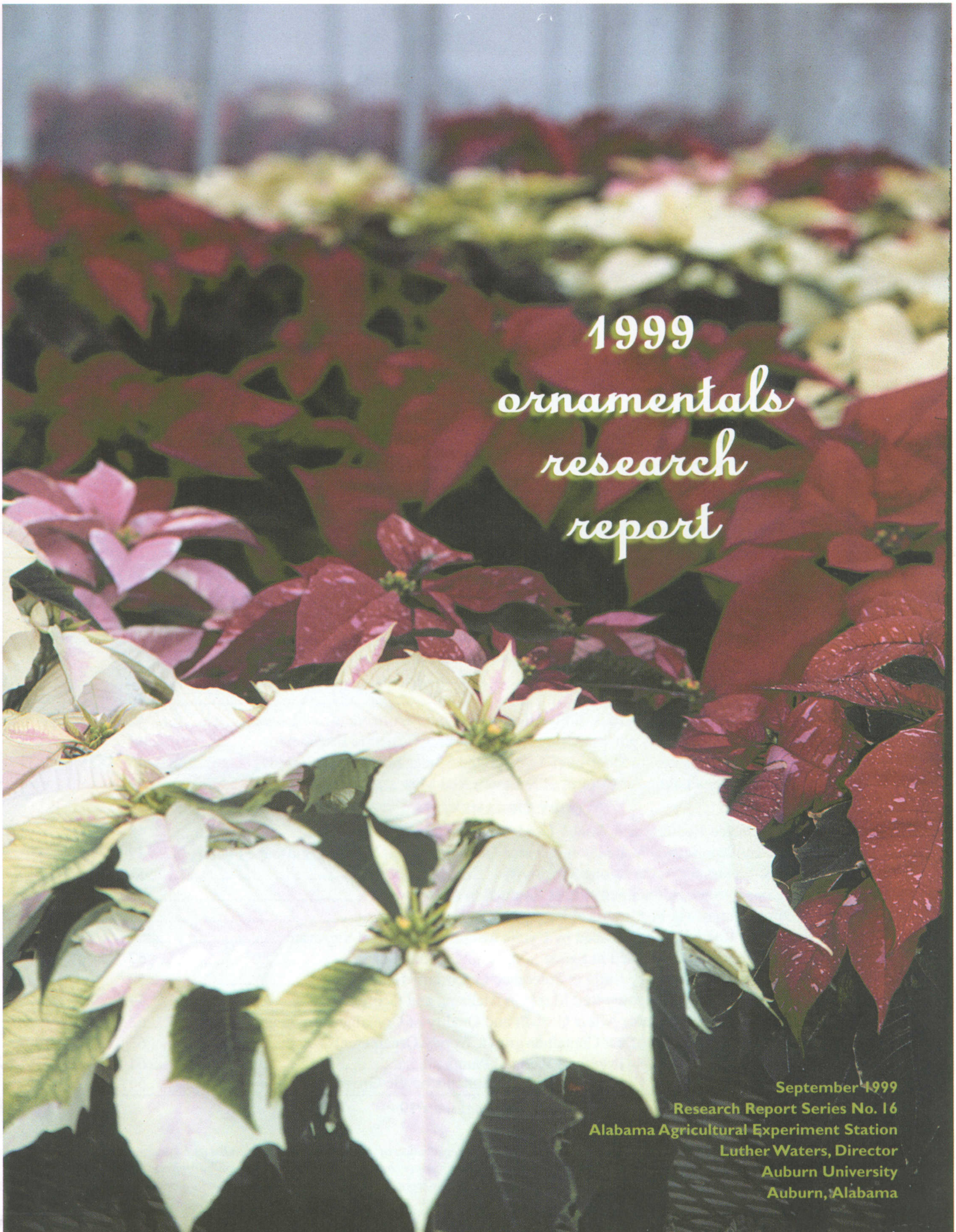

1999 ornamentals research report

September 1999
Research Report Series No. 16
Alabama Agricultural Experiment Station
Luther Waters, Director
Auburn University
Auburn, Alabama

CONTENTS

GREENHOUSE CROPS

INSECT, DISEASE, AND WEED CONTROL

WOODY ORNAMENTALS

FIRST PRINTING 3M, SEPTEMBER 1999

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GREENHOUSE CROPS

Effects of Foliar Application of Growth Regulators on *Coreopsis rosea*

Stephanie E. Burnett, Gary J. Keever, J. Raymond Kessler, and Charles H. Gilliam

Coreopsis rosea, or pink coreopsis, is a delicate, erect, finely branched herbaceous perennial, growing 12-18 inches tall, and producing 0.75-inch pink flowers. Characterized by rapid growth, pink coreopsis is often difficult to manage during production, requiring time-consuming pruning for size control. Various plant growth retardants (PGRs), including B-Nine, Cutless, and Sumagic, have been used to control excessive growth in horticultural crops including the closely related species *Coreopsis verticillata* 'Moonbeam' and *Coreopsis grandiflora.* However, no previous work has been published using PGRs on *Coreopsis rosea.* The objective of this study was to determine the effectiveness of B-Nine, Cutless, and Sumagic in controlling growth of pink coreopsis.

METHODS

Rooted cuttings of pink coreopsis were transplanted to 4-inch square pots containing Fafard #3 growing medium, and placed pot-to-pot. Before treatments were applied, plants were sheared to 2.5 inches above the pot rim, spaced on 8-inch centers, and provided night-break lighting from 10:00 p.m. to 2:00 a.m. to simulate long days. Growth retardants were applied at 0, 2,500, 5,000, or 7,500 parts per million (ppm) for B-Nine; 25, 50, 75, 100, 125, or 150 ppm for Cutless; and 10, 20, 30, or 40 ppm for Sumagic. Date of the first open flower, shoot height, and growth index [(height + width1 + width 2)/3, where width1 is widest point and width2 is perpendicular to width1] were collected at that time. Each plant was rated for market quality on a scale of 1-4 (1 = poor, unmarketable; 2 = fair, acceptable; 3 = highly marketable; 4 = excellent) when one-third of the flowers were open, with a quality of 2.5 or higher considered marketable.

RESULTS

Time to first flower was not significantly increased by any PGR, but was decreased by approximately 3 days for Cutless and Sumagic as compared to untreated controls (see table). At first flower, increasing rates of all PGRs reduced shoot height. Shoot heights at first flower of plants treated with the lowest and highest rates of each PGR were reduced 18 and 25% for B-Nine, 11 and 27% for Cutless, and 20 and 29% for Sumagic, respectively, relative to height of controls. Growth indeces followed trends similar to height.

EFFECTS OF FOLIAR APPLICATION OF PLANT GROWTH REGULATORS ON *COREOPSIS ROSEA* 'AMERICAN DREAM'

Growth retardant	Rate (ppm)	Height at first flower (cm)	Days to full flower[1]	Quality rating[2]
Control[3]	0	37	46	1.4
B-Nine	2500	30	50	2.7
	5000	31	47	2.6
	7500	28	47	2.8
Cutless	25	33	44	2.0
	50	32	42	2.1
	75	27	42	2.8
	100	31	45	2.6
	125	28	43	3.0
	150	27	44	3.0
Sumagic	10	30	45	2.3
	20	28	41	3.1
	30	27	42	3.1
	40	26	42	3.3

[1]When one-third of flowers were fully opened. [2]Quality rating: 1=poor, unmarketable; 2=fair, acceptable; 3=highly marketable; 4=excellent. [3]Water application.

Time to one-third flowers had opened (full flower) decreased by as much as 4 days with Cutless at rates of 75 ppm and increased slightly with higher rates. Time to full flower decreased as much as 5 days with Sumagic, while B-Nine had no effect on this measurement compared to controls.

Market quality rating of plants treated with B-Nine, Cutless, or Sumagic increased with increasing rate. Highest numerical values for market quality were obtained with B-Nine at 7,500 ppm, Cutless at 125 or 150 ppm, and Sumagic at 40 ppm. Control plants were considered unmarketable based on the ratio of height to pot size, while those treated with all PGR-rate combinations were considered marketable.

The growth retardants, B-Nine at 2,500-7,500 ppm, Cutless at 25-150 ppm, and Sumagic at 10-40 ppm, appear useful in the production of a superior pink coreopsis crop. These PGRs reduced plant size and enhanced plant quality without delaying flowering. In addition to improved quality, the compact size of treated plants should facilitate shipping and handling.

BA Application Promotes Offset Formation in Hosta Cultivars

James M. Garner, Gary J. Keever, D. Joseph Eakes, and J. Raymond Kessler

Previous studies demonstrated the effectiveness of benzyladenine (BA), marketed as BAP-10, in promoting the outgrowth of buds in hosta. Furthermore, offsets formed from BA-induced buds can be removed from the mother plant soon after elongation and rooted under intermittent mist. Initial studies were conducted using blue hosta yet considerable differences in response to BA application may be expected among the more than 1,500 hosta cultivars available. A study was conducted in 1995 to determine differences among hosta cultivars in response to BA. Of 10 cultivars evaluated, BA application promoted offset formation in five cultivars. To more fully understand the response of hosta cultivars to BA, this study evaluated 10 additional hosta cultivars in 1996.

METHODS

Single-eye plants (plants without offsets) of 10 hosta cultivars (see table) were treated with a foliar application of 0, 1,250, 2,500, or 3,750 parts per million (ppm) of BA at 0.5 gallon per 100 square feet on June 4, 1996. At 30 and 60 days after treatment (DAT), visible offset counts and a growth index were determined for each plant.

RESULTS

BA application promoted offset formation in all cultivars evaluated, but the response to BA concentration was cultivar-dependent. At 30 DAT, offset counts in treated plants were higher than those of controls in eight of the 10 cultivars (see table). Optimal BA concentration varied among cultivars. Offsets formed in controls of all cultivars except Halcyon (HC) and Samuel Blue (SB) at 30 DAT. Plants of HC receiving 3,750 ppm BA averaged 3.1 offsets, and plants of SB receiving 1,250 ppm BA averaged 5.9 offsets. In treated plants of the remaining cultivars, increases in offsets at the numeric optimum of the tested rates ranged from 0.9 offset for Stiletto (ST) to 6.2 offsets for Hyacinthina (HY), compared to controls. Optimal increase in offsets in ST, HC, HY, and Patriot (PT) was at 3,750 ppm BA, while in Great Expectations (GE), Golden Tiara (GT), SB, Fragrant Blue (FB), Medio variegata (MU), and Shade Fanfare (SF) maximum offset numbers were produced at 1,250 ppm.

At 60 DAT, offset counts for treated plants were higher than those of controls in all cultivars. In HC, no offsets formed in controls by 60 DAT, but plants receiving 3,750 ppm BA averaged 3.8 offsets. In the remaining cultivars, at the numeric optimum of the three BA rates, increases in offsets among treated plants at 60 DAT ranged from 2.1 offsets in GE to 7.6 offsets in ST, compared to controls.

Compared to controls, growth index of treated plants was increased or unaffected by BA treatment (data not shown). At 30 DAT, the growth index was higher for treated plants than for controls of HY and PT, with the growth index increasing with increasing BA rate. Growth index for treated plants was similar to controls in other cultivars at 30 DAT. At 60 DAT, the growth index was higher for treated plants than for controls in PT, SB, and ST, and similar to controls for all other cultivars. No phytotoxic symptoms were noted in any treatments in this study, and in many cases, plant appearance was enhanced by BA application due to BA-induced offsets.

Results of this study indicated that foliar application of BA can promote offset formation in a wide range of cultivars. BA application resulted in higher offset counts for plants of all evaluated cultivars within 60 days of BA application. Rate response was cultivar-dependent, with numerical optimum of the tested BA rates at 1,250 ppm for half the cultivars evaluated and at 3,750 ppm for the remaining cultivars.

Application of BA to hosta may reduce costs and accelerate production for a wide range of cultivars, including cultivars which are slow to produce offsets. In a previous study, BA application promoted offset formation in 50% of the cultivars evaluated, while in this study, BA application promoted offset formation in all cultivars within 60 DAT. These findings suggest that BA is effective in promoting offset formation in a wider range of cultivars than previously demonstrated.

Offset Counts of Hosta Cultivars at 30 and 60 Days After Treatment (DAT) with Four BA Rates

BA rate	FB[1]	GE	GT	HC	HY	PT	SB	SF	ST	UM
					30 DAT					
0	0.4	0.1	3.5	0.0	1.6	1.0	0.0	2.4	1.4	1.9
1,250	3.1	2.2	6.8	0.2	6.9	3.8	5.9	8.3	1.0	3.9
2,500	1.8	2.2	6.5	1.0	4.9	3.6	4.9	7.7	2.0	2.4
3,750	3.1	1.9	5.6	3.1	7.8	5.5	5.5	7.1	2.3	3.0
					60 DAT					
0	1.7	0.6	4.3	0.0	2.9	2.3	0.1	4.3	3.5	2.2
1,250	3.6	2.7	6.9	0.2	8.1	4.0	6.9	8.5	7.1	4.4
2,500	4.2	2.4	6.5	1.5	5.0	3.8	5.4	7.7	9.4	2.8
3,750	3.8	2.3	5.7	3.8	.9	5.7	5.9	7.2	11.1	3.7

[1]FB=Fragrant Blue, GE=Great Expectations, GT=Golden Tiara, HC=Halcyon, HY= Hyacinthina, PT=Patriot, SB= Samuel Blue, SF=Shade Fanfare, ST=Stiletto, UM= Medio variegata.

Presence of Offsets Reduces Hosta's Response to Benzyladenine

Gary J. Keever and Thomas J. Brass

Vegetative buds of hosta develop on rhizomes and in leaf axils, but the shoot apex appears to suppress outgrowth of these buds by apical dominance. A primary factor in the mechanism of apical dominance is a hormonal interaction between auxins and cytokinins. Auxin, produced at the shoot tip and transported basipetally, inhibits the release of buds from apical dominance. This action of auxin is antagonized by cytokinin.

A previous study demonstrated that application of the synthetic cytokinin, benzyladenine (BA), to single-shoot plants of blue hosta induced the outgrowth of lateral and rhizomic buds. Offsets formed from BA-induced buds were removed from treated plants within 30 days of BA application and rooted under intermittent mist. Application of this technique to hosta production would likely employ stock plants with various numbers of initial offsets. However, because apical dominance is at least partially controlled by auxins produced in the shoot tip, the presence of multiple shoot apices may alter the response of hosta to BA application. The objective of this study was to determined effects of number of initial offsets on response of blue hosta to a range of BA rates.

METHODS

Uniform plants of blue hosta were selected for uniformity and divided into three groups based on the number of offsets present: those with no offsets, those with one emerged offset, and those with two or three emerged offsets. Plants in each group received a single foliar spray of 0, 1,250, 2,500, or 3,750 ppm BA. At 30, 60, and 90 days after treatment (DAT), offset counts were recorded for each plant.

RESULTS

Generally, offset number increased with increasing BA rate, regardless of initial offset number. These offsets developed from both axillary and rhizomic buds. For plants with no initial offsets, offset counts increased from 0.1 to 3.1 at 30 DAT, with no further increase at 60 DAT, even with 3,750 ppm BA. Change in offset number 90 DAT, averaged across initial offset number, again increased with increasing BA rate.

At 30 DAT, change in offset number among controls was greatest for plants with no initial offsets, followed by those with one initial offset, and least for plants with two or three initial offsets (see table). When treated with 1,250 ppm or 3,750 ppm BA, plants with no or one initial offset formed similar numbers of offsets 30 DAT but more offsets than those with two or three initial offsets. A similar trend was detected 60 DAT with controls and plants treated with 1,250 ppm BA. However, plants with different initial offset numbers formed similar numbers of offsets 60 DAT when treated with 2,500 ppm or 3,750 ppm BA. At 90 DAT, plants with no initial offsets had a similar increase in offset number as those with one initial offset and a 143% greater increase compared to plants with two or three initial offsets.

These results indicate that the presence of one offset on stock plants had little or no effect on hosta's response to BA compared to stock plants with no initial offsets. However, the presence of two or three offsets reduced subsequent formation of offsets in response to BA application. One possible explanation for the observed response in hosta is that plants with two or three initial offsets produced more auxin than those with zero or one offset; thus, apical dominance was stronger and BA was less effective in promoting outgrowth of additional axillary or rhizomic buds.

The change in offset number decreased in controls with one (30 DAT) or two or three (30 and 60 DAT) initial offsets and at 30 DAT in plants with two or three initial offsets treated with 1,250 ppm BA. This decrease in offsets may reflect a random abortion of offsets.

These data show that BA stimulates outgrowth of lateral buds in hosta. However, fewer additional BA-stimulated buds are likely to develop into shoots when two or three initial offsets are present on the stock plants than when zero or one offset is present. These results provide a clearer understanding of stock plant response to BA application and should facilitate the development of a practical system for the accelerated multiplication of hosta.

CHANGE IN INITIAL OFFSET NUMBER OF BLUE HOSTA STOCK PLANTS TREATED WITH 0, 1,250, 2,500 OR 3,750 PPM BA

	Change in offset number								
	30 DAT			60 DAT			90 DAT[1]		
Initial offset number	0	1	2,3	0	1	2,3	0	1	2,3
BA rate (ppm)									
0	0.1	0.8	-1.4	0.1	0.1	-0.7	—	-0.3	—
1,250	1.5	2.3	-0.4	2.3	2.8	0.3	—	1.5	—
2,500	1.3	1.3	1.4	1.9	1.4	1.7	—	1.4	—
3,750	3.1	2.4	1.1	3.0	2.1	1.9	—	2.4	—

[1]Average across initial offset number.

Plant Growth Retardants Affect Growth and Flowering of *Achillea* × 'Coronation Gold' in 6-inch Pots

J. Raymond Kessler and Gary J. Keever

Achillea × 'Coronation Gold' is a widely-grown garden perennial with yellow flowers that blooms in early summer at a height of about 2.5 feet. *Achillea filipendulina*, one of the parents of this cultivar, has an obligate requirement for 8 weeks of vernalization at 41°F followed by long photoperiods (>14 hours or night-break lighting) for complete flowering. *Achillea* × 'Coronation Gold' responds in much the same way, but its flower stems grow too tall in containers under greenhouse conditions for market acceptance; therefore, it may benefit from plant growth retardants. This investigation was conducted to determine the plant growth retardant type, rate, and application timing required to produce a marketable greenhouse pot plant of *Achillea* × 'Coronation Gold' grown in 6-inch pots.

METHODS

Vegetatively propagated offsets of *Achillea* × 'Coronation Gold' grown in 72-celled flats were transplanted into 6-inch plastic pots containing Fafard 4-P. Plants were pruned to 1 inch above the substrate at the time of planting. Plants were then placed pot-to-pot in a plastic covered greenhouse under naturally occurring short photoperiods with a heating set point of 62°F and ventilation at 78°F. Fertilization throughout the experiment was applied weekly at 150 parts per million (ppm) nitrogen using a 20-10-20 fertilizer. Plants were watered/fertilized when the medium appeared dry, but before plants wilted. After 7 weeks growth, all plants were placed in a walk-in cooler at 40°F for 9 weeks. Incandescent light (60 watt) was provided at a minimum of 10 foot-candles for 24 hours per day and clear water was applied as needed while in the cooler.

After cooler treatment, plants were placed in a glass-covered greenhouse with a heating set point of 65°F, and ventilation at 76°F. Plants were provided long photoperiods beginning 1 week after removal from the cooler until the end of the experiment by lighting from 10:00 p.m. to 2:00 a.m. using a minimum of 10 foot-candles from incandescent lamps (60 watt). Plant growth regulator treatments were applied with a pressurized CO_2 sprayer set at 20 psi at a rate of 0.5 gallon per 100 square feet. B-Nine at 0, 2,550, 5,100, or 7,650 ppm; Bonzi at 0, 32, 64, or 96 ppm; Royal Slo-Gro at 0, 450, 900, or 1,350 ppm; or Sumagic at 0, 10, 20, or 30 ppm was applied 2 weeks, 4 weeks, or 2 and 4 weeks after removal from the cooler using half the concentration. After treatment, plants were spaced on 12-inch centers. Data recorded at the time of first open flower was flower date, shoot height, growth index [(height + width1 + width2)/3 where width1 is at the widest point, and width2 is perpendicular to width1], a market quality rating (1=very poor, unsalable; 2=poor, unsalable; 3=average, salable; 4=good, salable; 5=excellent, salable), and the length of the five longest lateral shoots. Flower date and shoot length were recorded when each flower head on a plant opened. A flower head was defined as open when 90% of the florets had expanded yellow petals. Once all the flowering shoots on a plant were open, the number of flowering and non-flowering shoots was recorded and a market quality rating (1=very poor; 2=poor; 3=average; 4=above average; 5=excellent) was assigned.

RESULTS

There was no effect of application timing. All growth retardants resulted in decreased shoot length with increasing concentration except Royal Slo-Gro (see table). Applications of Royal Slo-Gro resulted in delayed flowering, highly variable shoot lengths, and low market quality ratings. In addition, Royal Slo-Gro reduced the number of flowering shoots (data not shown), produced foliar chlorosis, and distorted flower heads. The highest

Response of *Achillea* × 'Coronation Gold' to Spray Applications of B-Nine, Bonzi, Royal Slo-Gro, and Sumagic

Growth retardant	Rate (ppm)	Days to flower	Flower shoot length (cm)[1]	Market quality rating[2]
B-Nine	0	43	46.7	2.0
	2550	44	41.1	2.0
	5100	46	36.8	2.7
	7650	47	31.7	3.3
Bonzi	0	42	46.2	2.2
	32	43	43.7	2.3
	64	43	40.9	2.9
	96	46	37.4	3.0
Royal Slo-Gro	0	43	47.1	2.0
	450	58	44.2	2.0
	900	63	43.6	2.0
	1350	65	46.8	2.0
Sumagic	0	42	46.9	2.1
	10	44	42.7	2.3
	20	45	42.1	2.8
	30	46	36.4	3.6

[1] English conversion 2.54 cm = 1 inch.
[2] Market quality rating: 1=very poor; 2=poor; 3=average; 4=above average; or 5=excellent.

rate of B-Nine, Bonzi, and Sumagic decreased shoot length by 32%, 19%, and 22% compared to untreated plants, respectively. The highest rate of B-Nine, Bonzi and Sumagic increased the time to flower by about 4 days compared to untreated plants while Royal Slo-Gro delayed flowering by more than 22 days. Market quality rating for plants treated with Royal Slo-Gro was low, averaging 2.0. Market quality rating increased with increasing concentration for B-Nine, Bonzi, and Sumagic with the highest rating, 3.6, given to Sumagic at 30 ppm.

B-Nine, Bonzi, and Sumagic at the highest rates resulted in sufficient shoot length control in *Achillea* × 'Coronation Gold' for it to receive average market quality ratings of 3.0 or higher (average and salable). A flowering delay of about 4 days would probably not be a significant problem in commercial application. However, labeled rates for Bonzi and Sumagic are well below the rates found effective in this study. It is probable that the cost of applying Bonzi or Sumagic at these high rates may be prohibitive. Therefore, B-Nine at 7,650 ppm may be the most cost effective plant growth retardant to use for greenhouse production of *Achillea* × 'Coronation Gold' in 6-inch pots. Quality of plants treated with Royal Slo-Gro was unacceptable.

Plant Growth Retardants Reduce Peduncle Elongation of *Achillea* × 'Coronation Gold' in 4-inch Pots

J. Raymond Kessler and Gary J. Keever

Achillea × 'Coronation Gold' is a widely grown garden perennial with yellow flowers that bloom in early summer at a height of about 2.5 feet. 'Coronation Gold' has an obligate requirement for 6 to 8 weeks of vernalization at 41°F followed by long photoperiods (>14 hours or night-break lighting) for complete flowering. Because control of flowering is known, 'Coronation Gold' has potential as a greenhouse pot crop, but flower peduncles grow too tall in small containers for market acceptance. Therefore, product quality may be improved by using plant growth retardants. This investigation was conducted to determine the plant growth retardant type, rate, and application timing required to produce a marketable greenhouse pot plant of *Achillea* × 'Coronation Gold' grown in 4-inch pots.

METHODS

Offsets of *Achillea* × 'Coronation Gold' were removed from vegetative stock plants and stuck in 6006-cell flats containing Fafard Germinating Mix. Offsets were rooted under intermittent mist in a shaded glass greenhouse under natural short photoperiod with 85°F bottom heat. Rooted offsets were removed from mist after 19 days and placed in a plastic covered greenhouse with a heating set point temperature of 65°F and ventilation at 78°F. Offsets were transplanted to 4-inch round plastic pots containing Fafard 4-P 31 days after sticking and initially spaced pot-to-pot on a greenhouse bench. Fertilization throughout the experiment was applied as a constant liquid fertilization consisting of 150 ppm nitrogen using a 20-10-20 with one clear water application per week to prevent soluble salts buildup. Plants were watered/fertilized when the medium appeared dry, but before plants wilted.

After 5 weeks growth, all plants were placed in a walk-in cooler at 40°F for 8 weeks of vernalization treatment. Incandescent light (60 watt) was provided at a minimum of 10 foot-candles for 24 hours per day and clear water was applied as needed while in the cooler. After vernalization, plants were placed in a glass covered greenhouse with a heating set point of 65°F and ventilation at 78°F. Plants were provided long photoperiods beginning 1 week after removal from the cooler until the end of the experiment by lighting from 10:00 p.m. to 2:00 a.m. using a minimum 10 foot-candles from incandescent lamps (60 watt). Plant growth retardant treatments were applied as a spray 1 week after removal from vernalization as follows: B-Nine at 0, 2,550, 5,100, or 7,650 ppm; B-Nine + Cycocel at 0+0, 1,275+1,534, 2,550+1,534, or 3,825+1,534 ppm, respectively; Bonzi at 0, 32, 64, 96, 128, or 160 ppm; Cutless at 0, 40, 80, or 120 ppm; Cycocel at 0, 767, 1,534, or 2,301 ppm; or Sumagic at 0, 11, 22, 33, 44, or 55 ppm. Plant growth retardants were applied with a pressurized CO_2 sprayer calibrated to 20 psi at a rate of 0.5 gallon per 100 square feet. After treatment, plants were spaced on 8-inch centers. Data recorded at the time of first open flower were flower date, shoot height, market quality rating (1=very poor, unsalable; 2=poor, unsalable; 3=average, salable; 4=good, salable; 5=excellent, salable), and length of the five longest lateral shoots.

RESULTS

The highest rates of B-Nine, B-Nine+Cycocel, Bonzi, Cutless, Cycocel, and Sumagic reduced peduncle length by 36%, 61%, 75%, 75%, 39%, and 52% compared to untreated plants, respectively (see table). However, the highest rates of B-Nine, B-Nine+Cycocel, and Bonzi increased time to flower by 5 days whereas Cutless, Cycocel, and Sumagic did not have an appreciable effect. The highest rates of Bonzi, Cutless, and Sumagic decreased flower size by 17%, 14%, and 18%, respectively, whereas B-Nine, B-Nine+Cycocel, and Cycocel did not have an appreciable effect. B-Nine and Cycocel had very little effect on market quality rating while increasing concentrations of B-Nine+Cycocel increased market quality rating. Market quality rating increased with increasing concentration of Bonzi, Cutless, and Sumagic up to the middle of the treatment range and then declined at higher concentrations. Market quality ratings of 2.6 or higher were received by plants treated with B-Nine+Cycocel at 3,825+1,534 ppm; Bonzi at 32, 64, and 96 ppm; Cutless at 40 ppm; and Sumagic at 11 and 22 ppm.

Bonzi and Sumagic at moderately high concentrations yielded adequate peduncle length control for acceptable quality 4-inch pots of *Achillea* × 'Coronation Gold'. However, the highest rates resulted in excessive stunting as indicated by the decrease in market quality ratings. B-Nine and Cycocel alone had only moderate effects on peduncle length and market quality rating but were considerably more effective in combination, indicating a synergistic effect. None of the treatments received market quality ratings greater than 3.0 because plants only had one to two flowering shoots and therefore were not full enough to warrant higher ratings. Further work needs to be done to increase the number of flowering shoots for a higher quality, 4-inch pot plant. A flowering delay of 3 to 5 days by several of the plant growth retardants would probably not be a significant problem in commercial application. These results provide growers with several choices of plant growth retardants for growing 'Coronation Gold' as a 4-inch pot crop in the greenhouse.

RESPONSE OF *ACHILLEA* × 'CORONATION GOLD' TO SPRAY APPLICATIONS OF B-NINE, B-NINE + CYCOCEL, BONZI, CUTLESS, CYCOCEL, OR SUMAGIC

Growth retardant	Rate (ppm)	Shoot height (cm)[1]	Flower diameter (cm)[1]	Market quality rating[2]	Days to flower
B-Nine	0	48.2	5.2	2.0	39
	2550	41.8	5.1	2.0	40
	5100	39.8	5.1	2.0	41
	7650	31.0	5.0	2.1	44
B-Nine+Cycocel	0	47.9	5.3	2.0	39
	1275+1534	32.3	5.2	2.1	40
	2550+1534	27.0	5.1	2.4	43
	3825+1534	18.8	4.9	2.8	44
Bonzi	0	47.6	5.4	2.0	39
	32	30.1	5.3	2.6	39
	64	20.5	4.7	3.0	42
	96	17.7	4.7	2.9	42
	128	12.3	4.6	2.3	42
	160	11.9	4.5	2.3	43
Cutless	0	45.2	5.0	2.0	40
	40	16.1	4.5	2.6	41
	80	13.4	4.5	2.4	42
	120	11.3	4.3	2.0	43
Cycocel	0	49.1	5.2	2.0	38
	767	40.8	5.1	2.0	40
	1534	37.6	5.0	2.2	41
	2301	30.0	4.9	2.3	41
Sumagic	0	48.4	5.6	2.0	40
	11	29.5	4.9	2.6	41
	22	26.0	4.7	2.9	41
	33	26.3	4.7	2.4	40
	44	25.6	4.6	2.3	41
	55	23.1	4.6	2.2	42

[1] English conversion 2.54 cm = 1 inch.
[2] Market quality rating: 1=very poor, unsalable; 2=poor, unsalable; 3=average, salable; 4=above average, salable; 5=excellent, salable.

Using Plant Growth Retardants to Produce *Coreopsis verticillata* 'Moonbeam' as a Greenhouse Pot Crop

J. Raymond Kessler and Gary J. Keever

Coreopsis verticillata 'Moonbeam' is a herbaceous perennial, which blooms in late spring to early summer. It has no vernalization requirement, but an obligate requirement for long photoperiods (>14 hours or night-break lighting) to flower. Because vegetative growth and flowering can be controlled using photoperiod, it may be possible to develop the plant as a greenhouse pot crop. However, *Coreopsis* may grow too tall in small containers under greenhouse conditions for market acceptance, and therefore may benefit from plant growth retardants. This study was conducted to determine the plant growth retardant type, application method, and rate required to produce a marketable greenhouse pot plant of *Coreopsis verticillata* 'Moonbeam' in 4-inch pots.

METHODS

Terminal cuttings (approximately 2.5 inches long) of *Coreopsis verticillata* 'Moonbeam' were removed from vegetative plants and stuck in 72-celled flats containing Fafard Germinating Mix. Cuttings were rooted using intermittent mist in a shaded glass greenhouse under natural short photoperiods with 85°F bottom heat. Rooted cuttings were removed from mist after 27 days and placed in an unshaded glass greenhouse with a heat set point temperature of 65°F and ventilation at 78°F. All cuttings received a soft terminal pinch 2 days after removal from propagation. Cuttings were transplanted to 4-inch square pots containing Sunshine Mix 1 19 days after pinching, and initially placed pot-to-pot on a greenhouse bench. Fertilization throughout the experiment was applied as a constant liquid feed consisting of 150 ppm nitrogen using a 20-10-20 with one clear water application per week to prevent soluble salts buildup. Plants were watered/fertilized when the medium appeared dry, but before plants wilted. All cuttings were sheared to 2.5 inches above the pot rim 13 days after transplanting.

Plant growth retardant treatments were applied 10 days after shearing. Long photoperiods were started the same day by lighting plants from 10:00 p.m. to 2:00 a.m. using a minimum of 10 foot-candles from incandescent lamps (60 watt). Growth retardant treatments consisted of A-Rest drench at 0, 0.125, 0.25, or 0.375 mg a.i./pot; Bonzi drench at 0, 0.125, 0.25, or 0.375 mg a.i./pot; B-Nine spray at 0, 2,550, 5,100, or 7,650 ppm; Bonzi spray at 0, 12, 24, 36, 48, or 60 ppm; Cutless spray at 0, 25, 50, 75, 100, 150, or 200 ppm; or Royal Slo-Gro spray at 0, 360, 720, 1,080, 1,440, or 1,800 ppm. Foliar spray solutions were applied at a rate of 0.5 gallon per 100 square feet using a pressurized CO_2 sprayer calibrated at 20 psi. Soil drench solutions were applied at 2 fluid ounces per pot. After treatment, plants were spaced on 8-inch centers. Data recorded at the time of first open flower was flower date, shoot height, growth index [(height + width1 + width2)/3 where width1 is at the widest point, and width2 is perpendicular to width1], market quality rating (1=very poor, unsalable; 2=poor, unsalable; 3=average, salable; 4=good, salable; 5=excellent, salable), and length of the five longest lateral shoots.

RESULTS

All growth retardants resulted in decreased shoot height, growth index, and lateral shoot length with increasing concentration except for Bonzi and Royal Slo-Gro sprays (see table). The highest rate of A-Rest and Bonzi drench, B-Nine, and Cutless decreased shoot height compared to untreated plants by 36%, 30%, 21%, and 36%, respectively. Bonzi spray did not affect shoot height, growth index, or lateral shoot length while the highest rate of Royal Slo-Gro increased shoot height by 30% and lateral shoot length by 19% compared to untreated plants, but had no effect on growth index. A market quality rating of 4.0 or higher (good, salable) was given to plants treated with B-Nine at 5,100 or 7,650 ppm or Cutless at 150 or 200 ppm. Plants given a Bonzi drench received poor market quality ratings despite plant size reductions similar to those treatments receiving average or good ratings because of distorted lateral shoots with an unacceptable increase in branch angle. The highest rate of B-Nine and Royal Slo-Gro delayed flowering by an average of 5 and 16 days, respectively, compared to untreated plants. The increase in shoot height and lateral shoot length with increasing concentration of Royal Slo-Gro was possibly due to delayed flowering resulting in more time for vegetative growth.

When applied as a foliar spray, both B-Nine and Cutless resulted in acceptable market quality plants of *Coreopsis verticillata* 'Moonbeam' when grown in 4-inch pots in the greenhouse. However, Cutless is not currently labeled for application to ornamentals. B-Nine was equally effective when applied at 5,100 or 7,650 ppm. However, the former concentration may be a better choice because it resulted in less flower delay (3 days compared to 5 days).

Response of *Coreopsis verticillata* 'Moonbeam' to Drench Application of A-Rest or Bonzi or Spray Application of B-Nine, Bonzi, Cutless, or Royal Slo-Gro

Growth retardant	Rate (ppm)	Shoot height (cm)[1]	Growth index[2]	Lateral shoot length(cm)[1]	Quality rating[3]	Days to flower
			Drench (mg a.i. per pot)			
A-Rest	0	35.1	43.7	34.3	2.0	33
	0.125	27.8	71.6	27.9	2.0	33
	0.250	26.1	37.1	23.5	2.6	32
	0.375	22.4	31.0	19.7	3.1	33
Bonzi	0	34.4	48.1	34.4	2.0	33
	0.125	27.6	45.3	31.1	2.0	33
	0.250	24.9	40.4	29.4	2.0	33
	0.375	24.0	38.9	26.9	2.0	33
			Spray (ppm)			
B-Nine	0	32.7	43.7	30.5	2.0	34
	2550	28.2	33.6	23.3	3.4	37
	5100	25.9	29.4	20.6	4.1	37
	7650	25.9	29.0	20.4	4.1	40
Bonzi	0	33.0	46.1	33.1	2.0	33
	12	33.9	45.0	30.6	2.0	31
	24	33.6	45.7	30.3	2.0	32
	36	33.8	47.0	32.3	1.9	32
	48	30.7	45.7	32.3	2.0	33
	60	30.4	43.7	31.1	2.0	32
Cutless	0	33.9	48.0	33.4	2.0	33
	25	30.7	41.5	30.0	2.1	33
	50	27.9	38.1	24.1	2.3	32
	75	25.9	32.1	20.8	3.0	32
	100	23.8	31.5	20.6	3.4	32
	150	23.3	31.7	20.5	4.0	32
	200	21.7	29.7	16.8	4.1	32
Royal Slo-Gro	0	33.7	46.8	34.0	2.0	32
	360	39.2	44.0	34.3	2.0	42
	720	40.1	43.7	37.1	2.0	45
	1080	42.3	45.6	39.6	2.0	45
	1440	42.2	44.2	39.2	2.0	47
	1800	43.7	44.0	40.4	2.0	48

[1] English conversion 2.54 cm = 1 inch.
[2] Growth index = (height + width1 + width2)/3 in centimeters. Width1 is at the widest point, and width2 is perpendicular to width1.
[3] Quality rating: 1=very poor, unsalable; 2=poor, unsalable; 3=average, salable; 4=good, salable; 5=excellent, salable.

Application Timing of B-Nine and Cutless after Shearing Affects Growth and Flowering of 'Moonbeam'

J. Raymond Kessler and Gary J. Keever

Coreopsis verticillata 'Moonbeam' is a herbaceous perennial, which blooms in late spring to early summer. It has no vernalization requirement, but an obligate requirement for long photoperiods (>14 hours or night-break lighting) to flower. Because vegetative growth and flowering can be controlled using photoperiod, it may be possible to develop the plant as a greenhouse pot crop. However, *Coreopsis* grows too tall in small containers under greenhouse conditions for market acceptance, and therefore may benefit from plant growth retardants (PGR).

In previous work, several PGRs were reported to be effective in reducing shoot height and improving market quality rating of *Coreopsis* grown in 4-inch pots when applied 10 days after shearing. In a second study (data not presented), a different series of PGRs were tested, some in common with the first study, with very poor results. In the case of the second study, PGR application were made 1 day after shearing rather than 10 days after shearing. We hypothesized that the timing of PGR application after shearing may have an impact on the effectiveness of treatments. Therefore, the purpose of this study was to determine the effects of application timing after shearing and concentration of B-Nine or Cutless applied as a foliar spray on plant size and flowering of *Coreopsis verticilata* 'Moonbeam'.

METHODS

Terminal cuttings (approximately 2.5 inches long) of *Coreopsis verticillata* 'Moonbeam' were removed from vegetative plants and stuck in 72-celled flats containing Fafard 3B. Cuttings were rooted using intermittent mist in a shaded glass greenhouse under natural photoperiod. Rooted cuttings were removed from mist, given a soft terminal pinch after 26 days, and placed in an unshaded glass greenhouse with a 65°F heat set point and ventilation at 78°F. Short photoperiods were maintained from the time of removal from propagation to when PGR treatments were applied by pulling black cloth from 7:00 p.m. to 10:00 a.m. daily. Cuttings were transplanted 21 days after removal from propagation to 4-inch square pots containing Fafard 3B, and initially placed pot-to-pot on a greenhouse bench. All cuttings were sheared to 2.5 inches above the pot rim 20 days after transplanting. Long photoperiods were provided beginning the day of shearing by lighting from 10:00 p.m. to 2:00 a.m. using a minimum 10 foot-candles from incandescent lamps (60 watt). Fertilization throughout the experiment was applied as a constant liquid feed consisting of 150 ppm nitrogen using a 20-10-20 with one clear water application per week to prevent soluble salts buildup. Plants were watered/fertilized when the medium appeared dry, but before plants wilted.

PGR treatments were B-Nine at 0, 2550, 5100 or 7650 ppm and Cutless at 0, 50, 100, or 150 ppm. The PGR treatments were applied at 0, 3, 6, 9, 12, or 15 days after shearing. Foliar spray solutions of the PGRs were applied at a rate of 0.5 gallon per 100 square feet using a pressurized CO_2 sprayer set at 20 psi. Data recorded at the time of first open flower was flower date, shoot height, and market quality rating (1=very poor, unsalable; 2=poor, unsalable; 3=average, salable; 4=good, salable; 5=excellent, salable).

RESULTS

Time to flower of *Coreopsis verticillata* 'Moonbeam' increased by seven days when B-Nine was applied at all concentrations compared to untreated plants over all application times (see table). All B-Nine concentrations reduced shoot height and increased market quality rating compared to untreated plants. The highest market quality rating, 3.2, was assigned to plants that received 5,100 ppm B-Nine and these plants were 36% shorter than untreated plants. Shoot height declined from 0 days after shearing to 6 or 9 days and then increased up to 15 days after shearing over all B-Nine concentrations (Figure 1). A mathematical model of the relationship between shoot height and application timing predicted that a minimum shoot height could be achieved by applying B-Nine between 6 and 8 days after shearing.

Response of *Coreopsis verticillata* 'Moonbeam' to Spray Applications of B-Nine and Cutless Across All Application Times

Growth retardant	Rate (ppm)	Days to flower	Shoot height (cm)[1]	Market quality rating[2]
B-Nine	0	42	32.9	2.1
	2550	51	22.8	3.0
	5100	51	21.2	3.2
	7650	49	24.5	3.1
Cutless	0	43	30.5	2.1
	50	44	15.8	3.0
	100	44	17.8	2.9
	150	45	17.2	2.8

[1] English conversion 2.54 cm = 1 inch.
[2] Market quality rating: 1=very poor, unsalable; 2=poor, unsalable; 3=average, salable; 4=good, salable; 5=excellent, salable.

Market quality rating increased from 0 days after shearing to 6 or 9 days and then declined up to 15 days after shearing over all B-Nine concentrations (Figure 2). A mathematical model of the relationship between market quality rating and application timing predicted that a maximum quality rating could be achieved by applying B-Nine between 6 and 8 days after shearing. Thus, the predicted application time frame after shearing for minimum shoot height also yielded the highest predicted market quality rating.

There was no effect of Cutless on time to flower compared to untreated plants (see table). All Cutless concentrations increased market quality rating compared to untreated plants over all application times. The highest market quality rating, 3.0, was assigned to plants that received 50 ppm Cutless and these plants were 48% shorter than untreated plants. There was no effect of application timing of Cutless on shoot height or market quality rating.

When applied as a foliar spray both B-Nine and Cutless resulted in acceptable market quality plants of *Coreopsis verticillata* 'Moonbeam' when grown in 4-inch pots in the greenhouse. The highest market quality rating and greatest control of shoot height was achieved when B-Nine was applied from 2,550 to 7,650 ppm, 6 to 8 days after shearing. The highest market quality rating and greatest control of shoot height was achieved when Cutless was applied from 50 ppm, but Cutless was more flexible than B-Nine in application timing. However, Cutless is not currently labeled for application to greenhouse or nursery crops.

Figure 1. Effect of all spray concentrations of B-Nine applied 0, 3, 6, 9, 12, or 15 days after shearing on shoot height of *Coreopsis verticillata* 'Moonbeam'.

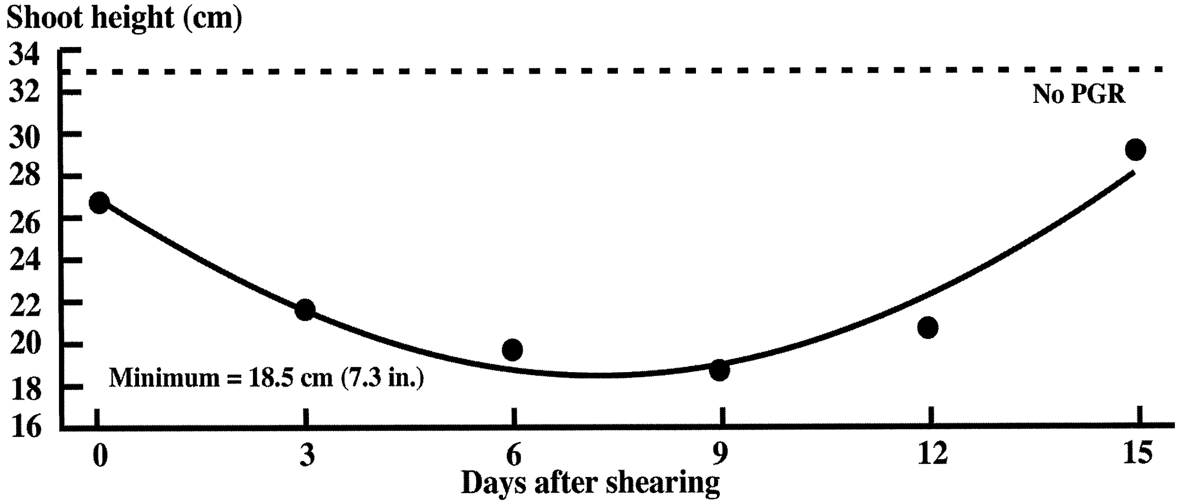
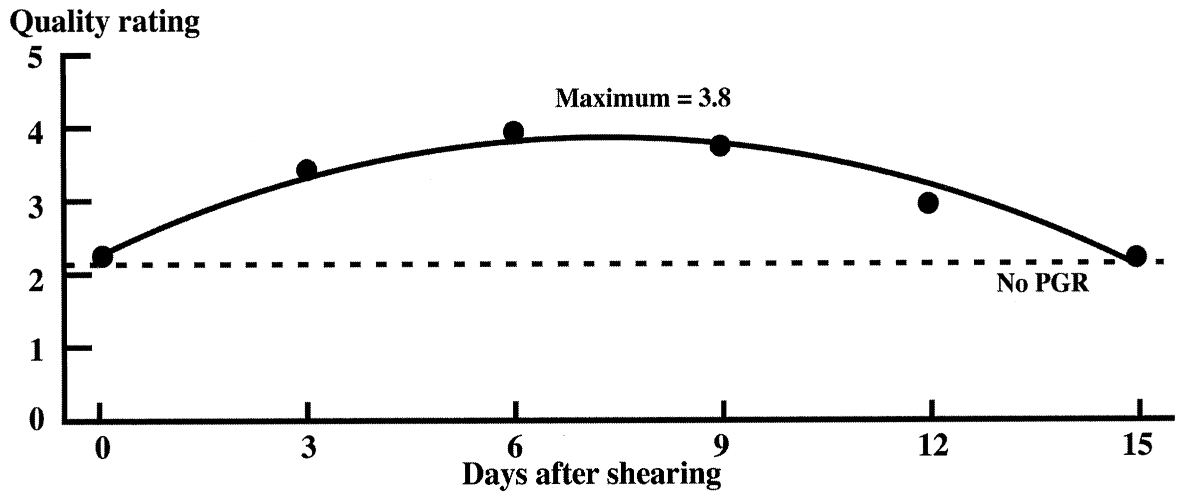


Figure 2. Effect of all spray concentrations of B-Nine applied 0, 3, 6, 9, 12, or 15 days after shearing on market quality rating of *Coreopsis verticillata* 'Moonbeam'.



Shasta Daisy Response to Photoperiod and Vernalization

J. Raymond Kessler and Gary J. Keever

Inconsistencies exist concerning the role of photoperiod and vernalization in flowering of Shasta Daisy (*Leucanthemum* × *superbum*) cultivars. In early studies, flowering was hastened by increased day length in several cultivars. In later studies, cultivars either were obligate long-day plants for flowering or required vernalization to flower. Recent work with 'Snow Lady' showed that long days, but not vernalization, hastened flowering, indicating a facultative response. This investigation was conducted to determine the role of photoperiod and vernalization time on growth and flowering of five Shasta Daisy cultivars.

METHODS

Transplants of 'Becky', 'Silver Princess', 'Snow Cap', 'Snow Lady', and 'Summer Snowball' Shasta Daisy 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. Plants were watered/fertilized when the medium appeared dry, but before plants wilted.

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 a.m. to 5:00 p.m.) 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 p.m. to 2:00 a.m. Fertilization resumed when plants were removed from the cooler. Beginning March 14, 1998, plants in SD treatments received black cloth from 5:00 p.m. to 8:00 a.m. daily until flower buds opened. Data recorded at the time of first open flower were flower date and shoot height. Quality rating (0-5) and flower shoot number were recorded when plants had five open flowers.

RESULTS

All plants of 'Becky' flowered under LD, regardless of vernalization time (VER), while none of the plants under SD flowered (see table). Time to flower decreased as VER increased under LD. Flower shoot number and quality rating increased with increasing VER up to 9 weeks. Shoot height was greatest after 6 weeks VER under LD. 'Becky' showed an obligate requirement for LD to flower, and plant growth characteristics and quality were improved by at least 6 to 9 weeks of VER under LD.

All plants of 'Silver Princess' and 'Snow Cap' flowered under LD while plants under SD flowered 69 or 49%, respectively, regardless of VER (see table). Flower shoot number generally increased and time to flower decreased with increasing VER under LD and SD in both cultivars. However, shoot height and market quality rating were unaffected by VER or day length. 'Silver Princess' and 'Snow Cap' showed a facultative requirement for LD to flower, but the daylength requirement could be overcome by 12 weeks of VER under SD where plants flowered 100%.

All plants of 'Snow Lady' and 'Summer Snowball' flowered under LD while plants under SD flowered 84% and 31%, respectively, regardless of VER (see table). Shoot height, flower shoot number, and market quality rating were unaffected by VER under SD in both cultivars. Time to flower decreased with increasing VER under SD in 'Snow Lady'. Greatest shoot height, flower shoot number and market quality rating occurred after 3 or 6 weeks of VER under LD in both cultivars. Time to flower decreased for both cultivars with increasing VER under LD in both cultivars. 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 for both cultivars. 'Snow Lady' and 'Summer Snowball' showed a facultative requirement for LD to flower, though a larger number of 'Snow Lady' plants flowered under SD. However, 'Snow Lady' plants under LD flowered 7.8 days earlier, were 2 inches taller, and had 3.6 more flowering shoots and a quality rating higher than plants under SD. For both cultivars, the daylength requirement could be overcome by 12 weeks of VER under SD where plants flowered 100%.

The Shasta Daisy cultivars tested in this study varied in response to photoperiod and vernalization time. 'Becky' showed an obligate requirement for LD to completely flower while 'Silver Princess', 'Snow Cap', 'Snow Lady', and 'Summer Snowball' showed a facultative response with 100% of plants flowering under LD and varying percentages flowering under SD. However all the facultative response cultivars flowered 100% under SD and 12 weeks VER, indicating that long VER periods may overcome the photoperiod requirement. For all five cultivars, shoot height, flower shoot number, and market quality rating increased while time to flower decreased with increasing VER up to 6 weeks under LD. Therefore, LD and 6 weeks VER would be needed to ensure rapid flowering and the highest plant quality using these five cultivars.

Response of Three *Leucanthemum* × *superbum* Cultivars to Short or Long Photoperiods and Vernalization Duration

Photoperiod	Vernalization (weeks)	Shoot height (cm)[1]	Flower shoot number	Market quality rating[2]	Days to flower	Flowering plants (%)
			'Becky'			
Short days	0	–	–	–	–	0
	3	–	–	–	–	0
	6	–	–	–	–	0
	9	–	–	–	–	0
	12	–	–	–	–	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
	12	61.1	7.0	2.4	45	100
			'Silver Princess'			
Short days	0	–	–	–	–	0
	3	21.5	2.6	1.9	57	90
	6	22.5	5.0	2.4	57	78
	9	21.8	6.3	2.4	46	78
	12	22.0	6.7	2.3	40	100
Long days	0	27.9	5.2	3.1	57	100
	3	30.4	7.7	3.1	51	100
	6	31.9	8.1	3.1	48	100
	9	24.6	8.0	3.1	39	100
	12	30.4	2.3	2.8	38	100
			'Snow Cap'			
Short days	0	15.7	1.3	0.0	75	33
	3	–	–	–	–	0
	6	17.3	2.0	1.3	61	89
	9	16.3	4.0	2.0	53	22
	12	17.3	5.7	2.7	47	100
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
	12	25.3	11.1	3.9	38	100
			'Snow Lady'			
Short days	0	15.6	6.9	2.3	60	78
	3	20.6	7.9	2.4	58	78
	6	19.7	7.3	3.0	56	78
	9	16.5	8.1	2.5	44	89
	12	18.3	8.4	2.9	41	100
Long days	0	22.4	7.8	3.1	49	100
	3	24.5	8.6	3.6	48	100
	6	27.3	14.1	3.3	46	100
	9	18.9	8.3	2.9	44	100
	12	21.1	8.4	2.6	38	100
			'Summer Snowball'			
Short days	0	37.0	1.0	0.0	64	22
	3	–	–	–	–	0
	6	44.5	1.0	1.0	53	22
	9	50.5	2.0	1.0	55	11
	12	38.9	2.6	1.8	52	100
Long days	0	53.2	4.0	2.4	65	100
	3	64.8	6.9	2.8	61	100
	6	66.7	7.9	2.7	59	100
	9	62.1	4.4	2.1	52	100
	12	52.7	7.1	2.4	52	100

[1] English conversion 2.54 cm = 1 inch.
[2] Quality rating: 1=very poor, unsalable; 2=poor, unsalable; 3=average, salable; 4=good, salable; 5=excellent, salable.

Alabama Winter Bedding Plant Performance, 1996-97

J. Raymond Kessler, Bridget K. Behe, and James S. Bannon

Twenty years ago, few gardeners considered planting bedding plants in the fall. However, planting cold-hardy annuals to provide color in the winter landscape has become very popular with the gardening public in Alabama. This practice is primarily due to the popularity of pansies, though several other cold-tolerant species can be grown in the same time frame. Pansies have been developed in such a wide range of types and flower colors that they have won the hearts of southern gardeners, extending the southern growing season to a year-round endeavor. As a consequence, efforts are underway to develop other annual bedding plant species with potential for the fall market such as Dianthus, snapdragons, and many others.

Consumers typically purchase cool-season bedding plants from late September to mid-November for planting in the home landscape. Bedding plant cultivars are frequently developed and marketed in a series. Cultivars in a series share common characteristics such as size, growth habit, or disease resistance, but differ from each other in flower color. The name on the label often begins with the name of the series followed by the flower color, e.g. 'Bingo Blue'. The majority of bedding plants are purchased in plastic market packs from garden centers, grocery stores, mass market outlets, and home centers. These retail outlets often maintain large displays containing a wide selection of bedding plants in a variety of types and flower colors. However, this selection often contains types and cultivars which are popular, but may not perform well under the environmental conditions of Alabama winters.

Winter weather in Alabama is highly variable from year to year with one year having periods of extreme cold followed by a warm spell, while other years may be relatively mild. Changeable winter conditions challenge many cool-season bedding plants to remain healthy and floriferous. In one year, a cool-season plant may maintain foliage and flowers throughout the winter months while in another year, the plant may be killed to the ground by a hard freeze or prolonged cold. Therefore, information on performance of different species and cultivars for the mild winters in Alabama is needed to help consumers make plant purchasing decisions for home gardens and commercial landscape environments. The purpose of this research was to determine the overall winter performance of cool-season flowering annual plants.

METHODS

The trial evaluated 312 cultivars from seven different bedding plant species at the E.V. Smith Research Center in Shorter, Alabama, during the winter of 1996-97. The Research Center is located 26 miles east of Montgomery, Alabama. Seeds for the trial entries were donated by several companies and transplants were grown by Wright's Greenhouse and Nursery, Inc., a nearby commercial transplant producer. Raised flower beds were tilled and amended with agricultural limestone and slow-release fertilizer (18-6-12) according to soil test recommendations. After transplanting, the flower beds were mulched with pine bark. No additional fertilizer was applied during the season. No fungicides or insecticides were applied during the trial period. Every effort was made to grow the plants using cultural practices that the average homeowner might use.

All plants were grown in full sun with rainfall supplemented using overhead sprinkler irrigation to provide an equivalent of 1 inch of water per week. No deadheading of spent flowers or other maintenance was performed on any of the plants with the exception of hand weeding.

Plants from each entry were evaluated every 2 weeks from October 31,1996 through April 24, 1997 using a 0 to 5 scale. Flowering plants were rated primarily on their floral displays, while size, shape, and freedom from insect or disease blemishes were also considered. A rating of 1 indicated a small display of foliage with no flowers present; 2–adequate amount of foliage with one or two flowers present; 3–sufficient foliage and floral display to be attractive in the landscape; 4–above average floral display and sufficient foliage display; and 5–superior floral display and sufficient foliage display. A rating of 0 indicated the plant had died. Any plant with an average rating of 2.5 or higher over the trial period could be considered acceptable in the landscape and would be a worthwhile addition to a garden located in temperate zone seven or eight.

RESULTS

Eight of the 10 best performing winter annual species were Johnny-jump-ups, *Viola tricolor* (Table 1). These plants are pansy-like violas with smaller, but more numerous flowers than pansies. Many of the best performing Johnny-jump-ups were from the 'Penny' or 'Springtime' series. Nineteen of the 35 entries rated 2.5 or higher. All cultivars in the top 19 were compact, low to the ground, and full of small, attractive, pansy-like flowers during most of the winter months.

Pansies are the traditional cool-season annual for fall planting in the southeastern United States. Of the 199 pansy entries in the trial in 1996-97, 51 rated 2.5 or higher. All cultivars rated 2.8 or higher are listed in Table 2. Though the cultivars in Table 2 are from a variety of sources, six cultivars are from the 'Universal' series, three cultivars from the 'Rally' series, and two cultivars each from the 'Accord' and 'Baby Bingo' series.

Based on the results from this study, two other species that should be considered for winter planting in Alabama gardens are China Pinks and Snapdragons. China pinks, *Dianthus chinensis*, are marginally hardy in central Alabama. During mild winters, the plants can maintain foliage through the season. Even in severe winters, foliage may be killed to the ground, but plants will resume growth and flower early in the spring. The best performing China pinks were 'Floral Lace Picotee', 'Award Mix', and 'Duchess Mix' with ratings of 2.3. The China pink cultivars in the trial did not perform as well as in past years, but provided very attractive mid-winter green or blue green foliage throughout the winter.

The best performing snapdragon, *Antirrhinum majus*, was 'Silks White' with a 1.9 rating, while 'Tahiti Red', 'Tahiti Rose', and 'Silks Yellow' tied for second place with a rating of 1.7. Scores for snapdragons reflect the fact that they do not bloom during winter months, but contribute pleasant green foliage to the landscape until they resume flowering in early spring. Unfortunately, reblooming in the spring of 1997 occurred after the winter annual study was concluded.

Seed companies and retailers are constantly developing new bedding plant cultivars. Recently, they have focused their efforts on the growing southern market by developing new bedding plant types and cultivars for the cool season in the southeast. Ongoing research is needed to evaluate these new products for their performance in southern landscapes to provide critical information for the gardening public.

Table 1. Average Rating for the Best 19 Johnny-jump-ups in the 1996-97 Winter Trial

Cultivar	Flower color	Avg. rating[1]
Penny Azure Wing	blue	3.8
Penny Violet Beacon	purple	3.7
Penny Violet Flare	purple	3.7
Penny Primrose	pink	3.5
Blackjack	black	3.4
Felix	yellow	3.1
Springtime Violet	purple	3.0
Alpine Summer	yellow	2.9
Fanfare White Blotch	white	2.8
Springtime Pure White	white	2.7
Alpine Wing	bicolor	2.7
Springtime Rose Blotch	rose	2.6
Springtime Deep Blue	blue	2.6
Fanfare Mixture	mix	2.6
Springtime Clear Blue	blue	2.6
Springtime Yellow Marble	yellow	2.5
Springtime Azure Blue	blue	2.5
Springtime Red	red	2.5
Springtime Mixture	mix	2.5

[1] Rating scale: 0=the plant died; 1=small display of foliage with no flowers present; 2=adequate amount of foliage with one or two flowers present; 3=sufficient foliage and floral display to be attractive in the landscape; 4=above average floral display and sufficient foliage display; and 5=superior floral display and sufficient foliage display.

Table 2. Average Rating for the Best 19 Pansies in the 1996-97 Winter Trial

Cultivar	Flower color	Avg. rating[1]
Purple and White Wink	bicolor	3.1
Rally Light Blue w/blotch	blue	3.0
Universal Plus rose Blotch	pink	2.9
Accord Banner Blue Blotch	blue	2.9
Universal Plus Yellow	yellow	2.9
Baby Bingo Beaconsfield	blue	2.9
Presto Mixture	mix	2.9
Universal Plus Violet blotch	purple	2.9
Frosty Cherry Imperial	pink	2.8
Skyline Yellow/Red Wing	yellow	2.8
Universal Plus Clear Mixture	mix	2.8
Accord Primrose	pink	2.8
Universal Plus True Blue	blue	2.8
Ultima Lavender Shades	purple	2.8
Rally Pure White	white	2.8
Delta Pure Violet	purple	2.8
Baby Bingo Midnight	purple	2.8
Rally Lilac Cap	purple	2.8
Universal Plus Blue Blotch	blue	2.8

[1] Rating scale: 0=the plant died; 1=small display of foliage with no flowers present; 2=adequate amount of foliage with one or two flowers present; 3=sufficient foliage and floral display to be attractive in the landscape; 4=above average floral display and sufficient foliage display; and 5=superior floral display and sufficient foliage display.

Alabama Summer Bedding Plant Performance in 1997

J. Raymond Kessler, Bridget K. Behe, and James S. Bannon

Gardening consumers are often bewildered by the wide range of flower colors and types of summer annuals available in the retail market. Consumers typically purchase warm-season bedding plants from late March to May for planting in commercial or home landscapes.

Bedding plant cultivars are frequently developed and marketed in a series. Cultivars in a series share common characteristics such as height, growth habit, or disease resistance, but differ from each other in flower color. The name on the label often begins with the name of the series followed by the flower color, e.g. 'Carpet Blue'. The majority of bedding plants are purchased in plastic market packs from garden centers, grocery stores, mass market outlets, and home centers. These retail outlets maintain large displays containing a wide selection of bedding plants in a variety of types, sizes, and flower colors. However, this selection often contains species and cultivars which are popular and perform well in middle and northern parts of the eastern United States, but may not perform well in Alabama.

Unique to Alabama and surrounding states are extended periods of hot, humid weather, periodic violent thunder storms, and periods of drought. These climatic stresses challenge many traditional bedding plants to remain healthy and floriferous throughout the long growing season. Many petunia cultivars for example become unattractive in mid to late summer because of elongated, "spindly" growth and damage to delicate flower petals from strong wind or rain. Older cultivars of zinnia contract foliar diseases such as powdery mildew during humid weather causing lower leaf loss. Most bedding plants must receive some supplemental water during periods of extended drought. Information on garden performance of different bedding plants for the hot, humid environment of Alabama is needed. Therefore, during the summer of 1997 we evaluated more than 300 cultivars for their garden performance.

METHODS

The trial consisted of 323 cultivars from 23 different bedding plant species at the E.V. Smith Research Center in Shorter, Alabama. The research center is located 26 miles east of Montgomery, Alabama. Seeds for the trial entries were donated by companies and plants were grown by Wright's Greenhouse and Nursery, Inc., a nearby commercial transplant producer. Every effort was made to grow the plants using cultural practices that the typical homeowner might use. Raised flower beds were tilled and amended with agricultural limestone and controlled-release fertilizer (18-6-12) according to soil test recommendations. After transplanting, the flower beds were mulched with pine bark nuggets. No additional fertilizer was applied during the season. No fungicides or insecticides were applied during the trial period.

All bedding plants were grown in full sun, with the exception of impatiens, which were grown under 60% black shade fabric. Rainfall was supplemented using overhead sprinkler irrigation to provide an equivalent of 1 inch of water per week. No deadheading of spent flowers or other maintenance was performed on any of the plants with the exception of hand weeding.

Plants from each entry were evaluated every 2 weeks from July 3 through September 29, 1997 using a 1 to 5 scale. Flowering plants were rated primarily on their floral displays, while size, shape, and freedom from insect or disease blemishes were also considered. A rating of 1 indicated a small display of foliage with no flowers present; 2–adequate amount of foliage with one or two flowers present; 3–sufficient foliage and floral display to be attractive in the landscape; 4–above average floral display and sufficient foliage display; and 5–superior floral display and sufficient foliage display. A rating of 0 indicated the plant had died. Any plant rated an average of 2.5 or higher could be considered acceptable in the landscape and would be a worthwhile addition to a garden located in temperate zone eight.

RESULTS

Highest overall rating were received by impatiens and wax begonia (*Begonia × semperflorens*) with 23 impatiens and 20 wax begonia cultivars receiving ratings greater than 3.0 (see table). Many impatiens cultivars in the 'Super Elfin' and 'Dazzler' series performed well. Wax begonias in the 'Eureka' series also performed well and are upright, tall growing types of begonia as opposed to the short rounded form of the more popular types. Three cultivars of ageratum (*Ageratum houstonianum*) had ratings greater than 3.0.

Annual vinca is noted for its tolerance of hot, dry locations in the landscape. All the annual vinca (*Catharanthus roseus*) cultivars in the trial received ratings higher than 2.5, nine had ratings greater than 3.0, and 'Pacifica Orchid', 'Pacifica Punch', and 'Blue Pearl' received the three highest ratings.

Three species of cockscomb were evaluated in 1997. Three plume cockscombs (*Celosia plumosa*)—'Castle Yellow', 'Century Red', and 'Forest Fire'—and two spike cockscomb (*Celosia spicata*)—'Flamingo Purple' and 'Flamingo Feather'—were rated higher than 2.9. However, cultivars of crested cockscomb (*Celosia cristata*) did not perform well with ratings less than 2.0.

Globe amaranth (*Gomphrena globosa*) is an old-fashion annual that is regaining popularity in the southeast due to its excellent heat tolerance and the development of new cultivars. Three cultivars evaluated in 1997 received ratings higher than 2.8: 'Woodcreek Red', 'Woodcreek Lavender', and 'Woodcreek Rose'. Another old-fashion annual, flowering tobacco (*Nicotiania alata*), had two cultivars receiving acceptable ratings (higher than 2.5)—'Prelude Rose' and 'Prelude Red'.

Zinnias (*Zinnia elegans*) have been grown in the southeast for more than a century, but are prone to foliar fungal diseases. Two cultivars that rated higher than 3.0 and appeared to be disease resistant were 'Oklahoma Formula Mix' and 'Blue Point Formula Mix'. Though a recent introduction to southern gardens, creeping zinnia (*Zinnia angustifolia*) is quickly proving its toughness and reliability. Unlike its upright counterpart, creeping zinnia is a low, spreading plant with characteristics similar to a flowering ground cover. Two cultivars rated higher than 2.5 in the 1997 trial, 'Goldsmith' and 'Star White'.

Of the 76 cultivars of petunia in the 1997 trial, only nine rated 3.0 or higher. Most of these can be found in a variety of flower colors in the 'Carpet' series. A new development in petunias for warm climates is tropical or spreading petunias. 'Purple Wave' and 'Pink Wave' appeared to thrive in the summer heat, rating 3.3 and 3.0, respectively. Portulaca (*Portulaca grandiflora*), which also has a spreading growth habit, had two cultivars rated

Average Rating Greater Than 3.0 for Flowers Grown in the 1997 Summer Trial Garden

Genus species Variety	Color	Avg. rating [1]
Ageratum houstonianum		
Blue Hawaii	Blue	3.8
Royal Hawaii	Blue	3.3
White Hawaii	White	3.0
Begonia × semperflorens		
Eureka Scarlet	Scarlet	4.0
Prelude White	White	3.9
Eureka Bronze Rose	Rose	3.9
Stara Deep Rose	Rose, dark	3.8
Stara Mi×ed	Mix	3.7
Stara White	White	3.7
Encore Red/Bronze	Red	3.6
Victory B Pink	Pink	3.6
Encore P/B	Pink	3.6
Prelude Pink	Pink	3.6
Encore Pink	Pink	3.5
Encore White/Bronze	White	3.4
Stara Pink	Pink	3.4
Super Olympia Red	Red	3.3
Eureka Rose	Rose	3.3
Prelude Rose	Rose	3.3
Vodka	White	3.2
Partyfun Mi×	Mix	3.2
Eureka Bronze Scarlet	Scarlet	3.1
Victory Bronze LeafWhite	White	3.1
Catharanthus roseus		
Pacifica Orchid	Magenta	3.5
Pacifica Punch	Red, fruit	3.3
Blue Pearl	Blue, light	3.1
Heat Wave Grape	Blue	3.1
Pacifica Blush	Pink, light	3.1
Apricot Delight	Peach	3.1
Grape Cooler	Blue	3.1
Blush Cooler	Pink, light	3.0
Pacifica Pink	Pink	3.0
Celosia plumosa		
Castle Yellow	Yellow	3.3
Century Red	Red	3.0
Celosia spicata		
Flamingo Purple	Purple	3.3
Gomphrena globosa		
Woodcreek Red	Red	3.3
Woodcreek Lavender	Lavender	3.1
Impatiens wallerana		
Super Elfin Melon	Rose	4.1
Impatiens wallerana, continued		
Showstopper Cherry	Red	3.9
Super Elfin Rose	Rose	3.8
Dazzler Deep Orange	Orange	3.7
Dazzler Pink	Pink	3.7
Pride Pink	Pink	3.6
Accent Salmon	Salmon	3.5
Pride Salmon Orange	Orange, salmon	3.5
Dazzler Cranberry	Red, berry	3.4
Accent Pastel Mixture	Mix	3.4
Bruno Orange	Orange	3.4
Accent Mystic Mix	Mix	3.4
Accent Deep Pink	Pink, dark	3.4
Mosaic Rose	Rose	3.4
Super Elfin Lipstick	Red	3.4
Pink Swirl	Pink, light	3.2
Accent Peppermint Mix	Mix	3.2
Dazzler Merlot Mix	Mix	3.1
Pride Rose	Rose	3.1
Tempo Rose	Rose	3.1
Bruno Rose	Rose	3.1
Impulse Cranberry	Red, berry	3.1
Bruno Salmon	Salmon	3.0
Petunia × hybrida		
Pink Wave	Pink	3.3
Purple Wave	Magenta	3.0
Fantasy Pink Morn	Pink	3.1
Carpet Pink	Pink	3.4
Carpet Salmon	Salmon	3.4
Carpet Rose	Rose	3.4
Carpet Velvet	Violet	3.2
Carpet Lilac	Lilac	3.2
Carpet Sky Blue	Blue, light	3.0
Salvia farinacea		
Victoria White	White	3.1
Tagetes patula		
Bonanza Harmony	Red	3.2
Bonanza Flame	Red	3.0
Zinnia elegans		
Oklahoma Formula Mix	Mix	3.5
Blue Point Formula Mix	Mix	3.0

[1] Rating scale: 0 =plant died; 1=small foliage display, no flowers; 2=adequate foliage, no flowers or few buds; 3=adequate to large foliage, relatively small floral display; 4=sufficient foliage and flowers to be attractive in the landscape; and 5=superior floral display, sufficient foliage.

2.5 or higher, 'Sundial Fuchsia' and 'Sundial Orange'.

Gardeners often rely on marigolds as a mainstay of the annual planting. There are two types of marigolds. African marigolds (*Tagetes erecta*) are generally tall with large flowers while French marigolds (*Tagetes patula*) are more compact with more numerous, but smaller flowers. Eight African marigolds and 17 French marigolds rated 2.5 or higher but only two rated greater than 3.0. The top two, 'Bonanza Harmony' and 'Bonanza Flame', are of the French type.

Most gardeners think of red-flowered scarlet sage (*Salvia splendens*) when annual salvia is mentioned. However, none of the 17 cultivars evaluated in 1997 received ratings higher than 3.0. A better salvia for the southeast is mealy-cup sage (*Salvia farinacea*). One cultivar rated 3.0 or higher, 'Victoria White'.

Verbena speciosa 'Imagination' was another excellent performer that received a rating of 2.5. This plant can be treated as a perennial in south Alabama. It has a low growing habit with finely dissected leaves and dark purple blooms which lasted into the fall.

Seed companies and retailers are constantly developing new bedding plant cultivars. Recently, they have focused their efforts on the growing southern market by developing new bedding plant cultivars for warm environments. Ongoing research is needed to evaluate these new products for their performance in the southern landscape.

Herbaceous Perennial Variety Trials in Central Alabama, 1996-1997

Jeff L. Sibley, J. Raymond Kessler, Bridget K. Behe, Darby M. Quinn, and James S. Bannon

Variety trials are generally ranked by growers as being one of the most valuable projects at public institutions and research and demonstration stations. While herbaceous perennials continue to gain popularity, many field trials continue to lump annuals and perennials together for evaluation. The objective of this study was to evaluate the overall performance of full-sun perennials in a USDA Hardiness Zone 8, AHS Heat Zone 8 environment in south-central Alabama (26 miles east of Montgomery, Alabama). Results from the study will assist horticultural professionals and consumers in similar climates with selection of flowering perennials for landscape use. Selections included in these trials were based on the plants landscapers and homeowners might find available in local nurseries or retail garden centers.

METHODS

In the spring of 1996, 57 species/cultivars of herbaceous perennials were planted for evaluation at the E.V. Smith Research Center (EVSRC) located in Shorter, Alabama. Raised beds of Norfolk-Orangeburg loamy sand soil (fine, loamy, siliceous, thermic Typic Kandiudults) were tilled and fumigated with methyl bromide 2 weeks before planting. No other fungicides or insecticides were applied during the trial period. A commercially available slow-release fertilizer (18-6-12) was pre-plant incorporated into the beds as per soil test recommendations and then side-dressed again in the following spring (1997). No additional fertilizer was applied during the growing seasons. Six beds, each 6 feet × 80 feet, were prepared for planting on April 11, 1996. Three plants per entry were grown in three separate beds (a total of nine plants per entry) in full sun. Evaluations began July 3, 1996. Rainfall was supplemented by overhead sprinkler irrigation to provide an equivalent of 1 inch of water per week. Minimum deadheading of spent flowers, weeding by hand, and cutting back in either the fall or spring were the only other maintenance activities performed during the trial.

Plants were evaluated every 2 weeks from July 3, 1996 through October 1997. Plants were rated by the same individual using a 0-5 scale in three categories: flowering, foliage, and overall appearance. Plants were rated primarily on their floral displays, while size, shape, and freedom from insect or disease blemishes were also considered. Ratings were as follows: 0–absence of a desired characteristic; 1–a minimal amount of the characteristic, but not impressive; could be considered negative in the "foliage" and "overall" categories; 2–a small amount of the characteristic, not very impressive in the "foliage" and "overall" categories; 3–sufficient display to be attractive in the landscape; 4–above average display and quite beneficial in the landscape; and 5–superior display and extremely showy in the landscape. Ratings were made in whole number units.

CLIMATIC CONDITIONS

Average daily air temperatures in the winter (December through February) of 1996 and 1997 were 1.5 and 2.6°F warmer than normal (daily air temperatures averaged over the years from 1961 through 1990), respectively (Table 1). Spring (March through May) of 1996 was cooler than normal by 0.6°F, while spring of 1997 was warmer than normal by 1.0°F. Average summer (June through September) temperatures in 1996 and 1997 were only 0.2 and 0.4°F warmer than normal, respectively. Fall

TABLE 1. AVERAGE DAILY SUNLIGHT, DAILY AIR TEMPERATURE, MONTHLY RAINFALL, AND CHILLING HOURS[1]

	Average sunlight[2] (w/m²)		Average air temperature (°F)			Total rainfall (in)			Chill hours[3] (hrs)	
	1996	1997	1996	1997	1961-1990	1996	1997	1961-1990	1996	1997
January	2299	2211	43.9	47.6	43.2	6.6	5.6	5.0	423	374
February	3267	2641	48.0	51.0	46.6	3.7	8.1	5.8	305	254
March	4062	4485	51.4	61.8	54.3	9.2	2.1	6.6	254	66
April	5182	5291	60.0	59.2	62.1	4.8	7.2	5.2	104	63
May	6627	5684	72.7	67.3	69.0	4.8	3.8	3.8	6	7
June	6545	5260	76.4	74.1	75.8	2.2	6.7	4.1	0	0
July	6135	6322	80.0	81.0	78.7	9.4	2.6	4.7	0	0
August	5696	5643	78.6	78.0	78.4	5.7	4.6	4.2	0	0
September	4744	5851	72.8	75.6	74.1	8.2	3.5	3.6	0	0
October	3466	M	62.9	63.9	63.7	1.4	3.2	2.6	42	50
November	2935	2661	54.5	50.5	54.8	22.6	8.4	4.1	187	243
December	2083	2177	49.0	45.7	46.8	4.3	6.1	5.2	316	430

[1] Data were provided by the National Weather Service. Rainfall data was collected on site. [2] Sunlight, or solar radiation, is measured in watts per square meter; M indicates unavailable data. [3] Number of hours less than 45°F.

(October through November) of 1996 and 1997 was warmer than normal by 0.7 and 2.1°F, respectively. Table 1 presents data on average daily sunlight, average rainfall, and average chilling hours (< 45°F) during 1996 and 1997.

RESULTS

BLOOM. The highest average bloom rating for any plant in 1996 was 4.9 for *Salvia leucantha* in October. It also performed well in September (4.5) and November (3.3) (Table 2). *Salvia leucantha* ratings for 1997 were 3.3 in September and 4.5 in October (Table 2). The second highest rating in 1996 was received by *Lythrum virgatum* 'Mordens Pink', also with a rating of 4.9 in July 1996; however, performance and bloom duration was not as long as *Salvia leucantha*. In 1996, *Coreopsis rosea* had a peak rating of 4.7 in July while *Coreopsis verticillata* 'Moonbeam' rated a 4.7 in July and kept on blooming with a rating of 4.1 in August. *Aster × frikartii* 'Monch' had a rating of 4.6 in July and a 4.0 in August 1996, also extending its effectiveness in the landscape. *Verbena canadensis* 'Alba' had peak rating in April 1997 of 4.4, while *Coreopsis verticillata* 'Zagreb' peaked in July 1996 with a rating of 4.2 and kept performing well into August with a 3.2. Another good performer was *Boltonia asteroides* 'Pink Beauty' which rated 3.6 in July and 4.2 in August 1996. Two of the longest blooming perennials evaluated were *Verbena bonariensis* with an average rating of 4.2, 4.0, and 3.4 for the months of July, August, and September 1996, respectively. In 1997, *Verbena bonariensis* started to show excellent color in May, June, and July with a ratings of 3.9, 3.7, and 3.2, respectively. *Lythrum salicaria* 'Robert' also had a long showing with a rating of 4.4 in July and a 3.9 in August 1996 and a 1997 rating of 3.4 in June and July and 3.9 in August. For a listing of selections with flower ratings of 3.0 or higher, see Table 2.

FOLIAGE. The perennial with the best foliage performance in this 2-year study was *Verbena tenuisecta* (Table 2). This ground cover type perennial received an average rating of 4.0 or above for every month evaluated in 1996, with the exception of August. From May through October of 1997, *Verbena tenuisecta* did not fall below a rating of 4.0. This indicates a very healthy, disease- and heat-resistant perennial. *Veronica spicata* 'Red Fox' had a shorter duration of high foliage ratings than *Verbena tenuisecta* but ranked second in foliage performance due to several high ratings during the 2 years. The third best foliage performer was *Scabiosa columbaria* 'Butterfly Blue'. This exceptional perennial kept a rating of 4.0 or higher for every month evaluated in 1996 except September and a rating of 4.0 or higher in March through June 1997. A few other outstanding foliage performers were *Helianthus angustifolius*, *Achillea* × 'Moonshine', *Baptisia alba* 'Pendula', *Coreopsis verticillata* 'Moonbeam', and *Physostegia virginiana* 'Vivid'. For a listing of selections with foliage ratings of 4.0 or higher, see Table 2.

OVERALL. The highest overall rating for the perennials in this study was *Lythrum virgatum* 'Mordens Pink' with an overall rating of 4.9 for July 1996 (Table 3). While the second highest overall rating was a tie between *Coreopsis rosea* and *C. verticillata* 'Moonbeam' at 4.8, 'Moonbeam' had another excellent rating of 4.2 for August 1996. Another selection with an overall rating of 4.0 or higher for 2 months was *Verbena bonariensis,* rating 4.2 and 4.0 for July and August 1996, respectively. The only selection to have a rating of 4.0 or higher for 2 months in 1996 and then 1 month in 1997 was *Salvia leucantha*. Any plant with an overall rating of 2.5 or higher could be considered a very good performing plant and would be a worthwhile addition to a full sun garden located in USDA Hardiness Zone 8 and AHS Heat Zone 8. However, to highlight only the very best overall performers, selections with an overall rating of 4.0 or higher are listed in Table 3.

Helianthus angustifolius and *Salvia uliginosa* responded well to pruning once or twice in the middle of the growing season to maintain a manageable height and

Table 2. Average Bloom and Foliage Rating for Best Performing Perennials in the 1996-97 Trial Garden[1]

Variety	Date	Bloom	Date	Foliage
Achillea × 'Moonshine'				
	–	–	7/96	4.6
	–	–	10/96	4.8
	–	–	12/96	4.7
	–	–	3/97	5.0
	–	–	4/97	5.0
	5/97	3.5	5/97	5.0
	6/97	3.7	–	–
Artemisia × 'Powis Castle'				
	–	–	7/96	4.7
	–	–	8/96	4.1
Aster × frikarkii 'Monch'				
	7/96	4.6	7/96	4.4
	8/96	4.0	8/96	4.0
Baptisia alba 'Pendula'				
	–	–	7/96	4.6
	–	–	8/96	4.2
	–	–	9/96	4.2
	–	–	4/97	4.2
	–	–	5/97	5.0
	–	–	6/97	5.0
	–	–	7/97	4.6
Boltonia asteroides 'Pink Beauty'				
	7/96	4.2	7/96	4.4
	8/96	3.7	8/96	4.6
Boltonia asteroides 'Snowbank'				
	7/96	3.6	7/96	4.6
	8/96	4.2	8/96	4.6
Boltonia asteroides var. *latisquama* 'Nana'				
	7/96	3.2	7/96	4.7
Ceratostigma plumbaginoides				
	7/96	3.8	7/96	4.1
Coreopsis rosea				
	7/96	4.7	7/96	4.9
	–	–	8/96	4.9
	–	–	9/96	4.3
Coreopsis verticillata 'Moonbeam'				
	7/96	4.7	7/96	4.7
	8/96	4.1	8/96	4.9
	–	–	9/96	4.5
	–	–	6/97	4.1
	–	–	7/97	4.7
	–	–	8/97	4.6
	–	–	9/97	4.4
Coreopsis verticillata 'Zagreb'				
	7/96	4.2	7/96	5.0
	8/96	3.2	8/96	5.0
	–	–	9/96	4.4
	–	–	5/97	4.3
	–	–	6/97	4.3
Dianthus plumarius 'Itsaul White'				
	–	–	7/96	4.3
	–	–	8/96	4.0
	–	–	5/97	4.3
	–	–	6/97	4.2
Echinacea angustifolia				
	–	–	5/97	4.0
Echinacea purpurea 'White Swan'				
	–	–	7/96	4.2
	8/96	3.9	8/96	4.1
Gaillardia × *grandiflora* 'Goblin'				
	–	–	5/97	4.0
Gaura lindheimeri				
	–	–	7/96	4.1
	–	–	4/97	4.5
	5/97	4.2	5/97	4.7
Geranium sanguineum 'Album'				
	–	–	4/97	4.3
	–	–	5/97	4.2
Helianthus angustifolius				
	–	–	7/96	4.8
	–	–	8/96	4.7
	10/96	3.4	–	–
	–	–	3/97	4.7
	–	–	4/97	5.0
	–	–	5/97	5.0
	–	–	6/97	4.7
	–	–	7/97	4.8
	–	–	8/97	4.2
Lythrum virgatum 'Mordens Pink'				
	7/96	4.9	7/96	4.2
	–	–	5/97	4.5
	7/97	3.1	–	–
Lythrum salicaria 'Robert'				
	7/96	4.4	7/96	4.5
	8/96	3.9	–	–
	–	–	4/97	4.3
	–	–	5/97	4.9
	6/97	3.4	6/97	4.1
	7/97	3.4	–	–
	8/97	3.9	–	–
Physostegia virginiana 'Vivid'				
	–	–	7/96	4.1
	–	–	10/96	4.1
	–	–	4/97	4.4
	–	–	5/97	4.9
	–	–	6/97	4.7
	–	–	7/97	4.5
Rudbeckia fulgida 'Goldsturm'				
	–	–	7/96	4.9
	8/96	4.0	8/96	4.4
	–	–	5/97	4.9
	–	–	6/97	4.4
	8/97	3.6	–	–
Salvia farinacea 'Strata'				
	7/96	3.6	–	–
Salvia farinacea 'Victoria Blue'				
	8/96	3.1	–	–
	5/97	3.4	–	–
Salvia farinacea 'Victoria White'				
	7/96	3.2	–	–
	8/96	3.3	–	–
	9/96	3.2	–	–
	–	–	3/97	4.0
	–	–	4/97	4.4
	5/97	3.8	–	–
Salvia leucantha				
	–	–	7/96	4.5
	–	–	8/96	4.6
	9/96	4.5	–	–
	10/96	4.9	–	–

TABLE 2, CONTINUED. AVERAGE BLOOM AND FOLIAGE RATING FOR BEST PERFORMING PERENNIALS IN THE 1996-97 TRIAL GARDEN[1]

Variety	Date	Bloom	Date	Foliage
Salvia leucantha, continued				
	11/96	3.3	–	–
	–	–	6/97	4.2
	9/97	3.3	–	–
	10/97	4.5	–	–
Salvia officinalis 'Purpurescens'				
	–	–	7/96	4.0
Salvia uliginosa				
	7/96	3.7	–	–
	9/96	3.2	–	–
	8/96	3.1	–	–
	–	–	4/97	5.0
	–	–	5/97	4.1
	6/97	3.6	–	–
Salvia van houttei				
	9/96	3.6	–	–
	10/96	4.0	–	–
Scabiosa columbaria 'Butterfly Blue'				
	–	–	7/96	4.3
	–	–	8/96	4.0
	–	–	10/96	4.2
	–	–	12/96	4.4
	4/97	4.1	4/97	4.9
	–	–	3/97	4.7
	–	–	5/97	5.0
	–	–	6/97	4.1
Sedum spectabile 'Brilliant'				
	–	–	3/97	4.9
	–	–	4/97	4.9
	–	–	5/97	4.8
	–	–	6/97	4.3
Sedum × 'Autumn Joy'				
	–	–	3/97	4.4
	–	–	4/97	4.4
	–	–	5/97	4.4
	–	–	6/97	4.4
Verbena canadensis 'Homestead Purple'				
	–	–	7/96	4.0
Verbena bonariensis				
	7/96	4.2	7/96	4.2
	–	–	3/97	4.1
	8/96	4.0	–	–
	9/96	3.4	–	–
	5/97	3.9	–	–
	6/97	3.7	–	–
	7/97	3.2	–	–
Verbena canadensis 'Alba'				
	7/96	3.4	7/96	4.0
	4/97	4.4	–	–
Verbena tenuisecta 'Alba'				
	–	–	6/97	4.3
	–	–	5/97	4.2
	–	–	7/97	4.1
Verbena tenuisecta				
	7/96	3.4	7/96	4.2
	–	–	9/96	4.1
	–	–	10/96	4.2
	–	–	11/96	4.2
	–	–	12/96	4.0
	5/97	3.4	5/97	4.7
	–	–	6/97	4.6
	7/97	3.3	7/97	4.9
	–	–	8/97	4.5
	–	–	9/97	4.2
	–	–	10/97	4.0
Veronica spicata 'Red Fox'				
	–	–	7/96	4.5
	–	–	8/96	5.0
	–	–	9/96	5.0
	–	–	10/96	4.8
	–	–	4/97	4.5
	–	–	5/97	4.7
	–	–	6/97	5.0
	–	–	7/97	4.3
	–	–	9/97	4.3

[1] Study conducted at the E.V. Smith Research Center of the Alabama Agricultural Experiment Station in Shorter, Alabama, from January 1996 through December 1997.

prevent plants from falling over. *Artemisia* × 'Powis Castle' responded better to early spring pruning than fall or winter pruning, due to a tendency to die from winter injury if pruned too early. *Dictamnus albus* 'Purpureus', known for its slow development, gradually increased in size each year and should not be dismissed until given a few years to mature. Another slow starter, *Baptisia alba* 'Pendula' has graceful arching limbs with rounded leaflets on pinnately compound leaves that are attractive, with or without flowers.

Among the most impressive performers were *Scabiosa columbaria* 'Butterfly Blue' and 'Pink Mist'. Once they started blooming, flowers were present on one or more plants even through the winter. *Scabiosa* had a tendency to re-seed in the immediate vicinity, not aggressively, but enough to provide additional plants for planting or to share with friends. Another favorite was *Verbena tenuisecta* with a moss-like carpet of foliage, which seems to almost always have a few flowers and sometimes was literally covered with dark purple blooms. *Verbena tenuisecta* 'Alba' also performed well, but seemed to produce fewer flowers. *Verbena canadensis* 'Homestead Purple' is another ground cover that produces purple flowers in mass but has a tendency to flower only along the edges of the spreading plant, leaving the center without blooms. *Verbena bonariensis* was also a favorite with a tall, open, airy habit and small purple flowers. *Geranium sanguineum* 'Album' produces delicate flowers on interesting palmate foliage and began to spread slowly, making a nice ground cover. *Rudbeckia fulgida* 'Goldsturm' was also a very good performer, with large, golden color ray flowers that attracted butterflies. *Salvia leucantha* was magnificent during its long bloom season (close to 3 months), with grey pubescent leaves providing a good backdrop for earlier flowering plants. Bumble bees were very attracted to the flowers.

See photos 1-12 on pages 34 and 35 of this publication for several of these high-ranking perennials.

Several plants performed well the first year, but did not over-winter. These could be treated as annuals and still be valuable additions to the landscape if replaced every year. One such selection was *Salvia van houttie* with dark maroon flowers that attracted hummingbirds. This plant was very showy, reaching approximately 3 feet tall and 2 feet wide and completely covered with blooms. Once the flowers fell, the dark maroon calyx remained, extending the "effective" period for several weeks. *Boltonia asteroides* var. *latisquama* 'Nana' also fell into this category of being treated as an annual, as did *Boltonia asteroides* 'Pink Beauty' and 'Snow Bank', along with *Gallardia* × *grandiflora* 'Goblin'. However, these three did produce seedlings to replace the mother plant. In general, *Coreopsis* selections ('Moonbeam', 'Zagreb', and *rosea*) were disappointing, performing beautifully the first year, but not blooming well in the second year.

Artemisia ludoviciana 'Silver King' became so invasive, it had to be removed from the trial. Therefore, we would not recommend planting it in a mixed border due to its aggressiveness. While *Lythrum* species are often considered invasive, we had very few seedlings germinate and no colonizing through underground stolons. Caution should still be used when planting this perennial, and it should not be introduced to native wetland areas.

Plants in this study generally performed better the first year after planting than the second year. Several selections did not re-emerge the second year, though some natural re-seeding occurred. Still other selections never fully recovered from the winter months or succumbed to stress in the summer. Plants that maintained an attractive foliage display while out of bloom and had highly rated bloom displays during the bloom season are worth incorporating into a full-sun perennial or mixed border in the southeastern United States. Gardeners and growers are encouraged to try plants in several locations to determine suitability for a particular area. However, plants with high ratings in this study are a good place to start. Many of these plants appear to tolerate a full-sun environment, require little care, and still perform well.

Performance of perennials in the landscape may vary from year to year as climatic conditions affect performance. Comparison of results from several display sites will increase the reliability of findings because weather, soil type, exposure, cultural practices, and other variables can greatly affect plant performance. Horticulturists are urged to visit several trial gardens to gain a better understanding of variety performance throughout a region or market area.

TABLE 3. AVERAGE OVERALL RATING FOR BEST PERFORMING PERENNIALS IN THE 1996-97 TRIAL GARDEN[1]

Variety	Date	Overall
Achillea × 'Moonshine'	5/97	4.3
Artemisia × 'Powis Castle'	7/96	4.0
Aster × *frikarkii* 'Monch'	7/96	4.2
Boltonia asteroides 'Pink Beauty'	7/96	4.1
Boltonia asteroides 'Snowbank'	8/96	4.1
Coreopsis rosea	7/96	4.8
Coreopsis verticillata 'Moonbeam'	7/96	4.8
	8/96	4.2
Coreopsis verticillata 'Zagreb'	7/96	4.4
Gaura lindheimeri	5/97	4.3
Lythrum virgatum 'Mordens Pink'	7/96	4.9
Lythrum salicaria 'Robert'	7/96	4.5
Rudbeckia fulgida 'Goldsturm'	8/96	4.0
Salvia leucantha	9/96	4.4
	10/96	4.7
	10/97	4.5
Scabiosa columbaria 'Butterfly Blue'	4/97	4.2
Verbena canadensis 'Homestead Purple'	4/97	4.2
Verbena bonariensis	7/96	4.2
	8/96	4.0
Verbena canadensis 'Alba'	4/97	4.4

[1] Study conducted at the E.V. Smith Research Center of the Alabama Agricultural Experiment Station in Shorter, Alabama, from January 1996 through December 1997.

1997 Poinsettia Cultivar Evaluations for Gulf Coast Greenhouse Conditions

Charles Hesselein, James C. Stephenson, John W. Olive, J. Raymond Kessler, and Gary J. Keever

According to the 1997 floricultural crop survey, poinsettias represent approximately one-third of the $701 million U.S. and $13.1 million Alabama wholesale potted flowering plant market. Over the years improved cultivars have greatly increased post harvest longevity, added a variety of colors, and improved handling and growing characteristics. These breeding improvements are one reason that these colorful plants have become a symbol of the Christmas season in many parts of the world.

METHODS

In the fall of 1997, 31 poinsettias cultivars (see table) were grown at the Ornamental Horticulture Station (OHS) in Mobile to determine their suitability for production in Gulf Coast greenhouses. Informal judging, growth, and flowering data indicate that many of these cultivars are suitable for production in Gulf Coast greenhouses.

In the summer of 1997, rooted cuttings were potted, one cutting per pot, into 6.5 inch azalea pots upon arrival at OHS (August 22 and August 26-27 1997). All plants were planted into a pine bark:peat moss medium (3:1 by volume) amended with 6 pounds dolomitic limestone, 2 pounds gypsum, and 1.5 pounds Micromax per cubic yard. Each pot was fertilized with 0.25 ounce Osmocote 14-14-14 placed on the top of the medium. Plants were fertigated weekly (starting at planting date and continuing until November 7) with 200-500 ppm nitrogen using Peter's 20-20-20, 20-10-20, or calcium nitrate fertilizer. Additional fertilizer inputs included two fertigations of sodium molybdate (0.3 ppm sodium molybdate) on September 22 and November 3 and two fertigations of epsom salt (1,200 ppm magnesium sulfate) on October 9 and November 4.

Plants were grown in glass-covered greenhouses with maximum day temperatures of 85°F and minimum night temperatures of 60°F. The terminal growth was removed from each plant (pinched) on September 8 to help stimulate branching. Five to seven nodes remained on each plant following pinching. Plants received one or two growth regulator applications to control plant height (see table). A tank combination of B-Nine (daminozide, 0.4 ounce per gallon) and Cycocel (chlomequat, 1.6 fluid ounces per gallon) was sprayed at each growth regulator application. Pest management consisted of an application of 0.5 teaspoon per pot of Marathon 1G (imidacloprid) on September 17, a drench of Truban 30 WP (etridiazole, 8 ounces per 100 gallons) and Cleary's 3336 4F (thiophanate-methyl, 10 fluid ounces per 100 gallons) on November 3, and three applications (November 14, November 21, and December 1) of the fumigant Exotherm Termil (chlorothalonil, 3.5 ounces per 775 square feet). An application of calcium chloride (0.15 ounce per gallon) was made on November 6 and 13 to attempt to control bract edge burn.

Data collected included: date of first bract color, date of anthesis (first observable pollen), number of bract clusters, diameter of largest bract cluster, plant height, and diameter [(width1 + width2)/2, where width1 is at the widest point and width2 is perpendicular to width1](see table). On December 3 an informal quality evaluation by color group was conducted. Twenty-eight of the thirty-one cultivars were separated into six bract color classifications: red, white, pink, marble, jingle bells, and other. A representative sample of three plants was selected for each cultivar and the cultivars in each color group were ranked from best to worst by ten judges (see table). The judging team consisted of station personnel, staff from the Mobile Botanical Gardens, and a local nurseryman.

RESULTS

Perhaps it was no surprise that 'Freedom Red' and the more recent introduction 'Freedom Bright Red' scored at the top of our red cultivars. 'Freedom Red' has been the industry standard for several years. The top three white cultivars were very difficult to rank; any of these appear suitable for Gulf Coast greenhouse production. 'Darylne Pink', a top rated pink cultivar, produced a large convex bract display with unique, bright red-pink bracts.

The cultivars receiving the greatest number of comments from our judges were the "other cultivars" category. 'Monet', 'Candy Cane', and 'Cortez Candy' (Photo 13, page 36) had similar bract appearance, a whitish background with pink and red flecking, as if someone had spray painted white poinsettia flowers with red and pink spray paint. 'Silverstar' (Photo 14, page 36) had red bracts that covered its unusual gray-green variegated foliage. The attractive foliage of 'Silverstar' makes it a candidate as a flowering foliage plant in tropical and protected subtropical climates. The 'Cortez' (Red, Pink, White, and Candy) series produced beautiful, large plants but these cultivars required special handling, as the stems were easily broken. 'Monet' and 'Candy Cane' were also difficult to handle with stems that were easily broken off. One cultivar, 'Dark Puebla', had bracts that did not fully develop until after Christmas.

Consumers and growers alike are fortunate that recent poinsettia breeding is producing such a wide variety of cultivars to help brighten the Christmas holiday season. Since many of these cultivars appear to be well suited for production in Gulf Coast growing conditions, local growers have many new choices for their poinsettia "portfolio."

Highlights of 1997 Mobile OHS Poinsettia Cultivar Trial

	Plant date[1]	Growth regulator applications[1]		Plant height[2] (in)	Diameter of canopy (in)	Diameter of largest bract	Number of bract clusters cluster[3]	First color[3]	Anthesis (pollen shed)[3]	Ranking within color group[4,5]
Red Cultivars										
Freedom Bright Red	8/22	–	9/24	12.4	19.8	12.4	8	9	13	1
Freedom Red	8/22	9/17	9/24	12.3	20.0	12.6	9	8	14	1
Peterstar Red	8/22	9/17	9/24	11.8	21.7	11.8	11	9	14	2
Picacho	8/26-8/27	–	9/24	11.1	18.6	11.3	11	8	14	3
Petoy Red	8/22	9/17	9/24	12.5	22.9	12.0	8	10	15	4
Sonora Red	8/26-8/27	–	9/24	11.1	20.1	12.8	9	8	14	4
Nobelstar[6]	8/26-8/27	9/17	9/24	10.9	18.9	11.5	10	8	13	4
Success	8/22	9/17	9/24	12.5	20.6	12.5	8	9	16	*
Cortez Red	8/26-8/27	–	9/24	13.4	22.6	13.5	8	10	15	*
White Cultivars										
Snow Cap	8/22	9/17	9/24	12.4	21.8	11.3	11	9	14	1
Pearl White	8/22	9/17	9/24	11.6	22.3	12.0	9	9	14	2
Whitestar	8/26-8/27	9/17	9/24	12.0	18.2	12.3	11	9	14	2
Freedom White	8/22	9/17	9/24	12.7	20.5	11.8	8	10	14	3
Peterstar White	8/22	9/17	9/24	11.9	21.2	12.4	9	9	15	3
Cortez White	8/26-8/27	–	9/24	12.2	22.3	12.8	8	9	14	4
Sonora White	8/26-8/27	–	9/24	10.5	19.6	11.2	9	9	14	5
Pink Cultivars										
Darlyne Pink	8/22	9/17	9/24	12.2	22.5	11.6	8	9	14	1
Peterstar Pink	8/22	9/17	9/24	11.5	20.9	12.4	11	9	15	1
Freedom Pink	8/22	9/17	9/24	11.6	19.2	11.2	8	10	14	2
Cortez Pint	8/26-8/27	–	9/24	12.1	23.1	13.4	8	10	14	3
Sonora Pink	8/26-8/27	–	9/24	11.3	20.2	12.3	10	9	14	3
Other Cultivars										
Monet	8/22	9/17	9/24	14.6	24.1	12.8	9	10	15	1
Candy Cane	8/22	9/17	9/24	14.3	22.8	10.8	9	12	15	1
Silverstar	8/26-8/27	–	9/24	10.3	18.4	11.4	11	8	14	1
Cortez Candy	8/26-8/27	–	9/24	13.2	21.3	13.9	7	10	14	3
Marble Cultivars										
Peterstar Marble	8/22	9/17	9/24	11.2	19.9	11.2	11	9	14	1
Marblestar	8/26-8/27	9/17	9/24	10.4	18.6	10.3	9	8	14	1
Sonora Marble	8/26-8/27	–	9/24	11.3	19.7	12.2	9	9	14	1
Dark Puebla	8/26-8/27	9/17	9/24	11.2	19.2	9.1	8	12	16	*
Jingle Bell Cultivars										
Sonora Jingle	8/26-8/27	–	9/24	10.9	19.3	11.2	10	8	13	1
Freedom Jingle Bell	8/22	9/17	9/24	12.0	19.9	11.7	9	9	14	2

[1]All planting was done and growth regulator applications were made in 1997.
[2]Plant height measured as inches from top of soil.
[3]Weeks after potting.
[4]Cultivars with * were too immature to be ranked at time of judging.
[5]Cultivars ranked from most to least preferred with a ranking of 1 being the most preferred cultivar within the color group.
[6]Propagator doesn't recommend classifying as red.

INSECT, DISEASE, AND WEED CONTROL

Reduced Herbicide Use with Recycled Paper

Danita R. Smith, Charles H. Gilliam, James H. Edwards, and John W. Olive

Controlling weed populations in container-grown nursery crops is essential for production of quality, marketable plants. A typical method of weed control is to broadcast granular herbicides with a cyclone spreader over the top of container-grown plants. Depending on growth habit and container spacing, non-target loss (herbicide falling between pots rather than in pots) can be as high as 86%. With most container nurseries making three to five applications of granular herbicide annually, this method of application results in significant non-target herbicide loss. Daily irrigation can further compound the problem by causing irrigation runoff. In many nurseries as much as 0.5-0.7 inches of water per day may be used during the growing season and this runoff water may contain herbicides, thereby threatening contamination of nearby water systems.

Two recently developed products with potential to reduce herbicide use in container nursery crop production are made from recycled waste paper. These products are pelletized recycled paper and crumbled recycled paper. Waste paper is ground with a hammer mill equipped with a series of three screens (the smallest about 0.25 inch), then compressed using pelletizing equipment to form pellets about 3/16 × 1 inch in size. To develop the crumble product, pellets are put through a granulator with variable pressure plates. Both recycled paper products are non-composted and have a C:N ratio of about 500:1.

Although using these recycled waste paper products may not be cost effective for every situation, there are situations where they could be of great value. Potential situations include large container production (10 gallons and larger) where increased pot spacing results in greater non-target herbicide loss, environmentally sensitive areas near surface water bodies, with plants that are difficult to weed due to thorns or spines, and in enclosed structures where herbicide use is restricted.

While recycled waste paper has a number of potential uses in the landscape, developing these recycled waste products into manageable forms may allow for use in container-grown crops. The objectives of this study were to evaluate these recycled paper products as non-chemical weed control alternatives for container production and to determine plant growth response to recycled waste paper used as a mulch on the surface of containers.

METHODS

Uniform liners of 'Fashion' azalea and 'Girard's Rose' azalea were potted in trade gallon containers on August 9, 1995. The medium was a pine bark:peat (3:1 by volume) with 15 pounds Nutricote (18-6-8), 6 pounds lime, and 1.5 pounds Micromax added per cubic yard. Plants were grown in full sun and received daily overhead irrigation as needed.

Two paper products, recycled paper crumble and recycled paper pellets were surface applied at one of two depths, 0.5 or 1 inch. Phosphorus (P) was applied to the recycled waste paper products in the pots as triple superphosphate (0-46-0), at either 0 or 7.5 ppm, based on the dry weight of the paper products. Previous work had demonstrated sensitivity of some bedding plants to aluminum in the recycled paper and this was the reason for adding P. Other treatments included fabric disks, a fabric disk with Spin Out (a copper hydroxide root growth regulator), Rout 3G applied at 3 pounds active ingredient per acre, and a non-mulched control. With all mulch treatments 30 prostrate spurge seeds were placed either under the mulch or on top of the mulch. On May 7, 1996, azaleas were repotted into 3-gallon containers using the same medium, remulched with the recycled waste paper treatments, and the treatment of Rout 3G reapplied.

Data collected were prostrate spurge number per pot 30 and 75 days after treatment (DAT), and spurge fresh weight 75 DAT for 'Fashion' azalea pots only. In 1996, after repotting, spurge number was determined 30 and 60 DAT and spurge fresh weights were determined in pots of both azaleas 60 DAT(see table). Growth index (height + 2 perpendicular widths/3) was determined for both species at 240 and 550 DAT. The pH of 'Fashion' containers was measured 7, 30, 90, 210, and 240 DAT.

RESULTS

WEED CONTROL. Recycled waste paper pellets applied to a depth of 1 inch suppressed spurge germination (0.0 spurge per pot 30 DAT; 0.3 spurge per pot 75 DAT), regardless of whether spurge seed were sown on top of the mulch or under the mulch. In contrast, recycled crumble provided poor spurge control at both depths and when spurge were sown on top of the mulch, there was increased spurge growth compared to when the seed were sown under the crumble mulch.

Better weed control from use of recycled pellets probably resulted from two factors. First, the pellets are three times the density of the crumble product, thus creating a greater barrier for weed seed germination under the mulch. Second, the recycled waste paper pellets absorb approximately three times their weight in water within a few days after application. As water is absorbed, the pellets swell, forming an interlocked mat of bonded pellets with a relatively smooth surface.

Results with the fabric disk showed limited spurge control with any treatment (data not shown). There was a seed placement effect 30 DAT with spurge number and 75 DAT with fresh weight with seed placement under the fabric resulting in less growth than seed placed on top of the fabric. Spurge also emerged around the container circumference and in the slit where the fabric disk fitted around the plant. There was a difference in the number of spurge if seed was placed under or on top of the fabric disk 30 DAT with spurge number being greater if seed were placed on top of the fabric disk. Spurge fresh weight at 75 DAT followed a similar trend.

Rout provided excellent spurge control. Spurge germination was about 70% by 75 DAT as evidenced by 20.5 spurge in the control treatment.

Recycled pellets at a 1-inch depth continued to provide excellent spurge control after the plants were repotted in May 1996. There was a relationship between mulch type and the addition of P on two of three weed variables measured with both azaleas. When P was added to the recycled crumble, spurge growth (fresh weight) was increased at both depths. With 'Girard's Rose' azalea 60 DAT, recycled pellets provided greater spurge control (spurge number per pot) than recycled crumble, and the 1-inch depth provided greater control than the 0.5 inch depth; data for 'Fashion' azalea followed a similar trend.

GROWTH INDICES. Both cultivars grown with recycled waste paper mulch were generally similar in size to non-treated control plants and Rout treated plants at 240 DAT. No treatment produced a negative effect on plant growth when comparing effects of recycled paper treatments on 'Girard's Rose'. At 550 DAT all recycled paper treatment effects on 'Girard's Rose' were similar to the effects on plants grown with Rout and non-treated control plants.

'Fashion' azalea growth indices at 240 DAT exhibited a relationship between mulch type and depth. Crumble-grown plants were similar at 0.5- inch and1-inch depths; however, plants grown with pellets were smaller at the 1-inch depth than those grown at 0.5 inch. The authors observed that the pelleted mulch appeared to retain more water than the crumble mulch. Since all treatments were watered similarly with overhead irrigation, the growth suppression with recycled pellets may be related to excess moisture.

At 550 DAT, 'Fashion' azalea growth indices were affected by mulch, depth, and P. Crumble-grown plants had larger growth indices compared to pellet-grown plants, and plants grown in the 0.5 depth were larger than those grown in 1 inch. Plants grown with P were larger than those without P.

pH. When P was added to recycled paper, medium solution pH was lower than for no P treatments. Initially, (7 DAT) the crumble recycled paper medium solutions had higher pH levels than pelleted; however, by 30 DAT pellet medium solution had a higher pH level than crumble and maintained a higher level throughout the study. The higher pH for pellets is probably due to the density of the pellets themselves, being three times more dense than the crumble. The pH of the waste paper pellets is approximately 6.8 and crumble approximately 7.0. Generally, pH values of the paper treatments with no P were more similar to that of the control than those treatments with P. Medium solution pH gradually became more acidic with all treatments over the course of the study, ranging from 5.6 - 6.6 at 7 DAT to 4.9 - 6.0 at 240 DAT. These levels are within acceptable ranges for container-grown nursery crops.

Previous work has shown the addition of P is necessary to alleviate Al toxicity with sensitive bedding plants. Our data show that with container-grown plants additional P was not beneficial for plant growth when recycled paper is used as a non-chemical weed control alternative. While plant quality was not rated, all plants had good foliar color. Repotting the trade gallon container-grown azaleas into 3-gallon containers and reapplying the mulch had no negative effect on azalea growth.

Our research shows that recycled waste paper in the pelleted form provides superior weed control compared to the crumble form and that the 1-inch depth is necessary to provide adequate weed control during a growing season. Additionally, two environmental issues are addressed with this product: a reduction in chemical use and an alternative application of a post-consumer by-product that would otherwise be disposed of in landfills.

Effects of Recycled Paper Mulches on Control of Prostrate Spurge Seed in Container-Grown Azaleas After Repotting

			'Girard's Rose'			'Fashion'		
Treatment	Depth (in)	P level (ppm)[1]	Spurge # 30 DAT[2]	Spurge # 60 DAT	Fresh wt.[3] 60 DAT	Spurge # 30 DAT	Spurge # 60 DAT	Fresh wt. 60 DAT
Pellet	0.5	0.0	0.25	2.3	3.1	0.29	2.1	3.5
Pellet	0.5	7.5	0.37	1.4	10.6	0.43	0.86	12.1
Pellet	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pellet	1.0	7.5	0.0	0.25	0.03	0.0	0.14	0.01
Crumble	0.5	0.0	1.9	4.0	5.6	1.0	3.0	0.26
Crumble	0.5	7.5	5.0	5.0	23.0	6.2	5.9	26.3
Crumble	1.0	0.0	1.4	2.0	3.5	1.6	2.3	4.0
Crumble	1.0	7.5	2.5	3.6	56.2	2.0	3.1	46.0
Rout 3G[4]		0.0	0.25	1.6	9.5	0.29	1.9	10.9
Control[5]		0.0	5.3	8.1	59.1	5.7	8.9	57.6

[1]Phosphorus source was triple superphosphate: ppm based on weight of recycled paper per pot. [2]Days after transplant. [3]Measured in grams. [4]Rout 3G herbicide applied at 3 pounds active ingredient per acre. [5]No mulch applied.

What Consumers Want from Organic Mulches

Danita R. Smith, Charles H. Gilliam, James H. Edwards, and Bridget K. Behe

Developing new products from recyclable material often requires considerable work. Issues facing those developers include not only the best way to manufacture the commodity, but also how to secure public acceptance of a non-traditional product. A case in point is the development of a mulch material made from recycled paper. Tascon Inc. introduced the product 4 years ago. The manufacturing process involves first grinding the paper and then reforming it into either pellets or a crumble. The product, known as EnviroGuard, has been tested at Auburn University and has proved to be effective for controlling weeds in nursery container production and in a landscape situation. In the initial stages of production the mulch was a gray color, but in studies conducted to evaluate the effectiveness of the mulch, it was noted that the color was not aesthetically pleasing as a landscape mulch. Pigments were added to create other colors, primarily rust and brown, attempting to make the mulch more appealing to consumers.

Mulching is a common practice for residential and commercial landscapers and several factors are considered when selecting a mulch. Since mulches are used over large areas, they are highly visible in the landscape and should be aesthetically pleasing, durable, and effective. Color is also an important consideration when selecting a mulch and good design uses color contrast to augment a landscape. Mulch should permit water to penetrate into the soil and allow for gas exchange between soil and air, and maintain effectiveness as it decomposes. Other factors affecting mulch selection include weed control, texture, and susceptibility to erosion by wind or water.

One alternative mulch that has been evaluated in several studies and in several forms, is recycled waste paper. Two recently developed paper mulches, generated from recycled waste paper, were evaluated in a previous study at Auburn University, and proved to be effective as landscape mulches for weed control and soil moisture retention.

Few studies have been conducted to evaluate consumer preferences and attitudes concerning various organic mulches and factors that affect consumer preference for mulch materials. The objective of this study was to evaluate the aesthetic value of three traditional mulches (pine bark, pine straw, and wheat straw), and the two new mulch products (in three different colors), developed from recycled waste paper (Photo 15, page 36). Reasons why consumers purchase mulch and the benefits that the consumers anticipated from the mulch were also identified.

METHODS

Two groups were surveyed. The first group surveyed consisted of 37 middle-aged adults (mean age 42) who were employed full-time in education related fields in the Auburn area. This group will be referred to as non-students. The second group consisted of 25 young adults who were students from a senior-level horticulture class at Auburn University (mean age 25). This group will be referred to as students. Participants were asked to complete a 13-item survey which requested information on past purchases of mulch, uses for mulch, mulch preference, and demographic information, (age, gender, income level, and education level). They were asked to indicate the time of their most recent purchase of plants and/or mulch, type of mulch purchased, and type of store/garden center from which they made their purchase. Participants were also asked what factors would most affect their decision when purchasing mulch, why they use mulch, and how many years they have gardened.

On two different dates the respondents were asked to rate nine different mulches that were used to mulch annual plant beds at the Patterson Greenhouse complex at Auburn University. The first rating was 2 weeks after the mulch was applied and the second rating was 6 weeks later. Plots were planted with either ageratum or marigold and mulched with one of the nine mulches. Each plot size was 4 feet × 4 feet and contained three plants each of either ageratum or marigold. The nine different mulches were pine bark, pine needles, wheat straw, gray recycled paper pellets, gray recycled paper crumble, brown recycled paper pellets, brown recycled paper crumble, rust recycled paper pellets, and rust recycled paper crumble. In the initial rating when the plants were young, approximately 75% of the ground (mulch) was exposed. By the second rating 50% or less of the ground (mulch) was exposed. Individuals were asked to rate plots on a scale of 1 - 5, where 1 = definitely would not purchase the mulch, 3 = may or may not purchase the mulch, and 5 = definitely would purchase the mulch.

RESULTS

The non-students had gardened for an average of 15 years; 92% owned their own home and had lived there an average of 8 years (28 years being the maximum). The average income range was $45,000 to $50,000, with 28% earning more than $65,000 a year.

The group consisting of 25 students, had gardened for an average of 6 years; 80% rented their place of residence and had lived there an average of 1 year. It was difficult to accurately determine their personal income level since several listed their parents' household income; however, 60% reported having annual incomes of less than $15,000.

Both groups showed a significant increase in frequency of purchase from 1994 to 1996. Seven percent of non-students purchased mulch in 1994, whereas 70% purchased mulch in 1996. Student percentage for mulch purchases rose from 15% to 55%, with 20% of the students not having purchased mulch in the last 3 years. Several survey participants stated that although they had not purchased mulch, they had raked pine needles to use as mulch. A greater percentage of both groups purchased mulch from a chain store (44%, each group) than from a local garden center (non-students 32% and students 20%) or other source (24% and 20%, respectively).

The type of mulch most frequently purchased by non-students and students respectively, was pine bark, 53% and 79%, followed by pine needles, 30% and 16%. Other sources have also indicated that mulches obtained from the excess of wood related industries are currently some of the most popular.

Both groups considered the soil moisture retention capacity of mulch second only to the aesthetic appeal of the mulch. The majority of the non-students reported that the reason they used mulch was to make the landscape neat (84%) and conserve moisture (73%). Students indicated aesthetics were the primary reason for using mulch (96%), followed by moisture retention (88%).

Both groups ranked pine bark as the mulch most likely to be purchased, followed by pine needles. Despite the differences between individuals in the two groups (age, income, rent vs own), there was no difference in selection of the most preferable mulch. Preference of mulch type did not change over time; however, the perception of the aesthetic value of a given mulch did change. For example, the perception of all pellets and pine needles was different in the first and second ratings (see table). All pellets, and particularly the gray, were given a higher aesthetic value in the second rating, while the pine bark and pine needles were given a lower aesthetic value.

The change in aesthetic perception of mulches was not surprising since mulches do change over time. Recycled paper mulches change considerably with changes in the gray-colored mulch more pronounced than the rust or brown. As the gray mulch aged, it became darker and appeared to blend more aesthetically with the surrounding area. The pellets also expanded as they absorbed water and as they began to break down they lost their 'hard' edges and assumed a softer texture.

ORGANIC MULCH PREFERENCES: FIRST AND SECOND RATING 6 WEEKS APART[1]

Mulch	Non-students		Students	
	First rating	Second rating	First rating	Second rating
Pine bark	4.6	4.1	4.7	4.6
Pine needles	3.7	3.5	4.2	3.8
Rust crumble	3.5	3.1	3.2	2.9
Brown crumble	3.4	3.0	3.1	2.8
Gray crumble	2.4	2.2	2.0	2.0
Rust pellet	2.1	2.5	2.0	2.2
Brown pellet	2.0	2.3	1.6	1.8
Gray pellet	1.5	2.3	1.4	1.9
Wheat straw	2.7	2.6	3.5	3.2

[1]Mulch rating is based on a scale of 1 - 5: 1 = definitely would not buy, 5 = definitely would buy.

The aesthetic perception of pine bark and pine needles also changed over time; however, it decreased rather than increased. Also, the pine bark tended to wash away from landscaped plots, whereas the paper mulch remained in place. Longer term evaluations than in the current study need to be conducted since mulches are typically replaced at least once a year in landscapes.

In every case, pine bark and pine needles were the most preferred mulches. Comparison of recycled waste paper mulches showed that crumble mulches were favored over pelleted mulches with rust and brown being the most preferred colors. Consumer perception of the aesthetic value of mulch changed over time with pellets improving in perception and all other mulches remaining the same or declining. These results may indicate that even though recycling and environmental issues continue to be of concern, the challenge will be for manufactures of recycled products to gain consumer acceptance of non-traditional commodities entering a market dominated by traditional products.

Evaluation of Garlic, Fish Oil, and Putrescent Egg Products as Deer Feeding Controls

Christine K. Harris, Eric Simonne, D. Joseph Eakes, and Keith Causey

There are an estimated 1.7 million deer in Alabama. The main strategies available to control deer feeding damage include physical barriers, scare tactics, extermination, and in some cases, shooting. Physical barriers are often expensive as well as unattractive additions to most residential and commercial landscapes. Scare tactics are only effective until the deer become accustomed to the tactic employed. Shooting is obviously an unacceptable alternative in populated suburban areas. One of the most selective and cost-effective approaches is chemical repellency.

To our knowledge, limited scientific data are available on the comparative efficacy of organic products. This study involved the testing of organic products containing garlic extract, fish oil, or putrescent whole egg solids as their active ingredients. The objectives of this research were to evaluate the continuous efficacy of selected organic products as deer feeding damage controls on horticultural crops and determine potential phytotoxicity.

METHODS

The study was conducted at the Auburn University Deer Pen facility. The enclosure is approximately 1 acre. Pine trees inside the enclosure provide adequate shade. Initially, 13 does and one buck were contained within the pen. Fawns were born mid-summer. No green vegetation was available to the deer other than that provided in the study. Water and deer feed were available to the deer *ad libitum*.

Three ornamental species were selected based on their importance to the landscape industry in the South and their perceived palatability to deer. 'Francee' hosta, 'Rosa' gomphrena, and 'Pacifica Red' vinca were grown off-site in trade-gallon pots following standard nursery practices in May and June 1998. Groups of nine uniform plants of each species were sprayed with selected products outside of the pen. All products were used as is and/or following the label's recommendations (Table 1). When required by the label, fresh product was mixed before each use.

Feeding damage on each plant was rated daily for 6 days. Differences in growth habit among plant species resulted in different damage rating scales. The vinca and gomphrena made a single stem. The rating scale for these species was 0 - 3 where 0 = no damage, 1 = one-third plant cut off, 2 = two-thirds plant cut off, 3 = plant cut at the pot line or uprooted. Hostas, however, make a rosette of leaves which vary in number from plant to plant. For hostas, the number of eaten leaves and remaining leaves were determined. All feeding damage data were transformed into percent destruction (0 = no damage; 100 = plant totally destroyed).

Products were ranked according to effectiveness for each batch. The ranks were added for each product to provide an overall rank sum index (ORSI). This allowed each product to be ranked for the entire study.

TABLE 1. CHARACTERISTICS AND APPLICATION RATES OF SELECTED PRODUCTS

Treatment number	Product name	Source	Active ingredient and formulation	Comments
1	None		Negative control	
2	Deer and rabbit repellent	Local retailer	Thiram	Ready-to-use spray; positive control
3	Garlic + fish oil (1X)	GRL[1]	1+1 gallons in 98 gallons of water	Spray; some mixing required
4	Garlic + fish oil (2X)	GRL	1+1 gallons in 48 gallons of water	Spray; some mixing required
5	Garlic + fish oil (3X)	GRL	1+1 gallons in 30 gallons of water	Spray; some mixing required
6	Deer Away Powder	Woodstream[2]	Putrescent whole egg solids	Ready-to-use powder
7	Deer Away Kit	Woodstream	Putrescent egg	Prokit; regulated
8	Deer Away Spray	Woodstream	Putrescent egg	Ready-to-use spray; deregulated
9	Garlic (3X)	GRL	1 gallon in 30 gallons of water	Spray; some mixing required
10	Fish oil (3X)	GRL	1 gallon in 30 gallons of water	Spray; some mixing required

[1] GRL: Garlic Research Labs, California.
[2] Woodstream Corporation, Pennsylvania.

RESULTS

When the three plant species were treated and presented simultaneously to the deer, it became evident that the level of protection provided by the organic products used in this test depended on the plant species on which they were applied. Damage rating results suggest that under these conditions, the plant species is likely more important than the organic product sprayed. Based on the level of damage, hosta, gomphrena and vinca were classified as having high, medium, and low palatability to deer, respectively.

Despite the fact that the efficacy of selected products was tested under extremely high deer pressure (14 deer per acre; no other source of live greenery available), differences were found among products. None of the products tested were phytotoxic over a 6-day period. In our observations, the smell of most of the products such as the garlic extract and fish oil did not carry over to the plants after spraying.

All products tested provided some level of protection against feeding damage incurred by white-tailed deer on the ornamental species (Table 2). Products containing putrescent whole egg solids were most effective in suppressing deer feeding. Treatments containing garlic and/or fish oil provided some protection, but were less effective than organic products containing egg solids.

Among the garlic + fish oil treatments, the 1x formulation provided less protection than the 2x and 3x formulations. Formulations of garlic and fish oil at 2x and 3x the recommended rate showed similar results.

Overall, the egg-based Deer Away Powder and Deer Away Spray were the most attractive products tested in this study due to their ready-to-use forms and effectiveness.

Table 2. Product Ranking Based on an Overall Rank Sum Index for Testing with Hosta, Gomphrena, and Vinca

Product	Product rank[1]
Control (None)	10
Deer and rabbit repellent	9
Garlic + fish oil (1X)	8
Garlic + fish oil (2X)	3
Garlic + fish oil (3X)	5
Deer Away Powder	1
Deer Away Kit	7
Deer Away Spray	2
Garlic (3X)	4
Fish oil (3X)	6

[1]1= most effective; 10= least effective.

Susceptibility of Indian Hawthorn Cultivars to Fireblight, Anthracnose, and Entomosporium Leaf Spot

Austin K. Hagan, J. Randall Akridge, John W. Olive, and Ken M. Tilt

Indian hawthorn (*Raphiolepis indica*), with its dark-green foliage, mounded canopy, and compact growth habit, is a fixture in Alabama's residential and commercial landscapes. In the nursery and landscape, Entomosporium leaf spot, which is caused by the fungus *Entomosporium mespili*, is the most common and damaging disease of Indian hawthorn. Unfortunately, Entomosporium leaf spot is not the only damaging disease on Indian hawthorn. Destructive outbreaks of fireblight, a bacterial disease caused by *Erwinia amylovora*, have also been seen on container stock in the nursery and landscape. A third foliar disease, anthracnose, caused by the fungus *Colletotrichum gloeosporides*, may also damage selected Indian hawthorn cultivars.

In recent years, a number of new cultivars of Indian hawthorn have been released by the nursery industry. Previous AAES reports have documented that cultivars of Indian hawthorn differ significantly in their susceptibility to Entomosporium leaf spot. A few suffer little more than light spotting of the lower leaves, while others may be completely defoliated. The reaction of cultivars of Indian hawthorn to the diseases fireblight and anthracnose is, however, unknown. This report summarizes data collected in 1997 and 1998 concerning the reaction of selected cultivars in a simulated landscape planting to Entomosporium leaf spot, fireblight, and anthracnose.

METHODS

In March 1994, the initial planting of dwarf and standard Indian hawthorn cultivars was established in a simulated landscape planting at the Brewton Experiment Field near Brewton, Alabama. In March 1995, 'Snow White' and 'Rosalinda', which are a dwarf and standard form, respectively, were added to the study. 'Bay Breeze' and 'Becky Lynn', both dwarf cultivars, were planted in the early spring of 1996 and 1998, respectively.

Soil pH and fertility in the beds were adjusted according to the results of a soil fertility assay. The beds were mulched with aged pine bark and watered as needed using a drip irrigation system. Twice each spring, approximately 0.5 cup of Osmocote 17-7-12 was uniformly distributed around each plant. A tank mixture of 1 pound of Gallery 75DF and 2 quarts of Surflan AS T/O were broadcast over the beds on a per acre basis to control annual weeds. Hand weeding and directed applications of recommended rates of Roundup or MSMA were used to control escaped weeds and invading centipedegrass. On May 19, 1997 and May 13, 1998, Entomosporium leaf spot was rated on a scale of 1 to 5 where 1 = no disease, 2 = 1 to 25 %, 3 = 26 to 50%, 4 = 50 to 75%, and 5 = 76 to 100% of leaves diseased or defoliated. On June 29, 1997 and August 5, 1998, fireblight severity was assessed on a scale of 0 to 4 where 0 = no disease, 1 = one or few blighted branch tips, 2 = numerous branch tips blighted and a few scaffold branches killed, 3 = major portion of bush killed, and 4 = bush dead. Anthracnose ratings were taken on June 29, 1997 and August 5, 1998 using the scale previously described for Entomosporium leaf spot.

RESULTS

Substantial differences in severity of Entomosporium leaf spot were noted in 1997 and 1998 among the cultivars screened. In both years, damage on individual cultivars ranged from unobtrusive spotting of a few scattered leaves to near complete defoliation (see table). Since the study was started in 1994, the disease ratings of some leaf spot-resistant cultivars, particularly for 'DwarfYedda' have gradually worsened.

In 1997, light to moderate spotting of the foliage with a very low level of disease-related leaf shed (disease ratings of 2.0 to 2.6) were noted for 'Olivia', 'Indian Princess', 'Eleanor Tabor', and 'Janice'. Of these, 'Olivia' visually had the least spotting of the foliage and no defoliation. Nearly all remaining cultivars suffered moderate to heavy spotting of the foliage along with considerable to near total defoliation. With disease ratings higher than 4.0, 'Springtime', 'Enchantress', 'Harbinger of Spring', 'Pinkie', and 'White Enchantress' proved extremely sensitive to Entomosporium leaf spot.

Ratings for Entomosporium Leaf Spot, Fireblight, and Anthrancnose on Cultivars of Indian Hawthorn, 1997-1998

Cultivar	Leaf spot ratings[1]		Fireblight ratings[2]		Anthracnose ratings[1]
	1997	1998	1997	1998	1997
Heather	4.0	4.8	0.2	0.1	1.0
Springtime	4.7	4.0	0.1	0.0	1.0
Pinkie	4.2	4.5	0.1	0.1	1.0
Enchantress	4.5	4.3	0.3	0.0	1.0
Harbinger of Spring	4.6	4.4	0.1	0.1	1.0
White Enchantress	4.2	4.0	0.0	0.1	1.0
Spring Rapture	4.0	4.5	0.0	0.3	1.0
Bay Breeze	3.6	4.8	0.0	0.1	1.0
Clara	3.0	3.5	0.1	0.0	1.0
Rosalinda	3.0	3.3	0.1	0.0	1.3
Majestic Beauty	3.0	3.5	0.6	0.0	2.7
Snow White	3.2	3.3	0.0	0.1	1.0
Jack Evans	3.0	Dead	4.0	Dead	1.0
Becky Lynn	–[3]	4.3	–	0.1	–
Dwarf Yedda	2.8	3.5	0.0	0.0	1.0
Janice	2.6	Dead	3.7	Dead	1.0
Eleanor Tabor	2.5	3.3	0.2	0.0	1.0
Indian Princess	2.3	2.7	0.2	0.1	1.0
Olivia	2.0	2.3	0.7	1.1	1.0

[1]Entomosporium leaf spot and anthracnose were assessed on a scale of 1-5 where 1 = no disease; 2 = 1 to 25%; 3 = 26 to 50%; 3 = 51-75%; 4 = 76 to 100% of leaves diseased or defoliated.
[2]Fireblight was rated on a scale of 0-4 where 0 = no disease; 1 = one to several spurs or shoot tips dead; 2 = numerous branch tips blighted and a few scaffold branches killed; 3 = major portion of bush killed; and 4 = bush dead.
[3]'Becky Lynn' was planted in March 1998.

Disease ratings for Entomosporium leaf spot taken in 1998 were higher, particularly for the leaf spot resistant cultivars 'Olivia', 'Indian Princess', 'DwarfYedda', and 'Eleanor Tabor', as compared with levels seen in the previous year. Heavy and frequent rainfall in January through March is largely responsible for this increase in leaf spot related damage. 'Olivia' and 'Indian Princess', as indicated by disease ratings of 2.3 to 2.7, suffered only light spotting of the leaves. Spotting of the lower leaves and premature defoliation was heavier on 'Dwarf Yedda' and 'Eleanor Tabor' than had been seen in 1998. Like the previous year, considerable spotting of the leaves and severe to near complete defoliation was noted on many of the remaining cultivars of Indian hawthorn.

A blossom blight and shoot dieback, which typically is associated with the disease fireblight, was first noted on selected cultivars in mid-May 1997. Within 2 months of the onset of symptoms, the cultivars 'Janice' and 'Jack Evans' had succumbed to this disease. Some fireblight-related shoot and limb dieback was also seen on 'Olivia' and 'Majestic Beauty'. Although some blossom blight was seen on a few cultivars, none suffered significant fireblight-related damage.

In 1998, significant limb dieback was limited to the 'Olivia'. On 10 additional cultivars, death of an individual spur(s) or lateral shoot(s) was seen but damage was light and unobtrusive.

Anthracnose, which typically appears in late spring or early summer, causes some spotting of the leaves and early leaf shed. Concentric rings of light and dark tissue give the large leaf spots, which may be an inch or more in diameter, a 'target spot' appearance. In 1997, disease development was limited to the two standard cultivars 'Majestic Beauty' and 'Rosalinda'. Of these, the heaviest damage was recorded on 'Majestic Beauty'. Due to unusually dry weather from April through August, no symptoms of anthracnose were noted in 1998 on any cultivars of Indian hawthorn.

In addition to Entomosporium leaf spot, fireblight and anthracnose are also potential threats to the health and beauty of Indian hawthorn in the nursery and landscape. Of these two diseases, fireblight is most likely to cause significant damage to Indian hawthorn, particularly in the nursery. As a result, the cultivars 'Janice' and 'Jack Evans' that are very susceptible to fireblight would be poor choices to produce in a nursery or install in landscapes. Dwarf cultivars 'Eleanor Tabor' and 'Indian Princess' suffered the least damage from all the above diseases. 'Olivia', which has good resistance to Entomosporium leaf spot, proved somewhat sensitive to fireblight. These disease-resistant Indian hawthorn cultivars can be produced in a nursery with few if any costly pesticide treatments. Also, they would be excellent choices for the low maintenance landscapes favored by most landscaper managers and homeowners. On the other hand, leaf spot-susceptible cultivars such as 'Heather', 'Springtime', 'Pinkie', 'Harbinger of Spring', 'White Enchantress', and 'Enchantress', which consistently suffered heavy defoliation in late winter and early spring, were unattractive and unthrifty. Such leaf spot-susceptible cultivars would require frequent fungicide applications in order to maintain their appearance and health.

Sensitivity of Selected Cultivars of Ground Cover and Shrub Roses to Black Spot and Cercospora Leaf Spot

Austin K. Hagan, J. Randall Akridge, and Ken M. Tilt

Few flowering shrubs can match the beauty, versatility, and popularity of roses. In recent years, interest of rose fanciers and landscape designers has expanded to include hybrid tea, Florabunda, and Grandaflora roses but also newly released cultivars of shrub and ground cover roses. Typically, diseases, particularly black spot, have a detrimental impact on the aesthetics and health of the vast majority of rose cultivars. Alabama's often wet and warm climate along with a long growing season, which favors the rapid development and spread of disease, mandates the adoption of an intensive, season-long fungicide spray program to maintain the health and beauty of most cultivated roses. Although the susceptibility of most hybrid tea, Florabunda, and Grandiflora roses is well known, the reaction of newly released shrub and ground cover roses to diseases is largely unknown. Also, little or no information is available concerning their adaptability to Alabama's hot summers.

Results of an AAES study started in the spring of 1998 indicate that selected cultivars of ground cover and shrub roses in a simulated landscape planting significantly differ in their susceptibility to black spot and Cercospora leaf spot. Although many of the cultivars tested proved highly susceptible to black spot, a few suffered only light to moderate damage and may be good choices in low maintenance landscapes.

METHODS

Bare-root roses were potted in a pine bark/peat moss (3:1 by volume) medium amended with 14 pounds of 17-7-12 Osmocote, 6 pounds of dolomitic limestone, 2 pounds of gypsum, and 1.5 pounds of Micromax per cubic yard. One month later, the potted roses were transplanted into raised beds at the Brewton Experiment Field where the fertility and pH had been adjusted according to the results of a soil assay. The beds were mulched with aged pine bark and a drip irrigation system was installed. During the growing season, the roses were watered as needed.

A tank mixture of 1 pound of Gallery 75DF and 2 quarts of Surflan T/O per acre was broadcast over the beds for preemergence weed control. Hand weeding and directed applications of recommended rates of Roundup or MSMA were used to control escaped weeds. Ammonium nitrate at the rate of 40 pounds per treated acre was broadcast monthly during the growing season over the beds. The severity of black spot and Cercospora leaf spot was rated on a scale of 1 to 10 on April 25, June 3, August 5, October 16, and December 3, 1998. The rating scale is described in the footnote to the table.

Reaction of Cultivars of Ground Cover and Shrub Roses to Black Spot and Cercospora Leaf Spot, Dec. 3, 1998

Cultivar	Black spot rating[1]	Cultivar	Black spot rating[1]
Royal Bonica	6.6	The Fairy	5.0[2]
Betty Prior	6.6	Fushia Meidiland	4.8
Sevillana	6.4	Nozomi	4.4
First Light	6.4	White Flower Carpet	4.2
Carefree Delight	6.2	Red Cascade	3.8
Bonica	6.1	*Rosa mutabulis*	3.8
Cherry Meidiland	6.0	*Rosa wichuraina*	3.6
Nearly Wild	5.8	Happy Trails	3.4
Jeeper's Creepers	5.6	Magic Carpet	3.0
Peach Meidiland	5.6	Ralph's Creeper	3.0
Sea Foam	5.2	Flower Carpet	2.6
Mystic Meidiland	5.2	Petite Pink Scotch	1.0
Livin' Easy	5.2		

[1]Black spot and Cercospora leaf spot were rated on a scale of 1-10 where 1 = no disease, 2 = very few spots in lower canopy, 3 = a few spots in lower and upper canopy, 4 = some spots with light defoliation in lower canopy, 5 = spots noticeable with noticeable defoliation, 6 = spots numerous with significant (50+%) defoliation, 7 = spots numerous with severe defoliation (75+%), 8 = upper canopy badly diseased with high (90%) defoliation, 9 = very few remaining leaves covered with spots, and 10 = plant defoliated.

[2]Disease rating for 'The Fairy' includes damage attributed to black spot and Cercospora leaf spot.

RESULTS

In 1998, weather patterns from late April through much of August were unusually hot and dry. As a result, the development and spread of black spot and other leaf diseases during that time was suppressed. In September, an excess of 30 inches of rain was recorded from two tropical storms. The weather, which remained relatively wet and unseasonably mild from October into early December, favored the onset and rapid spread of disease.

Although none of the 25 cultivars screened were immune to both diseases, considerable differences in the severity of black spot and Cercospora leaf spot were seen (see table). By far, black spot was the predominate disease observed. Black spot-related spotting of the foliage and early leaf shed was recorded on all but one cultivar 'Petite Pink Scotch', which remained free of this disease all season. With disease ratings of 2.6 to 3.8 at seasons-end, 'Flower Carpet', 'Ralph's Creeper', 'Magic Carpet', 'Happy Trails', *Rosa. wichuraiana*, *R. mutabulis*, and 'Red Cascade' generally suffered light to moderate spotting of the leaves in the lower to mid-canopy and possibly some light defoliation around the base of the plant. Moderate spotting of the leaves with increasingly heavier leaf shed was recorded for 'White Flower Carpet', 'Nozomi', and 'Fushia Meidiland'. The heaviest spotting and yellowing of the leaves and defoliation levels exceeding 50% (as indicated by disease ratings of 6.0 to 6.6) were noted for 'Cherry Meidiland', 'Bonica', 'Carefree Delight', 'First Light', 'Sevillana', 'Betty Prior', and 'Royal Bonica'. On the remaining cultivars with disease ratings of 5.0 to 5.8, black spot-related leaf spot and premature leaf shed was extensive.

Development of Cercospora leaf spot was also noted on two cultivars. On 'Petite Pink Scotch' (disease rating of 5.6), symptoms of only Cercospora leaf spot were observed while the 'The Fairy' (disease rating of 5.0) may have been damaged by both black spot and Cercospora leaf spot. On both cultivars, heavy spotting of the leaves in the lower and mid-canopy along with noticeable defoliation was observed.

Observations concerning the appearance of the foliage and plant vigor were also recorded during the growing season. Some cultivars tolerated the hot summer of 1998 while others did not. 'Magic Carpet', which demonstrated resistance to black spot in the December ratings, suffered greatly from the high summer temperatures. By August, this cultivar had shed nearly all of its leaves and shoot growth had ceased. Extensive bronzing or yellowing of the leaves along with some premature defoliation was noted that same month on 'White Flower Carpet' and 'Flower Carpet'. Like 'Magic Carpet', both of these cultivars had partial to full recovery by early December from summer heat stress. Some light bronzing or discoloration of the older leaves, particularly those around the base of the plant, was recorded on the majority of the remaining cultivars. The foliage of 'Fushia Meidiland', which appeared to have suffered from some mineral deficiency, remained yellow or chlorotic throughout much of the growing season. Among the cultivars tested, *R. mutabulis, R. wichuraiana*, 'Bonica', 'Jeeper's Creeper', 'The Fairy', 'Ralph's Creeper', 'Nozomi', 'Petite Pink Scotch', 'Livin' Easy', 'Nearly Wild', and 'Mystic Meidiland' appeared to have the best heat tolerance.

In summary, significant differences in the disease severity and general adaptability were noted among the 25 cultivars of ground cover and shrub roses. Those cultivars with the best resistance to disease and heat stress were 'Ralph's Creeper', 'Happy Trails', *R. mutabulis,* and *R. wichuraina;* all would be excellent choices in a low maintenance landscape. Although some light bronzing of the inner canopy was seen on 'Red Cascade', this cultivar also demonstrated disease resistance. The heat sensitive cultivars 'Flower Carpet', 'White Flower Carpet', and 'Magic Carpet' which appeared unsightly and unthrifty throughout much of the growing season, would be poor choices for landscape plantings across much of Alabama. To maintain plant health and beauty of the remaining roses, an intensive, season-long fungicide spray program would be required to keep black spot or Cercospora leaf spot in check.

Photo 1. *Aster × frikartii* **'Monch'.**

Photo 2. ***Boltonia asteroides*** **'Snowbank'.**

Photo 3. ***Coreopsis rosea.***

Photo 4. ***Coreopsis verticillata*** **'Zagreb'.**

Photo 5. ***Gaillardia × grandiflora*** **'Goblin'.**

Photo 6. ***Helianthus angustifolius.***

Photo 7. *Lythrum virgatum* **'Mordens Pink'.**

Photo 8. *Lythrum salicaria* **'Robert'.**

Photo 9. *Salvia leucantha.*

Photo 10. *Verbena canadensis* **'Homestead Purple'.**

Photo 11. *Verbena bonariensis.*

Photo 12. *Verbena tenuisecta* **'White'.**

Photo 13. Poinsettia cultivar 'Cortez Candy'.

Photo 14. Poinsettia cultivar 'Silverstar'.

Photo 15. Recycled paper mulches. Clockwise from the top: gray pellets and crumble, rust pellets and crumble, brown pellets, and crumble.

Photo 16. A dwarf burford holly branch heavily infested with tea scale.

Photo 17. Miticide efficacy as demonstrated by lack of mite damage on miticide-treated plants.

Photo 18. Marginal leaf necrosis cause by Pinpoint 15G and Orthene TTO 75SP treatments.

Foliar-applied Fungicides Fail to Control Phytophthora Shoot Blight and Root Rot on Annual Vinca

Austin K. Hagan and J. Randall Akridge

Within the last decade, Phytophthora shoot blight and root rot has become a common and devastating disease of annual vinca (*Catharanthus roseus*) in both production greenhouses as well as the landscape. Once introduced into landscape beds on diseased annual vinca, the causal fungus *Phytophthora parasitica* is impossible to eradicate. Available data indicate that all commercial lines of annual vinca are susceptible to Phytophthora shoot blight and root rot. Previous trials have demonstrated that Aliette WDG alone or tank-mixed with Fore 80W provided effective control of this disease on pot- and bed-grown annual vinca. AAES trials were conduced in a simulated landscape planting to confirm the efficacy of registered and experimental fungicides for the control of Phytophthora shoot blight and root rot on annual vinca.

METHODS

On May 29, 1998, annual vinca 'Peppermint Cooler' were planted on established raised beds in a Benndale sandy loam heavily infested with *P. parasitica.* They were planted in a square on 1-foot centers at the Brewton Experiment Field. Just prior to planting, approximately 400 pounds per acre of 13-13-13 fertilizer was tilled into the beds. Throughout the growing season, calcium nitrate was applied at 2-week intervals through the drip irrigation system at a rate of 10 pounds per acre. With the exception of the monthly drenches of Subdue 2E, all treatments were applied to run-off as directed foliar sprays at 2-week intervals from June 15 through August 24, 1998 at the rates specified in the table. Plant survival was determined on June 23, July 17, and August 5, 1998.

RESULTS

Populations of *P. parasitica* in the beds were so high that some of the plants in some test plots succumbed to the root rot phase of this disease no more than a week after the first fungicide application. By mid-July, substantial stand losses were noted in all plots except those treated with the 5 pounds of Aliette WDG or a combination of 5 pounds of Aliette WDG and 2 pounds of Fore 80W per 100 gallons of spray volume. Among all treatments, the lowest survival rate was the 45% recorded in the untreated controls.

By early August, none of the fungicide treatments proved effective in controlling Phytophthora shoot and root rot on annual vinca in beds heavily infested with *P. parasitica*. Among all fungicide treatments, the highest survival rate of only 50% was noted in the Heritage 50W-treated plots. Otherwise, the level of plant survival for most of the remaining treatments did not substantially differ from the 0% survival rate recorded in the untreated control. No phytotoxicity was observed at anytime during this fungicide trial.

In summary, fungicides are not necessarily the answer to controlling Phytophthora shoot blight and root rot on annual vinca. In beds where the causal fungus has not been introduced, previous fungicide trials indicate that Aliette WDG applied at 2-week intervals at 5 pounds per 100 gallons of spray volume gave effective season-long protection from this disease as compared with a 25% survival rate for the same treatment where the causal fungus was already well established in the beds. The combination of favorable weather patterns and high inoculum pressure was overwhelming and all fungicide treatment regimes failed to protect the annual vinca from attack by *P. parasitica*. Right now, the best defense against Phytophthora shoot blight and root rot in a pathogen-infested bed is planting a disease-resistant summer annual.

Evaluation of Fungicides for the Control of Phytophthora Shoot Blight and Root Rot on Annual Vinca

Treatment and rate	% Plant survival		
per 100 gal	June 23	July 17	Aug. 5
Untreated control	70	45	0
Aliette WDG 2.5 lb.	70	60	5
Aliette WDG 5.0 lb.	100	95	25
Aliette WDG 2.5 lb.+Fore 80W 2.0 lb.	95	70	25
Aliette WDG 5.0 lb.+Fore 80W 2.0 lb.	100	90	35
Fluazinam 500F 12 fl. oz.	90	80	35
Daconil Ultrex SDG 1.4 lb.	85	70	5
Subdue 2E 1.25 fl. oz. [1]	80	65	20
Heritage 50W 1.0 lb.	90	80	50

[1]Subdue 2E was applied monthly as a soil drench while the other treatments were applied as a foliar spray at 2-week intervals.

Evaluation of Bactericides for the Control of Fireblight on Crabapple

Austin Hagan and J. Randall Akridge

Fireblight, which is caused by the bacterium *Erwinia amylovora,* is a common and often damaging disease in the nursery and landscape on crabapple, flowering pear, and other related member of the rose family. Little information is available concerning the effectiveness of bactericides such as Agrimycin 17, Kocide 101 77W, Phyton 27, and Aliette WDG in controlling this disease on crabapple or other woody ornamental members of the Rose family. An AAES study was conducted to assess the efficacy of registered and experimental bactericides for the control of fireblight in a simulated landscape planting of crabapple.

METHODS

Bare-root crabapple (*Malus* sp.) 'Snowdrift' were planted in March 1995 in a Benndale sandy loam at the Brewton Experiment Field. Before planting, soil fertility and pH were adjusted according to the recommendations of a soil assay. After planting, the beds were mulched with aged pine bark. Twice each spring, 50 pounds per acre of 16-4-8 fertilizer was broadcast down each row of trees. For preemergent weed control, a tank-mix of 1 pound per acre of Gallery 75DF and 2 quarts per acre of Surflan T/O was broadcast over the beds.

Plots were hand weeded and spot-treated with Roundup to control escape weeds. All treatments were applied to run-off using an ATV-mounted electric sprayer with a single hand-held nozzle. Kocide 101 77W was applied as a dormant spray just before bud break in early March. All other treatments were applied weekly from mid-March until mid-May. Fireblight severity was rated on May19, 1997 and May 9, 1998 on a scale of 1 to 5 with 1 = no disease, 2 = one or a few diseased branch tips, 3 = numerous diseased branch tips with a few major branches killed, 4 = major portion of tree killed, and 5 = tree killed.

RESULTS

None of the treatments evaluated prevented the development of fireblight on crabapple. Of the six treatments, only Agrimycin 17 reduced the severity of fireblight in 1997 and 1998 as compared with the unsprayed control (see table). Damage on the Agrimycin 17-treated trees was limited to the blighting of scattered bloom clusters and shoot tips. In 1997, the dormant treatment of Kocide 101 77W failed to reduce the level of blighting below that on the unsprayed control. In 1998, Kocide 101 provided fireblight control equal to that given by Agrimycin 17. In 1997 and 1998, damage to both the unsprayed controls and the crabapples treated with Fluazinam 500F, Aliette WDG, and Phyton 27 was similar with symptoms that included considerable blighting of the flower clusters and shoot tips as well as the dieback of some lateral and scaffold limbs.

While none of the bactericides gave complete protection, Agrimycin 17 provided the most effective and consistent control of fireblight on crabapple. A dormant spray of Kocide 101 77W was as effective in controlling fireblight as Agrimycin 17 in one year while the other registered bactericides, Aliette WDG and Phyton 27, failed to reduce the disease severity in this study.

CHEMICAL CONTROL OF FIREBLIGHT ON CRABAPPLE 'SNOWDRIFT'

Treatment and rate per 100 gal.	Fireblight severity[1] 1997	1998
Agrimycin 17 0.5 lb.	1.5	1.5
Fluazinam 500F 12 fl. oz.	2.4	2.3
Aliette WDG 2 .0 lb.	2.7	2.9
Phyton 27 12.5 fl. oz.	2.8	2.5
Kocide 101 77W 12.0 lb.	2.3	1.8
Untreated control	2.6	2.4

[1]Fireblight severity was assessed on a scale of 1-5 where 1 = no disease, 2 = one or a few diseased branch tips, 3 = numerous diseased branch tips with a few major branches killed, 4 = major portion of tree killed, 5 = tree dead.

Comparison of Drenches and Directed Sprays of Heritage for Control of Phytophthora Shoot Blight of Annual Vinca

Austin K. Hagan and J. Randall Akridge

Heritage 50W, a product of Zeneca Inc. is the first representative of a new class of fungicides called strobilurins to be marketed in world. Activity against a broad spectrum of disease-causing fungi, including members of the water molds, is the most unique characteristic of this systemic fungicide. Due to a very favorable toxicology package, EPA has 'fast-tracked' the registration of the active ingredient (azosystrobin) in this fungicide on a variety of food crops as well as turfgrasses. Heritage 50W, which is currently registered only for use on turf, has quickly become the fungicide of choice of Alabama golf course superintendents for the prevention of Pythium blight and brown patch on bentgrass tees and greens. The effectiveness of Heritage 50W for controlling foliar and soilborne diseases on woody and herbaceous landscape crops has, however, not been extensively investigated.

Phytophthora shoot blight, a devastating disease in landscape plantings of annual vinca, has proven difficult to control with fungicides. When applied at 2-week intervals, Aliette WDG alone or in combination with Fore 80W has proven effective in some trials in Alabama and Florida but not in others in controlling this disease.

In an AAES study, the impact of fungicide placement, application rate, and treatment interval on the efficacy of Heritage 50W for the preventative control of Phytophthora shoot blight on annual vinca was assessed. Best disease control was provided by bimonthly directed applications of Heritage 50W at rates of 0.6 and 1.2 pounds per 100 gallons of spray volume.

METHODS

On May 29, 1998, annual vinca 'Tropical Rose' were planted on raised beds in a square on 1-foot centers on the Brewton Experiment Field in Escambia County, Alabama. Just before planting, 13-13-13 fertilizer at a rate of approximately 400 pounds per treated acre was broadcast over the beds and incorporated. Throughout the growing season, calcium nitrate at the rate of 10 pounds per acre was applied at 2-week intervals via the drip irrigation system. Two rates of Heritage 50W were applied as a soil drench and directed spray to the plants at 2- and 4-week intervals. Aliette SDG, which was applied at 1.1 pounds per 100 gallons of spray volume on a 4-week schedule, was included as a standard treatment. Fungicide treatments were applied from June 1 at the intervals specified in the table until August 24, 1998. Plant survival was rated on June 23, July 17, and August 5, 1998.

RESULTS

In 1998, unusually hot and dry weather patterns in June and much of July suppressed the onset and spread of Phytophthora shoot blight on annual vinca. At the first rating date, plant survival in nearly all plots was at or just below 100% (see table). When more seasonal rainfall and temperature patterns resumed in late July, shoot dieback symptoms typically associated with this disease became much more noticeable and stand thinning became noticeable. By early August, considerable differences in plant survival were noted between the fungicide treatments.

Selected directed sprays and soil drenches of Heritage 50W greatly improved the survival of 'Tropical Rose' annual vinca as compared with the non-treated control and Aliette WDG standard (see table). Overall, the directed sprays generally were more effective in controlling Phytophthora shoot blight than were the drench treatments. Equally effective control of Phytophthora shoot blight was obtained with directed sprays of the 0.6 and 1.2 pound per 100-gallon rates of Heritage 50W applied at 2-week intervals. On a 4-week treatment schedule, directed sprays of the 1.2 pound rate of Heritage 50W gave much better disease control as compared with the lower 0.6 pound per acre rate. The highest level of plant survival with drenches of

SURVIVAL RATE OF ANNUAL VINCA AS AFFECTED BY FUNGICIDE RATE, PLACEMENT, AND SPRAY INTERVAL

Fungicide and rate	Placement	Spray interval[1]	% Plant survival June 23	July 17	August 5
Heritage 50W 0.4 oz./1000 sq. ft.	Drench	2	100	100	70
Heritage 50W 0.4 oz./1000 sq. ft.	Drench	4	100	85	30
Heritage 50W 0.7 oz./1000 sq. ft.	Drench	2	100	100	75
Heritage 50W 0.7 oz./1000 sq. ft.	Drench	4	100	75	45
Heritage 50W 0.6 lb./100 gal.	Dir. sp.[2]	2	100	100	90
Heritage 50W 0.6 lb./100 gal.	Dir. sp.	4	100	100	35
Heritage 50W 1.2 lb./100 gal.	Dir. sp.	2	95	90	85
Heritage 50W 1.2 lb./100 gal.	Dir. sp.	4	100	95	70
Aliette WDG 1.1 lb./100 gal.	Dir. sp.	4	100	65	0
Untreated control	–	–	90	90	10

[1] Spray interval in weeks.
[2] Dir. sp. = directed spray.

Heritage 50W was obtained with both rates when applied on a 2-week spray schedule. Disease control at the 4-week treatment interval as indicated by survival rates of 30 and 45% for drenches of the low and high rates, respectively, was very poor.

Overall, Heritage 50W demonstrated good activity against Phytophthora shoot blight on annual vinca. Directed sprays of Heritage 50W at both rates when applied at 2-week intervals provided the most effective preventative control of Phytophthora shoot blight. Drench treatments applied on the same 2-week schedule proved somewhat less effective than directed sprays. When applied as a directed spray or soil drench at monthly intervals, Heritage 50W generally failed to control Phytophthora shoot blight on annual vinca.

Preemergence-applied Herbicides for Liriope

Christine K. Hayes, Charles H. Gilliam, Gary J. Keever, John W. Olive, and D. Joseph Eakes

Liriope is a herbaceous perennial commonly propagated by division. A current nursery practice (Flowerwood Nursery, Loxley, Alabama) is to delay herbicide application until 2 to 4 weeks after division. While these newly divided liners are in the nursery, weed infestation commonly occurs, resulting in the need for extensive hand weeding before preemergence herbicides are applied. Delayed application of preemergence herbicides is based on concerns that root suppression will occur with use of dinitroaniline (DNA) herbicides and that foliar injury will result following applications of non-DNA herbicides. The primary mode of action of DNA herbicides is through root suppression, but these herbicides have a low solubility, reducing their movement in the root zone.

Most of the preemergence herbicides used in nursery and landscape crop production are DNA herbicides or contain a DNA component. The objective of our study was to evaluate several preemergent herbicides for injury and root growth suppression of *Liriope muscari* 'Big Blue' immediately after division and potting.

METHODS

On April 22, 1997 'Big Blue' liriope was divided, and single bibs were planted in Lerio 3.25-inch SR 325 pots at the Paterson Greenhouse Complex, Auburn, Alabama. Shoots were not cut back and roots were pruned to 3 inches. Bibs were potted in a pinebark:sand (6:1 by volume) medium. Each cubic yard of this medium was amended with 10 pounds 18-6-12 Osmocote (Scotts Co.), 5 pounds dolomitic lime, and 1.5 pounds Micromax (Scotts Co.).

On April 24, 1997, 2 days after division, herbicides were applied (herbicides and rates are found in Table 1). Following treatment, containers were placed on a gravel bed in full sun and irrigated as needed with overhead irrigation. Experiment 2 was similar to experiment 1 with

TABLE 1. ROOT RATING, FOLIAR RATING, AND BIB NUMBER PER CONTAINER OF NEWLY DIVIDED LIRIOPE TREATED WITH 15 PREEMERGENT HERBICIDES, EXPERIMENT 1

Herbicide	Rate (lb ai/a)	—Root rating[1]— 60 DAT[3]	90 DAT	——Foliar rating[2]—— 30 DAT	60 DAT	90 DAT	—Bib number— 60 DAT	90 DAT
Ronstar 2G AG	4.0	1.8	3.0	2.1	1.8	1.5	2.9	4.5
Regal O-O	3.0	1.9	3.1	2.4	1.9	1.5	2.3	4.0
OH-2 3G	3.0	2.0	3.4	2.3	1.8	1.4	2.5	4.7
Kade G	1.0	1.9	2.9	1.7	1.9	1.6	2.6	4.5
Snapshot 2.5 TG	4.0	2.0	3.8	1.9	1.8	1.5	2.7	4.6
Pendulum 2G	3.0	2.2	3.6	1.9	1.5	1.3	3.3	5.6
Star II	2.4	2.0	3.3	2.0	1.9	1.4	2.2	4.8
Factor 65 WDG	1.0	1.8	3.1	2.0	1.7	1.4	2.4	4.4
Pen. 60 WDG	3.0	1.8	3.3	1.8	1.7	1.5	2.5	4.5
Surflan 4AS	3.0	1.3	2.3	1.7	1.5	1.8	1.9	3.2
Predict	3.0	1.6	3.1	2.6	2.7	2.3	2.9	4.3
Gallery	1.0	1.8	3.2	1.8	1.9	1.5	2.2	4.9
Image	0.5	1.7	3.3	2.0	1.8	1.8	2.8	5.2
Surflan + Gallery	3.0 + 1.0	1.3	2.6	2.0	2.0	1.5	2.0	3.8
Ronstar 2G	4.0	2.0	3.8	2.1	1.7	1.6	3.2	4.9
Control		1.9	3.5	1.9	1.7	1.25	2.9	4.8

[1] Root rating scale of 1 - 5 based on percent root coverage at the substrate-container interface where 1 = 0% root coverage, 2 = 25% root coverage, 3 = 50% root coverage, 4 = 75% root coverage, and 5 = 100% root coverage.
[2] Foliar rating based on a scale of 1 - 5 where 1 = no injury, 3 = moderate injury, and 5 = dead plant.
[3] DAT = days after treatment.

the following exceptions: liriope was divided on July 1, 1997 and treated on July 3, 1997.

RESULTS

EXPERIMENT 1. In experiment 1, root ratings of plants treated with granular-applied preemergent herbicides were similar to those of non-treated controls at both 60 and 90 DAT with the exception of plants treated with Regal Kade at 90 DAT. These plants exhibited a slightly lower root rating than control plants (Table 1). Liriope treated with Surflan or Surflan + Gallery exhibited suppressed root ratings at both 60 and 90 DAT when compared to non-treated controls. At both 60 and 90 DAT liriope treated with Gallery alone had similar root ratings to non-treated liriope, indicating root growth inhibition was caused by Surflan. When evaluating new shoot number (bibs), Surflan treated plants had the lowest number of new shoots at 60 and 90 DAT, with 34% and 33% fewer shoots, respectively, than non-treated control plants. Plants treated with Predict exhibited bleached foliage at 30, 60, and 90 DAT with some bleaching on new growth at 90 DAT. Plants treated with Regal O-O had a higher foliar rating at 30 DAT, but not 60 or 90 DAT, than did control plants.

AT 90 DAT, plants treated with Surflan, Image, or Predict had greater phytotoxicity ratings than untreated control plants. Injury to plants treated with Image or Predict was characterized by bleached spots or bands on the old and new foliage.

EXPERIMENT 2. Data from experiment 2 generally agreed with that of the first experiment in that granular herbicides had root ratings similar to non-treated control plants (Table 2). Plants treated with Regal O-O at 90 DAT were the only plants treated with granular herbicides to exhibit root ratings slightly lower than non-treated control plants. Again, plants treated with Surflan or Surflan + Gallery had lower root ratings than non-treated control plants at 30, 60, and 90 DAT. Image-treated plants had lower root ratings at 30 and 90 DAT than non-treated control plants.

Phytotoxicity ratings were generally higher in experiment 2 than in experiment 1. Plants in the second study were in a softer stage of growth when divided, possibly accounting for more injury from herbicides. Also, higher temperatures in July compared to April may have contributed to greater injury. As in experiment 1, Predict-treated plants exhibited bands of bleached foliage and had higher phytotoxicity ratings than control plants at 30 and 90 DAT. Regal O-O and OH-2, which both contain oxyfluorfen, caused foliar damage later in the study (60 and 90 DAT).

Results of these tests showed root or shoot growth of 'Big Blue' liriope was not affected by most granular herbicides when they were applied immediately after division. Surflan consistently suppressed root growth, while Predict-treated plants exhibited bleached foliage on old and new growth. All other spray-applied herbicides were safe when applied to 'Big Blue' liriope immediately after division.

TABLE 2. ROOT RATING AND FOLIAR RATING OF NEWLY DIVIDED LIRIOPE TREATED WITH 15 PREEMERGENT HERBICIDES, EXPERIMENT 2

Herbicide	Rate (lb ai/a)	Root rating[1] 30 DAT[3]	Root rating[1] 60 DAT	Root rating[1] 90 DAT	Foliar rating[2] 30 DAT	Foliar rating[2] 60 DAT	Foliar rating[2] 90 DAT
Ronstar 2G AG	4.0	1.5	3.1	3.7	1.5	1.3	1.7
Regal O-O	3.0	1.5	2.8	3.2	1.9	1.8	2.8
OH-2 3G	3.0	1.5	3.3	4.0	1.8	1.8	2.3
Kade G	1.0	1.5	2.6	3.6	1.8	1.3	1.8
Snapshot 2.5 TG	4.0	1.6	3.3	3.7	1.6	1.4	1.4
Pendulum 2G	3.0	1.5	3.2	3.8	1.5	1.2	1.8
Star II	2.4	1.5	3.1	3.8	1.5	1.6	1.8
Factor 65 WDG	1.0	1.6	3.2	3.8	1.3	1.2	1.6
Pendulum 60 WDG	3.0	1.5	3.5	4.0	1.7	1.3	1.5
Surflan 4AS	3.0	1.3	2.0	3.2	1.6	1.4	1.7
Predict	3.0	1.4	3.3	3.8	2.3	1.6	1.8
Gallery	1.0	1.5	3.3	4.0	1.6	1.2	1.5
Image	0.5	1.2	2.9	3.1	1.8	1.3	1.7
Surflan + Gallery	3.0 + 1.0	1.2	1.9	2.6	1.5	1.3	1.3
Ronstar 2G	4.0	1.5	3.2	3.7	1.6	1.3	1.7
Control		1.4	3.2	4.1	1.3	1.2	1.3

[1] Root rating scale of 1 - 5 based on percent root coverage at the substrate-container interface where 1 = 0% root coverage, 2 = 25% root coverage, 3 = 50% root coverage, 4 = 75% root coverage, and 5 = 100% root coverage.
[2] Foliar rating based on a rating scale of 1 - 5 where 1 = no injury, 3 = moderate injury, and 5 = dead plant.
[3] DAT = days after treatment.

Herbicide Adsorption and Release Properties of Five Ronstar-coated Fertilizers

Kevin R. Keel, James E. Altland, Charles H. Gilliam, Glenn R. Wehtje, Tim L. Grey, Gary J. Keever, and D. Joseph Eakes

In nursery crop production, herbicides are typically broadcast over the top of containers three or four times annually. Broadcast application results in up to 86% herbicide loss depending on plant size, habit, and container spacing. Recent reports have found elevated herbicide levels in nursery runoff water, suggesting that non-target herbicide losses may be a source of contamination for local drinking water supplies and surrounding bodies of water. Therefore, alternatives to broadcast application are needed to reduce potential problems with herbicides in nursery runoff water.

Several approaches have been evaluated to reduce herbicide loss from container-grown nursery crops, including containment ponds. This study concluded that herbicides did not accumulate in either pond sediment or water due to herbicide degradation in the containment pond. Another approach to reducing non-target herbicide loss is slow release tablets impregnated with herbicide; however, low water solubility resulted in insufficient weed control. This limitation can be partially overcome by adding a surfactant to the herbicide. More recently, several controlled-release fertilizers (CRFs) coated with Ronstar were evaluated for weed control. This technique used about 80% less herbicide than traditional broadcast applications. Weed control differed among the Ronstar-coated CRFs, suggesting that characteristics of the fertilizer influence herbicide activity.

The objective of this research was to determine Ronstar leaching rates from Ronstar-coated fertilizers and to evaluate factors affecting leaching rates. Additionally, we sought to determine if applying either a sticker or an oil to Ronstar-coated Osmocote would enhance uniformity of Ronstar leaching.

METHODS

EXPERIMENT 1. Five commonly used CRFs were evaluated: Meister 24-4-7 (Helena Chemical Co., Memphis, Tennessee), Nursery Special 12-6-6 (Pursell Industries, Sylacauga, Alabama), Polyon 24-4-12 (Pursell Industries), Osmocote 17-7-12 (Scotts Co., Marysville, Ohio), and Nutricote 20-7-10 (Florikan E.S.A. Corp., Sarasoto, Florida). Glass beads, 0.16 inches (4mm) in diameter were also coated with Ronstar to serve as a nonabsorbent control. Fertilizers were coated with commercially-formulated Ronstar (Ronstar 50WP) supplemented with sufficient radioactive Ronstar to facilitate detection. An aqueous solution of 5.0 mg ai/ml was prepared using both formulated and radioactive Ronstar. This solution (0.0164 ounces (492 microliters)) was applied to 20 grams (0.044 pounds) of each fertilizer, and allowed to air dry for 48 hours. The resulting concentration of Ronstar to fertilizer was 0.12mg ai/g.

Twenty grams (0.044 lb) of each Ronstar-coated fertilizer was placed into separatory funnels and 0.7 ounces (20 ml) of water was added, slightly covering the fertilizer. After 30 minutes, water was allowed to drain into a 4.2 ounce (125 ml) flask for 10 minutes. Leachate volume was measured and 0.03 ounce (1 ml) subsamples were assayed for radioactivity using liquid scintillation spectrometry. This procedure was repeated daily for 14 days. The amount of Ronstar in each leaching was determined by multiplying the amount of radioactivity in the 0.03 ounce (1 ml) subsample by the volume of leachate collected. The entire experiment was repeated twice. The number of leaching events required to remove 70 to 80% of the total applied Ronstar was determined (see table).

EXPERIMENT 2. Osmocote 17-7-12 was coated with Ronstar as previously described. The Ronstar-coated Osmocote was then coated with 0.0067 ounces (200 microliters) of either Complex (sticker; Riverside/Terra Corp. Sioux City, Iowa), Plex (sticker; Riverside/Terra Corp.), Prime Oil (Riverside/Terra Corp.), or Intac (Loveland Industries Inc., Greely, Colorado). Ronstar-coated Osmocote alone and Ronstar-coated Polyon alone were also included as control treatments. The 14-day leaching and Ronstar detection procedures were as previously described.

RESULTS

RONSTAR RELEASE RATES, EXPERIMENT 1. After one leaching, radioactive Ronstar recovered from glass beads and Nutricote exceeded 50% of the total Ronstar applied. Meister and Osmocote released 44% and 35%, respectively. Nursery Special (30%) and Polyon (22%) released the lowest percentages with the first leaching. With the third leaching, 18% of total applied Ronstar was recovered from Ronstar-coated Polyon while less than 10% was recovered from the glass beads or the other fertilizers. After three leaching events, 70-80% of the total Ronstar applied during the study was recovered from Meister, Osmocote, and Nutricote fertilizers, while 56% was recovered from Polyon. After the fifth leaching, Ronstar-coated Polyon consistently leached the highest level of Ronstar. For example, total Ronstar recovered at the seventh leaching event was less than 2.0% from Meister, Nutricote or Osmocote compared to 5.1% for Polyon. Polyon required about three times the number of leaching events to remove 70% of the applied Ronstar compared to Nutricote and Osmocote fertilizer (see table). The number of leaching events required to remove 70% of the Ronstar from Nursery Special was similar to Polyon. This would be expected since Nursery Special contains Polyon prils. Polyon and Nursery Special also required the most leaching events to remove 90% of the applied Ronstar (see table). In previous work, Ronstar-coated Polyon and Nursery Special fertilizers were more effective in controlling weeds than Osmocote. This enhanced weed control obtained in the field likely resulted from the extended release of herbicide from Polyon.

Number of Leachings Required to Remove 70% and 90% of Applied Ronstar

Fertilizer	Formulation	70%	90%
Osmocote	17-7-12	2.2	5.1
Nutricote	20-7-10	1.9	4.0
Meister	24-4-7	3.8	7.5
Nursery special	12-6-6	5.8	10.4
Polyon	24-4-12	6.3	11.3
Glass beads	—	4.8	8.8

RONSTAR LEACHING RATES, EXPERIMENT 2. The control treatments of Ronstar-coated Osmocote and Polyon alone resulted in leaching patterns similar to those in the first experiment. In the first leaching, 85% of the applied Ronstar was recovered from Osmocote, while only 24% was leached from Polyon. After the third leaching, Ronstar residue on Osmocote was essentially depleted as evident by less than 1% recovery from the remaining 11 leaching events. Ronstar recovery from Polyon ranged from 20-25% during each of the first three leaching events and was consistently higher than Osmocote throughout the duration of the study, except on day 1. When Plex was added to the Ronstar-coated Osmocote fertilizer, Ronstar recovery was similar to that for Ronstar-coated Osmocote alone. However, Prime Oil plus Ronstar-coated Osmocote fertilizer reduced Ronstar recovery compared to Ronstar-coated Osmocote alone. With the first leaching, 16% of the applied Ronstar was recovered from the Prime Oil plus Ronstar-coated Osmocote followed by recovery rates between 7% and 10% through the sixth leaching event. About 5% was recovered in the seventh through eleventh leaching events. When Intac or Complex was coated onto Ronstar-coated Osmocote, Ronstar recovery was similar to the pattern obtained with Prime Oil.

SURFACE CHARACTERISTICS OF FERTILIZERS. Polyon surface area was 23% greater than the fertilizer with the next largest surface area. The greater surface area of Polyon may contribute to its slow release and superior weed control properties. When these smaller prils are spread evenly over the container medium surface, a more even herbicide distribution is obtained relative to a fertilizer with larger prils. This conclusion is supported by previous work with herbicide tablets that showed definite circular rings of weed control around the tablets. Finally, assuming equal volumes of water from daily irrigation, greater fertilizer surface area may aid in retaining the herbicide against possible leaching, assuming adsorption is related to physical characteristics.

The surface of Polyon underwent apparent surface erosion over the 14 leaching events. Initial roughness of Polyon changed to a smoother more uniform appearance after leaching (data not shown). This suggests loss of the fertilizer coating, which would result in herbicide release. The surface structure of the other fertilizers appeared similar before and after the 14 leachings.

Superior weed control obtained with Ronstar-coated Polyon in previous work may be attributed to its ability to release the herbicide over a longer period of time compared to the other control release fertilizers tested. This improved weed control may result from either more uniform distribution over the substrate surface, or erosion of Polyon's surface. The addition of Intac, Prime Oil, or Complex to Ronstar-coated Osmocote altered the Ronstar recovery rate to a rate similar to that obtained with Ronstar-coated Polyon. Thus, superior weed control obtained with Ronstar-coated Polyon in previous work should be available with Ronstar-coated Osmocote with the addition of one of the successful additives. These data may provide future options to the nursery industry for reducing non-target herbicide loss while maintaining effective weed control.

Control of Tea Scale on 'Pink Snow' Camellia Using Root-absorbing Systemic Insecticides

Charles P. Hesselein, Joseph R. Chamberlin, and Michael L. Williams

Tea scale (*Fiorinia theae*) (Photo 16, page 36) is probably the most common and damaging pest of camellias and dwarf burford hollies as well as a pest of many other ornamental and fruiting crops. Controlling tea scale can be a problem because of the difficulty in contacting them with insecticide sprays. Factors which make spray contact difficult include tea scale's habit of heavily colonizing the undersides of older foliage, the cottony, waxy coating exuded by the male insects, the armored cover over the female's body which protects both her and her eggs, and nursery cultural practices which promote thick, difficult-to-penetrate plant canopies. In addition, this insect's non-synchronous, year-round life cycle makes targeting the vulnerable crawler stage with one or two sprays impossible. Media applied, root absorbing systemic insecticides may be one way of overcoming the obstacles to insect/insecticide contact. The objective of our test was to evaluate four media-applied systemic insecticides (Figure 1): four rates of Pinpoint 15G, Orthene TTO (OTTO) 75 SP (applied as a drench), Marathon 1G, and Marathon 60 WP (applied as a drench).

METHODS

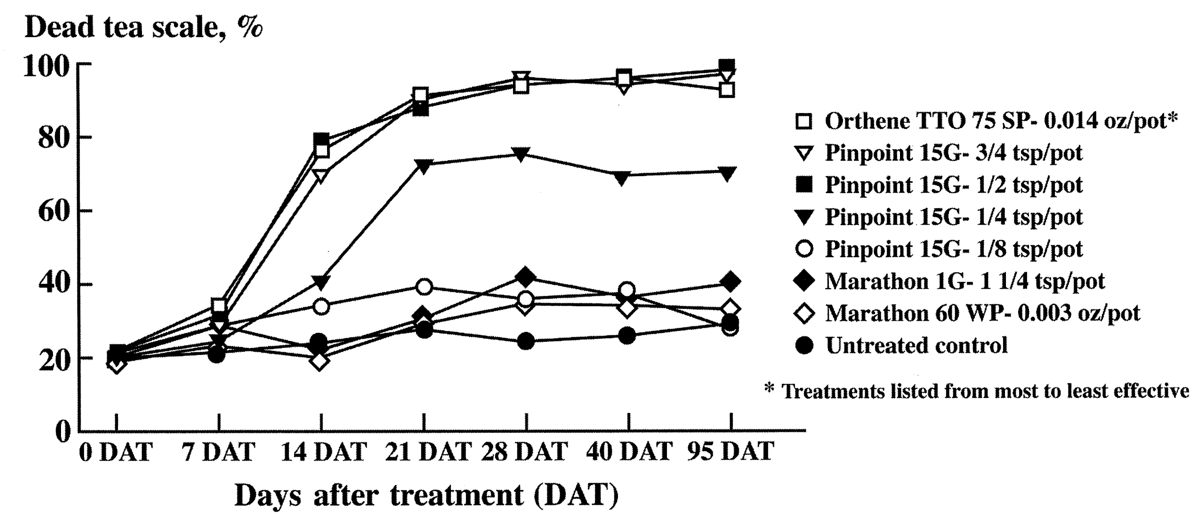
'Pink Snow' camellias (*Camellia sasanqua* 'Pink Snow') potted in a pine bark based medium in trade gallon containers were utilized for this study. The tea scale infested plants were obtained from a local nursery and were well established in their containers. Plants were treated on October 9, 1998 and the last data were collected on January 12, 1999 (95 DAT). To minimize insecticide loss through leaching, all treatments were applied or watered in with 4 ounces of water and plants were not irrigated for 24 hours following treatment. Plants were maintained under shade and irrigated as needed by overhead impact sprinklers throughout the course of the study.

RESULTS

No differences among treatments were detected until 14 DAT (Figure 1). The most effective treatments from 14 DAT through the conclusion of the trial were Pinpoint 15G at 0.5 and 0.75 teaspoon per pot and OTTO 75 SP treatments.The percentage dead adult female scale insects during the trial for the untreated control ranged from 20-29% while the percentage dead adult female scale insects in the most effective treatments ranged from 79% at 14 DAT to 98% at 95 DAT. The 0.25 teaspoon per pot Pinpoint 15G treatment also demonstrated some efficacy but was not as effective as the 0.5 and 0.75 teaspoon per pot Pinpoint 15G and OTTO 75 SP treatments. The two Marathon treatments and 0.125 (1/8) teaspoon per pot Pinpoint 15G proved ineffective for controlling tea scale.

Nursery producers have a difficult time controlling tea scale with conventional high volume insecticide sprays. This test demonstrates that even the low label rate of Pinpoint 15G (0.5 teaspoon) provides greater than 90% control of this insect.

Figure 1. Treatment-related death of adult tea scale insects.



An Evaluation of Selected Miticides for Control of Two-spotted Spider Mites on Marigolds

Charles P. Hesselein, Joseph R. Chamberlin, and Michael L. Williams

Two-spotted spider mites (*Tetranychus urticae*) are one of the most common and destructive arthropod pests encountered in the nursery and landscape industry. These tiny pests have a large host range, multiply very rapidly, and are notorious for developing miticide-resistant populations. One of the strategies for combating pesticide resistance is utilizing more than one chemical class (i.e., mode of action) in a pesticide spray rotation. The purpose of these studies was to determine the effectiveness of several miticides with the ultimate goal of helping growers make intelligent pesticide choices when determining mite control strategies.

METHODS

Two experiments were conducted testing six distinct active ingredients and a combination of two active ingredients (see table). Trade gallon 'Excel Primrose' marigolds (*Tagetes erecta*) were grown in the greenhouse at the Ornamental Horticulture Station in Mobile, infested with two spotted spider mites and treated 9 and 7 days later for experiments 1 and 2, respectively. To minimize insecticide loss, Orthene TTO and Pinpoint 15G treatments were applied or watered in with 4 fluid ounces of water and plants were not irrigated for 24 hours following treatment. All other treatments were sprayed with a hand-held sprayer until runoff.

RESULTS

EXPERIMENT 1. All rates of the tested miticides were somewhat to very effective for controlling two-spotted spider mites when compared to untreated plants (Figure 1 and Photo 17, page 36). The only exception to this occurred on the first sample date (6 days after treatment) where the 0.0013 and 0.0026 ounce per pot drenches of Orthene TTO were not yet effective. After 13 days all treatments had some efficacy compared to the untreated control. Drenches of 0.0026 and 0.0053 ounce per pot Orthene TTO, Pinpoint 15 G, Target Spray Oil, Hexygon, Avid, and Hexygon per Avid tank mix were the most effective treatments. By 34 DAT, mite populations from the untreated control plants appeared to be contaminating treated plants.

On sample dates 27 and 34 DAT, phytotoxicity was noted on treatments containing acephate (Orthene TTO 75 SP and Pinpoint 15 G). Phytotoxic symptoms consisted of marginal leaf necrosis (Photo 18, page 36).

EXPERIMENT 2. All treatments effectively controlled mites when compared to the untreated control (Figure 2).

The results of these tests indicate that growers have several excellent and unique miticides to use in their mite management programs. The use of two or more chemical classes in a miticide rotation should help prevent or delay the development of miticide resistance.

Testing a few plants for phytotoxicity prior to the widespread use of these or any unfamiliar pesticide is advisable, especially when the treated crop is not specified on the label. Always read and follow label instructions before using any pesticide.

Miticides Used For Control of Two-Spotted Spider Mites on 'Excel Primrose' Marigolds

Treatment	Rate	Active ingredient	Chemical class
Miticides used in experiment 1			
Untreated control	—	—	—
Orthene TTO 75 SP drench	0.0013 ounce per pot	acephate	organophosphate
Orthene TTO 75 SP drench	0.0026 ounce per pot	acephate	organophosphate
Orthene TTO 75 SP drench	0.0053 ounce per pot	acephate	organophosphate
Pinpoint 15G	0.026 ounce per pot	acephate	organophosphate
Target Spray Oil	1 gallon per 100 gallons	Petroleum oil	horticultural oil
Hexygon	1.5 ounces per 100 gallons	hexythiazox	thiazolidinone
Avid	4 fluid ounces per 100 gallons	abamectin	macrocyclic lactone
Hexygon per Avid tank mix			
Hexygon	1.5 ounces per 100 gallons	hexythiazox	thiazolidinone
Avid	4 fluid ounces per 100 gallons	abamectin	macrocyclic lactone
Miticides used in experiment 2			
Control	—	—	—
AC 303,630 (Pylon)	3 ounces per 100 gallons	chlorfenapyr	pyrrole
Sanmite	3 ounces per 100 gallons	pyridaben	pyridazinone

Figure 1. Miticide efficacy of pesticides evaluated in experiment 1.

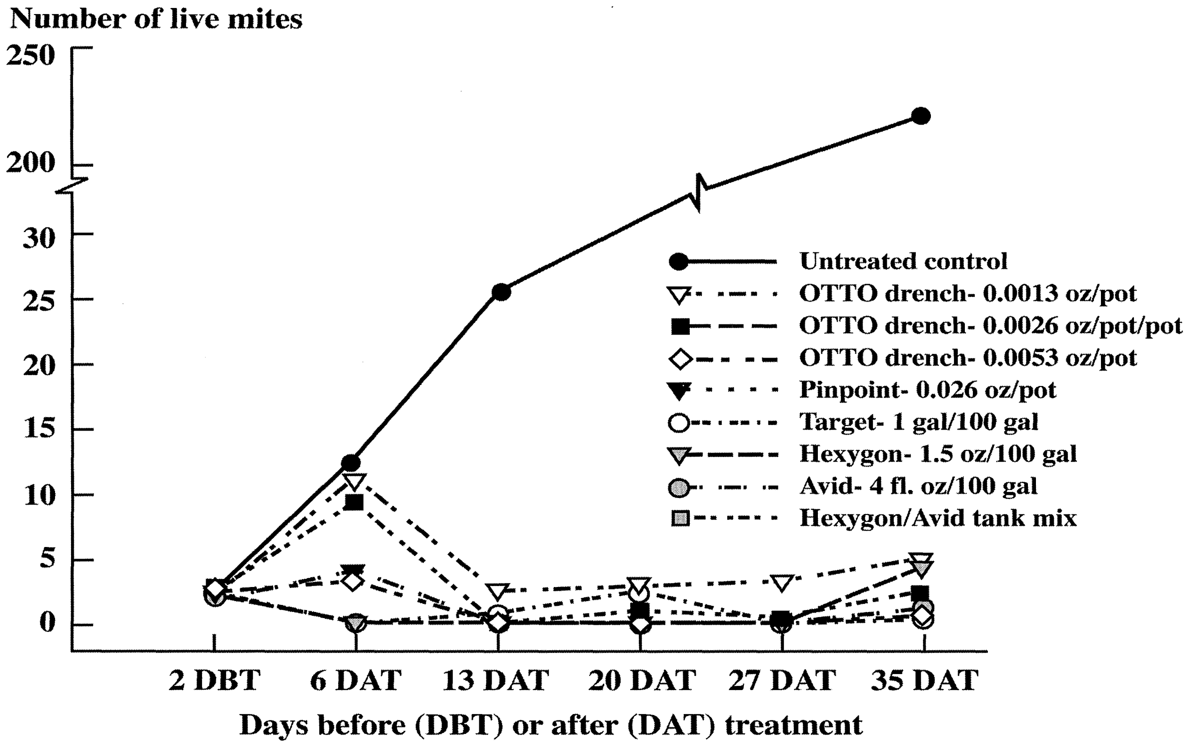
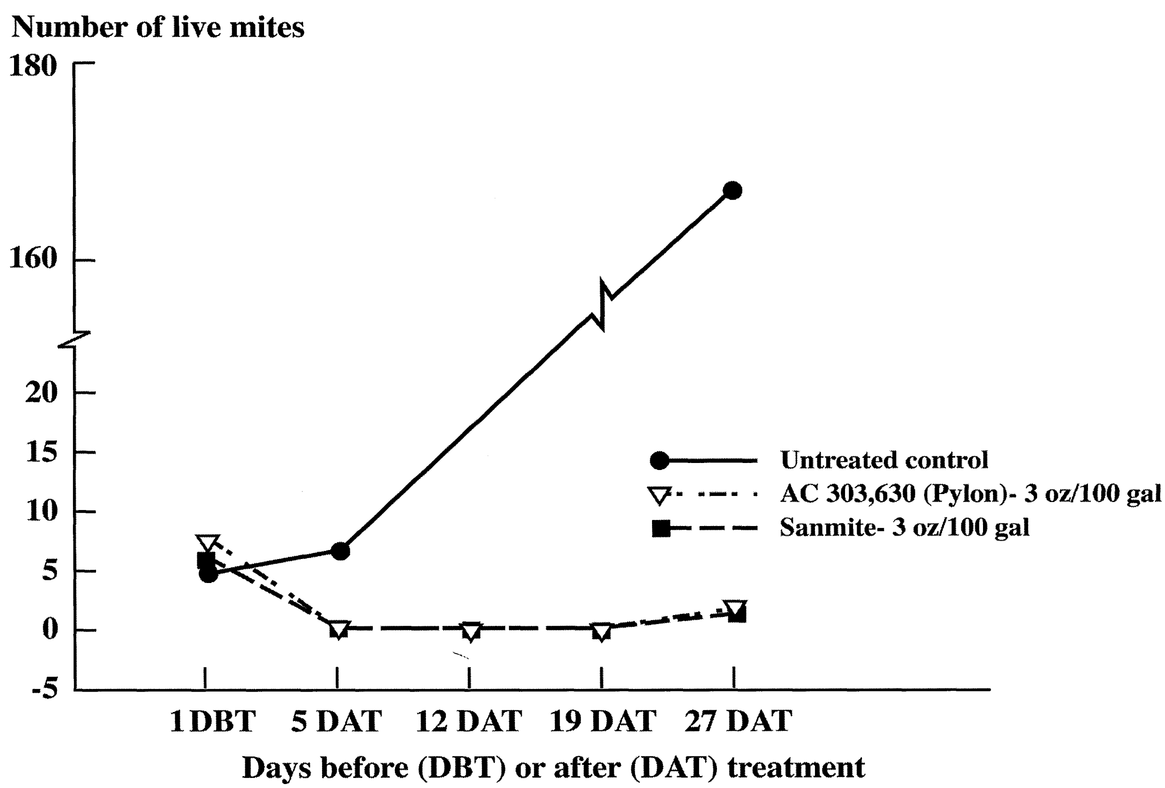


Figure 2. Miticide efficacy of pesticides evaluated in experiment 2.



Outdoor Labeled Miticide Evaluation for Control of Southern Red Mite

J.C. Stephenson

Mites continue to be one of the major pest groups on ornamental crops. Chemicals remain the preferred method of control in nursery situations. Due to the ornamental horticulture industry being minor in comparison to other areas of agriculture in the pesticide market, new materials are slow to be developed. This along with a reluctance of companies to re-register current products makes chemical control challenging.

The Southern Red Mite, *Oligonychus ilicius*, is a common pest on ericaceous plants, primarily azaleas, and camellias. This mite occurs in greatest abundance during the cooler months of the year. Feeding produces a bronze or brownish plant appearance followed by leaf drop, which is more pronounced with cooler temperatures.

METHODS

This efficacy test was a recommended rate evaluation of foliar-applied miticides with a current outdoor nursery label. Infested Robin Hill 'Redmond' azaleas growing in trade gallon containers with an amended pine bark-peat moss medium were used in this study. Treatments consisted of a single foliar-applied spray to all leaf surfaces to the point of runoff with the materials and rates listed in the table. Plants were grown in full sun and irrigated with overhead impact sprinklers as needed. Live mite counts were recorded at 7, 14, and 28 days after treatment (DAT). Eggs were not counted. A Llanfair Orchard Leaf Brushing Machine was used to brush mites from three, 4-inch terminal shoots per plant onto a biocular microscope counting disc with grid.

Live Mite Counts from Brushed Azalea Terminal Shoots

Treatment[1]	Rate/ 100 gal	Live mites/ terminal shoots[2]		
		7 DAT	14 DAT	28 DAT
Kelthane T/O	16 oz	25.5	47.5	43.3
Sunspray 6E	128 fl oz	20.0	51.0	50.5
Orthene TTO 75SP	10.7 oz	60.3	109.3	30.3
Tame 2.4EC	16 fl oz	64.5	106.5	42.3
Avid 0.15EC	4 fl oz	61.5	97.5	60.8
Hexygon 50WP	2 oz	28.0	8.8	4.3
Talstar F	38.4 fl oz	44.5	88.3	69.0
Untreated	—	87.5	125.5	50.8

[1]Treatment application March 24, 1998.
[2]Mite counts are a mean of four plants.

RESULTS

At 7 DAT, plants treated with Hexygon 50WP, Kelthane T/O, Sunspray 6E, or Talstar F had fewer mites than the untreated check. At 14 DAT, similar trends were observed, except Talstar F failed to provide significant control. Plants treated with Hexygon 50WP, an ovacide/ larvicide, had considerably lower mite numbers than any other treatment. At the last evaluation (28 DAT), Hexygon 50WP was the only chemical to provide significant control. Mites counted at this time on plants treated with Hexagon 50WP were almost all adult females.

In summary, this test indicates that a single application of the miticides tested is not sufficient to eradicate a preexisting infestation of Southern Red Mites. Kelthane T/O, Sunspray 6E, and Hexygon 50WP appear to be the most effective treatments with Hexygon 50WP providing the longest control.

WOODY ORNAMENTALS

Effects of Primo on Selected Bedding and Woody Landscape Plants

Gary J. Keever and John W. Olive

Height control of bedding plants and development of good form in woody landscape plants during production are essential to obtaining quality products. In this study, Primo (cimectacarb), a growth retardant labeled for warm- and cool-season turfgrasses, provided acceptable growth suppression in most species tested; however, phytotoxic symptoms which developed on all bedding plant species and two of four woody landscape species, resulted in unacceptable quality. Based on these results, the use of Primo as an alternative to other chemical growth retardants in the production of herbaceous and woody landscape plants is not recommended. Additionally, concentrations of Primo applied to species in this study are similar to those recommended for turfgrasses; this raises the concern of potential injury to herbaceous and woody plants in the landscape from drift or overspray when Primo is applied to turfgrasses.

METHODS

In the first experiment, plants of 'Celebrity Lilac' petunia, 'Accent Deep Pink' coleus, 'Goldcrest' cosmos, 'Accent Deep Pink' impatiens, 'Pinkie' periwinkle and 'Bronze Yellow' French marigold in 32-cell flats were treated with single foliar sprays of Primo at 0, 1, 10, 100, 500, or 1,000 parts per million active ingredient (ppm ai). A second experiment evaluated the response of four woody landscape plants to Primo. Single foliar sprays of Primo at 0, 500, 1,000, 1,500, 2,000, 2,500, and 3,000 ppm were applied to 'Nellie R. Stevens' holly, 'G. G. Gerbing' azalea, Japanese privet, and 'Royal Red' butterfly-bush.

RESULTS

EXPERIMENT 1. Within 3 days of treatment, foliage of all bedding plant species sprayed with 100, 500, or 1,000 ppm Primo appeared bleached. Symptoms were relatively minor on plants treated with 100 ppm but severe on those treated with the two highest concentrations. Bleaching occurred primarily on younger foliage and was concentrated near leaf tips and margins. At the termination of the experiment, 6 weeks after treatment (WAT), bleached foliage was still evident on petunia, coleus, impatiens, and marigold plants treated with the two highest concentrations of Primo. Flowers were present on petunia, impatiens, and periwinkle when treated; these flowers were bleached by 100, 500, and 1,000 ppm Primo and subsequent flowers that formed and opened during the study were bleached. Flowers that formed on marigold and cosmos opened without any abnormal symptoms while coleus did not flower.

Heights of impatiens, petunia, cosmos, and coleus were affected by Primo application (Table 1), while heights of marigold and periwinkle were not. Impatiens treated with the highest rate were 22% shorter than controls. Concentrations less than or equal to 100 ppm had minimal effect (5% or less), on the height of petunia or cosmos, whereas at 1,000 ppm, heights of petunia and cosmos were 64 and 31%, respectively, below that of the control. At concentrations of less than or equal to 10 ppm, height of coleus was similar to that of the control, whereas at 100 and 1,000 ppm heights were 22% greater and 19% less, respectively, than that of the control. The study was terminated 6 WAT because treatments had either made plants unmarketable or were ineffective in controlling shoot growth.

TABLE 1. HEIGHTS (CM) OF FOUR BEDDING PLANTS SPRAYED WITH PRIMO, MAY 14, 1990 (6 WAT[1])

Primo rate (ppm)	Impatiens[2]	Petunia[3]	Cosmo[4]	Coleus[5]
0	17.3	33.0	32.5	22.3
1	14.4	37.3	36.1	23.8
10	17.4	36.3	35.2	23.1
100	15.3	31.5	30.9	27.3
500	13.2	17.3	22.3	24.2
1,000	13.5	11.8	22.9	18.0

[1]WAT = weeks after treatment. [2]'Accent Deep Pink'. [3]'Celebrity Lilac'. [4]'Goldcrest'. [5]'Jazz Bronze'.

EXPERIMENT 2. At 2 and 4 WAT, new growth of azalea treated with Primo was distorted and chlorotic to bronze in color. Symptoms occured on all plants treated with Primo but intensified with increasing rate. At 10 WAT, new growth was healthy and vigorous in appearance; however, bronzed older foliage was still present at 2 and 4 WAT.

At 1 WAT new leaves of butterfly-bush were smaller compared to controls and chlorotic to bleached in appearance. Symptoms were present on all plants treated with Primo rates but were progressively more severe at higher rates. At 3 WAT, foliage of all treated plants was lighter green than that of control plants. Bleached leaf tips were present on plants treated with more than1,500 ppm Primo. Flowers on control plants were a normal deep purple color, while those of plants treated with 500 ppm Primo were a pale lavender, and those of plants treated with more than 1,000 ppm were bleached white. No discoloration of the foliage was present on holly or privet at any of the observational dates.

Growth index of azalea, butterfly-bush, and holly decreased with increasing Primo rate at 4 and 10 WAT. (Table 2). At 10 WAT, growth index of privet was not affected by Primo treatments, indicating that the growth rate of treated plants was faster than that of the control between 4 and 10 WAT. At 4 WAT, treated plants of privet were compact, but by 10 WAT shoots of treated plants had elongated excessively.

Findings of these two experiments indicate that Primo was effective at suppressing shoot growth of several herbaceous and woody landscape plants. However, at rates necessary for shoot control, phytotoxicity symptoms were common on foliage, flowers, or both of most tested species. Results also suggest that herbaceous or woody landscape plants may be injured by Primo application to nearby turf due to overspray or drift. The recommended rate of Primo for turf application is 1.5 ounces of product per 1,000 square feet in a volume of 0.5-2.5 gallons per 1,000 square feet. At these recommended rates, Primo would be applied at rates up to 2,810 ppm. These rates are much higher than rates that injured both herbaceous and woody landscape species in these experiments.

TABLE 2. GROWTH INDEX[1] OF FOUR WOODY LANDSCAPE PLANTS SPRAYED WITH PRIMO, EXPERIMENT 2

Primo rate	'G. G. Gerbing' azalea		'Royal Red' butterfly-bush		'Nellie R. Stevens' holly		Japanese privet
(ppm)	4 WAT[2]	10 WAT	3 WAT	10 WAT	4 WAT	10 WAT	4 WAT
0	27.7	44.9	60.3	78.6	33.7	46.7	33.7
500	22.0	41.3	62.0	94.3	29.3	44.6	33.0
1,000	25.5	42.1	59.1	81.8	28.1	41.0	30.2
1,500	23.8	38.5	55.5	71.6	24.7	34.2	27.8
2,000	18.9	33.2	55.0	84.1	25.5	36.7	29.8
2,500	21.3	37.0	51.0	71.5	24.7	34.7	30.0
3,000	21.3	33.9	42.2	61.3	23.8	31.8	30.4

[1]Growth index = (height + width1 + width2)/3, in centimeters. Width1 is at the widest point and width2 is perpendicular to width1.
[2]WAT = weeks after treatment.

Effect of Primo Rate and Application Volume on Selected Herbaceous and Woody Landscape Plants

Gary J. Keever and John W. Olive

Primo is an effective shoot growth retardant labeled for use on warm- and cool-season turfgrasses. However, foliage of some treated plant species in an earlier study became chlorotic to bleached when treated with Primo at 100 to 1,000 parts per million active ingredient (ppm ai), and flowers of plants treated with Primo at 100 to 3,000 ppm experienced a loss of pigmentation ranging from a slight fading to bleached white.

Recommended rates of Primo for turfgrasses range from 0.25 to 1.0 ounce per 1,000 square feet for approximately 50% growth suppression over a 4-week period, at one and one-half times these rates for excessively vigorous growth, and two times these rates for up to 8 weeks of suppression where temporary discoloration can be tolerated (Primo label). It is also recommended that Primo be applied in 0.5 to 2.5 gallons/1,000 square feet. When Primo is mixed at 0.25 to 1.5 ounces of product in 0.5 to 2.5 gallons, solution concentrations range from 94 to 2,810 ppm ai; these concentrations caused severe phytotoxicity to both herbaceous and woody landscape plants in a previous study. However, in the previous study, Primo was applied in a volume of 0.5 gallon per 100 square feet, a recommended volume/area for most plant growth regulator application to herbaceous and woody landscape species.

The objective of this study was to determine if application of Primo at rates and in volumes recommended for turfgrasses will adversely affect herbaceous and woody landscape plants that may be exposed due to overspray or drift.

METHODS

Uniform plants of heavenly bamboo, azalea, variegated liriope, coleus, impatiens, and periwinkle were treated on May 5, 1994 with all combinations of the followings: Primo at 0.25, 0.5, 1.0, and 1.5 ounces per 1,000 square feet in volumes of 0.5, 1.5, and 2.5 gallons per

1,000 square feet. Solution concentrations of active ingredient ranged from 94 to 2,810 ppm.

Plants were examined daily for the first 2 weeks following treatment for phytotoxicity symptoms and less frequently thereafter. Data were collected periodically. Bedding plants were pruned to a uniform height above the substrate to remove all foliage adversely affected by the first treatment application and treatments reapplied on July 6, 9 weeks after initial treatment and 3 weeks after pruning.

The experiment was repeated in 1995 with privet, 'G. G. Gerbing' azalea, 'Royal Red' butterfly-bush, 'Polo Velvet' petunia, 'Bronze Jazz' coleus, and rose periwinkle. Bedding plants were not pruned or retreated as in the first experiment.

RESULTS

EXPERIMENT 1. 'Bronze Jazz' coleus normally has dark red foliage with bright yellow margins. Within 2 days of treatment, foliage of coleus in all Primo treatments appeared bleached. Symptoms varied among treatments but was most evident on new foliage and was concentrated near leaf tips and margins. No other species showed any symptoms of phytotoxicity.

Injury rating made on coleus 4 days after treatment (DAT) reflects the effects of Primo application volume and rate (see table). Within volumes 0.5 gallon per 1,000 square feet and 2.5 gallons per 1,000 square feet, the injury rating increased as Primo rate increased. At the highest rate, bleaching was present on 20-40% of the foliage. Within the volume of 1.5 gallons per 1,000 square feet, the highest injury rating was given to plants treated with 1.0 ounce per 1,000 square feet of Primo. Within a given Primo rate, the injury rating increased as volume increased. At the three lower Primo rates, the injury rating was lowest when Primo was applied in the smallest volume. Considering that Primo was most concentrated in the smallest volume, one would expect the most injury in these treatments. However, treatment application in a volume of 0.5 gallon per 1,000 square feet resulted in incomplete leaf coverage which possibly resulted in less injury compared to that from the higher volume treatments.

Two weeks after reapplication, treatment differences were visually apparent among coleus treated with different Primo rates but not volumes. Plants treated with the lowest rate were paler than control plants which exhibited dark red leaves with bright yellow margins. Symptoms increased in severity as Primo rate increased. Thirteen weeks after treatment (WAT) and 4 weeks after reapplication, the foliar color rating reflected a similar trend to that reported in the foliar color rating at 4 WAT and observed 2 weeks after reapplication of treatments.

EXPERIMENT 2. Symptom development in coleus followed a similar pattern to that in the first experiment. Bleached spots on petunia flowers occurred within 24 hours of treatment with the two highest Primo rates. At 5 DAT, bleaching of flowers was more general and most severe in plants receiving the highest Primo rate. At 30 DAT, there were no obvious treatment effects in petunia, possibly because flowers showing injury at 5 DAT had fallen off by 30 DAT; this suggests injury to petunia from Primo was not long-term. Butterfly-bush was not in flower when treated and showed no visible adverse effects until flowering began. At 30 DAT, flowers on plants treated with either of the two highest Primo rates were slightly faded. At 60 DAT, flowers on plants treated with the three lowest Primo rates were slightly faded, while flowers on plants receiving the highest rate were almost white. At 30 DAT, immature leaves of azalea treated with the two highest rates of Primo were bronze in appearance.

In these experiments, several species of herbaceous or woody landscape plants were injured by Primo application. Foliage of coleus and 'G. G. Gerbing' azalea and flowers of petunia and butterfly-bush were particularly sensitive. Bleaching of the flowers in these cultivars represented a loss of red-purple pigmentation. Injury in most cases was worsened by increasing Primo rate, while application volume had less effect. In general, injury was less severe than previously reported on some of the same species. This is probably due to Primo being applied in a volume of 0.5 gallon per 100 square feet in the previous study, a recommended volume/area for most plant growth regulators, and in volumes recommended for turfgrass application, 0.5 to 2.5 gallons per 1,000 square feet, in the current study. While injury was less severe than previously reported, it was severe enough to adversely affect the landscape quality of sensitive species that may be exposed to Primo from drift or overspray during turfgrass application.

EFFECTS OF PRIMO APPLICATION VOLUME AND RATE ON INJURY RATING OF COLEUS 4 DAYS AFTER TREATMENT, EXPERIMENT 1

Volume	Injury rating[1] —Ounces of Primo/1,000 feet^2—				
gal/1,000 ft^2	0	0.25	0.50	1.0	1.5
0.5	1.0	1.6	1.9	1.9	3.1
1.5	1.0	2.4	3.0	3.7	2.1
2.5	1.0	2.7	2.7	3.0	3.6

[1]Injury rating: 1 = no injury; 2 = newer growth bleached (<20% of leaves affected); 3-5 = 20-40%, 40-60% and >60%, respectively, of leaves affected.

Screening Buddleia Cultivars for Acute Ozone Sensitivity

Douglas A. Findley, Gary J. Keever, Arthur H. Chappelka, Charles H. Gilliam, and D. Joseph Eakes

Ozone (O_3) was identified as a significant phytotoxic air pollutant during the 1950s and has progressively become a major air pollutant across the United States. Normally associated with urban areas with large numbers of automobiles, tropospheric O_3 is readily transported long distances to non-urban or rural areas. The major effects of O_3 on terrestrial vegetation include visible injury and reductions in growth, productivity, and plant quality. Visible injury from acute O_3 exposures (i.e. exposure to high concentrations for short periods of time) has been observed on a number of landscape plants in the northeastern United States. In a screening of landscape plants common in the southeastern United States to chronic ozone exposure, cultivar differences were observed in buddleia. Chronic O_3 effects are caused by exposure to frequent, relatively low hourly concentrations, with periodic random, intermittent peaks of relatively high hourly concentrations on one or more days. Sensitivity to chronic and acute O_3 exposures is not necessarily correlated. Based on these results and the fact that even minor foliar injury can make a plant undesirable or unmarketable, the objective of this study was to determine differences among buddleia cultivars in sensitivity to acute concentrations of O_3.

METHODS

Liners of eight buddleia cultivars were exposed to four O_3 treatments: 0, 125, 250, or 375 parts per billion (ppb) for 4 hours on 2 consecutive days in continuously stirred tank reactors located within a walk-in growth chamber. Plants were evaluated 2 and 7 days later using a severity index (SI) which is an estimated percentage of the leaves injured (PLI) and leaf area injured. A second experiment investigated the effects of both O_3 concentration and number of exposures. 'Black Knight' was exposed to O_3 concentrations of 0, 125, 250, or 375 ppb for 1 to 5 days for 4 hours daily.

RESULTS

The most common O_3 injury symptom was stippling of the upper leaf surface, which consisted of numerous small, reddish-purple, discrete spots. At O_3 concentrations of 250 and 375 ppb, visible injury was observed on both the oldest and most recently matured leaves. Visible injury was observed under all O_3 concentrations except the control for all cultivars except 'Charming Summer' and 'Lochinch' in which visible injury was only observed under the two higher concentrations (250 and 375 ppb) (see table).

When exposed to 125 ppb O_3, 'Black Knight', 'Opera', and 'Royal Red' had the highest SI, while the other five cultivars had much lower SI value. Although injury at 125 ppb was minor, these concentrations of O_3 have been recorded in urban areas of the southeastern United States during the summer, indicating a potential for injury under ambient conditions.

The SI ranged from 0.20 for 'Charming Summer' to 1.23 for 'Royal Red' when plants were exposed to an O_3 concentration of 250 ppb. Visible injury detected at this concentration was more severe than at lower concentrations with larger stipples and more leaves affected. This resulted in an increased SI for all cultivars. The SI ranged from 1.28 for 'Opera' to 4.56 for 'Pink Delight' when exposed to 375 ppb O_3. Foliar injury was extensive and was visible within 24 hours of the first exposure on the most severely injured cultivars, 'Black Knight', 'Nanho Blue', 'Pink Delight', and 'Royal Red'. One week after the final exposure the most severely injured leaves in all cultivars were senescing.

The effects of a 4-hour exposure to O_3 for 1 to 5 days was evaluated using 'Black Knight', an O_3-sensitive cultivar. The SI increased as both O_3 concentration and number of exposures increased with the highest SI (6.28) observed for plants given the most exposures of the highest O_3 concentration. No visible injury was observed on control plants, and only minor visible injury was observed on plants exposed to 125 ppb of O_3. The SI ratings were similar for plants exposed to 250 ppb of O_3 for 1 or 2 days, as well as for plants exposed to 0 or 125 ppb of O_3 for 1 to 5 days. Plants exposed to 375 ppb of

Severity Index (SI[1]) of Visible Foliar Injury for Buddleia Cultivars Exposed to Four Levels of Ozone

Ozone concentration (ppb)	Cultivar							
	'Black Knight'	'Charming Summer'	'Empire Blue'	'Lochinch'	'Nanho Blue'	'Opera'	'Pink Delight'	'Royal Red'
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
125	0.03	0.0	0.002	0.0	0.005	0.02	0.001	0.02
250	1.08	0.20	0.44	0.80	0.75	0.27	0.83	1.23
375	3.65	2.65	2.07	3.27	3.62	1.28	4.56	3.95

[1]Higher SI indicates more visible injury.

O_3 for 1 day or 250 ppb of O_3 for 2 or 3 days had similar SI ratings (SI of 0.60, 0.34, and 0.73, respectively). The SI was also similar for plants exposed to 2 days of 375 ppb of O_3 or 4 days of 250 ppb of O_3 (1.47 and 1.22, respectively). For a specific ozone exposure, which is the product of O_3 concentration and exposure duration, concentration was more important in inducing visible injury than number of exposures.

This study demonstrates that acute exposure to O_3 can cause visible injury to buddleia cultivars. Visible foliar injury is particularly detrimental to the value of landscape plants since visual appearance is a primary attribute in selection and use. Cultivars that appear most tolerant to elevated ozone concentrations include 'Empire Blue', and 'Opera'. 'Black Knight', 'Nanho Blue', 'Pink Delight', and Royal Red' appear more sensitive. Data collected in the O_3 exposure-response study indicate the importance of both concentration and number of exposures on visible injury. At concentrations currently found in urban areas of the southeastern United States, injury from acute exposure to O_3 would be relatively minor, but after extended periods of time (chronic exposure) injury could become extensive.

Styrene-lined and Copper-coated Containers Affect Production of Dogwood

Thomas J. Brass, Gary Keever, Charles H. Gilliam, and D. Joseph Eakes

Two negative factors associated with container production of nursery crops are high root-zone temperatures and root circling along the substrate-container interface. Temperatures can reach 122°F in nursery containers in the southern United States, due to direct solar radiation striking the container sidewalls. Elevated root-zone temperatures in excess of 104°F may lead to root injury or death, reduced shoot growth, and higher transpiration rates. Root malformation and circling in containers are common for trees with vigorously growing root systems. These conditions may lead to a less fibrous root system, a reduction in plant growth, or the formation of girdling roots which contribute to poor root regeneration and slow transplant establishment in the landscape. Copper compounds sprayed on the interior surface of containers control root malformation and circling. As a result, root malformation and circling are reduced, permitting increased root regeneration following transplanting.

Flowering dogwoods are naturally found in partial shade in well-drained, organic soils with roots maintained in a cool, moist environment. When dogwoods are grown in containers on beds exposed to full sun in the Southeast, root-zone temperature becomes an important factor. Several growers have expressed difficulty in producing container-grown dogwoods, presumably due to high substrate temperatures. This study examined the response of dogwood when grown in styrene-lined and/or copper-treated containers.

METHODS

An experiment which included all combinations of two dogwood cultivars, +/-styrene lining, and +/- copper coating was established on March 13, 1993. Styrene sheeting, 0.1 inch thick, was inserted into 3-gallon nursery containers covering the sidewalls but not the container bottom. Copper hydroxide at 13.4 ounces per gallon of latex base (Spin Out) was applied with a paint sprayer to the containers' interior surfaces or directly to the styrene, which was later inserted into the container. Uniform liners of 'Weaver's White' dogwood, an early bloomer in south Alabama, and 'Barton's White' dogwood, a Tennessee selection that blooms about a week later, were planted into containers using amended pinebark:sand substrate and grown in full sun.

Data on shoot and root growth were collected in July and December 1993. Four plants receiving each treatment were repotted into their original treatment containers to determine residual effects of copper on root suppression and copper and styrene's effects on growth of plants held for a second growing season. Six plants from each treatment were repotted into 7-gallon, non-treated black containers to determine treatment effects on new root growth outside the original rootball.

RESULTS

Treating containers with copper effectively reduced root circling at the substrate-container interface in both cultivars. However, plants grown in containers treated with copper had less root dry weight during the first year's production and less growth in height during the second season compared to those grown the first season in non-copper treated containers. Both cultivars repotted into 7-gallon containers had less trunk diameter growth and a lower percent surface root coverage when previously grown in containers treated with copper than in containers not treated with copper. Copper treatment also reduced root dry weights during the first year of production but had no effect on dry weights of newly generated roots outside the original rootball following repotting.

Dogwoods grown in styrene-lined containers had a greater percent surface root coverage and less root die-back during the first and second growing seasons in 3-gallon containers, in addition to greater growth in height during the second season. Plants originally grown in styrene-lined containers had more trunk diameter growth and a higher percent surface root coverage after being repotted into 7-gallon containers than those grown in non-lined containers. While substrate temperatures were not monitored in this study, the reduction in supraoptimal substrate temperatures by styrene lining, and the concomitant beneficial effects on plant growth from such a reduction have been previously reported. These results demonstrate potential beneficial effects of styrene-lining to dogwood, a species sensitive to supraoptimal substrate temperatures.

Percentage of Surface Root Coverage at the Substrate-container Interface

Copper	Styrene-lining			
	3 gallon[1]		7 gallon[2]	
	+	–	+	–
+	19.5	18.5	38.3	40.0
–	67.4	43.8	81.0	61.0

[1]July 1994.
[2]November 1994.

Control of Basal Sprout Regrowth in 'Bradford' Pear with Tre-Hold

Gary J. Keever, James C. Stephenson, and Donna C. Fare

During the growing season, numerous shoots or sprouts develop on the lower trunk of budded 'Bradford' pear, especially below the bud union, necessitating repeated hand removal. Tre-Hold, a commercial formulation of the plant hormone naphthelene acetic acid (NAA), has been effective in controlling watersprouts and rootsuckers on several fruit and nut crops, grapevines, and woody landscape plants but is not labeled for use on 'Bradford' pear. The objective of this study was to evaluate the effectiveness of Tre-Hold in controlling basal sprout development on 'Bradford' pear following terminal shoot removal.

METHODS

The terminal shoot of container-grown, budded, 4.5 to 5.5 foot, unbranched whips of 'Bradford' pear was pruned at 49 inches and Tre-Hold was applied to the lower 30 inches of each trunk on March 11, 1997. Treatments were Tre-Hold at 0, 2,875, 5,750, 8,625, and 11,500 parts per million active ingredient (ppm ai). Treatments were equivalent to Tre-Hold RTU (ready-to-use formulation) at 0, 0.25x, 0.5x, 0.75x, and x. Sprout numbers and lengths from the lower 30 inches of trunk both above and below the bud union were recorded at 30, 60, 120, 180, and 210 days after treatment (DAT). Plant height and diameter 6 inches above the bud union were measured at 240 DAT.

RESULTS

Trunks of trees sprayed with Tre-Hold developed an oil-soaked, darkened appearance following treatment that increased with concentration but diminished with time. Appearance was apparently due to the emulsion wax carrier but did not detract from overall plant quality. No other abnormal symptoms were observed on treated or non-treated trees. Sprouts on the trunk and rootstock and total sprout number decreased with all concentrations of Tre-Hold (see table). The most dramatic reduction in sprout numbers occurred between control plants and those receiving the lowest rate of Tre-Hold, with similar levels of sprout control for all rates.

Essentially all sprouts that developed on control plants were present 30 DAT with no change thereafter;

Sprout Numbers On 'Bradford' Pear Treated With Tre-Hold

Tre-Hold	Trunk sprout number[1]					Rootstock sprout number[2]					Total sprout number				
	DAT[3]					DAT					DAT				
(ppm ai)	30	60	120	180	210	30	60	120	180	210	30	60	120	180	210
0	5.2	5.3	5.3	5.3	5.3	1.6	1.6	1.6	1.6	1.6	6.8	6.9	6.96	6.9	6.9
2,875	0.3	0.3	0.3	0.3	0.4	0.6	0.6	0.6	0.9	1.0	0.9	0.9	0.9	0.9	1.4
5,750	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5
8,625	0.1	0.2	0.2	1.1	1.2	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.3	1.2	1.3
11,500	0.0	0.0	0.0	0.8	0.8	0.0	0.0	0.4	1.4	1.4	0.0	0.0	0.4	2.2	2.2

[1]Sprouts that developed on the lower 30 inches of each trunk above the bud union.
[2]Sprouts that developed from the rootstock.
[3]DAT = days after treatment.

more sprouts developed on trunks than on rootstocks. Very few trunk or rootstock sprouts developed on treated plants throughout the study, although there was a noticeable increase in total sprout numbers between 120 and 180 DAT in plants receiving the two highest Tre-Hold rates. This response may in part relate to the more viscous nature of solutions of higher concentrations. Spray solutions of higher concentrations foamed more and spread less readily when applied than those of lower concentrations, which may have reduced coverage.

Trunk sprout length was greater at 30, 60, and 120 DAT in control plants than in treated plants that formed sprouts. However, between 180 and 210 DAT, elongation of sprouts in treated plants accelerated such that sprout lengths were similar among all treatments at 210 DAT. In plants where sprouting from rootstocks occurred, sprout lengths were similar among treatments through 180 DAT. Between 180 and 210 DAT sprout length doubled in plants that had received the highest Tre-Hold rate; at 210 DAT average sprout length was three times that of control plants.

Tree height and change in diameter increased up to 5,750 ppm Tre-Hold before decreasing at higher rates. With 5,750 ppm, trees were 15% taller and increased 20% more in diameter than control plants. With the highest Tre-Hold rate, trees were 9% taller but change in diameter was 9% less compared to control plants. The stimulatory effects on tree height and change in diameter were inversely related to total sprout dry weight. Perhaps less photosynthate was channeled into developing sprouts, and, therefore, more was available for height and diameter increase in treated trees.

Results of this study indicate that Tre-Hold at concentrations less than that in the Tre-Hold RTU formulation (11,500 ppm) can provide excellent control of basal sprout in 'Bradford' pear. Concomitant to excellent sprout control, which should reduce expense incurred in hand pruning, was an increase in tree height and diameter with an application of Tre-Hold at 5,750 ppm. Based on results of this study, the manufacturer of Tre-Hold has expanded the label to include 'Bradford' pear.

Pot-in-pot Production of Red Maple Influenced by Cyclic Microirrigation and Substrate

Glenn B. Fain, Ken M. Tilt, Charles H. Gilliam, Harry G. Ponder, and Jeff L. Sibley

Irrigation systems, schedules, and growth substrate are major parameters affecting plant growth. A more efficient alternative to the standard practice of overhead irrigation is cyclic irrigation through a spray stake in an individual container. Spray stake irrigation can cause excessive leaching, if not properly monitored, due to the high application rates of emitters. Spray stake application efficiency can be increased by using cyclic irrigation. With cyclic irrigation, a plant's daily water allotment is subdivided into more than one application with prescribed intervals between applications. With conventional irrigation practices, the daily water allotment is applied in a single application.

Cyclic irrigation may improve irrigation application efficiency by allowing time for water to move through the micropore system of a container substrate. Growers using cyclic irrigation can expect greater plant utilization of applied nitrogen (N) and reduced water and nutrient loss from containers. Earlier work at Auburn has shown a 47% reduction in N leached from nursery pots irrigated with cyclic treatments compared to a single overhead application.

Pot-in-pot production, introduced around 1990, is a nursery production method that combines some of the benefits of both field and container production. A "socket" pot is permanently placed in the ground and a containerized plant is then placed inside the "socket" pot. Limited research has been done to determine potential benefits of cyclic irrigation in pot-in-pot production.

This study was conducted to determine the effects of cyclic microirrigation and pinebark substrates amended with coconut coir or peat on container effluent and growth of Red Sunset™ Maple (*Acer rubrum* 'Franksred').

METHODS

Seventy-two bare root liners, 5 to 6 feet in height, of *Acer rubrum* 'Franksred' were planted in 15-gallon containers in April 1997 in full sun. Three different substrate combinations were used: 100 percent pinebark, pinebark:peat (4:1 by volume), and pinebark:coconut coir (4:1 by volume). Each substrate was amended with 7.7 pounds per cubic yard dolomitic limestone and, after planting, trees were topdressed with 11.8 ounces of 15-9-11 plus slow release fertilizer (O. M. Scotts Co., Inc., Marysville, Ohio). Initial height and trunk caliper (diameter) were taken after trees were planted, and final growth measurements were taken at the termination of the study on September 23, 1997.

For each substrate, three irrigation treatments were compared: application of a given volume in a single application at 10:00 a.m.; the same volume divided into three applications at 10:30 a.m., 1:00 p.m., and 3:30 p.m.; or the same volume divided into six applications beginning at 8:00 a.m. with 90 minutes between cycles. Initial irrigation volume, April to mid-June (period one) was 2.5 quarts per plant; from mid-June to mid-July (period two) the volume was increased to 4.5 quarts per plant; and from mid-July until harvest (period three) the volume was increased to 5.8 quarts per plant. Irrigation was applied through maxi-jet spray stakes (Maxijet Inc., Dundee, Florida) with a Bowsmith model HPC6 pressure compensating emitter (Bowsmith Inc., Exeter, California) at a rate of 13.5 ounces per minute. Total leachate volume was collected from four replications of all treatments on a biweekly basis throughout the study. Soluble salts and pH readings were taken from all containers monthly. Leachate subsamples (3.4 ounces) were collected biweekly and frozen for N analysis at the end of the study. Total inorganic-N concentrations were used to calculate total inorganic-N lost per container (volume x concentration).

RESULTS

For the three substrates tested, total airspace was higher for pinebark at 21.8% than it was for pinebark:coir at 16.9%. Water-holding capacity was greatest for pinebark:peat and pinebark:coir. There were no differences in total porosity between substrates. Pinebark:peat had the lowest bulk density (Table 1).

Table 1. Airspace, Water-holding Capacity (WHC), Total Porosity (TP), and Bulk Density (BD) of Container Substrates

	—Substrate physical properties[1]—			
Treatment	Airspace[2]	WHC[3]	TP[4]	BD[5]
Pinebark	21.8	42.8	64.6	0.292
Pinebark:peat (4:1)	19.2	47.4	66.6	0.254
Pinebark:coir (4:1)	16.9	47.3	64.2	0.298

[1]Substrate physical properties determined using the North Carolina State University Porometer.
[2]Airspace: Percent volume filled with air after substrate is saturated and allowed to drain for 60 minutes.
[3]Water-holding capacity: Percent volume filled with water after substrate is saturated and allowed to drain for 60 minutes.
[4]Total porosity: Percent volume of the substrate comprised of pore space.
[5]Bulk density: Ratio (g/cm^3) of mass of dry solids to bulk volume of substrate.

Irrigation application efficiency was highest for pinebark:peat among substrate treatments for period two while pinebark and pinebark:coir were similar. During periods one and two, irrigation application efficiency was greatest for the six-cycle treatment followed by the three-cycle and single, respectively (Table 2). During period three, both cyclic treatments had the greatest irrigation application efficiency among all substrates. These results are consistent with prior research showing increased irrigation application efficiency with cyclic irrigation. Within the single irrigation treatment, pinebark:peat had the highest irrigation application efficiency followed by pinebark:coir and pinebark, respectively. Irrigation application efficiency appeared to increase as the season progressed, possibly due to increasing plant needs and environmental conditions.

Table 2. Effects of Cyclic Irrigation and Substrate on Irrigation Application Efficiency When Applied to *Acer rubrum* 'Franksred' in a Pot-in-pot Production System[1]

	Irrigation application efficiency (%)		
Treatment	Period 1	Period 2	Period 3
	Substrate		
Pinebark	72.1	86.3	87.1
Pinebark:peat (4:1)	80.2	92.8	93.8
Pinebark:coir (4:1)	72.2	87.1	89.7
	Irrigation		
Single	59.7	76.4	75.8
Three-cycle	75.3	91.2	96.3
Six-cycle	88.0	96.6	98.4

[1]Irrigation application efficiency = [(water volume applied-water volume leached)/water volume applied].

Tree growth was affected by substrates and irrigation treatment (Table 3). Shoot dry weight was about 8% greater with plants grown in pinebark:peat compared to plants grown in pinebark. Plants grown in pinebark:peat had a 17 and 12% greater height increase than those grown in pinebark:coir and pinebark, respectively.

Plants grown with cyclic irrigation had the greatest shoot dry weight among irrigation treatments with plants in the three-cycle and six-cycle having 23 and 17% greater shoot dry weight respectively than plants grown with a single irrigation application (Table 3). With trunk diameter, plants receiving three-cycle and six-cycle irrigation treatments had a 23 and 26% greater diameter increase respectively than plants grown with a single application irrigation. Tree height was also affected by irrigation treatment. Plants grown with three-cycle irrigation had a 16% greater height increase than plants grown

Table 3. Effects of Cyclic Irrigation and Substrate on Final Growth of *Acer rubrum* 'Franksred' in a Pot-in-pot Production System

Treatment	Shoot dry wt (g)	Trunk diameter[1] increase (cm)	Shoot height increase (cm)
	Substrate		
Pinebark	1203.8	1.72	109.4
Pinebark:peat (4:1)	1303.8	1.81	122.9
Pinebark:coir (4:1)	1223.8	1.74	105.3
	Irrigation		
Single	1098.3	1.51	103.8
Three-cycle	1349.2	1.86	120.6
Six-cycle	1283.8	1.90	113.3

[1] Diameter 15 cm above substrate surface.

with a single irrigation application. Our results support a previous study showing an increase in growth of 'Okame' Cherry (*Prunus* × *incamp*) with cyclic compared to a single irrigation application. Irrigation treatment had no effect on substrate pH. Irrigation treatment had an effect on electrical conductivity, with the six-cycle treatment having the highest electrical conductivity for the July and August samples (Table 4). More irrigation cycles and greater efficiency, or reduced leaching fraction allowed salts to accumulate in the substrate. However all electrical conductivity readings were below thresholds where root damage might be expected to occur.

Cyclic irrigation reduced total N leached by a minimum of 89% in June and August when compared to a single irrigation application (Table 4). While N concentration was generally higher in cyclic treatments, reduced leachate volume (i.e., greater irrigation application efficiency) resulted in less N leached. For example with the six cycle irrigation in August the N concentration was 34.6 mg/liter; however, total N leached per pot was 0.2 mg/pot. This is a 99% reduction compared to the single irrigation application. These data suggest greater retention of N with cyclic versus a single irrigation application. This agrees with previous work which showed a decrease in N leached when using cyclic irrigation compared to a single irrigation application. Leachate N concentration was greatest for 100% pinebark in June at 9.3 mg/liter compared to 5.5 and 6.0 mg/liter for pinebark:peat and pinebark:coir, respectively. There were no other differences between substrates on leachate N (data not shown).

With increasing emphasis on water quality as well as quantity used, growers should consider changing management practices to improve irrigation application efficiency of container-grown trees. Cyclic irrigation is one method of improving water quality by reducing runoff and nutrient loss from containers. Reducing N leached during production is an important environmental goal. Reduced leachate volume and increased N retention in the substrate may allow for more effective use of controlled-release fertilizer and thereby reduce potential negative impacts on the environment.

Both cyclic irrigation and pinebark:peat (4:1 by volume) substrate increase irrigation application efficiency by reducing leachate volume in a pot-in-pot production system. Our results indicate that cyclic irrigation may lead to increased growth in production of specimen trees. Both six- and three-cycle irrigation produced increased growth of *Acer rubrum* 'Franksred' compared to a single irrigation application. The pinebark:peat substrate (4:1 by volume) produced increased shoot dry weight over 100% pinebark and pinebark:coir (4:1 by volume). Leachate N concentration increased with cyclic irrigation; however, due to the reduced leachate volume with cyclic irrigation, less N was leached. Furthermore, many growers of large container plants can apply cyclic microirrigation methods without major changes in existing equipment.

TABLE 4. EFFECTS OF CYCLIC IRRIGATION AND SUBSTRATE ON LEACHATE NITROGEN AND ELECTRICAL CONDUCTIVITY[1]

	Nitrogen (mg/liter)			Nitrogen (mg/pot)			Conductivity (ds/m)		
Treatment	June	June	August	June	July	August	June	July	August
				Substrate					
Pinebark	9.3	18.6	23.2	3.2	3.6	12.3	0.25	0.33	0.42
Pinebark:peat (4:1)	5.5	11.9	30.3	0.4	2.2	9.7	0.24	0.034	0.51
Pinebark:coir (4:1)	6.0	10.5	20.0	2.7	3.1	5.7	0.23	0.30	0.38
				Irrigation					
Continuous	6.7	4.6	18.1	5.8	4.7	24.7	0.22	0.21	0.32
Three-cycle	3.9	7.5	22.3	0.5	3.0	2.8	0.25	0.28	0.44
Six-cycle	10.3	28.8	34.6	0.0	1.3	0.2	0.24	0.47	0.57

[1]Nitrogen concentration (mg/l) and electrical conductivity (dS/m) from 100 ml sub-samples collected by VTEM; total N lost (mg/pot) was for one irrigation event 1 day prior to VTEM based on volume of leachate collected (volume x concentration). Nitrogen analysis performed on a Timberline Model 380 Inorganic Nitrogen Analyzer. Electrical conductivity determined by a YSI Model 35 Conductance Meter.

Propagation of Golden Barberry Improved in Shade

Brian H. Murphree, Jeff L. Sibley, D. Joseph Eakes, and J. David Williams

The barberries, including both evergreen and deciduous species, are commonplace in landscapes across the United States and throughout the world. The Japanese barberry (*Berberis thunbergii*), a deciduous species, was introduced to the United States as an ornamental plant in 1864 by a Dutch botanist, Carl Peter Thunberg. Cultivars of *Berberis thunbergii* are among the most attractive ornamental plants in summer landscapes due to showy foliage in a number of colors. Despite prickly thorns, barberries continue to be a homeowner favorite and collectively, come close to being no-maintenance plants throughout USDA Hardiness Zones 4-8. Many *Berberis thunbergii* selections are adorned with small colorful leaves often turning a brilliant red in the fall, along with red berries which last through the winter on some selections. Although some species of barberries have been banned where wheat is a major crop because of the role they play in transmitting black stem rust to wheat, *Berberis thunbergii* selections are generally rust-resistant and practically pest and disease free.

Most research in *Berberis* species has focused on medicinal uses or pathogenicity of barberry with little research evaluating ornamental production or propagation of *Berberis* species. *Berberis thunbergii* species are generally rooted with indole butyric acid (IBA) solutions of 1,000 to 5,000 parts per million (ppm). Studies have shown that cuttings of *Berberis thunbergii* and *B. thunbergii* 'Atropurpurea' have an increased rooting response when stock plants are grown at less than full sunlight. However, there have been no reports concerning propagation of golden barberry cuttings under different light intensities. This study was conducted to evaluate the influence of shade on propagation of golden barberry.

METHODS

Studies were initiated on April 29, 1998 and September 18, 1998 using 3-4 inch long softwood medial stem cuttings of *Berberis koreana* x *thunbergii* 'Bailsel' (Golden Carousel™). 'Bailsel' is an interspecific cross between *Berberis koreana* and *Berberis thunbergii* 'Aurea' which was discovered as a chance seedling in field plots at Bailey Nurseries, Inc., in St. Paul, Minnesota. 'Bailsel' has a growth habit that is upright and arching with golden yellow hues on young foliage throughout the growing season that turn to orange and red in the fall.

Cuttings were taken from 3-gallon stock plants growing under a 50% shade in Auburn, Alabama. Cuttings were treated with 1,250 ppm IBA (Dip 'N Grow) for 3-5 seconds, and stuck in open trays lined with 24-cell inserts filled with a pinebark:sand (6:1 by volume) substrate amended with 5.0 pounds per cubic yard of dolomitic limestone. The experiment was conducted in a standard greenhouse under intermittent mist with treatments consisting of three shade levels based on full sun ambient light. Treatments were 60% shade, 70% shade, and 80% shade.

Subjective foliar color ratings were made weekly. Root dry weights were collected only for the study conducted in September. Rooted liners were harvested 57 days after treatments began (DAT). Roots rinsed free of substrate were evaluated using a root rating scale of 0 - 5 with 0 = plants having no roots and 5 = plants that were heavily rooted.

RESULTS

Initial signs of root development occurred for all treatments about 20 DAT. After 57 days, root ratings were higher in plants under 70% and 80% shade than 60% shade. Viability was lower and desiccation was greater among plants under the 60% shade level than those occupying either the 70% or 80% shade level (see table). Overall foliar color was improved under 70% and 80% shade levels (a more uniform golden hue) compared to cuttings rooted under 60% shade which developed a red hue or exhibited desiccation. Root dry weights were greater for cuttings under the 60% shade levels (see table) than 70% or 80% shade.

Based on the results of this study, we believe *Berberis koreana* × *thunbergii* 'Bailsel' can be successfully propagated from softwood cuttings in early summer or fall with solutions containing 1,250 ppm IBA. Furthermore, leaf retention, leaf color, and liner quality are improved as shade levels are increased. While various selections of barberry are thought of as tough, full-sun plants, this study along with other work suggests that golden barberry selections may actually be more suitably propagated in part-shade environments.

EFFECTS OF SHADE LEVEL ON PROPAGATION OF *BERBERIS KOREANA* × *THUNBERGII* 'BAILSEL'

Treatment	Root rating[1]		Viability[1]		Root dry weight[1]
	Study 1[2]	Study2[2]	Study 1	Study 2	Study 2
60% shade	2.8	2.7	86	100	9.32
70% shade	4.1	3.4	97	97	9.27
80% shade	4.0	4.1	100	96	9.27

[1]Root rating on 0 - 5 scale; Viability in percent; Root dry weight in grams.
[2]Study 1 conducted from April 29 to June 25,1998; Study 2 conducted from September 18 to November 14, 1998.

Flowering Dogwood Seed Sources Vary Little in Tolerance to Extreme Heat Stress

R. Brian Hardin, D. Joseph Eakes, Jeff L. Sibley, Charles H. Gilliam, and Gary J. Keever

Flowering dogwood is a shade-tolerant native tree ranging from Maine to Florida in the East and extending westward into Michigan and Alabama. It is one of the most popular small landscape trees in the United States. Southern nurseries commonly collect seed in southern areas and sell the seedlings to nurseries in the northern portion of the country. Although considered hardy from Arnold Arboretum Hardiness Zones 5 to 9 (USDA Hardiness Zones 6a to 9b), flowering dogwood seedlings from southern sources are not considered sufficiently hardy in Arnold Arboretum Zone 5 (USDA Zone 6a) and have minimal flower production. Because seedling performance is variable, many cultivars have been selected. There are approximately 60 valid cultivars of flowering dogwood with three natural variations: f. *rubra* Weston with red bracts, f. *xanthocarpa* Rehder with yellow fruit, and f. *pluribracteata* Rehder with more than four bracts. Many cultivars of these have originated in the southeastern United States.

Cultivars of flowering dogwood are often budded or grafted on seedling rootstocks, and the genetic makeup of the rootstock may determine the relative heat tolerance of a given cultivar. The objective of this study was to determine differences in heat tolerance of flowering dogwood seedlings grown from seed collected from native stock in three USDA Hardiness Zones (6a, 7a, and 8a) and two American Horticultural Society (AHS) Heat-Zones (7 and 8).

METHODS

Seed were collected from three sources, representing three USDA Zones and two AHS Zones: Rock Island, Tennessee, (35°41'N x 85°46'W; 6b; 7), Bankhead National Forest, Lawrence County, Alabama, (34°22'N x 87°30'W; 7a; 7), and Auburn, Alabama, (32°36'N x 85°29'W; 8a; 8) in October or November 1996. Following cold stratification at 41°F for 3 months in moist builders sand, seed were planted at a depth of 1 inch in 65 in^3 containers in an amended pinebark/sand (6:1 by volume) growth medium on March 6, 1997. Seedlings were grown in a double-wall polyethylene greenhouse in Auburn, Alabama, for 6 months with heat (minimum) and venting (maximum temperature) setpoints of 68°F and 80°F, respectively. On June 4, 1997, seedlings were topdressed with 0.11 ounce per pot of Osmocote 14-14-14 (0.01 ounce of N, P_2O_5, and K_2O) controlled release fertilizer (O.M. Scotts Co.). Powdery mildew was controlled using 3336-F Turf and Ornamental Fungicide (W.A. Cleary Chemical, Somerset, New Jersey) at the labeled rate every 10 to 14 days. Containers were grouped into trays spaced tray to tray. Trays were lined with landscape fabric (Weed-X; Dalen Products, Knoxville, Tennessee).

Excised portions of young, tender, actively growing roots 1 inch in length (0.018 ounces in weight) were subjected to procedures evaluating leakage of electrolytes from root cells. These procedures involved placing the root tissue in test tubes containing 0.03 fluid ounce of deionized water and exposing it for 30 minutes to 68, 86, 95, 104, 113, 117.5, 122, 131, or 140°F in a thermostatically controlled circulating water bath. After removal, roots were cut into 0.20 inch segments and returned to test tubes containing 0.6 fluid ounce of deionized water prior to incubation in an ice bath for 24 hours at 39°F. Measurements of initial conductivity (Accumet 50, Fisher-Scientific, Pittsburgh, Pennsylvania) of these samples were taken, after which the samples were autoclaved for 20 minutes at 250°F and incubated in an ice bath for 24 hours at 39°F prior to final solution conductivity measurements.

RESULTS

Electrolyte leakage was an effective method for determining the thermotolerance of flowering dogwood roots, with data appearing sigmoidal in nature for all provenances tested. USDA Zone 6b (AHS Zone 7) seedlings had the highest predicted critical temperature midpoint (T_m) at 126.3 ± 1.08°F, 2.2°F higher than that for USDA Zone 7a (AHS Zone 7) seedlings (124.2 ± 0.9°F), but similar to USDA Zone 8a (AHS Zone 8) seedlings (see table). Likewise, seedlings from USDA Zone 8a (AHS zone 8) at 124.7 ± 0.7°F were similar to those collected in USDA Zones 7a (AHS 7). Although USDA Zone 6b and 7a seedlings were statistically different, there may be little ecological difference in root thermotolerance among these provenances of flowering dogwood. In prac-

Predicted Critical Midpoint Temperature (T_M) for Root Electrolyte Leakage Following Exposure to Elevated Root-zone Temperatures for Flowering Dogwood (*Cornus florida* L.) Seedlings[1]

Seed origin	Zone[2]		T_m
Auburn, Ala.	8a	8	124.7
Bankhead National Forest, Ala.	7a	7	124.2
Rock Island, Tenn.	6b	7	126.3

[1]Means for predicted critical temperature parameters.
[2]USDA hardiness zone/AHS heat-zone, respectively, for area from which seed lots were gathered.

tical terms, one factor minimizing the small difference between USDA Zones 6b and 7a provenances is that although in different USDA Hardiness-Zones, Bankhead (USDA Zone 7a) is located in the same AHS Heat-Zone (7) as Rock Island, Tennessee, (USDA Zone 6b). Studies have shown a lack of interaction between temperature and provenance for *Acer saccharinum* (silver maple) from Minnesota and Mississippi, concluding that there was no evidence to support that root-zone heat would affect growth and water relations more in trees native to the northern climate than in those native to southern climate. Furthermore, significant indirect injury may also be realized long before direct injury occurs in natural populations.

No references were found investigating the possibility of genetic differences in heat tolerance of flowering dogwood rootstock. However, sufficient variability must exist in native populations for any improvement to be expected in breeding for a particular trait. While dogwood populations across the native range have been shown to have sufficient variability to warrant extensive selection regarding a number of morphological and physiological traits, the results of this study indicate that there is little genetic variability in root thermotolerance across this part [USDA Zones 6b - 8a (AHS Zones 7 and 8)] of the native range of flowering dogwood. Therefore, there should not be differences in heat tolerance among rootstocks that originate in USDA Zones 6b, 7a, or 8a.

This work provides valuable information regarding root thermotolerance for native populations of flowering dogwood in comparison to other species with a similar native range. However, based on the results of this study, we believe future studies investigating rootstock heat tolerance should be conducted on clonal material rather than open pollinated seed stock, thereby eliminating the possibility of seedling variability. Genetic variability within geographic regions in a provenance test of flowering dogwood seedlings evaluating susceptibility to dogwood anthracnose has been shown by others. Notable differences between two provenances from Oklahoma and between two provenances from Missouri indicated genetics of the parent tree to be more important than location where seed were collected. Therefore, even though minimal differences were found in this study, repeated evaluations from sibling trees in close proximity may reveal greater or lesser variation among seedlings. In addition, future studies evaluating root thermotolerance for seedlings from a wider range of USDA Zones, including zones 5 to 9, would be advantageous.

Effect of Environment on Container-grown Red Maple in Alabama and Georgia

Jeff L. Sibley, John M. Ruter, and D. Joseph Eakes

Container production of shade and ornamental trees is increasingly important to the horticulture industry. Aboveground and pot-in-pot production methods are less expensive and more profitable than traditional field-grown methods. Container production of trees offers numerous advantages over traditional field production methods including year-round availability of plant material. Little information about container production of red maple cultivars is available, with no previous reports of multiple cultivar by location studies. About 55 distinct cultivars of red maple are available in the nursery industry, many of which have become popular in field production but have not been evaluated in container production. Climatological data give an indication of differences in rainfall, length of growing season, and maximum/minimum temperatures with USDA hardiness zones ranging from 8b to 6a across Georgia and Alabama (Table 1). Studies have demonstrated effects of different climates on growth of field- and container-grown plants other than red maple. The objective of this study was to evaluate the growth of eight container-grown red maple selections at four locations in Georgia and Alabama with different growing environmental conditions and irrigation practices.

METHODS

Rooted cuttings and tissue cultured plantlets (2-10 inches tall) of *Acer rubrum* and *A.* × *freemanii*, obtained in April,1995 were transplanted on the same day in Auburn, Alabama, to 3-gallon containers in a pinebark:sand (6:1 by volume) substrate amended with 18 pounds per cubic yard of 17-7-12 Osmocote, 1.5 pounds per cubic yard Micromax, and 5.0 pounds per cubic yard dolomitic lime in May 1995. Trees were grown in full sun under standard nursery practices for 1 month in Auburn prior to transport to the four study locations in the second week of June 1995. Locations were Blairsville, Georgia, 34°53'N x 83°58'W, elevation 1,892 ft; Muscle Shoals, Alabama, 34°43'N x 87°37'W, elevation 516 ft; Auburn, Alabama, 32°36'N x 85°29'W, elevation709 ft; and Tifton, Georgia, 31°27'N x 83°31'W, elevation 357 ft, in USDA hardiness zones 6b, 7a, 8a, and 8a, respectively. Trees were arranged at each location on landscape fab-

Table 1. Length of Growing Season, Mean Monthly Maximum (T_{MAX}) and Minimum (T_{MIN}) Temperatures[1], and Monthly Rainfall Totals[2] by Location June 1995 - December 1996

	Blairsville			Auburn			Muscle Shoals			Tifton		
1995												
Growing season	5/4 - 10/22			3/10 - 11/12			3/11 - 11/14			3/10 - 11/12		
Frostfree days	171			247			238			247		
Rainfall events	65			80			70			69		
1996												
Growing season	5/2 - 10/13			3/12 - 11/11			4/11 - 11/13			3/13 - 12/20		
Frostfree days	164			244			206			282		
Rainfall events	57			63			70			65		
Month	T_{max}[1]	T_{min}	Rain[2]	T_{max}	T_{min}	Rain	T_{max}	T_{min}	Rain	T_{max}	T_{min}	Rain
1995												
June	25.7	13.0	18.3	30.2	18.9	8.7	30.1	18.4	7.3	30.1	19.2	9.4
July	30.2	16.7	12.0	35.2	22.0	7.9	33.4	21.6	14.7	33.2	21.7	9.4
August	29.7	18.8	18.5	33.3	23.3	12.3	33.5	23.1	12.5	32.6	22.0	5.6
September	25.2	14.1	6.5	30.1	18.9	5.8	28.9	16.8	5.8	30.2	18.1	1.6
October	21.2	6.6	22.4	25.2	13.9	27.4	23.1	10.8	13.1	27.2	14.1	4.0
November	13.1	0.4	13.4	17.6	5.1	7.9	14.6	3.3	12.4	18.7	5.0	6.3
December	9.2	-2.4	6.9	13.6	2.6	11.8	10.7	1.7	12.1	15.1	2.7	3.8
Mean[1] and total[2]	22.1	9.6	98.0	26.4	14.9	81.8	24.9	13.7	77.9	26.7	14.7	40.1
1996												
January	5.5	-5.4	25.9	13.2	3.6	15.8	9.2	0.6	16.3	15.9	2.2	7.9
February	8.7	-4.6	10.5	16.0	5.3	8.7	10.9	1.5	8.8	17.8	3.9	7.3
March	11.7	-1.9	18.0	17.7	6.7	22.9	14.2	3.6	13.9	17.9	6.0	19.4
April	18.9	2.7	12.4	24.0	10.5	5.5	21.5	9.2	16.6	23.6	10.1	9.7
May	25.1	11.1	12.9	28.7	17.1	3.0	28.8	17.1	3.7	30.0	17.4	2.9
June	27.1	14.8	14.6	29.4	19.7	5.8	30.8	19.6	8.4	31.2	19.7	5.2
July	28.4	16.7	9.2	31.3	21.7	13.2	32.1	21.2	16.4	33.3	21.9	2.5
August	28.1	16.3	9.8	29.9	20.7	4.7	31.1	19.8	14.9	31.6	20.6	15.5
September	24.4	12.7	15.4	27.3	17.9	12.1	27.6	15.7	17.0	29.6	18.3	10.1
October	20.4	6.1	2.8	22.2	12.2	1.6	22.7	10.8	10.1	24.7	11.9	7.1
November	12.1	0.6	14.4	16.6	7.5	8.1	14.5	6.1	14.5	19.4	6.7	3.3
December	11.4	-1.0	16.0	15.2	6.2	12.0	13.1	4.7	26.7	17.4	4.8	9.5
Mean[1] and total[2]	18.5	5.7	161.8	22.5	12.4	113.4	21.4	10.8	167.3	24.4	12.0	100.4

[1]Temperature in degrees Celsius.
[2]Rainfall in centimeters.

ric-covered beds pot to pot. All trees were pruned to a central leader the last week of July 1995. Trees were overhead irrigated, using standard production practices for each given location, at 0.5 inch per day in Blairsville and Tifton; and 1.5 inches per day in Muscle Shoals and Auburn as needed in 1995 and 1996. Dormant trees were transplanted to 10-gallon containers the second week of December 1995.

Daily maximum and minimum air temperatures and rainfall were averaged for each month and location in 1995-1996 (Table 1). All trees were transported to Auburn for harvest at the end of December 1996. Final caliper (stem diameter, 6 inches above the medium) and plant height were measured prior to dry weight measurements being taken for each tree.

RESULTS

Despite differences in temperature and moisture (irrigation and rainfall) among locations (Table 1), growth response across cultivars was similar in Blairsville and Tifton, and in Muscle Shoals and Auburn (Tables 2-3). Number of rainfall events varied little across locations during the two growing seasons; however, total rainfall was greater in Blairsville, Auburn, and Muscle Shoals, than Tifton in 1995 (Table 1). Total rainfall was greater in Blairsville and Muscle Shoals, than Auburn and Tifton in 1996. In a related container study, we found the greatest height growth for container-grown red maple cultivars occurred between May and July. The greater overall growth across cultivars at the Alabama locations, compared to the Georgia locations, is attributed to non-limiting irrigation at the Alabama locations during the greatest period of growth. Across all cultivars tree height was highest for trees grown in Muscle Shoals (Table 2). Auburn trees had greater height growth than Tifton trees, with the exception of 'Olson' (Northfire™). Four cultivars had similar height growth in Auburn and Blairsville.

Caliper increase was generally greater for the Alabama locations compared with the Georgia locations (Table 3). Caliper increase was the same for Blairsville and Tifton for all cultivars with the exception of 'Celzam' (Celebration™) and 'Landsburg' (Firedance™). Caliper increase was the same for Auburn and Muscle Shoals for all cultivars with the exception of 'Landsburg' and 'Franksred' (Red Sunset™). Based on the similarities in Blairsville and Tifton and in Muscle Shoals and Auburn, the overall differences in caliper increase are attributed to differences in irrigation and rainfall across locations more than differences in temperature. For most cultivars, differences in caliper growth in this study would be considered a marketable difference from a container production standpoint. Based on common practice in the nursery industry and the *American Standard for Nursery Stock*, for trees of a similar height, caliper increases are generally considered marketable in 0.25 inch increments up to 2 inches.

Much can be gained from this study regarding cultivar performance under dissimilar environmental conditions. Three cultivars—'Celzam', 'Landsburg', and 'Olson'—are new introductions and have not been included in container or field studies prior to this report. 'Franksred' demonstrated the greatest adaptability to the varied environmental conditions across locations. For each location 'Franksred' had the greatest height and caliper growth, with the exception of caliper at one location (Table 3), pointing out why this selection is often included in container studies. 'Olson' and 'Celzam' appear to be well adapted to container production in growing conditions of the Southeast. Based on the results of this study, we can not recommend 'Landsburg' as a suitable choice for container producers in the Southeast. This Zone 3 selection had the least height, caliper, and root growth for each of the four locations.

This study shows that differences in temperature and irrigation have a greater impact on growth of container-grown red maple cultivars by the end of the second year. In an earlier report no differences in first year tree height were found for 'October Glory' at three locations with dissimilar climates in Georgia and Alabama. Studies at Auburn in the 1980s found height growth was unaffected by irrigation rate in the first growing season in container-grown *A. rubrum* seedlings, but height and caliper growth increased as irrigation increased in the second year.

This study provides useful information regarding the impact of a long growing season on the growth of container-grown trees. For example, although Tifton had almost 4 months more frost-free days than Blairsville, these days apparently did not contribute to a growth advantage for Tifton over Blairsville as might be expected with container-grown ornamental shrubs. With primary shoot extension occurring early in the growing season in Tifton, the extended growing season may have caused a depletion in reserves through extended maintenance respiration. However, greater growth might have been realized from the longer growing season in Tifton, compared with Blairsville, if irrigation rates had replaced 100% of evapotranspiration, as opposed to 0.5 inches per day.

Table 2. Height Increase from Spring 1995 to December 1996 for Eight Red Maple Cultivars Grown at Four Locations[1]

	Location			
Cultivar	Blairsville	Auburn	Tifton	Muscle Shoals
October Glory	133.6	157.8	118.6	203.3
Franksred (Red Sunset™)	166.9	229.8	175.9	261.7
Armstrong	153.4	200.4	151.3	276.8
Fairview Flame	136.4	147.1	114.4	201.4
Celzam (Celebration™)	142.7	218.7	110.3	256.3
Autumn Flame	156.6	198.4	138.9	223.0
Landsburg (Firedance™)	129.8	146.6	109.9	196.9
Olson (Northfire™)	163.2	180.8	160.9	261.4

[1]Height increase (cm) determined by difference in initial height (6/95) and final height (12/96).

Table 3. Caliper Increase from Spring 1995 to December 1996 for Eight Red Maple Cultivars Grown at Four Locations[1]

	Location			
Cultivar	Blairsville	Auburn	Tifton	Muscle Shoals
October Glory	16.0	21.6	14.0	21.1
Franksred (Red Sunset™)	20.5	26.7	20.6	23.2
Armstrong	17.3	21.8	15.5	23.3
Fairview Flame	16.8	17.7	14.5	20.1
Celzam (Celebration™)	16.7	24.0	14.0	25.1
Autumn Flame	19.3	25.8	19.1	23.5
Landsburg (Firedance™)	10.9	11.0	7.7	13.9
Olson (Northfire™)	16.3	19.1	16.3	23.0

[1]Caliper increase (mm) determined by difference in initial caliper (6/95) and final caliper (12/96).

Dolomitic Lime and Micronutrient Rates Affect Growth and Quality of Container-grown Ornamentals

D.J. Eakes, C.H. Gilliam, G.J. Keever, and J.W. Olive

Pre-plant incorporation of dolomitic limestone and micronutrients as amendments to container media is a common nursery practice. Organic components, such as pine bark and peat moss, are acidic and are inherently low in phosphorus, calcium, magnesium, iron, and various micronutrients required for optimum plant growth. Dolomitic limestone is commonly added as a source of calcium and magnesium as well as a means to increase medium pH for these organic substrates. However, raising medium pH can have a detrimental affect on micronutrient availability. Manganese, boron, copper, and zinc are all less available for plant uptake when medium pH is above 6.0.

Previous research has shown that plant response to these amendments can be beneficial, detrimental, or have no effect based on the rate applied and the plant species being produced. Little or no work has been done looking at the impact that one amendment has on the other when used in an organic container medium. Therefore, the objective of this work was to determine the effects of dolomitic limestone and micronutrient rates on container medium solution pH and the growth and quality of seven container-grown species.

METHODS

On May 31, uniform liners of 'Formosa' azalea, 'Greenluster' Japanese holly, 'Burford' Chinese holly, 'Yellow Jacket' chrysanthemum, 'Wood's Dwarf' nandina, 'Meta Peka' hosta, and 'October Glory' red maple were potted in a pine bark:peat moss (3:1 by volume) medium amended with 14 pounds of Osmocote 17-7-12 (Scotts Co., Marysville, Ohio) per cubic yard. The six treatments were ground dolomitic limestone at 0, 5, or 10 pounds per cubic yard of medium combined with Micromax (micronutrient product from the Scotts Co., Marysville, Ohio) at the rate 0 or 1.5 pounds per cubic yard of medium pre-plant incorporated. All plants were produced at the Ornamental Horticulture Station in Mobile, Alabama, under overhead irrigation in trade gallon containers with the exception of the red maples which were grown in 10-gallon containers receiving drip irrigation.

Foliar color ratings (FCR), on a scale of 1-5 with 5 being dark green and 1 being bleached foliage, were made 30, 60, 120, and 360 days after potting (DAP) for all species except chrysanthemum. Plant growth indices (GI) [(height + width1 + width 2)/3, where width1 is at the widest point, and width2 is perpendicular to width1] for shrub species, and height and stem diameter for red maple were determined 360 DAP. Chrysanthemum FCR were made 30, 60, and 120 DAP, and GI was determined 150 DAP. Medium solutions were collected using the pour-through technique and the pH was determined on 7, 14, 45, 60, 90, 120, 200, 250, 270, 300, 330, and 360 DAP.

RESULTS

Foliar color ratings were similar among treatments within each species 30 DAP. However, by 60 DAP dolomitic limestone and micronutrient rates affected both red maple and dwarf nandina FCR. Best FCR for red maple occurred with trees receiving Micromax regardless of dolomitic limestone rate, and for those trees produced with no dolomitic limestone and no Micromax (see table). Dwarf nandina produced with 5 or 10 pounds of dolomitic limestone and 1.5 pounds of Micromax had the best FCR compared to plants in the remaining treatments. Within each of the other species, FCR were similar among treatments. At 120 DAP, red maple, dwarf nandina, and hosta FCR increased as dolomitic limestone rate decreased when no Micromax was supplied. When Micromax was added, plants in all dolomitic limestone rates had similar FCR and were similar to FCR of no dolomitic limestone, no Micromax plants. Although there was no interaction between dolomitic limestone and micronutrient rates for azalea, FCR increased as dolomitic limestone rates decreased (a rating of 4.1 for no dolomitic limestone to 3.5 for plants receiving 10 pounds of dolomitic limestone) or when Micromax was supplied (4.0 with Micromax and 3.5 without). No other plant species' FCR were affected by dolomitic limestone or micronutrient rate 120 DAP, and FCR for plants in all treatments were similar within species 360 DAP.

Growth indices of dwarf nandina and hosta 360 DAP and chrysanthemum 150 DAP increased as dolomitic limestone rate increased regardless of micronutrient rate. Greatest GI for both holly species occurred with the 5 or 10 pound rate of dolomitic limestone regardless of micronutrient rate. Height and stem diameter of red maple and GI of azalea were not affected by dolomitic limestone or micronutrient rates 360 DAP.

As dolomitic limestone rate increased, medium solution pH increased on each observation date through the study. Regardless of dolomitic limestone rate, medium solution pH decreased over time. The pH for the 10 pound rate of dolomitic limestone decreased from 6.6 on 45 DAP to 4.9 on 360 DAP while the 0 pound rate decreased from 4.4 on 45 DAP to 3.6 on 360 DAP. Micronutrient rate had no effect on medium solution pH on any observation date during the study.

Influence of Dolomitic Limestone and Micronutrient Rates on Foliar Color Rating of Container-grown Ornamentals[1]

Limestone rate (lbs/cu yd)	Micromax rate (lbs/cu yd)	Foliar color rating[2] 60 DAP[3] Red maple	Dwarf nandina	120 DAP Red maple	Dwarf nandina	Hosta
0	0.0	4.7	3.5	4.3	4.0	4.0
5	0.0	3.3	3.4	4.0	3.4	3.9
10	0.0	3.1	2.7	3.0	2.2	3.7
0	1.5	5.0	3.6	4.5	4.0	4.0
5	1.5	4.7	4.1	4.2	4.0	4.0
10	1.5	4.7	3.9	4.3	4.1	3.9

[1] Medium was pine park:peat moss (3:1 by volume) . [2] Foliar color rating based on a scale of 1- 5 with 1 being bleached, 2 chlorotic, 3 light green, 4 medium green, and 5 dark green foliage. [3] DAP = days after potting.

In summary, the addition of dolomitic limestone to the potting medium increased the size of dwarf nandina, hosta, chrysanthemum, and both holly species, while it had no affect on azalea or red maple. However, the quality of red maple, dwarf nandina, and hosta species declined with increasing amounts of dolomitic limestone when micronutrients were not supplemented in the potting medium. This work suggests that while dolomitic limestone is an inexpensive amendment, routine incorporation in substrates without micronutrients supplements may be unnecessary.

Dolomitic Limestone Form and Rate Affect Container-grown Woody Ornamentals

D.J. Eakes, J.L. Sibley, C.H. Gilliam, B.H. Murphree, and J.W. Olive

Dolomitic limestone at rates of 5 to 10 pounds per cubic yard of medium is commonly added to pine bark or peat moss based organic growing media used in container production of woody ornamental plants. Dolomitic limestone is used as an amendment to adjust medium pH and serve as a source of calcium and magnesium. Plant growth responses to the addition of dolomitic limestone vary according to the ornamental species being grown and rate of liming material applied.

Dolomitic limestone is usually preplant incorporated as a finely ground powder. Uniform distribution of the liming material throughout the growing medium during mixing is questionable. Pelletized dolomitic limestone has increased in popularity over the past few years for soil application of lime due to its ease of handling. No information is available on how pelletized lime compares to ground dolomitic limestone as a liming material in a container growing medium. Therefore the objective of this study was to compare pelletized dolomitic limestone with finely ground dolomitic limestone as a woody ornamental container medium amendment.

METHODS

In April 1996, uniform liners of 'Soft Touch' Japanese holly and 'Fashion' azalea were potted in a pine bark:peat moss (3:1 by volume) substrate amended with 14 pounds of Osmocote 17-7-12 and 1.5 pounds of Micromax per cubic yard. Treatments consisted of dolomitic limestone pre-plant incorporated at the rate of 5 or 10 pounds per cubic yard of medium as finely ground or pelletized dolomitic limestone. A control with no dolomitic limestone added to the growing medium was also evaluated for a total of five treatments. All plants were produced under overhead irrigation in trade gallon containers placed in full sun. Canopy growth index (GI) [(height + width1 + width2)/3 where width1 is at the widest point, and width2 is perpendicular to width1] and foliar color ratings (FCR) were determined monthly. Foliar color ratings were on a scale of 1-5 with 1 being bleached foliage and 5 being dark green. Medium leachate solutions were collected to determine pH on 7, 42, 60, 120, 180, 180, 240, 270, and 330 days after potting (DAP).

RESULTS

Medium solution pH increased with increasing rate of dolomitic limestone regardless of lime form (Table 1).

Table 1. Influence of Dolomitic Limestone Form and Rate on Medium Solution pH

Limestone formulation	Rate (lbs/cu yd)	Days after potting 7	42	60	120	180	240	270	330
Control	0	3.97	4.49	4.12	4.37	4.29	4.39	4.04	3.82
Pelletized	5	5.45	5.58	4.99	4.87	4.91	4.94	4.44	3.96
Pelletized	10	5.84	6.18	5.72	5.48	5.53	5.57	5.49	4.88
Finely ground	5	5.99	6.06	5.46	4.90	4.82	4.86	4.48	3.94
Finely ground	10	6.44	6.71	6.47	6.44	6.33	6.05	6.25	6.06

Finely ground dolomitic limestone increased medium solution pH to a greater extent than pelletized lime when applied at a similar rate, and differences in pH increased as lime rate increased. Addition of ground dolomitic limestone at 10 pounds per cubic yard of medium reduced FCR by 60 DAP and GI 330 DAP for 'Fashion' azalea compared to all other treatments (Table 2). The 10 pounds of finely ground dolomitic limestone treatment was the only treatment that had a medium solution pH that rose above 6.5 and remained above 6.0 for the duration of the experiment. All other treatments had medium solution pHs below 6.0 by 60 DAP. Amending with dolomitic limestone had no affect on FCR of 'Soft Touch' Japanese holly, regardless of the product form or rate. In contrast, the addition of dolomitic limestone at 10 pounds per cubic yard of medium in the pelletized form or at 5 pounds in the ground form per cubic yard of medium increased the GI for 'Soft Touch' Japanese holly when compared to the unlimed control plants. Holly plant size in all other treatments was similar.

In summary, finely ground dolomitic limestone was more effective in increasing medium solution pH when compared to the pelletized material. Finely ground dolomitic limestone preplant incorporated at the rate of 10 pounds per cubic yard of medium reduced the size and quality of 'Fashion' azalea. Lime form and rate had no affect on the foliar color of 'Soft Touch' Japanese holly plants but the addition of pelletized dolomitic limestone at 10 pounds per cubic yard or ground dolomitic limestone at 5 pounds per cubic yard of medium increased plant size.

Table 2. Influence of Dolomitic Limestone Form and Rate on 'Fashion' Azalea Foliar Color and Growth

Limestone formulation	Rate (lbs/cu yd)	Foliar color rating[1] 60 DAP[3]	Growth indices (in)[2] 330 DAP
Control	0	5.0	20.3
Pelletized	5	5.0	20.0
Pelletized	10	4.9	19.5
Finely ground	5	4.8	20.3
Finely ground	10	3.9	17.9

[1] Foliar color rating based on a scale of 1- 5 with 1 being bleached, 2 chlorotic, 3 light green, 4 medium green, and 5 dark green foliage.
[2] Growth index = (height + width1 + width2)/3. Width1 is at widest point and width2 is perpendicular to width1.
[3] DAP = days after potting.

Non-traditional Container Types Affect Growth of Wetland Plants

D.J. Eakes, G.J. Keever, C.H. Gilliam, and P.A. Merritt

As the value and function of wetlands become better understood, national policies are being developed requiring wetland preservation and restoration. In the past, most plants used for the purpose of wetland mitigation and restoration were harvested from native stands. Commercial production of these plants would prevent unnecessary environmental degradation. Along with the movement to maintain and restore wetlands, the popularity of water gardening in home and commercial landscapes has increased. Nursery owners have an opportunity to take advantage of this growing market by contract production of wetland plants and/or the production of ornamental wetland/aquatic plants for the landscape.

Although extensive research covering culture of typical woody and herbaceous container-grown plant production is available, there is little literature concerning container production of wetland plants. The objective of this work was to determine the effects of container hole position on the production of four wetland plant species.

METHODS

On May 23, four wetland species—canna, iris, smooth cordgrass, and soft stem rush—were planted into trade gallon containers of Metro Mix 500. The five container types used were (1) no holes, (2) four holes located at the bottom of the container, (3) four holes half way (3.2 inches) up the container side wall, (4) four holes three-quarters of the way (4.7 inches) up the container side wall, and (5) pot-in-pot which consisted of a trade gallon pot with four holes at the bottom placed in a full gallon socket pot lined with poly. All plants were fertilized with two Sierra (18-6-12 plus minor nutrients) tablets (2.39 grams of nitrogen) per pot placed just below each transplant. Plants were watered to 100% container capacity daily, and grown in a double wall poly greenhouse at a minimum set temperature of 65°F.

Plant growth index [(height + width1 + width2)/3, where width1 is the widest width, and width2 is perpendicular to width1], total shoot number (or leaf number of soft rush), visual shoot rating (a scale of 0-5 with 0 being dead and 5 being a large, healthy plant), and medium solution pH and soluble salt concentration were determined 60 days after potting (DAP) for each plant. Due to the rapid growth of canna, visual root ratings and shoot dry weights were also determined 60 DAP. At 90 DAP growth indices, total shoot numbers, and root and shoot visual ratings were determined for iris, rush, and smooth cordgrass. Plants were then harvested to determine shoot dry weights.

RESULTS

Growth indices for canna 60 DAP were greater for pot-in-pot plants and plants produced in pots with holes half way up the container side walls (Table 1). Plants produced in containers with holes three-fourths of the way up the container side wall had the lowest growth indices. Plants in the pot-in-pot containers had the highest visual shoot dry weights and plants produced in traditional containers with holes at the bottom had the lowest shoot dry weights. Visual root and shoot ratings for canna were highest for plants in the pot-in-pot treatment. Visual ratings were similar for cannas in all other treatments. Soft stem rush grown in the pot-in-pot treatment had higher growth indices, higher leaf and root ratings, and greater shoot dry weights than plants grown in the other four pot types (Table 2). There were no treatment differences with any growth parameters for smooth cordgrass or iris.

Table 1. Influence of Container Hole Position or Type on Growth of Canna 60 Days After Potting

Treatment	Growth indices (in)	Shoot rating[1]	Root rating[2]	Top dry weight (g/plant)
No holes	23.7	2.4	2.2	57.6
Bottom	23.9	2.7	2.9	47.8
1/2 up side	25.3	2.7	2.4	71.3
3/4 up side	21.0	3.1	2.6	64.5
Pot-in-pot	26.4	4.1	4.6	83.7

[1] Shoot rating based on a scale of 0 - 5 with 0 being dead and 5 being a large, dense, dark green plant.
[2] Root rating on a scale of 1- 5 with 1, 2, 3, 4, and 5 being 0%, 25%, 50%, 75%, and 100% root coverage, respectively at the container-rootball interface.

Table 2. Influence of Container Hole Position or Type on Growth of Soft Stem Rush 90 Days After Potting

Treatment	Growth indices (in)	Leaf rating[1]	Root rating[2]	Top dry weight (g/plant)
No holes	29.2	3.0	3.0	52.6
Bottom	26.8	2.7	3.0	40.4
1/2 up side	26.0	2.9	3.1	47.0
3/4 up side	26.8	2.6	3.1	48.3
Pot-in-pot	31.2	4.0	5.0	88.7

[1] Leaf rating based on a scale of 0 - 5 with 0 being dead and 5 being a large, dense, dark green plant.
[2] Root rating based on a scale of 1- 5 with 1, 2, 3, 4, and 5 being 0%, 25%, 50%, 75%, and 100% root coverage, respectively at the container-rootball interface.

Although medium solution pH and soluble salt ranges varied among species, treatment differences were similar. Lower soluble salts and higher pH levels were observed in pot-in-pot medium solution samples compared to samples from the other pot types. Medium solution pH averaged 5.7 for pot-in-pot soft stem rush while the remaining four pot treatments averaged 5.0 and ranged from 4.6 to 5.3. Soluble salt levels in pots with no holes, holes half way up the container side wall, and holes three-quarters up the container side wall ranged from 4.0 to 5.5 dS/m, while salt levels in containers with holes at the bottom and pot-in-pot containers averaged 0.5 dS/m.

In summary, canna and soft stem rush grown in a pot-in-pot system were larger, higher quality, more marketable plants than those grown in conventional containers regardless of drain hole position.

Effects of Cyclic Microirrigation and Copper Container Treatments on the Growth of White Cedar

Robert C. Trawick, Ken M. Tilt, Harry G. Ponder, and Gary J. Keever

With the prospect of increasing regulation of water usage in container nurseries, irrigation system efficiency has become of prime importance to the nursery industry. In typical overhead irrigation, water losses of 75-90% are common. Cyclic, or intermittent, irrigation is a relatively new practice where a plant's daily allotment of water is broken up into a series of irrigation events. Recent research indicates that cyclic irrigation can increase irrigation efficiency by as much as 38% compared to irrigation applied once per day without adversely affecting plant growth.

Another common problem in container nurseries is root-bound plants resulting from plants growing too long in a container or putting a vigorously rooting plant in a container that is improperly sized for the rapid growth of the roots. Root-bound plants are slower to establish following transplanting into a larger container or the landscape. Copper applied to the inner surface of containers is effective in reducing surface root development by chemically pruning roots of the plant as they encounter the container wall. Currently there are two copper treated containers available in the nursery industry, Spin-Out™ (Spin-Out™, Lerio Inc. Mobile, Alabama) containers coated with copper hydroxide and Root Right™ (Nursery Supplies, Chambersburg, Pennsylvania) containers impregnated with copper chloride

The objectives of this project were to test the effects of cyclic microirrigation on growth of Atlantic white cedar and to evaluate the effects of two commercial container copper treatments on root growth.

METHODS

Seventy-two Atlantic white cedar (*Chamaecyparis thyoides*) were planted in 3-gallon containers in April 1998. Of the 72 plants, 24 were planted into Root Right™ containers, 24 were planted into Spin-Out™ containers, and 24 were planted into untreated containers. The medium used was an 80:20 mixture of pinebark:peat moss amended with 5 pounds of dolomitic limestone and 7 pounds of Osmocote 15-9-11 plus minors per cubic yard.

Just after potting, ten randomly selected containers were saturated with water, allowed to drain for 20 minutes, and weighed to determine maximum water-holding capacity or "container capacity." Containers were weighed 1 day later to determine the amount of water utilized by the plant or lost to evaporation (container capacity - weight after 1 day). The difference in the weights gave the approximate volume of water to apply on a daily basis. This volume was applied to the plants daily in one application, or the volume was divided into three or six equal applications. The volume of water applied was adjusted monthly throughout the growing season. Irrigation was applied through maxi-jet spray stakes. Height, canopy widths, caliper measurements, and root ratings were recorded monthly from April through November.

RESULTS

Plants under cyclic irrigation had a larger growth index, [(height + width 1 + width 2)/3, where width1 is the widest width and width2 is perpendicular to width1], and caliper than those plants watered once per day (Figures 1 and 2). There were no differences in growth between the two cyclic treatments (three and six times per day).

Container treatments had several effects on plant growth (Figures 3 and 4). Plants treated with copper had a lower root rating (less root-bound) than those plants grown in the copper-free containers. Plants grown in Spin-Out™ containers had a lower root rating than those plants grown in the Root Right™ containers. Plants grown in the copper-treated containers had a larger caliper than plants grown in copper-free containers.

In summary, this study shows cyclic irrigation to have a positive effect on growth of Atlantic white cedar. While Spin-Out™ containers were more effective at controlling root circling than Root Right ™ containers, the Root Right ™ container provided more root control than copper-free containers and effectively prevented the plant from becoming root-bound.

Figure 1. Irrigation effect on growth index of Atlantic white cedar.

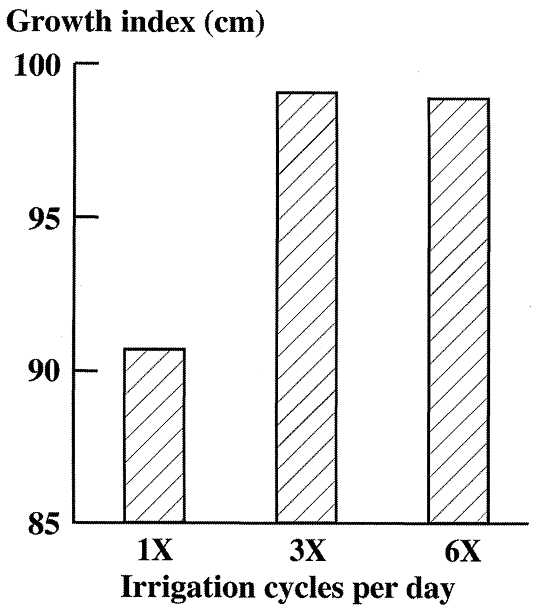


Figure 2. Irrigation effect on caliper of Atlantic white cedar.

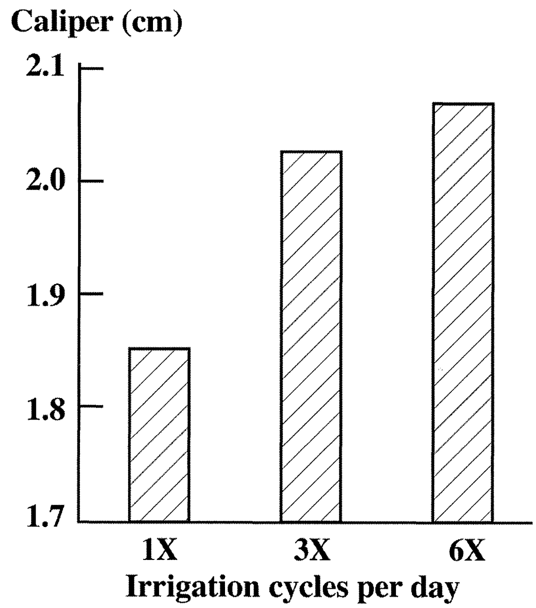


Figure 3. Container effect on root rating of Atlantic white cedar.

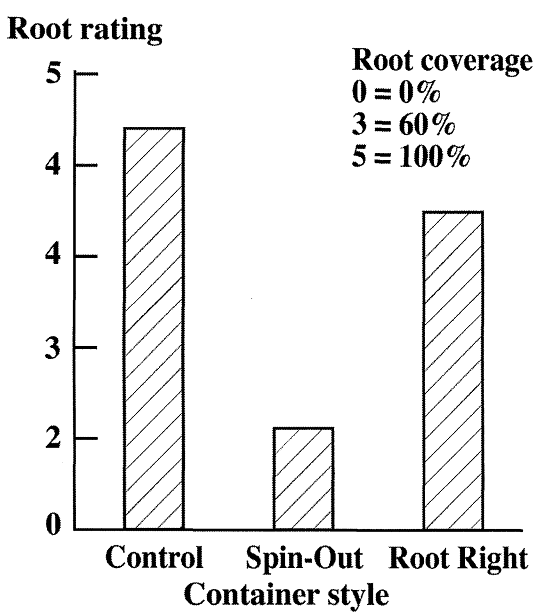


Figure 4. Container effect on caliper of Atlantic white cedar.