Sensitivity of Potted Foliage Plant Genotypes to Ethylene and 1-Methylcyclopropene

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Abstract. Exposure to 0.1, 1.0, or 10 µL−1 ethylene for 4 days at 21 °C reduced the display life of 17 commonly traded potted foliage plant genotypes (Aglaonema ‘Mary Ann’, Anthurium scherzerianum ‘Red Hot’ and ‘White Gemini’, Apleanthera squarrosa ‘Dania’, Chlorophytum comosum ‘Hawaiian’, Codiaeum variegatum pictum ‘Petra’, Diefenbachia maculata ‘Carina’, Dracaena marginata ‘Bicol’ and ‘Magenta’, Euphorbia millii ‘Gaia’, Euphorbia splendens ‘Short and Sweet’, Ficus benjamina, Polyscias fruticosa ‘Castor’, Radermachera sinica ‘China Doll’, Schefflera elegantissima ‘Gemini’, Schefflera arboricola ‘Gold Capella’, Spathiphyllum ‘Ty’s Pride’). Ethylene treatment hastened leaf and bract abscission or senescence. The responsiveness of plants to ethylene varied considerably; six genotypes were sensitive to 0.1 µL−1 ethylene, whereas three genotypes required exposure to 10 µL−1 ethylene to trigger visible injury. Four genotypes (Asplenium nidus, Chamaedorea elegans ‘Neathe Bella’, Hedera helix ‘Chicago’, Syngonium podophyllum ‘White Butterfly’) included in our study were insensitive to ethylene. Treating Aglaonema ‘Mary Ann’, Polyscias fruticosa ‘Castor’, and Schefflera arboricola ‘Gold Capella’ plants with 0.9 µL−1 1-methylcyclopropene (1-MCP, provided as EthylBloc™), a gaseous ethylene-binding inhibitor, for 4 to 5 h at 21 °C reduced the deleterious effects of ethylene. The release of 1-MCP from two sachets containing EthylBloc™ into a single shipping box also protected Apleanthera squarrosa ‘Dania’, Euphorbia millii ‘Gaia’, Polyscias fruticosa ‘Elegans’, and Schefflera arboricola ‘Gold Capella’ plants from ethylene injury after simulated transport. Our data reveal the genetic variation in ethylene sensitivity among potted foliage plants and highlight genotypes that benefit from 1-MCP treatment.

Potted foliage plants are high-value ornamental commodities used to decorate indoor and patio environments. In the United States, the wholesale value of potted foliage plant production was $498 million in 2010 (USDA, 2011). Popular genera include Aglaonema, Dieffenbachia, Dracaena, Epipremnum, Ficus, Hedera, Philodendron, and Syngonium (Chen et al, 2002). Most foliage plants used in the trade are endemic to the tropics and show tolerance to drought and low light conditions. With their attractive and diverse leaf forms, colors, and textures, potted foliage plant displays are recognized for enhancing human health, well-being, and productivity (Fjeld et al., 1998).

The marketability of foliage plants is frequently limited by premature leaf abscission, epinasty, and/or senescence during transport and retail display (Conover and Poole, 1984). For some species, this loss in quality has been correlated with exposure to the gaseous phytohormone ethylene (Marousky and Harbaugh, 1982; Woltering, 1987). Ethylene arising from anthropogenic (e.g., auto exhaust fumes) and biological (e.g., ripening fruit) sources can occasionally accumulate to physiologically active concentrations (e.g., 0.1 to 10 µL−1) inside enclosed areas used to distribute and store foliage plants (Hoyer, 1995; Skog et al., 2001). Although ethylene sensitivity varies significantly among potted flowering genotypes (Muller et al., 1998; Serek and Reid, 2000; Woltering, 1987), the response of foliage plants to ethylene has been less intensively studied. Identifying the relative ethylene sensitivity of different potted foliage plant genotypes could help optimize postproduction operations and handling procedures that reduce ethylene damage.

Treatment with silver thiosulfate (STS) liquid has long been relied on to extend the longevity of ethylene-sensitive ornamentals (Novak and Rudnicki, 1990). Silver ions bind to ethylene receptors in plant tissues and block ethylene action (Sisler et al., 1986). However, STS has been criticized on social and environmental grounds owing to concerns associated with handling and disposing silver solutions (Nell, 1992). Moreover, STS is presently not legalized for use on potted plants in the United States (J. Janssen, personal communication). In contrast, an alternative non-toxic gaseous inhibitor of ethylene binding, 1-MCP, is gaining commercial acceptance (Reid and Staby, 2008; Serek et al., 1994). Although treatment with 1-MCP has been reported to protect numerous potted flowering plants such as Kalanchoe blossfeldiana (Serek and Reid, 2000), Rosa ×hybrida (Serek et al., 1994), and Schlumbergera truncata (Serek and Sisler, 2001) against ethylene-induced floral organ abscission and senescence, there are limited publicly available data on its efficacy to protect potted foliage plants. To date, treatment of three potted foliage plant genera (Aglaonema ‘White Tip’, Ficus ‘Green Island’, Isora cocinea) with 100 to 300 nL−1 1-MCP for 2 to 8 h at 20 °C has been shown to prevent ethylene-mediated leaf abscission and/or senescence (Fan et al., 2009; Michaeli et al., 1999; Philosop-Hadas et al., 2005).

1-MCP is registered as EthylBloc™ (Floralife, Inc., Walterboro, SC) for use on ornamental plants (Reid and Staby, 2008). 1-MCP molecules are encapsulated in the α-cyclodextrin matrix of EthylBloc™ and then dissolved in water余个 releasing 28 µL of 1-MCP per sachet. It is approved for use in closed tents, coolers, and truck trailers. EthylBloc™ is also available in a paper sachet that potentially offers a more convenient mode of application (Kostansek, 2002). We previously reported that the release of 1-MCP from two sachets containing EthylBloc™ in a closed shipping box was sufficient to protect cut rose flowers against ethylene during and immediately after shipment (Macnish et al., 2010). The EthylBloc™ sachet system may also have potential to protect sensitive potted foliage plants during shipment.

In the current study, we quantified the ethylene sensitivity of 20 potted foliage plant genotypes traded in the United States. The efficacy of 1-MCP gas and sachet treatments to protect responsive genotypes against ethylene during simulated transport and retail display was also tested.

Materials and Methods

Plant material. Twenty clonally propagated foliage plant genotypes previously observed to display leaf abscission and/or senescence during postproduction handling (N. McDonald, personal communication) were selected for this study (Table 1). The plants were cultivated at commercial nurseries near Apopka, FL, using standard cultural practices. Briefly, they were planted in 10- or 12.5-cm-diameter round plastic pots containing a Canadian Sphagnum peatmoss-based mix. The plants were grown inside shaded greenhouses at average day/night temperatures of 13/24 °C (winter), 15/27 °C (spring), 22/35 °C (summer), and 15/27 °C (fall). On reaching a marketable stage, plants were transported from the nurseries to the laboratory at the University of Florida in Gainesville, FL, in an air-conditioned (≈20 °C) car within 2 h. Plants of uniform height, width, leaf number, and overall quality were then randomly assigned to treatments.
Table 1. The 20 potted foliage plant genotypes used in the ethylene sensitivity study, their mean height and width, and the number and timing of experiments.

| Genotype                  | Plant ht (cm)     | Plant width (cm) | Number of experiments | Time of experiments (months) |
|---------------------------|-------------------|------------------|-----------------------|----------------------------|
| Aglaonema 'Mary Ann'      | 31.2 ± 1.4        | 39.3 ± 2.0       | 2                     | August, December           |
| Anthurium scherzerianum 'White Gemini' | 47.7 ± 0.7     | 36.4 ± 2.7       | 2                     | June, July                 |
| Anthurium scherzerianum 'Red Hot' | 30.3 ± 2.8     | 40.9 ± 2.2       | 2                     | May, August, September     |
| Aphelandra squarrosa 'Dania' | 24.6 ± 0.8       | 31.4 ± 0.7       | 2                     | February, June             |
| Asplenium nidus           | 16.2 ± 1.3        | 24.0 ± 2.3       | 2                     | September, October         |
| Chamaedorea elegans       | 39.4 ± 2.5        | 32.9 ± 2.7       | 2                     | February, October          |
| Chlorophytum comosum 'Hawaiian' | 18.0 ± 0.7     | 35.3 ± 1.1       | 2                     | February, May              |
| Codiaeum variegatum pictum 'Petra' | 21.7 ± 0.9      | 33.8 ± 1.2       | 2                     | February, May, September, October |
| Dieffenbachia maculata 'Carina' | 25.1 ± 1.1        | 33.0 ± 1.2       | 2                     | August, September          |
| Drucaena marginata 'Bicolor' | 38.8 ± 1.3       | 40.8 ± 1.8       | 2                     | February, May              |
| Drucaena marginata 'Magenta' | 42.4 ± 2.4       | 43.0 ± 2.0       | 2                     | May, August                |
| Euphorbia splendens 'Short and Sweet' | 22.7 ± 0.5    | 25.3 ± 1.5       | 1                     | January                    |
| Ficus benjamina           | 39.8 ± 1.7        | 39.0 ± 2.8       | 2                     | June, July                 |
| Hedera helix 'Chicago'    | 15.3 ± 0.5        | 30.3 ± 1.6       | 2                     | August, November           |
| Polyscias fruticosa 'Castor' | 37.0 ± 0.8        | 24.4 ± 0.9       | 2                     | December                   |
| Radermachera sinica 'China Doll' | 20.7 ± 0.9       | 20.1 ± 0.8       | 2                     | October, December          |
| Schefflera arboricola 'Gold Capella' | 30.1 ± 2.2       | 38.3 ± 1.0       | 2                     | October, December          |
| Schefflera elegantissima 'Gemini' | 30.7 ± 1.0       | 17.2 ± 0.6       | 2                     | February, May              |
| Spathiphyllum 'Ty’s Pride' | 25.1 ± 1.7        | 39.7 ± 1.2       | 3                     | May, August, September     |
| Syngonium podophyllum 'White Butterfly' | 19.9 ± 0.6     | 35.9 ± 1.5       | 1                     | May                       |

Data (means ± se) are representative of five plants per experiment.

Expt. 1: Ethylene sensitivity. Plants were enclosed into 99-L glass aquariums and exposed to 0 (control), 0.1, 1.0, and 10.0 μL L−1 ethylene in flowing streams of air (0.6 L·min−1) for 4 d at 21°C in the dark to simulate interstate truck transport. Ethylene concentrations in the effluent air stream were quantified using a gas chromatograph (GC) (S5890 Series II; Hewlett Packard, Avondale, PA), fitted with a flame ionization detector and a 106.7 cm long × 0.3-cm internal diameter stainless steel column packed with alumina F-1 (80/100 mesh) (Supelco, Bellefonte, PA). An authentic ethylene standard (Air Liquid America Specialty Gasses LLC, Plumsteadville, PA) was used to calibrate the GC. After treatment, plants were removed from the aquarium and maintained for 14 d in an evaluation room at 21°C ± 40% to 60% relative humidity, and 10 µmol·m−2·s−1 of light (12 h·d−1) provided by cool white fluorescent bulbs. Plants were irrigated to field capacity with tap water every 2 to 3 d or as necessary. The experiment was repeated at least twice for most genotypes (Table 1) using seven replicate plants per treatment. Where variation in ethylene sensitivity was observed between experiments, data showing the most representative response are presented.

Expt. 2: 1-Methylcyclopropene gas treatment. The efficacy of 1-MCP treatment to protect three ethylene-responsive potted foliage plant genotypes (Aglaonema 'Mary Ann', Polyscias fruticosa 'Castor', Schefflera arboricola 'Gold Capella') against ethylene was tested. An equal number of plants of each genotype were randomly assigned to two matching treatment groups. Where variation in ethylene sensitivity was observed between experiments, data showing the most representative response are presented.

Expt. 3: 1-Methylcyclopropene gas and sachet treatment. Euphorbia millii 'Gaia', Polyscias fruticosa 'Elegans', and Schefflera arboricola 'Gold Capella' plants, with known or suspected sensitivity to ethylene, were placed into polyethylene tents and treated with 0 (control) or 0.9 or 10.0 μL·L−1 1-MCP gas for 5 h at 21°C as described in Expt. 2. The control and 1-MCP-treated plants were then sampled at random and packed into separate cardboard shipping boxes (50.8 cm long, 33.0 cm wide, 61.0 cm high) as per commercial practice. Sachets containing 2.5 g EthylBloc™ (Floralife, Inc.) were dipped in water for 1 s to activate 1-MCP release and immediately placed into half of the boxes (two sachets per box) containing control plants in accordance with the manufacturer’s instructions (Ami Ranwala, personal communication). Boxes were held at the existing control and 1-MCP concentrations. 1-MCP-treated plants did not contain sachets. Lids to all boxes were then closed. The boxes were maintained for 5 d at 15°C in the dark to simulate short-term interstate truck transport. The sachets remained inside boxes for the entire duration of simulated shipment. One replicate box per treatment was used. Each box was maintained separately in matching 15°C walk-in coolers to reduce the risk of 1-MCP leaching from sachets into adjacent boxes. At the completion of simulated shipment, plants were removed from boxes and allowed to equilibrate to 21°C. They were then treated with either 0 or 100 μL L−1 ethylene for 4 d at 21°C in the dark as described in Expt. 1. Depending on the genotype, five to eight replicate plants were used for each treatment. The plants were maintained for evaluation at 21°C as described in Expt. 1.

Expt. 4: Duration of 1-Methylcyclopropene treatment effects. The duration that 1-MCP gas and sachet treatments could protect sensitive potted foliage plants against ethylene during a simulated shipment was determined. Aphelandra squarrosa 'Dania' plants were treated with 0.1, 1.0, 5.0, and 10.0 μL·L−1 1-MCP for 0, 12, or 48 h at 21°C and then packed into boxes as outlined in Expts. 2 and 3. EthylBloc™ sachets were included in half of the boxes holding control plants as described in Expt. 3. One box per treatment was used. Plants in boxes were maintained for 3 or 7 d at 15°C in the dark to simulate short- and long-term shipment, respectively, and then subjected to one-way analysis of variance (ANOVA) using the generalized linear model procedure of SAS (Version 9.1; SAS Institute Inc., Cary, NC). When significant (P ≤ 0.05) treatment effects were determined by ANOVA, data means were separated by the least significant difference test at P = 0.05.
Results

Expt. 1: Ethylene sensitivity. Exposure to ethylene reduced the display life of 15 of the 20 potted foliage plant genotypes tested by accelerating leaf abscission and senescence (Fig. 1). Ethylene treatment stimulated leaf abscission from seven genotypes (Aphelandra squarrosa ‘Dania’, Codiaeum variegatum pictum ‘Petra’, Ficus benjaminia, Polyscias fruticosa ‘Castor’, Radermachera sinica ‘China Doll’, Schefflera elegantissima ‘Gemini’, and Schefflera arboricola ‘Gold Capella’), whereas it hastened leaf senescence, manifested as chlorophyll degradation, on eight other sensitive genotypes (Aglaonema ‘Mary Ann’, Anthurium scherzerianum ‘Red Hot’, Chlorophytum comosum ‘Hawaiian’, Dieffenbachia maculata ‘Carina’, Dracaena marginata ‘Bicolor’ and ‘Magenta’, Euphorbia splendens ‘Short and Sweet’, Syngonium podophyllum ‘White Gemini’, and treated at different times during the growing season (data not shown). For example, the overall abscission or senescence response varied by 0% (Radermachera sinica ‘China Doll’), 4.9% (Aglaonema ‘Mary Ann’), or 26% (Schefflera arboricola ‘Gold Capella’) between different harvests. However, we did observe considerable variation in ethylene sensitivity for Anthurium scherzerianum ‘Red Hot’ and Codiaeum variegatum pictum ‘Petra’; plants harvested in August, September, and/or February were insensitive to ethylene treatments, whereas those harvested in May were responsive to ethylene (Fig. 1).

The lowest ethylene concentration required to evoke leaf abscission or senescence varied among the different genotypes (Fig. 1). For example, treatment with 0.1 μL·L⁻¹ ethylene for 4 d at 21 °C induced leaf abscission or senescence on Aphelandra squarrosa ‘Dania’, Chlorophytum comosum ‘Hawaiian’, Euphorbia splendens ‘Short and Sweet’, Radermachera sinica ‘China Doll’, Schefflera elegantissima ‘Gemini’, and Schefflera arboricola ‘Gold Capella’ plants. By comparison, potted Dieffenbachia maculata ‘Carina’, Dracaena marginata ‘Bicolor’, and Ficus benjaminia ‘White Gemini’ plants were relatively less responsive and required exposure to 10 μL·L⁻¹ ethylene for 4 d to stimulate foliar injury. Of the highly sensitive species, levels of leaf abscission and senescence generally continued to increase in response to higher ethylene treatment concentrations (Fig. 1). Although all seven genotypes that displayed the abscission phenotype readily shed leaves immediately after removal from a 4-d exposure to ethylene, the development of leaf senescence varied significantly with the genotype (data not shown). For example, Anthurium scherzerianum ‘Red Hot’, Dracaena marginata ‘Magenta’, and Chlorophytum comosum ‘Hawaiian’ plants showed early signs of leaf senescence at the end of ethylene treatment, whereas Aglaonema ‘Mary Ann’ plants did not develop visible leaf senescence until 8 d post-treatment. Leaf senescence was typically confined to older basal leaves, whereas abscission occurred randomly with regard to leaf age and position on plants (data not shown).

Expt. 2: 1-Methylcyclopropene gas treatment. Treating Aglaonema ‘Mary Ann’, Polyscias fruticosa ‘Castor’, and Schefflera arboricola ‘Gold Capella’ plants with 0.9 μL·L⁻¹ 1-MCP for 4 h at 21 °C significantly reduced leaf abscission and senescence mediated by exposure to 1 or 10 μL·L⁻¹ ethylene immediately after 1-MCP treatment (Fig. 2).

![Figure 1](https://example.com/fig1.jpg)

**Fig. 1.** Leaf abscission and senescence responses for 15 potted foliage plant genotypes after treatment with 0, 0.1, 1.0, and 10 μL·L⁻¹ ethylene for 4 d at 21 °C and a subsequent 14-d display life at 21 °C. Data (mean ± se, n = 7) for each genotype followed by different letters are significantly different at P = 0.05. The genotypes were: Aglaonema ‘Mary Ann’, Anthurium scherzerianum ‘Red Hot’, Aphelandra squarrosa ‘Dania’, Chlorophytum comosum ‘Hawaiian’, Codiaeum variegatum pictum ‘Petra’, Dieffenbachia maculata ‘Carina’, Polyscias fruticosa ‘Castor’, Schefflera elegantissima ‘Gemini’, Dracaena marginata ‘Bicolor’, Dracaena marginata ‘Magenta’, Euphorbia splendens ‘Short and Sweet’, Ficus benjaminia, Radermachera sinica ‘China Doll’, Schefflera arboricola ‘Gold Capella’, and Syngonium podophyllum ‘White Gemini’. Typically, ethylene responses were very consistent for most genotypes harvested and treated at different times during the growing season (data not shown). For example, the overall abscission or senescence response varied by 0% (Radermachera sinica ‘China Doll’), 4.9% (Aglaonema ‘Mary Ann’), or 26% (Schefflera arboricola ‘Gold Capella’) between different harvests. However, we did observe considerable variation in ethylene sensitivity for Anthurium scherzerianum ‘Red Hot’ and Codiaeum variegatum pictum ‘Petra’; plants harvested in August, September, and/or February were insensitive to ethylene treatments, whereas those harvested in May were responsive to ethylene (Fig. 1).

The lowest ethylene concentration required to evoke leaf abscission or senescence varied among the different genotypes (Fig. 1). For example, treatment with 0.1 μL·L⁻¹ ethylene for 4 d at 21 °C induced leaf abscission or senescence on Aphelandra squarrosa ‘Dania’, Chlorophytum comosum ‘Hawaiian’, Euphorbia splendens ‘Short and Sweet’, Radermachera sinica ‘China Doll’, Schefflera elegantissima ‘Gemini’, and Schefflera arboricola ‘Gold Capella’ plants. By comparison, potted Dieffenbachia maculata ‘Carina’, Dracaena marginata ‘Bicolor’, and Ficus benjaminia ‘White Gemini’ plants were relatively less responsive and required exposure to 10 μL·L⁻¹ ethylene for 4 d to stimulate foliar injury. Of the highly sensitive species, levels of leaf abscission and senescence generally continued to increase in response to higher ethylene treatment concentrations (Fig. 1). Although all seven genotypes that displayed the abscission phenotype readily shed leaves immediately after removal from a 4-d exposure to ethylene, the development of leaf senescence varied significantly with the genotype (data not shown). For example, Anthurium scherzerianum ‘Red Hot’, Dracaena marginata ‘Magenta’, and Chlorophytum comosum ‘Hawaiian’ plants showed early signs of leaf senescence at the end of ethylene treatment, whereas Aglaonema ‘Mary Ann’ plants did not develop visible leaf senescence until 8 d post-treatment. Leaf senescence was typically confined to older basal leaves, whereas abscission occurred randomly with regard to leaf age and position on plants (data not shown).

**Fig. 2.** Leaf senescence and abscission from Aglaonema ‘Mary Ann’, Polyscias fruticosa ‘Castor’, and Schefflera arboricola ‘Gold Capella’ plants after a 14-d display life at 21 °C. Plants were treated with 0 or 0.9 μL·L⁻¹ 1-methylcyclopropene for 4 h at 21 °C on Day 0. They were then immediately exposed to 0 and either 1 μL·L⁻¹ (Polyscias, Schefflera) or 10 μL·L⁻¹ (Aglaonema) ethylene for 4 d at 21 °C before display life. Data (mean ± se, n = 7) for each genotype followed by different letters are significantly different at P = 0.05.
Despite greatly reducing leaf abscission, 1-MCP treatment did not render Polyscias fruticosa ‘Castor’ and Schefflera arboricola ‘Gold Capella’ plants completely insensitive to exogenous ethylene. For all three genotypes, treatment with 1-MCP did not extend the display life of control (0 μL·L⁻¹ 1-MCP) plants not exposed to exogenous ethylene. Levels of leaf abscission and senescence for these control plants were minor (0.2% to 2.4%) in the absence of exogenous ethylene.

Expt. 4: Duration of 1-methylcyclopropene treatment effects. Treatment with 0.9 μL·L⁻¹ 1-MCP for 5 h at 21 °C on Day 0 afforded Aphelandra squarrosa ‘Dania’ plants with protection against serial exposure to 1 μL·L⁻¹ ethylene for up to 7 d of subsequent simulated transport at 15 °C (Fig. 4). Pre-treating plants with 1-MCP via two EthylBloc™ sachets in shipping boxes at 15 °C was similarly effective in reducing ethylene-induced leaf abscission for the entire 7-d shipment plus 4 d of ethylene exposure. There was no leaf abscission from plants not exposed to ethylene (data not shown).

Discussion

Exposure to 0.1, 1.0, or 10 μL·L⁻¹ of ethylene for 4 d at 21 °C induced moderate to extensive leaf abscission and senescence in 17 common potted foliage plant genotypes (Figs. 1 and 3). Our findings corroborate similar reports that treatment with 1 to 15 μL·L⁻¹ ethylene for 3 to 7 d at 15 to 23 °C can accelerate leaf abscission and chlorosis in a variety of potted foliage plants, including Aglaonema, Aphelandra squarrosa, Dieffenbachia maculata, Dizygotheca elegans (synonym: Schefflera elegans), Dracaena marginata, Ficus benjamina, Fittonia verschaffeltii, Philodendron scandens, Radermachera sinica, and Schefflera arboricola (Fan et al., 2009; Marousky, 1979; Marousky and Harbaugh, 1979, 1982; Wang and Dunlop, 1990; Woltering, 1987). The current study extends these findings to show that several additional genotypes (Anthurium scherzerianum ‘Red Hot’ and ‘White Gemini’, Chlorophytum comosum ‘Hawaiian’, Codiaeum variegatum pictum ‘Peta’, Euphorbia millii ‘Gaia’, Euphorbia splendens ‘Short and Sweet’, Polyscias fruticosa ‘Castor’, Spathiphyllum ‘Ty’s Pride’) are also responsive to ethylene (Fig. 1). Taken together, our data highlight several foliage plant genotypes that require careful handling to avoid exposure to exogenous ethylene and/or transport-related stress that elevates rates of endogenous ethylene production (Graves and Gladon, 1985; Muller et al., 2000).

Considerable variation in ethylene sensitivity existed among the different potted foliage plant genera (Fig. 1) in line with previous reports (Marousky and Harbaugh, 1982; Woltering, 1987). The ethylene concentration applied for 4 d at 21 °C required to elicit leaf abscission or senescence varied from 0.1 μL·L⁻¹ (e.g., Radermachera) to 10 μL·L⁻¹ (e.g., Dieffenbachia). We also observed substantial intra- and interspecific variation in the response to ethylene. For example, Anthurium scherzerianum ‘Red Hot’ plants were sensitive to 1 μL·L⁻¹ ethylene, whereas the cultivar White Gemini was insensitive to 10 μL·L⁻¹ ethylene. Likewise, treatment with 0.1 μL·L⁻¹ ethylene induced 26% leaf abscission from Schefflera arboricola ‘Gold Capella’ and Schefflera elegans ‘Gemini’ plants, respectively (Fig. 1). This range of responses is similar to differences in ethylene sensitivity of floral organs of Kalanchoe blossfeldiana and Rosa hybrida cultivars (Macnish et al., 2010; Serek and Reid, 2000) and Dianthus and Chamelaucium spp. (Friedman et al., 2001; Macnish et al., 2004; Onozaki et al., 2001). Our data reveal the extent of genetic variation in ethylene sensitivity of a range of modern potted foliage plants and point to opportunities to breed for greater resistance to ethylene.

Our observation that ethylene-mediated leaf abscission occurred more rapidly than the development of visible leaf senescence is also in general agreement with an earlier report by Woltering (1987). Although the older leaves of many foliage plant species often abscise first in response to ethylene (Woltering, 1987), there was no such relationship for any of the genotypes tested in the current study. In contrast, ethylene-mediated leaf chlorosis was typically confined to the basal leaves of affected genotypes (e.g., Aglaonema ‘Mary Ann’). Fan et al. (2009) also reported that only the older basal leaves of Aglaonema ‘White Tip’ developed senescence symptoms after exposure to ethylene. These data concur with previous findings that ethylene often regulates leaf senescence in association with age-related factors (Grbic and Bleecker, 1995). Although our data represent the relative sensitivity of a range of foliage plant genotypes to treatment with 0.1, 1.0, and 10 μL·L⁻¹ ethylene for 4 d at 21 °C, it should only be taken as a general guide. For example, we found that the sensitivity of Anthurium scherzerianum ‘Red Hot’ and Codiaeum variegatum pictum ‘Peta’ plants varied with harvest time. The response of ornamentals to ethylene has previously been reported to be a function of the growing environment (Macnish et al., 2004; Woltering, 1987) and the ethylene treatment duration and temperature (Marousky, 1979; Marousky and Harbaugh, 1979).

Pre-treatment with the gaseous ethylene-binding inhibitor, 1-MCP, protected several sensitive potted foliage plant genotypes (Aglaonema ‘Mary Ann’, Polyscias fruticosa...
**Castor**, *Schefflera arboricola* (*Gold Capella*) against immediate exposure to ethylene (Fig. 2). Our findings are consistent with earlier reports that 1-MCP treatment can protect several potted flowering (e.g., *Kalanchoe blossfeldiana*, *Rosa hybrida*, *Schlumbergera truncata*) and foliage (e.g., *Aglonema* ‘White Tip’, *Ficus* ‘Green Island’, *Ixora coccinea*) plants against ethylene-induced floral organ and leaf abscission and senescence (Fan et al., 2009; Michaeli et al., 1999; Muller et al., 2000; Phillips-Hadas et al., 2005; Serek et al., 1994; Serek and Reid, 2000; Serek and Sisler, 2001). We also found that the release of 1-MCP from two sachets containing EthylBloc™ inside a closed shipping box protected *Euphorbia milii* ‘Gaia’, *Polyscias fruticosa* ‘Elegans’, and *Schefflera arboricola* ‘Gold Capella’ plants against ethylene-induced leaf abscission immediately after a 3-d simulated shipment at 15°C (Fig. 3). We previously reported that this 1-MCP sachet treatment can also protect cut rose flowers against ethylene during shipment (Macnish et al., 2010). Our findings highlight 1-MCP-releasing sachets as an alternative, simple, and practical strategy to protect sensitive ornamentals in handling situations (e.g., mixed shipments with fruits) in which ethylene can occasionally accumulate to biologically active concentrations.

Although 1-MCP is widely accepted to bind irreversibly to ethylene receptors (Sisler et al., 1996), its duration of residual activity is often short-lived in ornamental plants presumably as a result of the formation of new binding sites. For example, 1-MCP treatment protected the floral organs of *Chamaeleaunucinatum* ‘Lollypop’, ‘Alba’ and ‘Mid Pink’, *Grevillea* ‘Sylvia’ and *Pelargonium* petalum against ethylene for just 2 to 6 d at 20 to 21°C (Cameron and Reid, 2001; Macnish et al., 2000). In the present study, both the 1-MCP gas and sachet treatment protected *Aphelandra squarrosa* ‘Dania’ plants against ethylene-induced leaf abscission for 7 d of simulated shipment at 15°C plus 4 d at 21°C (Fig. 4). Thus, 1-MCP treatment may confer adequate protection to permit transport of foliage plants over relatively long distances (Conover and Poole, 1984). Pre-treatment with STS has also been shown to afford ornamental plants with long-term protection against ethylene (Cameron and Reid, 1981). The relatively long duration of 1-MCP treatment benefits for *Aphelandra squarrosa* ‘Dania’ foliage organs may reflect reduced rates of ethylene receptor turnover and/or metabolic activity associated with downstream ethylene signaling as compared with floral structures. Typically, leaf abscission proceeds more slowly than the shedding of floral organs (Sexton and Roberts, 1982; Woltering, 1987).

The present study draws attention to 17 commonly traded potted foliage plant genotypes that may require specialized handling to reduce ethylene-mediated quality loss. The observed differences in ethylene responsiveness among the genotypes highlight opportunities to exploit this variation to breed and select cultivars with improved postproduction performance. In cases in which ethylene accumulates to relatively high concentrations during the transportation and marketing of foliage plants, pre-treatment with antiethylenic compounds such as 1-MCP may help ensure against damage.

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