Mobility and Effects on Vase Life of Silver-containing Compounds in Cut Rose Flowers

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Abstract. The effects of silver-containing compounds used for prolonging the vase life of cut rose (*Rosa hybrida* L. 'Asami Red') flowers were investigated. Silver nitrate and RNA-Ag+tris (a ribonucleic acid-silver complex and tris(hydroxymethyl)aminomethane) increased the vase life by 2.7 days and prevented bent neck of cut rose flowers compared with the control, whereas silver thiosulfate (STS) did not have a significant effect on longevity. Fresh weights of the rose stems pretreated with silver nitrate or RNA-Ag+tris were maintained along with longer vase life. There were higher amounts of Ag⁺ in the basal parts of the stem in these treatments compared with STS treatment. Bacterial count at the cut surface of stems treated with either silver nitrate or RNA-Ag+tris were lower than STS-treated or control stems. These results indicated that the primary effect of silver-containing compounds on 'Asami Red' roses was antimicrobial.

Vase life of cut rose flowers is often terminated by a type of stem wilting commonly called bent neck, where the stem wilts just below the flower head. The presence of microorganisms may plug the xylem of the cut stem (Van Doorn, 1997). Thus, numerous experiments have been conducted on the postharvest treatment of rose flowers with bactericidal metal salts, including silver nitrate and aluminum sulfate (Halevy and Mayak, 1981).

Silver ion has a bactericidal property as well as inhibitory effect on ethylene action (Nowak and Rudnicki, 1990). Silver ion has low mobility in carnation flowers, while its negatively charged thiosulfate complex is transported at the same speed as phosphate, $\approx 2 \text{ m} \cdot \text{h}^{-1}$ (Veen and van de Geijn, 1978). The mechanism of the effect of silver thiosulfate on the postharvest life of cut roses and its effect on ethylene action are still unclear (Lukaszewska et al., 1990; Reid et al., 1989).

Recutting the flower stem after transport is a common practice in marketing because it improves water uptake into stems after dry storage, which is a priority for successful vase life (Thompson and Staby, 1983). Recutting, however, may remove the active ingredients of some postharvest pretreatments, especially relatively immobile metal ions.

To our knowledge, neither the mobility of silver ion in cut rose flowers nor the effect of silver nitrate on the number of bacteria in the xylem has been reported.

This study was undertaken to measure the effect and mobility of several silver-containing compounds in cut rose stems as a basis for developing effective flower preservatives for use after stem recutting.

Materials and Methods

Cut rose 'Asami Red' (trade name: Rotte Rose) flowers were hydroponically grown in rockwool culture in a commercial greenhouse.

Table 1. Water uptake, vase life, and bent neck of cut 'Asami Red' rose flowers after pretreating with silver thiosulfate (STS), silver nitrate, or RNA-Ag+tris.

Treatment	Water uptake ^a (mL/stem)	Vase life (d)	Bent neck (%)
Water control	2.56	9.3 $\pm$ 0.46 ^b	100
STS	2.02	8.3 $\pm$ 1.00	100
Silver nitrate	2.13	12.0 $\pm$ 0.00	0
RNA-Ag+tris	2.56	12.0 $\pm$ 0.00	0

^aMeasured immediately after the pretreatment of 4 h.

^bStandard error (n = 10).

Fig. 1. Bacterial count in the basal 1 cm of 'Asami Red' rose stems 9 d after pretreatment with STS, silver nitrate, or RNA-Ag+tris.

After harvest, the flowers were immediately transported dry to our laboratory and trimmed to 60 cm. Leaves on the lower 15-cm section of the stem were removed to minimize vase water contamination.

After a 4-h pulse with either silver thiosulfate (STS), silver nitrate, or RNA-Ag+tris (Meiji Milk Co., Odawara City, Japan), each with 0.075 mM Ag, the stems were rinsed and placed in tap water, boxed, and stored dry at 5 °C for 24 h to simulate transport, and recut and placed in tap water for determination of vase life. Vase life was defined as the days from the end of simulated transport to loss of ornamental value caused by bent neck, blueing, and/or abscission of petals. Uptake of vase solution was measured daily by weighing the vase solution and cut flower separately.

The number of bacteria in stem segments was determined after 8 d of vase life. Stem segments were surface sterilized with 95% ethanol, the epidermis and bark aseptically removed, and the segments cut into 1-cm pieces and placed in 20 mL of sterilized water with 0.05% (v/v) Tween 80 (polyoxyethylene monooleate; Sigma Chemical Co., St. Louis). Segments in water were spun in a vortex mixer for 3 min. Samples of this solution were diluted, placed on Plate Count Agar (Difco Laboratories, Detroit), and the number of colony-forming units (cfu) was counted after 48 h of incubation at 28 °C. Concentration of silver in each cut segment of the stem was determined using an atomic absorption spectrophotometer (Hitachi Z-6000, Tokyo) after ashing a dry sample of the stems at 400 °C for 15 h and extracting the silver with dilute HNO₃.

All experiments were performed in a controlled environment at 20 $\pm$ 2 °C and 40% to

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70% relative humidity, with 24-h lighting from cool-white fluorescent tubes providing photosynthetically active radiation of $4.5 \pm 1.5 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ at flower height.

Results and Discussion

Water uptake during the pretreatment periods was not significantly affected by the silver-containing compounds (Table 1). Both silver nitrate and RNA-Ag+tris increased by 30%. Flowers pretreated with silver nitrate or RNA-Ag+tris never had bent neck and had a long vase life, while all STS-treated and control flowers had bent neck and a short vase life (Table 1).

The bacterial count in the basal stem of control or STS-treated flowers was >100 times as great as that in silver nitrate or RNA-Ag+tris-treated flowers (Fig. 1). After pretreating with silver nitrate or RNA-Ag+tris, most silver was found in the basal 0–5 cm of the stems, whereas in stems pretreated with STS, a negligible amount of silver was detected in the basal segments (Fig. 2). Since silver concentration and water uptake were the same among treatments, this might result from differences in mobility among silver-containing compounds.

The distribution of silver suggests that little silver remains in or on the stem when the lower stem is recut during postharvest handling. Restricted distribution may explain why silver nitrate is rarely used as a commercial treatment for cut roses. Our results substantiate that vase life of cut roses is prolonged by the presence of silver in the basal 5 cm of the

stem. Silver undoubtedly affects vase life not by its ethylene-inhibiting action, but by its bactericidal property in this cultivar.

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Fig. 2. Distribution of silver in cut 'Asami Red' roses after pretreating with STS, silver nitrate, or RNA-Ag+tris for 4 h. Stem segment values are given as distance from the cut surface.