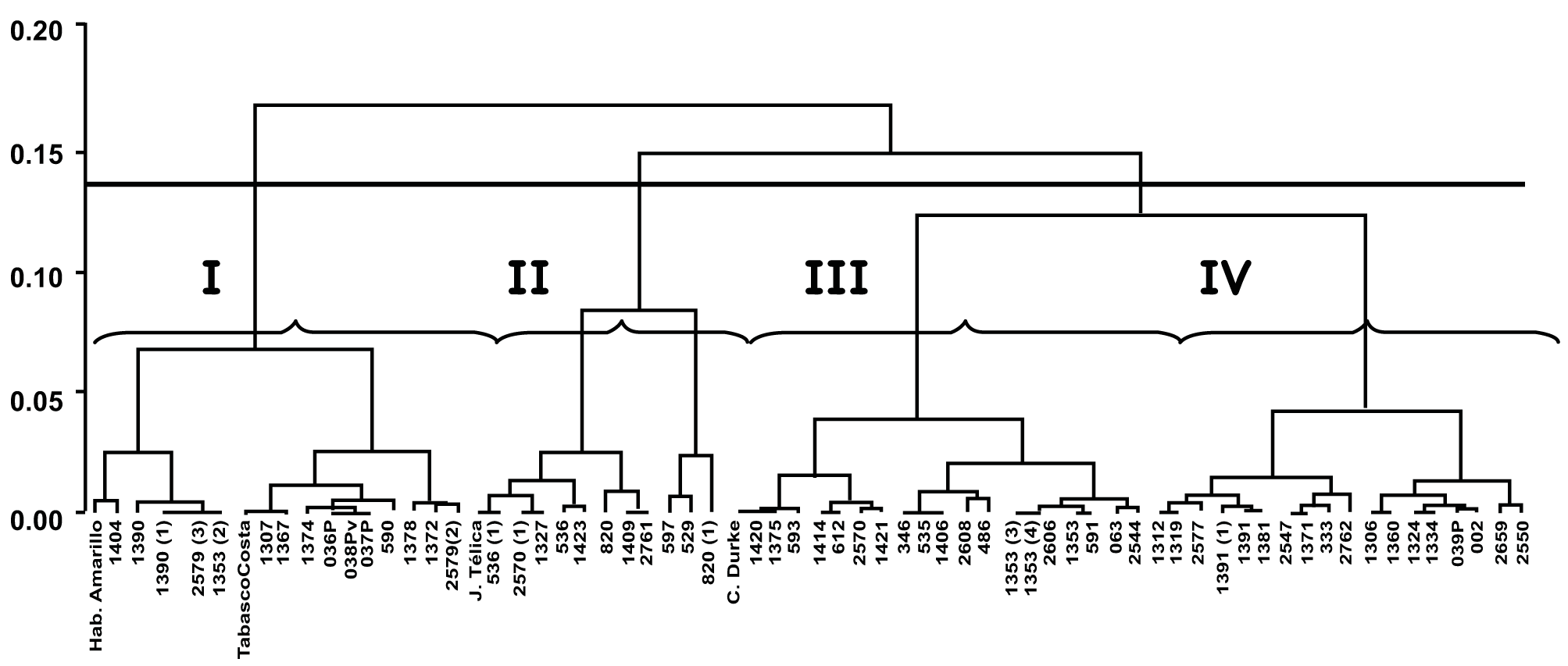
**Clustering analysis**

The dendrogram shows four representative groups (Figure 2), where its clusters corre­s-pond to materials with similar quantitative attributes, but showed no obvious relation­ship between species or collection environ­ments based on the passport data.

The first group represents 34% of the acce­ssions. This group consists of genotypes of all the studied species: yellow habanero, 1404, t.co, 1307.1367, 1374, 036P, 038Pv, 037P, 590, 1421.2570, 1414, 612, 1378, 1372, 2579-2, 1390, 1390-1456,2579-31353-2. Despite the differences between species, 87% of genotypes have in common narrow leaves (width is lower than the overall average 4.6 cm) and the corolla lenght is lower than the overall average (1.83 cm).

Group 2 is represented by jtel, 536-1, 2570 to 1.1327, 536, 1423.820, 1409 and 2761, 597, 529, 820-1 accessions, which mainly belong to *C. annuum*. Those are cha­racterized by solitary flowers and fruits with two cores. mThe presence of single flowers is a characteristic of the *C. annuum* species (Va­llejo *et al.*, 2006).

**Figure 2.** Dendrogram of the hierarchical classification analysis of 68 accessions of Capsicum from the existing Germplasm Bank of Corpoica Palmira. Retrieved from the principal component analysis (PCA) using SAS statistical software version 6.0 (1989).



The third group consists of accessions: Cayenne Durke, 1420, 593, 2608, 1353-3, 1353, 1353-4, 2606, 591, 063, 1375-1, 1421, 1414, 612, 535, 2570, 346, 2544, 1406 and 486. These accessions represent 30% of the studied population. ,This group includes most of the accessions of *C. baccatum* characterized by one flower per axillar bud and three locules in the fruit, which is representative of the *C. baccatum* specie.

The fourth group is comprised of acce­ssions: 1306, 1360, 002.1406, belonging to the *C. chinense* and *C. baccatum* species. These accessions are grouped by wider and longer leaves.

Group five consists of the accessions 1312, 1319-1, 1324, 2577, 1391-1, 1391, 1381, 2547.1371, 039p, 1334, 2659, 2550, 2762 and 333. This group includes acce­ssions of *C. annuum, C. chinense, C. baccatum* and *C. frutescens* species. Those have similar characteristics of plant architecture like wider and taller plants with big leaves, wall fruit thicker than the overall average, approxi­mately 80% have fruit length and weight lower than the overall average (5.23 cm) and (5.8 cm) respectively.

Cophenetic coefficient (0.78) indicates a high degree of correspondence between the similarity matrix and the dendrogram obtai­ned as a measure of dispersion. In other words, the hierarchical structure of the den­drogram represents in a tight way, the true distances between individuals.

**Conclusions**

* The studied accessions from the Germplasm Bank at Corpoica-Palmira, have a wide variability for qualitative and quantitative characters. Quantitative po­lymorphisms were primarily related with attributes of the fruit, foliage and flower structures. These results confirm what other authors have said about the variabi­lity of the *Capsicum* genus, which is defi­ned by the characteristics of fruit, followed by the architecture of the plant and flower descriptors.
* The variability that was found in this study indicates that there is germplasm with enough quality, excelling the acce­ssions 1391 (1) 1312, 1390, 346, 1353, 1324 and 039P. Those were identified as promising materials in sensory studies with capsaicin content of >1 mg/ml, sur­passing commercial controls. Moreover, those have outstanding yields and other organoleptic characteristics of great importance to the industry as color and aroma that can make it become an important germplasm for future breeding work.
* Morphological characterization was not distinguished between *C. annuum, C. chinense* and *C. frutescens* species, which were reflected in the clusering analysis. The discriminant analysis also indicated that *C. annuum, C. frutescens* and *C. chinense* species are phylogenetically close.

**Acknowledgements**

To the Ministry of Agriculture and Rural De­velopment of Colombia and the Colombian Vegetable and Fruit Association for suppor­ting this research. To the Colombian Agri­cultural Research Corporation (Corpoica) CI La Selva, Dr. Mario Lobo. To the Universidad Nacional de Colombia-Palmira. Dr. Gilberto Gomez Caribia from the Caribia Experimental Station. To the Corporation Research Center for Technology Management of Passiflora del Huila (CEPASS). To the farmers for their co­llaboration in the collections, and the stu­dents Fernando Silva and Hugo Mario Reyes for their collaboration in the development of this research.

**References**

Arias, J.; and Melgarejo, L. M. 2000. Ají. Historia, diversidad y usos. Instituto Amazónico de investigaciones científicas Sinchi. Minambiente y Colciencias. 29 p.

Bosland, P. W. 1996. *Capsicums*: Innovative uses of an ancient crop. En: Progress in new crops. Janick, J. (ed.). ASHS Press, Arlington, VA, USA. p. 479 - 487

García, M. A. 2006. Estudio de la variabilidad genética del género *Capsicum.* Proyecto de tesis doctoral. Palmira. Universidad Nacional de Colombia. 93 p.

IPGRI; AVRDC; CATIE. 1995. Descriptores para *Capsicum* (*Capsicum* spp.). Instituto Internacional de Recursos Fitogenéticos, Roma, Italia; Centro Asiático para el Desarrollo y la Investigación relativos a los Vegetales, Taipei, Taiwán; Centro Agronómico Tropical de Investigación y Enseñanza, Turrialba, Costa Rica. 51 p.

Lebart, W., L.; Morineau, A.; and Piron, M. 1998. Statistique exploratoire multidimensionnelle, ed. Dunod. París.

Nuez, F.; Gil, R.; and Costa, J. 1996. El cultivo de pimientos, chiles y ajíes. Madrid: Mundiprensa. 607 p.

Palacios-Castro, S.; and García-Dávila, M. A. 2008. Caracterización morfológica de 93 accesiones de *Capsicum* spp. del Banco de Germoplasma de la Universidad Nacional de Colombia- sede Palmira. Acta Agronómica 57 (4):247 - 252.

Pardey, C.; García, M.; and Vallejo-Cabrera, F. A. 2006. Caracterización morfológica de cien introducciones de *Capsicum* del Banco de Germoplasma de la Universidad Nacional de Colombia, sede Palmira. Acta Agronómica 55(3):1 - 9.

Pickersgill, B. 1997. Genetic resources and breeding of *Capsicum* spp. Euphytica 96:129 - 133.

Rohlf, F. J. 1994. Numerical taxonomy and multivariate analysis system. Versión 1.80 Applied Biostastics. Stauket, N.Y.

SAS Institute Inc. 1989. SAS/STAT User's Guide, Version 6, Fourth Edition, Volume 2, Cary, NC: SAS Institute Inc.

Votaba, E. J.; Nabhan, G. P.; and Bosland, P. W. 2002. Genetic diversity and similarity revealed via molecular analysis among and within an in situpopulation and ex situ accessions of chiltepin (*Capsicum annuum* var. *glabriusculum*). Cons. Gene. 3:123 - 129.

Vallejo, F. A.; García, M. A.; Durán, T. M.; and Pardey, C. 2006. Caracterización morfoagronómica de 195 introducciones de *Capsicum* del Banco de Germoplasma de la Universidad Nacional de Colombia- sede Palmira. 260 p.