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CROP PRODUCTION

# Ethylene, 1-methylcyclopropene and silver thiosulfate on the post-production of ornamental pepper

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**ABSTRACT**: *Species from Capsicum genus are used for different purposes and in more recent years as ornamental potted plant. Despite the increased commercial importance, there are only a few studies on the environmental factors affecting the post-production shelf life of these ornamental plants. The presence of ethylene induces various responses on potted peppers, reducing the shelf life of sensitive cultivars. This study aimed to evaluate the effects of ethylene and the inhibitors of ethylene action, 1-methylcyclopropene (1-MCP) and silver thiosulfate (STS) on the shelf life of potted 'Calypso' and 'MG 302' peppers. Cultivar 'MG 302' showed intermediate sensitivity to ethylene action, while the cultivar 'Calypso' showed complete abscission of leaves when exposed to ethylene. In both cultivars, treatment with STS + Ethylene presented symptoms of phytotoxicity in plants, while treatment with 1-MCP + Ethylene was effective in delaying senescence and abscission for the cultivar 'MG 302', while cultivar 'Calypso' showed abscission similar to control plants. Plants treated with STS showed the longest durability when compared to the other treatments, about six days for 'Calypso' and 18 days for 'MG 302'. Nevertheless, plants treated with 1-MCP also exhibited good shelf life, about six days for 'Calypso' and nine days for the 'MG 302'. Although the treatment with STS was more efficient on the plants shelf life, did not completely block the action of ethylene and exhibited some phytotoxicity, while the treatment with 1-MCP had good efficiency without inducing any toxicity.*
**Key words**: *ethylene action inhibitors, leaf abscission,* ***Capsicum annuum***.

## Etileno, 1-metilciclopropeno e tiossulfato de prata na pós-produção de pimenteiras ornamentais

**RESUMO**: *Espécies do gênero Capsicum estão sendo usados para diversas finalidades e nos últimos anos como planta ornamental de vaso. Apesar da crescente importância comercial, há poucos estudos sobre os fatores ambientais que afetam a sua vida útil de pós-produção destas plantas ornamentais. A presença de etileno induz várias respostas em pimenteiras em vasos, reduzindo a vida útil de prateleira de cultivares sensíveis. Este estudo teve como objetivo avaliar os efeitos do etileno e inibidores da ação do etileno, 1-metilciclopropeno (1-MCP) e tiossulfato de prata (STS) sobre a vida útil de vaso de pimenteiras das cultivares 'Calypso' e 'MG 302'. A cultivar 'MG 302' apresentou sensibilidade intermediária a ação do etileno, enquanto a cultivar 'Calypso' apresentou abscisão completa das folhas quando exposta ao etileno. Em ambas as cultivares, o tratamento STS + Etileno mostrou sintomas de fitotoxicidade nas plantas. O tratamento com 1-MCP + Etileno foi eficaz em retardar a senescência e abscisão apenas para a cultivar 'MG 302', enquanto a cultivar 'Calypso' mostrou abscisão foliar semelhante as plantas controle. Plantas tratadas com STS mostraram maior durabilidade quando comparadas aos outros tratamentos, cerca de seis dias para 'Calypso' e dezoito dias para 'MG 302'. No entanto, as plantas tratadas com 1-MCP também exibiram boa vida útil de prateleira, cerca de seis dias para 'Calypso' e nove dias para a 'MG 302'. Embora o tratamento com STS tenha sido mais eficiente na vida de prateleira das plantas, não bloqueou completamente a ação do etileno e apresentaram algum fitotoxicidade, enquanto o tratamento com 1-MCP teve boa eficiência sem induzir qualquer toxicidade.*
**Palavras-chave**: *inibidores da ação do etileno, abscisão,* ***Capsicum annuum***.

## INTRODUCTION

The species of the genus ***Capsicum*** presented large genetic variability and have being used for different purposes, mainly as condiment, but the marketing as potted ornamental plants has increased in the past decade (STOMMEL & BOSLAND, 2006). However, there are serious obstacles affecting the quality and shelf life of ornamental potted plants or at post-production phase, with special attention to adverse effects when exposed to ethylene (HOYER, 1996; SEGATTO et al., 2013).

A wide range of biotic and abiotic stresses may increase endogenous levels of ethylene, which may induce senescence of leaves and flowers (MAYAK et al., 2004; SIDDIKEE et al., 2011). Ethylene may accumulate to high concentrations in the atmosphere during growth in greenhouses, shipping and storage facilities due to lack of proper ventilation and scrubbing. FARANGUER et al. (2002) estimated that the deleterious effects of ethylene are responsible for 30% of losses in the floriculture industry. One way to control the ethylene effects in plants is the use of ethylene action inhibitors, so forth, blocking the effects of ethylene during shipping, storage and marketing of fresh products (PORAT et al., 1995).

According to FINGER et al. (2015), in order to improve post-production life, it is necessary to block the ethylene receptors before exposing the plant to ethylene during shipping, storage and retail stores or when plants are submitted to any stress that might induce ethylene production. There are several problems

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encountered at post-production stage that affect the quality and vase life of ornamental plants, but in general the exposure to ethylene is one of the most important.

Ion silver is the most potent inhibitor of ethylene action by competing for the binding sites of ethylene receptors (KUMAR et al., 2009). Silver is more effective when applied as silver thiosulfate (STS) - [$Ag(S_2O_3)_2^{-3}$], because has faster mobility and less phytotoxic than silver nitrate ($AgNO_3$) to the tissues (VAN ALTVORST & BOVY, 1995). 1-Methylcyclopropene (1-MCP) is another effective substance that blocks the action of ethylene in fruits, vegetables and ornamental plants in general. However, of effectiveness degree of 1-MCP in blocking the ethylene action varies among the plant species, stage of development, plant maturity, concentration, length of treatment and temperature during treatment (BLANKENSHIP & DOLE, 2003).

The goal of this study was to evaluate the effects of ethylene, 1-MCP and STS on post-production quality of ***Capsicum annum*** ornamental cultivars grown in pots.

## MATERIALS AND METHODS

Seeds from the cultivars 'Calypso' and 'MG 302' (***Capsicum annuum***) were sown in flats with single cells and transplanted to 760mL plastic pots when the plantlets had four to five true leaves. Pots containing one plantlet each were filled with commercial substrate Tropistrato HT® composition: pine bark, vermiculite, superphosphate, potassium nitrate (Vida Verde, LOT 14072106) and grown in a greenhouse for four months until ready for commercial sale. Pots were fertilized at every 20 days with 10g of NPK 10-10-10 and monthly with a diluted solution containing 150g $L^{-1}$ of commercial Ouro Verde Fertilizer® 15-15-20 NPK + Ca, S, Mg, Zn, B, Fe, and Mn (Bunge, Sao Paulo, Brazil). When commercial stage for sale was reached, according to RIBEIRO et al. (2015), 50% of the plants in a population showed at least 30% of fully ripe fruits (typical shape for each material, color demanded by the market, and no wilting). Afterwards, the pots were transferred to a room at 25±1°C, illuminated for 12 hours period with white fluorescent light (OSRAM, L40W/10S, USA) with intensity of 8-10µmol $s^{-1}$ $m^{-2}$ during the experimental period (SEGATTO et al., 2013).

Pots were then placed in a 90L sealed chambers for 1-MCP and ethylene treatment, according to the methodology of SEGATTO et al. (2013). Plants of all treatments were kept at 25±1°C under white fluorescent light with intensity of 8-10µmol $s^{-1}$ $m^{-2}$, 60-65% relative humidity and watered when needed (FINGER et al., 2015).

Plants were treated with 10µL $L^{-1}$ ethylene for 48 hours; fumigation of 1µL $L^{-1}$ 1-MCP for 6 hours; treated with 1µL $L^{-1}$ 1-MCP for 6 hours followed by 10µL $L^{-1}$ ethylene for 48 hours; plants were sprayed until run off with 5mL of 2mmol $L^{-1}$ STS; sprayed until run off with 5mL of 2mmol $L^{-1}$ STS per plant followed by treatment with 10µL $L^{-1}$ ethylene for 48 hours. The control plants were kept on the laboratory bench.

Leaf and fruit abscissions were determined at every three days by counting the total leaves during the whole period of shelf life, expressed in percentage compared to the initial leaf counting. Longevity and yellowing of the leaves were determined at every three days up to 18 days. The end of longevity occurred when the plants did not have commercial value, 50% of leaf and fruit abscission and/or 50% yellowing of leaves (FINGER et al. 2015).

Degree of green color and flavonoids of the leaves was evaluated in three leaves in each plant: base, center and top, the average of determinations were considered. The chlorophyll content of leaves was determined by the chlorophyll index – Chl, the flavonoids index – Flav and nitrogen balance index – NBI were also determined, giving the reason CHL/FLAV, nitrogen deficiency and protein rate marker. All these variables were evaluated at every three days with the help of a leaf-clip portable meter Dualex® 4, design to measure chlorophyll, epidermal flavonoids and nitrogen balance index (FORCE-A, Université Paris Sud, 91893 ORSAY CEDEX, France). This instrument is used for non-destructive assessment of plant status, especially in regards to the simultaneous assessment of Chl and Flav on the same leaf spot, and was equipped with 6mm diameter sensor in the measuring area and silicon photodiode detector (CEROVIC et al., 2012).

Pots were arranged in complete randomized block design with five replicates of one pot each. The average of the parameters analyzed were submitted to the standard error of the average (n=5) and SigmaPlot software was used for data analysis and graph design.

## RESULTS AND DISCUSSION

The treatment with 10µL $L^{-1}$ ethylene for 48 hours induced 100% abscission of leaves on cultivar 'Calypso' (Figure 1A and Figure 2A), while 'MG 302' showed intermediate response to ethylene with 42% of leaf abscission after treatment (Figure 1B and Figure 3A). Confirming the high sensitivity of 'Calypso' leaves to ethylene previously identified by SEGATTO et al. (2013) and FINGER et al. (2015). The sensitivity of ornamental plants to ethylene was roughly established at family level, but marked differences exist among the species and cultivars (SEREK et al., 2006).

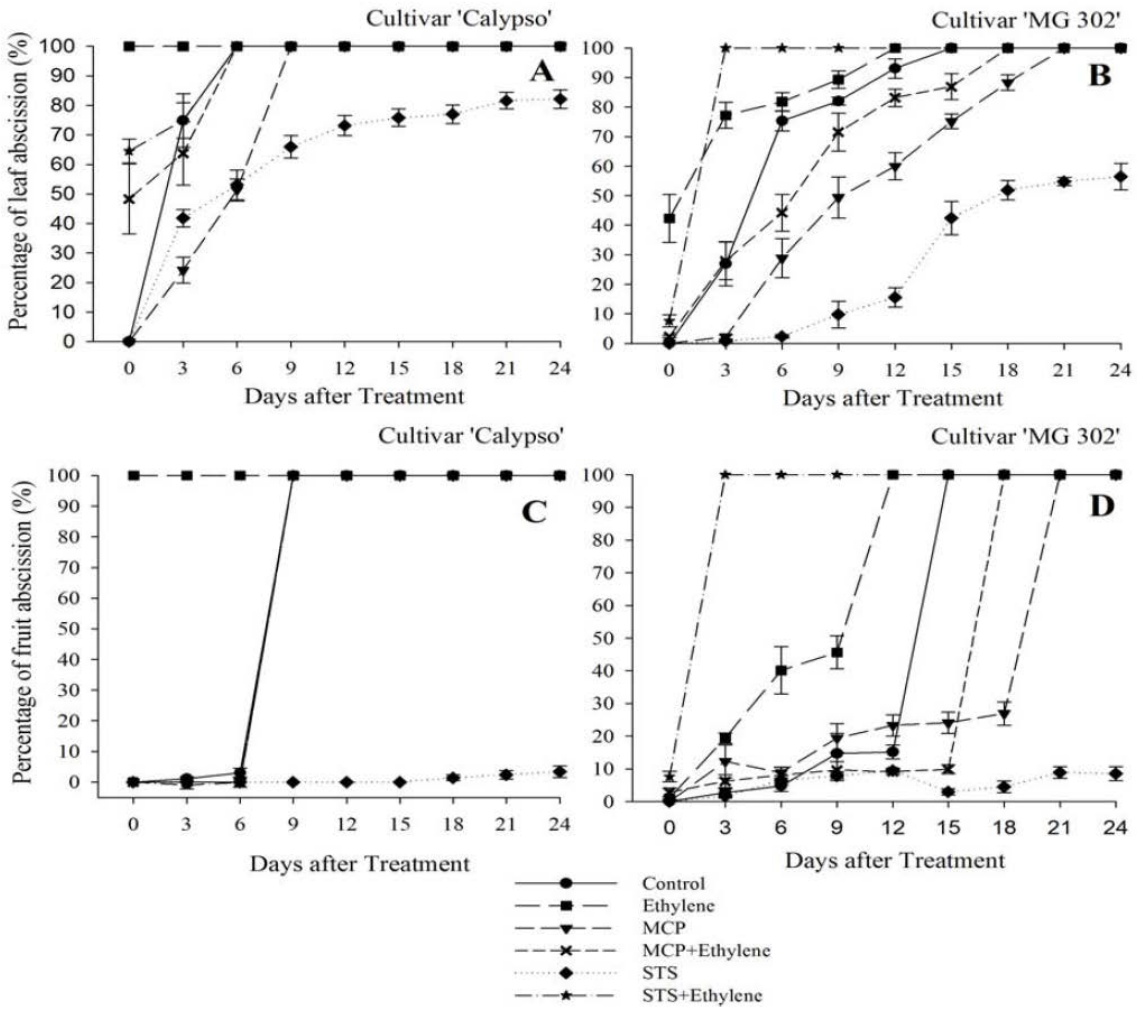


Figure 1 - Accumulated abscission in leaves (A, B) and fruits (C, D) of the ornamental pepper cultivars 'Calypso' and 'MG 302', after being treated with ethylene 48 hours, 1-MCP, 1-MCP + ethylene for 48 hours, STS and STS + ethylene for 48 hours and control. Values are a mean (± standard error) (n=5).

Sensitivity of ornamental plants to ethylene is roughly established at family level, but marked differences exist among species and cultivars (SEREK et al., 2006). Previously SEGATTO et al. (2013) reported that genotypes of ornamental pepper BGH 1039, BGH 7073, 'Calypso' and 'MG 302' had different levels of sensitivity to ethylene, in which the cultivar 'Calypso' and access BGH 1039 were classified as highly sensitive. The authors reported that ethylene unleashed a severe and rapid abscission of leaves for 'Calypso', but the cultivar 'MG 302' showed intermediate response to treatment, with abscission ranging from 15 to 38% after being exposed to 10µL $L^{-1}$ ethylene for 48 hours.

Plants treated with 1-MCP exhibited shelf life of about 6 days for 'Calypso' and 9 days for 'MG 302' (Figure 1 A, Figure 1 B, Figure 2 B and Figure 3 B). FINGER et al. (2015) concluded that 1-MCP treatment was effective in partially preventing the sudden fall of leaves in presence of exogenous ethylene in ornamental pepper 'Calypso'. Treatment of plants with 1-MCP has been effective in blocking the negative effects of ethylene different flowers, including some varieties of roses, geranium, ***Phalaenopsis***, dianthus and gentian (SHIMIZU-YUMOTO & ICHIMURA, 2012).

Treatment with 1-MCP followed by ethylene showed abscission similar to the control plants in cultivar 'Calypso'; however showed some efficacy for the cultivar 'MG 302', showing a durability of 6 days (Figure 1A, Figure 1B, Figure 2C and Figure 3C). According to PHEBE & ONG (2010), the effectiveness of 1-MCP in extending the shelf life varies with species and variety, ripening stages, and exposure temperature, concentration and duration. In

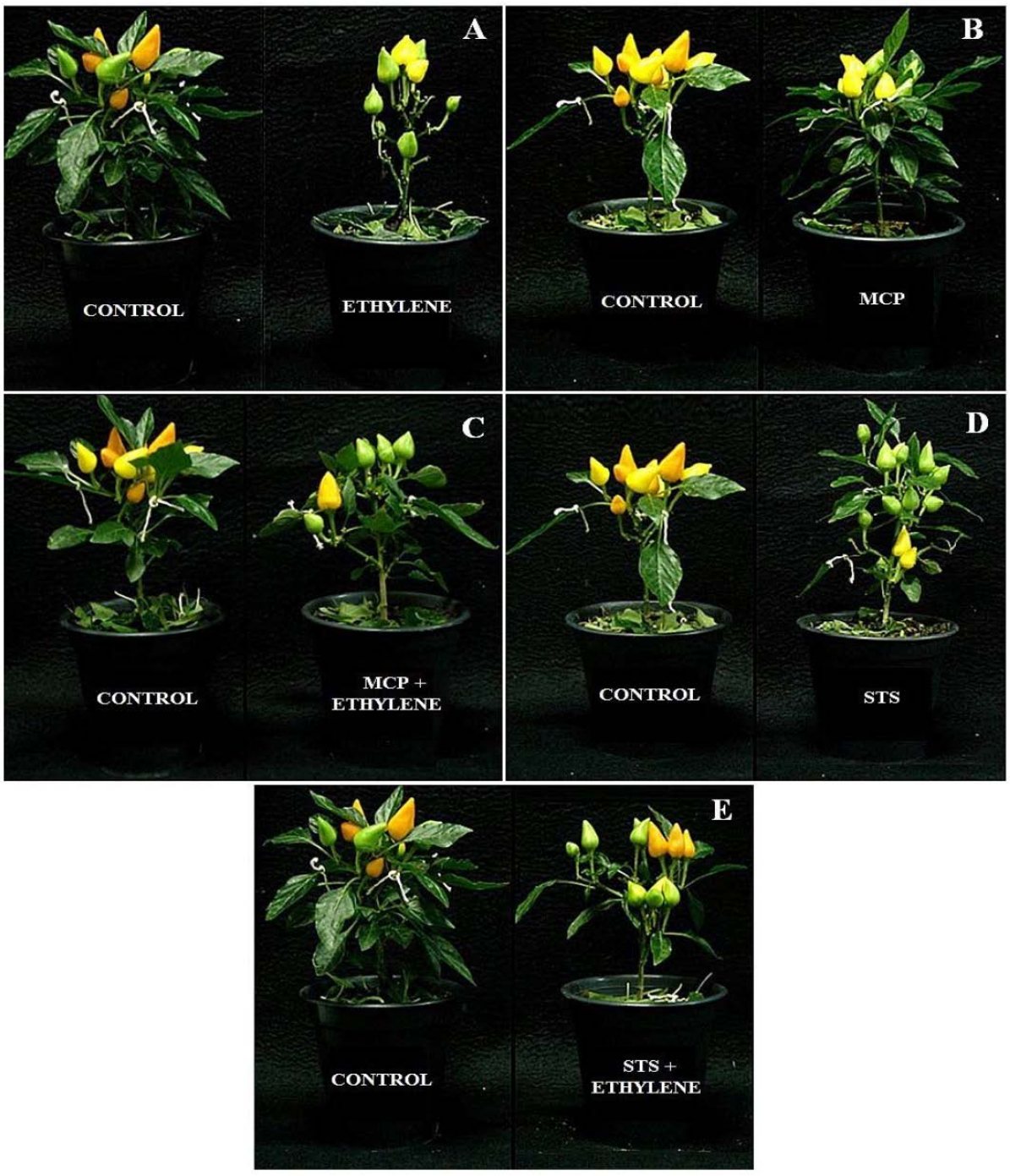


Figure 2 - Appearance of the ornamental pepper cultivar 'Calypso'. A - after treatment with ethylene for 48 hours, B - 6 days after treatment with 1-MCP, C- after treatment with 1-MCP + ethylene for 48 hours, D- 6 days after treatment with STS and E- after treatment with STS + ethylene for 48 hours.

this study the 1-MCP dose partially efficient, because did not blocked all ethylene receptors and when ethylene was applied, still triggered leaf abscission. Similar post-production behavior was also obtained when ***Regal Pelargonium*** genotypes were pretreated with 1-MCP before they had been exposed to ethylene (KIM et al., 2007).

Plants treated with STS showed improved durability when compared with other treatments, for about 6 days for 'Calypso' and 18 days for 'MG 302'

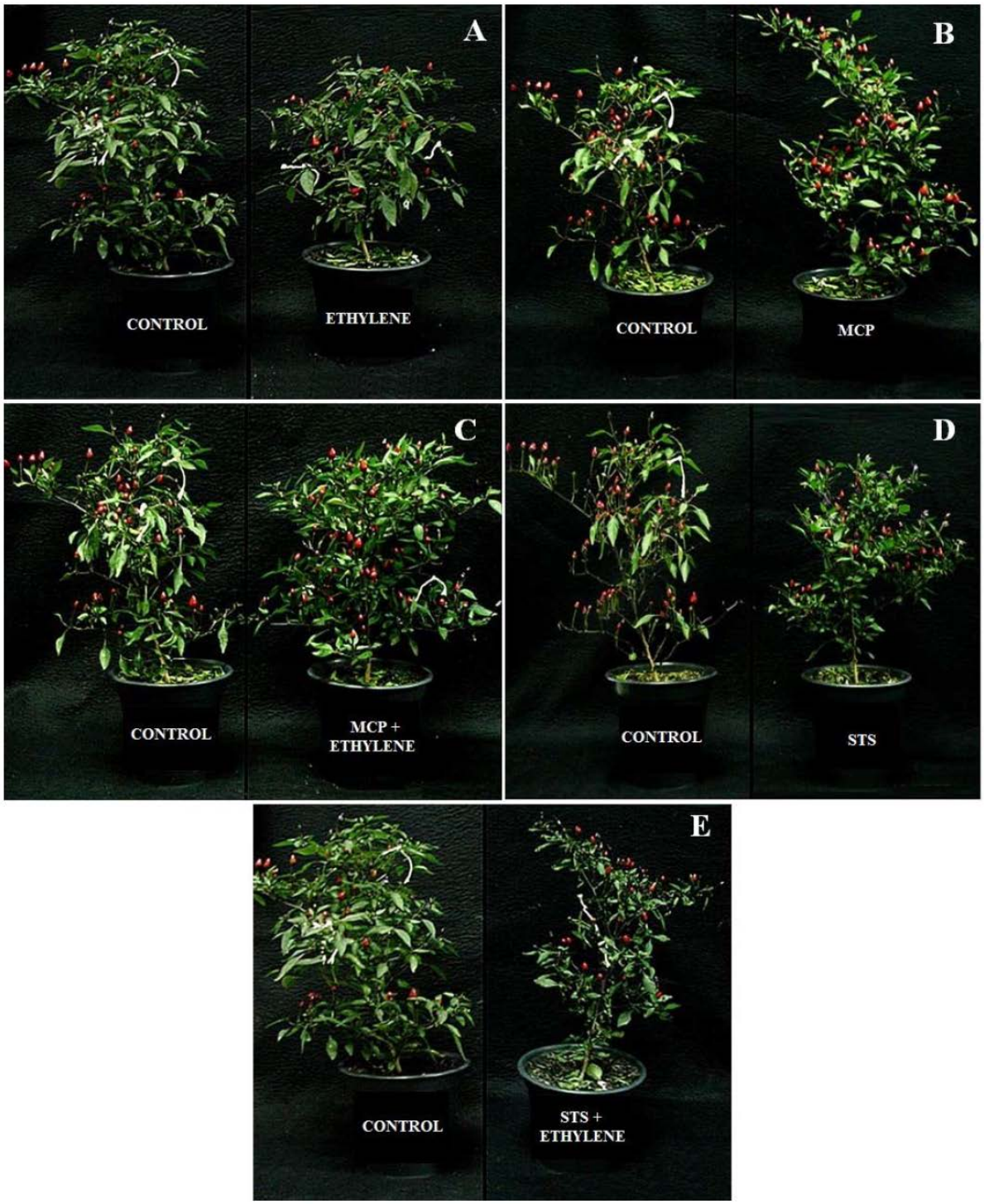


Figure 3 - Appearance of the ornamental pepper cultivar 'MG 302'. A - after treatment with ethylene for 48 hours, B - 9 days after treatment with 1-MCP, C- 6 days after treatment with 1-MCP + ethylene for 48 hours, D- 18 days after treatment with STS and E- after treatment with STS + ethylene for 48 hours.

(Figure 1A, Figure 1B, Figure 2D and Figure 3D). According MOURA et al. (2010) the performance of the STS depends on the cultivar, stage of development and concentration used. The application of 0.5, 1.0, 1.5 and 2.0mM STS in potted 'Rage' chrysanthemum increased in 50% the display time compared to non-treated plants and no effect in the same concentration were observed in 'Summer Time' and 'Davis'

(BARBOSA et al., 2005). In both cultivars, treatment with STS + Ethylene caused symptoms of phytotoxicity on the plants, showing senescence and abscission on 'Calypso' (Figure 1A and Figure 2E) and senescence and wilting on 'MG 302' (Figure 1B and Figure 3E).

Thus, pretreating these peppers with 1-MCP or STS complements the resistance to ethylene, but did not reduce the sensitivity to its action, once the treatment is completed. It has been suggested that only by incorporating genes of resistance in new cultivars it will be possible to improve the longevity of ethylene-sensitive ornamental plants (FINGER et al. 2015).

In general, fruit abscission percentage remained low during shelf life observations of all treatments (Figure 1C and Figure 1D), this research confirmed the low fruit abscission on 'Calypso' and higher rates of fruit abscission on 'MG 302' previously identified by SEGATTO et al. (2013). Ethylene effectiveness on pepper fruit abscission depends on length to exposure, concentration, temperature, stage of development and sensitivity of species or variety (SEREK et al., 2006; WATKINS, 2006).

The figure 4 shows the chlorophyll index (Chl), flavonoids index (Flav) and nitrogen balance

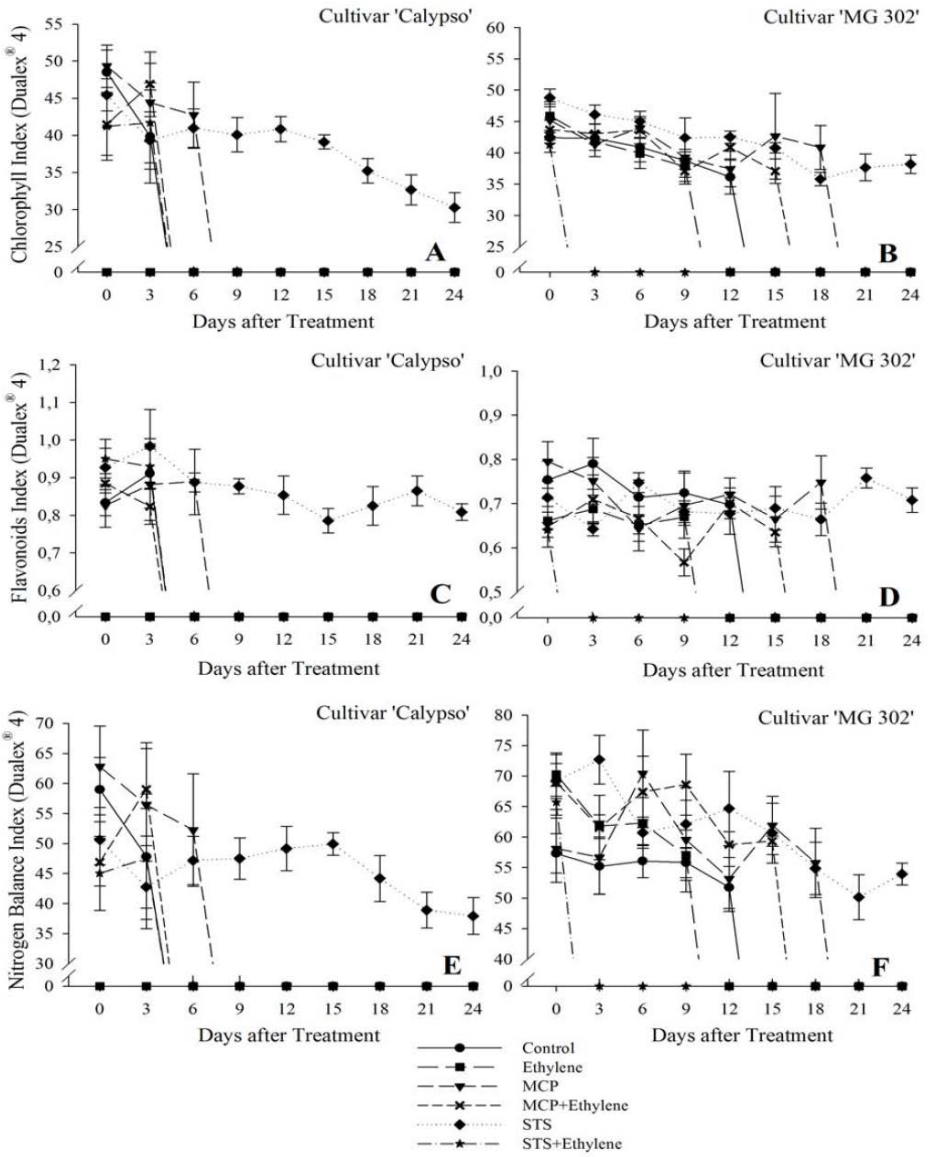


Figure 4 - Chorophyll Index – Dualex® 4 (A, B), Flavonoids Index – Dualex® 4 (C, D) and Nitrogen Balance Index – Dualex® 4 (E, F) of the ornamental pepper cultivars 'Calypso' and 'MG 302', after being treated with ethylene 48 hours, 1-MCP, 1-MCP + ethylene for 48 hours, STS and STS + ethylene for 48 hours and control. Values are a mean (± standard error) (n=5).

index (NBI) in plants of cultivars 'Calypso' and 'MG 302'. Except for the treated pots, which had loss of the leaves, a persistent decline of this parameters took place during post-production period, for the 'Calypso' treated with STS by the end of the evaluations there was a decrease of 33.4% (45.43 to 30.27) for Chl; 12.9% (0.92 to 0.81) for Flav and 25.0% (50.61 to 37.94) for NBI, much lower compared to the other treatments (Figure 4A, Figure 4C and Figure 4E).

And also for the 'MG 302' treated with STS and 1-MCP, showed a decrease of 21.7% (48.78 to 38.20) and 4.99% (45.22 to 40.85) for Chl; 0.9% (0.71 to 0.70) and 5.0% (0.79 to 0.74) for Flav; 22.0% (69.18 to 53.94) and 2.2% (58.10 to 55.77) for NBI, respectively (Figure 4B, Figure 4D and Figure 4F). In plants treated with 1-MCP were delayed yellowing of leaves, similar to data of FINGER et al. (2015). MARINO et al. (2003) observed that during vase life both species of *Asparagus* showed progressive senescence characterized by yellowing and falling of cladodes.

In order to improve post production life of ornamental peppers, it is necessary to block the ethylene receptors before exposing the plant to ethylene during shipping, storage and retail sales or when plants are submitted to any stress that induces ethylene production (FINGER et al., 2015). Ethylene acts by converting chlorophyll a and b in chlorophyllide and phytol, resulting in loss of green color usually at concentration varying from 1 to 10μL $L^{-1}$ (FERRANTE & FRANCINI, 2004).

## CONCLUSION

The action of ethylene inhibitors, 1-MCP or STS followed by ethylene do not completely block the ethylene action, but STS is more effective. STS cause some phytoxicity, while the treatment with 1-MCP had good efficiency without inducing any toxicity.

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