

Timing of Gibberellin₄₊₇ + Benzyladenine Sprays Influences Efficacy against Foliar Chlorosis and Plant Height in Easter Lily

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Abstract. The effects of Promalin® [PROM; 100 mg·L⁻¹ each of GA₄₊₇ and benzyladenine (BA)] sprays on leaf chlorosis and plant height during greenhouse production of ancymidol-treated (two 0.5-mg drenches per plant) Easter lilies (*Lilium longiflorum* Thunb. 'Nellie White') were investigated. Spraying with PROM at early stages of growth [36 or 55 days after planting (DAP)] completely prevented leaf chlorosis until the puffy bud stage, and plants developed less severe postharvest leaf chlorosis after cold storage at 4 °C for 2 weeks. When PROM was sprayed on plants in which leaf chlorosis had already begun (80 DAP), further leaf chlorosis was prevented during the remaining greenhouse phase and during the postharvest phase. PROM caused significant stem elongation (23% to 52% taller than controls) when applied 36 or 55 DAP, but not when applied at 80 DAP or later. The development of flower buds was not affected by PROM treatments. Although PROM sprays applied at 55 DAP or later increased postharvest flower longevity, earlier applications did not. Chemical names used: *N*-(phenylmethyl)-1*H*-purine 6-amine (benzyladenine, BA); α -cyclopropyl- α -(*p*-methoxyphenyl)-5-pyrimidinemethanol (ancymidol).

Leaf chlorosis during both greenhouse forcing and postproduction is a long-standing problem in Easter lilies. Gradual yellowing, which progresses from basal to upper leaves, is a common disorder and can result in significant reduction in market value. High levels of growth retardants, low phosphorus nutrition, early termination of fertilization, and root rot diseases all induce leaf chlorosis during greenhouse production (Jiao et al., 1986; Prince and Cunningham, 1989; Tsujita et al., 1978, 1979).

Recent studies have indicated that foliar sprays of PROM (GA₄₊₇ plus BA; Abbott Laboratories, North Chicago, Ill.) can prevent postproduction leaf chlorosis and senescence

of both Easter (Han, 1997) and Oriental hybrid lilies (*Lilium* cv. Stargazer) (Ranwala and Miller, 1998). The ingredient that prevents leaf chlorosis is GA₄₊₇, not BA, as commercial products containing only GA₄₊₇ (e.g., ProVide, Abbott Laboratories) are as effective as PROM (Han, 1997; Ranwala and Miller, 1998). Foliar sprays of PROM at 25 mg·L⁻¹ or greater at the puffy bud stage prevented postharvest leaf chlorosis in Easter lilies (Han, 1997). During postproduction, PROM prevented initiation of leaf chlorosis as well as further progression of leaf chlorosis already initiated (Han, 1997). From a commercial standpoint, treatment early in the crop (before plants are spaced) would be desirable. However, the feasibility of using PROM during greenhouse production to prevent both greenhouse and postharvest leaf chlorosis has not been evaluated. Possible problems associated with earlier application in the greenhouse could include: 1) short duration of protection against leaf chlorosis; and 2) promotion of stem elongation, causing excessive plant height.

The objectives of this study were to investigate: 1) the effects of timing of PROM treatment during greenhouse production on plant height and leaf chlorosis in ancymidol (growth retardant)-treated Easter lilies; and 2) the residual effects of the applications on postproduction quality and longevity.

Materials and Methods

Uniform Easter lily, 'Nellie White', plants (\approx 10 cm tall) in 15-cm-diameter green plastic pots were obtained from a commercial grower in western North Carolina 31 d after planting

(DAP) and subsequently grown in a polyethylene film-covered greenhouse at Clemson Univ. following standard cultural practices (Miller, 1992). Plants were grown from 23- to 25-cm-diameter case-cooled bulbs in a planting mix composed of 3 pine bark : 1 peat : 1 vermiculite (by volume). Plants were spaced 20 × 20 cm and were fertilized at each watering with a mixture containing 20N-4.4P-16.6K at 200 mg·L⁻¹ N, alternated with calcium nitrate plus potassium nitrate at the concentration of 200 mg·L⁻¹ each of N and K. All plants received full natural sunlight in the greenhouse. A setpoint temperature of 22/16 °C (vent/heat) was used during the experiment, with daytime temperatures occasionally rising to 27 °C.

Two days after receipt of the plants (33 DAP), 0.5 mg ancymidol (A-Rest; SePRO Corp., Carmel, Ind.) was applied to each pot as a 300-mL substrate drench. A second ancymidol drench at the same rate was applied 14 d later. At 36, 55, 80, or 90 DAP, plants were sprayed with 100 mg·L⁻¹ each GA₄₊₇ and BA from PROM. The spray solution contained 0.1% Tween 20 (polyoxyethylene sorbitan monolaurate) as a surfactant. The entire plant was sprayed to run-off, and control plants were sprayed with water plus surfactant. Height of plants sprayed on 35, 55, 80, and 90 DAP averaged 12.6, 25.9, 37.3, and 45.8 cm, respectively. While the volume of spray applied per plant was not measured, more volume was applied per plant on the later dates simply because the plants were larger.

At the puffy bud stage (90 DAP), plant height, the number of chlorotic and senescent leaves, and number of flower buds were recorded. Plants were then stored in the dark at 4 ± 0.5 °C and relative humidity 70% to 75% for 2 weeks, followed by transfer to a 22 °C postharvest evaluation room with environmental conditions as described earlier (Ranwala and Miller, 1998). The number of chlorotic or senescent leaves was recorded at 2-d intervals. A leaf was considered chlorotic if >20% of the leaf area was yellow. Each flower was tagged as it opened, and the date of senescence was recorded when the petals started wilting and became discolored. Flower longevity of a plant was calculated by averaging values for the first five flowers to open.

All data were subjected to analysis of variance (ANOVA) using a completely randomized design with eight replicates (plants) per treatment. Percentage data were arcsin transformed before ANOVA. Duncan's multiple range test was used for mean separation.

Results and Discussion

Average leaf number per plant was 79. Chlorosis began in the basal leaves of control plants (no PROM sprays) \approx 55 DAP, and gradually progressed upward throughout the remainder of the forcing period. At the puffy bud stage (90 DAP), \approx 11% of leaves were chlorotic or senescent in control plants (Table 1). PROM sprays at early stages of growth (36 or 55 DAP) completely prevented this gradual leaf chlorosis. When PROM was sprayed on plants where leaf chlorosis had already begun

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(e.g., 80 DAP), it prevented further chlorosis (Table 1). Similar observations have been reported in greenhouse Easter lilies by Heins et al. (1996), where chlorotic leaves decreased from 28% (no PROM) to 10% when PROM (100 mg·L⁻¹) was applied 60 d after emergence. In that study, PROM was more effective in preventing leaf chlorosis when applied at 60 d after emergence than at 30 or 90 d.

Although early applications of PROM significantly reduced or prevented leaf chlorosis during greenhouse forcing, they stimulated stem elongation. At the puffy bud stage, plants sprayed at 36 or 55 DAP were significantly taller [≈52% (23.5 cm) and 23% (10.5 cm), respectively] than nonsprayed plants (Table 1). Applications at later stages (80 or 90 DAP), however, did not increase plant height significantly.

Our data indicate that the effects of whole-plant foliar sprays of PROM on stem elongation are greatly influenced by timing. Since most stem elongation is completed by the puffy bud stage, PROM applied at that time should not increase stem height substantially, and this has been reported for both Easter and Oriental hybrid lilies (Han, 1997; Ranwala and Miller, 1998). In contrast, Heins et al. (1996) observed only a slight increase (2 cm) in height in plants treated with PROM even when both upper and lower leaves were treated. In that study, plants were grown pot-to-pot, which would have caused additional elongation of control plants.

When plants reached the puffy bud stage, they, together with a set of plants sprayed 2 h prior to cold storage (90 DAP), were cold-stored at 4 °C for 2 weeks. Plants that received no PROM rapidly developed leaf chlorosis during the postharvest phase (Fig. 1). Although plants sprayed with PROM at early stages (36 or 55 DAP) developed some postharvest leaf chlorosis (≈6%), the extent of chlorosis was much lower than in nonsprayed plants (>40%). Plants sprayed later (80 DAP) or at the puffy bud stage (90 DAP) developed chlorosis in the greenhouse, but <3% additional chlorosis developed during postharvest evaluation.

PROM sprays did not affect number of flower buds (Table 1), and in contrast to the findings of Heins et al. (1996), we observed no deformed flowers in PROM-treated plants either in the greenhouse or during postharvest evaluation. Although PROM sprays at later stages (≥55 DAP) increased postharvest flower longevity, early applications (<55 DAP) did not. We have observed similar increases in postharvest flower longevity when PROM was applied to 'Stargazer' hybrid lilies at the puffy bud stage (Ranwala and Miller, 1998).

The present study indicates the feasibility of using PROM sprays (100 mg·L⁻¹ each GA₄₊₇

Table 1. Effects of timing of a single PROM (100 mg·L⁻¹ each GA₄₊₇ and BA) spray during greenhouse forcing of 'Nellie White' Easter lilies. All plants were treated with ancymidol (0.5 mg/plant) 33 and 47 d after planting (DAP). Plant height, percentage of chlorotic or senescent leaves, and number of flower buds were determined at the puffy bud stage. Flower longevity was determined during a postharvest evaluation phase following 2 weeks of storage at 4 °C. Each value is the mean for eight replicate plants.

Time of PROM application (DAP)	Plant height (cm)	Chlorotic or senescent leaves (%)	No. of flower buds	Flower longevity (d)
No PROM	45.0 c ^z	11 a	5.8 a	6.0 c
36	68.5 a	0 c	5.8 a	6.2 c
55	55.5 b	0 c	5.9 a	6.9 b
80	47.2 c	8 b	5.5 a	7.8 a
90 (puffy bud)	45.8 c	12 a	6.0 a	7.9 a

^zMean separation within columns by Duncan's multiple range test ($P \leq 0.05$).

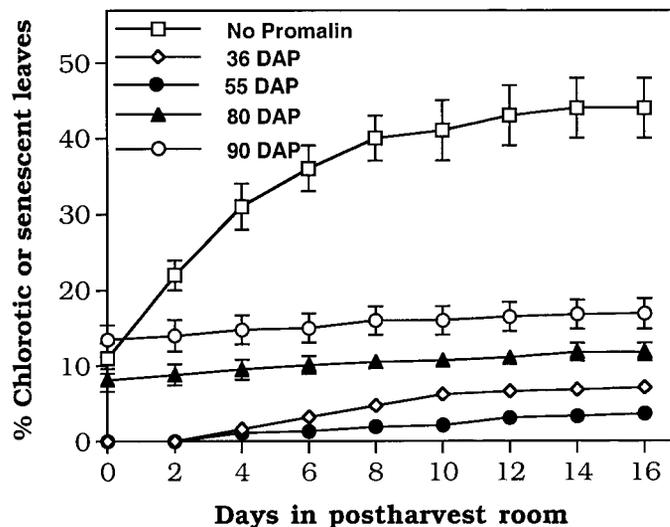


Fig. 1. Effects of timing of a single PROM spray during greenhouse forcing on leaf chlorosis in Easter lilies during postharvest evaluation. All plants were treated twice with ancymidol (0.5 mg per plant at 33 and 47 d after planting). Plants were sprayed once with PROM (100 mg·L⁻¹ each GA₄₊₇ and BA) on the date indicated. At the puffy bud stage, plants were cold stored at 4 °C for 2 weeks. Plants were then held at 22 °C for postharvest evaluation. Data are means ±SE (vertical bars) of eight replicate plants; if no bar is shown, it falls within the dimensions of the plotting symbol.

and BA) to prevent leaf chlorosis induced during greenhouse production. However, excessive stem elongation limits the use of this concentration of PROM at early stages of growth. Possible alternatives to avoid stem elongation may be to: 1) use lower concentrations of PROM that prevent leaf chlorosis (Han, 1997), but may not cause stem elongation; and 2) apply PROM only to foliage on the lower part of the stem.

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