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Selection of pepper genotypes for ornamentation based on ideotype

Seleção de genótipos de pimenta para ornamentação com base em ideótipo

Selección de genotipos de pimiento para ornamentación según ideotipo

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Abstract

Peppers of the Capsicum annuum species are the most suitable for use in ornamentation, for having characters that confer aesthetic value, for being easy to cultivate and for good adaptability in pot. Despite the great variability that exists, in Brazil few commercial varieties are used for this purpose. It is of interest to the plant breeder, an ideotype that contains all the

characteristics of interest for commercialization. The aim of the present study is to evaluate and select C. annuum genotypes, with potential for ornamentation that most closely resemble the proposed ideotype. 14 quantitative traits and seven qualitative traits were evaluated in 29 C. annuum genotypes, in a completely randomized design with five replications. The cultivar Calypso was used as an ideotype for presenting desirable characters to the ornamental pepper market. Nine genotypes were selected as the most similar to the Calypso ideotype (ideotype), with the potential to be used in future crossings between them and / or with the ideotype.

Keywords: Averages BLUP; Calypso; *Capsicum annuum;* Morphological characterization.

Resumo

Pimenteiras da espécie *Capsicum annuum* são as mais indicadas para uso na ornamentação, por apresentarem caracteres que conferem valor estético, por serem de fácil cultivo e pela boa adaptabilidade em vaso. Apesar da grande variabilidade existente, no Brasil poucas variedades comerciais são destinadas a esse fim. É de interesse do melhorista de plantas, um ideótipo que contenha todas as características de interesse para comercialização. O objetivo do presente estudo avaliar e selecionar genótipos de *C. annuum*, com potencial para ornamentação que mais se assemelham ao ideótipo proposto. Foram avaliadas 14 características quantitativas e sete características qualitativas em 29 genótipos de *C. annuum*, no delineamento inteiramente casualisado com cinco repetições. A cultivar Calypso foi utilizada como ideótipo por apresentar caracteres desejáveis ao mercado de pimenteiras ornamentais. Nove genótipos foram selecionados como os mais semelhantes ao ideótipo Calypso (ideótipo), com potencial para serem utilizados em futuros cruzamentos entre eles e/ou com o ideótipo.

Palavras-chave: Calypso; *Capsicum annuum*; Caracterização morfológica; Médias BLUP.

Resumen

Los pimientos de la especie Capsicum annuum son los más indicados para su uso en ornamentación, por tener caracteres que le confieren valor estético, por ser fáciles de cultivar y por su buena adaptabilidad en maceta. A pesar de la gran variabilidad que existe, en Brasil se utilizan pocas variedades comerciales para este propósito. Es de interés para el obtentor, un ideotipo que contiene todas las características de interés para la comercialización. El objetivo del presente estudio es evaluar y seleccionar genotipos de C. annuum, con potencial de ornamentación que se asemeje más al ideotipo propuesto. Se evaluaron 14 rasgos cuantitativos y siete rasgos cualitativos en 29 genotipos de C. annuum, en un diseño

completamente al azar con cinco repeticiones. El cultivar Calypso se utilizó como ideotipo para presentar caracteres deseables al mercado de pimientos ornamentales. Se seleccionaron nueve genotipos como los más similares al ideotipo Calypso (ideotipo), con potencial para ser utilizados en futuros cruces entre ellos y / o con el ideotipo.

Palabras clave: Calypso; *Capsicum annuum*; Caracterización morfológica; Promedios BLUP.

1. Introduction

Peppers play an important role in the fresh vegetable market in Brazil. Worldwide, peppers are important in the condiment, seasoning and canning segment (Dutra et al., 2011). In addition to the importance of food, peppers have excellent ornamental potential due to the small size of the plants; fruits and leaves of different colors and shapes; upright and showy fruits, with different colors at different stages of ripeness; durability of fruits and leaves and the ability to grow in containers as a perennial plant (Neitzke et al., 2010; Nascimento et al., 2013).

Capsicum annuum is one of the most used species in pot planting, due to its small size and the great variability of shapes and colors of the fruits (Rêgo et al., 2011; Finger et al., 2012). However, the ornamental pepper market lacks novelties and there is still a lot of variability to be explored within the *C. annuum* species. Morphological characterization is a way to collect information about the genotypes evaluated in a breeding program. The collected data, in the characterization, can be used to evaluate the potential of the genotypes, in addition to evaluating the existing variability in the population.

The genetic improvement of plants seeks an ideotype that contains all the characteristics of agronomic interest and allows the achievement of a final target for selection, replacing the trial and error method of gradually increasing the performance of the plant as a consequence (Rocha et al., 2018). According to Donald (1968), the ideotype can be defined as a model plant with a set of characteristics that can lead to high performance. Therefore, the creation of an ideotype focuses on several characteristics simultaneously.

The proposition of an ideotype allows the targeted selection of genotypes that contain desirable characteristics for the ornamentation market. Among the main desirable attributes for an ornamental pepper ideotype are compact, small plants, with good adaptability in a pot, with colorful fruits, with different colors in different ripening stages, small or medium fruits

and of different shapes. The objective of the work was to evaluate and select *C. annuum* genotypes with ornamental potential that most resemble the composite ideotype.

2. Methodology

2.1 Plant materials

The experiment was conducted in a greenhouse, in the Department of Plant Science. A completely randomized design was used, with 29 treatments (genotypes) and five replications, where the experimental unit consisted of one plant per pot. Were used 29 genotypes of *C. annuum* (Table 1), selected for their potential for ornamentation.

Table 1 – List of the 29 evaluated genotypes of *Capsicum annuum.*

Number of genotypes	Common name
1	NuMex Big Jim 1
2	NuMex Big Jim 2
3	NuMex Conquistador 1
4	NuMex Conquistador 2
5	NuMex Espanola Improved 1
6	NuMex Espanola Improved 2
7	NuMex Joe E Parker 1
8	NuMex Joe E Parker 2
9	NuMex Mirasol 1
10	NuMex Mirasol 2
11	NuMex New México 6-4 1
12	NuMex New México 6-4 2
13	NuMex Sandia 1
14	NuMex Sandia 2
15	NuMex Sweet 1
16	BGH 1039
17	BGH 7073
18	MG 302
19	Calypso

20	Cayenne
21	*Guaraci Cumari do Pará*
22	Jamaica Red
23	Jamaica Yellow
24	Peter
25	*Pimenta Doce Italiana*
26	*Pimenta Doce Comprida*
27	*Pimenta Amarela Comprida*
28	*Picante para Vaso*
29	*Vulcão*

Source: Authors.

Table 1 shows the 29 genotypes evaluated, with their respective common names. The first 15 were from New Mexico, the next three from the UFV germplasm bank (BAG-UFV) and the remaining 11 were commercial varieties.

2.2 Morpho-agronomic characterization

For the morpho-agronomic characterization of the genotypes, the ornamental potential associated with characters of interest for consumption was taken into account, considering that pepper plants can have dual purposes. The descriptors established by the International Plant Genetic Resources Institute for the genus *Capsicum* were taken as a base (IPGRI, 1995).

For the development of the research, the quantitative method was used, in which the collection of quantitative data was carried out by means of specific measurements of quantities using metrology. The collected numbers, with their respective units, generated data sets that were analyzed using mathematical techniques (Pereira et al., 2018).

14 quantitative characteristics were evaluated: PH-plant height (cm); SL-stem length (cm); SD-stem diameter (mm); CAD-canopy diameter (cm); LS-Leaf size (cm); CORD-diameter of the corolla (mm); FW-fruit weight (grams); FL-fruit length (mm); FD-fruit diameter (mm); TP-thickness of the pericarp (mm); FM- fresh matter (grams); DM - Dry matter (grams); NS/FR – number of seeds/fruit (direct count), NFR/PL - number of fruits per plant (direct count). The measurements related to dimensions were measured with the use of a digital caliper, and the weight data were taken on an analytical scale. Seven qualitative characteristics were evaluated: BD- branch density; LS-leaf shape; CC-corolla color; FS-Fruit

shape; IFC-immature fruit color; INFC-intermediary fruit color; RFC-ripe fruit color. The evaluations of the listed characteristics were visual.

2.3 Ideotype

In the present study, it was proposed as an ideotype to cultivate Calypso. The Calypso variety (genotype 19 - see Table 1) is a very popular among ornamental peppers, grown in Brazil and other countries (Finger et al., 2015). It is indicated as a potential ornamental pepper ideotype, as it presents characteristics of interest such as vigorous seedling, small size, large flowers, small fruits and large pedicels, which are important characteristics as large pedicels highlights the flowers and fruits among the leaves (Melo et al., 2014).

2.4 Statistical analyses

The BLUP means of quantitative characteristics Was adopted the mixed model statistical analyses via REML/BLUP (restricted residual maximum likelihood and best linear unbiased prediction). The model for a completely randomized design was used (model 83) (Resende, 2007):

$$y = Xu + Zg + e$$

Where: Y = data vector; u = scalar referring to the overall mean (assumed as fixed); g = vector of genotypic effects (assumed as random); e = vector of residue (random). The uppercase letters X and Z, represent the incidence matrices for these effects.

To evaluate the distance between the genotypes and the ideotype, the average Euclidean distance between each of the 28 genotypes and the cultivar Calypso was calculated using the BLUP means of quantitative characteristics. The analyzes were performed using the program R (R Development Core Team, 2015).

3. Results and Discussion

The standardized average Euclidean distance between each genotype and the cultivar Calypso (Ideotype) was calculated, based on the BLUP means of the quantitative characteristics as shown in Table 2.

Table 2 - BLUP means of the 14 quantitative characteristics and the description of the seven qualitative characters evaluated, regarding the 9 genotypes that most resemble the ideotype. PH - Plant height (cm); SL - stem length (cm); SD - stem diameter (mm); CAD – canopy diameter (cm); LS - leaf size (cm); DCO - diameter of the corolla (mm); FW - fruit weight (grams); FL - fruit length (mm); FD - fruit diameter (mm); TP - thickness of the pericarp (mm); FM - fresh mass (grams); DM - dry mass (grams) and NS/FR - number of seeds per fruit (direct count), NFR / PL - number of fruits per plant (direct count); BD - branch density; LS - leaf shape; COC - corolla color, FS - fruit shape, IFC - immature fruit color; INFC - intermediate fruit color and RFC - ripe fruit color.I-intermediary, S-escarce, O-oval, L-lanceolate, W-white, WP-white with purple border, P-purple, LIY-light-yellow, T-triangular, AB- acampanulated and in block, E-elongate, LG-light green, G-green, LEY-lemon-yellow, B-black, DG-dark-green, OR-orange, Y-yellow, PO-pale-orange, R-red, POY-pale-orage-yellow.

Genotype	PH	SL	SD	CAD	LS	DCO	FW	FC	FD	TP	FM	DM	NS/FR	NFR/PL	BD	LS	COC	FS	IFC	INFC	RFC
Calypso	30.89	12.66	6.01	37.23	11.42	17.84	3.64	26.04	19.26	2.09	3.30	0.49	35.04	7.71	I	O	W	T	LG	OR	PO
Picante para Vaso	43.95	20.73	4.94	39.94	6.40	18.01	0.96	17.79	7.60	0.76	0.77	0.16	29.29	3.01	I	O	W	T	G	P	R
BGH 7073	55.94	21.80	5.45	41.46	9.49	15.84	1.66	36.79	7.39	1.41	1.43	0.25	29.85	5.75	I	O	WP	T	P	OR	R
Jamaica Yellow	58.43	31.26	5.72	36.89	10.58	16.14	7.67	26.47	24.68	1.51	7.06	0.94	37.15	3.99	I	O	W	AB	G	Y	POY
BGH 1039	47.72	24.83	5.84	40.28	12.26	17.47	2.41	29.11	13.86	1.58	2.02	0.36	45.71	33.58	I	L	W	T	LEY	OR	R
Vulcão	60.91	26.97	5.75	31.64	10.80	19.95	1.48	27.37	7.93	0.97	1.27	0.24	26.62	8.30	S	O	W	T	G	P	R

MG 302	65.71	24.66	5.57	42.65	9.47	15.72	0.77	13.38	6.85	1.01	0.65	0.13	28.45	3.99	I	O	P	T	B	OR	R
NuMex Mirasol 1	55.26	41.43	5.96	36.72	13.64	21.01	4.29	47.41	16.02	1.47	3.51	0.74	54.13	3.40	S	O	LIY	T	DG	OR	R
Pimenta Amarela Comprida	44.13	23.58	5.42	35.37	11.42	25.02	13.30	71.07	24.70	2.23	12.92	1.49	31.30	6.34	I	O	W	T	LEY	OR	R
Peter	63.31	36.79	6.39	41.46	11.12	25.12	7.66	55.23	17.15	1.37	7.01	1.17	40.10	5.55	I	O	W	E	G	P	R

Source: Authors.

Table 2 shows the data regarding the means of the quantitative characteristics and the descriptions of the qualitative characteristics of the nine genotypes that most closely resemble the ideotype. They are: Picante Para Vaso, BGH 7073, Jamaica Yelow, BGH 1039, Vulcão, MG 302, Numex Mirasol 1, Pimenta Amarela Comprida and Peter. The qualitative characteristics evaluated are also presented for comparison purposes. With the purpose of jointly evaluating the potential of these genotypes in comparison with the ideotype. When evaluating the potential of the same genotypes for ornamentation based on factor analysis, Guimarães et al. (2020) selected 12 genotypes and among them were the genotypes: *Picante Para Vaso*, Jamaica Yelow, BGH 1039 and *Vulcão*.

All genotypes presented mean values for plant height and stem length higher than those of Calypso. Rêgo et al. (2012) highlighted the importance of evaluating the height of ornamental pepper trees for the selection of genotypes aimed at the genetic improvement of *Capsicum*. Small plants (6 to 32 cm high) can be grown in gardens and pots, while plants of greater height (height over 80 cm) are recommended for garden cultivation (Costa et al., 2019).

Barroso et al. (2012) state that the harmony between the architecture of the plant and the size of the pot is important for determining the quality of an ornamental pepper tree. In addition, according to the authors, to maintain the harmony of small ornamental pepper trees, small leaves are interesting (Pessoa et al., 2018). The genotypes Picante para Vaso, BHG 7073, Jamaica Yellow, Vulcão, MG 302 and Peter have smaller leaves than those of the Calypso plants.

Another characteristic of interest in breeding, which influences the size is the diameter of the stem, since plants with a very thin stem tend to lodging and lose their commercial value (Neto et al., 2014). The diameter of the stem must be large enough to support the weight of the plant and fruit (Ferreira et al., 2015). Only the cultivar Peter had a higher stem diameter than Calypso.

Higher values of corolla diameter were found for the varieties Picante para Vaso, Vulcão, Numex Mirasol 1, Pimenta Amarela Comprida and Peter. Santos et al. (2013) reported that the selection of genotypes with large flowers is important not only in the ornamental aspect. According to the authors, plants with large flowers have potential for use in ornamental pepper breeding programs, because they provide beauty to the plant and are impressive and attractive to consumers.

The fruits of ornamental pepper trees are of great value mainly for their dual purpose, and can be used for consumption, in addition to granting beauty to ornamental plants (Rêgo &

Rêgo, 2016). This characteristic has added value to pepper plants, configuring itself as another way to increase the financial return for the producer (Finger et al., 2012; Rêgo & Rêgo, 2016). As a result, the study of fruit characters such as pericarp thickness, number of seeds per fruit, fresh mass and dry mass, becomes interesting.

The plants of the Calypso cultivar present fruits with an average of 26.04 mm in length and 3.64 grams. The genotypes Jamaica Yellow, Numex Mirasol 1, Pimenta Amarela Comprida and Peter showed higher values for these characters. However, Picante para Vaso and MG 302 have smaller and lighter fruits, when compared to the ideotype. Small fruits indicate a greater possibility of obtaining erect fruits, more prominent in the foliage. These fruits are ideal for growing in small pots, due to the small size of the plants (Silva et al., 2015). Large and long fruits are generally more attractive to the market of fresh pepper (Cardoso et al., 2018).

The pericarp thickness is directly correlated with the production (Rêgo et al., 2011) and influences the increase in the firmness of the fruits. It is an important aspect in quality, as fruits with a thicker wall are more resistant to damage during handling and have a fresher appearance (Cardoso et al., 2018). On the other hand, thinner fruits can be used for processing, due to the higher content of soluble solids (Lannes et al., 2007). Apart from Pimenta Amarela Comprida, the other selected genotypes have less thick pericarp than of the Calypso cultivar fruits.

The genotypes with the highest levels of fresh and dry matter were Jamaica Yellow, Numex Mirasol 1, Yellow pepper and Peter. Fruits with higher dry mass contents are more suitable for the production of dehydrated products, as it is easier to reduce the moisture content (Lannes et al., 2007).

The BGH 1039 genotype showed the highest number of fruits per plant (33 fruits). Higher amounts of fruits per plant and small fruits are aspects of interest for cultivation in pots and use in interior decoration (Pessoa et al., 2018). Holambra (2018) recommended a minimum of 10 fruits for ornamental peppers. However, it was emphasized that, for varieties with larger fruits, a smaller number of fruits per pot was sufficient for commercialization, as observed for the variety Calypso, which showed an average of seven fruits per plant in this experiment.

The simultaneous occurrence of fruits of different colors on the same plant, due to the different stages of ripening, contributes to the ornamental aspect. Thus, this trait should be considered by breeders in the development of new ornamental pepper cultivars (Neitzke et al., 2016). There is a growing demand for plants with flowers and purple, dark purple and black

fruits (Stommel & Griesbach, 2005). As verified in genotypes BGH 7073 which presents white flowers with purple margins and immature purple fruits and MG 302 with purple flowers and black immature fruits. In addition to the cultivars *Picante para Vaso*, *Vulcão* and Peter which have purple intermediate fruits.

The different shapes, sizes and colors of the fruits make the plants more attractive to consumers (Carvalho et al., 2006). Among the five types of peppers with the highest ornamental value, plants with elongated fruits were indicated, such as those presented by the cultivar Peter, and the triangular (Neitzke et al., 2016), as verified in the other cultivars, with the exception of Jamaica Yelow as it presented bell-shaped and in-block fruits.

Capsicum breeding programs can be developed through the selection of individuals from pre-existing populations, as well as through hybridization (Santos et al., 2014). Hybridization is a breeding method widely used in peppers for the development of new cultivars (Nascimento et al., 2015). The recommended genotypes present characters of interest with mean values close to those of the ideotype (Calypso). Thus, they can be used in crosses with the cultivar Calypso. The crossing of genotypes with the ideotype allows to improve and add new characteristics and increase variability while maintaining the existing ideals characters (Rocha et al., 2018).

4. Conclusion

The genotypes: *Picante Para Vaso*, BGH 7073, Jamaica Yelow, BGH 1039, *Vulcão*, MG 302, Numex Mirasol 1, *Pimenta Amarela Comprida* e Peter showed greater proximity to the Calypso ideotype. The selected genotypes can be used in crosses with each other and mainly with Calypso, for the development of heterotic hybrids in future breeding programs.

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