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Performance of pepper cultivars, for fresh market, based on fruit traits

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ABSTRACT

Different studies report that pepper fruit cuticle and pericarp thickness vary among marked cultivars and these variations likely influence many fruit quality traits, especially water loss rates. Thus, the objectives of this work was to evaluate the fresh market performance of pepper cultivars based on fruit traits, and indicate the cultivars of *Capsicum* spp. with less probability of post harvest water loss. Pepper fruits, belonging to *C. chinense*, *C. frutescens* and *C. baccatum* species, were collected in an experimental area at Bonfim's settlement, Alagoinha, Paraíba, Brazil. After harvest, fruits were taken to the laboratory of biotechnology at Centro de Ciências Agrárias of the Universidade Federal da Paraíba. Fruits were characterized according to pericarp thickness, fruit weight, and fruit length, larger and smaller fruit diameter. The experimental design was completely randomized with eight treatments and four repetitions. Analysis of variance, mean test, heritability, and ratio of coefficient of genetic variation by coefficient of environmental variation, genotypic and environmental correlation, and Tocher's grouping method were performed. The cultivar habanero vermelha had better performance for fruit weight and larger and smaller fruit diameter. On the other hand 'dedo de moça' presented the longest fruits and major pericarp thickness. These two cultivars also belonged to different groups based on Tocher's method. The genetic correlation between pericarp thickness and fruit weight was high (0.70) and highly significant. Fruit wall thickness also presented highly significant genotypic correlation with larger fruit diameter (0.93) and small fruit diameter. (0.93). Those finds indicate that indirect selection for pericarp thickness could be done based on larger fruit diameter. These correlations are trustworthy and important due to the high heritability values presented for these traits. Some authors suggest selecting fruits with higher cuticle thickness and fruit width values due to lower water loss. Thus, we suggest that small farmers cultivate 'habanero vermelha' and 'dedo de moça' in order to produce fruits with extended shelf life.

Keywords: *Capsicum* spp., water loss, heritability, variability.

RESUMO

Desempenho de cultivares de pimenta, baseado em caracteres de frutos, para consumo *in natura*

Diferentes estudos relatam que a cutícula e a espessura do pericarpo variam entre cultivares de pimenta e que estes atributos podem interferir em vários aspectos da qualidade do fruto e, em especial, na perda de água pós-colheita. Dentro deste contexto, o objetivo deste estudo foi avaliar o desempenho de diferentes cultivares de pimenteiras baseado em características de frutos e indicar possíveis cultivares com menor perda de água pós colheita. Frutos pertencentes às espécies *C. chinense*, *C. frutescens* e, *C. baccatum* foram coletados em campo experimental instalado no assentamento Bonfim, Município de Alagoinha, Paraíba, Brasil. Após a coleta, os frutos foram levados ao Laboratório no Centro de Ciências Agrárias da Universidade Federal da Paraíba. Os frutos foram caracterizados quanto a espessura do pericarpo, peso dos frutos, comprimento do fruto, maior e menor diâmetro do fruto. O delineamento utilizado foi inteiramente casualizado, com oito tratamentos e quatro repetições. Realizou-se análise de variância, teste de média, herdabilidade, razão coeficiente de variação genética pelo coeficiente de variação ambiental e agrupamento de Tocher. A cultivar habanero vermelha apresentou os maiores valores para peso do fruto e de maior e menor diâmetro do fruto. Por outro lado, a cultivar 'dedo de moça' apresentou os frutos mais longos. Estas duas cultivares foram agrupadas em diferentes grupos, de acordo com o método de Tocher. A correlação genotípica entre a espessura do pericarpo e peso do fruto foi altamente significativa (0,70). A espessura do pericarpo apresentou alta correlação com maior diâmetro do fruto (0,93) e menor diâmetro do fruto (0,93), ambas altamente significativas. Estes valores de correlação são confiáveis, uma vez que estas características apresentaram alta herdabilidade. Estes valores indicam que é possível selecionar-se indiretamente para a espessura de pericarpo por meio da seleção de frutos mais largos. Alguns autores sugerem que frutos com cutícula mais espessa e frutos mais largos devem apresentar menor perda de água pós colheita. Desta forma sugerimos que pequenos produtores cultivem 'habanero vermelha' e 'dedo de moça', em ordem de obter frutos com maior vida de prateleira.

Palavras-chave: *Capsicum* spp., perda de água, herdabilidade, variabilidade.

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Pepper plants (*Capsicum* spp.) belong to the Solanaceae family (Pickersgill, 1997), *Capsicum* genus and englobe about 30 identified species. Five of these species (*C. annuum*, *C. baccatum*, *C. chinense*, *C. frutescens* and *C. pubescens*) are domesticated (Stommel & Bosland, 2006). In Brazil four species occur: *C. annuum*, *C.*

chinense, *C. frutescens* and *C. baccatum*, being the bell's pepper (*C. annuum*) production the predominant one (Costa *et al*., 2015).

Peppers are vegetables consumed all over the world (Silva *et al*., 2015). Pepper fruits are important sources of natural antioxidants such as vitamin C, carotenoids and vitamin E (Santos *et al*., 2019). Pepper production's scene looks promising due to the increase of these species' consumption for food and ornamental purposes (Rêgo & Rêgo, 2018).

For food purposes the pepper market can be divided into two great groups: *in natura*, usually in small portions and also processed, which includes sauces, pickles, dehydrated flakes and powder as a food ingredient (Silva *et al*., 2015), being this market a segment with great potential for growth in all continents (Domenico *et al*., 2012). Pepper agribusiness has socioeconomical importance because it evolves from family agriculture (small farms) to small agroindustries (artesanal), medium and multinationals (Ulhoa *et al*., 2014).

Biometric fruit characterization has great importance and consists of the plant's morphological aspects evaluation (Macedo *et al*., 2009), and is able to define post-harvest handling as well as the acceptance of the product by consumer's market (Dutra *et al*., 2017).

Intense water loss appears to be the major factor limiting post-harvest longevity of pepper fruits and, therefore, hindering their distribution on the fresh market (Tafolla-Arellano *et al*., 2018). Several studies report that pepper fruit's cuticle and pericarp thickness vary among marked cultivars and this variation likely influences many fruit quality traits, especially water loss rates (Banaras *et al*., 1994; Maalekuu *et al*., 2003; Rêgo *et al*., 2009; Ilic *et al*., 2014).

Few pepper genotypes have been studied about their cuticle/exocarp variability (Parsons *et al*., 2013), and most of those studies are about *C. annuum* species despite the high genetic variability of other C*apsicum* species (Sousa & Maluf, 2003; Rêgo *et al*., 2009).

The Genetic and Breeding Research Group of Center for Agricultural Sciences at the Federal University of Paraíba has developed projects together with small farmers in order to start fresh market pepper cultivars production in Paraíba State. Thus the objective of this research was to evaluate the performance of pepper cultivars based on fruit traits, and indicate the cultivars of *Capsicum* spp. with less probability of post harvest water loss.

MATERIAL AND METHODS

Pepper fruits were collected in an experimental field of family farmers located on Bonfim's settlement, county of Alagoinha (06º57'00"S, 35º32'42"W), Paraíba, Brazil. After harvest, fruits were taken to the Biotechnology and Plant Breeding Laboratory of Centro de Ciências Agrárias (CCA) of Universidade Federal da Paraíba (UFPB). Plant material was derived from eight pepper cultivars of the species *C. chinense* ('habanero amarela', 'habanero vermelha', 'pimenta de cheiro amarela', 'biquinho vermelha', and 'cabeça roxa'), *C. frutescens* ('tabasco' and 'malagueta') and *C. baccatum* ('dedo de moça').

Fruits were characterized according to pericarp thickness, fruit weight, fruit length, larger and smaller fruit diameter. The fruit dimensions measurements were obtained with a digital pachymeter (digital pachymeter Leetools®). In order to obtain weight a digital scale was utilized (Bel engineering®). The experimental design was completely randomized with eight treatments (cultivars) and four repetitions. Each repetition was measured based on the means of five fruits.

Analysis of variance was performed with subsequent grouping of the means by Scott Knott's test ($p \leq 0.01$). The heritability and the ratio of coefficients of genetic variation by coefficient of environmental variation (CVe) were estimated according to Cruz *et al*. (2012):

$$h^2 = \frac{\sigma_g^2}{\sigma^2} \qquad (1)$$

Where h^2 is heritability, $\sigma^2 g$ is genotypic variance, and σ^2 is the environmental variance.

$$CV_g = \left(\frac{\sqrt{\sigma_g^2}}{m}\right) \times 100 \qquad (2)$$

Where CV_g is the coefficient of genetic variation, $\sigma^2 g$ is the genotypic variance, and m is the mean of the trait.

$$CV_e = \left(\frac{\sqrt{\sigma^2}}{m}\right) \times 100 \qquad (3)$$

Where CVe is the coefficient of environmental variation, σ^2 is the environmental variance, and m is the mean of the trait.

The correlations were tested with the Student's t-test ($p \leq 0.01$). Tocher's method (Rao, 1952) based on Mahalanobis' generalized distance was used to analyze genetic divergence among cultivars. All analyses were performed using Genes software (Cruz, 2016).

RESULTS AND DISCUSSION

Significant differences were observed ($p \leq 0.01$) among pepper cultivars for all traits, showing variability between treatments.

Coefficient of variation values ranged from 7.175 to 18.649% for the traits fruit length and pericarp thickness, respectively. This variation may be associated to the species in this study and with an existing variability on the evaluated traits. According to Silva *et al*. (2011), the coefficient of variation in pepper plants for average fruit weight, larger and smaller fruit diameter and pericarp thickness showed amplitude depending on the traits and species studied. This may also be associated with other aspects, such as number of repetitions.

All evaluated traits presented high heritability estimates (h^2), with values superior to 90%, pericarp thickness (90.16%), fruit weight (98.14%), fruit length (98.82%), larger fruit diameter (96.82%) and smaller fruit diameter (99.29%). When the heritability shows values close to or equal to 100% it is an indication that the given trait is controlled by gene action and therefore being recommended cultivar selection based on these phenotypes in order to achieve genetic gain in the next

Table 1. Mean values for biometric fruit traits in pepper cultivars (*Capsicum* spp.). Areia, UFPB, 2020.

Cultivars	PT (cm)	FW (g)	FL (cm)	LFD (cm)	SFD (cm)
Habanero amarela	0.23a	8.00a	3.09c	2.30b	2.22a
Habanero vermelha	0.17b	7.92a	3.02c	2.76a	2.31a
Pimenta de cheiro amarela	0.18b	3.75c	3.45c	1.56c	1.11b
Tabasco	0.16b	2.19d	4.44b	1.09d	0.48d
Biquinho vermelha	0.18b	1.43d	2.00d	1.40c	0.39d
Cabeça roxa	0.15b	1.97d	2.31d	1.43c	0.79c
Dedo de moça	0.22a	5.33b	5.41a	1.52c	0.83c
Malagueta	0.11c	0.52e	1.88d	0.72e	0.36d

PT= pericarp thickness; FW= fruit weight; FL= fruit length; LFD=larger fruit diameter; SFD= smaller fruit diameter.

Table 2. Estimates of the phenotypic correlation coefficient (rP), genotypic correlation coefficient (rG) and environmental correlation coefficient (rE) for biometric fruit traits in pepper plants (*Capsicum* spp.). Areia, UFPB, 2020.

Variables		FW	FL	LFD	SFD
	rP	0.66^{ns}	0.53^{ns}	0.58^{ns}	0.50^{ns}
PT	rG	0.70**	0.57^{ns}	0.62^{ns}	0.54^{ns}
	rE	-0.04^{ns}	-.023^{ns}	-0.03^{ns}	-0.34^{ns}
	rP		0.36^{ns}	0.93**	0.93**
FW	rG		0.35^{ns}	0.93**	0.93**
	rE		0.648^{ns}	0.55**	0.18^{ns}
	rP			0.08^{ns}	0.05^{ns}
FL	rG			0.07^{ns}	0.05^{ns}
	rE			0.21^{ns}	0.01^{ns}
	rP				0.95**
LFD	rG				0.95**
	rE				0.58**

^{ns}Non-significant; **significant at 1% by F test. PT= pericarp thickness; FW= fruit weight; FL= fruit length; LFD= larger fruit diameter; SFD= smaller fruit diameter.

generations (Leite *et al*., 2016). Pessoa *et al*. (2018) also recommend genotype selection based on pepper fruit traits with high heritability values. CVg/CVe ratio values were superior to 1 for all evaluated traits, pericarp thickness (1.74), fruit weight (4.19), fruit length (5.30), larger fruit diameter (3.18) and smaller fruit diameter (6.87). When these values are superior to 1 it is an indication that genetic variation is higher than environmental variation and that there are possibilities of genetic gain with selection (Cruz *et al*., 2012). The accumulation of knowledge about these parameters may allow the establishment of more effective breeding strategies aiming to develop superior cultivars (Alves *et al*., 2006), based on the selection's goal. Thus, selecting cultivars based on traits with high heritability and high CVg/CVe ratio, close to or superior to 1 will provide genetic gain with selection.

Cultivars were grouped by Scott Knott's test at 1% in distinct classes (Table 1). The traits fruit weight and larger fruit diameter formed five classes and presented the highest variation among cultivars for these traits. This information makes it possible to indicate pepper cultivars for commercialization.

Based on pericarp thickness, the cultivars were divided into three classes with the highest mean values for 'habanero amarela' and 'dedo de moça' 0.23 and 0.22 cm, respectively (Table 1). The smallest value for this trait (0.11 cm) was observed for 'malagueta'. The remaining cultivars presented similar behavior for this trait. This trait is related to pepper plant's commercialization (Heinrich *et al*., 2015) because it influences the increase in fruit firmness, and firmer fruits with thick pericarp, are more resistant to injuries during post-harvest handling (Ferrão *et al*., 2011) such as water loss (Parsons *et al*., 2013; Ilic *et al*., 2014). According to Cruz *et al*. (2019), pepper fruits with pericarp thickness mean values superior to 0.16 cm are recommended for *in natura* commercialization.

Habanero peppers presented larger and heavier fruits. According to Finger *et al*. (2012), fruits with these characteristics are for both, processed sauce and fresh fruit market. On the other hand, 'malagueta' presented the smallest mean values for fruit weight (0.52 g) (Table 1). This cultivar is one of the most well-known and widely commercialized peppers, has conical fruits, erect, with very thin wall and soft pulp (Mengarda & Lopes, 2012). These species have high amount of capsaicinoids, substance that provides the typical spiciness of this species (Santos *et al*., 2019). Since this pepper's processing is, in most cases, homemade, producers' orientation and monitoring quality aspects of the product is a must in order to prevent losses by

deterioration (Rebouças *et al*., 2013).

Regarding fruit length, cultivars were grouped into four distinct classes (Table 2), 'dedo de moça' peppers presented major values for this trait (5.41cm) and 'malagueta' was the smallest one (1.88 cm). 'Dedo de moça' is one of the most consumed peppers in Brazil, they have elongated fruits which measure approximately 6.0 cm. This cultivar is used for fresh market as well as for processing liquid sauces (Carvalho *et al*., 2009). The mean values of fruit length observed in this work are similar to the values reported by Chunthawodtiporn *et al*. (2018**)**, not presenting variation within this species, and probably suffer less environments variation.

The cultivar with the highest mean value for larger fruit diameter was 'habanero vermelha' (2.76 cm), and 'malagueta' presented the smallest one (0.726 cm) (Table 1). Fruit length, fruit diameter and pericarp thickness are valuable traits for pulp yield, adding economic value to these cultivars (Abud *et al*., 2018).

Among the three types of correlation (phenotypic, genotypic or environmental), the genotypic correlation is interesting for plant breeding given that it evolves a combination of hereditary nature (Nogueira *et al.*, 2021).

The genotypic correlation (r_g) between pericarp thickness and fruit weight was high and highly significant (0.70) (Table 2). There is the possibility of indirect selection when the genotypic correlation between two traits is high. It is also critical to consider costs, infrastructure, complexity and time necessary to evaluate these traits (Leite *et al*., 2016; Freitas *et al*., 2021). Fruit weight also presented highly significant genotypic correlation with larger fruit diameter (0.93) and small fruit diameter (0.93). The larger and smaller fruit diameter was highly correlated (0.95). Rêgo *et al*. (2011) demonstrated that pericarp thickness had significant and positive correlation with larger and smaller fruit diameter; fruit weight and fruit dry matter. When the coefficient of correlation is close to 1, higher is the association between two variables (Miot, 2018). Those finds indicate that indirect selection for pericarp thickness could be done based on larger fruit diameter since it is easier to measure, and is not necessary to cut the fruit. These correlations are trustworthy and important due to the high heritability values presented for these traits, close to 1.

Four groups were formed by Tocher's grouping method (Table 3). This group number based on the biometric fruit traits demonstrates large variability among the evaluated cultivars. Group I was constituted by three cultivars: ('biquinho vermelha', 'malagueta' and 'cabeça roxa'). Group II ('habanero amarela', and 'habanero vermelha') and group III ('tabasco' and 'dedo de moça') were formed by two cultivars each. Group IV was formed by only one cultivar ('pimenta de cheiro amarela'). Pessoa *et al*. (2019) emphasize that pepper cultivars belonging to distinct groups present fruits with diverse phenotypic characters. It is important to highlight that 'habanero vermelha' had better performance for fruit weight and larger and smaller fruit diameter. On the other hand 'dedo de moça' presented the longest fruits and major pericarp thickness. These two cultivars also belonged to different groups based on Tocher's method. Some authors suggest that by selecting fruits with higher cuticle thickness and fruit width values we are indirectly selecting fruits with lower water loss (Ferrão *et al*., 2011; Parsons *et al*., 2013; Ilic *et al*., 2014). Thus, we suggest the small farmers to cultivate 'habanero vermelha' and 'dedo de moça' in order to have fruits with extended shelf life.

Table 3. Grouping of the eight pepper cultivars according to the quantitative fruit traits using Tocher's method. Areia, UFPB, 2020.

Groups	Cultivars
I	biquinho vermelha, malagueta, cabeça roxa
II	habanero amarela, habanero vermelha
III	tabasco, dedo de moça
IV	pimenta de cheiro amarela

REFERENCES

ABUD, HF; ARAÚJO, RF; PINTO, CMF; ARAÚJO, EF; ARAÚJO, AV; SANTOS, JA. 2018. Caraterização morfométrica dos frutos de pimentas malagueta e biquinho. *Revista Brasileira de Agropecuária Sustentável* 8: 29-39.

ALVES, JCS; PEIXOTO, JR; VIEIRA, JV; BOITEUX, LS. 2006. Herdabilidade e correlações genotípicas entre caracteres de folhagem e sistema radicular em famílias de cenoura, cultivar Brasília. *Horticultura Brasileira* 24: 363-367.

BANARAS, M; LOWNDS, NK; BOSLAND, PW. 1994. Relationship of physical properties to postharvest water loss in pepper fruits (*Capsicum annuum* L.). *Pakistan Journal of Botany* 26: 321-326.

CARVALHO, SIC; RIBEIRO, CSC; HENZ, GP; REIFSCHNEIDER, FJB. 2009. 'BRS Mari': nova cultivar de pimenta dedo de moça para processamento. *Horticultura Brasileira* 27: 571-573.

CHUNTHAWODTIPORN, J; HILL, T; STOFFEL, K; DEYNZE, AV. 2018. Quantitative trait loci controlling fruit size and other horticultural traits in bell pepper (*Capsicum annuum*). *Plant Genome* 11: 1-11.

COSTA, LV; BENTES, JLS; LOPES, MTG; ALVES, SRM; VIANA JÚNIOR, JM. 2015. Caracterização de acessos de pimentas do Amazonas. *Horticultura Brasileira* 33: 290-298.

CRUZ, CD. 2016. Genes software – extended and integrated with the R, Matlab and Selegen. *Acta Scientiarum. Agronomy* 38: 547-552.

CRUZ, CD; REGAZZI, AJ; CARNEIRO, PCS. 2012. Modelos biométricos aplicados ao melhoramento genético. Viçosa, BR: UFV. 514p.

CRUZ, DRC; VIRTUOSO, MCD; FARIA, LR; CABRAL, FS; SARTI, JK; VALE, LSR. 2019. Avaliação morfológica de genótipos de pimentas bode desenvolvidos no IF Goiano - Campus Ceres. *Revista Brasileira Multidisciplinar* 22: 1-10.

RÊGO, ER; RÊGO, MM. 2018. "Ornamental pepper", in ornamental crops. Switzerland. Huylenbroeck J (ed). (Springer International Publishing Switzerland) 11: 529-565.

DOMENICO, CI; COUTINHO, JP; GODOY, HT; MELO, AMT. 2012. Caracterização agronômica e pungência em pimenta de cheiro. *Horticultura Brasileira* 30: 466-472.

DUTRA, FV; CARDOSO, AD; MORAIS, OM; VIANA, AES; MELO, TL; JÚNIOR, NSC. 2017. Características físicas e químicas de acessos de umbuzeiros (*Spondias tuberosa* Arr. Cam). *Revista de Ciências Agrárias* 40:

814-822.

FERRÃO, LFV; CECON, PR; FINGER, FL; SILVA, FF; PUIATTI, M. 2011. Divergência genética entre genótipos de pimenta com base em caracteres morfo-agrônomicos. *Horticultura Brasileira* 29: 354-358.

FINGER, FL; RÊGO, ER; SEGATTO, FB; NASCIMENTO, NFF; RÊGO MM. 2012. Produção e potencial de mercado para pimenta ornamental. *Informe Agropecuário* 33:14-20.

FREITAS, AF; LOPES, R; CUNHA, RNV; PINA, AJA; RESENDE, MDV; JÚNIOR, RAG. 2021. Valores genotípicos e correlações genéticas para componentes e teor de óleo do cacho de híbridos entre caiaué e dendê. *Colloquium Agrariae* 17: 79-92.

HEINRICH, AG; FERRAZ, RM; RAGASSI, CF; REIFSCHNEIDER, FJB. 2015. Caracterização e avaliação de progênies autofecundadas de pimenta biquinho salmão. *Horticultura Brasileira* 33: 465-470.

ILIĆ, ZS; LJUBOMIR, Š; MIRECKI, N; FALLIK, E. 2014. Cultivars differences in keeping quality and bioactive constituents of bell pepper fruit during prolonged storage. *Journal of Advances in Biotechnology* 4: 313-318.

LEITE, WS; PAVAN, BE; MATOS FILHO, CHA; ALCANTARA NETO, F; OLIVEIRA, CB; FEITOS, FS. 2016. Estimativas de parâmetros genéticos, correlações e índices de seleção para seis caracteres agronômicos em linhagens F_8 de soja. *Comunicata Scientiae* 7: 302-310.

MACEDO, MC; SCALON, SPQ; SARI, AP; SCALON FILHO, H; ROSA, YBCJ; ROBAINA, AD. 2009. Biometria de frutos e sementes e germinação de *Magonia pubescens* st.hil (sapindaceae). *Revista Brasileira de Sementes* 21: 202-211.

MAALEKUU, K; ELKIND, Y; FALLIK, E; SHALOM, Y; TUVIA-ALKALAI, S. 2003. Quality evaluation of three sweet pepper cultivars after prolonged storage. *Advances in Horticultural Science* [rivista dell'ortofloroftutticoltura italiana] 17: 1000-1005.

MENGARDA, LHG; LOPES, JC. 2012. Qualidade de sementes e desenvolvimento inicial de plântulas de pimenta malagueta e sua relação com a posição de coleta de frutos. *Revista Brasileira de Sementes* 34: 644-65.

MIOT, HA. 2018. Correlation analysis in clinical and experimental studies. *Jornal Vascular Brasileiro* 17: 275-279.

NOGUEIRA, APO; SEDIYAMA, T; SOUSA, LB; HAMAWARI, OT; CRUZ, CD; PEREIRA, DG; MATSUO, E. 2021. Análise de trilha e correlações entre caracteres em soja cultivada em duas épocas de semeadura. *Bioscience* Journal 28: 877-888.

PARSONS, EP; POPOPVSKY, S; LOHREY, GT; ALKALAI-TUVIA, S; PERZELAN, Y; BOSLAND, P; JENKS, MA. 2013. Fruit cuticle lipid composition and water loss in a diverse collection of pepper (*Capsicum*) *Physiologia Plantarum* 149: 160-174.

PESSOA, AMS; RÊGO, ER; CARVALHO, MG; SANTOS, CAP; RÊGO, MM. 2018. Genetic diversity among accessions of *Capsicum annuum* L. through morphoagronomic characters. *Genetics and Molecular Research* 17: 1-15.

PESSOA, AMS; REGO, ER; SANTOS, CAP; VASCONCELOS, MC; MESQUITA, JCP; REGO, MM. 2019. Potential of pepper plant accessions for ornamental purposes using diallel analysis. *Anais da Academia Brasileira de Ciências* 91: 1-16.

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

RAO, CR. 1952. Advanced statistical methods in biometric research. New York: John Wiley & Sons. 390p.

REBOUÇAS, TNH; VALVERDE, RMV; TEIXEIRA, HL. 2013. Bromatologia de pimenta malagueta in natura e processada em conserva. *Horticultura Brasileira* 31: 163-165.

RÊGO, ER; FINGER, FL; CRUZ, CD; RÊGO, MM. 2009. A diallel study of yield components and fruit quality in chilli pepper (*Capsicum baccatum*). *Euphytica* 168: 275-287.

RÊGO, ER; NASCIMENTO, NFF; NASCIMENTO, MF; SANTOS, RM; LEITE, PSS; FINGER, FL. 2011. Caracterização fenotípica para caracteres de porte em família F_2 de pimenteiras ornamentais. *Horticultura Brasileira* 29: 1-9.

SANTOS, EPL; CARVALHO, EEN; BRITO, TRC; LEAL, TCAB; AUGUSTA NETO, A; RIBEIRO, GRS; BARBOSA, TF. 2019. Manutenção da qualidade pós-colheita de pimenta de cheiro (*Capsicum chinense*) armazenadas sob atmosfera modificada e refrigeração**.** *Journal of Biotechnology and Biodiversity* 7: 241-248.

SILVA, AR; CECON, PR; RÊGO, ER; NASCIMENTO, M. 2011. Avaliação do coeficiente de variação experimental para caracteres de frutos de pimenteiras. *Revista Ceres* 58: 168-171.

SILVA, HW; COSTA, LM; RESENDE, Q; OLIVEIRA, DEC; SOARES, RS; VALE, LSR. 2015. Higroscopicidade das sementes de pimenta (*Capsicum chinense* L.). *Revista Brasileira de Engenharia Agrícola e Ambiental* 19: 780-784.

SOUSA, JA; MALUF, WR. 2003. Diallel analyses and estimation of genetic parameters of hot pepper (*Capsicum chinense* Jacq). *Scientia Agrícola* 60:105-113.

STOMMEL, JR; BOSLAND, PW. 2006. Ornamental pepper, *Capsicum annuum*. In: Anderson N (ed). Flower Breeding and Genetics: Issues, Challenges and 64 opportunities for the 21st Century. Dordrecht, The Netherlands: Springer 1: 561-599.

TAFOLLA-ARELLANO, JC; BÁEZ-SAÑUDO, R; TIZNADO-HERNÁNDEZ, ME. 2018. The cuticle as a key factor in the quality of horticultural crops. *Scientia Horticulturae* 232: 145-152.

ULHOA. AB; PEREIRA, TN; SILVA, RN; RAGASSI, CF; RODRIGUES, R; PEREIRA, MG; REIFSCHNEIDER, FJB. 2014. Caracterização molecular de linhagens de pimenta do tipo Jalapeño amarelo. *Horticultura Brasileira* 32: 35-40.