GA₃ and Benzylaminopurine Delay Leaf Yellowing in Cut *Alstroemeria* Stems

Peter R. Hicklenton

Agriculture Canada Research Station, Kentville, N.S. B4N 1J5, Canada

Additional index words. vase life, postharvest, leaf senescence, *Alstroemeria hybrida*

Abstract. Leaf yellowing of *Alstroemeria hybrida* L. 'Rio' and 'Jacqueline', as measured by sphere spectrophotometry, was significantly delayed in vase life studies when the ends of cut stems were immersed in solutions of BAP or GA₃ immediately following harvest. When BAP or GA₃ was used alone at 50 mg·liter⁻¹, foliage color and color intensity did not diminish during 14 days of storage in tap water. BAP and GA₃ also showed interaction effects on leaf color, but little was gained by using combinations of chemicals. Chemical names used: 'N-benzylaminopurine (BAP); gibberellin (GA₃).

The popularity of *Alstroemeria* with consumers is due in part to the long postharvest life of the inflorescence. Flowering shoots bear cymose inflorescences with three, or rarely four, florets per cyme. When shoots are harvested as the primary (distal) floret is unfolding, total vase life may be as long as 21 days, terminating with the senescence of the tertiary floret (Healy and Lang, 1989). Unfortunately, the quality of cut shoots is often diminished by the premature yellowing of the foliage, which often loses turgor and becomes moribund before senescence of the secondary florets. For this reason, foliage is commonly removed from shoots used in mixed bouquets. This practice is generally unsatisfactory for shoots that are sold individually.

Several studies have addressed the problem of postharvest foliage yellowing in a range of horticultural crops. In cut flowers, including *Alstroemeria*, discoloration has been reduced by foliar sprays of the cytokinin BAP (Halevy and Mayak, 1981). In other species, foliar applications of gibberellins can also prevent chlorosis and delay yellowing (Fletcher and Osborne, 1966). Spraying or dipping foliage in chemical solutions is a difficult postharvest procedure and it is doubtful that such treatments could be adopted on a commercial scale. Chemical control of leaf discoloration would, however, be feasible if the bases of cut shoots could be immersed (pulsed) for a short period in solutions immediately after harvest.

This study was designed to investigate foliage color retention in cut *Alstroemeria* shoots following pulses with various concentrations

and combinations of GA₃ and the cytokinin BAP.

Flowering shoots of 'Jacqueline' and 'Rio' *Alstroemeria* were harvested on 17 Jan. and 13 Feb. 1990 from 18-month-old plants growing in a commercial greenhouse. Plants had been subjected to supplemental radiation from high-pressure sodium lamps (80 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PAR) for 16 h·day⁻¹ since 1 Oct. 1989. Shoots between 80 and 100 cm long were pulled from the rhizome as the primary florets opened, and were cut transversely before being placed in solutions containing 0, 12.5, 25, 37.5, or 50 mg of BAP, GA₃, or BAP plus GA₃/liter (Sigma, St. Louis). Six shoots per treatment were left in the pulsing solutions for 4 h and then placed in tap water (pH 6.8; conductivity 8 to 12 dS·cm⁻¹) held in polypropylene containers and moved to a room lit by incandescent lamps (12 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PAR at flower height) and held at 18 $\pm$ 2°C for 14 days. A single leaf was removed from the uppermost whorl on 20 randomly selected shoots for color analysis using a sphere spectrophotometer (Hunterlab Ultrascan; Hunter Assoc.

Reston, Va.). Leaves were placed on the instrument's 10-mm² viewing port with the adaxial surfaces facing the quartz-halogen lamp. The technique was similar to that used to detect leaf color changes in stored cabbage (Chipman and Thorpe, 1979). Color difference measurements were made in the RSIN (reflectance specular included) mode. At the end of 14 days, three leaves were removed from the uppermost whorl of each experimental shoot, and final color difference measurements were performed.

The experiment was designed as a full factorial arrangement of chemical treatment and concentration in six experimental blocks. Each block consisted of a holding container with 50 shoots (25 of each cultivar) representing the 25 postharvest pulse treatments. Color components 'b' (a yellowness to blueness index where yellowness increases with index value) and 'L' (a color shade index where color intensity decreases with value) were used to describe leaf color at the start and end of the experiment (MacKinney and Little, 1962). Similar data were obtained for each harvest date. Only results from the 13 Feb. harvest are presented.

For 'Jacqueline', mean values of 'L' and 'b' immediately after harvest were 31.0 ($\pm$ SEM 0.6) and 8.5 ($\pm$ SEM 0.2), respectively. For 'Rio', equivalent index values were 28.0 ($\pm$ SEM 0.5) and 10.5 ($\pm$ SEM 0.3). The difference between 'b' values for 'Jacqueline' and 'Rio' quantifies the greater "yellowness" of mature foliage of 'Rio'. Stems of 'Jacqueline' and 'Rio', pulsed in tap water, showed significant decreases in foliage quality (yellowing and decreased color intensity) over 14 days (Tables 1 and 2). For 'Jacqueline', 'L' and 'b' values increased by 45% and 92%, respectively, and for 'Rio' by 73% and 44%, respectively. Foliage appearance was very poor on these stems at the end of 14 days, although secondary florets had not yet senesced.

Pulse treatments of GA₃ and BAP effectively reduced or eliminated foliage yellow-

Table 2. Leaf color indices 'L' and 'b' of *Alstroemeria* 'Rio' 14 days after BAP and GA₃ postharvest treatments.

GA ₃ concn (mg·liter ⁻¹)	BAP concn (mg·liter ⁻¹)									
	0		12.5		25.0		37.5		50.0	
	L ^z	b	L	b	L	b	L	b	L	b
0	48.4	15.1	40.5	14.0	36.0	12.8	32.1	11.5	31.3	10.3
12.5	44.8	13.9	37.5	13.2	33.7	12.1	31.6	11.1	31.7	10.2
25.0	40.7	12.8	34.9	12.2	31.4	11.6	30.9	10.9	31.4	10.4
37.5	36.2	11.8	31.8	11.4	29.1	11.2	30.2	10.4	32.7	10.1
50.0	32.3	10.5	28.3	10.7	27.3	10.6	29.4	10.2	32.6	10.1
Significance (L)						Significance (b)				
GA ₃						GA ₃				
Linear**						Linear**				
Quadratic ^{NS}						Quadratic ^{NS}				
Dev. ^{NS}						Dev. ^{NS}				
BAP						BAP				
Linear**						Linear*				
Quadratic**						Quadratic ^{NS}				
Dev. ^{NS}						Dev. ^{NS}				
GA ₃ × BAP**						GA ₃ × BAP**				
SEM (GA ₃ × BAP) n = 6, df = 120: 0.35						0.12				

^aMean values for L and b immediately after harvest were 28.0 and 10.5, respectively.

^{NS}***Nonsignificant or significant at P = 0.05 or 0.01, respectively.

Received for publication 17 Dec. 1990. Contribution no. 2079 of Agriculture Canada Research Station, Kentville. I thank Gordon's Greenhouses Ltd., Oxford, N.S., for donation of *Alstroemeria* stems, and K.G. Cairns for technical assistance. Partial support for this work was provided by the Canada-N.S. Agri-Food Development Agreement. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

Table 2. Leaf color indices 'L' and 'b' of *Alstroemeria* 'Rio' 14 days after BAP and GA₃ postharvest treatments.

GA ₃ concn (mg·liter ⁻¹)	BAP concn (mg·liter ⁻¹)									
	0		12.5		25.0		37.5		50.0	
	L ^z	b	L	b	L	b	L	b	L	b
0	48.4	15.1	40.5	14.0	36.0	12.8	32.1	11.5	31.3	10.3
12.5	44.8	13.9	37.5	13.2	33.7	12.1	31.6	11.1	31.7	10.2
25.0	40.7	12.8	34.9	12.2	31.4	11.6	30.9	10.9	31.4	10.4
37.5	36.2	11.8	31.8	11.4	29.1	11.2	30.2	10.4	32.7	10.1
50.0	32.3	10.5	28.3	10.7	27.3	10.6	29.4	10.2	32.6	10.1
Significance (L)					Significance (b)					
GA ₃					GA ₃					
Linear**					Linear**					
Quadratic ^{NS}					Quadratic ^{NS}					
Dev. ^{NS}					Dev. ^{NS}					
BAP					BAP					
Linear**					Linear*					
Quadratic**					Quadratic ^{NS}					
Dev. ^{NS}					Dev. ^{NS}					
GA ₃ × BAP**					GA ₃ × BAP**					
SEM (GA ₃ × BAP) n = 6, df = 120: 0.35					0.12					

Mean values for L and b immediately after harvest were 28.0 and 10.5, respectively.

^{NS}, **, *** Nonsignificant or significant at P = 0.05 or 0.01, respectively.

ing over the 14 days and maintained color intensity in both cultivars. When used alone, 50 mg of BAP or GA₃/liter resulted in the lowest 'b' values and the best foliage appearance. In 'Jacqueline', color intensity was maximal (lowest and nearly equal 'L' values) at 37.5 and 50 mg GA₃ or BAP/liter, whereas in 'Rio' intensity increased linearly with GA₃ and BAP concentration. Chemical treatments also showed significant interaction effects on 'L' and 'b' values in both cultivars. For 'Jacqueline', lowest 'b' values occurred in stems treated with a combination of 25 or 37.5 mg BAP/liter and 50 mg GA₃/liter. For 'Rio', 50 mg BAP and GA₃/liter resulted in the lowest 'b' values. For all practical purposes, however, leaf color was

not improved by addition of the other chemical when either GA₃ or BAP was present at 50 mg·liter⁻¹ in the pulse solution.

Neither GA₃ nor BAP can be considered to be a universal inhibitor of chlorophyll breakdown or leaf senescence. In some plant species (e.g., broccoli), pulsing cut stems with BAP concentrations as low as 5 mg·liter⁻¹ effectively prevents discoloration, while in others it is ineffective even at much higher concentrations (Halevy and Wittwer, 1966). Responses to gibberellins are also inconsistent and only in one or two cases have both chemicals been shown to be effective in stabilizing chlorophyll and leaf protein and preventing yellowing and discoloration (Beevers, 1966; Beevers and Guernsey,

1967). The results of the present study indicate that, in *Alstroemeria*, GA₃ and BAP can be used independently or in combination to delay leaf senescence simply by immersing cut stems for 4 h immediately following harvest. Use of either chemical at 50 mg·liter⁻¹ will significantly increase vase life of *Alstroemeria* by allowing full opening of primary through tertiary florets, in the presence of fresh, green foliage.

[Noted added in proof: After submission of this paper, another report of the effects of BAP and GA₃ on leaf yellowing in *Alstroemeria* appeared in *HortScience* [26(3):314]. These results confirm the effectiveness of GA₃ in delaying leaf yellowing, but BAP was less effective than in the present study.]

Literature Cited

- Beevers, L. 1966. Effect of gibberellic acid on the senescence of leaf discs of nasturtium (*Tropaeolum majus*). *Plant Physiol.* 41:1074-1076.
- Beevers, L. and F.S. Guernsey. 1967. Interaction of growth regulators in the senescence of nasturtium leaf discs. *Nature (London)* 214:941-942.
- Chipman, E.W. and E. Thorpe. 1979. Effect of maturity and frost on the leaf color of storage cabbage. *Can. J. Plant Sci.* 59:429-435.
- Fletcher, R.A. and D.J. Osborne. 1966. Gibberellin as a regulator of protein and ribonucleic acid synthesis during senescence in leaf cells of *Taraxacum officinale*. *Can. J. Bot.* 44:739-745.
- Halevy, A.H. and S. Mayak. 1981. Senescence and post harvest physiology of cut flowers—Part 2. *Hort. Rev.* 3:59-143.
- Halevy, A.H. and S.H. Wittwer. 1966. Effect of growth retardants on longevity of vegetables, mushrooms and cut flowers. *Proc. Amer. Soc. Hort. Sci.* 88:582-590.
- Healy, W. and D. Lang. 1989. Postharvest handling of *Alstroemeria*. *HortScience* 24:641-643.
- MacKinney, G. and A.C. Little. 1962. Color of foods. AVI, Westport, Conn.