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Ethylene, Simulated Shipping, STS, and AOA Affect Corolla Abscission of New Guinea Impatiens

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Abstract. **Exposure to exogenous ethylene (C_2H_4) caused corolla abscission of New Guinea impatiens *(Impatiens* × *hawkeri* 'Sunfire'). Abscission varied with time of exposure and C_2H_4 concentration. Ethylene at ≥ 1 µl·liter^{-1} and exposure times of 4 or more hours caused 80% to 100% corolla abscission. Simulated shipping of untreated control plants caused ≈ 65% corolla abscission. Plants pretreated with silver thiosulfate (STS) and (aminooxy)acetic acid (AOA) and subsequently exposed to simulated shipping were not different from one another, and both treatments reduced corolla abscission to ≈ 20% when applied at 1.0 mM. Plants pretreated with STS and exposed to exogenous C_2H_4 showed 0% abscission, whereas plants pretreated with AOA showed no reduction in abscission when compared with control plants.**

New Guinea impatiens flower year round, are available in a variety of flower colors and attractive foliage patterns, and can be produced as hanging baskets, bedding plants, and potted plants. A disadvantage associated with New Guinea impatiens is that many corollas abscise during shipping, handling, and retailing.

Ethylene is the causal agent of abscission and senescence of many types of flowers and floral organs (Woltering, 1987). Silver ion blocks the action of C_2H_4 (Beyer, 1976), and the anionic thiosulfate complex of silver is a mobile and effective antiethylene agent in plant tissues (Veen and van de Geijn, 1978). Foliar sprays of STS have been used widely in studies of floral organ abscission. Corolla abscission of *Streptocarpus* caused by simulated shipping was reduced by STS foliar sprays (Agnew et al., 1985). *Streptocarpus* flower and bud abscission caused by exogenous C_2H_4 also was reduced by STS foliar sprays (Rewinkel-Jansen, 1986). Cameron and Reid (1981) showed that STS foliar sprays reduced flower and bud abscission of *Schlumbergera* plants exposed to C_2H_4 or darkness at 26C. Later work by Cameron and Reid (1983) proved that STS delayed or prevented petal abscission of *Pelargonium,* flower abscission of *Calceolaria,* and bracteole abscission of *Bougainvillea.*

AOA inhibits the activity of l-aminocyclopropane-1-carboxylic acid synthase, an enzyme essential to C_2H_4 biosynthesis (Yu et al., 1979). Thus, AOA is an inhibitor of C_2H_4 biosynthesis and STS is an inhibitor of C_2H_4 action, and their functions are fundamentally different. AOA has not been tested as a foliar spray on potted plants, but it has been tested as a treatment for cut flowers. Fujino et al. (1980) and Wang and Baker (1980) showed that AOA extended the postharvest life of carnation flowers. Fujino et al. (1980) and Broun and Mayak (1981) showed that AOA inhibited C_2H_4 biosynthesis in carnation flowers, and when AOA-treated flowers were exposed to exogenous C_2H_4 the compound provided no protection against C_2H_4.

The objectives of this research were to: 1) determine if exogenous C_2H_4. or simulated shipping cause corolla abscission of New Guinea impatiens and 2) test the efficacies of foliar sprays of STS and AOA for the

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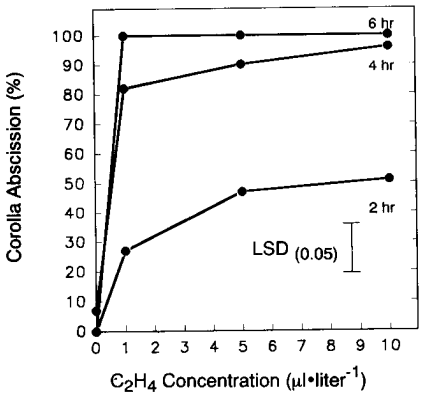

Fig. 1. Effect of C_2H_4 concentration and exposure time on corolla abscission of *Impatiens* ×*hawkeri* 'Sunfire' plants. Interaction least significant difference is shown to provide a measure of experimental error rather than statistical significance.

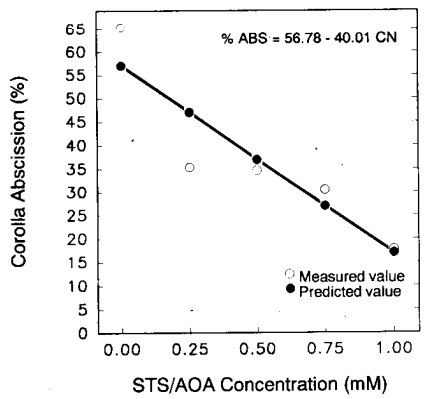

Fig. 2. Effect of STS and AOA spray pretreatment concentration on corolla abscission of *Impatiens* ×*hawkeri* 'Sunfire' plants handled under simulated shipping conditions. Regression equation is: Abscission percentage (% ABS) = 56.78 − 40.01 Concentration (CN).

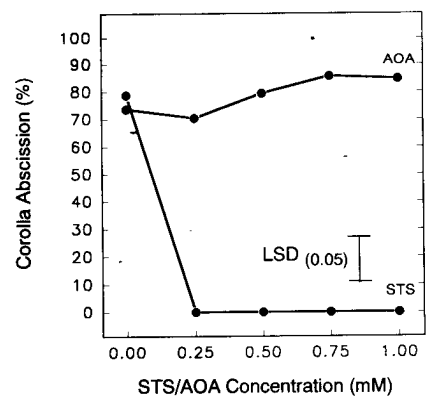

Fig. 3. Effect of STS and AOA spray pretreatment concentrations on corolla abscission of *Impatiens* ×*hawkeri* 'Sunfire' plants exposed to C_2H_4(l µl·liter^{-1}) in air for 4hr. Interaction least significant difference is shown to provide a measure of experimental error rather than statistical significance.

prevention of corolla abscission that maybe caused by simulated shipping or exogenous C_2H_4.

Plant production, selection, and abscission data procurement. Impatiens ×*hawkeri* 'Sunfire' (Mikkelsen's, Ashtabula, Ohio) rooted cuttings were planted into 13-cm (0.8-liter) plastic pots filled with a growing medium that contained 1 soil :2 sphagnum peat :2 perlite (by volume). Consecutive crops of plants for each experimental period grew in a greenhouse under natural photoperiod at 21/16C (day/night) from l Nov. 1987 to 10 Feb. 1988. Plants for each experiment were selected for uniformity from blocks of ≈ 100 plants. Plants flowering for the first time after propagation with a minimum of six (range of six to 11) flowers at anthesis were considered representative of the marketable stage. All corolla abscission data were recorded immediately after the plants were removed from the container used for the experiment. Preliminary experiments revealed that no additional corollas abscised when plants were observed from several hours to several days after the experiment. Corollas abscised while they still were turgid, and they did not show any signs of discoloration, damage, or wilting.

Table 1. Analysis of variance of the effect of STS or AOA spray pretreatment concentrations on corolla abscission of *Impatiens* ×*hawkeri* 'Sunfire' plants handled under simulated shipping conditions.

Source	df	F	P R > F
Chemical	1	3.86	0.060
Concn	4	8.98	<0.001
Chemical × concn	4	0.75	0.569

Exposure to exogenous C_2H_4(Expt. 1). The response to exogenous C_2H_4 was determinedly placing plants into glass vessels (22 liter) that were ventilated continuously with C_2H_4/air mixtures at a rate of two air exchanges/hr. Four C_2H_4 concentrations (0, 1,5, and 10 µl·liter^{-1}) were combined factorially with three exposure times (2, 4, and 6 hr). The experiment was conducted at 23 ± lC and 5 to 14 µmol·s^{-1}·m^{-2} irradiance continuously from cool-white fluorescent lamps.

C_2H_4 inhibitor spray pretreatment technique for Expts. 2 and 3. To determine if STS or AOA effectively reduced corolla abscission caused by simulated shipping or exposure to C_2H_4, plants were selected for uniformity from the experimental block, any open flowers were removed, plants were sprayed with ≈ 30 ml of pretreatment solution (0, 0.25, 0.50, 0.75, or 1.0 mM STS or AOA), and plants were returned to the greenhouse to reflower. When a minimum of six flowers were at anthesis (7 to 10 days), simulated shipping or C_2H_4 exposure commenced. Preliminary experimentation showed that STS and AOA caused phytotoxicity when applied at concentrations of 4 mM or higher (data not presented). At these concentrations, AOA caused the plants to collapse and die within 24 hr, while STS caused foliar necrosis. No phytotoxicity resulted at the pretreatment chemical concentrations used for these experiments.

C_2H_4, inhibitor spray pretreatment/simulated shipping (Expt. 2) and exposure to C_2H_4 (Expt. 3). The response to simulated shipping of plants pretreated with STS or AOA (Expt. 2) was determined by placing pretreated plants into perforated, polyethylene sleeves and placing sleeved plants into ventilated cardboard boxes. Boxes were held in a dark growth chamber at 25 ± lC for 72 hr. Pretreated plants were exposed for 4 hr to C_2H_4(1 µl·liter^{-1}) in air (Expt. 3) by the procedure described above.

Statistical design and analysis. Exposure of untreated plants to four concentrations of exogenous C_2H_4 for three periods of time (Expt. 1) was conducted four times as a randomized, complete-block experiment with four single-plant replicates per treatment. Simulated shipping of plants pretreated with STS or AOA (Expt. 2) was conducted three times as a randomized, complete-block experiment with five concentrations of STS or AOA and four single-plant replicates per treatment. Exposure of STS- or AOA-pretreated plants to exogenous C_2H_4 (Expt. 3) was conducted twice as a randomized, complete-block experiment with five concentrations of STS or AOA and three single-plant replicates. Analysis of variance of all percentage corolla abscission data was performed individually on each run of each experiment to test for significant differences in corolla abscission resulting from the treatments. After confirmation that the results from each run within the experiment were the same, we chose data from one representative experiment for presentation. Interaction least significant difference values ($\alpha = 0.05$) were calculated and are shown to give the reader an indication of the size of the experimental error. They are not used for testing statistical significance between treatments. The regression equation is presented when applicable (Expt. 2). Regression equations are not presented for Expts. 1 and 3 because they would not aid interpretation of the data.

Plants exposed to C_2H_4 (Expt. 1) abscised more corollas than did control plants, and the greatest increase was observed between 0 and 1 µl C_2H_4/liter (Fig. 1). Exposure to C_2H_4 concentrations of 1, 5, or 10 µ1·liter^{-1} for 6 hr caused 100% corolla abscission, and exposure to 5 or 10 µl·1iter^{-1} for 4 hr caused 90% to 100% abscission. Percentage corolla abscission was lower for 2-hr than for 4- or 6-hr exposures. These data illustrate the sensitivity of this species to exogenous C_2H_4 and show that it should be placed in the most sensitive classification of Weltering (1987). These data also illustrate that threshold effects are prevalent for both time (> 2 to 4 hr) and C_2H_4 concentration (> 1 µl C_2H_4/liter) because there is not a direct dosage response (i.e., percentage abscission at 10 µl C_2H_4/liter for 2 hr does not equal percentage abscission at 5 µl C_2H_4/liter for 4 hr). We did not determine whether a direct dosage response is present for exposure times of <4 hr in combination with C_2H_4 concentrations of <1 µl·liter^{-1}.

Control plants subsequently exposed to simulated shipping conditions (Expt. 2) showed ≈ 65% corolla abscission (Fig. 2). Plants pretreated with STS or AOA at any given concentration were not different from one another (Table 1), but as the concentra-

tion of the C_2H_4-inhibitor pretreatment increased, abscission decreased linearly (Fig. 2). If the regression line is valid beyond 1.0 mM, then a concentration of ≈ 1.5 mM of either chemical would reduce abscission induced by simulated shipping to near zero (Table 1; Fig. 1). Both STS and AOA offered some, but not complete, protection from corolla abscission induced by simulated shipping. Better control of corolla abscission in *Streptocarpus,* compared with New Guinea impatiens, was achieved with STS in simulated shipping studies by Agnew et al. (1985). The data in our report reinforce the notion that New" Guinea impatiens are extremely susceptible to shipping stresses. Factors other than C_2H_4, such as temperature, absence of light, or duration of shipping, may contribute to corolla abscission of New Guinea impatiens induced by simulated shipping, and the resultant abscission may be reduced but not eliminated by using STS or AOA.

When plants were pretreated with STS or AOA foliar sprays and then exposed to exogenous C_2H_4 (Expt. 3), they showed strikingly different responses. STS foliar sprays, regardless of the concentration above zero, completely eliminated corolla abscission caused by exposure to C_2H_4. Conversely, AOA foliar sprays provided no protection against exogenous C_2H_4 (Fig. 3). These data for STS corroborate similar research on other species (Beyer, 1976; Cameron and Reid, 1981, 1983). Although there is no information on the efficacy of AOA on corolla abscission of potted plants, and, therefore, no direct comparisons can be made, these data parallel those of Fujino et al. (1980) and Broun and Mayak (1981) that showed that AOA did not confer protection against exogenous C_2H_4 to carnations.

We found no other reports in which AOA has been shown to reduce corolla abscission of potted plants induced by simulated shipping or has proven effective as a foliar spray. In addition, no phytotoxicity resulted from AOA foliar sprays at the concentrations reported in these studies. AOA shows promise for use in the prevention of the negative effects of shipping on flowering potted plants. This is the case especially in light of the environmental concerns over the use of STS and the relationship of STS use and increased *Pythium ultimum* sensitivity of potted *Pelargonium* (Hausbeck et al., 1989).

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