Growth Retardant Application to *Canna* x *generalis* 'Florence Vaughan'[1]

L.L. Bruner[2], G.J. Keever[3], J.R. Kessler, Jr.[4], and C.H. Gilliam[3]
Department of Horticulture
Auburn University, AL 36849

Abstract

The effects of 15 to 45 ppm Cutless (flurprimidol), 2500/1500 to 7500/1500 ppm B-Nine/Cycocel tank mixes (daminozide/chlormequat chloride), and 20 to 60 ppm Sumagic (uniconazole) on the vegetative growth and flowering of *Canna* x *generalis* 'Florence Vaughan' were determined during container nursery production and landscape establishment. Vegetative heights 30 and 60 days after treatment (DAT) and vegetative and inflorescence heights at first and second flower were suppressed by all plant growth retardants (PGRs). There was no delay in flowering of the first inflorescence from any PGR treatment, and a three to seven day delay in flowering of the second inflorescence with only Sumagic. Vegetative height was suppressed quadratically 14–28% (30 DAT) and linearly 19–40% (60 DAT) by increasing Cutless rates. Inflorescence heights of plants treated with 15 or 30 ppm Cutless were suppressed proportionally to foliage heights without any detrimental effect on floral display. Heights of plants treated with Cutless and transplanted into the landscape at 60 DAT were similar to those remaining in containers at 90 DAT, and 7 cm (3 in) and 11 cm (3.5 in) taller at 120 and 150 DAT, respectively. Vegetative heights of plants in both locations were suppressed linearly by Cutless, 15–33% (90 DAT) and 7–12% (120 DAT) with height suppression effects dissipating by 150 DAT. Vegetative height was suppressed quadratically by B-Nine/Cycocel, 5–14% and 16–28% at 30 and 60 DAT, respectively. However, response was inconsistent with rate at all sampling dates both in containers and in the landscape. B-Nine/Cycocel treated plants were suppressed quadratically up to 33% (90 DAT) and up to 17% (120 DAT). Plants transplanted and treated with B-Nine/Cycocel were suppressed linearly 14–23% (90 DAT) and 6–16% (120 DAT). At 150 DAT, B-Nine/Cycocel treated plants were similar in height to control plants; with transplanted plants around 10 cm (4 in) taller than those remaining in containers. Sumagic suppressed vegetative height quadratically 28–33% (30 DAT) and 50–52% (60 DAT). At 60 DAT, the height suppression was excessive and leaf orientation was altered to a less upright position. Inflorescence height suppression by Sumagic was considered excessive with first and second flower occurring below the surrounding foliage. Compared to those transplanted into the landscape at 60 DAT, plants treated with Sumagic and remaining in containers were 12% (90 DAT), 36% (120 DAT), and 37% (150 DAT) shorter. In both locations, Sumagic suppressed vegetative height quadratically 46% (90 DAT) and 29% (120 DAT) compared to control plants. Compared to control plants, at 150 DAT, treated plants remaining in containers were suppressed to a greater extent (32–43%) than those transplanted into the landscape (11–14%).

Index words: growth retardant, plant growth regulator, canna lily, herbaceous perennial.

Growth regulators used in this study: B-Nine (daminozide), [butanedioic acid mono (2,2-dimethylhydrazide)] and Cycocel (chlormequat chloride), (2-chlorethyl) trimethylammonium chloride tank mixes; Cutless (flurprimidol), α-(1-methylethyl)-α-[4-(trifluromethoxy)phenyl]-5-pyrimidinemethanol; Sumagic (uniconazole), E-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)pent-1-ene-3-ol.

Species used in this study: 'Florence Vaughan' canna lily (*Canna* x *generalis* L. H. Bailey 'Florence Vaughan').

Significance to the Nursery Industry

Controlling canna lily height would benefit growers and retail facilities by reducing shipping costs and maintenance. Cutless at 15 and 30 ppm was effective in controlling height of canna lily, without any detriment to the overall floral display. Excessive inflorescence retardation and altered plant form observed at 45 ppm support the use of a maximum of 30 ppm Cutless. Plants treated with 15 ppm Cutless were only 7% shorter than controls at 120 days after treatment (DAT), a non-discernable difference to consumers. The residual effects from Cutless at any rate were not influenced by whether plants remained in container production or were transplanted into the landscape. Treated plants grew at a more rapid rate than controls following 60 DAT, although heights of treated plants were suppressed compared to controls until treatment effects dissipated completely by 150 DAT. Due to its effectiveness at low application rates, Cutless could provide a cost-effective means of reducing plant height that should facilitate shipping and reduce maintenance during production and marketing of canna lily. Additionally, the consistent height control provided by Cutless through 120 DAT combined with the increased growth rate of treated plants once suppression lessened would benefit the grower, retailer, and consumer by meeting the expectations of each; lower maintenance and shipping costs followed by rapid landscape establishment and enhancement.

B-Nine/Cycocel tank mixes provided less overall height suppression of canna lily than Cutless without excessive inflorescence retardation or changes in leaf orientation; however, height response was inconsistent with rate. Sumagic at all rates tested resulted in excessive height suppression throughout container production. These effects were considered detrimental and would likely reduce the plant's marketability.

Introduction

The tall, upright foliage [110 cm (45 in)] and continuous flowering of *Canna* x *generalis* 'Florence Vaughan' or canna lily make this traditional, herbaceous perennial popular with consumers. Sulphur-yellow flowers with an orange blotch typically extend 10 cm (4 in) above the foliage when in bloom,

[1]Received for publication November 6, 2000; in revised form May 29, 2001.
[2]Graduate Student.
[3]Professor.
[4]Associate Professor.

mid-summer through fall (17). The plant's tall, upright nature and rapid growth make it difficult to manage during production and at retail facilities due to frequent blow-over when grown in 11.4 liter (#3) or smaller containers. Additionally, taller plants increase shipping costs, especially when plants are racked for shipment. Plant growth retardants (PGRs) are effective in suppressing the height of numerous crops (2, 3, 5, 11, 16, 18) and may benefit production of canna lily. Previous research with Cutless, a plant growth retardant labeled for turfgrasses, has shown it effective on canna lilies (4). However, Cutless at rates previously tested on cannas, 50, 100, and 150 ppm, resulted in excessive inflorescence retardation reducing the overall floral display. Additionally, at rates previously tested, canna's typical upright leaf orientation was altered to a less upright form by restricting internode elongation, resulting in a less desirable plant form.

Bonzi and B-Nine are effective in height suppression of numerous plant species (5, 6, 16, 18), but were not consistently effective in suppressing canna lily height (4). Sumagic is similar in chemical form to Bonzi but more effective in height suppression of many crops (2, 3, 7, 8). Additionally, in previous research, B-Nine/Cycocel combinations were more effective in controlling plant height than either PGR alone (1).

Cutless at lower rates, Sumagic, or B-Nine/Cycocel tank mixes may offer benefits in the production, shipping, and marketing of canna lilies. B-Nine, Cycocel, and Sumagic are labeled for use on herbaceous crops in greenhouse environments. B-Nine is also labeled for use in nurseries, while Cutless is labeled for use on turfgrasses only. While these PGRs have been effective on numerous horticultural crops, none are specifically labeled for use on canna lily during nursery production.

Postproduction PGR effects are a concern to both growers and consumers. Once plants reach marketable size or stage they may be held in containers for an extended period until sold in the retail market. Continued height suppression of plants remaining in containers would reduce maintenance in the wholesale and retail settings. Previous research has shown that plant size can be suppressed by limiting container volume (10, 14). However, continued height suppression may be a disadvantage once plants are transplanted into the landscape. Previous research has shown the persistence of PGR effects in the landscape is dependent on species and PGR rate (12, 13). Cutless at 100 and 150 ppm suppressed height of canna lilies linearly 14–18% (1998) and 10–23% (1999) 30 days after transplanting into the landscape with suppression effects dissipating by 60 days after transplanting (4). Persistent and excessive suppressed growth in the landscape may reduce customer satisfaction. The objective of this study was to determine the effects of several rates of four PGRs on the height and flowering of canna lily during container production and subsequent landscape establishment.

Materials and Methods

On March 3, 2000, dormant canna lilies (*Canna* x *generalis* 'Florence Vaughan') in 3.8 liter (#1) containers were quartered and repotted into 11.4 liter (#3) containers. The pine bark:sand (7:1 by vol) substrate was amended per m^3 (yd^3) with 7.2 kg (12 lb) 17N–3P–10K (Osmocote 17–7–12, The Scotts Company, Marysville, OH), 0.9 kg (1.5 lb) Micromax (The Scotts Company), and 3.0 kg (5 lb) dolomitic limestone. Plants were grown outdoors in full sun at a 60 cm (2 ft) spacing and under twice daily overhead irrigation for a total of 1.8 cm (0.7 in) per day.

Initial height measurements were taken prior to treatment application. Initial heights ranged from 31 (12 in) to 44 cm (17 in) and plants were blocked by height accordingly. On April 14, 2000, plants were moved into a polyethylene greenhouse and PGRs were applied as foliar sprays in a volume of 0.2 liter/m^2 (2 qt/100 ft^2) using a CO_2 sprayer with a flat spray nozzle at 1.4 kg/cm^2 (20 psi). Temperature ranged from 18.8C (66F) to 21.1C (70F) and relative humidity was 81% during treatment application. At the time of treatment, plants were vegetative and undergoing the spring flush of growth. Treatments included B-Nine/Cycocel tank mixes at 2500/1500, 5000/1500, and 7500/1500 parts per million (ppm); Cutless at 15, 30, and 45 ppm; Sumagic at 20, 40, and 60 ppm; and an untreated control. Rates tested have been documented as effective on various crops (4, 15, 16, 18) or in the case of Cutless, below those previously reported as excessive on canna lilies (4). Plants were returned to the nursery container area on the day after treatment.

The experimental design was a randomized complete block, with 10 single plant replications. Plant vegetative height, from the substrate surface to the tallest vegetative point (uppermost leaf tip), was measured at 14, 30 and 60 days after treatment (DAT) and at first and second flower. Plants were observed daily for flowering, and days to flower of the first and second inflorescence (DTFF and DTSF) recorded; inflorescence heights and scape lengths were measured at first and second flower. DTFF and DTSF were defined as the number of days from PGR application until the first fully opened bloom on the first and second inflorescence, respectively. Inflorescence height was measured from the substrate surface to the top of the inflorescence of the first fully opened flower. Scape length was measured from the base of the last fully open leaf on the shoot to the base of the inflorescence.

Following data collection at 60 DAT (July 15, 2000), six replications of each treatment were transplanted into the landscape with the remaining four replications left in containers to assess residual PGR effects. Thereafter, only vegetative heights of the containerized and landscape plants were recorded at 90, 120, and 150 DAT. The experimental design in the landscape was a randomized complete block design. Landscape beds contained an organic soil amended with non-composted pine bark [screen size <12.5 mm (0.5 in)] to a depth of 5–7.5 cm (2–3 in) and mulched with 2.5 cm (1 in) of pine bark. Plants were spaced about 60 cm (2 ft) on center in the landscape beds. Landscape beds were located in full sun and irrigated as needed. Data were analyzed using orthogonal contrasts to test rate responses within a PGR and to compare locations; control plants were included in regression analyses.

Results and Discussion

Increasing rates of Cutless suppressed vegetative height linearly 1–11% (14 DAT) and quadratically 13–27% (30 DAT) (Table 1). There was no delay in flowering on either the first or second inflorescence of Cutless treated plants (Table 2). In a previous study with canna lilies, Cutless effects on flowering varied from a six-day delay to an 11-day acceleration in flowering (4).

Vegetative height was suppressed quadratically by Cutless at first and second flower with treated plants 20–39% and

Table 1. **Vegetative heights (cm) of *Canna* x *generalis* 'Florence Vaughan' treated with Cutless, B-Nine/Cycocel, or Sumagic 14 through 60 DAT.**

		Container production		
	Rate (ppm)	**14 DAT**	**30 DAT**	**60 DAT**
	Control	52.9	68.3	99.1
Cutless	15	52.4	59.7	81.2
	30	48.1	49.6	68.1
	45	47.4	49.9	60.3
Significance[z]		L***	L***Q*	L***
	Control	52.9	68.3	99.1
B-Nine/Cycocel	2500/1500	52.9	59.6	72.6
	5000/1500	52.7	65.6	84.6
	7500/1500	53.0	63.5	82.0
Significance		NS	Q*	L*Q*
	Control	52.9	68.3	99.1
Sumagic	20	45.9	46.3	48.8
	40	46.0	46.7	48.6
	60	49.3	49.6	50.4
Significance		L*Q***	L***Q***	L***Q***

[z]Linear (L) or quadratic (Q) response at the 5% (*) or 0.1% (***) level. Control included in regression analysis.

21–33% shorter than controls, respectively (Table 2). At first flower, inflorescence heights were linearly suppressed 18–55% by increasing rates of Cutless, with a quadratic suppression of 23–43% at second flower. At first flower, inflorescence suppression of plants treated with 15 or 30 ppm Cutless was proportional to foliage, with both foliage and inflorescence 17–20% (15 ppm) and 36% (30 ppm), respectively, shorter than those of control plants. At these rates, inflorescences extended about 12 cm (5 in) above the foliage, and scape lengths were essentially the same as those of control plants. At second flower, inflorescences extended 11 cm (4.3 in) above foliage for plants treated with 15 ppm Cutless, but were suppressed to a height equal to foliage with 30 and 45 ppm Cutless. Scape lengths for the second flowering event were suppressed linearly with similar lengths at the lowest rate of Cutless to 33% shorter compared to those of control plants. No obvious differences in leaf orientation were observed at the 15 or 30 ppm rates compared to control plants. However, leaves of plants treated with 45 ppm Cutless appeared less upright during container production and similar in appearance to excessive vegetation suppression observed with canna lilies in a previous study (4).

At 60 DAT, vegetative height of Cutless-treated plants was linearly suppressed 18–40% with increasing rates compared to control plants (Table 1). These results are similar to a previous canna lily study, where height was suppressed by Cutless to a greater extent at 60 DAT than at 30 DAT (4). At 90, 120, and 150 DAT, location × rate interactions were nonsignificant, hence, data were pooled. At 90 DAT (Table 3), plants in containers and those transplanted into the landscape were similar in height. Plants in the landscape were 7 cm (3 in) and 11 cm (3.5 in) taller than in containers at 120 and 150 DAT, respectively. However in both locations, height was suppressed linearly by Cutless, 15–32% at 90 DAT and 7–12% at 120 DAT, respectively, compared to control plants. At the lowest rate of 15 ppm, this suppression was 15 cm (6 in) at 90 DAT and 7 cm (2.5 in) at 120 DAT, which would not likely be discernable by consumers. Height suppression from Cutless treatments dissipated completely by 150 DAT. During the dissipation of treatment effects, plants treated with all rates of Cutless grew more rapidly than control plants throughout the remainder of the study. The difference was most dramatic between 90 and 120 DAT with changes in height of 16 cm (6.3 in) at 15 ppm, 21.3 cm (8.4 in) at 30 ppm, and 30 cm (11.8 in) at 45 ppm compared to 8.3 cm (3.3 in) for control plants.

Vegetative height was suppressed quadratically during container production with increasing rates of B-Nine/Cycocel and was first evidenced at 30 DAT, with treated plants 5–14% (30 DAT), 9–14% (first flower), 16–28% (60 DAT), and 13–35% (second flower) shorter than control plants (Table 1 and 2). There was no delay in time to first or second flower (Table 2). First flower occurred about 50 DAT, with second flower occurring about 58 DAT. At first and second flower, inflorescence heights of treated plants extended above

Table 2. **Vegetative and inflorescence heights at first and second flower for *Canna* x *generalis* 'Florence Vaughan' treated with Cutless, B-Nine/Cycocel, or Sumagic.**

		First flower				Second flower			
	Rate (ppm)	**Days to flower**	**Vegetative height (cm)**	**Inflorescence height (cm)**	**Scape length (cm)**	**Days to flower**	**Vegetative height (cm)**	**Inflorescence height (cm)**	**Scape length (cm)**
Control	0	49	90.8	104.2	29.8	57	98.7	115.8	34.7
Cutless	15	50	73.0	86.3	29.8	58	78.3	89.3	34.1
	30	51	58.9	68.1	28.7	60	66.5	66.6	26.7
	45	51	55.6	46.4	14.9	57	66.7	66.4	23.7
Significance		NS	L***Q*	L***	L***Q***	NS	L***Q*	L***Q***	L***
B-Nine/Cycocel	2500/1500	49	64.8	75.1	26.1	62	64.6	68.6	24.75
	5000/1500	49	82.7	98.4	34.8	57	86.4	103	31.11
	7500/1500	51	78.4	87.5	29.3	61	84.7	97.5	36.6
Significance[z]		NS	Q**	Q*	NS	NS	Q***	Q**	Q***
Sumagic	20	51	44.3	29.0	4.7	62	44.5	30.6	5.8
	40	51	45.6	26.3	5.1	64	44.5	29.9	5.8
	60	51	48.0	27.7	4.6	61	47.5	44.3	11.8
Significance		NS	L***Q***	L***Q***	L***Q***	Q*	L***Q***	L***Q***	L***Q***

[z]Nonsignificant (NS), linear (L), or quadratic (Q) response at the 5% (*), 1% (**), or 0.1% (***) level. Control included in regression analyses.

Table 3. Vegetative heights (cm) of *Canna* x *generalis* 'Florence Vaughan' treated with Cutless, B-Nine/Cycocel, or Sumagic 90 through 150 days after treatment (DAT).

	Rate (ppm)	Vegetative heights (cm)					
		90 DAT		**120 DAT**		**150 DAT**	
		Across location					
	Control	102.2		110.5		119.2	
Cutless	15	87.4		103.5		115.0	
	30	76.4		97.7		112.1	
	45	69.7		99.7		115.8	
Significance[z]		L***		L*		NS	
Location × Rate		NS		NS		NS	
		Across Cutless rate[y]					
		Container	Landscape[x]	Container	Landscape	Container	Landscape
		78.9a	77.1a	98.8b	105.5a	107.5b	118.8a
		Container	Landscape	Container	Landscape	Landscape and Container Combined	
	Control	96.0a	106.3a	104.0a	114.8a	119.2	
B-Nine/Cycocel	2500/1500	65.0b	82.8a	87.2b	103.5a	108.0	
	5000/1500	87.2a	92.3a	98.3a	108.5a	111.9	
	7500/1500	96.5a	82.8a	106.0a	96.7a	112.9	
Significance		Q***	L**	Q*	L**	NS	
Location × Rate		* (0.05)		* (0.03)		NS	
		Across B-Nine/Cycocel rate					
						Container	Landscape
						104.6b	114.9a
		Across location					
						Container	Landscape
	Control	102.2		110.5		109.8b	125.5a
Sumagic	20	52.3		79.8		75.5b	112.2a
	40	53.5		76.0		63.0b	112.5a
	60	56.7		79.1		72.5b	108.3a
Significance		L*** Q***		L*** Q***		L*** Q***	L**
Location × Rate		NS		NS		* (0.013)	
		Across Sumagic rate[x]					
		Container	Landscape	Container	Landscape	Container	Landscape
		62.1b	70.8a	59.6b	92.4a	80.2b	114.8a

[z]Nonsignificant (NS), linear (L), or quadratic (Q) response at the 5% (*), 1% (**), or 0.1% (***) level. Control included in regression analysis.

[y]Control not included in contrasts comparing locations.

[x]Plants were transplanted to landscape 60 DAT (July 15, 2000).

foliage 9–16 cm (3.5–6.3 in) and 4–17 cm (1.5–6.7 in), respectively, compared to 14 and 17 cm (5.5 and 6.6 in) for control plants. Plants responded differently to increasing rates in the two locations. At 90 and 120 DAT, height was suppressed quadratically in containers, up to 33% (90 DAT) and 17% (120 DAT), and linearly in the landscape, 14–23% (90 DAT) and 6–16% (120 DAT) (Table 3). Plants treated with increasing rates of B-Nine/Cycocel responded differently to the two locations (container vs landscape). Containerized plants treated with the lowest rate of B-Nine/Cycocel were 21% and 16% shorter than those in the landscape at 90 and 120 DAT, respectively. This implies that growth suppression with the lowest rate of B-Nine/Cycocel was dissipating more quickly in plants transplanted into the landscape than in those maintained in containers. By 150 DAT, plants were no longer affected by B-Nine/Cycocel rate at either location, with transplanted plants slightly taller [10 cm (4 in)] than containerized plants.

The range of plant heights observed within each B-Nine/Cycocel treatment was much greater than those within control, Cutless, or Sumagic treatments. For example, plants treated with the lowest rate of B-Nine/Cycocel ranged in height at 60 DAT from 50–114 cm (20–45 in) [coefficient of variation (CV) 30.5, higher CV means greater range], compared to the height ranges of control plants of 81–114 cm (32–45 in) (CV 10.4), and the lowest rate of Cutless of 53–75 cm (21–30 in) (CV 13.9). The large range of variation within each of the B-Nine/Cycocel treatments suggests inconsistent height suppression and would result in an unpredictable, non-uniform crop.

Sumagic provided consistent, significant height suppression throughout container production; however, suppression included inflorescence retardation and alteration of leaf orientation. Vegetative height suppression, first evidenced at 14 DAT, was quadratic in response to increasing PGR rate throughout the study (Table 1). Treated plants were 6–14% (14 DAT) and 28–33% (30 DAT) shorter than control plants. There was no delay in flowering of the first inflorescence, but a three to seven day delay in flowering of the second (Table 2). Inflorescence height and scape length were suppressed by all Sumagic rates at first and second flower. Previous research with bedding plants has shown similar delayed flowering and stunted inflorescences with Sumagic at similar application rates (9). At first and second flower, inflorescences were 15 cm (6 in) to 21 cm (8 in) and 3 cm (1.2 in) to 15 cm (6 in) below foliage, respectively. Scape lengths were suppressed 85% at first flower and 65–83% at second flower. Inflorescence retardation was considered excessive and detracted from the floral display, which would likely reduce marketability. Vegetative heights at first and second flower were suppressed quadratically with increasing PGR rate from 47–52% (first flower) and 56% (second flower) compared to controls. Vegetative height at 60 DAT was quadratically suppressed with increasing PGR rate with treated plants 50–52% shorter than control plants (Table 1). At all Sumagic rates, leaf orientation appeared altered due to restriction of internode elongation. Similar results were observed with *Pyracantha* x 'Teton' with treated plants wider than tall, atypical of the normal plant form (15).

The excessive inflorescence retardation and altered leaf orientation of 'Florence Vaughan' canna lily were similar to effects from 100 and 150 ppm Cutless in a previous study with the same cultivar (4). The overall plant form, at these rates of Sumagic and with higher rates of Cutless, was uncharacteristic of canna lily and would likely be detrimental to marketability.

Interactions between plant location (container vs landscape) and Sumagic rate for plant height were not significant at 90 and 120 DAT. Therefore, main effects only are discussed. Plants remaining in containers were around 8 cm (3 in) shorter at 90 DAT and 33 cm (13 in) shorter at 120 DAT than those in the landscape regardless of Sumagic rate. With increasing Sumagic rates there was a quadratic suppression of 45–49% (90 DAT) and 29–31% (120 DAT) compared to controls in both locations. There was a significant interaction between Sumagic rate and plant location at 150 DAT, with greater height suppression in containers compared to plants transplanted into the landscape. Vegetative height of treated plants remaining in containers was suppressed quadratically 32–43% compared to a linear suppression of 11–14% with increasing PGR rate in transplanted plants. Evidence of canna lilies outgrowing treatment effects was seen in new shoot production that eventually increased in height above that of treated foliage. Plants remaining in containers were significantly pot-bound by 60 DAT, demonstrated by the visible distortion of their plastic pots from rhizomes and roots. New shoot production following transplanting into the landscape at 60 DAT appeared much greater than that of plants remaining in containers, resulting in taller plants exhibiting less overall suppression.

In summary, Cutless applied at 15 or 30 ppm was effective in controlling height of canna lily without any detriment to the overall floral display. Excessive inflorescence retardation and altered plant form observed with 45 ppm Cutless make this rate unacceptable for use on plants marketed in the season of application. Residual effects from Cutless were not influenced by plant location, and at 15 ppm treated plants were only 7% shorter than controls at 120 DAT with no suppression effects at 150 DAT.

At the rates tested, B-Nine/Cycocel provided height suppression without excessive inflorescence retardation or altered leaf orientation. However, large variations in height suppression were observed within B-Nine/Cycocel treatments and response was inconsistent with rate. Therefore, height suppression from B-Nine/Cycocel may be less predictable than with Cutless and possibly result in a non-uniform crop.

At the rates tested, Sumagic exhibited effective, but excessive height suppression during container production. Based on the excessive retardation of inflorescence height at all rates tested and altered plant form, plant marketability may be reduced, even at the lowest rate. Sumagic at rates below 20 ppm could provide height control without excessive retardation and suppression and may warrant further study. Height suppression at 20 ppm lessened by 120 DAT with treated plants 29% shorter than controls. Plants remaining in containers at 90 and 120 DAT were 15% and 36% shorter than those transplanted into the landscape across Sumagic rate and vegetative height was suppressed quadratically by Sumagic at both locations. By 150 DAT, there was greater height suppression from Sumagic in containers (32–43%) than in the landscape (11–14%). These results support previous research in which shoot growth was suppressed by restricting root volume (10, 14).

Literature Cited

1. Bailey, D. and B. Whipker. 1998. Height control of commercial greenhouse flowers. Horticulture Information Leaflet 528, North Carolina Cooperative Extension Service.

2. Banko, T.J. and M.A. Stefani. 1989. Effectiveness of growth retardants: paclobutrazol, uniconazole, and daminozide. Amer. Nurseryman 169:107.

3. Barrett, J.E. and T.A. Nell. 1986. Evaluation of XE-1019 and paclobutrazol for height control of flowering annuals. Proc. Plant Growth Reg. Soc. Amer. 13th annual meeting. St. Petersburg Beach, FL.

4. Bruner, L.L., G.J. Keever, C.H. Gilliam, and J.R. Kessler. 2000. Growth regulation of *Canna* x *generalis* 'Florence Vaughan'. J. Environ. Hort. 18:171–174.

5. Dasoju, S., M.R. Evans, and B.E. Whipker. 1998. Paclobutrazol drenches control growth of potted sunflowers. Hort Technology 8:235–237.

6. Gilbertz, D.A. 1992. Chrysanthemum response to timing of paclobutrazol and uniconazole sprays. HortScience 27:322–323.

7. Gok, Y.Y. and G. McDaniel. 1987. Growth retarding effects of uniconazole on bedding plant species. HortScience 22:315.

8. Hamada, M., T. Hosoki, and T. Maeda. 1990. Shoot length control of tree peony (*Paeonia suffruticosa*) with uniconazole and paclobutrazol. HortScience 25:198–200.

9. Keever, G.J. and W.J. Foster. 1991. Production and postproduction performance of uniconazole-treated bedding plants. J. Environ. Hort. 9:203–206.

10. Keever, G.J., G.S. Cobb, and R.B. Reed. 1985. Effects on container dimension and volume on growth of three woody ornamentals. HortScience 20:276–278.

11. Keever, G.J. and C.H. Gilliam. 1994. Growth and flowering response of butterfly-bush to Cutless. J. Environ. Hort. 12:16–18.

12. Latimer, J.G. 1991. Growth retardants affect landscape performance of zinnia, impatiens, and marigold. HortScience 26:557–559.

13. Latimer, J.G. and P.A. Thomas. 1997. Responses of nine containerized perennials to Sumagic. HortScience 32:593.

14. NeSmith, D.S. and J.R. Duval. 1998. Transplant production and performance: The effect of container size (Abstr). Hort Technology 8:495–498.

15. Norcini, J.G. 1991. Growth and water status of pruned and unpruned woody landscape plants treated with Sumagic (uniconazole), Cutless (flurprimidol), or Atrimmec (dikegulac). J. Environ. Hort. 9:231–235.

16. Pisarezyk, J.M. and W.E. Splittstoesser. 1979. Controlling tomato transplant height with chlormequat, daminozide, and ethephon. J. Amer. Hort. Sci. 104:342–344.

17. Still, S.M. 1994. Manual of Herbaceous Ornamental Plants. Stipes Publishing, L.L.C., Champaign, IL. p. 161.

18. Whipker, B.E. and S. Dasoju. 1998. Potted sunflower growth and flowering responses to foliar applications of daminozide, paclobutrazol, and uniconazole. HortTechnology 8:86–88.