Pulsing with Fresco or commercial preservatives lengthened vase life and reduced leaf chlorosis of cut lilies and gladiolus

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Lilies and gladioli are among the most important cut flowers grown throughout the world. However, leaf chlorosis is a major postharvest disorder that can limit their vase life. The chlorosis starts on lower leaves and proceeds upwards, reducing stem quality and causing early senescence. This problem is accentuated by shipping or cold storage, resulting in early leaf wilting or abscission (Han, 2001). But storage or shipping at low temperatures is necessary for transportation and marketing of cut stems to distant markets. Fluctuations in temperature during shipping/ storage or transit time greatly affect cut lilies and loss of quality starts quickly when stems are placed the retail or consumer environment after transit/storage. Additionally, cultivars vary in exhibiting leaf chlorosis symptoms (Leonard et al., 1998).

Although several studies on use of different concentrations and application methods of gibberellins and cytokinin have been conducted on cut lilies to control leaf chlorosis, limited information has been reported on pulsing at low concentrations under low temperature used commercially for transportation or storage of cut lilies. Moreover, to our knowledge, no study is reported on effect of gibberellins and benzyladenine on postharvest performance of cut gladiolus. Therefore, the objectives of this study were to evaluate the effects of a new plant growth regulator proprietary product, Fresco (GA_{4+7} plus BA), on leaf chlorosis and vase life extension, and to compare the effects of different concentrations of Fresco with two commercial floral

preservatives, Chrysal BVB or Chrysal Bulb Flower Food, on postharvest quality and leaf chlorosis of cut lilies and gladioli.

Procedures. Cut stems of lilies and gladiolus were received from The Sun Valley Group, Arcata, CA, and Glad-A-Way Gardens, Santa Maria, CA, respectively, during October-November 2013 at the Postharvest Laboratory, Department of Horticultural Science, North Carolina State University (NCSU), Raleigh, NC, USA. Stems of 'Cobra' oriental hybrid or 'Cappuccino', 'Dot Com', or 'Orange Art' Asiatic hybrid lilies and 'Alice', 'Mammoth', 'Passion', or 'Scarlet' gladioli were harvested in California, USA, in the morning when no flowers/florets were opened, hydrated in water, packed dry in standard floral boxes without any further treatment, and transported to the NCSU laboratory within 4 days of harvest. On arrival, stems were sorted into uniform groups on the basis of number of opened florets and stem caliper, labeled, recut to 60 or 80 cm lengths for lilies or gladioli, respectively, and placed in respective pulsing solutions. Solutions included gibberellins (GA_{4+7}) plus BA (Fresco) at 2.5, 5.0, or 10.0 mg L^{-1} or commercial preservatives, Chrysal BVB at 2 mL L^{-1} or Chrysal Bulb Flower Food at 10.0 g L^{-1}. Chrysal BVB was not tested on 'Scarlet' gladiolus. All solutions were prepared using tap water (pH 7.3, EC 0.26 dS m^{-1}), which was also used as control without any added compound. All solutions and stems were placed at 3 ± 1 °C in dark for 20 h. Thereafter, stem ends were rinsed in water and stems were placed in vases containing 700 mL tap water (pH 7.4, EC 0.25 dS m^{-1}), with three stems per vase at 21 ± 1 °C with 40-60% relative humidity and a 12 h photoperiod provided by cool-white fluorescent lamps.

Lily Results. Pulsing of cut stems of lilies with GA+BA at 5 mg L^{-1} or 2 mL L^{-1} Chrysal BVB for 20 h at 3 ± 1 °C extended the vase life and controlled leaf chlorosis of 'Cobra' oriental and 'Cappuccino' and 'Dot Com' Asiatic lilies (Table 1). Cut 'Orange Art' Asiatic lilies

performed best when pulsed with GA+BA at 10 mg L^{-1}. Chrysal BVB also extended the vase life and controlled leaf chlorosis, but Chrysal Bulb Flower Food had no effect on vase life extension or preventing leaf chlorosis of lilies. Chrysal BVB was developed as a grower-applied treatment to prevent leaf yellowing and promote flower opening, while Chrysal Bulb Flower Food was intended as final product to be used in vases. It is clear that the grower-applied pulsing treatment worked as intended, while the Chrysal Bulb Flower Food is probably better suited as a final solution.

Gladiolus Results. For cut gladiolus, pulsing with GA+BA at 10 mg L^{-1} extended the vase life of 'Alice', 'Mammoth', and 'Passion', while 'Scarlet' had the longest vase life when pulsed with 5 mg L^{-1} GA+BA. Use of Chrysal BVB also extended the vase life of 'Alice', 'Mammoth' and 'Passion'. Gladiolus stems had no or minor leaf yellowing with a significant difference found only for 'Alice in which stems pulsed with GA+BA had less leaf yellowing.

Summary. Cut stems of lilies and gladioli should be pulsed with 5.0 – 10.0 mg L^{-1} GA+BA or 2 mL L^{-1} Chrysal BVB at 3 ± 1 °C in dark for 20 h before shipping for longest vase life and preventing leaf yellowing. Commercial growers and wholesalers should consider maintaining postharvest quality of cut lilies and gladioli and increase financial returns by pulsing cut stems with GA+BA or Chrysal BVB to control leaf yellowing in addition to vase life extension.

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Table 1. Effect of GA_{4+7} plus BA (Fresco) or commercial pulsing solutions (Chrysal BVB or Chrysal Bulb Flower Food) on vase life, fresh weight change at d 6, quality at d 6, water uptake at d 6, number of flowers opened and number of yellow leaves at termination, and termination symptoms (leaf wilting or petal abscission) of 'Cobra' oriental lily and 'Cappuccino', 'Dot Com' and 'Orange Art' Asiatic lilies.

Treatments	Vase life (d)	Fresh weight change at d 6 (g)	Quality on scale 1-10, 1 is good	Water uptake (mL)	Flowers opened (no.)	Yellow leaves (no.)
			'Cobra' Oriental lily			
Tap water	9.5 c	6.4 c	2.8 c	635	2.6 b	3.2 a
2.5 mg L^{-1} GA+BA	12.8 b	12.4 ab	1.2 a	603	3.0 ab	0 b
5.0 mg L^{-1} GA+BA	14.1 ab	11.6 ab	1.0 a	589	3.6 a	0 b
10.0 mg L^{-1} GA+BA	13.9 ab	13.5 a	1.1 a	619	3.4 a	0 b
Chrysal BVB	14.3 a	11.4 ab	1.3 a	579	3.3 a	0 b
Chrysal Bulb Flower Food	9.5 c	8.8 bc	2.1 b	587	2.6 b	0.3 b
Significance	< 0.0001	0.0263	< 0.0001	NS	0.0095	< 0.0001

			‘Cappuccino’ Asiatic lily			
Tap water	6.6 c	-4.4 b	6.3 b	353 a	3.9	13.7 a
2.5 mg L^{-1} GA+BA	8.4 b	-0.5 ab	2.9 a	341 a	3.7	5.9 b
5.0 mg L^{-1} GA+BA	9.1 ab	-0.6 ab	2.7 a	321 a	4.1	3.6 c
10.0 mg L^{-1} GA+BA	8.8 ab	1.0 a	3.0 a	332 a	3.5	2.1 cd
Chrysal BVB	9.4 a	2.3 a	2.5 a	317 a	3.9	0.7 d
Chrysal Bulb Flower Food	6.3 c	-3.4 b	6.9 b	249 b	3.5	13.0 a
Significance	< 0.0001	0.0301	< 0.0001	0.0023	NS	< 0.0001
			‘Dot Com’ Asiatic lily			
Tap water	8.9 d	0.8 d	4.2 c	582	2.7	14 a
2.5 mg L^{-1} GA+BA	13.9 b	4.8 bc	1.2 a	578	3.2	1 b
5.0 mg L^{-1} GA+BA	15.4 a	8.1 a	1.0 a	568	3.2	0 b
10.0 mg L^{-1} GA+BA	15.9 a	8.3 a	1.1 a	573	3.2	0 b
Chrysal BVB	16.4 a	7.7 ab	1.0 a	587	3	0 b
Chrysal Bulb Flower Food	10.6 c	3.7 cd	2.9 b	548	3.1	14 a
Significance	< 0.0001	0.0001	< 0.0001	NS	NS	< 0.0001

‘Orange Art’ Asiatic lily

Tap water	13.1 e	7.4	2.9 c	577 ab	6.5	12 a
2.5 mg L^{-1} GA+BA	14.9 d	11.8	1.0 a	562 b	6.7	0 b
5.0 mg L^{-1} GA+BA	16.9 c	13.1	1.0 a	505 b	7.1	0 b
10.0 mg L^{-1} GA+BA	19.8 a	10.3	1.0 a	551 b	6.3	0 b
Chrysal BVB	18.7 b	10.4	1.1 a	508 b	5.9	0 b
Chrysal Bulb Flower Food	13.8 e	10.7	2.5 b	638 a	6.7	13 a
Significance	< 0.0001	NS	< 0.0001	0.0142	NS	< 0.0001

Table 2. Effect of GA_{4+7} plus BA (Fresco) or commercial pulsing solutions (Chrysal BVB or Chrysal Bulb Flower Food) on vase life, fresh weight change at d 6, quality at d 6, water uptake at d 6, number of flowers opened and number of yellow leaves at termination of 'Alice', 'Mammoth', 'Passion' and 'Scarlet' gladiolus. Chrysal BVB was not tested on 'Scarlet'.

Treatments	Vase life (d)	Fresh weight change at d 6 (g)	Quality on scale 1-10, 1 is good	Water uptake (mL)	Flowers opened (no.)	Yellow leaves (no.)
			'Alice'			
Tap water	6.7 c[d]	-0.5 c	4.5 b	210 b	9.9	0.9 a
2.5 mg L^{-1} GA+BA	7.5 ab	12.7 ab	3.7 ab	243 a	10.3	0.3 bc
5.0 mg L^{-1} GA+BA	7.9 ab	6.1 bc	3.4 a	240 a	10.7	0.3 bc
10.0 mg L^{-1} GA+BA	8.1 a	13.5 a	3.1 a	254 a	11.2	0.1 c
Chrysal BVB	8.0 ab	6.5 abc	3.1 a	264 a	10.9	0.1 c
Chrysal Bulb Flower Food	7.5 b	8.4 ab	3.8 ab	212 b	9.2	0.5 b
Significance[e]	< 0.0001	0.0263	< 0.0001	NS	0.0095	< 0.0001

			‘Mammoth’			
Tap water	7.5 d	23.0	3.9 c	240 d	10.6 b	0
2.5 mg L^{-1} GA+BA	8.3 bc	18.6	3.3 abc	255 cd	10.5 b	0
5.0 mg L^{-1} GA+BA	8.9 ab	24.7	3.2 ab	261 bc	11.0 b	0
10.0 mg L^{-1} GA+BA	9.5 a	25.2	2.7 a	276 ab	12.1 a	0
Chrysal BVB	9.2 a	25.6	3.3 abc	281 a	12.3 a	0
Chrysal Bulb Flower Food	7.8 cd	21.8	3.5 bc	262 abc	10.5 b	0
Significance	< 0.0001	NS	0.0109	0.0010	< 0.0001	-
			‘Passion’			
Tap water	7.9 d	12.9 c	4.2 c	228 c	13.5 c	0.4
2.5 mg L^{-1} GA+BA	9.3 b	17.4 bc	1.9 a	275 ab	14.6 b	0.5
5.0 mg L^{-1} GA+BA	9.6 ab	21.5 ab	1.6 a	281 ab	14.3 bc	0.6
10.0 mg L^{-1} GA+BA	9.9 a	20.7 ab	2.1 a	298 a	15.7 a	0.7
Chrysal BVB	9.3 b	18.5 bc	2.1 a	295 ab	15.1 ab	0.5
Chrysal Bulb Flower Food	8.5 c	24.9 a	3.0 b	267 b	13.5 c	0.0
Significance	< 0.0001	0.0115	< 0.0001	0.0003	0.0001	NS

			‘Scarlet’			
Tap water	7.0 c	-4.2 b	4.7 a	214	10.3	0.1
2.5 mg L^{-1} GA+BA	7.1 c	1.3 a	3.7 bc	228	10.7	0
5.0 mg L^{-1} GA+BA	7.8 a	3.0 a	3.4 c	234	10.2	0
10.0 mg L^{-1} GA+BA	7.5 ab	2.7 a	4.0 bc	233	10.7	0
Chrysal Bulb Flower Food	7.2 bc	6.3 a	4.2 ab	221	10.7	0.2
Significance	0.0001	0.0073	0.0063	NS	NS	NS