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Pulse Treatment with Silver Nitrate Extends Vase Life of Anthuriums[1]

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Abstract. **Short pretreatments of stems of anthurium flowers (*Anthurium andraeanum* André) with silver nitrate solutions increased vase life by 40 to 60% after a simulated shipping. Significant improvement was obtained with a single 10-minute treatment with 1 mM silver nitrate. Maximum postharvest life was obtained with flowers treated with silver nitrate within 12 hours of harvest. Silver nitrate treatment was effective on flowers ranging from half to full maturity. No measurable silver was translocated to the spathe or spadix. Silver thiosulfate complex was not as effective as silver nitrate. For response to silver treatment following simulated shipping of 3 days, 2 cm of stem had to be removed before placing in a vase solution. Continuous maintenance of the flower before and after simulated shipping in a commercial preservative was not significantly better than a single pulse with silver nitrate or a combination of silver nitrate pulse and commercial preservative.**

Senescence of cut anthurium flowers is expressed as spadix browning and necrosis, spathe blueing, and loss of spathe gloss (6). The life of anthurium flowers is apparently limited by the development of a water deficit (10). Watson and Shirakawa (10) suggested that the spadix was the major site of water loss, which could be reduced by spadix waxing. A loss of 1% fresh weight resulted in a loss of spathe gloss (6). Late in anthurium senescence, spathe and spadix abscission occurs.

Silver nitrate and silver acetate are effective bactericides used in preservative solutions (1). Silver ion is also an effective antiethylene agent (2). Since silver nitrate is relatively immobile in carnation stems (5), silver nitrate could extend postharvest vase life by reducing bacterial stem blockage and by acting as an antiethylene agent in the wound response at the cut stem where mobility might not be required.

The objective of this study was to develop silver treatments which would extend vase life in a simulated shipping treatment. Vase life extension due to silver ion was compared to continuous treatment with a low concentration of ethanol, cobalt, and a commercial preservative.

Materials and Methods

'Ozaki Red' anthurium flowers were obtained from commercial nurseries on the island of Hawaii. Flowers were harvested in the morning and received at the laboratory that afternoon. Two centimeters of flower stem were removed before treatment began. Flowers were at least 3/4 mature (6), and ones showing spathe damage were discarded.

Flower vase life was evaluated daily. Spadix senescence (necrosis) was ranked on a 1 to 5 good-to-bad scale; spathe blueing on a 1 to 4 scale, 0% to 100% blueing; and spathe condition on a 1 to 4 scale, no loss to full gloss loss and wilting. Flowers were discarded if they had a 4 for spadix senescence, 3 for spathe color, or 4 for spathe condition. Ten or 12 flowers were used in each treatment, and they were evaluated individually.

Stems were pulse-treated for 10 to 60 min in silver nitrate solutions ranging in concentration from 1 to 10 mM. Silver thiosulfate complex was prepared and used as described by Reid et al. (7). After silver treatment, the stems were rinsed with deionized water. In the simulated shipping tests, flowers were packed in moistened, shredded newspaper in standard boxes with a plastic liner. The packed boxes were held at 22°C unless otherwise specified. Upon unpacking, 2 cm of stem was removed

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in the air and flowers were immediately placed in a filled 1-liter conical flask containing either deionized water or a commercial preservative (Floralife) made up in deionized water. Solutions were replenished every 2 to 3 days. The flowers were kept at 22°, 70–80% relative humidity, estimated air movement of 1.18 liters/sec, and a 10- to 12-hr mix of indirect sunlight and fluorescent light (ca. 10 watt/m^2).

Silver uptake was determined on stem, spathe, and spadix tissues which were dried and dry-ashed (500°C) overnight before silver was determined by atomic absorption spectroscopy.

Results

Postharvest holding solution treatment. Effects of various postharvest holding solutions on total anthurium vase life are shown in Table 1. A single pulse treatment with silver nitrate and silver thiosulfate complex increased postharvest life at least 40%. Maintaining the flower stem in solution of the commercial preservative (Floralife) was not significantly different from the silver nitrate pulse treatment or continuously holding in 1.5 mM cobalt chloride. Ethanol (2% v/v) in the vase solution increased total vase life. Floralife, $CoCl_2$, and ethanol were not pulsed.

Silver treatment time and concentration. The mean vase life of flowers treated with different silver nitrate concentrations for different pulse times is shown in Fig. 1. Treatment of 10 min in 1 mM silver nitrate significantly improved vase life. Cutting of the flower stems after the simulated shipping period was essential for both untreated and silver nitrate-treated flowers for maximum vase life (Table 2). Cutting of the stem in air gave best results. Cutting stem under water at 22° or 36°C was less effective.

Flower maturity and response to silver treatment. Flowers pulsed with silver nitrate or maintained continuously in commercial preservative had significantly longer vase life than control flowers, irrespective of flower maturity (Table 3). The more mature the flower at harvest, the longer the postharvest life, with silver nitrate being more effective with the more mature flowers. Pulsing in silver thiosulfate complex was less effective than pulsing in silver nitrate or keeping flowers continuously in commercial preservative.

Postharvest time before silver treatment. Treatment of the flower stems within 11 hr from harvest was required for maximum flower life (Table 4). All silver nitrate treatments significantly increased vase life over the untreated control.

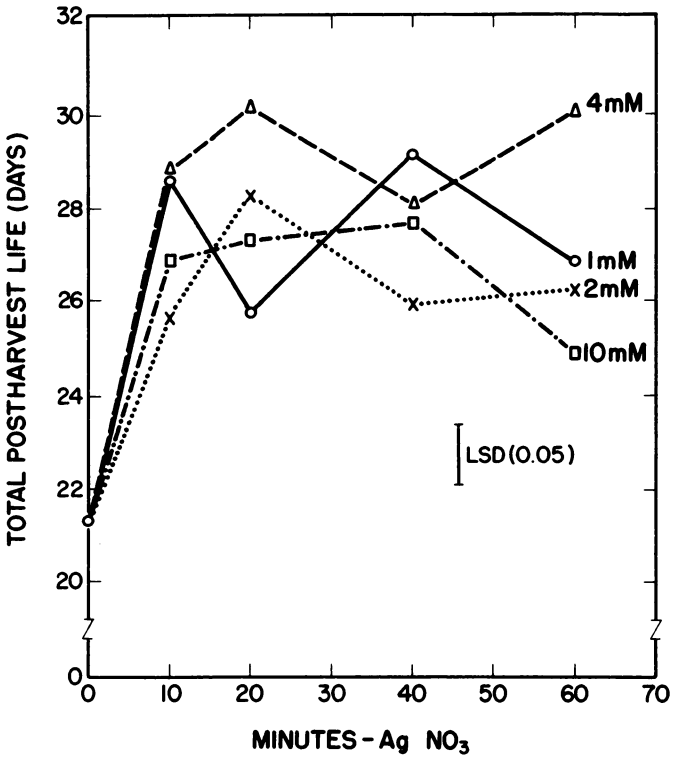

Fig. 1. Relationship between flower longevity and silver nitrate pulse time and concentration. Flowers were treated within 12 hours of harvest, held overnight in deionized water, and packed for 3 days. Two cm of stem was then removed, and flowers were placed in deionized water vase solutions.

Silver nitrate mobility in flower stems. No silver movement to the spathe was detected and little movement in the stem was indicated (Table 5) when pulsed with silver nitrate.

Discussion

Anthurium flower longevity can be extended by a 10-min pulse with 1 mM silver nitrate. Although there was no significant improvement in longevity with higher concentrations or longer times (Fig. 1), treatment of 40 min and 4 mM was used routinely, to insure that all flowers received an adequate treatment. There was no evidence of phytotoxicity in any test. Considerable variation was found in total postharvest life between different batches of flowers, ranging from a low of 7 days (Table 2) to a high of

Table 1. Effects of various postharvest holding solution treatments on total anthurium vase life.

Treatment	Total[z] vase life (days)
Control—DI water	7.25 g[x]
Control—3 day pack → DI water	13.25 f
$AgNO_3$ → 3 day pack → DI water[y]	21.5 bcd
$Ag(S_2O_3)_2^{3-}$ → 3 day pack → DI water[y]	18.5 de
$AgNO_3$ → 3 day pack → Floralife (20 g/liter)	21.88 abc
Floralife 20 g/liter → 3 day pack → Floralife	23.0 ab
2% ETOH → 3 day pack → 2% ETOH	16.75 e
1.5 mM $CoCl_2$ → 3 day pack → 1.5 mM $CoCl_2$	24.75 a

[z]Total vase life includes the overnight period in solution after harvest and the 3 days in the pack.
[y]$AgNO_3$ and $Ag(S_2O_3)_2^{3-}$ both pulsed 40 min, 4 mM.
[x]Mean separation by Duncan-Waller multiple range test, 5% level.

Table 2. Effects of various cutting procedures on total flower life after 3 days of packaging.[z]

Treatment	Total life (days) Control	$AgNO_3$[y]
Control deionized water	7.3 d[x]	---
Packed 3 days → no cutting	7.9 d	8.6 d
→ cut 2 cm under (22°C) DI[w] water[w]	13.3 c	21.5 a
→ cut 2 cm in air, place DI water	17.4 b	22.3 a
→ cut 2 cm under 36°C DI water, allowed to cool	14.1 c	17.3 b

[z]Flowers were harvested, treated with Ag^+ if required, held overnight in deionized water, packed with moistened newspaper 3 days, unpacked, and placed in deionized water.
[y]Pulsed 40 min, 4 mM Ag within 12 hr of harvest.
[x]Mean separation within and between columns by Duncan-Waller multiple range test, 5% level.
[w]DI water, deionized water.

Table 3. Effects of flower maturity and postharvest treatment on vase life.

Treatment	Total vase life (days)[z]		
	1/2 Mature[y]	3/4 Mature	Mature
Control DI water	38.5 i[x]	39.2 i	43.8 f
Tap water	41.7 fgh	38.8 i	42.0 fg
$AgNO_3$ (4 mM, 40 min)	50.5 de	53.3 bc	64.3 a
$Ag(S_2O_3)_2^{3-}$ (4 mM, 40 min)	40.5 ghi	48.3 e	48.3 e
Floralife (20 g/liter)	51.8 cd	54.3 bc	55.1 b

[z]Flowers were treated within 8 hr of harvest. Two cm of stem was removed before treatment or placing in vase solution. Flowers were held continuously in Floralife or deionized water after silver treatments.
[x]Mean separation within and between columns by Duncan-Waller multiple range test, 5% level.
[y]Flower maturity as the percentage of total length of spadix having open floret (6): 1/2 mature, 53%; 3/4 mature, 84%; mature, 95%.

Table 5. Silver concentration in stem and spathe of anthurium flowers following a pulse treatment of 40 min with 4 mM $AgNO_3$.

Samples	Silver concentration (μg/g dry wt)		
	Base of stem[z] 0–5 cm	Middle of stem 14–19 cm	Spathe
Immediately after treatment:			
Control	<0.5[y]	<0.5	<0.5
$AgNO_3$	83	2	<0.5
After 5 days in deionized water:			
Control	<0.5	<0.5	<0.5
$AgNO_3$	80.5	1.5	<0.5
After 10 days in deionized water:			
Control	<0.5	<0.5	<0.5
$AgNO_3$	78	2	<0.5

[z]All flower stems were trimmed to 35 cm before treatment (4 flowers per treatment).
[y]Limit of sensitivity ca. 0.5 μg/g dry wt.

44 days (Table 3) for untreated flowers. The avererage life was about 20 days. This variation was presumably a reflection of differences in flower quality due to preharvest conditions, since different flower batches were obtained from different growers and at different times of the year. Irrespective of the intrinsic postharvest flower longevity, silver nitrate treatment significantly increased this life.

Silver thiosulfate complex treatment of carnations significantly increased postharvest life, whereas pulsing with silver nitrate was ineffective (7). Silver ion is relatively immobile in stems (Table 5) unless in a complexed form, such as the thiosulfate complex (8). The failure of the silver thiosulfate complex to increase anthurium flower longevity more than the nitrate form indicates a different mode of action. The advantage of silver nitrate was not lost when 2 cm of stem was removed (Table 2). In fact, failure to recut after silver nitrate treatment and packing for 3 days eliminated a silver response. The site of silver action was probably at or near the cut flower stem.

Low concentrations of ethanol (2% v/v) in the vase solution significantly increased total vase life (Table 1). A similar response in carnations was associated with inhibition of ethylene synthesis (4). The improvement in vase life by cobalt chloride (Table 1) might be due to its suppression of microbial growth (9). In anthurium, therefore, silver could be acting both as an antimicrobial agent (1) inside the cut stem end and by reducing ethylene-related wound responses (3) which could lead to blockage of the water-conducting tissue. The fact that untreated flowers cut under water had a shorter life than those cut in air (Table 1) could be due to the sweeping of microbial contamination into the conducting tissue with the water or the presence of air limiting the amount of wound clogging of the water-conducting tissue. This limitation of damage to water-conducting tissue by cutting in air agreed with the common finding that flowers stored at room temperature had a longer postharvest life than those held continuously in deionized water. Work is underway to utilize dry storage as a method to extend postharvest life allowing surface shipment.

Table 4. Influence of time of silver nitrate treatment (4 mM, 40 min) after harvest on vase life of anthurium flowers.

Treatment	Total life from harvest (days)[z]
Control—deionized water	13.3 d[y]
$AgNO_3$ treatment, 4 hr after harvest	23.5 a
11 hr after harvest	22.7 a
16 hr after harvest	18.0 b
24 hr after harvest	15.4 bc
After 3 days packed	16.8 c

[z]Flowers were held before and after silver nitrate treatment in deionized water for 24 hr after harvest, packed for 3 days, and then placed in deionized water.
[y]Mean separation by Duncan-Waller multiple range test, 5% level.

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