horticultura brasileira

Scientific communication

RIBEIRO, WS; CARNEIRO, CS; FRANÇA, CFM; PINTO, CMF; LIMA, PCC; FINGER, FL. 2018. 1-MCP efficiency in quality of ornamental peppers. *Horticultura Brasileira* 36: 510-514. DOI - http://dx.doi.org/10.1590/S0102-053620180414

1-MCP efficiency in quality of ornamental peppers

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ABSTRACT

1-MCP has been effectively used as an antagonist of ethylene deleterious actions in flowers and ornamental plants. The objective was to evaluate the efficiency of 1-MCP (0.0, 0.5, 1.0 and 1.5 g m^{-3}) in maintaining post-production quality of exogenous ethylene sensitive ornamental pepper. Two commercial varieties were evaluated: Pimenta Colorida and Pimentão Ornamental, both *Capsicum annuum*. The pre-treatment with 1-MCP, regardless of the applied concentration, was effective in blocking the ethylene action reducing the leaves abscission, flowers and fruits of both genotypes by 100%. Plants pretreated with 1-MCP had postproduction life increased by eight and nine days for Pimenta Colorida and Pimentão Ornamental, respectively. The 1-MCP application at the concentration of 1.0 g m^{-3} is efficient in maintaining ornamental quality and prolonging the shelf life of Pimenta Colorida and Pimentão Ornamental.

Keywords: *Capsicum annuum*, ornamental plants, sensitivity, transport.

RESUMO

Eficiência do 1-MCP na qualidade de pimenteiras ornamentais

O 1-MCP tem sido efetivamente utilizado como antagonista das ações deletérias do etileno em flores e plantas ornamentais. O objetivo foi avaliar a eficiência do 1-MCP (0,0; 0,5; 1,0 e 1,5 g m^{-3}) na manutenção da qualidade pós-produção de pimenteiras ornamentais sensíveis ao etileno exógeno. Foram avaliadas duas variedades comerciais: Pimentão Ornamental e Pimenta Colorida, ambas *Capsicum annuum.* O pré-tratamento com 1-MCP, independente da concentração aplicada, foi eficaz em bloquear a ação do etileno reduzindo em 100% a abscisão de folhas, flores e frutos de ambos os genótipos. As plantas pré-tratadas com 1-MCP tiveram a vida de pós-produção aumentada em oito e nove dias para Pimenta Colorida e Pimentão Ornamental, respectivamente. A aplicação de 1-MCP na concentração de 1,0 g m^{-3} é eficiente em manter a qualidade ornamental e prolongar a vida de prateleira da Pimenta Colorida e Pimentão Ornamental.

Palavras chave: *Capsicum annuum*, plantas ornamentais, sensibilidade, transporte.

Received on March 14, 2017; accepted on September 14, 2018

Species of the genus *Capsicum* have different ethylene sensitivity levels. In potted peppers, ethylene triggers a series of deleterious responses, among them, the abscission of fruits and leaves as a reaction to tissue sensitivity. However, other negative effects are visible, such as the acceleration of chlorophyll degradation and the senescence process (Beaudry & Kays, 1998; Krajayklang *et al.*, 2000; Brackmann *et al.*, 2004; Segatto *et al*., 2013).

The need for chemical protection against the ethylene action has been recommended for many ornamental potted plants, in which low ethylene concentrations cause rapid losses in ornamental quality (Serek *et al.*, 1994). In this sense, cyclopropenes have been effectively used to prevent the deleterious ethylene effects on plants (Sisler & Serek, 1999).

The effects of these compounds as ethylene antagonists are attributed to their molecular structure which allows very strong binding to the low valence electron donor compounds present at the receptor. They compete with ethylene for their binding sites and remain bound to these receptors for a long time, thus avoiding the ethylene-dependent responses (Sisler & Serek, 1997, 1999).

1-MCP is one of the most useful compounds among cyclopropenes for this purpose. It is non-toxic, stable at room temperature, active at relatively low concentrations, providing protection for a long period of up to 12 days after a single exposure, without any detectable odor (Finger & Barbosa, 2006). However, depending on the shelf-life of these plants, the sensitivity of the plant tissue can be resumed by the synthesis of new binding sites allowing the ethylene action resumption (Blankenship & Dole, 2003).

So, one of the most sought goals in the post-production stage of ornamental plants, including pepper plants, is the nullification or delay of the deleterious effects caused by ethylene with minimal application of antagonists. The *Epidendrum ibaguense* orchid treated with 1-MCP had shelf life doubled when compared to control flowers (Finger *et al.*, 2008). Similar results were obtained in cultivars of *Phalaenopsis*, where the

1-MCP application inhibited the floral buds and flowers abscission, effectively blocking the ethylene action (Sun *et al.*, 2009).

Fumigation with cyclolefins 1-DCP and 1-OCP have been shown to be efficient in reducing the flower abscission rate in potted mini-roses even when ethylene is not the primary agent in inducing plant senescence (Buanong *et al*., 2005).

The 1-MCP effectiveness in delaying the senescence symptoms on majority of ornamental plants is dependent on application temperature, concentration and stage of plants development (Finger & Barbosa, 2006).

The objective of the present research was to evaluate the 1-MCP action on the longevity of two ornamental pepper cultivars, sensible to ethylene.

MATERIAL AND METHODS

Localization, obtainment and maintenance of seedlings

Pepper seedlings were produced in protected environment in polystyrene trays filled with commercial Bioplant® substrate. After reaching two to three pairs of leaves, seedlings were transplanted into 900 mL vessels (11 cm high, 9.5 cm basal diameter, 13.5 cm upper diameter). Bioplant® commercial substrate was used to fill the vessels.

At planting, the substrate was fertilized with 2.5 g of NPK 0-10-10 formulation. During the experiment, fertilization was done every 20 days with 10 g of NPK formulation 10-0-10.

Plants were watered, from sowing to transplanting, once a day with enough water to moisten the substrate until field capacity. From transplanting until establishment of the seedlings, the substrate was watered with 150 mL of water/pot daily. From the initial establishment period of the seedlings until the last day of the experiment, the substrates were watered with 150 mL of water/pot daily. During watering, the water was deposited directly on the substrate, with occasional wetting of the leaves.

1-MCP application

The commercial cultivars Pimenta Colorida and Pimentão Ornamental (*Capsicum annuum*) were used in this experiment. Plants were taken to the laboratory at the commercialization point, characterized by 50% of the population with at least 30% fully ripened fruits, visually determined (fruits with the maximum growth size and typical size of each species, with the specific color demanded by the market and not wilted). The treatments were carried out in a 60 L hermetic chamber, where the plants remained in the dark and without irrigation during the treatment, simulating the transport condition. In this environment, the commercial product EthylBloc® (0.14% i.a., Rohm and Hass Química Ltda., São Paulo, Brazil) was dissolved in water at 50°C, releasing 1-MCP gas. The treatments were composed of: 1) External control, in which the plants were kept in bench condition with average temperature of 20ºC and 8-10 (µmol s^{-1} m^{-1} of fluorescent light; 2) Internal control, in which the plants were kept inside the chambers without the ethylene application or 1-MCP; 3) Ethylene at 10 μL^{-1}; 4) 0.5 g m^{-3} of 1-MCP; 5) 1.0 g m^{-3} of 1-MCP; 6) 1.5 g m^{-3} of 1-MCP; 7) 0.5 g m^{-3} of 1-MCP + 10 μL^{-1} of ethylene; 8) 1.0 g m^{-3} of 1-MCP + 10 μL^{-1} of ethylene; 9) 1.5 g m^{-3} of 1-MCP + 10 μl^{-1} of ethylene.

Before and after the treatment's application and also during the post-production phase the plants were evaluated on:

Accumulated abscission of leaves, fruits and flowers (%)

The accumulated abscission of leaves, fruits and flowers (%) was determined by the total count of leaves, fruits and flowers, respectively, before and after the treatments during the whole experiment. Only completely expanded leaves were counted. We counted the closed flower buds, in anthesis, completely opened and the fertilized ones. Fruits were separated by maturation stage in green, ripe-green and ripe.

Post-production phase

After application of the treatments, the plants were transferred to the interior of a room at 20-25°C and 7-10 µmol s^{-1} m^{-2} of fluorescent light, simulating the interior of shops, supermarkets and residences. This phase was determined by the days between removing the plants from the chamber until the day they were commercially inadequate, that is, when they had 50% leaf abscission and/or fruit and/or 50% leaf senescence. Leaf senescence recognition was obtained by grouping the genotypes according to a common pattern of senescence.

Data analysis

The experiment was set up in a completely randomized design with 9 treatments and 3 replicates. The experimental unit consisted of one plant per pot. To analyze the data, a descriptive analysis with standard error calculation was performed. The PRISM program was used to obtain the graphs.

RESULTS AND DISCUSSION

The treatment with 1-MCP was effective in blocking the ethylene action reducing the leaves and fruits abscission of Pimentão Ornamental. There was no abscission of leaves and fruits in the plants treated with 1-MCP of the ethylene action in all evaluated concentrations; however, those treated with 1-MCP in the concentrations of 0.5 and 1.5 g m^{-3} maintained the 100% response of flower abscission and flower buds similar to plants treated with ethylene alone. In pre-treated 1-MCP peppers at 1.0 g m^{-3}, 0% flower abscission and floral buds were observed even after 48 hours of exposure to ethylene (Figure 1).

This suggests that ethylene application was not sufficient for the synthesis of new binding sites nor the removal of 1-MCP of the same. 1-MCP binds to ethylene receptors with a half-life of diffusion between 7 and 12 days, which in most cases exceeds the shelf life of ornamental peppers (Serek *et al*., 1995). Compared with ethylene, which has a diffusion time of 2 to 10 minutes, it can be concluded that the binding of 1-MCP to the ethylene receptor can be regarded as irreversible; however, once the 1-MCP receptor complex is metabolized, the process is reversed, and new receptors are synthesized (Sisler &

Serek, 1999).

Although fruit abscission was reduced in plants treated with 1-MCP, the same proportion of immature fruits abscision was found in plants treated with ethylene, with values higher than 50%. On the other hand, the external control plants presented a higher proportion of abscision of mature fruits; behavior due to ordinary senescence processes.

The fruits of the plants pretreated with 1-MCP at all concentrations did not change their coloration whereas, the fruits of plants treated with ethylene for only 48 hours accelerated the transformation of green and green mature fruits to the red color.

For 'Pimenta Ornamental' plants, 1-MCP treatment was also effective in blocking the ethylene action by reducing leaf, fruit and flower abscission (including flower buds) by 100% at all evaluated concentrations.

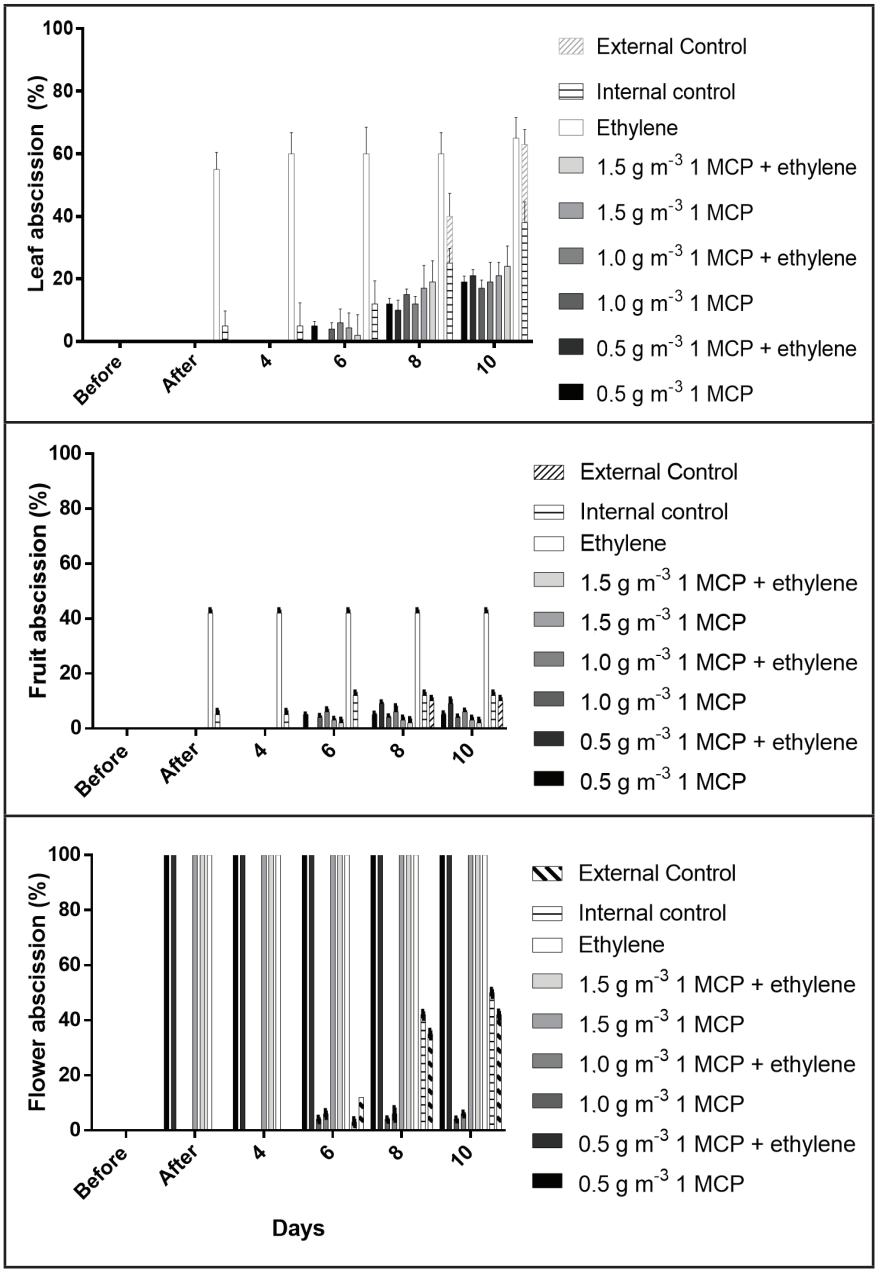

Figure 1. Accumulated abscission (%) of leaves, fruits and flowers of 'Pimentão Ornamental' (Capsicum annuum) in vase before (day 0) and after 0.5, 1.0 and 1.5 g m-3 and without application of 10 µL L-1 of ethylene for 48 hours. Vertical bars indicate standard deviation of the average (n= 3). Viçosa, UFV, 2015.

When exposed to exogenous ethylene, the percentage of accumulated abscission of leaves was 63.70%, that of flowers 100% and that of fruits was 10.41%. Of the total fallen fruits, 100% were of green maturation stage. After the removal from the chamber, some leaves that persisted on the plant were yellowed (Figure 2).

It became evident that the fruits in green mature stage that persisted on the plant, had the color intensified with the application of 10 µL L^{-1} of ethylene. Fruit abscission was not observed in internal and external control plants.

The ornamental pepper lasted only one day after the application of ethylene for 48 hours, while plants treated with 1-MCP lasted eight days in the bench condition. Plants treated with only 1-MCP had the post-production phase increased compared to the plants of the external control, suggesting that the low radiation (8-10 µmol s^{-1} m^{-2} fluorescent light) of the room in which the plants were subjected to after treatment, induced ethylene synthesis, and that 1-MCP was effective in inhibiting the effect of this hormone produced by light stress.

Cavatte (2013), evaluating the light and temperature action on the longevity of ornamental peppers BGH 1039 and Roxa (*Capsicum annuum*), found that 1-MCP drastically inhibited leaf fall in both varieties when exposed to high temperature. However, the response of 1-MCP to inhibit the ethylene effects, in the same work, depended on the variety and the luminosity conditions in which the plants were submitted.

The treatment with 1-MCP + ethylene was effective in reducing leaf abscission of Calypso cultivar, classified according to the same research as highly sensitive to exogenous ethylene. The cultivar Calypso also did not present fruit abscission when submitted to the same treatment (Segatto *et al.*, 2013).

In orchids of the genus *Cymbidium*, the 1-MCP application extended the longevity of the stems regardless of the ethylene presence in the atmosphere after treatment with 1-MCP (Heyes & Johnston, 1998).

In other flower studies, 1-MCP treatment has the greatest effect on

inhibiting the ethylene deleterious action when applied prior to exposure to the hormone and the beneficial effect decreases if 1-MCP is applied together or after ethylene (Blankenship & Dole, 2003). *Matthiola incana* stems treated with 1 mL L^{-1} of ethylene for 48 hours, promoted 100% petal abscission, and induced leaf epithelia. These effects were completely inhibited by pre-treatment with 500 nL L^{-1} of 1-MCP for 6 hours.

Celikel & Reid (2002) found similar results on pre-treated *Consolida ambigua* with 1-MCP. In researches performed with *Dianthus caryophyllus*, 1-MCP application at 0.5 nL L^{-1} concentration during 24 hours was effective in blocking the deleterious effects of ethylene (Serek & Sisler, 1997, 2001). Accelerated yellowing and early foliar leaves abscission, ethylene effect observed in brassicaceae, is reversed with the use of 1-MCP. With application of 100 mg L^{-1} of Ethrel, *Consolida ambigua* longevity was reduced by about 69%, compared to control inflorescences. On the other hand, fumigation with 0.5 g m^{-3} of 1-MCP increased longevity by 33% over the control (Santos *et al.*, 2005).

For the studied ornamental pepper varieties, pre-treatment with 1-MCP at 1.0 g m^{-3} concentration, was effective in inhibiting the ethylene action and reducing leaf, flower and fruit abscission.

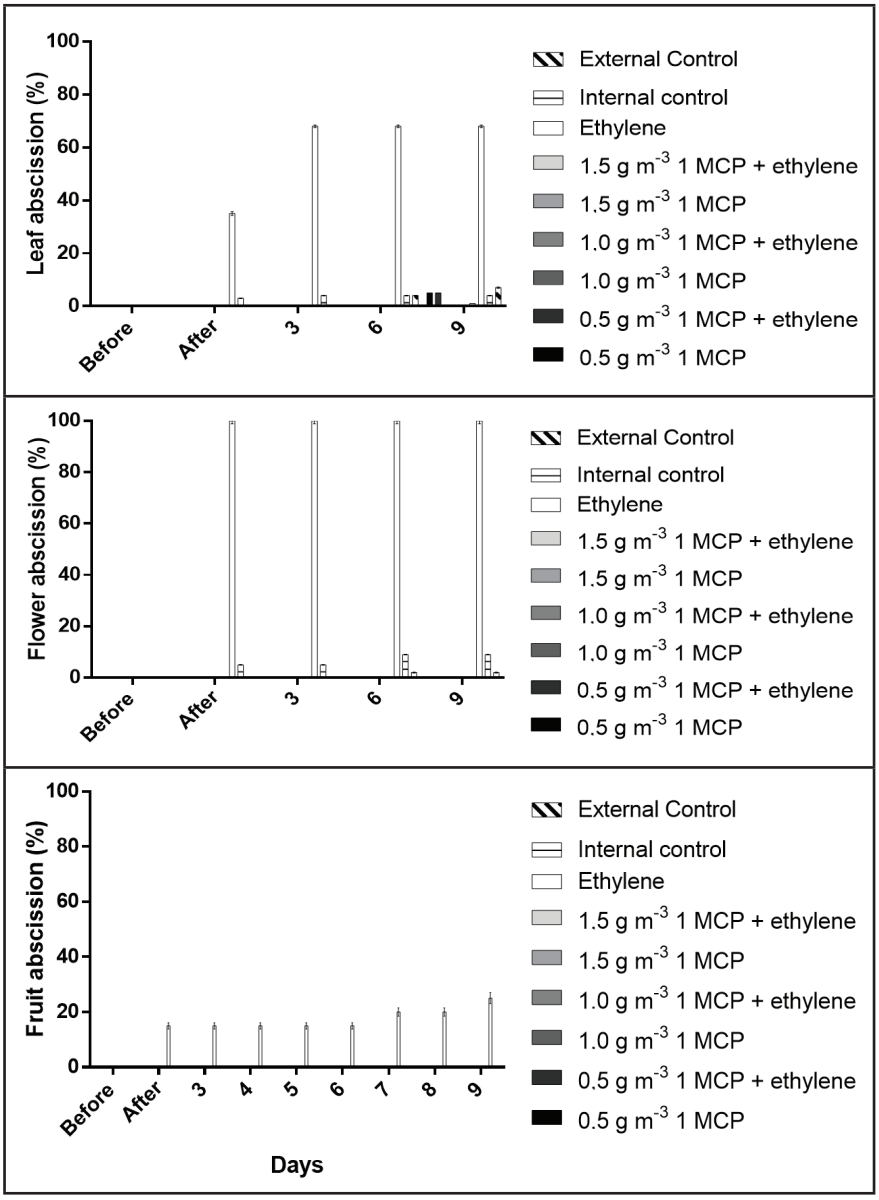

Figure 2. Accumulated abscission (%) of leaves, flowers and fruits of Capsicum annuum before (day 0) and after the application of 0.5, 1.0 and 1.5 g m-3 with and without application of 10 µL L-1 of ethylene for 48 hours. Vertical bars indicate standard deviation of the average (n= 3). Viçosa, UFV, 2015.

ACKNOWLEDGMENTS

To Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG) and Comissão de Aperfeiçoamento de Pessoal do Nível Superior (CAPES).

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