



Efficiency of 1-methylcyclopropene (1-MCP) treatment after ethylene exposure of mini-*Phalaenopsis*



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ABSTRACT

Phalaenopsis orchids are popular around the world, but sensitive to the phytohormone ethylene. Ethylene can cause flower wilting, drop of buds and flowers. 1-Methylcyclopropene (1-MCP) is an ethylene receptor inhibitor and effective when applied to plants before or at the same time as exposure to ethylene. In the current study, the timing of 1-MCP postharvest treatment in relation to ethylene exposure was investigated in two different mini *Phalaenopsis* cultivars. The aim was to determine how long 1-MCP treatment can be delayed (postponed) after exposure to ethylene had been initiated in order to effectively avoid critical losses in plants. *Phalaenopsis* cultivars 'Allen' and 'Venice' were exposed to 100 nL L⁻¹ of ethylene for a week and 200 nL L⁻¹ of 1-MCP, was applied either at the same time or at time points spanning from 6 to 51 h, after ethylene treatment was initiated. After 42 h of ethylene exposure followed by 1-MCP treatment, 'Allen' and 'Venice' displayed 91.4% ± 3.8 and 28.9% ± 4.3 senesced flowers, respectively, but when 1-MCP was applied 24 h after ethylene exposure, the percentage of senesced flowers was similar to simultaneous start of ethylene and 1-MCP exposure. Colorimetric assessment appeared not to be a fruitful parameter to determine senescence although loss of gloss in flowers and buds toward the advance in time after ethylene exposure started was visually noted. Furthermore, percentage of water dropped to similar levels in 'Allen' when 1-MCP application was delayed to 42 h after initiation of ethylene exposure compared to plants solely treated with ethylene and electrolyte leakage started to increase to statistically different values compared to atmospheric air treated plants after 27 h of delay of 1-MCP application after ethylene exposure commenced, thus correlating to the increased senescence exhibited by this cultivar. Collectively, 24–27 h of ethylene exposure followed by 1-MCP treatment showed to be the threshold time span that 1-MCP application can be delayed to stop or even reverse the negative effects of ethylene exposure.

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1. Introduction

Ornamental plants have always been important around the world due to the wide variety of colors and scents that plants can produce. *Phalaenopsis* orchids definitely belong to this category as consumers are fascinated mainly by the long lasting flowers (Hou et al., 2012). *Phalaenopsis* are produced in large quantities, e.g. 7.4 millions in Denmark in 2014 (Floradania, 2014) and are then transported to several countries across Europe. Long distance

transport can potentially subject plants to stress circumstances, increase ethylene production and cause bud drop or flower wilting, thus decreasing the value of the product (Chang et al., 2013; Zheng et al., 2008).

Ethylene, being a key factor in senescence in climacteric plants, is a gaseous phytohormone regulating several physiological processes in plants, e.g. seed germination, root initiation, flower development, fruit ripening, senescence and reactions to biotic or abiotic stresses (Lin et al., 2009). It is also known that ethylene can be detrimental to climacteric flowers, even at very low concentrations, causing senescence of flowers, wilting (Hew and Yong, 2003) and abscission (Van Doorn, 2002). Biosynthesis of ethylene can be induced by stress situations; i.e. prolonged darkness periods, pathogen attack, lack of water, wounding and shaking (Muller et al., 1998; Olsen et al., 2015) and that makes transport a criti-

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cal step as plants are potentially subjected to mechanical damage and/or other stress inducing situations leading to ethylene accumulation in the surrounding environment. Moreover, accumulation of ethylene from other sources in storage facilities can reduce shelf life due to critical exposure to ethylene and promotion of senescence (Ansari and Tuteja, 2014; Bower et al., 2003; Erdoğan et al., 2008).

The effect of ethylene has been studied in mini-*Phalaenopsis* revealing sensitivity in trace amounts, additionally significant differences were observed among cultivars (Sun et al., 2009). To prevent deleterious effects of ethylene on ornamental plants, several chemical inhibitors of the ethylene pathway are being used (Blankenship and Dole, 2003). Currently, silver thiosulfate (STS) and 1-methylcyclopropene (1-MCP) are the most applied substances to inhibit ethylene action in ornamental plants. However, since silver is toxic for humans and hazardous for the environment, its use is sought avoided (Olsen et al., 2015). In a study with *Phalaenopsis amabilis*, a single application of 1-MCP had effect against ethylene induced wilting for 6–8 days whereas three applications at different times provided protection for up to 30 days, extending vase life and showing that de novo synthesis of ethylene receptors restores ethylene sensibility (Hou et al., 2012). In potted plants, i.e.: with longer shelf life, the continuous formation of new ethylene receptors can restore ethylene sensitivity in time (Serek et al., 2006; Sisler and Serek, 1999) and become a postharvest issue, requiring new 1-MCP application strategies to overcome this issue.

The conventional application time for 1-MCP is immediately after harvest or prior to transport (Koukounaras and Sfakiotakis, 2007). Another treatment strategy was explored in two apple cultivars, where 1-MCP application was applied from 1 to 10 days after harvest. Data showed that firmness of 'Cortland' apples was unaffected at the end of storage after 4 months under controlled atmosphere with 1-MCP application applied 1–7 days after harvest, while 'McIntosh' apples did not maintain firmness when application took place later than one day after harvest (Moran, 2006).

1-MCP application and its effectiveness in delaying senescence are often investigated in combination with concurrent application of ethylene. In contrast, Hansen et al. (2013) investigated equivalent treatments combined with 1-MCP applications 2 h before, at the same time and 24 h after ethylene exposure commenced in two mini-*Phalaenopsis* cultivars. 1-MCP application 2 h before and at the same time of ethylene treatment had a positive postharvest effect on both cultivars with 0% wilted or abscised flowers and buds regardless the treatment. However 1-MCP application 24 h after ethylene exposure [1-MCP 24 h] had been initiated demonstrated significant improvement of plant quality compared to plants treated solely with ethylene [E], e.g. wilted buds were 15% [1-MCP 24 h] and 90% [E] in 'Allen' and 18% [1-MCP 24 h] and 83% [E] in 'Venice', basically showing that there is some time available to apply 1-MCP after ethylene exposure occurred and counteract the damage. The authors suggested that further experiments with increased replicates were necessary to confirm the preliminary findings.

The purpose of the current study was to investigate the effectiveness of this novel strategy of 1-MCP application in plants previously exposed to exogenous ethylene. The specific aim was to determine the time span that treatment with 1-MCP, after ethylene exposure, can be effective to avoid potential critical losses in plants, simulating ethylene exposure during transport. Furthermore, another point of interest was the possible differences between two cultivars, 'Allen' and 'Venice', regarding ethylene sensitivity. Ornamental quality was evaluated through postharvest performance, color measurements, water content and conductivity and the results are discussed from the commercial perspective of the product.



Fig. 1. Mini-*Phalaenopsis* 'Allen' on the left and 'Venice' on the right.

2. Materials and methods

2.1. Plant material and experimental design

Potted mini-*Phalaenopsis* of the cultivars 'Allen' and 'Venice' were provided by SOGO Team ApS, (Odense, Denmark) at commercial maturity stage, non-treated with any sort of keeping quality compound, transported from the nursery to the university's facilities in less than 3 h and placed in the greenhouse. Commercial maturity stage was defined as 2 inflorescences per plant with 2 open flowers and 3 flower buds for 'Allen' and 3 open flowers and 4 flower buds for 'Venice'. Both cultivars have double colored flowers, 'Allen' exhibits purple-ish middle lobe with orange-yellow edges while 'Venice' is mainly white with light purple veins in the petals and sepals and the labellum and column are characterized by a light yellow color (Fig. 1).

2.2. Ethylene and 1-MCP exposure

Two experiments were conducted with similar goals. Experiment 1 had the objective of investigating senescence, floral and bud abscission and water content and color variation of petals after different time delays of 1-MCP application after ethylene exposure. Plants of each cultivar were placed inside sealed glass tanks (128 L) and treated with atmospheric air [–E–M]; solely ethylene [+E–M]; solely 1-MCP [–E+M]; ethylene and 1-MCP at the same time [+E+M]; and ethylene followed by postponed application of 1-MCP with the delay being 6 h [+E+M 6 h], 18 h [+E+M 18 h], 24 h [+E+M 24 h] and 42 h [+E+M 42 h] after ethylene exposure was initiated.

Experiment 2 was conducted to observe the electrolyte leakage in petals and buds after ethylene exposure followed by delayed application of 1-MCP. The treatments were: atmospheric air [–E–M]; solely ethylene [+E–M]; solely 1-MCP [–E+M]; ethylene and 1-MCP at the same time [+E+M]; and ethylene followed by postponed application of 1-MCP with the delay being 21 h [+E+M 21 h], 27 h [+E+M 27 h], 45 h [+E+M 45 h] and 51 h [+E+M 51 h] after ethylene exposure was initiated.

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