Reduction of Postproduction Quality Loss in Potted Miniature Roses

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Abstract. Potted miniature roses (*Rosa* × *hybrida* L. 'Belle Sunblaze') held after production in simulated home conditions (21C, continuous fluorescent light) yellowed prematurely, flower buds and leaves abscised, and flower buds failed to open. These symptoms were accelerated when the plants were exposed to low concentrations (1 µl-liter⁻¹) of ethylene in the absence of inhibitors. Spray application of 100 µl BA/liter reduced leaf yellowing but had no significant effect on flower opening or bud abscission. Spray application of 1 mM silver thiosulfate (STS) strongly promoted flower display but did not prevent leaf yellowing. A combined BA and STS treatment greatly improved the postproduction quality of rose plants, particularly if applied 1 day before harvest. Chemical name used: benzyladenine (BA).

Potted miniature roses, once mainly produced for Mother's Day and Easter, are becoming a popular year-round potted plant. New cultivars having a wider range of colors and other improved characteristics have led to increased consumer demand. Even these new cultivars, however, have a short life under the warm, low-light conditions of the home. Under these conditions, the leaves of potted roses yellow and abscise and flower buds fail to open. Halevy and Kofranek (1976) showed that the cytokinin 6-(benzylamino)-9-(2-tetrahydropyryl)-9 *H*-purine (PBA) greatly reduced leaf abscission and senescence, and prevented bud drop in three potted rose cultivars. Later, Clark and Kelly (1991) showed that the cytokinins BA and trans-zeatin reduced leaf chlorosis on several newer rose cultivars.

Ethylene has been implicated as an important agent in reducing quality in many ornamentals, including potted flowering plants (Moe and Fjeld, 1985) and cut roses (Reid et al., 1989). Applying silver thiosulfate (STS) reduced the effects of exogenous ethylene and of enhanced endogenous ethylene production from environmental stresses in species such as *Pelargonium*, *Schlumbergera*, *Streptocarpus*, *Impatiens*, and *Zygocactus* (Agnew et al., 1985; Cameron and Reid, 1981, 1983). Flower bud abscission and lack of bud opening typical of potted roses in a home environment suggest an ethylene effect. We report here the reaction of some new potted miniature rose cultivars to postproduction stresses, and the effect of cyto-

kinin, ethylene, and STS applications on those reactions.

Materials and Methods

Potted (378-cm³, 10-cm-diameter pot) 'Orange Meilandina', 'Belle Sunblaze', 'Scarlet', and 'American Independence' miniature roses were produced under commercial conditions. At various times before normal harvest, uniform plants were sprayed to runoff with solutions containing various concentrations of BA, the anionic STS complex prepared as described by Reid and Farnham (1980), or both. All spray solutions, including the water control, contained 1.9% ethanol (used to solubilize the BA) and 0.4% of the sticker/spreader Nufilm P (Miller Chemical and Fertilizer Corp., Hanover, Pa.).

Treated plants were sleeved on the normal harvest date, boxed, and held for 4 days at 4C to simulate normal commercial handling. They then were placed in a simulated home environment [21 ± 1C, continuous light from cool-white fluorescent lights (3 µmol·s⁻¹·m⁻²)]. Every 2 days, quality changes were recorded, including leaf yellowing (i.e., all leaflets in the compound leaf showed some yellowing), flower buds showing petal color, number of open flowers (i.e., at least one petal reflexed perpendicular to the pedicel), and number of healthy and yellowed flower buds.

Immediately after applying growth regulators, four plants of each treatment were sleeved, boxed, and transported to Davis, Calif., where they were placed in the greenhouse for 2 days so that they reached normal harvest maturity. Plants then were placed in fish tanks ventilated with a flowing air stream (32 liters·h⁻¹) containing 1 µl ethylene/liter. After 4 days, leaf yellowing and petal, bud, and flower abscission were scored using hedonic scales: 0–5 (dark green to completely yellow) and 0–3 (no abscission to complete abscission), respectively.

Each treatment was replicated five to six times (a replicate was a single potted plant).

The plants were placed in a randomized complete block design when evaluated in simulated home conditions. Analysis of variance was performed on square-root-transformed data to homogenize mean variances. Orthogonal contrasts were separated at *P* ≤ 0.05, 0.01, and 0.001. Data presented in Fig. 1 were back-transformed.

Results and Discussion

In preliminary experiments, the response of four cultivars to the interior environment was tested. All showed substantial leaf and bud yellowing 2 weeks after harvest, but 'American Independence' and 'Scarlet' developed the symptoms more slowly than 'Orange Meilandina' or 'Belle Sunblaze' (Table 1). The response of 'Orange Meilandina' to BA and to various STS concentrations was then tested. Plants sprayed with 2 and 4 mM STS developed necrotic leaf spots and bleached petals, which indicates that these concentrations were phytotoxic. BA application reduced leaf senescence, and the STS spray promoted the longevity of flower buds and open flowers (data not shown).

BA (100 µl-liter⁻¹) and STS (1 mM) were applied alone or in combination to 'Belle Sunblaze' 1 day before harvest. In the interior environment, the plants rapidly lost display quality as measured by the percentage of healthy open flowers and flower buds (Fig. 1A and Table 2) and cumulative number of yellowed leaves (Fig. 1B and Table 2). In addition to these major effects, there were also more subtle effects on flower size and color. Flowers that opened in the interior environment tended to be paler and smaller than those that opened in the greenhouse. This difference may reflect the poor carbohydrate status of plants growing below the photosynthetic compensation point of 30 to 65 µmol·s⁻¹·m⁻² (Jiao et al., 1988).

Halevy and Kofranek (1976) demonstrated that applying cytokinins reduced post-production leaf yellowing in potted miniature roses;

Table 1. Effect of 7 and 14 days of simulated home conditions on leaf yellowing and flower yellowing and abscission of four potted miniature rose cultivars (21C, continuous fluorescent light).

Cultivar	Holding duration (days) ^{2,3}	
	7	14
<i>Leaf yellowing</i>		
Orange Meilandina	3.1 a	4.2 a
Sunblaze	2.8 a	3.7 a
Scarlet	1.1 b	2.4 b
American Independence	0.9 b	2.2 b
<i>Flower yellowing and abscission</i>		
Orange Meilandina	2.3 a	3.0 a
Sunblaze	2.1 a	3.0 a
Scarlet	0.2 b	1.1 b
American Independence	0.4 b	1.7 b

¹Leaf yellowing and flower yellowing and abscission rated using hedonic scales: 0–5 (dark green to completely yellow) and 0–3 (no yellowing or abscission to complete yellowing or abscission), respectively.

²Mean separation in columns by Duncan's multiple range test, *P* ≤ 0.05.

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Fig. 1. Effect of BA and silver thiosulfate (STS) on (A) percent healthy flowers and flower buds and (B) leaf yellowing on potted *Rosa x hybrida* 'Sunblaze'.

Table 2. Statistical analysis of the effect of BA and silver thiosulfate (STS) on percent healthy flowers and flower buds and on the number of cumulative yellow leaves at a given day after treatment.

Comparison	Days after treatment											
	2	4	6	8	10	12	14	16	18	20	22	24
<i>Healthy flowers and flower buds (%)</i>												
BA vs. none	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS
STS vs. none	NS	NS	*	**	***	***	***	***	*	*	NS	NS
BA x STS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	NS	NS
<i>Cumulative yellow leaves</i>												
BA vs. none	NS	NS	NS	NS	*	**	**	**	***	***	***	**
STS vs. none	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BA x STS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS, *, **, *** Contrast at given date nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

this also was true for 'Sunblaze'. Applying BA ($100 \mu\text{l-liter}^{-1}$) 1 day before harvest dramatically reduced the development of leaf yellowing (Fig. 1B and Table 2). In 'Sunblaze', however, cytokinin application only slightly reduced bud quality and increased flower longevity (Fig. 1A and Table 2).

Leaf yellowing and flower bud abscission was greatly accelerated by exposing plants to ethylene in the absence of STS or BA + STS (Table 3). Depending on the cultivar, ethylene exposure can inhibit, accelerate, or modify flower opening in cut roses (Reid et al., 1989). Faragher and Mayak (1984) and Mor et al. (1989) have shown that cut roses produce substantial amounts of ethylene in response to stresses such as cold storage and ultraviolet irradiation. These considerations suggested that the deleterious effects of the interior environments on quality loss of potted roses might also be mediated by ethylene.

The modest effect of STS on leaf yellowing in the absence of exogenous ethylene (Fig. 1B and Table 2) suggested that leaf yellowing under simulated home conditions was largely due to factors other than stress-induced ethylene. Studies with an ethylene-resistant *Arabidopsis* mutant have shown that leaf yellowing can be rapid in the absence of ethylene

effects (Zacarias and Reid, 1990). STS application had pronounced effects on the health and development of flower buds and flowers (Fig. 1A and Table 2). Of particular interest was the observation that flower buds continued to develop color in STS-sprayed plants, even at the end of their useful display life. This result is consistent with the observation that low concentrations of ethylene prevent buds from opening in some rose cultivars (Reid et al., 1989).

The STS + BA treatment had a prolonged and significant effect on flower and leaf quality (Fig. 1 and Table 2). There was no positive interaction of the combined STS and BA treatments, except for a minor effect on flowers on day 20—the end of the plant's display life (Fig. 1A and Table 2). The STS and BA effects appear to be independent of each other, at least during the first 2 weeks of display life. This combined treatment could provide a practical means for preventing quality loss in miniature roses in the home. Applications made 1 week before harvest were less effective than those made 1 day before harvest (data not shown). Therefore, plants in production should be sprayed 1 day before harvest, allowed to dry, and packed the following day.

Halevy and Kofranek (1976) cited differ-

Table 3. Effect of BA and silver thiosulfate (STS) on plants in a $1\text{-}\mu\text{l}$ ethylene/liter atmosphere after 4 days at 21°C .

Chemical	Characteristic	
	Leaf yellowing ^{a,y}	Flower abscission ^y
None	4.75 a	3.25 a
BA	4.25 a	2.75 a
STS	2.75 b	1.75 b
BA + STS	1.75 c	0.25 c

^aMean separation in columns by Duncan's multiple range test, $P \leq 0.05$.

^yLeaf yellowing and abscission were scored using hedonic scales: 0-5 (dark green to completely yellow) and 0-3 (no abscission to complete abscission), respectively.

ences in cultivar response to home conditions and suggested selecting cultivars that thrive under low light. The pronounced response of miniature rose cultivars to exogenous ethylene (Table 3) may provide a tool for breeders to screen plants rapidly so that future selections perform better than those that are presently being released.

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