GROWTH REGULATORS

Joyce Latimer
Section Editor and Moderator

Twenty-eight students competed In the Bryson L. James Student Research Competition and twenty-nine research projects were presented in poster form, which were displayed for review during the SNA Research Conference and Trade Show, this year. Their research is presented in the topical sections which follow and are designated as Student or Poster papers.

Increasing Flowers in Container Grown Hybrid Rhododendron

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Nature of Work: Container grown hybrid rhododendrons displaying flowers or flower buds have enhanced retail sales potential over plants without flowers or flower buds. Manipulation of fertilizer and irrigation have traditionally been used to increase flower bud set in container grown hybrid rhododendrons with little effectiveness for some nurseries. Earlier research demonstrated that plant growth regulators have potential for increasing hybrid rhododendron flower bud set as drench applications (3) and hybrid mountain laurel with spray applications (1,2).

This research was undertaken to evaluate the effectiveness of Sumagic (Uniconazole-P) spray applications under different growing conditions on the same as well as different cultivars of hybrid rhododendrons. Rates were chosen based upon what has been successful in NC and VA nurseries for mountain laurel. Timing was determined based upon experience with mountain laurel as well as due to the failure of August spray applications to increase rhododendron flower bud formation under NC nursery conditions in 1996 (unpublished data).

Tests were conducted under commercial growing conditions at one nursery in the piedmont (USDA Hardiness Zone 7b) and two nurseries in the mountains of NC (USDA Hardiness Zone 6b). ‘Nova Zembla’ was grown in the piedmont as well as in a mountain nursery. ‘Roseum Elegans’ was also grown in the Piedmont while ‘Chionoides,’ ‘English Roseum,’ and ‘Purpureum Elegans’ were all grown in mountain nurseries.

Thirty plants were selected for each cultivar at each site. Plants were in three gallon pots at piedmont nurseries with smaller plants in two gallon pots at mountain nurseries. Ten individual plant replicates were either sprayed with water, 50 ppm Sumagic or 100ppm Sumagic to full foliar and upper stem coverage in mid to late July 1997. Sumagic solutions were applied with an air powered 2.44 qt sprayer. Treatments were randomized within the ten replicates.

Initial height and width measurements were recorded at the inception of the experiment and at the end of the experiment to determine a season long growth index. Phytotoxicity was visually evaluated one day, one week and two weeks following treatment. In early November, the end of the growing season, the number of flower buds per plant was counted. Plants were overwintered in an unheated white plastic covered winter protection structure then three representative plants of each cultivar were moved to the greenhouses at the Mountain Horticultural Crops Research Station, Fletcher, NC in March to observe flower development. Data for each cultivar tested at each nursery was analyzed as a separate experiment.

Results and Discussion: No phytotoxicity or significant difference in growth occurred on any cultivar. However, there was a significant difference in the average number of flower buds per plant with results varying by cultivar and nursery. All flowers developed normally.

'Nova Zembla' (Table 1) plants had a significant increase in flower buds when either 50 or 100 ppm Sumagic spray was applied. There was no significant increase in the number of flower buds per plant by increasing Sumagic rate from 50 to 100 ppm. Similar results occurred for cultivars 'Roseum Elegans' and 'Purpureum Elegans' (Table 2) However, there was a significant increase in the number of flowers buds when rates of application increased from 50 to 100 ppm with the cultivars 'Chionoides' and 'English Roseum' (Table 3). 'Roseum Elegans' were growing in 3 gallon pots in the piedmont while all other cultivars in Table 2 were growing in two gallon pots in the mountains.

Table 1. Number of flower buds per plant for Rhododendron 'Nova Zembla' growing in a 3 gallon container as affected by rate of Sumagic spray applied in July 1997. Flower buds were counted in November 1997.

	Nursery Locations	
ppm Sumagic	Mountains	Piedmont
0	0.5 a	4.0 a
50	4.6 b	10.8 b
100	5.2 b	12.1 b

Differences exist at the 5% confidence level for Duncan's New Multiple Range Test where letters following numbers differ within columns.

Table 2. Number of flower buds per plant for rhododendron cultivars growing in a 3 gallon container as affected by rate of Sumagic spray applied in July 1997. Flower buds were counted in November 1997.

	Cultivar	
ppm Sumagic	'Purpureum Elegans'	'Roseum Elegans'
0	1.0 a	3.8 a
50	4.0 b	12.0 b
100	3.4 b	12.6 b

Differences exist at the 5% confidence level for Duncan's New Multiple Range Test where letters following numbers differ within columns.

Table 3. Number of flower buds per plant for rhododendron cultivars 'Chionoides' and 'English Roseum' growing in a 3 gallon container as affected by rate of Sumagic spray in July 1997. Flower buds counted in November 1997.

	Cultivar	
ppm Sumagic	'Chionoides'	'English roseum'
0	0.7 a	0.0 a
50	4.1 b	1.4 b
100	6.2 c	2.6 c

Differences exist at the 5% confidence level for Duncan's New Multiple Range Test were letters following numbers differ within columns.

Significance to the Industry: Under western North Carolina growing conditions, the number of flower buds on all five cultivars of hybrid rhododendrons tested was significantly increased when sprayed in mid July with as low as 50 ppm Sumagic.

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Acknowledgements: Special thanks to NC Extension Agents David Curtis and John Vining as well as cooperating nurseries for their help in conducting this nursery-based research.

Greenhouse and Landscape Evaluation of Perennial Bedding Plants Treated with Three Plant Growth Regulators

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Nature of Work: The wide diversity of perennials being grown by greenhouse and nursery operators has led to the need to screen containerized perennial bedding plants for response to chemical growth regulators during greenhouse production and to evaluate the subsequent effect of growth regulators on the landscape performance of the perennials.

Fall-planted perennial plugs were held in a cold frame over winter, moved into the greenhouse in March 1998. After resumption of growth, the plants were treated with foliar spray applications of 5000 ppm B-Nine (applied every 2 weeks), a tank mix of 5000 ppm B-Nine and 1500 ppm Cycocel, or Sumagic at 0, 15, 30, 45, or 60 ppm. Vegetative plant height was measured at 3 and 5 weeks after treatment (WAT). After the 5 WAT measurement, plants were planted in raised landscape beds at the Coastal Gardens in Savannah, Georgia. Plant height was measured at 4 and 8 weeks after planting in a landscape bed.

Results and Discussion: Eight of the nine species tested were responsive to B-Nine during greenhouse production (Tables 1, 2, 3) with height reductions, relative to untreated control, ranging from 10% with *Lantana* camara to 38% with *Heliotropium arborescens* at 5 WAT. B-Nine was applied at 2-week intervals, resulting in three applications during greenhouse production. A single application of a tank mix of B-Nine and Cycocel effectively reduced (18% to 38% reduction) the height of four species, and gave moderate (10% reduction) height control of *Gaura lindheimeri* at 5 WAT. Three species, *Salvia greggii, Gaura lindheimere*, and *Perovskia atriplicifolia* were excessively affected by a single application of the higher rates of Sumagic, about a 45% height reduction in each case. *Salvia leucantha* control plants reached their maximum vegetative height at 3 WAT where treatment with 60 ppm Sumagic reduced plant height by 44%. Over the next two weeks, the linear response of plant height to Sumagic persisted (results not shown). The linear response of the plant height over the rate of Sumagic application shows promise for rate selection. Growth of *Buddleia davidii, Gaillardia grandiflora* and *Lantana* camara was only slightly to moderately controlled by Sumagic.

Carryover effects on vegetative plant height in the landscape was observed at 4 WAP in *Salvia greggii, Gaura, Lantana, Asclepias*, and *Perovskia*, but only *Gaura* treated with high rates of Sumagic exhibited persistent growth delays at 8 WAP (Tables 1, 2, 3).

Significance to Industry: The lack of information available on the wide variety of perennial plants being commercially grown makes the use of chemical growth regulators very difficult. This study provides initial information on plant response to several plant growth regulators during greenhouse production. The rates used provide a starting ground for growers wishing to apply these retardants in their own production systems. Followup evaluation in the landscape will continue Spring and Summer 1998.

Table 1. Vegetative height of perennials in the greenhouse at 3 and 5 weeks after treatment (WAT) with growth regulators and at 4 and 8 weeks after planting (WAP) in the landscape.

Treatment	Rate	Plant height (cm)					
		Buddelia davidii 'Royal Red'		*Salvia greggii*		*Gaura lindheimeri* 'Whirling Butterflies'	
Greenhouse:		*3 WAT*	*5 WAT*	*3 WAT*	*5 WAT*	*3 WAT*	*5 WAT*
B-Nine	5000 ppm	11.0 a[z]	19.3 b	16.1 a	17.5 b	10.3 c	18.6 c
B-Nine/ Cycocel	5000 ppm/ 1500 ppm	13.1 a	25.1 a	14.2 b	15.8 b	14.6 ab	23.7 b
Control	0 ppm	13.4 a	27.1 a	16.7 a	25.6 a	16.6 a	26.4 a
Sumagic	15 ppm	12.6 a	25.2 a	16.0 a	14.6 b	14.0 b	20.2 bc
	30 ppm	14.0 a	29.9 a	12.6 bc	17.4 b	10.9 c	17.6 c
	45 ppm	11.4 a	24.6 a	12.4 c	15.5 b	8.8 c	15.0 d
	60 ppm	11.7 a	23.1 ab	12.2 c	14.2 b	9.4 c	14.3 d
Landscape:		*4 WAP*	*8 WAP*	*4 WAP*	*8 WAP*	*4 WAP*	*8 WAP*
B-Nine	5000 ppm	33.0 a	52.6 a	43.4 ab	57.8 a	20.2 c	20.8 ab
B-Nine/ Cycocel	5000 ppm/ 1500 ppm	24.6 a	42.4 a	48.2 a	54.1 a	23.4 b	21.3 ab
Control	0 ppm	26.5 a	50.6 a	38.4 bc	50.0 a	28.8 a	22.7 a
Sumagic	15 ppm	26.6 a	48.8 a	40.5 bc	59.0 a	23.0 b	20.4 ab
	30 ppm	30.3 a	52.8 a	39.8 bc	51.6 a	18.7 cd	19.5 bc
	45 ppm	27.0 a	45.2 a	40.3 bc	55.7 a	17.3 d	17.7 c
	60 ppm	30.4 a	55.2 a	36.7 c	54.9 a	16.6 d	18.0 c

[z]Mean separation by LSD ($P < 0.05$) across all growth regulator treatments within a species at each date.

Table 2. Vegetative height of perennials in the greenhouse at 3 and 5 weeks after treatment (WAT) with growth regulators and at 4 and 8 weeks after planting (WAP) in the landscape.

Treatment	Rate	Plant height (cm) *Gaillardia grandiflora* 'Burgundy'		*Heliotropium arborescens* 'Fragrant Blue'		*Lantana camara* 'Confetti'	
Greenhouse:		*3 WAT*	*5 WAT*	*3 WAT*	*5 WAT*	*3 WAT*	*5 WAT*
B-Nine	5000 ppm	6.4 bc[z]	10.0 b	9.2 abc	12.7 d	8.2 c	11.4 b
B-Nine/ Cycocel	5000 ppm/ 1500 ppm	5.8 c	11.1 b	9.3 abc	13.8 d	9.2 ab	14.3 a
Control	0 ppm	9.0 a	13.6 a	10.1 ab	20.4 ab	9.4 ab	13.2 a
Sumagic	15 ppm	8.3 a	12.2 ab	10.8 a	21.3 a	8.4 bc	10.9 b
	30 ppm	7.8 ab	11.6 ab	8.6 c	18.6 bc	7.6 c	10.4 b
	45 ppm	5.9 c	11.9 ab	9.8 ab	20.1 ab	7.5 c	11.5 b
	60 ppm	6.6 bc	11.5 b	8.2 c	16.4 c	9.6 a	13.4 a
Landscape:		*4 WAP*	*8 WAP*	*4 WAP*	*8 WAP*	*4 WAP*	*8 WAP*
B-Nine	5000 ppm	17.2 a	21.1 a	NA	NA	17.8 bc	21.6 a
B-Nine/ Cycocel	5000 ppm/ 1500 ppm	17.3 a	22.4 a	NA	NA	21.3 a	25.5 a
Control	0 ppm	15.6 a	23.1 a	NA	NA	16.4 c	19.7 a
Sumagic	15 ppm	16.9 a	21.2 a	NA	NA	17.6 c	21.4 a
	30 ppm	16.8 a	22.6 a	NA	NA	17.6 c	23.6 a
	45 ppm	17.3 a	20.7 a	NA	NA	17.1 c	22.1 a
	60 ppm	16.1 a	23.0 a	NA	NA	21.1 ab	26.7 a

[z]Mean separation by LSD ($P < 0.05$) across all growth regulator treatments within a species at each date.

Table 3. Vegetative height of perennials in the greenhouse at 3 and 5 weeks after treatment (WAT) with growth regulators and at 4 and 8 weeks after planting (WAP) in the landscape.

		Plant height (cm)					
Treatment	Rate	*Asclepias tuberosa*		*Salvia leucantha*		*Perovskia atriplicifolia*	
Greenhouse:		*3 WAT*	*5 WAT*	*3 WAT*	*5 WAT*	*3 WAT*	*5 WAT*
B-Nine	5000 ppm	14.6 a[z]	15.8 a	16.6 bc	17.0 b	18.7 c	19.9 b
B-Nine/ Cycocel	5000 ppm/ 1500 ppm	14.9 a	15.7 a	17.2 bc	21.4 abc	21.2 c	22.2 b
Control	0 ppm	17.8 a	18.0 a	26.5 a	25.8 a	28.2 a	29.4 a
Sumagic	15 ppm	17.4 a	18.2 a	18.6 b	22.9 ab	25.0 b	29.0 a
	30 ppm	13.8 ab	15.4 a	18.2 b	18.2 bc	18.0 c	20.6 b
	45 ppm	13.0 b	12.4 a	15.8 bc	16.8 bc	16.8 cd	21.1 b
	60 ppm	13.9 ab	14.5 a	14.8 c	15.9 c	14.6 d	16.4 c
Landscape:		*4 WAP*	*8 WAP*	*4 WAP*	*8 WAP*	*4 WAP*	*8 WAP*
B-Nine	5000 ppm	18.5 abc	20.7 a	24.8 a	39.9 a	37.7 bc	56.9 a
B-Nine/ Cycocel	5000 ppm/ 1500 ppm	18.0 abcd	20.4 a	31.4 a	49.1 a	51.6 a	66.9 a
Control	0 ppm	20.3 ab	24.4 a	27.8 a	42.5 a	45.6 ab	63.8 a
Sumagic	15 ppm	21.0 a	20.5 a	33.0 a	48.7 a	35.5 bc	56.1 a
	30 ppm	16.8 bcd	14.4 a	26.0 a	43.5 a	37.0 bc	55.1 a
	45 ppm	14.4 d	18.6 a	25.4 a	43.3 a	33.9 c	58.2 a
	60 ppm	15.6 cd	18.0 a	29.4 a	48.7 a	35.1 bc	50.3 a

[z]Mean separation by LSD ($P < 0.05$) across all growth regulator treatments within a species at each date.

Shasta Daisy Response to Photoperiod and Vernalization

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Nature of Work: Inconsistencies exist concerning the role of photoperiod and vernalization in flowering of Shasta Daisy (*Leucanthemum x superbum*) cultivars. Flowering was hastened by increased day length in several cultivars (3,4). Individual cultivars either were obligate long day plants for flowering (2) or required vernalization to flower (5). Recent work with 'Snow Lady' showed that long days, but not vernalization, hastened flowering (facultative response) (1). This investigation was conducted to determine the role of photoperiod and vernalization time on growth and flowering of three *Leucanthemum x superbum* cultivars.

Transplants of *Leucanthemum x superbum* 'Becky', 'Snow Cap', and 'Snow Lady' (Green Leaf Enterprises, Inc., Leola, PA) in 72-celled flats were transplanted to 6-inch pots containing Fafard #3 medium on October 10, 1997. Plants were grown in a double-layer polyethylene-covered greenhouse with a heating set point of 65°F and ventilation at 78°F. Fertilization of plants consisted of a weekly application of 150 ppm nitrogen using 20-10-20.

On February 14, 1998, 54 plants of each cultivar were placed in a walk-in cooler at 40°F for 3, 6, or 9 weeks and were irrigated as needed with clear water. While in the cooler, plants received nine hours of incandescent light (8:00 AM to 5:00 PM CST) at a minimum of 10 foot-candles. Eighteen control plants of each cultivar were placed in a glass-covered greenhouse with a heating set point of 64°F and ventilation at 76°F. Control plants and those removed from vernalization were placed under either natural short days (SD) or long days (LD) provided by incandescent light from 10:00 PM to 2:00 AM CST. Fertilization resumed when plants were removed from the cooler. Beginning March 14, 1998, plants in short-day treatments received black cloth from 5:00 PM to 8:00 AM CST until flower buds opened. The experiment was a split block design with nine single-pot replications per treatment. Data recorded at the time of first open flower was flower date and shoot height. Quality rating (0-5) and flower shoot number were recorded when plants had five open flowers.

Results and Discussion: All plants of 'Becky' flowered under LD, regardless of vernalization time (VER), while none of the plants under SD flowered (Table 1). Time to flower decreased and flower shoot number and quality rating increased with increasing VER. Shoot height was greatest after six weeks VER under LD. 'Becky' showed an obligate requirement for LD to flower, and plant growth characteristics and quality were improved by at least six weeks of VER under LD. All plants of 'Snow Cap' flowered under LD and 36% flowered under SD, regardless of VER (Table 1). Shoot height and flower shoot number increased after plants received six weeks of VER under LD. Overall quality rating was greater under LD than under SD. Time to flower decreased with increasing VER under LD. 'Snow Cap' showed a facultative requirement for LD to flower. However, this response may be viewed as obligate in practical application because the number of plants flowering under SD was low. All plants of 'Snow Lady' flowered under LD and 81% flowered under SD, regardless of VER (Table 1). Shoot height was greater overall under LD than under SD with the greatest shoot height occurring after three or six weeks of VER. Flower shoot number was also greater overall under LD than under SD with the greatest flower shoot number occurring after six weeks VER under LD. Though there was no difference in quality rating with increasing VER under SD or LD, quality rating under LD was higher overall than under SD. Time to flower decreased with increasing VER under SD and LD, and was shorter under LD than under SD. 'Snow Lady' showed a facultative requirement for LD to flower, though a large number of plants flowered under SD. However, plants under LD flowered 7.8 days earlier, were 2 inches taller, had 3.6 more flowering shoots and a quality rating higher than plants under SD. Therefore, LD would be beneficial in practical application.

Significance to Industry: The Shasta Daisy cultivars tested in this study varied in response photoperiod and vernalization time. 'Becky' showed an obligate requirement for LD to completely flower while 'Snow Cap' and 'Snow Lady' showed a facultative response. However, in all three cultivars, shoot height, flower shoot number, and market quality rating increased while time to flower decreased with increasing VER up to six weeks under LD. Therefore, LD and six weeks VER would be needed to ensure rapid flowering and the highest plant quality.

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Table 1. Response of three *Leucanthemum* x*superbum* cultivars to short and long photoperiods and vernalization duration.

Photoperiod	Vernalization (weeks)	Shoot Height (cm)[z]	Flower Shoot Number	Quality Rating[y]	Days to Flower	Flowering Plants (%)
			'Becky'			
Short days	0	–	–	0.0	–	0
	3	–	–	0.0	–	0
	6	–	–	0.0	–	0
	9	–	–	0.0	–	0
Long days	0	45.4	4.8	1.7	63	100
	3	57.9	5.8	2.4	59	100
	6	66.1	7.7	2.7	56	100
	9	47.9	8.3	2.8	46	100
		Q***[x]	L***	L***Q**	L***Q**	
			'Snow Cap'			
Short days	0	15.7	0.4	0.0	75	33
	3	–	–	–	–	0
	6	17.3	1.8	1.1	61	89
	9	16.3	0.9	0.4	53	22
		ns	ns	ns	Q**	
Long days	0	26.6	4.8	3.3	55	100
	3	26.6	8.8	3.9	52	100
	6	30.6	11.1	4.0	48	100
	9	25.8	9.9	3.8	44	100
		L***Q**	L***Q***	ns	L***Q***	
			'Snow Lady'			
Short days	0	15.6	5.3	1.8	60	78
	3	20.6	6.1	1.9	58	78
	6	19.7	5.7	2.3	56	78
	9	16.5	7.2	2.2	44	89
		Q*	ns	ns	L**	
Long days	0	14.5	7.8	3.1	49	100
	3	22.4	8.6	3.3	47	100
	6	27.3	14.1	3.3	46	100
	9	18.9	8.3	2.9	44	100
		Q***	Q**	ns	L***	

[z] English Conversion 2.54 cm = 1 inch.

[Y] Quality Rating: 0=no flowers, 1=very poor, unsalable; 2=poor, unsalable; 3=average, salable; 4=good, salable; 5=excellent, salable.

[X] Not significant (ns) or significant linear (L) or quadratic (Q) trend at P=0.05 (*), 0.01(**), or 0.001 (***).

Growth Retardants Promote Branching, Control Growth of Perovskia (Russian Sage)

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Nature of Work: *Perovskia atriplicifolia* (Russian Sage) is a perennial species with small, light blue flowers on delicate gray-green foliage. In Virginia, flowering continues from mid-June to late September or early October. Just prior to flowering, stems elongate rapidly and may reach 3 to 4 ft. in height. The rapidly elongating stems can make production in containers difficult. Pruning or shearing may be used to produce shorter, more extensively branched plants, to make production and handling easier and to produce more marketable plants. However, pruning is labor intensive and time consuming. In this study we evaluated three plant growth retardants, applied individually or in certain combinations, for promotion of branching and retardation of stem elongation.

Perovskia atriplicifolia plants grown in a pine bark medium in 1-gallon containers were sheared to a height of 15 cm (6 in.) on June 20, 1997. One day later the plants were treated with foliar sprays of Florel at 0, 500, or 1000 ppm or with B-Nine at 5000 ppm or Sumagic at 15 ppm. One week after these treatments were applied, sprays of B-Nine (5000 ppm) or Sumagic (15 ppm) were applied to some of the plants previously treated with Florel (500 and 1000 ppm). A randomized complete block design was used with 3 plants per treatment per block.

Plant heights and widths were measured on July 8 (17 days after the initial treatments). On July 11, the number of secondary shoots were counted and measured on one primary shoot of one plant per treatment per block (4 plants per treatment). The number of days after treatment (DAT) to flowering was also determined.

The Florel (500 and 1000 ppm) and the Sumagic treatments, applied individually, reduced plant height by 26% (Fig. 1). The B-Nine treatment reduced height by 18%. Combination treatments (Florel followed by Sumagic or, Florel followed by B-Nine) provided additional height control. Florel at 500 or 1000 ppm also promoted secondary shoot development (Fig. 2). Additional treatments with B-Nine or Sumagic had little effect on this response. Florel delayed flowering by about 7 to 10 days (Fig. 3).

Significance to Industry: The results of this study show that height control of *Perovskia atriplicifolia* may be obtained with B-Nine, Sumagic, or Florel. Florel or Sumagic treatments were somewhat more effective than B-Nine. Florel also stimulated secondary shoot development.

Acknowledgement: We would like to thank Lancaster Farms, Inc., Suffolk, Virginia, for providing plants and funding for this experiment.

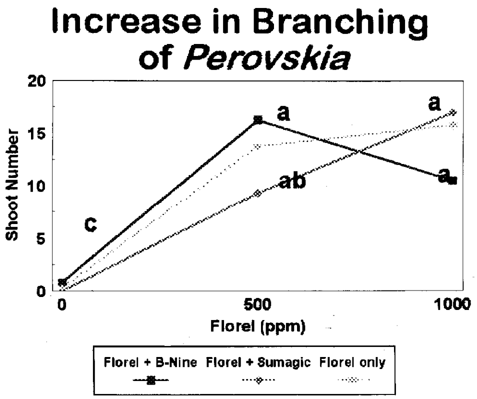

Fig. 2. Number of secondary shoots counted on one primary shoot per plant 3 weeks after Florel treatment.

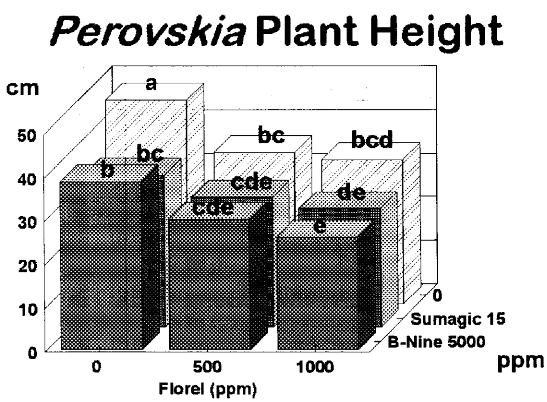

Fig. 1. Plant heights (cm) of *Perovskia* treated with Florel (0, 500, or 1000 ppm) or B-Nine (5000 ppm) or Sumagic (15 ppm), or with Florel followed by B-Nine or Sumagic one week later.

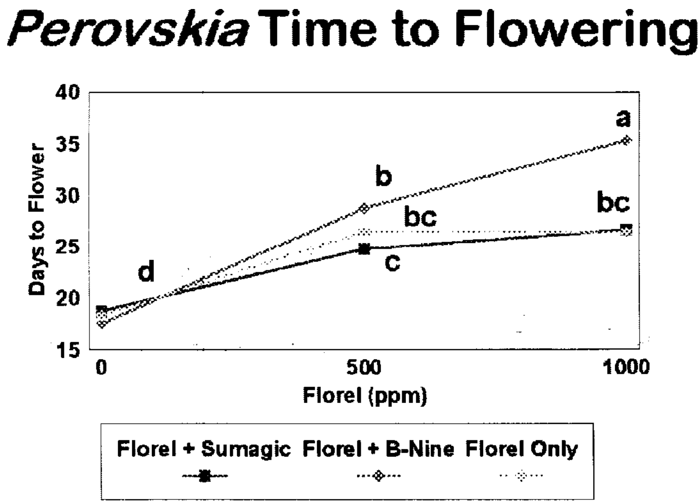

Fig. 3. Number of days from initial treatment for flowers to begin to show blue color.

Plant Growth Retardants Affect Growth and Flowering of *Coreopsis rosea*
(Student)

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Nature of Work: *Coreopsis rosea*, or pink coreopsis, is an erect finely-branched herbaceous perennial, growing 12-18 inches tall. Pink coreopsis is often difficult to manage during production because of rapid growth, requiring pruning for size control (1). Plant growth retardants (PGRs) have been used successfully to control undesirable growth in horticultural crops (2, 3, 4, 5), including the closely related, *Coreopsis verticillata* 'Moonbeam' (6). The objective of this study was to determine the effectiveness of B-Nine, Bonzi, Cutless and Sumagic in controlling the growth of pink coreopsis to provide nurserymen a cost-effective alternative for managing growth during production.

Rooted cuttings of pink coreopsis were transplanted from cell packs to 4-inch pots containing Fafard #3 growing medium on January 26, 1998 and spaced pot-to-pot. Plants received liquid fertilization weekly at 150 ppm nitrogen using a 20-10-20 fertilizer and were watered when the medium appeared dry, but before plants wilted. On February 14, 1998, plants were sheared to 2.5-inches above the pot rim, spaced on 8-inch centers, and provided long-day photoperiods using night-break lighting from 10:00 PM to 2:00 AM CST. Growth retardants were applied on March 12, 1998 as foliar sprays (2 qt/100 ft2) at rates of 0, 2500, 5000, or 7500 ppm for B-Nine; 25, 50, 75, 100, 125, or 150 ppm for Cutless; 10, 20, 30, or 40 ppm for Sumagic; and 25, 50, 75, or 100 ppm for Bonzi. The experimental design was a randomized complete block with 10 single plant replications. Plants were blocked by initial size. Initial plant height and growth index [(height + widest width + width perpendicular to first width) â 3] were recorded on March 13, 1998. Date of the opening of the first flower (ray flower petals reflexed perpendicular to the peduncle), shoot height, and growth index were collected at that time. Each plant was rated for market quality on a 1-4 scale (1 = poor, unmarketable; 2.5 = marketable; 4 = excellent) when one-third of the flowers were open, and the date was recorded.

Results and Discussion: Time to first flower was not affected by the PGRs (data not shown). At first flower, increasing rates of all PGRs, except Bonzi, reduced shoot height (Table 1). Shoot height of plants treated with the highest rate of each PGR was reduced 25% for B-Nine, 27% for Cutless, and 29% for Sumagic relative to control plants. Growth index followed a similar trend (data not shown). Time to one-third of flowers opened (TTF) decreased with Cutless rates up to 75 ppm before increasing to that similar to control plants. TTF decreased as much as 5 days with Sumagic, while B-Nine and Bonzi had no effect on TTF. Market quality rating of plants treated with B-Nine, Cutless and Sumagic increased with increasing concentration compared to control plants. Control plants were considered unmarketable, while those treated with all PGR-rate combinations, except Cutless at 25 and 50 ppm and all rates of Bonzi, were marketable.

Significance to Industry: Cutless, Sumagic, and B-Nine appear useful in the production of a high-quality pink coreopsis crop. These PGRs reduced plant size and increased market quality rating without delaying flowering. Cutless and Sumagic decreased the number of days to full flowers, thus reducing production time.

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Table 1. Plant growth regulator effects on *Coreopsis rosea.*

Growth regulator	Rate (ppm)	Height at first flower (cm)	Days to full flower[z]	Quality rating[y]
Control	0	37.0	46	1.4
B-Nine	2500	30.4	50	2.7
		L*** [x]	NS	L*** Q***
	5000	30.8	47	2.6
	7500	27.6	47	2.8
Cutless	25	32.9	44	2.0
		L***	Q*	L***
	50	32.2	42	2.1
	75	27.2	42	2.8
	100	30.7	45	2.6
	125	27.5	43	3.0
	150	27.1	44	3.0
Sumagic	10	29.8	45	2.3
		L*** Q*	L***	L*** Q***
	20	28.3	41	3.1
	30	26.5	42	3.1
	40	26.2	42	3.3

[z]When one-third of flowers were fully opened.
[Y]Quality rating: 1 = poor, unmarketable; 2.5 = marketable; 4 = excellent.
[X]Non-significant (NS) or significant, linear (L) or quadratic (Q) response at P = 0.05 (*) or 0.001 (***).

Root Mass and BA Affect Offset Formation in *Hosta*
(Student)

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Nature of Work: Hostas increase in area by forming offsets that arise from axillary and rhizomic buds. However, crown division, the traditional propagation method for hosta, yields few offsets on an annual basis because many cultivars are slow to form them.

Outgrowth of axillary and rhizomic buds in hosta is inhibited by apical dominance, a process regulated by an internal balance between auxin and cytokinins. Benzyladenine (BA) is a synthetic cytokinin effective in promoting elongation of inhibited buds (Cline, 1988). Keever (1994) observed that BA application induced offset formation in hosta. Plants with no offsets at the time of BA application produced more offsets than those with multiple offsets (Keever et al., 1998). These offsets could be harvested and rooted under intermittent mist. Rooting percentage was positively correlated with the number of unfurled leaves on the offsets (Keever et al., 1995). Garner et al. (1997) found that BA response was cultivar dependent, and sequential applications of BA were necessary to continue the positive response to BA after offset removal (Garner et al., 1998).

Although BA-induced offset formation was demonstrated a fast and effective method for propagating hosta, results were often highly variable within a treatment, even though efforts were made to ensure plants were uniform. To decrease this variability, it is necessary to investigate other factors that may interact in BA- induced offset formation; one factor may be root mass at the time of treatment. Our objective was to examine the effects of root mass and BA application on offset formation in two hosta cultivars, ‘Francee’ and ‘Francis Williams.’

Stock plants of each cultivar were divided, visually rated based on root mass (small, medium, and large), and potted in one-gallon containers using amended pinebark medium. Ten plants from each root mass group were sprayed with 3000 ppm BA using a CO_2 sprayer at 20 psi (2 qt./ 100 ft.^{2}) and ten plants from each root mass group were controls. Offset number was recorded 30 and 60 days after treatment (DAT). Growth index (GI) [(height + width at widest point + width 90° to first width)/3] and offset stage of development (SOD, number of unfurled leaves) of each offset were recorded 60 DAT (Auburn only). This experiment was conducted at the Ornamental Horticulture Substation in Mobile, Alabama and in Auburn, Alabama during 1997.

Results and Discussion: Offset formation in response to treatments generally was consistent at the two locations; hence only results from Mobile are reported. There was a significant interaction between root mass (RM) and BA for offset number in both cultivars 30 DAT and in 'Francee' 60 DAT (Table 1). Offsets increased as RM increased for BA-treated (+BA) and for untreated plants (-BA) 60 DAT. At 60 DAT, offset number was higher for +BA plants with large root masses than those with small root masses. BA-treated 'Francee' with medium (30 DAT) or large (30 and 60 DAT) RM produced more offsets than corresponding –BA 'Francee.' Large RM 'Francis Williams' produced more offsets than small or medium plants 30 and 60 DAT (Tables 1 and 2), but only in +BA plants 30 DAT. Relative to –BA 'Francis Williams', offset numbers were higher for +BA plants with small root masses only at 30 DAT and across all RM groups 60 DAT.

GI increased as RM increased, but BA had no effect on GI (data not shown). Offsets on +BA plants had a higher SOD than offsets on –BA plants. SOD was not affected by root mass treatments.

Significance to the Industry: BA is effective in inducing outgrowth of axillary and rhizomic buds in hosta although in 'Francee' the response was more evident in plants with large RM. GI, but not SOD, increased as RM increased. Offset formation tended to be positively correlated with increasing RM in both cultivars, regardless of BA application. BA did not affect GI, but BA did affect SOD. These results agree with previous studies (Keever et al., 1995).

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Table 1. Root mass and BA effects on offset number in hosta 30 and 60 days after treatment (DAT) (Mobile).

	Offset number		
	'Francee'		'Francis Williams'
Root mass class	30 DAT	60 DAT	30 DAT
		+ BA	
small	0.0c[z]	1.3b	0.6b
medium	4.0b	3.3ab	0.7b
large	10.2a	6.9a	2.4a
		- BA	
small	0.2a	1.5c	0.1a*[y]
medium	0.1a*	3.2b	0.0a
large	0.4a*	4.0a*	0.3a

[z]BA x RM interaction significant at P=0.05; mean separation within +/- BA by single degree of freedom contrasts.

[y]Means for –BA treatments followed by an asterisk are significantly different from corresponding root mass class means for +BA treatments; P=0.05.

Table 2. Root mass and BA main effects for 'Francis Williams' hosta 60 days after treatments (DAT) (Mobile).

Offset number				
Root mass class			BA	
small	medium	large	+	-
0.3b[z]	0.4b	1.2a	0.2b	1.0a

[z] BA and RM interaction not significant.

Benzyladenine Induces Branching in Eleven New *Hosta* Cultivars

(Student)

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Nature of Work: New *Hosta* cultivars are rapidly being introduced to the nursery industry, and a means to quickly produce high numbers of these cultivars is needed. The success of benzyl adenine (BA) to induce offset formation has been marginal in some *Hosta* cultivars (Garner et. al. 1995). A new product, N-6-Benzylaminopurine (BAP-10), has shown increased success in inducing offset formation in *Dieffenbachia, Spathiphyllum, and Syngonium* (Christiansen, 1997). The effect of BAP-10 on *Hosta* was investigated in an attempt to increase the amount of offsets available for propagation .

Single shoot *Hosta* cultivars ‘Great Expectations’, ‘Paul’s Glory’, ‘Elvis Lives’, ‘Fragrant Bouquet’, H. *montana* ‘Aureo Marginata’, ‘Frosted Jade’, ‘Hoosier Harmony’, ‘Mountain Snow’, ‘Abba Dabba Doo’, ‘Iron Gate Delight’, and ‘Black Hills’ were obtained from tissue culture and transplanted into 4" pots. A 3,000 ppm BAP-10 spray was applied to runoff on April 24, 1998 to ten replicates of each cultivar. Offset counts were made one month later for BAP-10 treated plants and controls.

Results and Discussion: Analysis of variance indicated significance at the $P < 0.0001$ level of the main effects of cultivar and BAP-10 as well as cultivar x BAP-10 interaction. Each cultivar treated with BAP-10 had increased offset formation, but the number of offsets formed due to BAP-10 application was different among the cultivars (Figure 1). Cultivars ‘Abba Dabba Doo’, ‘Frosted Jade’, ‘Iron Gate Delight’, ‘Paul’s Glory’, and ‘Elvis Lives’ had the highest amount of offset formation while cultivars ‘Great Expectations’ and ‘Fragrant Bouquet’ had the lowest amount of offset formation due to BAP-10. BAP-10 offset formation by cultivars ‘Hoosier Harmony’, H. montana ‘Aureo Marginata’, ‘Mountain Snow’, and ‘Black Hills’ were not different from any of the other cultivars.

Hostas treated with BAP-10 had improved offset formation, which may lead to an increase in the amount of propagules produced in a given time. Further research will examine the ability to propagate offsets, and the effect reapplication of BAP-10 will have after offsets are removed.

Significance to industry: New Hosta cultivars are being introduced to the nursery industry at growing rates to keep pace with consumer demand. As with any crop, it is important for the grower to produce needed numbers in the shortest time period possible. BAP-10 shows promise for increasing the rate of production of new Hosta cultivars by increasing the number of offsets per plant, thus allowing the grower to meet consumer demand more quickly.

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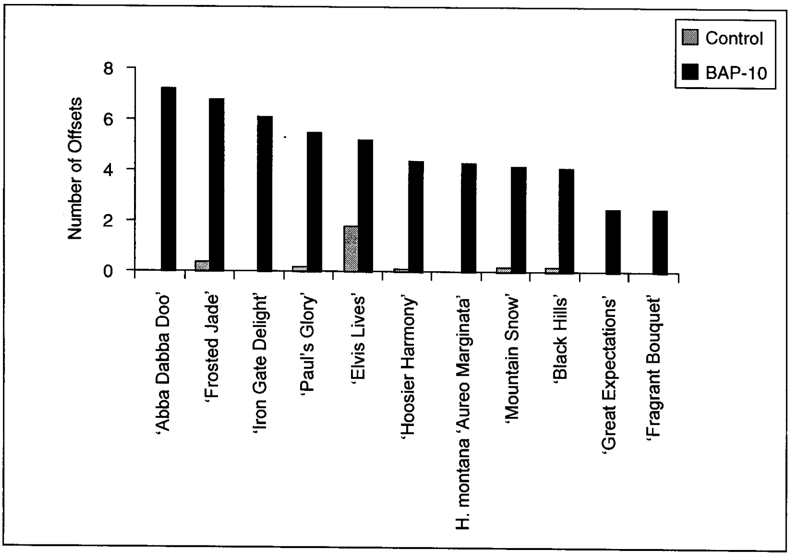

Figure 1. Offset formation of Hosta treated with N-6-benzylaminopurine (BAP-10) versus untreated control.

Photoselective Greenhouse Covers for Plant Growth Regulation

(Student)

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Nature of Work: Chemical height control is a standard practice in commercial horticultural operations, but non-chemical alternatives are gaining popularity due to species specificity of chemicals and increased restrictions on chemical usage. Alternative methods for controlling plant height, such as, manipulation of temperature and light quality in the greenhouse have been investigated to completely or partially substitute for the use of chemical growth regulators. Removal of stem elongation stimulating far-red (FR) light with liquid copper sulfate ($CuSO_4$) filters has been shown to be effective in height control of many species (McMahon and Kelly, 1990, Rajapakse and Kelly, 1992). However, liquid filters are not commercially viable due to difficulty in handling, high construction and maintenance costs, and phytotoxicity of chemicals from any leakage. Therefore, our goal is to develop photoselective greenhouse covering or shading material with FR absorbing dyes to alter greenhouse light quality. This paper reports on the plant growth response to photoselective greenhouse covers with FR intercepting dyes.

Five PVC frame growth chambers (1 m x 0.8 m x 0.8 m) were covered with 2.5-mm thick photoselective panels that contained varying concentrations of FR intercepting dyes. The filters are identified by the following code names given by Mitsui Chemicals Inc. Japan; as control, YBM-1# 85, YBM-1# 75, YBM-1# 65, and YBM-1# 55. The number followed by YBM-1 indicates photosynthetic photon flux (PPF) transmission by the panels. A sixth chamber was covered with polycarbonate panels filled with 4% $CuSO_4$. Two fans in opposite sides of each chamber ensured proper airflow and prevented heat build-up. Light quality was measured at the beginning and at the end of the experiment using a Li-COR spectroradiometer. Photosynthetic photon flux was adjusted to be the same in all the chambers.

Uniformly rooted ‘Bright Golden Anne’ chrysanthemum cuttings were planted one each in 0.6 m^3 square plastic pots containing a commercial medium. Plants were acclimatized for one week under greenhouse conditions. Following the establishment period, eight plants were placed in growth chambers covered with photoselective filters. Plants were fertigated daily with Peter’s 20-10-20 at the rate of 200ppm of N. Plant height was measured at weekly intervals for 4 weeks. Average internode length was calculated as plant height / number of leaves. At the end of 4 weeks, leaf and stem dry mass were measured following drying at 85° C (185°F).

In a separate experiment, photosynthesis and respiration of the plants grown under spectral filters were measured at bi-weekly intervals using a CIRAS Photosynthesis-meter. The 4th, 8th and 12th fully opened leaves from the apex were selected on each plant for photosynthesis and respiration measurements. Photosynthetic measurements were taken between 10 am and noon on clear days and the respiration measurements were taken in a dark room maintained at room temperature of 27°C (81°F).

In a third experiment, plants were exposed to the filtered light in selected chambers only for a specific part of the day [morning (sunrise to midday), evening (mid-day to dusk) or continuous] to determine if this is sufficient to achieve height reduction without reducing drymass.

Results and Discussion: YBM-1 filters removed FR light from the sunlight without altering blue and red(R) wavelengths (Table 1). As the dye concentration increased, PPF decreased and FR removal increased resulting in higher R: FR. YBM-1 filters reduced chrysanthemum height (Fig. 1). The height reduction increased as the dye concentration increased. Height reduction was evident in two weeks and maximum reduction occurred after three weeks of exposure. On day 21, the height reduction by YBM-1 #85 was 6.6% while that by YBM-1 #55 was 22.8% compared to control. The filters reduced both stem and leaf dry mass compared to control (data not shown), but no significant differences in dry mass were found between #65 and #55. As the R: FR ratio increased, the rate of photosynthesis decreased though the respiration rate did not change significantly (Table 2). The decrease in the dry mass of the plants grown under higher R: FR ratios can be mainly attributed to the decrease in the rate of photosynthesis. Further experiments are required to determine when the acclimatization takes place to altered light conditions. The plants that received continuous exposure were shorter than those exposed in the morning or evening (Fig. 2). Evening exposure was more effective in reducing height than morning exposure.

Table 1: Percentage transmission of different wavelength regions and R: FR of transmitted light. Percentages are based on total transmission between 400-800 nm.

Treatment	R:FR	% Blue	% Red	%Far-Red
Control	1.1	19	28	26
YBM-1 #85	1.6	20	30	19
YBM-1 #75	2.7	21	31	13
YBM-1 #65	4.3	21	30	8
YBM-1 #55	6.4	19	29	5
$CuSO_4$	12.7	38	15	1

Table 2: Effect of photoselective greenhouse covers on photosynthesis and respiration.

		Photosynthesis ($\mu mol\ CO_2\ m^{-2}s^{-1}$)		Respiration ($\mu mol\ CO_2\ m^{-2}s^{-1}$)	
Treatment	R:FR	Day 14	Day 28	Day 14	Day 28
Control	1.1	9.7 ± 0.4	9.5 ± 0.3	2.00 ± 0.07	1.58 ± 0.06
YBM-1 #75	2.3	8.8 ± 0.6	8.1 ± 0.3	1.96 ± 0.56	1.58 ± 0.05
YBM-1 #55	5.4	7.7 ± 0.3	7.7 ± 0.3	1.74 ± 0.04	1.67 ± 0.07
$CuSO_4$	12.7	6.9 ± 0.4	6.5 ± 0.4	1.77 ± 0.05	1.64 ± 0.76

Significance to Industry: As public awareness increases regarding the impact of chemical usage on non-targeted species and environmental pollution, interest in the use of less or non-chemical alternatives to regulate plant growth will increase. Our results show that photoselective greenhouse covers effectively alter greenhouse light quality to produce short and compact plants without chemicals. Future development of commercial greenhouse covers or shading material may potentially reduce cost and health risks of growth regulating chemicals, reduce greenhouse temperatures while increasing worker comfort and reducing environmental pollution.

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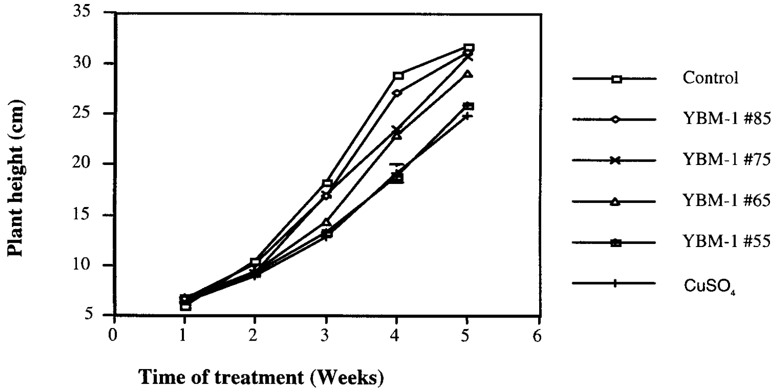

Fig. 1. Weekly height increase of spectral filter grown chrysanthemum plants.

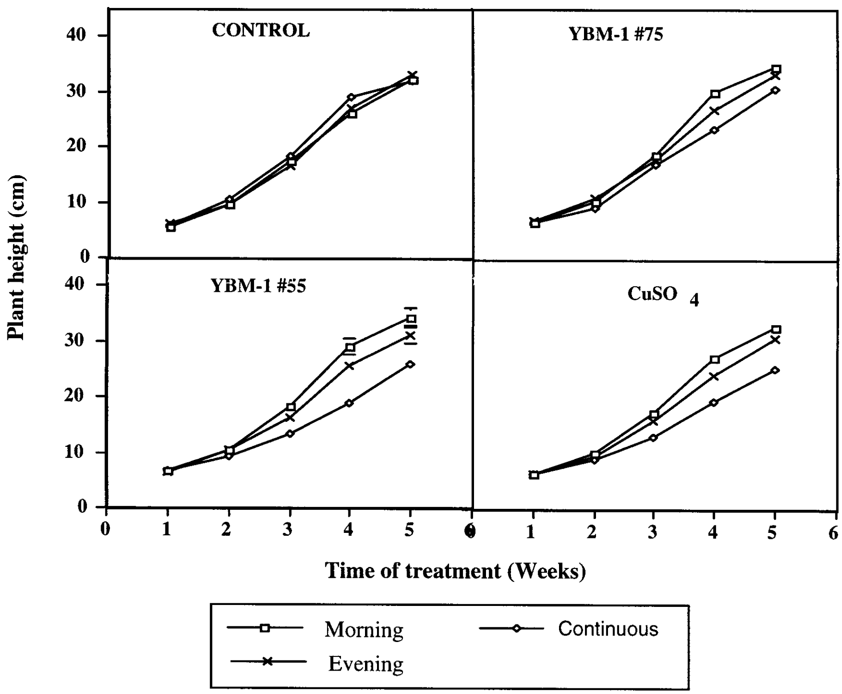

Fig. 2. Weekly height increase of spectral filter grown chrysanthemum plants with different exposure times.