Reduction of Induced Abscission of Geranium (*Pelargonium hortorum*) Petals and Snapdragon (*Anthirrinum majus*) Florets Using Three Anti-Ethylene Compounds[1]

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STABY

Abstract. Premature petal drop of individual cut geranium florets induced with a 2,000 ppm ethephon (5 ml/1.5 m^2) spray was reduced by using 0.5 to 2.0 mM AVG, 0.1 to 1.0 mM AOA, or 0.0005 to 1.0 mM STS in the holding solution. Floret drop of snapdragons induced with 150 ppm ethephon in the holding solution was prevented and vase life was extended by a 12-hr pretreatment in silver thiosulfate solution prior to ethephon treatment. **Nomenclature**: AVG, aminoethoxyvinylglycine; AOA, aminooxyacetic acid: ethephon, (2-chloroethyl) phosphonic acid; STS, silver thiosulfate; geranium, *Pelargonium* x *hortorum* Bailey; snapdragon, *Anthirrinum majus* L.

Additional index words. aminoethoxyvinylglycine, aminooxyacetic acid, silver thiosulfate, postharvest physiology, cut flowers.

INTRODUCTION

Postharvest physiology of cut flowers and potted plants has been investigated to lengthen the time consumers may enjoy floricultural crops. Factors which reduce the keeping quality of cut flowers are physiological and microbial stem plugging, excessive desiccation, low respirable substrate, poor flower color stability, lack of control of flower opening and development, and ethylene injury (Mayak and Halevy, 1980).

Staby and Reid (1980) estimated that 30 percent of all floriculture crops die prematurely due to ethylene-induced disorders. Many flowers are adversely affected by endogenous as well as exogenous ethylene. Under some conditions plants may produce sufficient quantities of ethylene to induce senescence. Snapdragons abscise florets (Fischer, 1949) and hybrid geraniums dropped petals (Armitage et al.,

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1980; Miranda and Carlson, 1981) when exposed to ethylene.

Amrhein and Wenker (1979) reported that AVG (aminoethoxy vinyl glycine), AOA (aminooxyacetic acid), and similar analogs inhibit ethylene synthesis. The analogs are aminooxy-compounds similar to AOA and AVG (Amrhein and Wenker, 1979). Miranda and Carlson (1981) reported AVG to be effective in reducing petal drop in hybrid geraniums. The action of AVG is theorized to be the blockage of the ACC-producing enzyme which not only reduces ACC production but reduces the basic level of ethylene in the tissue (Butler et al., 1980). Inhibition by AOA has been shown to take place at the 1-amino-cyclopropane-1 carboxylic acid forming enzyme (Adams and Yang, 1977). A difference in the modes of action of the aminooxy-compound and silver has been noted by Brown and Mayak (1981). AOA inhibition of ethylene is reduced with time, and AOA must be provided on a constant basis to insure continued inhibition of ethylene synthesis. Such a response indicates that metabolism of the chemicals to an inactive state occurs in the plant. Such an inactivation does not take place when silver compounds are used. Harkema et al. (1991) has reported that only minor amounts of AOA appear in carnation (*Dianthus caryophyllus* L.) petals and AOA must be present in the petals to be effective. These workers suggested spray treatments rather than stem absorption treatments for effective action. Bureau and Drollard (1985) found that AOA treatment of carnation completely inhibited the burst of ethylene occurring after harvest and lowered phospholipids and fatty acid degradation (in particular unsaturated fatty acids: linoleic, linolenic, and oleic) associated with ethylene inhibition. AOA increased vase life and delayed loss of membrane integrity.

Silver nitrate has been used to reduce the effect of ethylene on carnations (Halvey and Kofranek, 1977), roses (Cho and Lee, 1979), geraniums (Miranda and Carlson, 1981), and other flowers (Veen, 1983). However, silver nitrate is not freely absorbed into plant tissue through the vascular system and causes unsightly spotting when applied as a spray. Veen and Van de Geijn (1978) showed that an anionic silver complex, silver thiosulfate (STS), could be freely absorbed through cut ends of carnation stems.

Butler et al. (1980) noted that with STS, silver accumulated in gynecia, ethylene synthesis decreased, and action of exogenous ethylene was inhibited. Beyer (1976) proposed that the mode of action of silver ion was inhibition of ethylene action rather than inhibition of ethylene production because the low concentration of ethylene during stages is not altered by STS treatment. STS has been found to inhibit ethylene action in carnations (Butler et al., 1980; Veen and Van de

Geijn, 1978), hybrid geraniums (Miranda and Carlson, 1981), and snapdragons (Nowak, 1981).

The objective of the current investigation was to compare the effect of three anti-ethylene compounds AVG, AOA, and STS on the reduction of induced abscission of geranium petals and snapdragon florets.

MATERIALS AND METHODS

Chemical reduction of induced petal abscission in geraniums. Seedling *P.* x *hortorum* Bailey 'Jackpot' flowers were harvested from outdoor grown plants on 14 Jul 1989. Individual, newly opened, florets were selected for uniformity and placed (one per vial) in 2-ml vials filled with various concentrations of AVG, and AOA, and STS solutions (Table I). CT 2000 (a commercial STS formulation manufactured by Smithers-Oasis, Co., Kent, OH) was used to make the STS solutions. Deionized water was used in each treatment formulation and also served as the control. Vials were completely randomized and held on a large sheet of foam plastic. Florets remained in these solutions in a room maintained at 24 C $\pm$ 1 for 12 hr under 0.43 to 1.25 klx irradiance. A 3.65- to 4.8-liter orifice mist blower was used to mist 2,000 ppm ethephon over the top of all florets at a rate of 5 ml per 1.5 m^2 after the 12-hr treatment in the various solutions. The number of florets abscised was determined before and after 24 hours ethephon application. A floret was considered abscised when one or more petals had fallen.

Extension of vase life and reduction of floret abscission of snapdragon. *A. majus* L. 'Houston' flowers were harvested on July 23, graded, S.A.F. fancy or better (Rogers, 1992) and placed in tap water for 1 hr before being placed in treatment solutions. Stems were cut to uniform 60-cm length, placed in 250-ml Erlenmeyer flasks (4 stems as an experimental unit) containing 200 ml of one of the following solutions: AOA at 0.1 mM, 1.0 mM, or 2.0 mM; 1.0 mM STS (from CT 2000); 0.03 mM STS (from Silflor 50, a commercial STS formulation, used as a pretreatment for carnations, manufactured by Floralife Inc., Buff Hill, IL); and deionized water control. Flowers were placed in these treatment solutions for 12 hr. The treatment solution was replaced with an induction solution consisting of 150 ppm ethephon; the induction treatment lasted for 24 hrs. This solution was then replaced with deionized water and changed daily for the remainder of the experiment. Flowers were evaluated daily and were considered unacceptable when foliage wilted, or when the first florets browned, abscised, or wilted. Percent flowering stems non-abscised was recorded when less than 5 florets on a stem remained turgid (after approximately one week).

Table I. Effect of anti-ethylene holding solutions on petal abscission of 'Jackpot' geranium induced with a 2,000 ppm ethephon spray.

Treatment[a]		Flowers per treatment: Number abscised	Flowers per treatment: Number non-abscised	Test $\chi 2$
Deionized water		16	0	
AVG		25	23	
AOA		30	33	
STS 1.0mM		31	32	15.29*[b]
0.0005 mM STS		12	4	
0.001 mM		4	12	
0.05 mM		6	9	
1.0 mM		9	7	8.84*
AVG	0.5 mM	10	6	
	1.0 mM	7	9	
	2.0 mM	8	8	1.17 N.S.
AOA	0.1 mM	11	5	
	0.5 mM	7	8	
	1.0 mM	6	10	
	1.5 mM	6	10	4.18 N.S.

[a]STS = silver thiosulfate, AVG = aminoethoxyvinylglycine, AOA = aminooxyacetic acid.

[b]* = Significant at 5% level.

Data were analyzed by contingency table analysis. Percentage data were transformed (arcsin or square root) and analyzed by analysis of variance and Duncan's multiple range test.

RESULTS AND DISCUSSION

Chemical reduction of premature petal abscission of geranium. Flowers pretreated in STS, AOA, and AVG solutions abscised less than the check flowers after ethephon spray treatment (Table I). Differences between treatment concentrations of AOA and AVG were not significant in this experiment. STS at solutions containing 0.01 mM were effective in reducing petal abscission. Staby and Reid (1980) reported that an effective range exists below which STS activity increases with concentration and above which life decreases with concentration due to phytotoxicity. Results of the present research agree with recent work by Miranda and Carlson (1981) which reported that STS and AVG effectively reduced abscission in geraniums. Veen (1983) noted that when STS is used as a spray on geraniums to inhibit petal drop, the quantity of chemical used is so small that the cost of a treatment is balanced by the benefits obtained. Our research also indicates AOA to be effective in reducing petal abscission.

Extension of vase life and reduction of floret abscission of 'Houston' snapdragons. The vase life of 'Houston' snapdragon was extended by pretreatment in 1.0 mM STS solution for 12 hr (Table II). Abscission of 'Houston' snapdragons was reduced by AOA concentrations above 1.0 mM and by 1.0 mM STS. However, STS gave the greatest improvement in vase life with no floret abscission. Florets died and dried on the stem in the STS treatments. Furthermore, no stem browning occurred with STS-treated stems but browning was present in all other treatments. Browning of the stems may indicate phytotoxicity.

Wang et al. (1977) documented that floret abscission in snapdragon is closely related to ethylene production, and that abscission was inhibited by rhizobitoxine analogs. The current research confirms the work of Nowak (1981) as to the effectiveness of STS inhibition of floret abscission and extension of vase life of snapdragons.

Vase life of snapdragons was unaffected by AOA, however AOA did reduce floret abscission (Table II). Nowak (1981) has reported increased longevity and quality with AOA pretreatments. Differences between our results and those of Nowak (1981) could be due to the differences in snapdragon cultivars, ethylene concentration, the addition of sucrose in the pretreatment solution, and longer pretreatment time (20 hr).

This study confirms that STS and AVG are effective in reducing petal abscission in geranium, however AOA also is effective. The application of AOA may be an alternative to the application of STS which may be prohibited in the future for environmental reasons. It's use as a spray on geraniums warrants investigation despite the relatively high cost (approximately $30 per gram). Floret abscission in snapdragon can be reduced by placing stems in either a STS or AOA solution for 12 hr. In addition to reducing floret abscission, STS prolonged the vase life of snapdragons.

Table II. Effect of pretreatment with anti-ethylene solutions on vase life and floret abscission of 'Houston' snapdragons treated with a 150 ppm ethephon solution for 24 hr.

Treatment[a]	Vase life	Mean abscised
	(Days)	
Deionized water	3.2 a[b]	48.4 a
AOA 0.1 mM	4.0 a	39.6 a
1.0 mM	3.9 a	10.0 bc
2.0 mM	4.0 a	8.2 c
STS 0.03 mM	4.0 a	25.8 ab
1.0 mM	7.1 b	0.0 c

[a]AOA = aminooxyacetic acid; STS = silver thiosulfate.
[b]Means in columns followed by different letters significant at 5% level, Duncan's new multiple range test using arcsin transforms.

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