Chemical Growth Retardant Effects on Easter Lilies

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ABSTRACT

Plants of Lilium longiflorum Thunb. 'Nellie White' received the following treatments during forcing: 1) control; 2-3) one or two sprays of 50 mg·liter^{-1} ancymidol; 4-9) one or two sprays of 5, 10, or 15 mg·liter^{-1} XE-1019; or 10) one spray of 20 mg·liter^{-1} XE-1019. All growth retardant treatments reduced plant height compared to controls. Plant height decreased linearly with increasing concentration of XE-1019 for both one- and two-spray treatments. High concentrations of XE-1019 delayed anthesis; ancymidol treatments did not. Individual corolla length was not affected by treatments. Treatments did not affect daughter bulb depletion or new daughter bulb growth. Total leaf area and leaf dry weight decreased as XE-1019 concentration increased; ancymidol treatments did not affect leaf area, but did reduce leaf dry weight. Leaf total soluble carbohydrate decreased with increasing concentration of XE-1019.

INTRODUCTION

Ancymidol is effective for controlling Easter lily stem elongation, and XE-1019 reportedly controls hybrid lily (Lilium sp.) stem elongation. However, an analysis of carbohydrate partitioning in response to these growth retardants has not been conducted for Easter lilies. Potential effects from the use of growth retardants include a delay in flowering and a reduction in individual flower size. Also, modification of leaf canopy architecture may be expected, possibly leading to reduced whole-plant photosynthesis caused by mutual leaf shading. Reductions in irradiance reduce leaf and flower bud carbohydrate concentration in Easter lily resulting in increased reserve hydrolysis and carbohydrate export from daughter bulbs.

In geranium, chlormequat reduced levels of leaf soluble sugars and starch. If growth retardant applications lead to a reduction in Easter lily leaf carbohydrate, a reduction in daughter bulb dry weight might occur. For this reason, we determined the concentrations of leaf starch and soluble carbohydrate as well as bulb dry weights at anthesis. Therefore, the objectives of this work were: 1) examine the effects of XE-1019 and ancymidol treatments on growth and development of Easter lilies; and 2) discern if treatments alter the carbohydrate status/partitioning in Easter lilies.

MATERIALS AND METHODS

Bulbs of L. longiflorum 'Nellie White' were placed into 4.5°C dark storage for 6 weeks, beginning 27 October 1987. On 8 December 1987, bulbs were removed from the cooler, potted one per 15 cm-diameter plastic container, and placed into a 26°/15° (venting/night) greenhouse. The growth medium consisted of a 1 soil: 2 sphagnum peat: 2 perlite (by volume) mixture amended with 890 g treble superphosphate, 593 g potassium nitrate, 593 g magnesium sulfate, 4.75 kg ground dolomitic limestone, and 74 g Frit Industries Trace Elements No. 555 (Peters Fertilizer Products, W.R. Grace & Co., Fogelsville, Pa.) per cubic meter. The plants were fertilized at each watering with 300 mg·liter^{-1} each of N and K supplied from 776 and 550 mg·liter^{-1} of potassium nitrate and ammonium nitrate, respectively. Fertilizer solution was maintained at 6.0 pH by injecting 75% (w/w) technical grade phosphoric acid into the system, supplying 37 mg·liter^{-1} P at every watering.

Ten plants each received the following treatments: 1) control; 2-3) one or two sprays of 50 mg a.i.·liter^{-1} ancymidol; 4-9) one or two sprays of 5, 10, or 15 mg a.i.·liter^{-1} XE-1019; and 10) one spray of 20 mg a.i.·liter^{-1} XE-1019. The first applications were made on 22 January 1988; plant shoots averaged (± SD) 8.0 ± 0.8 cm long, at this time. Plants receiving a second spray (trts 3, 5, 7, and 9) averaged a shoot length of 15 ± 0.9 cm when the second application was made. All applications were made spraying 204 ml of solution evenly over 1 m^2 of bench area. Plant spacing was 25 x 25 cm; each pot should have received 3.2 ml of spray, using this application method.

Days to visible bud and to anthesis were calculated from the date the bulbs were potted and placed into the greenhouse. Anthesis was recorded when the first flower opened. The number of flower buds, plant height (from the soil surface to the top of the inflorescence), and inflorescence length (from the base to the highest point on the inflorescence) were recorded at anthesis. On 31 March 1988, 5 flowering plants from each treatment were harvested for further analysis; number of leaves, total leaf adaxial surface area, stem length to base of inflorescence, length of open flowers, fresh weights of tissues, and dry weights of tissues were recorded for each. Leaf surface area measurements were taken using a LiCor LI-3100 Area Meter (LiCor, Inc. Lincoln, Neb.).

A 20-leaf sample was collected from each plant, frozen in liquid nitrogen, freeze-dried, and ground through a 20-mesh screen prior to carbohydrate and starch analysis. Soluble carbohydrates were extracted and determined using high performance liquid chromatography. Leaf starch concentration was determined via a glucose oxidase method, following amyloglucosidase hydrolysis of the insoluble residue. The corolla length of all flowers that had reached anthesis (average of 3 per plant) was measured from the point of pedicel attachment to the point where tepals reflexed outward. All data were subjected to one-way analysis of variance, and single degree of freedom contrasts were conducted for appropriate comparisons.

RESULTS

Days to anthesis, plant height, and inflorescence length all were affected by the growth retardant treatments applied (Table 1). Time required for plants to reach anthesis increased with an increase in XE-1019 dose applied for both one-and two-spray treatments. Ancymidol treatments did not delay anthesis compared to controls whereas XE-1019 treatments did. No treatment affected the appearance of visible flower buds and plants averaged (± SD) 83 ± 5 days from the start of forcing to the visible bud stage. Plant height (from the soil surface to the top of the inflorescence) decreased with increasing concentration of XE-1019 for both one- and two-spray treatments.

All growth retardant treatments reduced the plant height, as compared to the controls. However, reductions achieved with one spray of 5 or 10 mg a.i.·liter^{-1} XE-1019 were slight (Table 1). Inflorescence length (from the base to the top of the inflorescence) was less than controls for all growth retardant treatments except for one application of ancymidol or one application of 5 or 10 mg a.i.·liter^{-1} XE-1019; two-spray treatments resulted in the shortest inflorescence lengths, regardless of chemical applied. None of the chemical treatments applied affected flower bud number and plants averaged 6.4 ± 1.2 buds at anthesis.

Plants harvested 31 March 1988 did not differ in total leaf number (data not presented), and they averaged 81 ± 9 leaves each. Total leaf area per plant decreased linearly as XE-1019 concentration increased for both one- and two-spray treatments (Table 2). Ancymidol treatments did not result in a significant reduction in plant leaf area as compared to control plants, but the higher concentrations of XE-1019 did. There was no treatment effect in leaf percent (w:w) water content (data not presented); it averaged 90% ± 1% for all plants.

Leaf dry weight decreased with increasing concentrations of XE-1019 for both one- and two-spray treatments. Ancymidol treatments also reduced leaf dry weight as compared to controls (Table 2). No treatment difference was measured for specific leaf weight (data not presented), and leaves averaged 60 ± 6 $mg \cdot cm^{-2}$ and 7.3 ± 0.7 $mg \cdot cm^{-2}$ for fresh specific weight and dry specific weight, respectively. Both stem length and stem dry weight were less for plants in growth retardant treatments than for controls (Table 2). There was no treatment effect on stem percent (w:w) water content (data not presented), and stems averaged 90% ± 1%. No difference in leaf starch concentration was detected (data not presented), and leaves averaged 33 ± 5 mg of starch per gram of leaf dry weight.

Leaf total soluble carbohydrate concentration was affected by treatment and was reduced in ancymidol and XE-1019 treated plants compared to controls (Table 2). However, a single application of 10 or 15 mg or two applications of 5 mg $a.i. \cdot liter^{-1}$ XE-1019 did not reduce leaf total soluble carbohydrate concentration. An increase in XE-1019 concentration resulted in a decrease in leaf soluble carbohydrate concentration for two-spray treatments. No treatment effect was evident for individual corolla length (data not presented); corolla length averaged 15 ± 1 cm, regardless of treatment.

No treatment differences were observed for any bulb growth parameters we measured (data not presented). The number of new daughter bulbs, total new daughter fresh and dry weight, and daughter bulb fresh and dry weight averaged 1.6 ± 0.6, 10.7 ± 2.8 g, 2.8 ± 0.7 g, 54.1 ± 8.6 g, and 14.6 ± 2.7 g, respectively.

DISCUSSION

In this experiment, we examined four visible points of concern for producers: 1) effective control of stem length; 2) effective control of inflorescence length; 3) undesirable reduction in individual corolla size; and 4) undesirable delay in flowering. All chemical treatments did reduce total plant height; however, two-spray treatments were more effective in controlling pedicel elongation, resulting in a shorter inflorescence. When control of pedicel length is desired, multiple applications (applying growth retardants later in the plant's development) should be considered.

No treatment reduced corolla length, suggesting that Easter lily flower elongation is regulated by gibberellins or other factors unaffected by ancymidol and XE-1019 concentrations employed in this experiment. Thus, both stem and inflorescence length can be regulated without adverse effects on individual flower size. From a production standpoint, the only visible disadvantage to treatments employed was an increase in forcing time, especially with the highest concentration of XE-1019 used. However, one spray of 15 mg or two sprays of 5 mg $a.i. \cdot liter^{-1}$ XE-1019 effectively controlled plant height without increasing forcing time or reducing foliar soluble carbohydrate concentration.

The high dose XE-1019 treatments reduced the concentration of soluble carbohydrate in Easter lily leaves (Table 2). One explanation for the decrease in leaf carbohydrate may be mutual leaf shading due to altered canopy architecture in treated plants. In our experiment, internode length was reduced 57% as a result of the highest XE-1019 concentration. This reduction could limit light penetration into the canopy, and reduce whole plant photosynthetic rate and photosynthate production. An examination of whole plant photosynthesis related to growth retardant treatments will be necessary to investigate this hypothesis.

Previous work indicated dry weight export from daughter bulbs is enhanced as a result of low leaf carbohydrate concentration. While some growth regulator treatments reduced the concentration of leaf soluble carbohydrate, treatments did not increase export of dry matter from daughter bulbs, or reduce import by new daughter primordia. It is possible that the 25% reduction in leaf carbohydrate observed for the highest concentration of XE-1019 was not large enough to increase export from daughter bulbs. Overall, growth retardant treatments had no effect on bulb reserve depletion or morphological development in our experiment.

Table 1. Effects of ancymidol and XE-1019 on Easter lilies harvested at anthesis.[z]

	Treatment	Days from planting to anthesis	Plant height (cm)[y]	Inflorescence length (cm)[x]
1)	Control	113	37.2	10.7
	Ancymidol			
2)	50 mg·liter^{-1}, one spray	114	29.9	10.8
3)	50 mg·liter^{-1}, two sprays	116	29.4	9.1
	XE-1019			
4)	5 mg·liter^{-1}, one spray	114	35.3	10.4
5)	5 mg·liter^{-1}, two sprays	113	29.0	9.8
6)	10 mg·liter^{-1}, one spray	115	34.6	10.2
7)	10 mg·liter^{-1}, two sprays	117	27.5	9.3
8)	15 mg·liter^{-1}, one spray	115	28.6	9.4
9)	15 mg·liter^{-1}, two sprays	118	22.6	7.1
10)	20 mg·liter^{-1}, one spray	121	21.4	9.2
	Contrasts			
	Ancymidol vs. control	NS[w]	***	NS
	XE-1019 vs. control	*	***	**
	One spray XE-1019 linear	***	***	*
	Two sprays XE-1019 linear	*	***	***

[z] Based on 10 replications.
[y] Measured from the soil surface to the top of the inflorescence.
[x] Measured from the base to the top of the inflorescence.
[w] F-test of contrast or treatment trend is nonsignificant (NS) or significant at $0.05 \geq \alpha > 0.01$ (*), $0.01 \geq \alpha > 0.001$ (**), or at $\alpha \leq 0.001$ (***). One-way analysis of variance F-test significant at $\alpha \leq 0.001$ for all 3 variables reported.

Table 2. Effects of ancymidol and XE-1019 on Easter lilies harvested after 114 days of forcing.[z]

	Treatment	Total leaf area (cm^2)	Total leaf dry wt (g)	Stem length (cm)[y]	Stem dry wt (g)	Leaf total soluble carbohydrate ($mg \cdot g^{-1}$ dry wt)[x]
1)	Control	1464	11.2	22.4	3.9	128
	Ancymidol					
2)	50 $mg \cdot liter^{-1}$, one spray	1252	8.9	17.0	3.0	108
3)	50 $mg \cdot liter^{-1}$, two sprays	1381	9.9	16.4	3.0	118
	XE-1019					
4)	5 $mg \cdot liter^{-1}$, one spray	1484	11.2	21.9	3.8	118
5)	5 $mg \cdot liter^{-1}$, two sprays	1411	10.2	15.8	2.9	121
6)	10 $mg \cdot liter^{-1}$, one spray	1538	11.9	20.8	3.8	125
7)	10 $mg \cdot liter^{-1}$, two sprays	1263	9.4	15.8	2.7	110
8)	15 $mg \cdot liter^{-1}$, one spray	1329	9.7	15.3	2.8	121
9)	15 $mg \cdot liter^{-1}$, two sprays	1043	7.5	11.8	2.0	105
10)	20 $mg \cdot liter^{-1}$, one spray	1037	6.6	9.6	1.7	96
	Contrasts					
Ancymidol vs. control		NS[w]	*	***	*	*
XE-1019 vs. control		*	*	***	***	*
One spray XE-1019, linear		***	***	***	***	**
Two sprays XE-1019, linear		***	**	*	*	*

[z]Based on 5 replications.
[y]Measured from the soil surface to the base of the inflorescence.
[x]Total soluble carbohydrate is the sum of the major HPLC peaks: sucrose, glucose, fructose, and an unknown eluting between sucrose and glucose.
[w]F-test of contrast or treatment trend is nonsignificant (NS) or significant at $0.05 \geq \alpha > 0.01$ (*), $0.01 \geq \alpha > 0.001$ (**), or at $\alpha \leq 0.001$ (***). One-way analysis of variance F-test significant at $\alpha \leq 0.001$ for first 4 variables reported and significant at $0.01 \geq \alpha > 0.001$ (**) for leaf total soluble carbohydrate.