Selection of ornamental peppers elite lines for ethylene-insensitive

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ABSTRACT

Peppers belongs to *Capsicum* genus and have a lot of different varieties. They can be different uses such as potted ornamental plants. Retail market for this type of pepper requires the development of a greater number of commercial cultivars with adequate ornamental characteristics as well as an extended shelf life (post-production). Ethylene exposure causes adverse effects in ornamental pepper post-production. Then, the goal of this study was to select ornamental pepper elite lines (*Capsicum annuum* L.) for ethylene-insensitive. The experiment was conducted at the Laboratory of Plant Biotechnology of the Center for Agricultural Sciences of the Federal University of Paraíba, Areia, PB. The experiment was arranged in a completely randomized design. Eight elite lineages and two control cultivars evaluated at three times 48, 72 and 96 hours after ethylene exposure were disposed in a split-plot arrangement. Each treatment was composed of ten repetitions. The data were submmited to analysis of variance, Scott-Knott criteria (5%), and regression analysis. The leaves demonstrated to be more sensitive to ethylene while fruits were more insensitive. It is recommended selection of UFPB lines: 56.8.24.1; 56.26.15.1 and 56.26.34.1 to participate in trials tests aiming at registration of new ethylene-insensitive cultivars.

Keywords: leaf abscission; *Capsicum annuum*; senescence.

INTRODUCTION

Pepper plants from *Capsicum* genus are considered important genetic resources for brazilian plant biodiversity, with many varieties differing in types, color, size and flavor. They have different uses such as condiment, although commercialization as ornamental potted plants have been increasing in the last decade, both in domestic market as well as for exportation (Stommel & Bosland, 2006; Segatto *et al*., 2013; Finger *et al*., 2015; Do Rêgo & Do Rêgo, 2018).

Pepper plants used for ornamental purposes are, in general, from the species *Capsicum annuum* L., which presents traits that enhance this potential such as variegated leaves, compact height, leaves, flowers and fruits with different sizes and colors. (Do Rêgo & Do Rêgo, 2016; Pessoa *et al*., 2018).

Retail market for this type of pepper requires the development of a greater number of commercial cultivars with adequate ornamental characteristics as well as an extended shelf life (post-production). There are still few reports on the behavior of *Capsicum* species cultivated in pots and the influence of environmental factors in its longevity (Finger *et al*., 2015).

There are major obstacles affecting quality and shelf-life of ornamental plants in post-production, including exposition of low light intensity and water stress, even though ethylene exposure is one of the most important (Høyer, 1996; Finger *et al*., 2006; Segatto *et al*., 2013).

Ethylene causes a series of deleterious responses such as leaves' yellowing caused by chlorophyll degradation, fruits and leaves' abscission and also accelerated senescence process (Iqbal *et al*., 2017). Small amounts of ethylene in the environment, 10µl/L, affect post-harvest quality of ornamental peppers (Segatto *et al*., 2013).

In general, ethylene itself is one of main factors responsible for reducing the longevity of many ornamen-

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tal plants, especially when exposed during transport (Nascimento *et al*., 2015; Lima *et al*., 2017). Ethylene's negative effect on sensitive varieties is one of the major factors that reduce commercialization of ornamental peppers (Segatto *et al*., 2013).

It is important to improve ornamental pepper plants for ethylene resistance to improve the shelf life in markets sale. In this context, the goal of this study was to select ethylene-insensitive elite lines of ornamental peppers (*Capsicum annuum* L.).

MATERIALS AND METHODS

The experiment was conducted at the Laboratory of Plant Biotechnology of the Center for Agricultural Sciences of the Federal University of Paraíba (Centro de Ciências Agrárias da Universidade Federal de Paraíba - CCA-UFPB), Areia, Paraíba, Brazil.

Ten elite lines of ornamental peppers were used: eight eline lineages (17.15.4.1; 55.50.44.1; 17.15.48.1; 55.50.4.1; 56.8.24.1; 56.26.15.1; 56.26.33.1 and 56.26.34.1), and two lineages controls (UFPB 77.3 and UFPB 134); belonging to the active germplasm bank from CCA-UFPB, originated from controlled self pollination of F_5 population. The original crossing was between UFPB77.3 x UFPB134, and successive generations following the pedigree method.

The seeds were sown in styrofoam (polysterene) trays, containing 180 cells filled with commercial substrate Plantmax®. When the plants had six permanent leaves, they were transplanted to 900 ml pots, containing the same substrate and kept in greenhouses until frutification.

Daily irrigations were conducted and weekly fertirrigations with nutritious solution (Mesquita *et al*., 2016). The phytosanitary treatments were made when necessary, during the whole cycle, in order to minimize damage caused by pests and diseases.

When the plants were ready to commercialize, with at least 50% of fully ripe fruits (Nascimento *et al*., 2015), the plants were transferred from the greenhouse to the laboratory of Biotechnlogy of UFPB where leaf counting, fruit counting and quantification of chlorophyll (a e b) were made. After these measurements, plants were storaged in hermetic sealed chambers with capacity for 60L (Santos *et al*., 2013) and temperature 25 °C. Ethylene applications were made with a graduated syringe, injecting gas through silicon septs already existing in the chambers at concentration of 10μL L^{-1} (Segatto *et al*., 2013). The variable measurements were made after 48 hours of ethylene exposure (Nascimento *et al*., 2015), the amount of time necessary for the plant to start losing commercial value.

The variables evaluated were leaf abscission (LA), fruit abscission (FA), chlorophyll a (Cloa) e chlorophyll b (Clob). Leaves and fruits losses were expressed in percentage, regarding time zero, after the exposure (Nascimento *et al*., 2015). Leaves and fruits were counted after day zero, those which remained in the plant and, in fruit case, those which did not present wilt signals (Lima *et al*., 2017).

For chlorophyll a and b analysis three completed expanded leaves were randomly selected and evaluated. The leaves chosen were one from the base, one from the intermediate portion and one from the top of each plant, using ClorofiLOG®. The evaluations were made according to the same interval cited for leaves, flowers and fruits.

The experiment was arranged in a completely randomized design. Eight elite lineages and two control cultivars evaluated at three times 48, 72 and 96 hours after ethylene exposure were disposed in a split-plot arrangement. Each treatment was composed of ten repetitions.

The data were submitted to analysis of variance, Scott-Knott criteria (5%), and regression analysis. All statistical analysis was performed with GENES software (Cruz, 2016).

RESULTS AND DISCUSSION

It was observed significant interaction between lineages and time for the characteristics leaf abscission and chlorophyll b and chlorophyll *a* ($p < 0.05$) (Table 1), showing that ornamental peppers populations behave differently for those characteristics on the different ethylene exposure times. Santos *et al*. (2015) e Santos *et al*. (2013) when studying post-production of ornamental peppers also observed significant interaction in population x time for leaf abscission.

The characteristic fruit abscission showed significant differences just for ethylene exposure time (Table 1). This shows that plant exposure to ethylene 10μL L^{-1} during the evaluation time was enough to harm ornamental peppers' commercial value.

Ornamental peppers elite lineages varied in plant sensitivity to ethylene for characteristics such as leaf abscission and percentage of chlorophyll a and b degradation (Table 2). According to studies performed by Serek *et al*. (2006) the ethylene-sensitive in ornamental plants usually occurs in the family level. In ornamental peppers it also varies according to the family and cultivar evaluated (Santos *et al*., 2013; Segatto *et al*., 2013).

Regarding leaf abscission, the lines 56.26.34.1 e 56.26.15.1 exhibited the smallest rates of leaf abscission after 96 hours after they were took from the containers, presenting values of 68,46% e 69,56%, respectively (Table 2). According to Finger *et al*. (2015) the leaves senescence, after ethylene exposure, reduce the shelf life and post-production, making commercialization impossible. Segatto *et al*. (2013) e Lima *et al*. (2017) reported leaf loss of 100% in cultivar Calypso when compared to control plants, after exposure to the same amounts of ethylene used in our study.

Leaf losses after ethylene exposure were also reported in colored peppers (53%), ornamental bell pepper (78,7%) and orange pepper (8,5%) (Ribeiro *et al*. 2019), however these data refers only to losses after 48h hours of exposure to ethylene in order to simulate the time when plants would be at transportation. The cultivars, studied by these authors, accumulated losses over the following days and they were greater than 53%. Besides that, cultivars studied by these authors have very low leaf number as showed in the pictures, when compared to leaf numbers from the elite lines of our study (Table 3). It was observed that lines 56.26.34.1 and 56.26.15.1 were more tolerant to ethylene's action and even at the end of 96 hours still maintained 57 and 53 leaves, respectively (Table 3).

Table 1: Summary of analysis of variance for leaf abscission (LA), fruit abscission (FA), chlorophyll a (Cloa) and b (Clob) in F_6 of ornamental peppers elite lineages

F. V.	Characteristics/Mean Square			
	LA	FA	Cloa	Clob
Lineages	471.11^{ns}	713.22^{ns}	216.77^{ns}	152.14^{ns}
Error a	501.22	601.07	368.53	472.50
Time	5,5030.19*	765.62*	1,5302.6*	18,364.65*
Lineages x Time	247.61*	44.13^{ns}	208.65*	242.12*
Error b	94.62	39.09	121.69	103.54

^{ns} Not signifcant, * Significant by F test ($p \leq 0.05$).

Table 2: Unfolding lineages x time interactions after ethylene exposure of leaf abscission (LA), chlorophyll a (Cloa) and chlorophyll b (Clob) in *Capsicum annuum* L

Variables	LinesUFPB:	Time (hours)			Equation	R^2
		48	72	96		
LA	77.3	26.58b	61.77a	83.47a	Y= -28.06 + 1.2x	0.98
	134	23.68b	68.65a	86.56a	Y = -3.25 + 33.44x	0.94
	17.15.4.1	31.60b	60.14a	76.67a	Y = 11.06 + 22.53x	0.97
	17.15.48.1	31.77b	55.85b	77.59a	Y = 9.25 + 22.91x	0.99
	55.50.4.1	34.31b	60.30a	84.45a	Y = 9.54 + 25.07x	0.99
	55.50.44.1	29.32b	56.87b	76.24a	Y = 7.22 + 23,46x	0.99
	56.8.24.1	31.91b	56.34b	80.75a	Y = 7.49 + 24.42x	0.99
	56.26.15.1	29.53b	50.92b	69.56b	Y = 9.97 + 20.01x	0.99
	56.26.33.1	44.56a	65.65a	79.47a	Y = 28.31 + 17.45x	0.98
	56.26.34.1	33.02b	52.72b	68.46b	Y = 15.96 + 17.72x	0.99
Clo*a*	77.3	10.54a	23.03a	36.58b	Y = -2.65+13.02x	0.99
	134	9.14a	21.41a	31.93b	Y = -1.96 + 11.39x	0.99
	17.15.4.1	13.57a	21.32a	28.89b	Y = 5.94 + 7.66x	0.99
	17.15.48.1	15.26a	20.40a	30.32b	Y = 6.93 + 7.53x	0.96
	55.50.4.1	10.04a	18.68a	53.12a	Y = 15.8 + 21.54x	0.89
	55.50.44.1	9.57a	19.16a	37.52b	Y = -5.86 + 13.97x	0.96
	56.8.24.1	10.01a	17.22a	31.37b	Y = -1.82 + 10.68x	0.96
	56.26.15.1	6.45a	14.67a	31.12b	Y = -7.25 + 12.23x	0.96
	56.26.33.1	8.74a	18.78a	30.60b	Y = -2.48 + 10.93x	0.99
	56.26.34.1	9.10a	15.71a	35.22b	Y = -6.11 + 13.06 x	0.92
Clo*b*	77.3	12.21a	26.99a	48.38a	Y = -6.97 + 18.08X	0.98
	134	18.05a	30.23a	39.45b	Y = 7.84 + 10.7x	0.99
	17.15.4.1	15.21a	27.31a	37.10b	Y = 4.65 +10.94x	0.99
	17.15.48.1	13.83a	24.38a	34.65b	Y= 3.46 + 10.41 x	0.99
	55.50.4.1	10.44a	22.93a	56.94a	Y = -16.39 + 23.25x	0.93
	55.50.44.1	14.84a	26.44a	42.09b	Y = 0.54 + 13.62x	0.99
	56.8.24.1	13.16a	27.91a	33.47b	Y = 4.53 +10.15x	0.93
	56.26.15.1	12.77a	25.23a	40.48b	Y = -1.55 + 13.85x	0.99
	56.26.33.1	11.68a	26.16a	32.95b	Y = 2.32 + 10.63x	0.95
	56.26.34.1	13.14a	23.36a	40.64b	Y = -1.78 + 13.75x	0.97

Means followed by the same letter, at the column, are not significantly different by Scott-Knott criteria ($p \leq 0.05$).

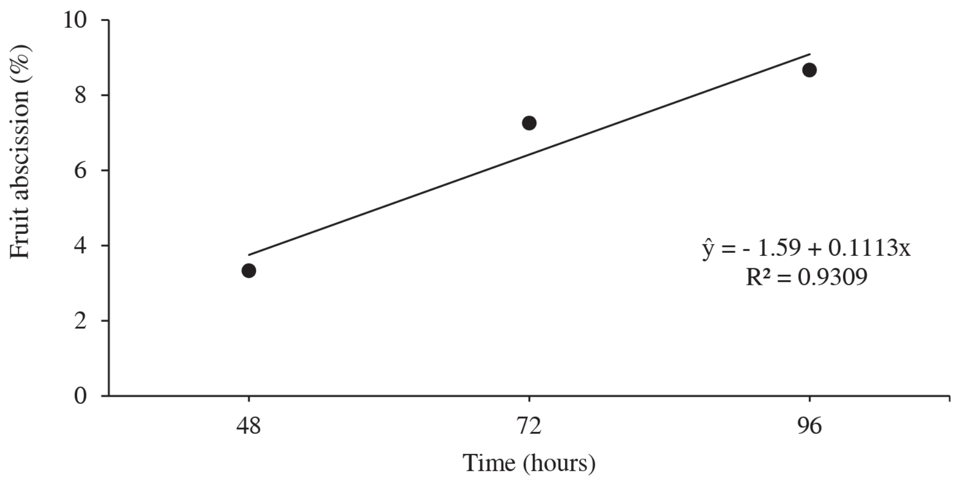

Figure 1: Percentage of fruit abscission after application 10 µL/L of ethylene during 48h, 72h and 96h in F_6 lines of *Capsicum annuum* L.

Table 3: Means of leaf number (LN) in F_6 lineages and control genotypes of ornamental peppers at 0 and 96 hours after ethylene application

Lineages	Time	
	Zero hour	**96 hours**
77.3	226.4	33.0
134	137.8	19.0
17.15.4.1	169.1	41.0
17.15.48.1	223.4	52.0
55.50.4.1	165.3	31.0
55.50.44.1	153.7	41.0
56.8.24.1	227.6	46.0
56.26.15.1	195.0	57.0
56.26.33.1	178.0	39.0
56.26.34.1	170.8	53.0

For Cloa and Clob there was no differences among the tested lineages at 48 and 72 hours. At 96 hours after ethylene's exposure, lineage 55.50.4.1. showed the major values of Cloa. Regarding Clob lineage 55.50.4.1. and the genitor 77.3 showed the major values (Table 2). Finger *et al*. (2015) did not observe significant decrease of Cloa in cultivar Calypso, although they detected loss in Clob.

There was a tendency in increase loss percentage of leaves, Cloa and Clob along the observation time with the regression model adjusted with R^2 greater than 0,89 (Table 2). Santos *et al*. (2015), when working with ornamental pepper genotype BGH7073 also observed adjusts to linear regression for percentage of leaf abscission after ethylene exposure of 10µL L^{-1}. Increasing time after the ethylene exposition may increase chlorophyll degradation (Streit *et al*., 2005). This fact was corroborated by this study.

Ethylene's action is one of the most important factors that affect quality and shelf life of ornamental potted peppers plants in post production (Finger *et al*., 2015; Do Rêgo & Do Rêgo, 2018). Therefore, it is important to have knowledge about the factors concerning post-harvest longevity of ornamental peppers in order to allow transportation and storage with maintenance of plant's quality.

Fruit loss percentage increased during observation time after ethylene exposure (Figure 1). Ribeiro *et al*. (2018) studying fruit loss caused by ethylene's exposure, in three varieties of ornamental peppers found loss values varied from 4,1 to 27,8%. On average, fruit loss percentage did not differ among lineages evaluated in this work and it was smaller than 10% (Figure 1). For Cultivar Calypso fruit loss percentage is null after 48 hours of ethylene exposure (Finger *et al*., 2015).

CONCLUSIONS

Elite lineages 56.26.15.1 and 56.26.34.1 must be selected to preliminary trials in F_7, because they were ethylene-insensitive showing the smallest percentage values of leaf abscission, chlorophyll a and chlorophyll b, keeping their commercial value.

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REFERENCES

Cruz CD (2016) Genes Software - extended and integrated with the R, Matlab and Selegen. Acta Scientiarum, 38:547-552.

Do Rêgo ER & Do Rêgo MM (2016) Genetics and Breeding of Chili Pepper *Capsicum* spp. In: Rêgo ER, Rêgo MM & Finger FL (Eds.) Production and breeding of chilli peppers (*Capsicum* spp.). Switzerland, Springer. p.57-80.

Do Rêgo ER & Do Rêgo MM (2018) Ornamental pepper. In: Van Huylenbroeck J (Ed.) Ornamental crops. Melle, Springer. p.529-565.

Finger FL, Santos VR, Barbosa JG & Barros RS (2006) Influência da temperatura na respiração, produção de etileno e longevidade de inflorescências de esporinha. Bragantia, 65:363-369.

Finger FL, Silva TP, Segatto FB & Barbosa JG (2015) Inhibition of ethylene response by 1-methylcyclopropene in potted ornamental pepper. Ciência Rural, 45:964-969.

Høyer L (1996) Critical ethylene exposure for *Capsicum annuum* 'Janne'is dependent on an interaction between concentration, duration and developmental stage. Journal of Horticultural Science, 71:621-628.

Iqbal N, Khan NA, Ferrante A, Trivellini A, Francini A & Khan MIR (2017) Ethylene role in plant growth, development and senescence: interaction with other phytohormones. Frontiers in Plant Science, 8:01-19.

Lima PCC, Ribeiro WS, Oliveira MMT, Costa LC & Finger FL (2017) Ethylene, 1-methylcyclopropene and silver thiosulfate on the post-production of ornamental pepper. Ciência Rural, 47:01-08.

Mesquita JCP, Rêgo ER, Silva AR, Silva Neto JJ, Cavalcante LC & Rêgo MM (2016) Multivariate analysis of the genetic divergence among populations of ornamental pepper (*Capsicum annuum* L.). African Journal of Agricultural Research, 11:4189-4194.

Nascimento MF, Rêgo ER, Nascimento NF, Santos R, Bruckner CH, Finger FL & Rêgo MM (2015) Correlation between morphoagronomic traits and resistance to ethylene action in ornamental peppers. Horticultura Brasileira, 33:151-154.

Pessoa MAS, Rêgo ER, Carvalho MG, Santos CAP & Rêgo MM (2018) Genetic diversity among accessions of *Capsicum annuum* L. through morphoagronomic characters. Genetics and Molecular Research, 17:01-15.

Ribeiro WS, Carneiro CDS, França CDFM, Pinto CMF, Lima PCC & Finger FL (2018) 1-MCP efficiency in quality of ornamental peppers. Horticultura Brasileira, 36:510-514.

Ribeiro WS, Carneiro CDS, França CDFM, Pinto CMF, Lima PCC, Finger FL & Costa FB (2019) Paclobutrazol application in potted ornamental pepper. Horticultura Brasileira, 37:464-468.

Santos RMC, Rêgo ER, Ferreira APS, Nascimento MF, Nascimento NFF, Coca GC, Rêgo MM, Borém A & Finger FL (2015) Inhibition of ethylene action by 1-MCP in post-production Ornamental Peppers. Acta Horticulturae, 1060:255-259.

Santos RMC, Rêgo ER, Nascimento MF, Nascimento NFF, Rêgo MM, Borém A & Costa DS (2013) Ethylene resistance in a F_2 population of ornamental chili pepper (*Capsicum annuum*). Acta Horticulturae, 1000:433-438.

Segatto FB, Finger FL, Barbosa JG, Rêgo ER & Pinto CMF (2013) Effects of ethylene on the post-production of potted ornamental peppers (*Capsicum annuum*). Acta Horticulturae, 1000:217-222.

Serek M, Woltering EJ, Sisler EC, Frello S & Sriskandarajah S (2006) Controlling ethylene responses in flowers at the receptor level. Biotechnololy Advances, 24:368-381.

Streit NM, Canterle LP, Canto MWD & Hecktheuer LHH (2005) The Chlorophylls. Ciência Rural, 35:748-755.

Stommel JR & Bosland PW (2006) Ornamental pepper, *Capsicum annuum*. In: Anderson NO (Ed.) Flower breeding and genetics: issues, challenges, and opportunities for the 21st Century. Netherlands, Springer. p.561-599.