Ethylene-Induced Flower Bud Abortion in Easter Lily is Inhibited by Silver Thiosulfate

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ABSTRACT

Flower bud abortion, or "blasting" was shown to be at least partially caused by treating plants with ethephon, a chemical that releases ethylene. In floricultural greenhouses, ethylene could accumulate to levels that could induce commercially significant levels of flower bud injury. Silver thiosulfate (STS) was shown to be a potent inhibitor of ethephon injury. STS at (1 to 2 mM) could be applied as early as the visible bud stage (approximately 5 to 6 weeks before flowering) without phytotoxic effects. Using current silver prices, the material cost for our treatment is less than 0.4 cents per plant. Based on these results, a preventative STS application could potentially reduce much of the flower bud abortion seen in commercial greenhouses.

INTRODUCTION

Easter lilies (*Lilium longiflorum* Thunb.) are an important floricultural crop in the United States. Based on 1986 data, the wholesale value of the crop was nearly $30 million, nationwide.

One of the production problems with Easter lily is bud abortion, or "blast," a physiological disorder that causes arrested development and death of floral buds before flowering. Commercially, bud abortion refers to arrested bud development at an extremely early stage. Evidence of bud abortion is a tiny bump at the base of the inflorescence, usually subtended by a non-developed axillary leaf of 5 to 20 mm in length. Blasting usually refers to death of larger (1/4 inch in length or greater) buds. Blasted buds are diagnosed by a rapid drying of the tissue at the base of the bud, followed by the death, but not abscission, of the bud. Since lilies are priced partially by the number of flowers or "bud count," it is imperative to reduce or eliminate bud abortion for maximum grower profit.

MATERIALS AND METHODS

Experiments were carried out during a 2-year period. Bulbs (8" - 9" circumference) of *Lilium longiflorum* 'Nellie White' were received from Dahlstrom and Watt Bulb Farms Inc., and placed into 4^0 C dark storage. After 6 weeks of storage, bulbs were removed from the cooler, and potted in 1.8 liter plastic containers and placed into a greenhouse using 26^0 C venting and 15^0 C night temperatures. The growth medium consisted of a 1 soil: 2 sphagnum peat: 2 perlite (v/v/v) mixture amended with 4.75 kg ground dolomitic limestone, 890 g treble superphosphate, 593 g potassium nitrate, 593 g magnesium sulfate, and 74 g Frit Industries Trace Element No. 555 (Peters Fertilizer Products, W.R. Grace and Co., Fogelsville, Pa.) per cubic meter. The plants received constant liquid fertilization at each watering with 300 mg/liter N and K, each supplied from 776 and 550 mg potassium nitrate and ammonium nitrate per liter, respectively. Fertilizer solution was maintained at 6.0 pH by injecting 75% (w/w) technical grade phosphoric acid into the system, supplying 37 mg P/liter at every watering.

To control development of the root-rot complex, a preventative fungicidal drench containing 0.5 fl. oz Subdue + 8 oz Terraclor per 100 gallons was applied at 8 oz per pot two days after planting. Four weeks after planting, 8 oz Banrol per 100 gallons were applied, and eight weeks after planting, 8 oz Truban + 2.67 oz Benlate per 100

gallons were applied, each as a drench. The Banrot and Truban/Benlate drenches were repeated at 12 and 16 weeks after planting, respectively.
Ethephon solutions were made using the commercial product, Florel, which has an a.i. of 3.9% 2-chloroethylphosphonic acid. In 1988 experiments, solutions contained 1 drop of dish-washing detergent per 100 ml. In 1989 experiments, solutions contained 0.1% Tween-20 as a surfactant.

Silver thiosulfate (STS) stock solutions consisted of $AgNO_3$ (0.1 M) and $Na_2S_2O_3$ (0.1 M) and were stored in dark bottles at room temperature. Dilute STS was prepared on the day of the experiment by adding appropriate amounts of each stock to distilled water and then adding the $AgNO_3$ solution slowly to the $Na_2S_2O_3$ solution to prevent silver precipitation. A molar ratio between silver and thiosulfate of 1 to 4 was used in all experiments. A surfactant of 0.1% Tween-20 was used unless otherwise stated.

Each year, we treated 10 plants with each of the following treatments: 0, 200, or 400 mg/liter ethephon (0, 1.38, and 2.77 millimolar, respectively). The ethephon treatments were made by spraying 10 ml of solution on the flower buds and upper 1/4 of the plant. Control plants received no ethephon. Plants were observed for bud abortion after application of ethephon treatments and percent bud abortion was calculated for each treatment.

To determine the extent of protection by STS, plants were first treated with 0, 1, or 2 mM STS. STS was applied at visible bud + 2 weeks. Two days later, ethephon was applied at the rates of 0, 300 and 600 ppm ethephon (0, 2.07, or 4.15 millimolar, respectively), in a factorial design. In 1989, we used the same STS rates, and reduced the ethephon rates to 0, 200 and 400 ppm (0, 1.38, and 2.77 mM, respectively). Plants were observed for bud abortion.

To determine the length of effectiveness of STS sprays on Easter lily, plants were treated with STS at three growth stages: 1) flower bud initiation (FBI), 2) visible bud (VB), or 3) visible bud + 3 weeks (VB + 3 weeks). FBI, VB, and VB + 3 weeks occurred Jan. 25, Feb. 21 and March 5, 1989, respectively. At each application time, three levels of STS were used: 0, 1, or 2 mM STS. At visible bud + 4 weeks (i.e., 1 week after the last STS application), all plants were treated with 0, 1.38, or 2.76 mM ethephon, in a factorial design. Fifteen plants were used per replication. Plants were observed for bud blast.

RESULTS AND DISCUSSION

From Table 1, it is clear that ethephon induced substantial levels of bud blast. More blast was seen with higher levels of ethephon. Definite symptoms of bud blast were evident within 5 to 6 days after ethephon application. Table 2 shows that STS reduced the level of damage caused by earlier ethephon application. STS at 2 mM was more effective than at 1 mM. No phytotoxicity was seen at the STS levels we report here. In other experiments, phytotoxicity (black and brown spots on the leaves and buds) was noted with higher (4 mM and greater) levels of STS. STS tended to lose effectiveness with earlier, as compared to later, applications (Table 3). When STS was applied at flower bud initiation (late January), little positive response was seen. Real and useful reductions in bud abortion were seen, however, with STS applications at the visible bud stage and later (Table 3).

These results strongly indicate the usefulness of STS as a preventative measure against ethylene injury in Easter lilies, and confirm that bud abortion is, at least partially, caused by ethylene. We have yet to test whether other environmental factors that cause bud abortion (such as elevated temperature and severe root rot) can be ameliorated by STS.

Researchers outside of Arizona have found ethylene levels of 0.02 to 1.0 ppm (parts per million) in moderately well-sealed polyethylene glasshouses equipped with gas-fired heaters. Exhaust gas from gas-fired heaters contains ethylene. Improperly adjusted or inadequately vented heaters can easily cause damaging ethylene levels within a short time period. Also, ethylene contamination in the atmosphere of urban areas can be substantial. For example, it has been reported that ethylene levels can range from 50 to 500 ppb (0.05 to 0.5 ppm) in urban and industrial areas. Others speculate that vehicular emissions in urban areas of California are responsible for yearly floricultural losses (e.g. bedding plants) amounting to tens of thousands of dollars.

We calculated the cost of this preventative treatment. Using a silver nitrate price of $480 for 500 grams (Sigma Chemical Co. St. Louis, Mo.), we estimate the material cost to be 0.164 to 0.325 cents per pot for the treatment levels we used.

The STS treatment should not be viewed as a replacement for proper cultural procedures, greenhouse maintenance, and common sense. Be aware of the causes and sources of ethylene, and take steps to eliminate all ethylene from the greenhouse environment.

NOTES AND ACKNOWLEDGMENTS

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Table 1. Bud abortion in Easter lily as influenced by ethephon application. Ethephon was applied 2 weeks before flowering.

Ethephon (mM)	1988	1989
0 mM	0	2.1
1.38 mM	37.2	49.3
2.77 mM	53.7	56.7
Ethephon	***	***

[z]Means based on 30 plants per treatment. *** = significant at the 0.001 level.

Table 2. Ethephon-induced flower bud abortion inhibited by silver thiosulfate (STS) in Easter lily. STS was applied at VB + 3 weeks. Subsequent ethephon applications were made two days later. 1988 experiment on top, 1989 experiment on the bottom.

	Ethephon (mM)		
STS	0	2.07	4.15
0 mM	0[z]	74.7	100
1 mM	0	21.5	68.1
2 mM	0	3.8	54.4

	Ethephon (mM)		
STS	0	1.38	2.77
0 mM	0[z]	49.0	69.0
1 mM	0	1.3	26.8
2 mM	0	2.9	12.7
Ethephon	***		
STS	***		
Ethephon x STS	***		

[z]Means based on 10 plants per treatment. *** = significant at the 0.001 level.

Table 3. Length of STS effectiveness against ethephon-induced bud abortion in Easter lily. STS was applied at the three growth stages: 1) flower bud initiation (FBI), 2) visible bud (VB), or 3) visible bud + 3 weeks (VB + 3). Ethephon was applied at VB + 4 weeks.

	Developmental Stage								
	FBI			VB			VB + 3		
	Ethephon (mM)			Ethephon (mM)			Ethephon (mM)		
STS (mM)	0	1.38	2.76	0	1.38	2.76	0	1.38	2.76
0 mM	0.8[z]	39.7	55.6	0.8	38.9	60.9	0	32.8	61.3
1 mM	1.1	39.8	55.9	0	13.9	39.4	0.9	3.1	6.3
2 mM	0	31.9	59.4	0	5.5	23.4	0.8	0.8	0.8
Time			***						
Ethephon			***						
STS			***						
Time x STS			***						
Time x Eth			***						
STS x Eth			***						
Time x Eth x STS			***						

[z]Means based on 15 plants per treatment. *** = significant at the 0.001 level.