

Postharvest Control of Botrytis Rot of Roses with Carbon Dioxide

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ABSTRACT

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Botrytis flower rot was reduced, flower quality improved, and vase life lengthened by holding cut flowers of the rose cultivars Samantha, Royal Red, Pauls Pink, and Bettina in 10, 20, or 30% CO₂ at 10–12 C for 6 days. The results suggest a greater control of Botrytis rot than would result from a simple inhibition of the pathogen by CO₂.

Additional key words: *Botrytis cinerea*

Botrytis cinerea Pers. causes a rot of rose flowers during periods of high humidity or rain coupled with temperatures lower than 21 C (1,2,4,8). Symptoms may occur before or after harvest and begin as small circular spots on the petals (white on red petals or light brown on white petals). Advanced decay is brown and soft with a characteristic gray mold formed on the rotting surface.

High CO₂, although effective in reducing growth of *Botrytis* in other crops (5,14,18), has not been considered acceptable for use on stored cut flowers in general (12,13); it also may cause bluing of red roses (16). However, exposure of roses to CO₂ at 10–15 C is reported to maintain or extend the life of rose flowers compared with storage without CO₂ (17). Early results of our study indicated that postharvest use of CO₂ may be useful to control Botrytis rot of roses (9). Roses commonly are held at about 10 C during transportation to market (10,11). Consequently, we investigated the use of CO₂ to control postharvest Botrytis rot of roses at this temperature.

MATERIALS AND METHODS

We used rose (*Rosa* sp.) cultivar Samantha (red) in two tests and Royal Red (red), Pauls Pink (pink), and Bettina (orange) in three tests. In all tests, freshly harvested roses were placed in water and held at 10–12 C in sealed chambers with air or air with 10, 20, or 30% CO₂.

Four bunches per atmosphere (25 flowers per bunch) of Samantha or two bunches per atmosphere for the other

cultivars were held in water for 6 days in sealed chambers for each test. The chambers were opened after 3 days, and 10 flowers from each bunch were rated for Botrytis rot, quality, and color. After inspection, all flowers were returned to the chambers, the chambers were closed, and the CO₂ levels reestablished. The roses were reexamined and rated after an additional 3 days of treatment. No visible color differences related to the treatments were observed after 6 days of treatment and thus are not reported. Vase life was determined after the second evaluation. In two of the tests, one bunch of each cultivar was also held at 2.5 C for 6 days, and vase life was determined.

To evaluate vase life, flowers for the first series of tests using Samantha roses were placed in fresh water and held at room temperature and humidity. Because of variation between replicates and the odor of bacteria in the vases containing water, flowers in all other tests were held in a 9-g/L solution of Floralife preservative (Floralife, Inc., Chicago, IL) to determine the vase life. The vase life of the flowers was determined by recording daily the number of rotting, off-color, or otherwise unsuitable flowers. The mean vase life for each treatment is reported.

The concentration of CO₂ was analyzed with a CO₂ analyzer (Thermco Instrument Co., La Porte, IN) when each atmosphere was established and just before the chambers were opened. The CO₂ content of the chambers to which no CO₂ was added ranged from 2 to 4% after 3 days. This CO₂ accumulation resulted from respiration of the roses while in the sealed chambers. The CO₂ content in the 10, 20, or 30% CO₂ chambers changed little ($\pm 2\%$) during the tests.

Botrytis rot was rated on a scale of 1–10, where 1 = no rot; 2 = one spot on any petal not larger than 0.5 mm; 4 = less than 5% rot, rot in spots smaller than 5 mm but larger than 0.5 mm; 6 = less than 5% rot, rot in spots on any petal larger

than 5 mm; 8 = 5–20% of the flower rotting; and 10 = 20–100% of the flower rotting. Flower quality was rated on a scale of 2–10, where 2 = 20–90% of the flower showing severe damage, 4 = 10–20% of the flower showing severe damage, 6 = 0.5–10% of the flower showing severe damage, 8 = slight damage of any kind, and 10 = perfect.

RESULTS

In all tests, addition of CO₂ to the storage container significantly reduced the severity of Botrytis rot and improved the quality and vase life of the roses compared with flowers held without elevated CO₂ (Table 1, Fig. 1). Consistent significant differences ($P = 0.05$) in flower quality and Botrytis decay occurred when the flowers were held at high CO₂ levels. Quality evaluation was influenced by the rot, and in both rot and quality ratings, the differences among tests appeared to reflect variation caused by growing conditions before harvest. Significant differences found in one test for a specific cultivar were not consistent.

When variation caused by bacterial growth in the vase was reduced by the use of Floralife, the vase life increased consistently with the level of CO₂ during storage (Table 1). Roses of three cultivars held in 30% CO₂ in the later tests had a vase life of 6 days, which was similar to that for roses held 6 days at 2.5 C.

In the final two tests, we included roses that had been inoculated by spraying the flowers of each of the three cultivars with a spore suspension of *B. cinerea*. These roses were held in air or 30% CO₂. After 6 days, petals from 10 inoculated and uninoculated flowers per cultivar in the two tests were plated onto potato-dextrose agar. *B. cinerea* was recovered from 79% of the inoculated flowers held without added CO₂ but from only 13% of those held with 30% CO₂. *B. cinerea* was recovered from 62% of the uninoculated flowers held without added CO₂ and from 7% of those held with 30% CO₂.

DISCUSSION

According to our results, the postharvest application of CO₂ may be useful on some rose cultivars to control Botrytis flower rot. Some cultivars not tested may be more sensitive to CO₂ than those we tested; therefore, each one should be carefully evaluated for tolerance to CO₂. The higher than normal storage temper-

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Table 1. Effect of adding CO₂ to storage atmosphere on quality of roses held at 10–12 C for 3 or 6 days

Time of examination and quality criteria	Tests with Samantha ^a (% CO ₂)				Tests with three cultivars ^b (% CO ₂)			
	0	10	20	30	0	10	20	30
	After 3 days							
Botrytis rot (rating) ^c	3.2 ^d	2.9	1.8	1.7	2.2	1.8	1.4	1.2
Flower quality (rating) ^e	7.6	7.6	7.8	7.9	8.4	8.5	8.6	8.7
After 6 days								
Botrytis rot (rating) ^c	4.4	2.8	1.5	1.6	4.3	2.6	1.7	1.3
Flower quality (rating) ^e	7.6	7.7	8.0	7.3	7.5	8.3	8.5	8.6
Flower vase life (days) ^f	6.2	8.4	7.7	6.6	3.8	4.7	5.8	6.1

^a Results of two tests; each datum represents the mean of eight replicated samples.

^b Results of three tests; each datum represents the mean of 18 replicated samples, six per cultivar.

^c Botrytis rot rating on a scale of 1–10, where 1 = no rot; 2 = one spot on any petal not larger than 0.5 mm; 4 = less than 5% rot, rot in spots smaller than 5 mm but larger than 0.5 mm; 6 = less than 5% rot, rot in spots on any petal larger than 5 mm; 8 = 5–20% of the flower rotting; and 10 = 20–100% of the flower rotting. Mean of 10 flowers per replicate.

^d Standard analysis of CO₂ as a continuous variable showed groups of data (shown in italic) significantly ($P = 0.05$) affected by CO₂.

^e Flower quality rating on a scale of 2–10, where 2 = 20–90% of the flower showing severe damage, 4 = 10–20% of the flower showing severe damage, 6 = 0.5–10% of the flower showing severe damage, 8 = slight damage of any kind, and 10 = perfect. Mean of 10 flowers per replicate.

^f Sum of days of life for each flower divided by the number of flowers (20 per replicate).

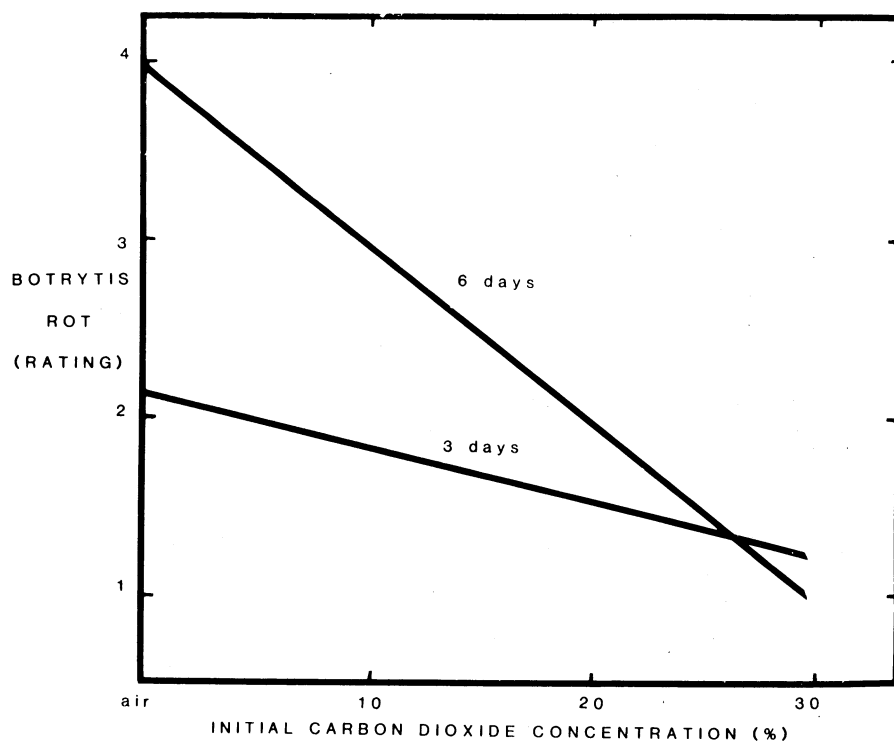


Fig. 1. Effect of CO₂ concentration in the atmosphere on Botrytis rot of cut rose flowers stored at 10–12 C. Rating scale for rot: 1 = no rot, 2 = lesion smaller than 0.5 mm, and 4 = lesion 0.5–5 mm.

ature used in these tests may influence phytotoxicity, and CO₂ may not provide effective Botrytis rot control when cold temperature is required to maintain flower quality.

The longer vase life and the reduced recovery of the pathogen suggest that CO₂, or some factor associated with the CO₂ treatment, affected control to a greater degree than would be expected from a simple inhibition of the pathogen. CO₂ is usually considered inhibitory but not lethal to *B. cinerea* (15,20). The chambers used in this study were sealed

during treatment, but some gases other than CO₂ could accumulate and influence the results (6). Other factors that could contribute to control would include a variation in water activity associated with the controlled atmosphere, stimulation of microorganisms antagonistic to *B. cinerea* (19), or an enhancement of a host defense mechanism (3,7). Further study is needed to evaluate the mechanism and nature of the control achieved by the use of CO₂ in this study before practical broad use of CO₂ on rose flowers can be recommended.

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