Use of Growth Retardants to Promote Flowering of Mountain Laurel, *Kalmia latifolia* L.[1]

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Abstract

Spray treatments of the growth retardants A-Rest (ancymidol at 0, 53, 106 ppm), Bonzi (paclobutrazol at 0, 10, 50, 100, 200, 400, 600 ppm) and Sumagic (uniconazole at 0, 10, 25, 50, 75, 100, 200, 300 ppm) were applied to container-grown Mountain laurel (*Kalmia latifolia* L.) to evaluate their effectiveness for promotion of flower initiation and inhibition of shoot elongation. A-Rest had no effect on flower initiation at the concentrations tested. Bonzi promoted a moderate increase in inflorescences on one cultivar evaluated. Uniconazole sprays of 50 ppm or higher increased inflorescence numbers of most cultivars tested. Application in the spring to plants two years from propagation gave the most consistent results, however, with some cultivars, applications following the second growth flush as late as early August promoted flower initiation. Uniconazole treatments also reduced stem elongation resulting in more compact growth. Stem elongation was retarded with increasing concentrations of uniconazole for the growth flush in the spring in the year following treatment. The results of this study show that Sumagic (uniconazole) in the range of 50 to 75 ppm increases inflorescence numbers without excessive growth inhibition when applied in the spring to most cultivars two years from propagation.

Index words: growth regulator, growth retardant, flowering, flower initiation.

Chemicals used in this study: Sumagic (uniconazole), E-1-[4-chlorophenyl]-4,4dimethyl-2-[1,2,4-triazol-1-yl]-1-penten-3-ol; Bonzi (paclobutrazol), 2RS,3RS-1-[4-chlorophenyl]-4,4-dimethyl-2-[1,2,4-triazol-1-yl]-pentan-3-ol; A-Rest (ancymidol), alpha-cyclopropyl-alpha-(4-methoxy-phenyl)-5-pyrimidine methanol.

Significance to the Nursery Industry

Mountain laurel (*Kalmia latifolia* L.) tend to have excessive shoot growth during container production and often take more than three years from propagation to begin flowering. This study showed that spray applications of uniconazole (Sumagic) of 50 and 75 ppm promoted flower bud initiation when applied to most cultivars two years from propagation. Results were most consistent when treatments were applied in the spring following the first growth flush; however, with some cultivars, applications following the second growth flush as late as early August increased inflorescence numbers. Treated plants had a compact growth habit, and growth of the first flush in the spring following treatment was inhibited. This growth inhibition had the effect of making the flowers more visible over the surface of the plant. Paclobutrazol (Bonzi) increased inflorescence numbers for one cultivar evaluated but was generally less effective than uniconazole at the concentrations tested.

Introduction

Mountain laurel (*Kalmia latifolia* L.) is an ericaceous shrub native to the eastern United States. The inflorescence consists of a terminal flower cluster or corymb with numerous flowers, the open corolla of each being about 2.5 cm (1 in) across (4). These inflorescences or bud clusters develop in late summer to fall at stem terminals, the buds appearing very small and insignificant at that time. The buds enlarge the following spring and then open usually in late spring or early summer after new shoot growth has begun. *Kalmia* may be produced commercially either in field nurseries or in containers. They may reach landscape size after 2 years in production, however, many cultivars fail to begin flowering at that time. It would be commercially advantageous to have flowering plants at least by the third spring from propagation. Stuart (6) showed that the chemical growth retardants chlorphonium (Phosphon) and chlormequat chloride (Cycocel) could induce early flower initiation in *Rhododendron*. Jaynes (4) had some success in limiting vegetative growth and stimulating flower initiation on *Kalmia* using Cycocel and Phosphon. Gent (1, 2) reported control of stem elongation and promotion of flowering of *Kalmia* using the triazole chemicals paclobutrazol (Bonzi) and uniconazole (Sumagic). In this study, we evaluated uniconazole spray rates and application times on several *Kalmia* cultivars. Similar but not identical experiments were conducted at wholesale nurseries in both Virginia and North Carolina during the period from 1994 to 1997.

Materials and Methods

General cultural practices. *Virginia*. The experiments were conducted at Historyland Nursery in Montross, VA, with plants grown using standard cultural practices. Liners of *Kalmia latifolia* L. in 10 cm (4 in) pots were potted in May into 7.6 liter (2 gal) containers of composted pine bark medium amended with 2.7 kg/m^3 (4.5 lbs/yd^3) dolomitic limestone and 0.6 kg/m^3 (1.0 lb/yd^3) Micromax then top-dressed with 10 g (0.35 oz) Nursery Special 12N–2.6P–5K (12–6–6, 3 month formulation). The plants were grown outdoors, on gravel beds, under full sun for the remainder of the growing season. Following overwintering in polyethylene-covered houses, these plants provided the 1 year (2 gal) material for experiments initiated in the spring. The 7.6 liter (2 gal) plants, re-planted into 19.0 liter (5 gal) containers in August of their

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second season and later overwintered, provided the 2 year (5 gal) plants for the Virginia experiments referred to below.

North Carolina. The experiments were conducted at Buds and Blooms Nursery, Brown Summit, NC. *Kalmia* in 3.8 liter (1 gal) containers that were re-planted into 11.4 liter (3 gal) containers in May of their second season provided the 2 year (3 gal) plants for the North Carolina experiments referred to below. Medium was 80% composted pine bark, 20% sphagnum peat (by vol) amended with 3 kg/m^3 (5.0 lbs/yd^3) dolomitic limestone, 0.6 kg/m^3 (1 lb/yd^3) STEP, and 6 kg/m^3 (10 lbs/yd^3) Scott ProKote Plus 20N–1.3P–8.3K (20–3–10). The plants were maintained outdoors on gravel beds during the growing season.

General experimental procedures. Plants were treated in the first or the second year from propagation as described above. In 1994, spray solutions of paclobutrazol (Bonzi formulation, Uniroyal Chemical Co., Naugatuck, CT) and uniconazole (Sumagic formulation, Valent U.S.A. Corp., Walnut Creek, CA) were applied to wet the leaves and stems. In subsequent years, only the uniconazole was used for treatments with the exception of the 1996 North Carolina experiment, which included spray treatments of ancymidol (A-Rest formulation, SePRO Corp., Carmel, IN). Sprays were applied with a CO_2-pressurized sprayer at 235 kPa (34 psi) using volumes of approximately 25 ml (0.85 oz) per plant for the 1 year (2 gal) plants and 50 ml (1.7 oz) per plant for the 2 year (5 gal) plants in Virginia. In the North Carolina experiments, a volume of 40 ml (1.3 oz) per plant was used for the 2 year (3 gal) plants. All experiments utilized a completely randomized design with each cultivar treated as a separate experiment.

1994 Experiments. Virginia. *Kalmia* ‘Freckles’, ‘Carol’, and ‘Bullseye’ were used. ‘Freckles’ and ‘Carol’ were 1 year plants, while the ‘Bullseye’ were 2 year plants. On May 20, 1994, following the first growth flush of the season, the plants were sheared lightly and spray treatments of paclobutrazol at 0, 10, 50, 100, 200, 400, and 600 ppm, or of uniconazole at 0, 10, 50, 100, 200, and 300 ppm were applied. Five single-plant replicates per treatment were used for each cultivar. The plants were grown at the nursery in full sun, under standard cultural conditions. On October 6, 1994, stem terminals with flower buds (inflorescences) were counted, and lengths of the three longest shoots from the point of shearing were obtained.

1995 Experiments. Virginia. On May 26, 1995, following the first growth flush of the season, spray treatments of uniconazole at concentrations of 0, 25, 50, 100, 150 and 200 ppm were applied to both 1 year and 2 year plants of Kalmia ‘Nipmuck, ‘Olympic Fire’, and ‘Bullseye’. The plants were sheared lightly to shape just prior to treatment. On July 20, after the second growth flush, the same treatments were applied to an additional set of plants of the same age and cultivars as used for the May treatments. These plants were not sheared prior to treatment but had been sheared after their first growth flush at the same time as the first group of plants. Five single-plant replicates per spray treatment were utilized for each of the two application dates in a 2-factor factorial experiment (cultivars and age groups were treated as separate experiments). Plants were maintained as previously described. On November 11, 1995, inflorescences were counted and plant heights were measured. On May 24, 1996, inflorescence counts were confirmed and lengths of new (spring growth) shoots were measured.

North Carolina. On May 18, 1995, after the first growth flush, spray treatments of uniconazole at concentrations of 0, 50, 100, and 200 ppm were applied to unsheared, 2 year (3 gal.) plants of Kalmia ‘Bullseye’, ‘Carousel’, and ‘Olympic Fire’. Ten single-plant replicates per treatment were utilized. In November, inflorescences were counted and 5 of the longest stems per plant were measured. Following evaluation, three representative plants of each treatment from each cultivar were taken to the Mountain Horticultural Crops Research and Extension Center, Fletcher, NC, where they were planted into simulated landscape plots in a completely randomized design in the spring of 1996. These plants were evaluated for growth and survival in the spring of 1997.

1996 Experiments. Virginia. *Kalmia* ‘Nipmuck’, ‘Olympic Fire’, and ‘Bullseye’, both 1 year and 2 year plants were used. Sprays of uniconazole at 0, 50, 75, 100, and 150 ppm were applied on June 6, following the first growth flush. The plants were sheared lightly just prior to treatment applications. On August 2, following the second growth flush, the same spray treatments were applied to another set of plants of the same cultivars and ages as the earlier set, without prior shearing. Five plants per spray treatment were used for each of the two application dates, in a 2-factor factorial experiment (cultivars and age groups were treated as separate experiments). On October 15, plants were evaluated by counting the number of inflorescences, and by measuring plant heights from the surface of the container medium. Inflorescences were recounted and lengths of new shoots were measured on May 6, 1997.

North Carolina. Two year unsheared plants of ‘Nipmuck’, ‘Olympic Fire’, and ‘Carousel’ were used. Uniconazole sprays were applied at 0, 75 or 150 ppm or ancymidol (A-Rest) sprays were applied at 53 or 106 ppm following the second growth flush on August 14, 1996. Ten single-plant replications per treatment of each cultivar were used. Height, width and number of inflorescences for each plant were determined on November 12.

1997 Experiments. Virginia. *Kalmia* ‘Nipmuck’, ‘Olympic Fire’, and ‘Carousel’, 2 year (5 gal) plants were used. Spray treatments of uniconazole at 0, 75, 100, or 150 ppm were applied on June 5, following the first growth flush, to unsheared plants and to plants that had been sheared lightly just prior to treatment. On August 8, following the second growth flush, the same spray treatments were applied to another group of randomly selected sheared and unsheared plants of the same cultivars and size as for the June treatments. Five plants per spray treatment were used for each of the two application dates and the two shearing treatments in a 3-factor factorial experiment (cultivars were treated as separate experiments). Plants were evaluated on November 19 by counting the number of inflorescences and by measuring plant heights from the surface of the container medium.

North Carolina. Two year unsheared plants of *Kalmia* ‘Minuet’, ‘Sarah’ and ‘Richard Jaynes’ were treated with sprays of uniconazole at 0, 50, 75, 100, and 150 ppm on July 2, 1997. Five plants per treatment for 'Minuet' and 'Sarah', and 4 plants per treatment for 'Richard Jaynes' were used. Height, width and number of inflorescences were recorded for each plant on November 19.

Data for all experiments were subjected to analysis of variance or factorial analysis of variance where appropriate. One-way analysis of variance with single degree of freedom orthogonal polynomial contrasts were used where rate response to uniconazole concentrations were tested, or Dunnett's test (5) at $P \leq 0.05$ was used to compare treatment means to control means.

Results and Discussion

1994 Experiments. The uniconazole treatments promoted a moderate increase in the number of inflorescences for 'Freckles' (linear response), 1 year plants, and a large increase (quadratic response) for 'Bullseye', the 2 year plants (Table 1). Applications of uniconazole to the 1 year 'Carol' plants appeared to promote inflorescence development, but the increase was non-significant at P = 0.05. For 'Freckles' and 'Bullseye', uniconazole concentrations of 50 ppm and above were particularly effective. Paclobutrazol increased the number of inflorescences for 'Freckles' (linear response) but 'Carol' and 'Bullseye' plants were unaffected. For those treatments that resulted in increases in the number of inflorescences, shoot growth decreased correspondingly with increasing treatment concentrations. Growth regulator treatments that increased the number of inflorescences also reduced shoot growth in the spring of the year after treatment application. (data not shown).

1995 Experiments. Virginia. Although the 1 year 'Nipmuck' plants failed to develop inflorescences with treatment applications either in May or July, treatment date had a major effect on inflorescence development for the 1 year plants of 'Olympic Fire' and 'Bullseye'. The 1 year plants of these two cultivars initiated inflorescences when treatments were applied after the second growth flush in July, but not if applied after the first flush (data not shown). Concentrations of 50 to 100 ppm uniconazole were most effective in promoting inflorescence formation for these plants. The 1 year 'Olympic Fire' treated with 50 ppm uniconazole in July responded with a mean of 27 inflorescences vs. 0 for the controls. One year 'Bullseye' with the same treatment developed a mean of 34 inflorescences vs. a mean of 7 for the controls. The 2 year 'Nipmuck' and 'Olympic Fire' plants initiated inflorescences when treatments were applied to either the first or second growth flush. All treatments of 50 ppm and above resulted in increases in inflorescences (Fig. 1). Inflorescence numbers were unaffected by application time, however, plant height was affected by application time. Treatments applied in July resulted in plants that were larger than when treatments were applied in May. This result is due to the July treatments being applied after the second growth flush was completed. However, shoot growth the following spring was generally retarded more if the treatments were applied in July, after the second growth flush (data not shown; similar growth responses were observed in 1996, with data

Table 1. Effect of paclobutrazol and uniconazole concentration on number of inflorescences and on shoot growth for three *Kalmia* cultivars either one year in production ('Freckles' and 'Carol', 2 gal containers) or two years in production ('Bullseye', 5 gal containers) (Virginia, 1994).

	Cultivar					
	'Carol'		'Freckles'		'Bullseye'	
Paclobutrazol conc. (ppm)	Inflorescences[z]	Shoot length (cm)[y]	Inflorescences	Shoot length (cm)	Inflorescences	Shoot length (cm)
0	3	23.4	7	26.0	18	22.3
10	0	27.4	16	16.0	22	26.7
100	0	30.2	13	18.4	17	22.0
200	2	20.6	9	20.0	23	21.7
400	0	23.2	20	14.4	35	20.7
600	1	22.4	34	3.2	18	21.7
Significance[x]	NS	NS	$L^{0.0001}$	$L^{0.0002}$	NS	NS
Uniconazole conc. (ppm)						
0	0	29.2	13	31.6	9	14.7
10	1	14.4	7	21.0	26	21.3
50	5	19.2	28	14.4	49	23.7
100	9	3.0	28	5.4	89	16.3
200	15	7.2	27	3.6	83	8.7
300	7	2.6	29	5.2	94	6.0
Significance	NS	$Q^{0.001}$	$L^{0.02}$	$Q^{0.0001}$	$Q^{0.0009}$	$L^{0.0003}$

[z]Mean number of inflorescences per plant.

[y]Shoot length = mean of the three longest shoots measured from the point of shearing. Measurements taken 140 days after treatment.

[x]Regression response linear (L) or quadratic (Q) at the indicated probability level, or not significant (NS) at $P \leq 0.05$.

Fig. 1. ***Kalmia* 'Olympic Fire' treated after 2 years in production (beginning the 3rd season) with uniconazole sprays of 200, 150, 100, 50, 25, and 0 ppm (left to right). Sprays were applied on July 20, 1995, following the 2nd growth flush of the season. Photo was taken in the spring of 1996.**

presented in Tables 3 and 4). The 2 year 'Bullseye' plants were excluded from the study due to excessive plant death/ disease, apparently from *Phytophthora* root rot.

North Carolina. *Kalmia* 'Bullseye', 'Carousel' and 'Olympic Fire' all responded to increased concentrations of uniconazole from 50 to 200 ppm by increasing numbers of inflorescences . 'Carousel' was the most responsive with the 200 ppm-treated plants developing a mean of 61 inflorescences per plant compared to a mean of 2 inflorescences per plant for the controls (Table 2). Height measurements of these plants in a simulated landscape in 1997 showed that growth of 'Carousel' and 'Olympic Fire', treated in 1995 with 200 ppm uniconazole, continued to be retarded by about half that of the controls (data not shown). Those plants treated with 50 and 100 ppm lacked any measurable effects on height control. The 'Bullseye' plants treated in 1995 grew normally regardless of the treatments used. All of the 1995-treated plants that were transplanted to the simulated landscape developed inflorescences in the fall of 1996 and flowered normally in 1997; however, inflorescence counts were not taken at that time.

1996 Experiments. Virginia. Unlike the results of 1995, none of the 1 year plants produced inflorescences regardless of cultivar (data not shown). The reason for this difference from the 1995 results is unknown. Treatment applications were made a few days later than they were in 1995 but the plants appeared to be at about the same stage of development. Possibly environmental differences affected physiological maturity enough so that these younger plants failed to produce inflorescences in response to the treatments, even though shoot growth was inhibited to levels similar to those in 1995.

The 2 year plants did increase inflorescence numbers in response to uniconazole treatments. There was a significant interaction effect between application date and concentra-

Table 2. Effect of uniconazole concentration on number of inflorescences for three *Kalmia* cultivars two years in production (3 gal containers). Spray treatments were applied May 18, 1995, following the first growth flush of the season (North Carolina experiment, 1995).

Uniconazole conc. (ppm)	Cultivar: 'Carousel' Inflorescences[z]	'Olympic Fire' Inflorescences	'Bullseye' Inflorescences
0	2	0	0
50	37*	4	8
100	41*	9*	12*
200	61*	14*	16*

[z]Mean number of inflorescences per plant. Asterisk (*) following means within columns indicates significant difference from the control (0 ppm) at the 5% level with Dunnett's test.

tion on inflorescence numbers for 'Nipmuck' (Table 3). 'Nipmuck' had a large increase in inflorescence numbers with increased uniconazole concentration when application was after the first growth flush, while there was no increase in inflorescence numbers when application followed the second flush. 'Bullseye' increased inflorescence numbers in response to uniconazole concentration when the application followed either the first or the second growth flush, however, the increase was greater when application followed the first flush. 'Olympic Fire' also produced more inflorescences when applications followed the first growth flush. In 1995, application of treatments to the second flush of 2 year plants resulted in a flowering response similar to application to the first flush. The better flowering response from treatments applied following the first growth flush is more consistent with the results obtained by Gent (2) who observed better flower bud initiation with applications earlier in the season.

There was a significant uniconazole application date by concentration interaction effect on plant height for 2 year 'Nipmuck' and 'Olympic Fire' (Table 3). Increased concentrations of uniconazole resulted in reduced height for these cultivars when application was after the first growth flush, while there was no significant reduction in height due to concentration when application was following the second flush. Uniconazole caused reduced plant height for 'Bullseye' when applied following either the first or the second growth flush.

Stem elongation of the 1996-treated plants continued, for the most part, to be inhibited through the first growth flush of 1997 (Table 4). There was a significant interaction effect between uniconazole concentration and application date for the 1 year 'Nipmuck' plants. For these plants, there was a greater reduction in shoot growth at the 150 ppm concentration when application was after the first flush rather than after the second flush, however, there was a greater reduction in shoot growth at the 50 and 75 ppm concentrations when application followed the second growth flush as opposed to the first flush. There was also a significant concentration and application date interaction effect for the 1 year 'Bullseye' plants. For these plants, uniconazole application after the first flush in 1996 had no effect on shoot growth in the spring of 1997, while application after the second flush in 1996 resulted in shoot growth in the spring of 1997, which decreased in a linear manner with increasing uniconazole concentration. Only the 2 year 'Nipmuck' and the 1 year 'Bullseye' plants treated in June 1996 showed no significant growth inhibition during the spring growth flush of 1997. In all other cases, stem elongation decreased in a linear manner with increasing uniconazole concentration for treatment applications both in June and in August of 1996 (Table 4). Gent (3) showed uniconazole in the range of about 0.4 to 0.6 mg per plant reduced stem elongation to half that of the control in the year following treatment of *Kalmia*. Our measurements are only for the first growth flush rather than for the entire season after the year of treatment; however, it appeared that inhibition of stem elongation of our plants was less than that of Gent's plants. Our application rates were from 2.5 to 7.5 mg per plant for the 2 year plants and, only at the higher rates, achieved a reduction in stem elongation approximately half that of the controls for the first growth flush. Perhaps greater growth reduction would have been seen if measured for the entire year or, differences in cultivars or climate may account for differences in growth response.

North Carolina. A comparison of growth indices taken in mid-August, 1996, vs. mid-November, 1996, showed that applications of uniconazole in August reduced additional

Table 3. Effect of uniconazole concentration and application date on number of inflorescences and on plant height for three *Kalmia* cultivars two years in production (5 gal containers) (Virginia experiment, 1996).

Uniconazole conc. (ppm)	Cultivar					
	'Nipmuck'		'Olympic Fire'		'Bullseye'	
	Inflorescences[z]	Height (cm)	Inflorescences	Height (cm)	Inflorescences	Height (cm)
	Application after 1st growth flush (June 6, 1996)					
0	20	68.0	6	70.5	13	72.8
50	84*	58.3*	20	57.8*	23	67.3
75	94*	52.0*	19	55.3*	67*	55.8*
100	100*	54.5*	30	53.5*	54	62.0*
150	94*	50.5*	47	52.0*	69*	59.8*
	Application after 2nd growth flush (August 2, 1996)					
0	19	64.8	0	65.8	16	77.3
50	30	66.0	3	60.0	12	69.0
75	29	63.8	2	62.8	25	68.0*
100	18	63.5	4	62.8	11	68.3*
150	23	63.0	2	62.5	45*	65.5*
Significance[y]						
Appl. date (D)	0.0001	0.0001	0.0001	0.0009	0.0004	0.0001
Conc. (C)	0.0001	0.0005	NS	0.0001	0.0002	0.0001
D × C	0.0001	0.0057	NS	0.007	NS	NS

[z]Mean number of inflorescences per plant. Asterisk (*) following means within columns indicates significant difference from the control (0 ppm) at the 5% level with Dunnett's test.

[y]P values for factors indicated. NS not significant at P ≤ 0.05.

Table 4. Effect of uniconazole concentration and application date on stem length (cm) of the first growth flush of 1997 for *Kalmia* cultivars. Treated in 1996 when one or two years in production (2 and 5 gal containers, respectively) (Virginia experiment, 1996).

Uniconazole conc. (ppm)	Cultivar					
	'Nipmuck'		'Olympic Fire'		'Bullseye'	
	1 year[z]	2 year	1 year	2 year	1 year	2 year
	Application after 1st growth flush (June 6, 1996)					
0	12.6[y]	11.0	14.6	14.3	14.0	13.8
50	12.4	10.5	11.6	10.8	13.4	12.5
75	8.8	8.8	10.2	8.5	14.0	9.3
100	8.8	9.5	8.8	6.7	14.4	10.5
150	4.8	9.7	6.6	6.3	14.4	9.5
Regressions[x]	$L^{0.0001}$	NS	$L^{0.0001}$	$L^{0.0001}$	NS	$L^{0.0007}$
	Application after 2nd growth flush (August 2, 1996)					
0	13.8	9.5	14.2	13.8	14.2	12.0
50	10.6	8.3	10.2	9.5	11.8	12.3
75	6.4	8.0	8.0	7.3	10.2	10.3
100	8.8	7.5	7.8	5.5	9.4	9.3
150	8.0	6.8	6.6	5.8	8.0	8.3
Regressions	$L^{0.0001}$	$L^{0.0001}$	$L^{0.0001}$	$L^{0.006}$	$L^{0.0001}$	$L^{0.01}$
Significance[w]						
Appl. date (D)	NS	0.0004	0.024	0.033	0.0001	NS
Conc. (C)	0.0001	NS	0.0001	0.0001	0.02	0.0004
D × C	0.0025	NS	NS	NS	0.003	NS

[z]Plants were 1 year or 2 years in production when treatments were applied the year before shoots were measured.

[y]Mean stem length (cm) of the three longest shoots per plant of the first growth flush of 1997 on plants treated in 1996.

[x]Regression response linear (L) at the indicated P value or not significant (NS) at $P \leq 0.05$. Control included in regression, n = 5.

[w]P values for factors indicated. NS not significant at $P \leq 0.05$.

Table 5. Effect of uniconazole concentration, shearing, and application date on number of inflorescences for three *Kalmia* cultivars two years in production (5 gal containers) (Virginia experiment, 1997).

Uniconazole conc. (ppm)	Cultivar					
	'Nipmuck'		'Olympic Fire'		'Carousel'	
	Shear	No shear	Shear	No shear	Shear	No shear
	Application after 1st growth flush (June 5, 1997)					
0	6[z]	0	0	0	7	7
75	0	16	6	35*	28	75*
100	0	6	4	34*	35	63*
150	5	9	15	22	32	73*
	Application after 2nd growth flush (August 7, 1997)					
0	0	0	0	0	8	22
75	0	0	2	9	17	53*
100	0	0	2	2	38*	91*
150	0	0	0	4	23	60*
Significance[y]						
Application date (D)	0.0007		0.0001		NS	
Shear (S)	NS		0.0004		0.0001	
Concentration (C)	NS		0.005		0.0001	
D × S	NS		NS		0.03	
S × C	NS		NS		0.01	
D × S × C	NS		NS		NS	

[z]Mean number of inflorescences per plant. Asterisk (*) following means within columns indicates significant difference from the control (0 ppm) at the 5% level with Dunnett's test.

[y]P values for factors indicated. NS not significant at $P \leq 0.05$.

growth during that three-month period from 57% for 'Olympic Fire' (75 ppm) to 100% for 'Nipmuck' (150 ppm). However, none of the plants treated with uniconazole this late in the season developed inflorescences (data not shown). Apparently the August 14 application date was too late to stimulate flower initiation. This result was consistent with studies by Gent (2) who found that *Kalmia* treated with either paclobutrazol or uniconazole on August 25 failed to initiate flower buds although earlier treatments stimulated flower bud initiation.

Ancymidol treatments failed to affect either growth inhibition or inflorescence production (data not shown).

1997 Experiments. Virginia. Uniconazole application promoted an increase in inflorescences on 'Olympic Fire' when applied to unsheared plants in June following the first growth flush. There was little increase in inflorescences when treatments were applied to sheared plants in June or if applied to sheared or unsheared plants in August (Table 5). There was a significant shearing by uniconazole concentration interaction for 'Carousel'. The number of inflorescences on 'Carousel' increased greatly when uniconazole was applied to unsheared plants. There was little increase, however, when applied to sheared plants (Table 5). This response was similar for applications made either in June or in August. These results indicate that shearing the plants prior to treatment reduces the promotion of inflorescence development due to uniconazole treatments. Although uniconazole reduced shoot growth of 'Nipmuck', flowering was little affected due to these treatments. This result was surprising because 'Nipmuck' responded to uniconazole with large increases in inflorescences in 1995 and 1996.

North Carolina. Uniconazole treatments applied July 2 promoted large increases in numbers of inflorescences on both 'Minuet' and 'Sarah' (data not shown). Optimum concentration for both of these cultivars was 50 ppm in this experiment. Plants treated with 50 ppm uniconazole produced a mean of 39 inflorescences for 'Sarah' and 62 inflorescences for 'Minuet' vs. 2 and 1 respectively for the controls. Higher concentrations failed to increase flowering for 'Minuet', and promoted only a slight increase for 'Sarah'. Growth indices for these two cultivars were also greatly reduced by uniconazole treatments. The 50 ppm treatment reduced growth for the season for both cultivars by approximately 75% compared to the controls. Flowering response of 'Richard Jaynes' was unaffected.

We found under the conditions of our experiments that spray treatments of uniconazole in the range of 50 to 75 ppm significantly increased inflorescence numbers for most cultivars of *Kalmia* evaluated. Some, but not excessive, growth inhibition of the first flush the spring following treatment was also observed. This result could be considered desirable in that the flowers are exposed rather than covered by long vegetative shoots and are, therefore, more visible. Spray concentrations in this range provided about 2.5 to 3.8 mg/plant to plants two years from propagation. Gent (1, 2) found uniconazole sprays of 1.5 to 12 ppm or 0.15 to 1.2 mg/plant to be effective on *Kalmia* plants of the same age. This apparent difference in dose response may be due to cultivar differences or differences in growing conditions. They could also be due to differences in application technique. Gent used higher spray volumes (100 ml/plant) utilizing repeated applications. This technique may allow for more efficient uptake of the chemical by the plant as opposed to a one-time spray of lower volume. However, Gent also reports fewer inflorescences (2–10 per plant) than we often obtained with the higher doses.

Our most consistent results were obtained with plants that were two years from propagation although in the 1994 and 1995 experiments uniconazole treatments stimulated inflorescence development on plants only one year from propagation. Why this response was obtained in some years and not others is unknown. Jaynes (4) suggested a certain minimum size has to be reached before flowering can be induced. Growing conditions the year prior to treatment may influence attaining this critical size. With some cultivars, uniconazole treatments applied as late as early August promoted flower bud initiation; however, application early in the growing season following the first growth flush gave the most consistent results.

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