horticultura brasileira

Pesquisa / *Research*

SILVA CQ; JASMIM JM; SANTOS JO; BENTO CS; SUDRÉ CP; RODRIGUES R. 2015. Phenotyping and selecting parents for ornamental purposes in chili pepper accessions. *Horticultura Brasileira* 33: 066-073. DOI - http://dx.doi.org/10.1590/S0102-053620150000100011

Phenotyping and selecting parents for ornamental purposes in chili pepper accessions

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ABSTRACT

The market for ornamental peppers in Brazil is arising and breeding new cultivars adapted to Brazilian environmental conditions is necessary. This work describes the characterization of 22 pepper accessions (*Capsicum* spp.) considering traits related to ornamental purposes, analyzes the genetic dissimilarity among the accessions and indicates promising genotypes that can be used as parental in crosses. Thirteen qualitative and eight quantitative descriptors were studied. The experiment was carried out in greenhouse using a randomized block design with three replications and four plants per plot. UPGMA clustered the accessions in 11 groups for qualitative and eight groups for quantitative descriptors. Data joint analyses using Gower´s algorithm resulted in 10 clusters, a similar pattern observed for qualitative characters (77% of similarity). Fruit length was the most important trait to discriminate the accessions while changing color during fruit ripening was less important in accessions discrimination. However, this descriptor cannot be discarded during phenotyping because it is a very important trait aiming ornamental breeding. Desirable traits for ornamental use as small height, intermediate growth habit, three to five stages for fruit ripening maturation, early flowering and fruit set were identified in five accessions (UENF 1623, UENF 1626, UENF 1627, UENF 1632 and UENF 1750). Other seven accessions (UENF 1615, UENF 1641, UENF 1717, UENF 1738, UENF 1741, UENF 1790 and UENF 1799) had also ornamental interest for garden growing because of the plant height, along with fruit color, size and shape. Accessions UENF 1623, UENF 1626, UENF 1627, UENF 1632 and UENF 1750 can be recommended for crosses seeking pepper ornamental breeding, based on genetic divergence and suitable agronomic traits.

Keywords: *Capsicum* spp., morphological characterization, descriptors, genetic resources, genebank.

RESUMO

Fenotipagem e seleção de genitores em acessos de pimentas para fins ornamentais

O crescimento do mercado das pimentas para fins ornamentais no Brasil demanda cultivares adaptadas às condições ambientais brasileiras. Este trabalho teve como objetivos caracterizar 22 acessos de *Capsicum* spp. considerando-se 13 descritores qualitativos e oito quantitativos relacionados ao potencial ornamental; estimar a dissimilaridade entre os acessos, a contribuição relativa dos caracteres avaliados e indicar genitores para cruzamentos em programas de melhoramento para fins ornamentais. O experimento foi conduzido em casa de vegetação, em blocos ao acaso com três repetições e quatro plantas por parcelas. Onze grupos foram formados pelo método UPGMA para as características qualitativas e oito para as quantitativas. Na análise conjunta dos dados observou-se a formação de 10 grupos, com 77% de similaridade aos grupos observados para análise qualitativa. O caráter quantitativo que mais contribuiu para a discriminação entre os acessos foi o comprimento do fruto e o que teve menor contribuição foi a mudança de coloração na maturação dos frutos. Todavia, esse caráter não pode ser descartado numa etapa de seleção de acessos com potencial ornamental, visto que a atratividade da planta encontra-se na variação de cor que seus frutos possuem, conferindo-lhe um grande valor estético. Cinco acessos (UENF 1623, UENF 1626, UENF 1627, UENF 1632 e UENF 1750) com potencial ornamental foram identificados para cultivo em vaso, tendo em comum porte baixo, hábito de crescimento intermediário e prostrado, estádios de maturação variando de três a cinco, florescimento e frutificação precoce. Outros sete acessos (UENF 1615, UENF 1641, UENF 1717, UENF 1738, UENF 1741, UENF 1790 e UENF 1799) foram indicados para cultivo como arbusto em função do porte, da coloração, do tamanho e da forma dos frutos. Indica-se os acessos UENF 1623, UENF 1626, UENF 1627, UENF 1632 e UENF 1750 para serem utilizados como genitores em programas de melhoramento de pimentas ornamentais com base na divergência genética e em suas características agronômicas de interesse.

Palavras-chave: *Capsicum* spp., caracterização morfológica, descritores, recursos genéticos, banco de germoplasma.

(Recebido para publicação em 9 de junho de 2014; aceito em 13 de novembro de 2014)
(*Received on June 9, 2014; accepted on November 13, 2014*)

The consumer market of peppers has recorded significant growth demanding new cultivars specifically developed to be used as ornamental plants (Rêgo *et al*., 2012). The attractive and aesthetic value of ornamental peppers is mainly due to the change of color during the ripening of fruits, as well as to the different shapes and

sizes of fruits (Fabri, 2006). Pepper plants show morphological diversity such as variegated foliage, short stature, and fruits with varied coloration in the different maturation stages that contrast with the foliage giving them ornamental value. These characters associated with the possibility to grow plants in small pots results in an interesting combination endowing peppers for use as decorative indoor flower pot product, attracting even those who do not like to eat the fruit, but want to enjoy them for ornamental purposes (Stommel & Bosland, 2005; Carvalho *et al*., 2006).

Despite the great variability and attractiveness, studies on peppers for ornamental purposes in plant breeding programs in Brazil are still scarce (Rêgo *et al*., 2013) and the number of breeders acting in the ornamental market is much smaller when compared with other fields of action (Ramalho *et al*., 2010). However, *Capsicum* germplasm kept in Brazilian collections show wide variability that can be used in breeding with the aim of developing new *Capsicum* cultivars for ornamental purpose (Neitzke *et al*., 2010). Information available on the accessions kept in germplasm banks generated from morpho-agronomical studies and from genotypic and phenotypic differences is directly linked to their use in genetic breeding programs (Sudré *et al*., 2010; Rêgo *et al*., 2011b; Signorini *et al*., 2013).

This study aimed to characterize 22 *Capsicum* spp. accessions based on qualitative and quantitative descriptors related to the ornamental potential; to estimate the dissimilarity between accessions and the relative contribution of the evaluated characters and to indicate potential parental for the use in hybridizations to develop a breeding program for ornamental purposes.

MATERIAL AND METHODS

Plant material and experimental conditions - Twenty-two *Capsicum* spp. accessions from the germplasm collection of the Universidade Estadual do Norte Fluminense (Table 1). The accessions were selected based on preliminary results obtained by Bento *et al*. (2007).

The experiment was conducted in a greenhouse in Campos dos Goytacazes, Rio de Janeiro state, Brazil, from September 2011 to March 2012. Sowing was performed in polystyrene trays (128 cells) filled with Vivatto® vegetable organic substrate. After the emergence of four pairs of mature leaves, seedlings were transplanted to five-liter plastic pots containing soil, sand and manure at the proportion 1:1:1. The study used randomized block design with three replicates, with four plants per plot, totaling 264 plants.

Morpho-agronomical characterization - Twenty-one descriptors proposed by IPGRI (1995) were used, 13 qualitative and eight quantitative ones, observing the vegetative and reproductive traits of plants. For the qualitative descriptors (Table 2) related to the vegetative part, data were obtained from the mode of observations taken in three plants per accession in each block and for the characterization of the reproductive part, five fruits per plant were considered. Pungency analysis was based on the staining of the placenta, as described by Derera (2000). Quantitative characteristics were based on the mean values observed in each treatment in which the following items were evaluated: 1) plant height (HGT, cm, measured from the base of the plant to the highest point of the canopy, when 50% of plants had ripe fruits); 2) number of days to flowering (DFL, calculated from the sowing up to the time when at least half of the plants had at least one open flower). Regarding the fruit characteristics, the following items were evaluated: 1) total number of fruits (TNF); 2) length of the fruit (LoF); 3) diameter of the fruit (DoF); 4) fruit weight (FRW); 5) days to fruiting (DFR) and 6) days to the change of maturity stage of the fruits (DMF). For the analysis of LoF, FRW and DoF, the means from five randomly selected ripe fruits were used. LoF and DoF were measured with a digital pachymeter, expressed in millimeters (mm). FRW was equal to the mass of the fruits obtained in grams (g) carried out on an analytical balance. DFR was calculated from the transplanting up to the time when 50% of plants had ripe fruits in the first and second bifurcations, and DMF was obtained by marking the fruits, just after setting, with colored woolen yarns and by counting the number of days for color change from its initial stage to the next, until complete ripeness.

Qualitative data were analyzed based on descriptive statistics and multivariate analysis. As for the quantitative data, multivariate analysis was used considering Unweighted Pair Group Method with Arithmetic Mean (UPGMA) method and the relative importance of features according to Singh (1981). Means were grouped according to Scott-Knott test (1974) and the analyses were performed by Genes software (Cruz, 2013).

A common data matrix was produced including qualitative and quantitative variables. A dendrogram was constructed using Gower's algorithm (Gower, 1971; Franco *et al.*, 2005). Gower's distance is a metric distance between two individuals (*I* and *j*) and defined as:

$$D_{ij} = \frac{\sum_{k=1}^{p} w_{ijk} * d_{ijk}}{\sum_{k=1}^{p} w_{ijk}}$$

Where W_{ijk} is a weight given to the *ijk*th comparison, assigning values of 1 for valid comparisons and value of 0 for invalid comparisons (when the value of the variable is missing one or both individuals); S_{ijk} is the contribution of the *K* variable to the total similarity between individuals *i* and *j*, and it takes values between 0 and 1. For a nominal variable, if the value of the *K* variable is the same for both individuals, *i* and *j*, then $S_{ijk} = 1$; otherwise, it equals 0; for a continuous variable$S_{ijk} = 1 - |X_{ik} - X_{jk}| / R_k$ where X_{ik} and X_{jk} are the values of the *K* variable for the *i* and *j* individuals, respectively, and R_k is the range (maximum value minus minimum value) of the *K* variable in the sample. The division by R_k eliminates scale differences among variables, producing a value within the [0,1] interval and equal weighs.

RESULTS AND DISCUSSION

Qualitative traits

Eleven accessions (UENF 1623, UENF 1626, UENF 1627, UENF 1641, UENF 1717, UENF 1738, UENF 1765, 1750, UENF 1751, UENF 1794 and UENF 1799) showed intermediate growth habit, while 10 accessions showed erect growth habit (UENF 1554, UENF 1615, UENF 1635, UENF 1706, UENF 1714, UENF 1741, UENF 1772, UENF 1776, UENF 1780 and UENF 1790) and UENF 1632 showed prostrate growth habit. According to Carvalho *et al*. (2006), the choice of ornamental plants is directly related to the height of the plant, since consumers prefer the lower-sized plants for cultivation in pots, and the growth habit is associated with the size of the plants. The accessions with growth habit varying from intermediate to prostrate tend to show a lower height and, therefore, they are more accepted in the market of ornamental plants.

The predominance of oval shape (13 accessions) was observed in the characterization of leaf shape, with the exception of accessions UENF 1554, UENF 1615, UENF 1635, UENF 1738, UENF 1765, UENF 1776, UENF 1790 and UENF 1794 which showed deltoid shape and accession UENF 1627 which showed lanceolate leaves. The color of the leaves for the most of the accessions was green, except UENF 1750, which showed dark green leaves. The predominant color of the stem was green, with the exception of accession UENF 1750, with green stem with purple stripes, and UENF 1751, which stem was purple. The color and shape of leaves and stems are also important on the aesthetic aspects, which provide appeal to ornamental peppers, which stems are generally green without branches and the green leaves contrast with the diversity of fruits color and show lanceolate shape.

Regarding the color of the corolla, there were 12 accessions with white color and one accession (UENF 1750) with purple color and also purple stripes. Of the 22 evaluated accessions, twelve (UENF 1615, UENF 1635, UENF 1706, UENF 1714, UENF 1738, UENF 1751,

Table 1. Passport data and means for eight quantitative characters of the 22 *Capsicum* spp. accessions from the germplasm collection of the Universidade Estadual do Norte Fluminense (UENF) {dados de passaporte de oito caracteres quantitativos de 22 acessos de *Capsicum* spp. da coleção de germoplasma da UENF}. Campos dos Goytacazes, UENF, 2012.

Register UENF	Species	Origin	HGT[1/2] (cm)	TNF	LOF (mm)	DOF (mm)	FRW (g)	DFL	DFR	DMF
1554	*C. chinense*	Goiânia-GO	160.1a	114.7	13.6f	13.7b	5.7d	74.0a	110.0b	32.0
1615	*C. chinense*	Viçosa-MG	95.8c	194.0	31.8d	17.8a	11.3c	76.3a	100.3b	33.0
1623	*C. annuum* var. *annuum*	Campos-RJ	43.3e	69.3	29.1d	14.1b	16.9b	21.7d	29.0e	40.3
1626	*C. annuum* var. *annuum*	Campos-RJ	53.3e	66.7	21.1e	10.5c	11.2c	25.3d	32.3e	33.3
1627	*C. annuum* var. *annuum*	Campos-RJ	51.5e	41.7	39.1c	9.8c	13.8c	29.3d	36.3e	41.0
1632	*C. annuum* var. *annuum*	Porto Seguro-BA	32.6e	48.0	29.6d	18.1a	26.3a	27.7d	37.7e	46.7
1635	*C. baccatum* var. *pendulum*	Miranda-MS	101.6c	110.3	14.5f	18.9a	16.8b	51.3c	60.0d	42.0
1641	*C. chinense*	Viçosa-MG	70.1d	59.0	26.9d	10.9c	4.4d	76.3a	89.0c	31.5
1706	*C. chinense*	Viçosa-MG	126.0b	118.3	29.8d	12.9b	7.7d	59.0b	69.7d	38.5
1714	*C. baccatum* var. *pendulum*	Peru	139.0a	118.3	25.5d	13.6b	8.4d	67.0b	74.3c	34.0
1717	*C. annuum* var. *annuum*	Renascença-PR	107.4c	80.0	14.7f	15.0b	8.4d	40.5c	39.0e	40.7
1738	*C. baccatum* var. *pendulum*	Viçosa-MG	83.3d	174.3	19.8e	18.3a	24.1a	41.7c	55.0d	33.0
1741	*C. annuum* var. *annuum*	Campos-RJ	86.3d	68.7	53.5a	13.3b	17.1b	33.0d	39.0e	39.7
1750	*C. annuum* var. *glabriusculum*	Campos-RJ	37.9e	200.7	11.3f	7.9d	11.1c	33.7d	46.0e	33.3
1751	*C. chinense*	Parintins-AM	121.6b	42.5	45.1b	9.9c	12.5c	81.0a	122.3a	52.0
1765	*C. chinense*	Belém-PA	99.6c	107.0	15.1f	17.3a	9.1c	52.3c	76.0c	32.0
1772	*C. chinense*	Bequimão-MA	120.8b	124.3	21.7e	16.7a	9.6c	55.7c	98.0b	29.7
1776	*C. frutescens*	Rosário-MA	151.8a	116.0	21.5e	6.9d	2.7d	82.0a	122.7a	37.7
1780	*C. chinense*	Bequimão-MA	119.9b	140.0	16.5f	12.0c	5.0d	73.3a	103.0b	34.5
1790	*C. frutescens*	São Luís-MA	95.8c	63.7	28.2d	14.9b	14.1c	50.3c	85.0c	33.7
1794	*C. chinense*	São Luís-MA	96.2c	81.0	57.9a	17.8a	27.6a	48.0c	67.0d	39.0
1799	*C. annuum* var. *annuum*	Bequimão-MA	79.1d	137.3	19.1e	7.9d	5.3d	47.3c	48.0e	36.3
Averages			94.95	101.83	26.97	13.82	12.56	52.35	71.03	37.03

[1/]HGT= plant height (altura da planta); TNF= total number of fruits (número total de frutos); LoF= length of the fruit (comprimento do fruto); DoF= diameter of the fruit (diâmetro do fruto); FRW= fruit weight (massa do fruto); DFL= days to flowering (dias até o florescimento); DFR= days to fruiting (dias até frutificação); DMF= days to change the maturity stage of the fruit (dias até mudança do estádio de maturidade do fruto); [2/]Means followed by the same letter do not differ from each other by the Scott-Knott test ($p>0.05$) {médias seguidas por letras iguais na coluna, não diferem pelo teste Scott-Knott, 5%}.

Table 2. Descriptors, observed classes and evaluation period of 13 qualitative descriptors of *Capsicum* spp. (descritores, classes observadas e período de avaliação de 13 descritores qualitativos de *Capsicum* spp.). Campos dos Goytacazes, UENF, 2012.

Descriptors concerning vegetative characteristics[1]	**Classes according to IPGRI**[2] **(1995)**	**Evaluation period**
GH	3= prostrate; 5= intermediate; 7= erect	50% of ripe fruits
SC	1= green; 2= green with purple stripes; 3= purple; 4= other	Plant fruiting stage
LC	1= yellow; 2= light green; 3= green; 4= dark green; 5= light purple; 6= purple; 7= variegated; 8= other	50% of ripe fruits
LS	1- deltoid; 2-oval; 3-lanceolate	50% of ripe fruits
Descriptors relating to the flower[3]		
CCO	1= white; 2= light yellow; 3= yellow; 4= greenish yellow; 5= purple with white base; 6= white with purple base; 7= white with purple edge or purple with white; 8= purple; 9= other	50% of plants in the first flowering stage
CAN	1= white; 2= yellow; 3= pale blue; 4= blue; 5= purple; 6= other	After anthesis
PFL	3= pendant; 5= intermediate; 7= erect	At anthesis
SCO	1= circular; 2= campanulate; 3= other	After anthesis
Descriptors relating to the fruit[4]		
NRS[5]	Two, three, four, five or more	Initial coloration at the unripe stage up to the ripe one
PFR	1= pendant; 2= erect; 3= intermediate	50% of the plants with fruits
PSF	0= non-persistent; 1= persistent	After the fruit reach the final stage of ripening
SFR	1= elongate; 2= nearly round; 3= triangular; 4=campanulate; 5= cylindrical; 6= other	50% of the plants with fruits
PGY	0= non-pungent; 1= pungent	Fruit in the last ripening stage

[1]GH= growth habit (hábito de crescimento); SC= stem color (cor da haste); LC= leaf color (cor da folha); LS= leaf shape (formato da folha); CCO= corolla color (cor da corola); CAN= anther color (cor da antera); PFL= flower position (posição da flor); SCO= corolla shape (formato da corola); NRS= number of ripening stages (número de estádios de amadurecimento); PFR= fruit position (posição do fruto); PSF= fruit persistence (persistência do fruto); SFR= fruit shape (formato do fruto); PGY= pungency (pungência); [2]*International Plant Genetic Resources Institute* (currently *Bioversity International*); [3]checked with the open flower in the first flowering (avaliado com a flor aberta no primeiro florescimento); [4]checked in the last ripening stage, except NRS (avaliado no último estádio de amadurecimento, exceto NRS); [5]Characteristic not considered in the descriptors of IPGRI (1995) {característica não considerada na lista dos descritore do IPGRI (1995)}.

UENF 1765, UENF 1772, UENF 1776, UENF 1780, UENF 1790 and UENF 1794) showed different color from the one presented in the descriptors, being classified as others and being named as follows: greenish white; white with yellow spots; white with green spots; greenish white with purple midline of petals. For the anther color, the accessions UENF 1554, UENF 1641, UENF 1741, UENF 1772, UENF 1776, UENF 1780, UENF 1790 and UENF 1794, showed blue anthers; on the other hand, the accessions UENF 1706, UENF 1750 and UENF 1751 showed purple color; four other accessions (UENF 1623, UENF 1714, UENF 1738 and UENF 1765) showed yellow anthers and seven accessions were classified as others, such as: green and brown. The scorolla shape that prevailed among the accessions was circular, except for the accessions UENF 1635 and UENF 1714, which showed campanulate shape. As for flower position, four accessions (UENF 1554, UENF 1615, UENF 1641 and UENF 1772) showed an intermediate flower position and the other 18 accessions were erect. Floral morphological characteristics are important in the identification of the species *Capsicum* (Viñals *et al*., 1996; Moreira *et al*., 2006), besides the fact that the color variation in the anthers contrasting with the petals and the presence of pigmentations denote beauty and attract attention in the stages prior to fruiting.

Accessions UENF 1571, UENF

1615, UENF 1741, UENF 1772 and UENF 1794 produced pendant fruits, accessions UENF 1554, UENF 1706 and UENF 1765 produced fruits in intermediate position and the other accessions produced erect fruits. As for an important feature in ornamental terms, fruit persistence, with the exception of five accessions (UENF 1554, UENF 1641, UENF 1714, UENF 1738 and UENF 1765) all other accessions produced persistent fruits. According to Vieira (2002), erect fruits are showier when associated with coloring, and they are more used for indoor decoration and the fruit persistence on the plant is related to the extension of the ornamental effect.

Considering the fruit shape, seven accessions (UENF 1627, UENF 1641, UENF 1741, UENF 1751, UENF 1776, UENF 1790 and UENF 1794) were elongated, six accessions (UENF 1554, UENF 1635, UENF 1717, UENF 1750, UENF 1765 and UENF 1780) were rounded, six other accessions were triangular (UENF 1623, UENF 1626, UENF 1632, UENF 1706, UENF 1714 and UENF 1799), two accessions were campanulate (UENF 1615 and UENF 1772) and accession UENF 1738 was classified as other (round with elongated top).

One accession (UENF 1615) showed two ripening stages, 10 accessions three ripening stages, other 10 accessions showed four ripening stages and one accession five different ripening stages. The variation in the number of stages is important because it highlights color variations in a single plant, thus attracting the consumer's attention. According to Neitzke *et al*. (2010) the most important qualitative characteristics for the genus *Capsicum*, in relation to the aesthetic aspect for ornamental use, are related to changes in fruit color in unripe and ripe stages, and to leaf and corolla colors.

The analysis of pungency of the fruits identified that only six (UENF 1717, UENF 1741, UENF 1751, UENF 1772, UENF 1780 and UENF 1799) of 22 accessions are not pungent. The absence of pungency is important due to the use of these plants in environments that can be reached by children and pets. However, pungent plants are attractive because they have dual purpose: decorative and edible.

Table 3. Relative contribution of eight quantitative traits for genetic divergence according to the Singh's method (1981) among 22 *Capsicum* spp. accessions from the germplasm collection of the UENF {contribuição relativa de oito caracteristicas quantitativas para divergência genética, conforme o método de Singh (1981)}. Campos dos Goytacazes, UENF, 2012.

Traits	Value (%)	Accumulated value (%)
Fruit lenght	31.3394	31.34
Plant height	20.3218	51.66
Diameter of the fruit	19.9230	71.58
Days to fruiting	16.7223	88.30
Days to flowering	6.0945	94.40
Fruit weight	3.2401	97.64
Number of fruits	1.4852	99.13
Days to change the maturity stage of the fruit	0.8737	100.00

Quantitative traits

There was a significant difference for most of the studied traits, except for the total number of fruits and days for the change of ripening stage of fruits, assessed by F test ($p>0.05$) (Table 1). Means for plant height separated the accessions into five groups, in which the highest means were between 139.0 cm (UENF 1714) and 160.1 cm (UENF 1554) and the lowest ones ranged from 32.6 cm (UENF 1632) to 53.3 cm (UENF 1626). Neitzke *et al*. (2010),

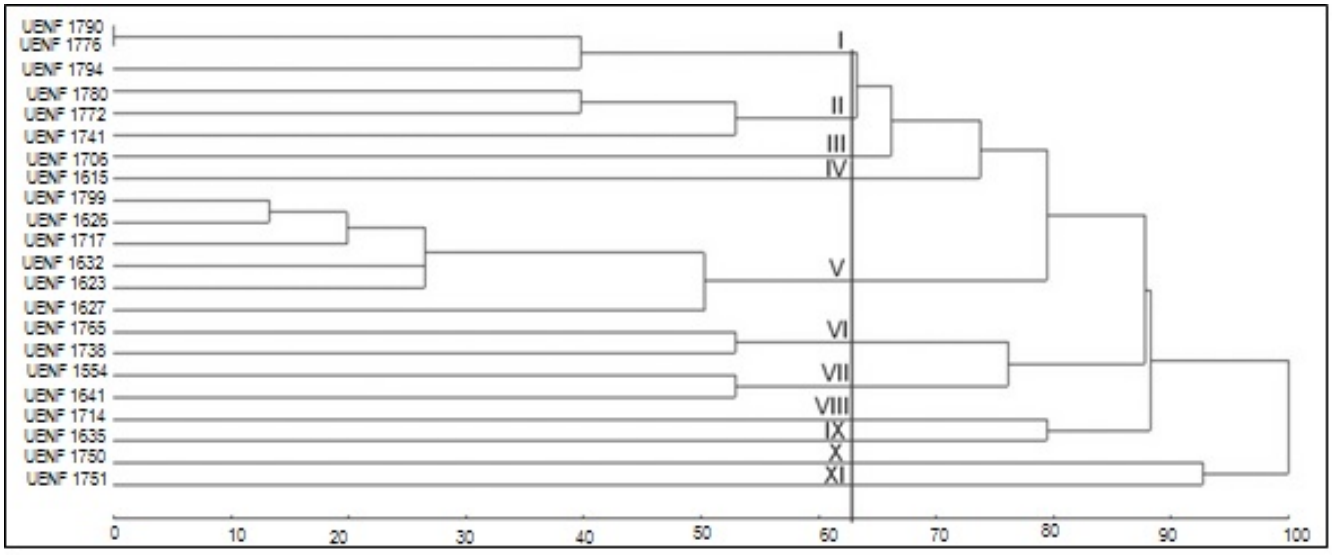

Figure 1. Dendrogram of genetic dissimilarity among 22 accessions of *Capsicum* spp. obtained from UPGMA method using coefficient of simple coincidence based on 13 qualitative traits (dendrograma de dissimilaridade genética entre 22 acessos de *Capsicum* spp., obtido pelo método UPGMA, usando coeficiente de coincidência simples, baseado em 13 características qualitativas). Campos dos Goytacazes, UENF, 2012.

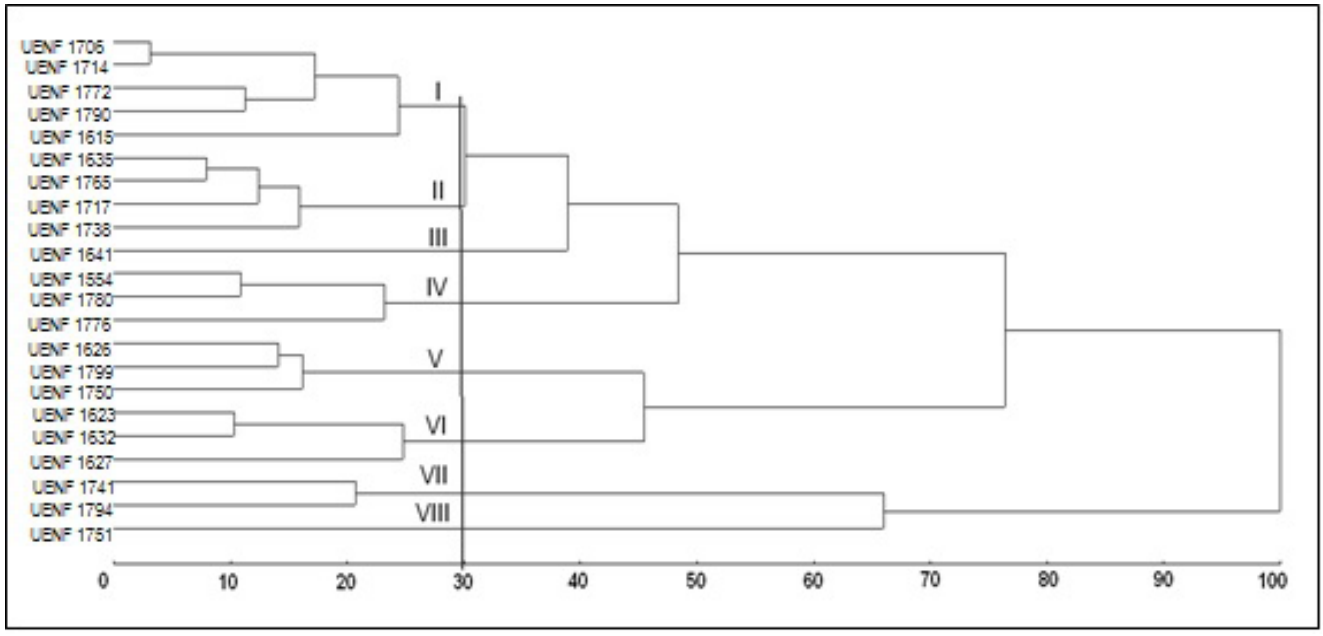

Figure 2. Dendrogram of genetic dissimilarity among 22 accessions of *Capsicum* spp. obtained from UPGMA method using Mahalanobis generalized distance based on eight quantitative traits (dendrograma de dissimilaridade genética entre 22 acessos de *Capsicum* spp., obtido pelo método UPGMA, usando distância generalizada de Mahalanobis, baseado em oito características quantitativas). Campos dos Goytacazes, UENF, 2012.

studying the genetic dissimilarity among pepper accessions with ornamental potential, identified that plant height was the characteristic that less formed classes according to the Scott-Knott test at 5% probability, recording lower variability among accessions. The same authors reported that this feature is of great importance when it comes to ornamental plants, since smaller plants are preferred and attractive for cultivation in pots.

In relation to the length of the fruit, the highest means ranged from 53.5 mm (UENF 1741) to 57.9 mm (UENF 1794) and the lower ones varied from 11.3 mm (UENF 1750) to 16.5 mm (UENF 1780); for the diameter of the fruits, the highest means ranged from 17.3 mm (UENF 1765) to 18.9 mm (UENF 1635) and the lowest ones varied from 6.9 mm (UENF 1776) to 7.9 mm (UENF 1799 and UENF 1750); for fruit weight, the means were between 26.3 mm (UENF 1632) and 27.6 mm (UENF 1794) and the lowest ones ranged from 2.7 mm (UENF 1776) to 8.4 mm (UENF 1714 and UENF 1717). Fruits of smaller size and lower weight are ideal for ornamental purposes, due to the small size of the plants.

Regarding precocity, the earliest accessions flowered between 21 days (UENF 1615) and 28 days (UENF 1627) and produced fruits between 29 (UENF 1615) and 32 days (UENF 1626).

Relative contribution of quantitative characters

By Singh's method (1981), which is used to assess the relative importance of eight quantitative characteristics, it was determined that six of them contributed with 97.64% to genetic divergence, while two of them contributed with only 2.36% (Table 3).

The characteristic that most contributed to the genetic divergence was the length of the fruit (LoF), with 31.34%, and ranged from 11.3 to 57.9 mm. According to Bento *et al*. (2007), this trait is very important because using this variable it is possible to determine the most appropriate way to use the accessions. These authors reported that small chili-type fruits (*C. frutescens*) are mostly used in industrialized sauces, while larger fruits are preferably consumed fresh. Regarding the ornamental market, the preference for plants with smaller fruit length and diameter was also observed.

Another important variable for the study of divergence was plant height (HGT), with 20.32% contribution to the variability among accessions. HGT ranged from 32.6 to 160.1 cm, and this descriptor is relevant for the characterization of accessions because plants with lower size are preferred by consumers when it comes to cultivation in pots (Carvalho *et al*., 2006). However, plants higher than those used for the cultivation in pots may also be used in ornamental gardens (Neitzke *et al*., 2010).

The fruit diameter was the third variable that most contributed to the divergence with 19.92%, ranging from 6.9 to 18.9 mm. This characteristic associated with fruit length is important in the harmonization of fruits with plant size.

The fourth important characteristic to the divergence among accessions was days to fruiting, explaining 16.72% of the variance, with means observed from 29 to 123 days after flowering. The fifth variable that most contributed to the divergence among accessions was days to flowering, with 6.09%, ranging from 22 to 82 days after sowing. These two descriptors are important, since the fruit is the main attractive in the ornamental pepper and, in general, the earliest genotypes, in terms of flowering and fruiting, are the most desirable ones to meet the consumer market.

Although fruit weight, number of

fruits and days to change ripening stages have had a low contribution (3.24%, 1.48% and 0.87%, respectively) for the divergence of the evaluated accessions, these characteristics are important for the identification of accessions with ornamental potential and they should not be discarded during germplasm characterization and evaluation stages.

Traits with greater contribution to genetic divergence were related to the fruit and not to the size of the plant. The same result was observed by Rêgo *et al*. (2011a) although Silva Neto *et al*. (2014) observed different results.

Genotypes clustering regarding the qualitative characteristics

Regarding the qualitative characteristics, the UPGMA method separated the accessions into 11 groups (Figure 1), considering the cutoff with approximately 52% dissimilarity among accessions.

Group I was composed of the accessions UENF 1776, UENF 1790 and UENF 1794, which were characterized for producing persistent fruits, for having an elongated fruit and more than three ripening stages (NRS). In this group, the possible presence of duplicates was observed since the distance between accessions UENF 1776 and UENF 1790, both of *C. chinense* was null, although they have been collected in different municipalities of the Maranhão state. Group II was formed by accessions UENF 1741, UENF 1772 and UENF 1780 having in common the absence of pungency and NRS greater than three. Group III was formed only by accession UENF 1706 with persistent fruits, elongated shape of fruit and NRS greater than four. Group IV comprised only one accession (UENF 1615) characterized by persistent fruits. Group V was composed of accessions UENF 1623, UENF 1626, UENF 1627, UENF 1632, UENF 1717 and UENF 1799 all *C. annuum* var. *annuum*, and they were similar regarding the intermediate growth habit (GH), except for the accession UENF 1632 prostrate, persistent fruits and NRS greater than three. Group VI was formed by accessions UENF 1738 (*C. baccatum* var. *pendulum*) and UENF 1765 (*C. chinense*) having in common the intermediate GH and NRS greater than three; group VII had only two accessions (UENF 1554 and UENF 1641) both *C. chinense* with NRS greater than three.

Only accession UENF 1714, with triangular fruit shape and NRS greater than three, was allocated in group VIII. Group IX was composed only of accession UENF 1635 (*C. baccatum* var. *pendulum*) and had persistent fruits and NRS equal to four. Group X was formed by accession UENF 1750 (*C. annuum* var. *glabriusculum*) that have intermediate GH, persistent fruits, and NRS equal to five. Sudré *et al*. (2005) recommend an accession of the same species for ornamental purposes. Group XI was formed by accession UENF 1751 (*C. chinense*) with intermediate GH, no pungency, persistent fruits, elongated fruit shape and NRS equal to three. Groups V and X were those allocating accessions with ornamental potential, having qualitative traits of interest for ornamental purposes, such as: an intermediate GH, persistent fruits and NRS greater than three; and they could be employed in future genetic breeding programs.

Genotypes clustering regarding quantitative characteristics

In the dendrogram obtained by UPGMA method for quantitative traits, eight clusters were formed (Figure 2), with the cutoff established at approximately 30% dissimilarity.

Group I was composed of accessions UENF 1615, UENF 1706, UENF 1714, UENF 1772 and UENF 1790, which have in common: fruit length between 21.7 and 31.8 mm, fruit diameter from 12.9 to 17.8 mm, FRW from 8.4 to 14.1 g. Group II was formed by accessions UENF 1635, UENF 1765, UENF 1717 and UENF 1738. They were allocated in this group because of the similarity in plant height ranging from 83.3 to 107.4 cm. Ornamental plants with this size are not suitable for cultivation in pots because they are considered high, but these accessions may have potential use in gardens. The LoF in the accessions of this group ranged between 14.5 and 19.8 mm, DoF from 15.0 to 18.9 mm and DFL from 41 to 51 days after sowing.

The third group was composed only by accession UENF 1641 (*C. chinense*), characterized by having less number of fruits per plant (59 fruits) compared with other accessions studied in this paper. This accession was also considered late regarding days to flowering and days to fruiting (77 and 89 days, respectively). Group IV was composed of accessions UENF 1554, UENF 1780 and UENF 1776 with HGT ranging from 119.9 to 160.1 cm, LoF from 13.6 to 21.5 mm, FRW from 2.7 to 5.7 g, DFL ranging from 73 to 74 days after sowing.

Group V was formed by accessions UENF 1626, UENF 1750 and UENF 1799 which showed DoF from 7.9 to 10.5 mm, FRW from 5.3 to 11.2 g, DFL from 26 to 47 days after sowing and DFR from 33 to 48 days after flowering. Group VI was composed of accessions UENF 1623, UENF 1627 and UENF 1632 that were grouped due to the HGT from 32.6 to 43.3 cm. These accessions are indicated for ornamental use in pots, for having lower size in common, LoF from 29.6 to 39.1 mm, DFL from 22 to 29 days after sowing and DFR from 29 to 38 days after flowering.

Group VII was formed by accessions UENF 1741 and 1794, which resemble regarding LoF (from 53.5 to 57.9 mm). Group VIII was formed only by accession UENF 1751 which is a late accession, with flowering occurring within 81 days after blooming and fruiting occurring 123 days after flowering and 52 days for the change of the color of the fruit.

Based on the analysis of quantitative data, it was possible to discriminate accessions UENF 1776 and UENF 1790, considered possible duplicates by the dendrogram generated by qualitative data, since these accessions were allocated in groups I and IV, respectively.

The accessions were grouped differently when used qualitative and quantitative data separately. The qualitative data analysis enabled a better separation of accessions to the formation of a larger number of groups to a distance greater than the quantitative data. Similar results were obtained by Neitzke *et al*. (2010).

Genotypes clustering regarding qualitative and quantitative characteristics

The joint analysis of qualitative

and quantitative data provided the formation of ten groups by UPGMA clustering method considering the cutoff with approximately 30% dissimilarity between accessions. Comparing the dendrograms obtained by different distances (coefficient of simple coincidence, Mahalanobis generalized distance and Gower's algorithm), there was an 77% concordance between the groups forming the qualitative data and joint analysis data. However, Finger *et al*. (2010) obtained an equitable contribution of binary and quantitative matrices, and multicategoric regarding the joint matrix.

The accessions with ornamental potential were divided into two groups (V and X), when considering the qualitative descriptors, and also in two groups (V and VI) for quantitative descriptors. All accessions listed in these groups belong to the species *C. annuum*, which facilitates obtaining hybrids and establishing breeding programs. The following accessions can be recommended as parents: UENF 1623, UENF 1626, UENF 1627, UENF 1632, UENF 1750 and UENF 1799, due to their desirable characteristics in terms of ornamental use. For the allocation in different groups in relation to qualitative and quantitative traits, the following crossings are recommended: UENF 1750 x UENF 1623; UENF 1750 x UENF 1627 and UENF 1750 x UENF 1632.

ACKNOWLEDGEMENTS

The authors thank the CNPq and FAPERJ for granting scholarships to the first author and for the research support.

REFERENCES

BENTO CS; SUDRÉ CP; RODRIGUES R; RIVA EM; PEREIRA MG. 2007. Descritores qualitativos e multicategóricos na estimativa da variabilidade fenotípica entre acessos de pimentas. *Scientia Agraria* 8: 147-154.

CARVALHO SIC; BIANCHETTI LB; RIBEIRO CSC; LOPES CA. 2006. *Pimentas do gênero* Capsicum *no Brasil*. Brasília: Embrapa Hortaliças. 27p.

CRUZ CD. 2013. Genes: a software package for analysis in experimental statistics and quantitative genetics. *Acta Scientiarum Agronomy* 35: 271-276.

DERERA F. 2000. *Condiment paprika:* breeding, havesting and commercialization, 33p.

FABRI EG. 2006. *Pimenta*. Globo Rural. p.96-97.

FINGER FL; LANNES SD; SCHUELTER AR; DOEGE J; COMERLATO AP; GONÇALVES LSA; FERREIRA FRA; CLOVIS LR; SCAPIM CA. 2010. Genetic diversity of *Capsicum chinensis* (Solanaceae) accessions based on molecular markers and morphological and agronomic traits. *Genetics and Molecular Research* 9: 1852-1864.

FRANCO J; CROSSA J, TABA S, SHANDS H. 2005. A sampling strategy for conserving genetic diversity when forming core subsets. *Crop Science* 45: 1035-1044.

GOWER JC. 1971. A general coefficient of similarity and some of its properties. *Biometrics* 27: 857-871.

IPGRI. 1995. *Descriptores para* Capsicum *(*Capsicum *spp.)*. 51p.

MOREIRA GR; CALIMAN FRB; SILVA DJH; RIBEIRO CSC. 2006. Espécies e variedades de pimenta. *Informe Agropecuário* 27: 16-29.

NEITZKE RS; BARBIERI RL; RODRIGUES WF; CORREA IV; CARVALHO FIF. 2010. Dissimilaridade genética entre acessos de pimenta com potencial ornamental. *Horticultura Brasileira* 28: 47-53.

RAMALHO MAP; TOLEDO FHRB; SOUZA JC; TEIXEIRA RA. 2010. *Competências em melhoramento genético de plantas no Brasil*. Viçosa: Editora Arka. 104p.

RÊGO ER; NASCIMENTO MF; NASCIMENTO NFF; SANTOS RMC; FORTUNATO FLG; RÊGO MM. 2012. Testing methods for producing self-pollinated fruits in ornamental peppers. *Horticultura Brasileira* 30: 669-672.

RÊGO ER; RÊGO MM; CRUZ CD, FINGER FL; CASALI VWD. 2011a. Phenotypic diversity, correlation and importance of variables for fruit quality and yield traits in Brazilian peppers (*Capsicum baccatum*). *Genetic Resources and Crop Evolution* 58: 909-918.

RÊGO ER; RÊGO MM; FINGER FL; NASCIMENTO NFF; NASCIMENTO MF; SANTOS RMC. 2013. Brazilian ornamental pepper breeding program: a consortium among universities, small farmers and government agencies. In: Meeting on genetics and breeding of *Capsicum* and eggplant. Eucarpia 15: 431-434.

RÊGO ER; RÊGO MM; MATOS IWF; BARBOSA LA. 2011b. Morphological and chemical characterization of fruits of *Capsicum* spp. accessions. *Horticultura Brasileira* 29: 364-371.

SCOTT A.; KNOTT M. 1974. Cluster-analysis method for grouping means in analysis of variance. *Biometrics* 30: 507-512.

SIGNORINI T; RENESTO E; MACHADO MFPS; BESPALHOK DN; MONTEIRO ER. 2013. Genetic diversity of species of *Capsicum* based on allozymes data. *Horticultura Brasileira* 31: 534-539.

SILVA NETO JJ; RÊGO ER; NASCIMENTO MF; SILVA FILHO VAL; ALMEIDA NETO JX; RÊGO MM. 2014. Variabilidade em população base de pimenteiras ornamentais (*Capsicum annuum*). *Revista Ceres* 61: 84-89.

SINGH D. 1981. The relative importance of characters affecting genetic divergence. *The Indian Journal of Genetic and Plant Breeding* 41: 237-245.

STOMMEL JR; BOSLAND PW. 2005. Pepper ornamental, *Capsicum annuum*. In ANDERSON NO (ed). *Flower breeding and genetics: Issues, challenger and opportunities for the 21st century*. The Netherlands: Kluwer Academic Publishers. p.561-599.

SUDRÉ CP; GONÇALVES LSA; RODRIGUES R; AMARAL JUNIOR AT; RIVA-SOUZA EM; BENTO CS. 2010. Genetic variability in domesticated *Capsicum* spp. as assessed by morphological and agronomic data in mixed statistical analysis. *Genetics and Molecular Research* 9: 283-294.

SUDRÉ, CP; RODRIGUES R; RIVA EM; KARASAWA M; AMARAL JÚNIOR AT. 2005. Divergência genética entre acessos de pimenta e pimentão utilizando técnicas multivariadas. *Horticultura Brasileira* 23: 22-27.

VIEIRA MA. 2002. *Uso de polímero hidroabsorvente efeitos sobre a qualidade de substratos hortícolas e crescimento de mudas de pimentão ornamental***.** Pelotas: UFPel-FAEM. 113p (Dissertação mestrado).

VIÑALS FN; ORTEGA RG; GARCIA JC. 1996. *El cultivo de pimientos, chiles y ajies*. Madri: Mundi-Prensa. 607p.