SECTION 7
GROWTH REGULATORS

Dr. Will Witte, Section Chairman
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Suppression of Basal Sprouts on *Betula nigra*

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Nature of Work: River birch, *Betula nigra, is* considered a valuable landscape plant for both its tolerance to poorly drained sites as well as attractive exfoliating bark. Trees are most frequently sold as three to five trunk or as single trunk specimens. Both forms sell best with exfoliating bark visible.

River birch frequently produces multiple basal sprouts during the first few years of nursery production. These sprouts must be removed by repeated pruning to allow the development of single or three to five stem specimens as well as to facilitate performing cultural practices near the base of the tree. Any cultural practice that would reduce or eliminate the need for pruning would be welcome by river birch growers.

NAA sprays have demonstrated effectiveness in controlling basal sprouts on many crops (1,2,3). Therefore, tests were established on river birch to determine whether NAA sprays: 1. could reduce or eliminate the need for pruning and 2. were phytotoxic.

Experiment 1: On June 18, 1991 all sprouts and branches were removed from a height below 3 ft. then the basal two feet of each stem was sprayed with either water or aqueous solutions of 0.5, 1.0 or 2.0% NAA prepared from the commercial product ‘Tre-Hold’ (15.1% 1-Naphthaleneacetic acid, ethyl ester). The total number of sprouts per tree were counted at the end of the growing season. There were four trees per treatment in each of three replicates in a RCB design.

Experiment 2: March 17, 1992 trees were prepared as in Experiment 1, utilizing the same experimental design, then sprayed with 0.00, 0.25, 0.50 or 1.00 % NAA. Sprouts were counted on June 29, 1992.

Experiment 3: Sprouts and branches were not removed. March 17, 1992 plants were sprayed with 0.0, 0.5 or 1.0% NAA. Treatment consisted of single trees with five replicates in a completely random design.

Monthly visual inspection was made for phytotoxicity in all three experiments.

Results and Discussion: The results of experiment one (Table 1) were promising with all three spray treatments having significantly fewer basal sprouts and no phytotoxicity. However, there were no significant differences among NAA concentrations.

In experiment two (Table 1) a lower rate, 0.25% NAA, was added to the test to determine whether a lower concentration could be used and still suppress sprout development. Fifteen weeks after spraying, all NAA treatments had significantly fewer basal sprouts than the control with no significant difference among NAA treatments. No phytotoxicity occurred as a result of spring NAA spray application.

Table 1. Number of basal sprouts on trunk pruned river birch following spraying with NAA.

Percent NAA	1991	1992
Control	7.6 a	1.9 a
0.25		0.3 b
0.50	2.5 b	0.3 b
1.00	1.2 b	0.0 b
2.00	0.3 b	

*Rp05 Duncan's New Multiple Range Test

Experiment three was designed to determine whether pruning was necessary before spraying. These trees were not pruned before they were sprayed. Existing basal sprouts were not burned back or damaged by the sprays. No significant differences existed in the number of basal sprouts present after fifteen weeks regardless of spray concentration.

Significance to Industry: 1. NAA sprays significantly reduced the number of basal sprouts occurring on field grown river birch while causing no phytotoxicity. While sprouts were not eliminated entirely in all trees, labor needed to prune should be drastically reduced. The duration of this response and the possible need for annual or more frequent reapplication has not yet been determined. 2. Trees must have existing basal sprouts removed before they are treated. NAA sprays will not control existing sprouts at the concentrations tested.

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Chemical Growth Control of Container-Grown Woody Plants

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Nature of Work: During nursery production, container-grown woody plants often require frequent trimming or shearing to control vegetative growth and to improve plant form. Chemical growth regulators are an alternative possibility for controlling growth of some of these plants. Some gibberellin biosynthesis inhibitors have shown promise in controlling growth and maintaining desirable form for woody plants (1).

In this study, we evaluated granular and wettable powder (spray) forms of flurprimidol (Cutless). These were compared with dikegulac sodium (Atrimmec), and Off-Shoot-O, an older chemical pinching agent. Plants used in the study included Abelia grandiflora, Cotoneaster dammeri 'Coral Beauty', Photinia x fraseri, and Ilex x attenuata 'Fosteri'. All were beginning their second season of growth at the time the treatments were applied. They had been stepped up to 3 gallon containers except for the Abelia, in 1 gallon containers. The medium was 4 parts pine bark, 1 part sand, with 4 lbs./cu. yd. dolomitic limestone, 13 lbs. Osmocote 17-7-12, and 1.5 lbs Micromax incorporated. The plants were sheared lightly to a uniform size and shape (according to species) prior to application of the treatments. Only the Off-Shoot-O treatments and an unsheared control treatment were not sheared. There were 5 single-plant replicates of each treatment for each plant species, in a completely randomized design.

The spray treatments were applied with a CO_2 sprayer set at 30 psi. The spray was applied with sufficient volume to completely wet the foliage. The Cutless spray treatments were prepared from Cutless 50W to provide active ingredient concentrations of 600, 800, and 1000 ppm. An Atrimmec treatment was applied at 4440 ppm to all species except Abelia which received 1480 ppm (label recommendations). The Off-Shoot-O was applied to unsheared plants at a concentration of 3 oz./qt. (label recommendation). Water sprays were applied to sheared and unsheared plants for controls. Cutless 0.33G granular treatments were applied manually at rates of 0.5, 1.0, and 1.5 lb./Acre by spreading the granules evenly over the surface of the container medium. All treatments were applied on 9 May 1991. The plants were measured 28 Aug. 1991.

Results and Discussion: Effects of treatments on plant heights and widths are summarized in Tables 1 and 2. Treatment effects on Abelia were primarily on width due to the arching growth habit. All Cutless treatments on Abelia resulted in more compact plants with shorter internodes. Significantly reduced widths were obtained with the 800 ppm spray, and 1.5 lb./A granules. The Atrimmec spray (1480 ppm) also produced very compact plants and stimulated increased branching and shoot development toward the center of the plant.

Cotoneaster also exhibited differences in width due to reduced shoot elongation from the Cutless and Atrimmec treatments. Very attractive, compact plants were obtained with the 600 ppm spray and the 0.5 lb/A G Cutless treatments.

Ilex 'Fosteri' and Photinia are both plants that exhibit a strongly upright growth habit. Therefore, the greatest differences were seen in plant height. Ilex 'Fosteri' have a tendency to send up a single main leader, leaving the center of the plant rather sparse. The Cutless treatments prevented the main leader from elongating excessively, producing very attractive, compact shrubs. Atrimmec also produced compact Ilex plants, with more dense shoot growth due to the stimulation of branching. Photinia is a very rapidly growing plant that can quickly outgrow its container. Significant height reductions were obtained with all Cutless treatments and with Atrimmec. The plants appeared normal otherwise.

Significance to the Industry: Both Cutless and Atrimmec were very effective in controlling excess shoot elongation and maintaining compact growth of Abelia, Cotoneaster, Photinia, and Ilex 'Fosteri'. Cutless controlled shoot elongation without stimulating additional branching, while Atrimmec promoted branching on Abelia, and Ilex 'Fosteri'. The Off-Shoot-O treatments were not significantly different from the controls for any of the plants evaluated.

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Table 1. Effects of Cutless, Atrimmec and Off-Shoot-O on growth of Abelia and Cotoneaster.

	Abelia		Cotoneaster	
Treatments	Height[z]	Width	Height	Width
Trimmed Control	42.2a	67.0a	54.2a	108.0a
Cutless W 600 ppm	32.0ab	59.1ab	41.0bc	76.8b
Cutless W 800 ppm	36.2ab	52.3bc	34.6cde	60.3bc
Cutless W 1000 ppm	36.6ab	55.5abc	34.2cde	57.4c
Cutless G 0.5 lb/A	34.0ab	56.0abc	33.2cde	71.3bc
Cutless G 1.0 lb/A	35.4ab	55.6abc	29.8e	69.5bc
Cutless G 1.5 lb/A	32.4ab	53.3bc	30.6de	58.9c
Atrimmec[y]	26.8b	43.7c	41.4bc	62.6bc
Off-Shoot-O	38.0ab	68.4a	47.0ab	107.1a
Untrimmed Control	36.4ab	61.3ab	40.8bcd	117.8a

[z]Measurements in centimeters. Mean separations within columns by LSD, 5% level.

[y]Atrimmec concentration 1480 ppm for Abelia, 4440 ppm for Cotoneaster.

Table 2. Effects of Cutless, Atrimmec and Off-Shoot-O on growth of Ilex 'Fosteri' and Photinia.

Ilex		Photinia		
Treatments	Height[z]	Width	Height	Width
Trimmed Control	82.0c	51.4b	109.2ab	56.9abc
Cutless W 600 ppm	56.6def	39.Id	67.2e	55.0abc
Cutless W 800 ppm	56.0def	36.8d	63.2e	46.6c
Cutless W 1000 ppm	50.2f	36.8d	74.8de	50.2bc
Cutless G 0.5 lb/A	65.2d	42.5cd	96.8bc	62.0a
Cutless G 1.0 lb/A	64.8de	40.Id	78.2cde	54.5abc
Cutless G 1.5 lb/A	52.6ef	41.2cd	74.8de	62.8a
Atrimmec 4440 ppm	54.2def	47.Ibc	84.0cd	55.0abc
Off-Shoot-O	109.8b	59.4a	115.8a	60.Iab
Untrimmed Control	137.6a	58.7a	126.8a	63.8a

[z]Measurements in centimeters. Mean separations within columns by LSD,
5% level.

Growth of Flowering Annuals following Field Application of Daminozide and Paclobutrazol

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Nature of Work: Landscape plantings of flowering annuals are usually grown under optimum nutrition and irrigation. Within a short period of time, some species can become overgrown and leggy for the planting site. Lodging of plants can further add to unsightliness. As a result, landscape managers usually remove and replace the plantings two to three times per year at high cost.

The use of growth inhibitors for controlling size of landscape annuals was suggested by Cathey (1) but little research has been conducted using the compounds for this purpose. Some studies with annuals have shown that activity of growth inhibitors applied in the greenhouse can continue controlling growth after planting in the landscape (5,6). The turfgrass industry has effectively countered excessive growth of turf by use of growth inhibitors such as flurprimidol and paclobutrazol (4). In this experiment, the use of daminozide and paclobutrazol was tested as a means of controlling growth of landscape annuals.

Tagetes erecta 'Inca Orange', Petunia hybrida 'Celebrity Red', Zinnia elegans ' Yellow Marvel' seed was planted on 23 April 1990 and seedlings were transplanted into #1803 (85 cm^3/cell) flats at the two to three true leaf stage. Petunias were clipped to a uniform size the week of 28 May. Growth regulators were not used during the greenhouse phase. Seedlings were transplanted to the field on 13 June into a randomized block design with three replications of four plants each per species. Species were treated as separate experiments. Seedlings were planted four per row in 6' (1.8 m) beds at 18" (46 cm) spacing between rows. Spray treatments were daminozide (B-Nine SP, Uniroyal Corp., Middlebury, Conn) at 1250, 2500 or 5000 ppm or paclobutrazol (Bonzi, Uniroyal Corp.) at 30 ppm (marigolds) or 60 ppm (petunias and zinnias) with an untreated control. Daminozide and paclobutrazol were applied to thoroughly wet shoots on the first day of each month + 2 days starting in July. With paclobutrazol treatments, ground was protected from overspray with newspaper or cardboard. Marigold, zinnia and petunia were treated for 2, 3 and 4 months, respectively. Width (two perpendicular measurements) and height of each plant were recorded within 1 day of treatment. Plants were rated subjectively from 1 = poor to 5 = excellent. A flower grade was assigned on the same scale based on number and attractiveness of blooms.

Results and Discussion: Data were tested using analysis of variance and mean separation by Duncan's multiple range test. Growth data did not have a month by treatment interaction and were pooled by treatment (Table 1). Paclobutrazol did not inhibit growth in height or plant width in the species tested. Although leaf number was not recorded, the lack of growth inhibition may be due to the greater number of leaves covering the stems in older plants. Since some studies have shown that paclobutrazol is primarily active in xylary tissues (1,8), leaves are not an active uptake site for the compound. Later applications of paclobutrazol were also less effective in controlling height of chrysanthemum than those made earlier (3). In this experiment, contact with roots was also eliminated by preventing overspray from contacting the ground. Since these rates were relatively low for each species, higher rates may overcome this problem.

Daminozide also had little effect on plant growth. This may be related to the late planting date and establishment of the seedlings, which generally required applications to be made at high summer temperatures (80F+), which are not as effective as those made at lower temperatures. With petunia, there was a slight rate effect for plant height.

Flower grade did have a significant month by treatment interaction and was therefore analyzed by month (Table 2). Flowering of all species treated with paclobutrazol was similar to untreated plants. Daminozide caused a slight reduction in quality of marigold and zinnia during August but flower quality was similar to untreated plants on final date of data collection. Daminozide has delayed flowering in other studies (7) and the rate of flower bud formation may have been reduced concomitantly with height. Petunias were not affected by daminozide except for a slight reduction in flower grade in November. Plant grade was not affected by treatments (data not shown).

Significance to Industry: The use of growth regulators may offer a means of controlling growth of landscape annuals to avoid costly bed renovations but use of daminozide proved problematic. Use of the compound above 85F is not recommended due to reduced efficacy and therefore, warm summer temperatures often preclude its use. Paclobutrazol may be practical but, as results found in greenhouse studies, rapidly growing plants under high temperatures will require higher concentrations than those used here.

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Table 1. Growth of field-grown flowering annuals to daminozide and paclobutrazol applied monthly[z].

Treatment (ppm)		Height (in)	Width (in)
		Marigold	
Untreated		20.3 abY	19.4 NS
Daminozide	1250	21.0 a	20.4
	2500	19.6 b	19.7
	5000	20.2 ab	19.7
Paclobutrazol	30	20.4 ab	19.9
		Petunia	
Untreated	8.4 a	16.4 NS	
Daminozide	1250	8.0 a	16.6
	2500	7.0 b	16.0
	5000	7.1 b	15.6
Paclobutrazol	60	8.6 a	16.8
		Zinnia	
Untreated		23.4 b	22.9 ab
Daminozide	1250	25.6 a	24.1 a
	2500	22.7 b	20.9 b
	5000	22.1 b	21.5 ab
Paclobutrazol	60	25.6 a	24.1 a

[z]Marigold, zinnia and petunia were treated for 2, 3 and 4 months, respectively.
[y]Mean separation by Duncan's MRT, P = 0.05, NS = not significant. Data were pooled by treatment since month by treatment interaction was not significant.

Table 2. Flower grade of annuals treated monthly with daminozide or paclobutrazol. Marigold, zinnia and petunia were treated for 2, 3 and 4 months, respectively.

		Flower Grade[z]			
Treatment	(ppm)	August	September	October	November
		Mariqold			
Untreated	- - - -	3.0 a[y]	4.0 NS		
Daminozide	1250	2.8 a	4.0		
	2500	2.6 ab	4.0		
	5000	2.3 b	4.0		
Paclobutrazol	40	2.8 a	4.0		
		Petunia			
Untreated	- - - -	2.7 NS	1.0 NS	2.4 NS	2.4 ab
Daminozide	1250	3.1	1.0	2.9	1.8 ab
	2500	2.8	1.0	3.0	1.4 b
	5000	2.5	1.0	3.3	1.6 ab
Paclobutrazol	60	2.8	1.0	2.8	2.6 a
		Zinnia			
Untreated	- - - -	3.1 ab	4.0 a	1.3 NS	
Daminozide	1250	3.3 ab	4.0 a	1.6	
	2500	3.1 ab	3.8 ab	1.0	
	5000	3.0 b	3.6 b	1.4	
Paclobutrazol	60	3.6 a	4.0 a	2.0	

[z]Graded on 1 = poor to 5 = excellent.

[y]Mean separation by Duncan's MRT, P=0.05, NS=not significant.

Photosynthesis and Flowering Responses of *Forsythia x intermedia* 'Spectabilis' Following Uniconazole Application

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Nature of Work: There is increasing interest in the use of plant growth regulators on woody ornamentals to reduce vegetative growth and the frequency of pruning. The triazole compound, uniconazole (Sumagic), effectively retards growth of several woody ornamental species without injury (Norcini & Knox, 1989; Sterret, 1988; Viagro-Wolff & Warmond, 1987). However, little information is available on the effects of uniconazole on responses other than shoot growth, such as photosynthesis (Pn) and flowering. Researchers have evaluated the effects of a similar triazole, paclobutrazol, on Pn with results varying from inhibition (Wample & Culver, 1983), stimulation (Jaggard et al., 1982) or no effect (Wood, 1984). Such differing responses to paclobutrazol provide a conflicting picture of how one may expect photosynthetic responses of a plant to respond following uniconazole application. Therefore, the objectives of this research were to evaluate the flowering and photosynthetic responses of *Forsythia x intermedia* Zab. 'Spectabilis' following foliar application of uniconazole.

Liners of forsythia were potted into 4 quart containers with a calcined clay substrate (Turface, Aimcor Inc., Deerfield, Ill.). Uniconazole was applied as a foliar spray at five rates; 0, 90, 130, 170 or 210 ppm; 0 ppm was maintained as a nonpruned control. The experimental design was a split plot with four replicates assigned to blocks based on initial plant size. Uniconazole rates were randomly allocated to main plots and five harvest dates [0, 40, 80, 120 and 365 days after treatment (DAT)] were randomly allocated to subplots within each main plot. The first harvest date (0 DAT) consisted of 20 plants (4 plants per treatment) while subsequent harvests consisted of 40 plants (8 plants per treatment). Plants were maintained under drip irrigation applied twice daily at 500 ml/container/application. Nutritional status of plants was maintained via liquid fertilization applied twice weekly through the growing season using Peters 20-10-20 Peat Lite Special and calcium sulfate ($CaS0_4$) providing 200 ppm N and 15 ppm Ca, respectively.

Leaf net photosynthetic rate and stomatal conductance of 40 plants (8 plants per treatment) were measured 14, 36, 49, 55, 62, 77, 120 and 365 DAT utilizing a LI-COR 6200; a portable closed infra-red gas exchange system (Li-COR, Lincoln, Neb.). Carbon exchange rates, air and leaf temperatures and relative humidity inside the chamber were monitored concurrently with photosynthetically active radiation during each measurement. Following overwintering of the 40 plants allocated to the fifth harvest date, corolla area of 10 flowers from each plant was measured utilizing an image analyzer (Digital Image Analysis System, Decagon Devices Inc. Pullman, Wash.). Flower number per plant was determined weekly for 9 weeks.

Results and Discussion: The uniconazole by sample date interaction was significant for Pn response so sample dates were analyzed individually. Uniconazole significantly affected Pn at 55, 77 and 365 DAT. At these DAT, regression analysis indicated a positive linear relationship between uniconazole rate and level of Pn.

Conductance response differed from Pn in that no significant differences were evident between the 5 uniconazole rates. In addition, there was no uniconazole by sample date interaction indicating a similar transpiration response occurred for all sample dates.

Forsythia began flowering the last week of January and continued for a period of 9 weeks. Uniconazole treated plants flowered earlier than nontreated plants. However, all plants had similar numbers of flowers when flowering was completed. Regression analysis of corolla area data indicated a positive linear relationship between uniconazole rate and corolla area.

Significance to Industry: Uniconazole can have a lasting effect on the photosynthetic capacity of 'Spectabilis' forsythia up to one year after foliar application. The overall effect appears to be positive, resulting in an elevated level of carbon assimilation over a growing season. How this might effect the overall growth response is not known. Flowering response of 'Spectabilis' forsythia following uniconazole application indicates an extension of the flowering period with a potential increase in corolla area. An earlier and longer flowering period with larger flowers could potentially provide more attractive plants for sale.

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Growth Response of Fortune Rose to Application of Paclobutrazol

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Georgia

Nature of Work: Fortune rose *(Rosa x Fortuneana* Lindl.) is a deciduous flowering shrub which is grown for its double white flowers in the spring. The plant is also used as an understock for many ornamental roses in Florida (2). Vigorous shoot growth which requires multiple prunings and limited root growth are two problems associated with the production of marketable Fortune rose plants in containers. Paclobutrazol is a gibberellin biosynthesis inhibitor known to retard the growth of woody landscape plants (1). The purpose of this study was to investigate the effects of paclobutrazol applied as a liquid drench on the growth of Fortune rose.

Seventy-two plants were grown in 2.8 liter (#1) pots and were uniformly pruned on 26 June 1991. The potting medium consisted of 4 pine bark : 1 sand (by volume). Liquid fertilizer (lON-1.5P-8.5K) was applied with each irrigation at the rate of 100 mg N/liter (ppm). Plants were grown in full sun and were irrigated as needed using overhead sprinklers.

Paclobutrazol (Clipper 2 SC, ICI Americas, Inc., Richmond, CA) was applied as a single 100 ml (3.5 oz) drench at the rate of 0, 5, 10, 20, and 40 mg ai/pot on 28 June 1991. Measurements at the termination of the study (30 September 1991) were shoot dry weight and root dry weight. Root:shoot ratio and total biomass were calculated from shoot and root dry weight data. The experimental design was completely randomized with eight replicate plants per treatment. Data were evaluated by analysis of variance (SAS Institute, Inc., 1989, Cary, NC).

Results and Discussion: Paclobutrazol influenced all growth parameters except root dry weight (Table 1). Shoot dry weight decreased quadratically in response to increased rate of paclobutrazol application. At the lowest rate (5 mg ai/pot) shoot dry weight was reduced by 33%. At 40 mg ai/pot shoot dry weight was reduced by 65%. While root dry weight was not significantly influenced by rate of paclobutrazol application (P=0.07), there was a general trend for increased root dry weight with application of paclobutrazol (Table 1).

Root:shoot ratio responded quadratically to rate of paclobutrazol application (Table 1). Root:shoot ratio increased approximately 3.7 and 6.3 times, respectively, for the 5 and 10 mg ai/pot treatments compared to the untreated control. Total plant biomass decreased linearly in response to rate of application (Table 1). The only treatment which had less total biomass than the control was 40 mg ai/pot.

Significance to Industry: Growth of Fortune rose can be controlled with the use of paclobutrazol. A rate of 5 mg ai/pot was determined to be the optimal dose of paclobutrazol for growth control in this study. Rates greater than 5 mg ai/pot resulted in excessive retardation of shoot growth based on shoot dry weight. Paclobutrazol can be used as a tool to manage shoot growth and increase the root:shoot ratio of Fortune rose.

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Table 1. Influence of rate of paclobutrazol application on growth parameters of Fortune rose *(Rosa x Fortuneana).*

Rate (mg ai/pot)	Shoot dry weiqht (g)	Root dry weight (g)	Total plant biomass (g)[z]	Root:shoot ratio[y]
0	113	37	150	0.3
5	76	80	156	1.1
10	50	88	138	1.9
20	52	87	139	1.7
40	40	69	109	1.8
ANOVA[x]				
Linear	**	NS	*	**
Quadratic	**	NS	NS	**

[z]Total plant biomass = (shoot dry weight + root dry weight).

[y]Root:shoot ratio = (root dry weight/shoot dry weight).

[x]Significance tests (n=8): ** $\leq$ 0.01, * $\leq$ 0.05, NS > 0.05.

Evaluation of Bonzi and Cycocel as Growth Regulators for Three Rose Cultivars

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Tennessee

Nature of Work: Maintaining compact, uniform growth of rose in early spring, as days get warmer, continues to be a challenge in the nursery industry. This problem is more severe under reduced light levels, high temperature, and close plant spacing conditions in overwintering houses. Overwintering houses are often ventilated by opening endwalls during the day to reduce growth rates, but this practice alone is not sufficient to produce compact growth of some rose cultivars. Plant growth regulators (PGRs) control growth of several woody ornamental plants (1,2,4). Few studies have been conducted to evaluate effects of PGRs on rose (3).

Bonzi™ (paclobutrazol; Imperial Chemical Industries, Australia) and Cycocel™ (chlormequat; American Cyanamid Co., Princeton, NJ), two commercially available growth regulators, were foliar-applied at eight rates to three rose cultivars: 'Don Juan', 'Queen Elizabeth' and 'Proud Land'. All plants were sorted for uniformity. These cultivars were selected because they are difficult to maintain in a compact form. Specific PGR treatments are shown in Table 1. Plant growth regulators were applied to 'Don Juan' either once (March 23) or twice (March 23 and April 3). Plant growth regulators were applied to 'Proud Land' and 'Queen Elizabeth' either once (April 3) or twice (April 3 and 16). Water was foliar-applied as a control.

All PGR treatments and the control were applied to the point of run-off using a 0.5 gallon hand-pump sprayer. Volume of liquid applied to each plant averaged 0.8 oz. (25 ml). The average initial shoot length of the three cultivars was 2.4 inches (6 cm). This study was conducted in an overwintering house covered with clear copolymer at a commercial nursery.

The experiment was conducted as a completely randomized design with five replications per treatment. Each cultivar was treated as a separate experiment so no statistical comparisons were made among cultivars. Data collected included shoot length (average length of three longest shoots), flower number (buds larger than 2 mm), plant quality (compactness and uniformity of growth) and phytotoxicity. Quality ratings ranged from 0 to 5 where 0 represented a dead plant and 5 represented best quality. Quality ratings did not take foliar injury into account since a separate phytotoxicity rating was taken. The phytotoxicity rating was the percent foliar injury found on the three leaves with the most injury. Quality ratings and phytotoxicity ratings were an average of values from a three-person panel.

Results and Discussion: No statistical differences in shoot length, flower number, or plant quality were detected in any of the three rose cultivars (data not presented).

With 'Don Juan', two applications of Cycocel at 750 ppm or 1000 ppm caused significant phytotoxicity. The highest rate, 2000 ppm, which was applied only on March 23, did not cause foliar damage. In fact, none of the treatments which were applied only on March 23 caused foliar damage. It is possible that the PGRs were partially washed off since irrigation was applied the evening after applying treatments to prevent cold temperature injury.

Foliar injury occurred when Cycocel was applied to 'Queen Elizabeth' twice at 750 or 1000 ppm or when applied once at 1000, 1500, or 2000 ppm. Plants treated with 2000 ppm Cycocel produced leaves with as much as 50% foliar damage, which was statistically greater than all other treatments.

With 'Proud Land', foliar damage occurred when 750 or 1000 ppm Cycocel was applied twice or when 1500 or 2000 ppm Cycocel was applied once. Unlike 'Queen Elizabeth', a single application of Cycocel at 1000 ppm did not cause foliar injury to 'Proud Land'. Rates of Bonzi as high as 400 ppm did not cause foliar injury to any of the cultivars used.

Significance to the Industry: Bonzi and Cycocel did not influence shoot growth, compactness and uniformity of growth or flower number in the three rose cultivars used. Bonzi did not cause foliar damage to the three cultivars at the rates used. Cycocel applied twice at 750 ppm or above caused foliar injury on the rose cultivars used in this study. Cycocel applied once at rates of 1000 ppm or above should be avoided because of the potential for phytotoxicity. It is not known whether timing would affect effectiveness of the PGRs.

Table 1. Rates and frequency of Bonzi and Cycocel used in this study.

Bonzi rates:	Cycocel rates:
25 ppm twice	250 ppm twice
50 ppm once	500 ppm once
50 ppm twice	500 ppm twice
100 ppm once	750 ppm twice
100 ppm twice	1000 ppm once
200 ppm once	1000 ppm twice
200 ppm twice	1500 ppm once
400 ppm once	2000 ppm once

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Growth Response of Seedlings of Flame Azalea to Manual and Chemical Pinching

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Nature of Work: Two experiments were conducted to study the influence of manual pinching and a combination of manual and chemical pinching on the growth response of seedlings of flame azalea [Rhododendron calendulaceum (Michx.) Torr] (1). In the first experiment, seedlings were subjected to the following manual pinching treatments at the 10-, 12-, 14-, or 16-leaf stage: no pinching, removal of the terminal two nodes [approximately 1.25 cm (0.5 in) and removal of terminal growth [approximately 2.5 - 5.0 cm (1-2 in)] leaving six nodes. The second experiment consisted of application of dikegulac [Atrimmec; sodium salt of 2, 3:4, 6-bis-0-(1-methylethylidene)-a-L-xylo-2-hexulofuranosonic acid], at 0, 2000, 4000, 6000, or 8000 ppm to both nonpinched and manually-pinched plants (removal of the terminal two nodes at the 16-leaf stage).

Results and Discussion: Results of the first experiment showed that the greatest number of lateral shoots (5.3) was produced by removing the terminal two nodes at the 16-leaf stage. Generally, the number of lateral shoots increased with the leaf stage at which manual pinching was imposed. Removal of terminal growth, leaving six nodes, resulted in the lowest leaf, stem and root dry weights at each leaf stage. In the second experiment, dikegulac (Atrimmec) treatment significantly affected the number of lateral shoots and dry weight of leaves, stems and roots. The number of lateral shoots increased linearly with concentration up to 4000 ppm. At 6000 and 8000 ppm, the average number of shoots produced (9.4 and 9.6), respectively was similar to 4000 ppm. Both pinched and nonpinched plants treated with dikegulac (Atrimmec) produced more lateral shoots than manual pinching alone. Dry weights of leaves, stems and roots decreased as the concentration increased. However, the number of lateral shoots and dry weights of leaves, stems and roots of pinched and nonpinched plants were not significantly different when treated with dikegulac (Atrimmec).

Significance to Industry: Lack of branching is a problem during production of flame azalea. These studies showed that lateral shoot development in seedlings may be stimulated by either manual or chemical pinching. Generally, the number of lateral shoots increases with the leaf stage at which manual pinching is imposed. The highest number of shoots results by removing the terminal two nodes at the 16-leaf stage. Both pinched and nonpinched plants treated with dikegulac (Atrimmec) produce more lateral shoots than manual pinching alone. The number of shoots increases linearly with increasing concentration of dikegulac (Atrimmec) over a range of 0 to 4000 ppm, whereas, responses to 4000, 6000, and 8000 ppm are comparable. However, considerable reduction in leaf, stem and root dry weights occurs with increasing concentration. This research also demonstrates that pinching the seedlings manually prior to dikegulac (Atrimmec) treatment does not result in a significantly greater number of lateral shoots compared to dikegulac (Atrimmec) treatment of nonpinched plants.

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Influence of Sumagic on Field Grown Elaeagnus and Leyland Cypress

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Nature of Work: Pruning of landscape trees and shrubs to control excessive vegetative growth and improve plant form is a major expense in utility and landscape maintenance. Sumagic is a triazole growth retardant labeled for use on bedding plants and several potted crops, but not on woody landscape plants. Results of several tests indicate that Sumagic is effective in suppressing growth of woody landscape plants in containers (Keever et al., 1990; Norcini and Knox, 1990; Warren, 1990). The influence on field-grown landscape plants has not been studied. The objective of this research was to determine the influence of soil- and foliar-applied Sumagic on two established, field-grown woody landscape species under simulated low maintenance landscape conditions.

Uniform #1 gal. plants of thorny elaeagnus and leyland cypress were planted on Dec. 4, 1988 in a Marvyn loamy sand soil of pH 5.5. Plants were pruned for uniformity on Apr. 12, 1990, and topdressed each spring with Osmocote 17-7-12 at 1 Tbsp/plant. On Apr. 12, 1990, the following Sumagic treatments were applied: a single drench application of 15, 30 or 45 mg a.i. in 17 ounces of distilled water applied around the base of each plant, a single foliar spray of 500, 1000 or 1500 ppm solution applied to uniformly wet foliage and stems, and a non-treated control. There were 7 treatments with 4 replicates of 4 plants each in a randomized complete block design within species. Growth indices were measured on July 18, 1990, Dec. 6, 1990, and Dec. 10, 1991 (leyland cypress only). On Dec. 18, 1991, 4 replicates of 2 plants each of thorny elaeagnus were cut at ground level, dried and weighed.

Results and Discussion: Growth indices of elaeagnus were not affected by Sumagic rate when measured in July 1990, although there was a slight downward trend with increasing drench rates (Table 1). Mean growth indices of drench-treated plants (90.9) were significantly less than those of sprayed (102.5) or untreated plants (97.7). By Dec. 1990, growth indices were similar among plants treated by the different application methods. Rate response at this time was not significant except for a quadratic response to drench rates. Shoot growth was relatively uniform during the 2 months after pruning. However, plants developed vigorous, rank shoots thereafter that made growth indices a poor indicator of vegetative growth. Shoot dry weights (SDW) of thorny elaeagnus decreased with increasing rates of drench-applied Sumagic. SDW of plants receiving 15, 30 or 45 mg a.i./plant were 16, 37 and 61%, respectively, less than those of control plants. Drench application resulted in significantly lower SDW than spray application (6.0 lb vs 9.2 lb) or than no treatment (9.7 lb). SDW were not affected by increasing rates of foliar-applied Sumagic.

Growth indices of leyland cypress were not influenced by application method or rate on any of the sampling dates. All plants were densely pyramidal in form and uniform in appearance.

No phytotoxicity or foliar color differences were observed on either species in any treatment during the experiment. Flowering of elaeagnus in fall 1990 appeared heavier on plants receiving a drench application of Sumagic compared to those sprayed, and heavier on plants sprayed with 1500 ppm than on those sprayed with a lower rate or not treated.

Significance to Industry: Drench-applied Sumagic is effective in retarding growth of in-ground thorny elaeagnus for at least two growing seasons under landscape conditions. This material should offer those involved in landscape maintenance an additional tool for managing this vigorous species. Regular, but less pruning will still be required to remove rank shoots. At the rates tested, Sumagic applied as a foliar spray is ineffective in retarding shoot growth of established thorny elaeagnus. Sumagic is not effective at the rates tested when applied as either a foliar spray or drench to established leyland cypress under landscape conditions.

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Table 1. Response of thorny elaeagnus to drench or foliarly-applied Sumagic (uniconazole).

Method of application	Rate	Growth index[z] July 18, 1990	Growth index[z] Dec. 6, 1990	Shoot dry weight (kg) Dec. 18, 1991
	(mg a.i./plant)			
Drench	15	92.3	150.6	3.68
	30	93.2	174.2	2.76
	45	87.2	154.0	1.71
Foliar	(ppm)			
	500	98.1	153.6	4.32
	1000	106.8	158.0	4.08
	1500	102.5	153.2	4.17
Control	—	97.7	151.3	4.38
Contrast[y]				
Drench vs spray		**	NS	**
Drench vs control		*	NS	**
Spray vs control		NS	NS	NS
Significant terms[x]				
Drench (D)		NS	Q	Q
Spray (S)		NS	NS	NS
D x S		NS	NS	NS

[z]Growth index = (height + width at widest point + width 90° to first width)÷3, in cm.

[y]NS, *, **: Nonsignificant (NS) or significant at 5% (*) or 1% (**) level.

[x]NS, Q: nonsignificant (NS) or quadratic response (1% level); control included in regression analysis.

Evaluation of Plant Growth Regulators on Petiole And Shoot Growth of Herbaceous Perennials

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Nature of Work: Commercial production and management of perennials, especially pre-cooled plugs, can be fraught with problems. Growers in the south wishing to take advantage of precooled plugs of tall growing perennials must maintain optimal growth in the greenhouse prior to bloom initiation. Many of these perennials respond to optimal greenhouse conditions by a rapid stretching of leaves and inflorescences, resulting in poor quality plants out of scale with the container (1, 2, 6). Controlling growth and reducing stem length should produce perennials with greater consumer appeal and fewer management problems associated with stretched, weak inflorescence (7). Recent work involving application of plant growth regulators to perennials has yielded potential new uses for existing chemicals (3, 4, 5).

The objective of this study was to establish the concentration ranges necessary to obtain growth control in rosette forming perennials. In this report, we will focus on assessment of four chemical growth regulators having potential for use to improve height/spread management.

Rooted plugs of Lobelia fulgens, and Aquilegia 'Music Mix' as well as corms of Liatris spicata 'Floristan' selected for uniformity and potted up in 10 cm pots. Treatments were initiated on 14 May 1992, five weeks after transplant. One plant/pot was used as the treatment unit. Treatments involved spraying foliage to the point to wetness with incremental rates of B-Nine (daminozide), Royal Slo-Gro (maleic hydrazide), Cutless (flurprimidol), and Bonzi (paclobutrazol). An untreated control group was included in the randomized complete block experimental design. There were five replications of two pots each within each treatment.

Plants were grown in polyethylene greenhouses at the Griffin Experiment Station, and maintained using standard practices for perennial production. Effects of chemical growth regulators on plant height were evaluated at two-week intervals after treatment application.

Results and Discussion: Perennials achieve one-half their full growth, when grown from plugs, in about five to eight weeks. Plants were treated just prior to expansion of inflorescence. Growth of Lobelia inflorescence was not affected by application of B-Nine two weeks after treatment, but height was at 10,000 ppm concentration at four weeks (Table 1). Royal Slo-Gro reduced inflorescence height between 900 and 1200 ppm.

Bonzi affected inflorescence growth linearly in relation to increasing concentration, with the greatest control at 40 ppm at two and four week periods. However, the relatively small amount of control suggests that our selected concentration ranges for either chemical was below the productive range for Lobelia. Cutless treated inflorescences exhibited strong linear height reduction with greatest control at 40 ppm for both evaluation periods (Table 1) .

Columbine responded poorly to the selected concentration ranges of Cutless and Bonzi. No significant height (length of petiole) reduction was seen (Table 2). Application of B-Nine did not significantly affect petiole height at two weeks post treatment, but plants showed a significant height reduction in relation to increasing concentration at four weeks. Royal Slo-Gro significantly reduced petiole height at two weeks, but by the four week evaluation period, plants had grown and the significance of the differences was lost (Table 2). Again, this data suggests that concentration ranges effective on other perennials and ornamentals are not suitable for Columbine.

Height of Liatris inflorescence was not significantly affected by B-Nine at any concentration tested (Table 3). Plants were evaluated an additional two week period without PGR response. Royal Slo-Gro treated plants showed a linear reduction in plant growth with increasing concentration at four weeks and six weeks post treatment, with the 1200 ppm rate reducing inflorescence growth substantially. A more precise concentration range between 800 and 1000 ppm may yield even better results (Table 3).

Bonzi application to Liatris did not reduce inflorescence growth at two weeks post treatment. A quadratic reduction in plant height with increasing concentration was seen at four weeks, but not at six weeks as the plants appeared to grow out of the PGR effects. Rates for Bonzi may need to be increased to be effective on Liatris.

In conclusion, Royal Slo-Gro appeared to have potential for use on Liatris as a height control agent. B-Nine, Cutless and Bonzi at the concentrations we chose had less (commercially) significant effects when applied five weeks after plug transplant to our selected perennials. Higher concentrations or earlier application dates may be necessary to obtain desired height control. We are continuing work to establish the proper physiological stage and concentration range for these and other perennials.

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Table 1. Effect of plant growth regulators on height of containerized lobelia treated 5 weeks after transplanting.

Chemical	Rate (ppm)	Plant ht (cm) after treatment 2 wk	4 wk
B-Nine	0	32	59
	2,500	34	57
	5,000	28	51
	7,500	32	53
	10,000	24	38
Significance[z]		NS	Q**
Royal Slo-Gro	0	32	53
	300	37	61
	600	35	42
	900	29	22
	1,200	28	25
Significance		L*,Q***	L*
Bonzi	0	36	61
	10	30	55
	20	28	50
	30	30	56
	40	25	48
Significance		L**	L*
Cutless	0	36	61
	10	28	51
	20	29	54
	30	24	37
	40	23	31
Significance		L***,Q*	L*

[z] L,Q:Linear or quadratic trends, respectively.
*,**,***,NS Significant at P≤0.10, 0.05, 0.01, or nonsignificant, respectively.

Table 2. Effect of plant growth regulators on height of containerized columbine treated 5 weeks after transplanting.

Chemical	Rate (ppm)	Plant ht (cm) after treatment 2 wk	4 wk
B-Nine	0	18	19
	2,500	18	17
	5,000	15	15
	7,500	17	15
	10,000	15	15
Significance[z]		NS	L**,Q*
Royal Slo-Gro	0	21	20
	300	18	20
	600	17	20
	900	14	18
	1,200	16	15
Significance		L***,Q**	NS
Bonzi	0	20	19
	10	18	18
	20	18	19
	30	20	20
	40	16	18
Significance		NS	NS
Cutless	0	18	19
	10	18	19
	20	19	21
	30	16	18
	40	16	19
Significance		NS	NS

[z] L,Q:Linear or quadratic trends, respectively.

*,**,***,NS Significant at P<0.10, 0.05, 0.01, or nonsignificant, respectively.

Table 3. Effect of plant growth regulators on height of containerized Liatris treated 4 weeks after corms were planted.

Chemical	Rate (ppm)	Plant ht (cm) after treatment 2 wk	4wk	6 wk
B-Nine	0	52	85	96
	2,500	51	85	101
	5,000	52	84	100
	7,500	54	86	103
	10,000	54	87	102
Significance[z]		NS	NS	NS
Royal Slo-Gro	0	48	79	94
	300	52	82	92
	600	46	58	61
	900	41	43	50
	1,200	40	40	40
Significance		NS	L**	L***
Bonzi	0	56	93	106
	10	57	92	101
	20	51	84	99
	30	56	90	99
	40	59	98	107
Significance		NS	L*Q**	NS

[z] L,Q:Linear or quadratic trends, respectively.

*,**,***,NS Significant at $P \leq 0.10$, 0.05, 0.01, or nonsignificant, respectively.

Effects of Plant Growth Regulators on Lateral Branching and Shoot Growth of Hypericum

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Georgia

Nature of Work: Commercial production and management of ornamental groundcovers is especially difficult due to the cyclic nature of market demand. During peak periods, production cannot keep pace with demand due to many species possessing strong apical dominance resulting in few cuttings per stock plant (3). Secondly, vining plants held during the slack market periods become entwined and require numerous man-hours to harvest, usually with damage to the plant (personal communication - Georgia based growers). Greater management efficiency and consumer appeal may be possible if better control over branch induction and growth could be obtained (2, 5). Recent work has shown the potential of plant growth regulators (PGR's) in the management of groundcovers and woody ornamentals production (1, 4, 5, 7).

In our initial study, we identified three PGR's with potential for improving groundcover production management (6). The objective of the current study was to establish the effects of each PGR within expanded concentration ranges suggested by the first study. We expanded the study to include dormant and active growth application periods. The data presented here focuses upon the lateral branch production and height of <u>Hypericum</u> calycinum.

Rooted cuttings of <u>Hypericum</u> were selected for uniformity in the fall and allowed to become naturally dormant. Treatments were initiated on 24 Jan, 1992. Two hypericum plants/pot were used as the treatment unit. Treatments involved spraying foliage to the point of wetness with incremental rates of Atrimmec (dikegulac sodium), Royal Slo-Gro (maleic hydrazide), and Promalin (BA and GA4 + GA7). An untreated control group was included in the randomized complete block experimental design. There were five replications of two pots each within each treatment. Plant height and number of branches were recorded.

An identical experiment was initiated 14 April 1992 using actively growing hypericum cuttings selected as described above. All plants from both experiments were grown in polyethylene greenhouses and maintained using standard practices for groundcover production.

Results and Discussion: Hypericum treated with Atrimmec during active growth exhibited a strongly linear growth reduction between 0 and 4800 ppm accompanied by a linear and quadratic trend toward increased number of lateral branches (Table 1). The greatest number of lateral branches per plant occurred at 3200 ppm, over 400% increase compared to control plants five months after treatment. Application of Atrimmec during dormancy did not give control of shoot growth but increased the number of new branches by over 200% at the 4000 ppm concentration. Baseline branch induction was increased naturally in the dormant plants by shoot terminal dieback due to winter freezing. The apparent differences in response of dormant and actively-growing hypericum plants to Atrimmec may allow the grower flexibility to increase branch number with or without affecting shoot length when desired. Induction of branching on newly transplanted cuttings is especially worthy of further work in relation to container plant establishment.

Spring application of Royal Slo-Gro to actively-growing hypericum resulted in 52% reduction of shoot length at 1800 ppm, but no additional reduction with higher concentrations (Table 2). The number of lateral branches showed a 225% increase at 2700 ppm, but a reduction at concentration beyond that. Dormant plants treated with Royal Slo-Gro exhibited a marked reduction of shoot growth, up to 59% at 3600 ppm. The number of lateral branches was reduced as the concentration increased beyond 1800 ppm, resulting in a 65% reduction at 5400 ppm.

Promalin applied to actively growing Hypericum caused a 26% increase in shoot length at 1000 ppm (Table 3). Lateral branches were increased 200% at the 1000 ppm concentration. Neither height nor number of branches were affected by application of Promalin to dormant hypericum. It appears that Promalin may be useful in situations when shoot growth needs to be increased, rather than controlled.

In conclusion, Atrimmec and Promalin may be potential tools in management programs where control of shoot growth and an increase in the number of lateral branches produced for cutting are desired. Increased lateral branch production may improve plant appearance and coverage in the landscape setting, as well as customer appeal in containers.

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Table 1. Effects of Atrimmec Application on Plant Height and Branching of Hypericum.

	Spring Application[y]		Dormant Application[z]	
Atrimmec (ppm)	Plant Height (cm)	No. Branches	Plant Height (cm)	No. Branches
0	22.9	1.8	19.0	5.0
800	24.1	2.6	20.0	6.6
1600	14.9	6.1	18.9	8.8
2400	13.8	6.3	19.3	9.3
3200	11.6	7.6	17.4	9.3
4000	8.5	6.1	16.9	10.1
4800	9.5	6.1	16.0	9.5

[z]Dormant treatment applied Jan. 24,1992.

[y]Spring treatment applied to actively growing plants April 14,1992.

*,**,***, NSSignificant at P≤0.10,0.05,0.01, or nonsignificant respectively.

Table 2. Effects of Royal Slo-Gro Application on Plant Height and Branching of Hypericum

	Spring Application[y]		Dormant Application[z]	
Royal Slo-gro	Plant Height	No. Branches	Plant Height	No. Branches
	(cm)		(cm)	
0	21.8	2.0	20.1	6.3
900	21.2	1.9	20.0	5.3
1800	9.6	4.2	14.5	6.4
2700	9.9	4.5	9.4	3.6
3600	9.3	2.5	8.2	2.8
4200	8.9	2.4	9.0	2.3
5400	9.3	2.5	8.7	2.2
Linear	***	***	***	*
Quadratic	***	***	***	NS

[z]Dormant treatment applied Jan. 24, 1992.

[y]Spring treatment applied to actively growing plants April 14, 1992.

*,**,***,[NS]Significant at PC≤ 10, 0.05, 0.01 or nonsignificant respectively.

Table 3. Effects of Promalin Application on Plant Height and Branching of Hypericum.

	Spring Application[y]		Dormant Application[z]	
Promalin	Plant Height (cm)	No. Branches	Plant Height (cm)	No. Branches
0	23.5	2.0	19.4	5.2
250	26.7	2.4	21.1	5.5
500	27.7	2.9	22.8	7.9
750	30.4	3.5	20.5	6.9
1000	31.7	4.3	23.6	7.5
1250	30.1	3.8	21.5	9.4
1500	29.1	3.4	22.6	9.2
Linear	***	***	NS	NS
Quadratic	***	NS	NS	NS

[z]Dormant treatment applied Jan. 24, 1992.

[y]Spring treatment applied to actively growing plants April 14, 1992.

*,**,***,[NS]Significant at $P \leq 0.10$, 0.05, 0.01 or nonsignificant respectively.