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Hypoestes phyllostachya Responds to Growth Regulators

James T. Foley and Gary J. Keever

PINK POLKA DOT PLANT, *Hypoestes phyllostachya* Bak., though usually considered an indoor plant, has the potential to be a popular addition to the herbaceous garden border. The plant has the uncommon characteristic of dark green foliage mottled with bright pink spots. *Hypoestes* forms a loosely branched mound 18 to 24 inches in height and is easily grown from seed. It prefers moist, well-drained soil and full sun. It may also grow in partial shade, producing a more open habit. Pinching is suggested when growing *Hypoestes* to decrease height and encourage branching. Despite pinching, however, the plant has an unkempt appearance that reduces the overall effect. By reducing plant height, a more compact habit may be achieved, concentrating color and thereby increasing the foliage effect.

Chemical growth retardants are commonly applied to bedding plants to produce more compact plants and extend the duration of attractiveness for sales. Reducing height may make *Hypoestes* more attractive to consumers as a pot crop or bedding plant. Paclobutrazol (Bonzi®) is effective in height control of chrysanthemum, geranium, and various other flowering annuals. Chlormequat chloride (Cycocel®) has growth retarding activity on dianthus, geranium, and many ornamental plants. The objective of this experiment was to improve plant quality of *Hypoestes* by suppressing shoot elongation with use of chemical growth retardants.

Seeds of *H. phyllostachya* Pink Splash were sown on December 11, 1987, in flats of Pro-Mix BX® drenched with benomyl fungicide and placed under intermittent mist (5 seconds per 10 minutes) in a double polyethylene greenhouse with minimum day/night temperatures of 70°F/60°F. Once cotyledons had fully emerged, seedlings were removed from mist on January 8, 1988, and 11 days later were transplanted to 4-inch pots of identical growth medium. Foliar spray treatments were applied just before runoff on February 23, 1988, and consisted of one or two applications of paclobutrazol at 25, 50, or 100 mg per liter and one or two applications of chlormequat chloride at 3,500 mg per liter; second applications were made 2 weeks after initial treatment. An untreated control was included for comparison. Buffer-X® was added as a surfactant at 0.2 percent by volume to spray solutions. Plants were about 1.6 inches tall with about three axillary shoots per plant when treated. The pruned treatment was pinched to one set of true leaves at a height of about 1.2 inches just prior to growth regulator application. Plant height was measured at 2-week intervals beginning 2 weeks after initial application until experiment termination at week 12. Plants were fertilized weekly with 200 mg per liter N from 20-10-20 Peters Peatlite Special®. Plant quality was based on plant size and shape relative to pot size and foliage color.

One and two applications of 3,500 mg per liter chlormequat chloride provided the greatest suppression of growth throughout the experiment when compared to the control, table 1. Plants treated with chlormequat chloride exhibited darker green foliage compared to the control, an effect observed in other plants when this chemical was applied. These high-quality plants were also compact and consistently mounded, making them potentially more attractive to consumers. Four weeks after a single application of each rate of paclobutrazol, plant height was suppressed compared to the

TABLE 1. PLANT HEIGHT OF *HYPOESTES PHYLLOSTACHYA* AS AFFECTED BY GROWTH SUPPRESSANTS AT ONE AND TWO APPLICATIONS

Treatment	Plant height[1], by weeks after treatment				
	2	4	6	8	12
	cm	*cm*	*cm*	*cm*	*cm*
Paclobutrazol-1 application					
25 p.p.m.	4.6	6.1	11.1	19.8	46.3
50 p.p.m.	4.9	5.6	8.7	15.0	36.9
100 p.p.m.	4.7ns[2]	5.1ns	7.0q	10.5q	28.11
Paclobutrazol-2 applications					
25 p.p.m.	5.5	7.1	13.6	23.1	47.9
50 p.p.m.	5.1	5.6	13.3	31.6	31.6
100 p.p.m.	4.6ns	5.4ns	7.1q	11.2q	30.9c
Chlormequat chloride-1 application					
3,500 p.p.m.	4.7	5.0	6.5	8.8	22.6
Chlormequat chloride-2 applications					
3,500 p.p.m.	4.1	4.4	5.7	7.6	22.0
Control	6.2	8.8	18.6	29.0	53.3
LSD[3]	1.3	1.9	4.3	5.7	5.1

[1]Measurements in the tables are given in centimeters (2.5 cm = 1 inch).
[2]l = linear; q = quadratic; c = cubic; ns = not significant; control included in regression.
[3]Mean separation within columns by a protected Fisher's least significance test, P = 0.05; LSD used for comparisons among growth retardants.

control and height decreased as rate increased with either one or two applications of paclobutrazol. Leaf color of paclobutrazol-treated plants did not vary from the control and plants were loosely branched with a sprawling habit. Due to this loose branching habit, paclobutrazol-treated plants were of lower quality compared to the chlormequat chloride treatment.

One or two applications of chlormequat chloride at 3,500 mg per liter acts to enhance the pink spots against the green background of the leaves, while reducing plant height. This results in a low, mounded plant and concentrates foliage color, making *Hypoestes* more effective in mass plantings.

Foley is Graduate Student and Keever is Associate Professor of Horticulture.

Response of Two Forcing Azalea Cultivars to Bonzi and B-Nine Applications

Gary J. Keever

FLORIST AZALEAS respond to long photoperiods, warm temperatures, ample moisture, and nutrients with rapid vegetative growth. This rapid growth necessitates frequent pruning to produce well-branched plants before flower buds initiate and develop. Short days and growth retardants hasten flower initiation and bud development. Daminozide (B-Nine®) and chlormequat (Cycocel®) are the principal growth retardants applied to florist azaleas. Complete flower bud development requires chilling, followed by warm temperatures during forcing.

An excessive period from final pruning to the start of forcing usually increases the development of vegetative axillary shoots (bypass shoots) during forcing. These shoots often must be removed by the grower or florist before marketing. Bypass shoots are a particular problem on cultivars forced in January or later. In previous research, paclobutrazol (Bonzi®), which is not labeled for florist azaleas, effectively suppressed bypass shoot development of forcing azaleas. The objective of this test was to determine if the plant growth retardant currently labeled for florist azaleas, daminozide, or the retardant paclobutrazol could control bypass shoots if applied just prior to or immediately after chilling.

Uniform liners of Dorothy Gish White (mid-season, white) and Roadrunner (late-season, red, which readily forms bypass shoots) florist azaleas were potted into 6-inch containers of amended peat moss:shavings (3:2, by volume) growth medium March 1987. Plants were placed in a double polyethylene greenhouse in a commercial nursery in Semmes, Alabama, and maintained according to common commercial practices. Plants were pruned in July and sprayed the following day with 3,627 p.p.m. dikegulac (Atrinal®) to increase lateral branching. Six and 8 weeks later, plants were sprayed with 3,000 p.p.m. daminozide to suppress vegetative growth and hasten flower bud formation. Plants were held at 40°F minimum temperature in a polyethylene greenhouse until February 17, 1988, when they were transferred to a double polyethylene greenhouse at Auburn University and maintained at the same minimum temperature until treatments were applied.

TABLE 2. GROWTH REGULATOR TYPE, TIME OF APPLICATION, AND RATE EFFECTS ON BYPASS SHOOT AND FLOWER DEVELOPMENT OF DOROTHY GISH WHITE AZALEA

Treatment	Bypass shoots		Days to full bloom[2]	Bloom diameter[3]
	Number	Length[1]		
		cm	*No.*	*cm*
Paclobutrazol				
Applied 1 day before cooling: 50 p.p.m.	4.2	1.5	25.4	5.8
100 p.p.m.	5.2	1.4	27.0	6.0
150 p.p.m.	3.6	1.2	27.0	5.8
Applied 1 day after cooling: 50 p.p.m.	5.7	2.7	24.7	5.9
100 p.p.m.	6.0	2.6	25.4	5.8
150 p.p.m.	5.4	1.8	28.8	5.9
Daminozide				
Applied 1 day before cooling: 3,000 p.p.m.	9.1	3.4	25.0	5.9
Applied 1 day after cooling: 3,000 p.p.m.	7.5	3.4	24.0	5.9
Control	7.7	3.5	22.3	6.3
Significance of contrasts[4]				
Before vs. after	ns	*	ns	ns
Paclobutrazol vs. daminozide	*	*	*	ns
Paclobutrazol vs. control	*	*	*	*
Daminozide vs. control	ns	ns	*	*
Significance of paclobutrazol rate[5]	l	l	l	c
Time x rate interaction	ns	ns	ns	ns

[1]Mean length of three longest bypass shots on each plant.
[2]Days to full bloom beginning when plants were moved from cooler to greenhouse.
[3]Mean of three randomly selected blooms per plant.
[4]ns = not significant; * = significant at 5 percent level.
[5]Control included in regression analysis; l = linear, c = cubic.

Treatments consisted of foliar sprays of two growth retardants applied either 1 day before cooling or 1 day after removing plants from the cooler. A single paclobutrazol spray of 50, 100, or 150 p.p.m. or a single daminozide spray of 3,000 p.p.m. was applied. A nontreated control was included for comparison. Pre-cooling treatments were applied on February 23, 1988, and all plants were subsequently cooled in the dark at 38°F for 4 weeks. Plants were removed from the cooler on March 24 and placed under shade (47 percent light exclusion) in a double polyethylene greenhouse at 68°F minimum night temperature. On March 25, post-cooling treatments of the same rates of paclobutrazol and daminozide were applied. After 3 days, shade cloth was removed and plants were forced in full sun.

Time until flowering was determined from the time plants were removed from the cooler until 75 percent of flowers were fully open. At this time, flower number and diameter (three randomly selected blooms per plant) and bypass shoot number and length (mean length of the three longest bypass shoots on each plant) were determined.

Bypass shoot number and length decreased as paclobutrazol rate increased for both cultivars, tables 2 and 3. Applying paclobutrazol after cooling was as effective in controlling bypass shoot development as applying paclobutrazol before cooling, with the exception of shorter bypass shoots on Dorothy Gish White treated before cooling. Plants treated with paclobutrazol developed fewer bypass shoots than did daminozide-treated plants or control plants, which developed similar numbers of bypass shoots. Paclobutrazol suppressed bypass shoot length of both cultivars compared to the control and of Dorothy Gish White, but not Roadrunner, compared to daminozide. Daminozide was more effective in suppressing bypass shoot length than the control on Roadrunner but not on Dorothy Gish White.

Days to flower for both cultivars increased with increasing rates of paclobutrazol, from 22 days to 29 days for Dorothy Gish White and from 33 days to 41 days for Roadrunner. The time paclobutrazol was applied relative to cooling did not influence days to flower. Paclobutrazol delayed flowering compared to daminozide and the control, and daminozide delayed flowering of Dorothy Gish White compared to the control. Bloom diameter either decreased (Dorothy Gish White) or was not affected (Roadrunner) by increasing rates of paclobutrazol. The decrease with Dorothy Gish White was from 2.5 to 2.3 inches. Daminozide application also resulted in smaller blooms on Dorothy Gish White compared to the control. Neither time of application (before or after cooling) nor growth regulator (paclobutrazol vs. daminozide) affected bloom diameter of either cultivar.

Bypass shoot development is more extensive when there is excessive time from final pinch to forcing, particularly on certain cultivars forced in January or later for the florist trade. Paclobutrazol applications of 50, 100, or 150 p.p.m. suppress bypass shoot development, while minimally affecting bloom size. However, flowering is likely to be delayed. Applications made just prior to or immediately after cooling were equally effective in controlling bypass shoot development. Daminozide is less effective than paclobutrazol in controlling bypass shoot development. Paclobutrazol may provide the grower of forcing azaleas an additional tool for controlling bypass shoots on late season cultivars.

Keever is Associate Professor of Horticulture.

TABLE 3. GROWTH REGULATOR TYPE, TIME OF APPLICATION, AND RATE EFFECTS ON BYPASS SHOOT AND FLOWER DEVELOPMENT OF ROADRUNNER AZALEA

Treatment	Bypass shoots		Days to full bloom[2]	Bloom diameter[3]
	Number	Length[1]		
		cm	*No.*	*cm*
Paclobutrazol				
Applied 1 day before cooling: 50 p.p.m.	11.4	5.6	35.7	5.8
100 p.p.m.	12.3	5.7	38.6	5.8
150 p.p.m.	12.5	5.8	37.5	5.9
Applied 1 day after cooling: 50 p.p.m.	14.5	5.9	41.0	5.9
100 p.p.m.	10.3	5.9	37.6	5.8
150 p.p.m.	12.3	6.0	40.7	5.9
Daminozide				
Applied 1 day before cooling: 3,000 p.p.m.	15.3	5.4	32.4	5.9
Applied 1 day after cooling: 3,000 p.p.m.	18.7	5.3	33.0	5.7
Control	17.3	6.9	32.5	5.8
Significance of contrasts[4]				
Before vs. after	ns	ns	ns	ns
Paclobutrazol vs. daminozide	*	ns	*	ns
Paclobutrazol vs. control	*	*	*	ns
Daminozide vs. control	ns	*	ns	ns
Significance of paclobutrazol rate[5]	q	q	q	ns
Time x rate interaction	ns	ns	ns	ns

[1]Mean length of three longest bypass shoots on each plant.
[2]Days to full bloom beginning when plants were moved from cooler to greenhouse.
[3]Mean of three randomly selected blooms per plant.
[4]ns = not significant; * = significant at 5 percent level.
[5]Control included in regression analysis; q = quadratic; ns = not significant.

Postproduction and Marketing of *Nandina domestica* as a Potted Foliage Plant

Bridget K. Behe, C. Fred Deneke, and Gary J. Keever

PRODUCTION of foliage plants has stabilized in the past 10 years, indicating that the market has peaked in sales for many varieties currently on the market. New or improved products are often introduced to "restart" the life cycle for many products, generating more sales and more profits. For foliage plants, the introduction of new varieties may stimulate sales and profits for plant retailers. According to an industry expert, a high-volume supermarket floral department can expect to sell 6 to 12 four-inch foliage plants each week.

Nandina domestica, or nandina, is a frequently planted, woody landscape shrub. The cultivars Harbour Dwarf and San Gabriel have shown promise as interior landscape plants and have potential to be sold through retail outlets, particularly supermarket floral departments. The objectives of this research were to determine the postproduction performance and the market potential for these two cultivars of nandina as potted foliage plants.

To study postproduction performance, tissue-cultured plugs of Harbour Dwarf and San Gabriel nandina were potted on June 1, 1990, in 6-inch containers using a medium of 7 pine bark:1 sand (by volume) amended per cubic yard with 5 pounds dolomitic lime, 1.5 pounds Micromax®, and 14 pounds of Osmocote® 18-6-12. Plants were grown in Mobile, Alabama, under either 30, 47, or 62 percent shade. On October 23, plants were moved to a simulated consumer environment to evaluate postproduction performance. The postproduction environment consisted of an insulated room with fluorescent lamps maintained at an average temperature of 70°F.

Both cultivars of nandina performed well as interior foliage plants for at least 4 months in the simulated consumer environment. There were trends for increased plant width of Harbour Dwarf and increased height of San Gabriel with increasing shade.

To determine the market potential and consumer perception of nandina, plugs of Harbour Dwarf and San Gabriel were planted in a medium as previously described. Plants were grown for 12 to 16 weeks in 4½-inch azalea pots. A care tag was added to the pot to aid customers in the identification and care of the plant. A self-addressed, stamped postcard survey form was attached to the pot, to be completed and returned by the purchaser or gift recipient.

Test plants were sold in two Birmingham, one Auburn, and one Opelika, Alabama, and two Columbus, Ohio, supermarket floral departments. Ten plants of each variety were tested in separate 4-week studies at each location. Harbour Dwarf plants were evaluated from September 25 to October 23, 1990. San Gabriel plants were evaluated from October 23 to November 23, 1990. A total of 60 Harbour Dwarf and 60 San Gabriel plants was distributed to six stores in an 8-week period. Plants were test marketed at a price of $2.99, comparable to the price of other foliage plants in the same size pot.

TABLE 4. PERCENTAGES OF SURVEY RESPONDENTS RATINGS SIX FACTORS CONCERNING THEIR PURCHASES OF *NANDINA DOMESTICA*

Factor	Respondents' rating[1]				
	1	2	3	4	5
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Newness	60	10	5	14	11
Problem free	50	22	10	9	9
Use inside	47	6	22	11	14
Price	38	3	18	12	29
Smallness	35	24	19	11	11
Form	29	26	19	10	16

[1]Rated from most important (1) to least important (5), as an average for Harbour Dwarf and San Gabriel.

Sales of all 4-inch foliage plants averaged 12.2 plants per store per week. Sales of the Nandina cultivars averaged 1.9 plants per store per week. Thus, the new nandina foliage plants captured 16 percent of the market for 4-inch foliage plants.

Forty of 120 postcards were returned (33 percent response rate). Of those responding, 90 percent were female and 10 percent were male. Twenty-six percent had completed a high school education or less, while 44 percent had completed a 4-year college degree or more. The average years of education completed was 14.7. The median age was 49 years. No other demographic information was collected. A majority of consumers, 78 percent, purchased only one nandina at the time of the purchase. Most of the plants purchased were for personal use, 90 percent, while 10 percent were purchased for use as gifts.

Consumers were asked to rate the importance of six characteristics pertaining to the foliage plants: the newness of the plant, the ability to use the plant inside the home, its pest and disease resistance, the small size of the plant, price, and the form of the plant. Attributes were rated as most important by a different percentage of respondents: newness, 60 percent; problem free, 50 percent; use inside, 47 percent; price, 38 percent; small size, 35 percent; and form, 29 percent. Price was rated unimportant by the most respondents (29 percent), while the form of the plant (16 percent) and use inside (14 percent) were rated as unimportant by the most respondents. Thus, when prices of other foliage plants are equal, the newness of the plant was identified as an important factor to a majority of the purchasers.

The consumer perception reported here, combined with the sales data, indicate that the *N. domestica* cultivars Harbour Dwarf and San Gabriel have good potential in the marketplace as interior foliage plants. Their post-production evaluation indicated that they should perform well in an interior environment, and the market information indicates that consumers appreciate them for their newness and are willing to purchase them at a price similar to other foliage plants of the same size.

Behe is Assistant Professor, Deneke is Assistant Professor, and Keever is Associate Professor of Horticulture.

Evaluation of Growth Regulators on Lisianthus as Potted Plants and for Cut Flowers

C. Fred Deneke and Gary J. Keever

LISIANTHUS (*Eustoma grandiflorum*) is a herbaceous plant native to the Central United States that produces flowers over 3 inches in diameter in colors of blue, white, or pink. It is grown both for cut flowers, for which long stems are desirable, and for use as a flowering potted plant, for which compact plant growth is desirable. Therefore, different chemical growth regulators are needed to produce lisianthus for the two uses. The objectives of this research were to evaluate growth retardants for restricting excessive vegetative growth of lisianthus as a potted plant and gibberellic acid for promoting stem elongation for cut flower uses.

Plugs of lisianthus Yodel Blue were potted in 6-inch azalea pots using Pro-mix BX® on March 14, 1990. Plants were pinched to three nodes on April 3. For an evaluation of growth retardants, plants were treated on April 17 with foliar sprays of uniconazole (Sumagic®) or B-Nine®, or a drench of A-Rest®. Additional plants received a foliar spray of gibberellic acid on April 19 to evaluate growth stimulation. Gibberellic acid was reapplied on April 26 and May 3. Plants were fertilized weekly with 300 p.p.m. N from Peters® 20-10-20.

The highest rate of A-Rest produced the shortest flowering plants, followed by the highest rate of Sumagic, table 5. Lower rates of Sumagic, both rates of B-Nine, and the low rate of A-Rest produced plants 15 to 20 inches tall, which were similar to the heights of nontreated plants. Time to flowering was increased by 11 days for the highest rates of Sumagic and A-Rest. Flower diameter and number of flower buds were not influenced by any of the treatments. Lisianthus Yodel Blue can be grown as a flowering potted plant by using either a spray application of 25 p.p.m. Sumagic or a drench of 1.0 mg active ingredient (a.i.) A-Rest per pot. These treatments were judged to produce plants of appropriate height for a flowering potted plant.

TABLE 5. EFFECTS OF THREE GROWTH RETARDANTS ON PLANT HEIGHT AT FLOWERING AND TIME TO FLOWERING FOR LISIANTHUS

Treatment	Plant height	Days to flower
	In.	*No.*
Sumagic		
5 p.p.m.	17.6 ± 2.0[1]	46 ± 3
10 p.p.m.	15.2 ± 3.6	45 ± 2
15 p.p.m.	14.8 ± 4.2	50 ± 3
20 p.p.m.	15.5 ± 3.1	48 ± 2
25 p.p.m.	12.8 ± 4.1	50 ± 2
B-Nine		
2,500 p.p.m.	17.7 ± 3.2	44 ± 3
5,000 p.p.m.	16.0 ± 2.9	44 ± 2
A-Rest		
0.5 mg a.i./pot	16.0 ± 3.4	44 ± 1
1.0 mg a.i./pot	10.9 ± 3.3	50 ± 3
Control	19.5 ± 2.0	39 ± 2

[1]Mean ± standard deviation.

TABLE 6. EFFECTS OF THREE GIBBERELLIC ACID APPLICATIONS ON PLANT HEIGHT AT FLOWERING AND TIME TO FLOWERING FOR LISIANTHUS

Rate, p.p.m.	Plant height	Days to flower
	In.	*No.*
0	21.1 ± 2.5[1]	42 ± 2[1]
25	23.5 ± 2.3	37 ± 2
50	23.6 ± 2.5	36 ± 2
75	24.4 ± 3.1	37 ± 3
100	24.9 ± 1.7	36 ± 2
125	25.6 ± 2.1	41 ± 2
150	22.5 ± 2.2	36 ± 2

[1]Mean ± standard deviation.

Three applications of 25 to 125 p.p.m. gibberellic acid increased plant height by only 2 to 4 inches, table 6. The highest rate of gibberellic acid resulted in plant heights similar to nontreated plants. Time to flowering decreased slightly with the gibberellic acid-treated plants. Flower diameter and number of flower buds were similar for all treatment rates. Gibberellic acid appears to have limited usefulness in increasing stem lengths of lisianthus Yodel Blue for use as cut flowers.

Deneke is Assistant Professor and Keever is Associate Professor of Horticulture.

Uniconazole Suppresses Bypass Shoot Development and Alters Flowering of Two Forcing Azalea Cultivars

Gary J. Keever and William J. Foster

GROWTH RETARDANTS are commonly applied to forcing azaleas to suppress internode elongation, promote flower bud initiation and development, and inhibit the growth of vegetative shoots that develop basipetally to flower buds (bypass shoots). Daminozide (B-Nine®) and chlormequat chloride (Cycocel®) are the principal growth retardants applied to forcing azaleas, both of which have undesirable side effects: delayed flowering, smaller flower size, and greater bypass shoot development for daminozide and delayed flowering and smaller plant size for chlormequat chloride.

Triazole inhibitors, a relatively new group of plant bioregulants represented by paclobutrazol (Bonzi®) and uniconazole (Sumagic®), have growth retardant activity on a wide range of crop species. Paclobutrazol sprays of 150 and 200 p.p.m. controlled bypass shoot development, increased flower number and size, and decreased forcing time of forcing azaleas when compared to daminozide. The objective of this study was to compare the effects of uniconazole, a less active triazole growth retardant, on bypass shoot development and flowering of forcing azaleas with daminozide and paclobutrazol.

Uniform liners of Redwings and Gloria azaleas were potted December 16, 1988, into 7½-inch azalea pots of amended 3 sphagnum peatmoss:2 softwood shavings (by volume) growth medium. Plants were placed in a double polyethylene greenhouse in a commercial azalea nursery in Semmes, Alabama, and maintained according to common commercial practices. Plants were sheared on March 22 and June 25, 1989; 1 day after each shearing, plants were sprayed with dikegulac to increase lateral branching. Plants were transferred to an outdoor shade structure July 20. The following treatments were applied on September 15: single uniconazole sprays of 0, 5, 10, 15, 25, 50, 75, 100, 150, and 200 p.p.m., single paclobutrazol sprays of 150 or 200 p.p.m., and a daminozide spray of 3,000 p.p.m. repeated 1 week later.

Plants were cooled in the dark at 39°F for 6 weeks beginning November 1. Plants were removed from the cooler on December 13 and forced into flower in an unshaded double polyethylene greenhouse. Time until flowering was determined from the time plants were removed from the cooler until flowers were fully open. At that time, flower number and diameter (three randomly selected flowers per plant) and bypass shoot number and length (mean length of the three longest bypass shoots of each plant) were determined.

Bypass shoot number and length of Gloria and Redwings decreased with increasing concentrations of uniconazole, tables 7 and 8. At concentrations above 50 p.p.m., essentially no bypass shoots developed on either cultivar. Plants treated with paclobutrazol sprays of 150 or 200 p.p.m. developed bypass shoot numbers and lengths similar to uniconazole sprays of 10 p.p.m. or less. Gloria sprayed with daminozide exhibited more bypass shoots than plants sprayed with uniconazole or paclobutrazol, or the control plants. Bypass shoot numbers and lengths of Redwings treated with daminozide were similar to those of paclobutrazol-treated plants and plants sprayed with the lower concentrations of uniconazole.

Days to flower for both cultivars increased with increasing concentrations of uniconazole. The delay in flowering was most pronounced when plants were sprayed with uniconazole concentrations of 50 p.p.m. or higher. Comparisons of days to flower among growth retardants varied with cultivar. Days to flower was similar when Redwings were sprayed with daminozide, paclobutrazol, or 25 p.p.m. or lower uniconazole. Days to flower of Gloria was similar for plants sprayed with daminozide or 150 p.p.m. or lower uniconazole, but greater than that of plants treated with 150 p.p.m paclobutrazol.

Flower number increased (Gloria) or was minimally affected (Redwings) by lower concentrations of uniconazole when compared to the control; flower numbers of plants treated with uniconazole decreased dramatically at concentrations higher than 75 p.p.m. Paclobutrazol or daminozide sprays resulted in similar flower numbers to uniconazole sprays of 75 p.p.m. or lower, but more flowers than on plants treated with the three highest concentrations of uniconazole.

Flower diameter increased slightly (Redwings) or was not affected (Gloria) by increasing concentrations of uniconazole. Flower diameters of plants treated with

TABLE 7. PLANT GROWTH RETARDANT EFFECTS ON BYPASS SHOOT AND FLOWER DEVELOPMENT OF GLORIA AZALEA

Treatment	Bypass shoots		Days to open flowers[2]	Flowers	
	Number	Length[1]		Number	Diameter[3]
		cm	*No.*		*cm*
Uniconazole					
5 p.p.m.	2.1	3.0	41	359	6.7
10 p.p.m.	3.1	1.8	40	307	7.0
15 p.p.m.	2.0	1.8	42	323	6.9
25 p.p.m.	.7	1.4	44	336	6.7
50 p.p.m.	1.3	1.7	46	333	7.2
75 p.p.m.	.0	-	47	347	6.6
100 p.p.m.	.0	-	49	283	7.2
150 p.p.m.	.0	-	49	215	7.1
200 p.p.m.	.0	-	55	142	7.0
Significance of rate[4]	q	q	c	c	ns
Paclobutrazol					
150 p.p.m.	1.0	3.2	39	332	6.8
200 p.p.m.	1.9	2.8	41	338	7.1
Daminozide					
3,000 p.p.m.	7.4	3.6	45	312	7.1
Control	2.0	4.9	37	315	6.8
LSD[5]	3.5	1.6	4.6	59	-[6]

[1]Mean length of three longest bypass shoots on each plant.
[2]Days to full bloom beginning when plants removed from cooler to greenhouse.
[3]Mean of three randomly selected blooms per plant.
[4]Significance of regression analysis at P=0.05: q=quadratic, c=cubic, ns=nonsignificant.
[5]Mean separation within columns by a protected Fisher's least significance test, P=.05; LSD used for comparisons among growth retardants.
[6]F value not significant.

TABLE 8. PLANT GROWTH RETARDANT EFFECTS ON BYPASS SHOOT AND FLOWER DEVELOPMENT OF REDWINGS AZALEA

Treatment	Bypass shoots		Days to open flowers[2]	Flowers	
	Number	Length[1]		Number	Diameter[3]
		cm	*No.*		*cm*
Uniconazole					
5 p.p.m.	3.0	2.5	44	274	7.3
10 p.p.m.	2.8	2.8	45	275	7.4
15 p.p.m.	2.5	1.7	46	268	7.2
25 p.p.m.	2.1	1.6	48	268	7.1
50 p.p.m.	1.8	1.1	53	273	7.2
75 p.p.m.	.5	1.0	56	249	7.5
100 p.p.m.	.0	-	60	215	7.5
150 p.p.m.	.0	-	60	158	7.1
200 p.p.m.	.0	-	63	148	7.3
Significance of rate[4]	c	q	c	c	l
Paclobutrazol					
150 p.p.m.	3.6	2.8	44	311	7.3
200 p.p.m.	4.5	2.7	46	260	6.9
Daminozide					
3,000 p.p.m.	4.4	3.1	46	260	7.3
Control	5.5	3.5	46	267	6.9
LSD[5]	3.4	1.1	3.9	46	0.4

[1]Mean length of three longest bypass shoots on each plant.
[2]Days to full bloom beginning when plants removed from cooler to greenhouse.
[3]Mean of three randomly selected blooms per plant.
[4]Significance of regression analysis at $P=0.05$: c=cubic, q=quadratic, l=linear.
[5]Mean separation within columns by a protected Fisher's least significance test, $P=.05$; LSD used for comparisons among growth retardants.
[6]F value not significant.

paclobutrazol or daminozide were similar to each other and to those of uniconazole-treated plants.

Reductions in bypass shoot number and length of Redwings occurred with uniconazole concentrations as low as 5 p.p.m.; concentrations of 25 p.p.m. and 10 p.p.m. were required to achieve a similar reduction in bypass shoot number and length, respectively, of Gloria. Flowering was minimally delayed with the lower concentrations of uniconazole, but was delayed a week or longer with concentrations of 50 p.p.m. or higher. Flowering, as indicated by flower number and diameter, was enhanced with lower concentrations of uniconazole, but flower number was greatly reduced with concentrations above 75 p.p.m.

Uniconazole sprays were much more effective in controlling bypass shoots than paclobutrazol sprays of similar concentrations or than two daminozide sprays of 3,000 p.p.m. Daminozide was the least effective retardant in suppressing bypass shoot development of Gloria, but similar in effect to paclobutrazol and the lower concentrations of uniconazole when applied to Redwings.

Keever is Associate Professor of Horticulture and Foster is former Superintendent of the Ornamental Horticulture Substation.

Alice du Pont *Mandevilla* Responds to Sumagic

Gary J. Keever and C. Fred Deneke

THE GENUS *Mandevilla* consists of more than 100 species of tropical and subtropical twining vines and shrubs. Alice du Pont, the most widely available cultivar of *Mandevilla*, is grown for greenhouse use or as a horticultural annual in temperate areas, photo 1 (page 18). The cultivar blooms over a long season and is useful for arbors, trellises, or other supports about which the stems can twine.

The vigorousness of Alice du Pont creates production problems for the grower since consumers are interested in manageable plants in flower. To produce flowering plants, growers frequently contend with excess vegetative growth that twines around other plants and structures. Sumagic®, an experimental growth regulator, has effectively suppressed growth of bedding and pot plants. This research investigated the effects of single or multiple applications of Sumagic on vegetative growth and flowering of Alice du Pont *Mandevilla.*

In two experiments conducted in 1989, rooted cuttings of Alice du Pont were potted into #1 containers of amended 7 pine bark:1 sand. Plants were pruned to two nodes before applying Sumagic and were fertilized weekly with 300 p.p.m. N from 20-10-20. Plant height

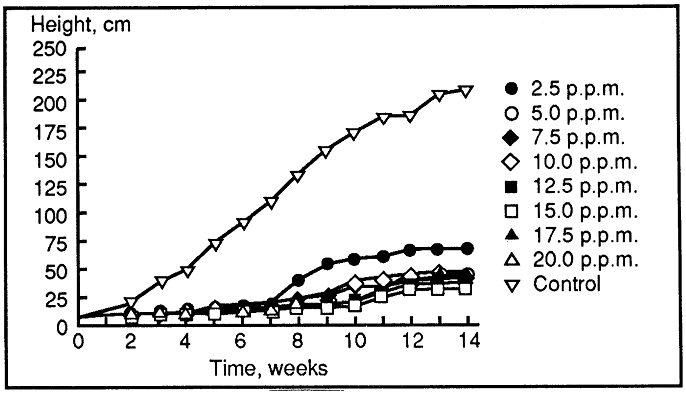

FIG. 1. Height of Alice du Pont *mandevilla* in response to multiple Sumagic applications reapplied as needed.

was measured weekly until plants were in full flower, when flower diameter and days to flower were determined.

In preliminary work, a single application of 30 p.p.m. or higher Sumagic retarded growth excessively for at least 6 weeks, after which plants began to exhibit normal growth. All rates of Sumagic induced leaf cupping, delayed flowering, and reduced bloom size. In the first experiment, one or two applications of 0, 5, 10, 15, or 20 p.p.m. Sumagic were applied. The second application was applied to all treatments (rates) when plants treated with 10 or 15 p.p.m. began to regrow normally. In the second experiment, applications of Sumagic from 0 to 20 p.p.m. in 2.5-p.p.m. increments were repeated as necessary when plants within a treatment (rate) resumed a normal growth pattern.

In the first experiment, single applications of 5, 10, 15, or 20 p.p.m. Sumagic did not provide acceptable control of internode elongation. With two applications of Sumagic, 5 p.p.m. was inadequate, 10 and 15 p.p.m. were acceptable, and 20 p.p.m. was excessive in controlling shoot elongation. In the second experiment, multiple applications of all tested rates of Sumagic effectively suppressed elongation, figure 1. As the concentration of Sumagic increased, the interval between applications increased from 28.5 days with 2.5 p.p.m. to 39.5 days with 20 p.p.m.

Multiple applications of Sumagic from 2.5 to 20 p.p.m. reapplied when shoots begin to elongate is an effective means of controlling excessive vegetative growth of *Mandevilla* and may provide growers with an additional management tool in the production of this flowering horticultural annual.

Keever is Associate Professor and Deneke is Assistant Professor of Horticulture.

Growth Inhibition of *Dianthus* Species

James T. Foley and Gary J. Keever

WHEN USED as bedding plants or pot crops, carnation, *Dianthus caryophyllus*, and garden pinks, *D. chinensis*, are treated as annuals, blooming the first year from seed. Annual carnation produces large double blooms traditionally used as cut flowers, while garden pinks bloom in loose clusters of single flowers and are more commonly used as bedding plants; both species provide a showy display of blooms in shades of red, pink, or white. When these plants are offered as pot crops, they should be proportional in height for 4-inch pots. Growth retardants or pruning may be needed to meet size specifications.

Paclobutrazol (Bonzi®) suppresses stem elongation of many plant species including chrysanthemum, geranium, and a wide variety of other floriculture crops. Chlormequat chloride (Cycocel®), labeled for use on poinsettia, effectively inhibited shoot elongation of *D. chinensis* and *D. barbatus* cultivars and Reiger begonia when applied at 3,000 p.p.m. and ivy geranium at 1,500 p.p.m. Ancymidol (A-Rest®) has effectively retarded the growth of English ivy with the application of 0.125-mg drenches and chrysanthemum with foliar sprays of 62 p.p.m.

Seeds of Knight Hybrid Scarlet annual carnation and Queen of Hearts garden pinks were sown in 36-cell

TABLE 9. ANNUAL CARNATION PLANT HEIGHTS IN RESPONSE TO FOUR PLANT GROWTH REGULATORS

Treatment	Plant height, by weeks after treatment applied				
	2	4	7	10	14
	cm	*cm*	*cm*	*cm*	*cm*
Paclobutrazol					
100 p.p.m.	7.3	10.2	13.9	16.3	17.0
200 p.p.m.	6.3l[1]	8.8l	11.6	14.0q	14.4q
100 p.p.m. + pruning	5.4	7.8	12.9	17.6	18.7
Chlormequat chloride					
3,500 p.p.m.	8.1	10.6	17.3	21.9	24.7
Ancymidol					
100 p.p.m.	9.8	15.5	28.3	31.1	33.4
Pruned	6.6	10.8	20.3	30.3	33.1
Control	8.7	14.3	26.1	31.1	31.6
LSD[2]	1.4	1.9	2.4	3.6	3.7

[1]Significance of regression analysis at P=0.05, l=linear; q=quadratic; control, but not plant growth regulator + pruning treatment, included in regression.
[2]Mean separation within columns by a Fisher's least significance test, P=0.05; LSD used for comparisons among growth regulators.

flats of Pro-Mix BX® and placed in a double polyethylene greenhouse under intermittent mist (10 seconds/5 minutes) until cotyledons had fully emerged. Minimum day/night temperatures in the greenhouse were 70°F/60°F. Seedlings of both *Dianthus* species were transplanted to 4-inch pots on January 29, 1988, 17 days prior to treatment with foliar sprays.

Treatments were applied just prior to runoff to annual carnation and garden pinks when plants were about 3.1 inches and 4.7 inches tall, respectively. Treatments consisted of paclobutrazol at 100 or 200 p.p.m.; ancymidol at 100 p.p.m. (applied to carnations only); two applications of chlormequat chloride at 3,500 p.p.m. applied 3 weeks apart; and an untreated control. The surfactant Buffer-X® was added at 0.2 percent to spray solutions. There were also two treatments which included pruning of plants above the fourth node to a height of about 1.6 inches. These treatments consisted of pruning alone or pruning with an application of paclobutrazol at 100 p.p.m. on annual carnation or 200 p.p.m. on garden pinks. Plants were fertilized weekly with 200 p.p.m. N from 20-10-20 Peters Peatlite Special.®

Height from the growth medium surface to the vegetative shoot apex of annual carnation was determined 2, 4, 7, 10, and 14 weeks after treating; heights of garden pinks were measured 2, 4, and 8 weeks after treating. Terminal data consisted of numbers of axillary shoots longer than 0.4 inch, number of flowers and flower buds, and shoot dry weight. Days to first fully open flower from date of seeding were also taken as plants flowered.

Beginning at week 4 and continuing through the study (week 14), the height of annual carnation treated with paclobutrazol decreased as rate increased, table 9 and photo 2 (page 18). Fewer axillary shoots developed on paclobutrazol-treated plants than on control plants, table 10. Neither days to flower, bloom number, nor flower bud number was affected by paclobutrazol application. Shoot dry weight decreased at the higher paclobutrazol rate. Plant height was suppressed with chlormequat chloride application beginning at week 4 and continued throughout the study; however, paclobutrazol was more effective in suppressing growth during the same time period. There were no other differences between growth regulator treatments and the control.

The pruned treatment grew to a height equal to that of the control by week 10 and produced a greater number of axillary shoots; however, flowering was delayed about 11 days. Numbers of blooms, flower buds, or shoot dry weight did not differ from the control when plants were pruned. When pruning was combined with 100 p.p.m. of paclobutrazol, plant height was suppressed compared to the pruned treatment beginning at week 4 and continuing throughout the study. Axillary shoot numbers and dry weight decreased when pruning was combined with paclobutrazol compared to the pruned treatment; flower number was decreased while bud number and days to flower did not differ from the pruned treatment. Plants treated with ancymidol did not differ from the control in any of the observations measured.

At the higher paclobutrazol rates, plant height of garden pinks was suppressed beginning 2 weeks after spray application until the study ended at week 8, table 11 and photo 3 (page 18). Secondary and tertiary axillary shoots and shoot dry weight were suppressed with paclobutrazol application; primary axillary shoots were suppressed at the 200 p.p.m. rate. Total number of flowers and days to flower did not differ from the control when plants were treated with paclobutrazol. When pruning was combined with paclobutrazol at 200 p.p.m., plant height was suppressed compared to the pruned treatment beginning at week 4; however, plant height did not differ from the unpruned 200 p.p.m. paclobutrazol treatment. Fewer secondary and tertiary axillary shoots developed on plants pruned and treated with 200 p.p.m. paclobutrazol as compared to pruned plants. Flower number and shoot dry weight of plants pruned and treated with paclobutrazol were less than with the pruned treatment, while days to flower did not differ.

TABLE 10. ANNUAL CARNATION AXILLARY SHOOT, FLOWER, AND FLOWER BUD NUMBER AND DRY WEIGHT IN RESPONSE TO THREE PLANT GROWTH REGULATORS, 14 WEEKS AFTER TREATMENT

Treatment	Axillary shoots	Flowers	Flower buds	Shoot dry weight	Days to flower[1]
	No.	*No.*	*No.*	*Grams*	*No.*
Paclobutrazol					
100 p.p.m.	13.0	9.7	13.7	9.0	143.4
200 p.p.m.	14.0q[2]	9.3ns	16.9ns	7.9q	145.3ns
100 p.p.m. + pruning	18.0	5.3	19.4	8.8	156.4
Chlormequat chloride					
3,500 p.p.m.	13.1	13.1	12.0	10.5	140.1
Ancymidol					
100 p.p.m.	15.1	16.4	12.6	13.5	139.0
Pruned	23.1	12.4	15.1	14.2	153.0
Control	16.3	13.4	11.4	14.0	141.6
LSD[3]	2.2	4.3	5.6	1.6	6.4

[1]Days to flower = number of days from date of seeding to anthesis of first flower.
[2]Significance of regression analysis at P=0.05: q=quadratic; ns=nonsignificant; control, but not plant growth regulator + pruning treatment, included in regression.
[3]Mean separation within columns by a Fisher's least significance test, P=0.05; LSD used for comparisons among growth regulators.

TABLE 11. PLANT HEIGHTS OF GARDEN PINKS IN RESPONSE TO TWO PLANT GROWTH REGULATORS, PRUNING, OR COMBINATIONS

Treatment	Plant height, by weeks after treatment		
	2	4	8
	cm	*cm*	*cm*
Paclobutrazol (1 application)			
100 p.p.m.	6.7	10.6	19.0
200 p.p.m.	6.2q[1]	7.7q	13.0q
200 p.p.m. + pruning	4.6	7.7	12.8
Chlormequat chloride (2 applications)			
3,500 p.p.m.	9.1	23.7	32.0
Pruned	6.3	14.3	31.5
Control	12.3	26.2	34.6
LSD[2]	1.8	3.3	3.4

[1]Significance of regression analysis at P=0.05: q= quadratic; control, but not plant growth regulator + pruning treatment, included in regression analysis.
[2]Mean separation within columns by a Fisher's least significance test, P=0.05; LSD used for comparisons among growth regulators.

Chlormequat chloride was ineffective in height control. Shoot dry weight and number of tertiary axillary shoots decreased with the application of chlormequat chloride when compared to the control; no other observations were significantly different. When plants were pruned, heights were less than the control through week 4, while shoot dry weight, flower number, and primary and tertiary axillary shoots were less compared to the control. Days to flower was delayed about 12 days as a result of pruning.

Growth regulator application did not induce any symptoms of phytotoxicity, such as chlorosis, on either species. Both species displayed darker green foliage as a result of paclobutrazol application, which may add to plant quality. Experimentation on each species was terminated after all plants had bloomed, 8 weeks after treating of garden pinks and 14 weeks after treating of annual carnation; effects of paclobutrazol application persisted until experimentation of both species had been terminated. Two applications of chlormequat chloride inhibited shoot elongation of annual carnation, though not as effectively as paclobutrazol. Garden pinks may require at least three applications of chlormequat chloride at 2-week intervals to suppress shoot elongation; two applications at 3-week intervals were ineffective.

TABLE 12. FLOWER NUMBER, DAYS TO FLOWER, AND SHOOT DRY WEIGHT OF GARDEN PINKS IN RESPONSE TO TWO PLANT GROWTH REGULATORS, PRUNING, OR COMBINATIONS

Treatment	Flowers	Days to flower	Shoot dry weight
	No.	*No.*	*Grams*
Paclobutrazol (1 treatment)			
100 p.p.m.	46.2	97	5.6
200 p.p.m.	44.7l[2]	98ns	4.9q
200 p.p.m. + pruning	12.6	110	3.7
Chlormequat chloride (2 applications)			
3,500 p.p.m.	45.5	99	7.9
Pruned	27.9	108	8.3
Control	52.5	96	10.4
LSD[3]	10.8	4.0	1.0

[1]Days to flower = number of days from date of seeding to opening of first flower.
[2]Significance of regression analysis at P=0.05: l=linear; q=quadratic; ns=nonsignificant; control, but not plant growth regulator + pruning treatment, included in regression analysis.
[3]Mean separation within columns by a Fisher's least significance test, P=0.05; LSD used for comparisons among growth regulators.

Foley is Graduate Student and Keever is Associate Professor of Horticulture.

Consumer Preferences for Annual Bedding Plant Containers

Bridget K. Behe, Ginger Purvis, and Charles H. Gilliam

PACKAGING of many products, which includes the container itself, influences consumer purchases. For ornamental horticultural products, this influence has not yet been defined. Some garden center managers reported that customers want larger, more mature plants and are willing to pay the extra costs involved. Consumers like these larger bedding plants because they provide "instant color" to their home landscapes. The objective of this study was to determine consumer preferences for pansy plants in three types of containers: 6-plant cell packs (black), 6-inch plastic pots (black), and a plastic grow bag (white), photo 4 (page 18).

Uniform pansy plants (*Viola* × *wittrockiana*) were grown by a commercial producer using standard cultural practices. These plants were then containerized in each type pot or bag and placed in a greenhouse for 2 or 4 weeks until used in the study. Two 4-packs were used for the cell packs, eight plants were used in the bag, and two 6-inch pots (three plants each) were used.

Seventy-four consumers participated in a personal interview and written questionnaire study at two garden center locations on two Saturdays in Montgomery, Alabama, in October and November, 1989. Consumers were evaluated for characteristics of age, education, household size, gender, and income. They were also asked their perceptions of certain plant and container characteristics. Finally, they were asked to select one group of pansy plants they would most prefer if making a purchase that day. No prices were indicated on the different containers.

Respondents by age group were 25-34 (17 percent), 35-49 (36 percent), and 50-79 (47 percent). Seventy-five percent of the respondents had completed some college or had earned a college degree. Median per capita income was $10,416, while average per capita income was $9,767. Fifty-one percent of the respondents stated that their households contained only two people and the mean number of persons in each household was 2.4. Thirty-seven percent of the respondents were male and 63 percent were female.

Respondents were asked to rank the importance of several plant and package characteristics. Consumer ratings were evaluated using a 9-point Likert Scale, table 13. Ninety percent of the respondents indicated that

TABLE 13. CONSUMER PERCEPTION RATING OF EIGHT PLANT CHARACTERISTICS

Characteristic	Rated most important 1-4	Rated neutral 5	Rated least important 6-9
	Pct.	*Pct.*	*Pct.*
Health and appearance of plant	90	1	8
Shape or form of the plant	86	6	9
Color of the flowers on the plant	80	9	10
Color of the leaves on the plant	78	6	16
Size of the plant	53	25	21
Price of the plant	49	26	26
Care and planting instructions	49	12	42
Type of container plant comes in	18	7	75

the health of the plant was an important attribute. Conversely, the type of container in which the plant was sold was given an important rating by only 18 percent of the respondents.

Consumers were asked to indicate their attitudes or perceptions about buying plants on a 5-point Likert scale. Only 14 percent of the respondents strongly agreed or agreed with the statement, "I usually grow plants in the container I buy them in." Eighty-nine percent agreed or strongly agreed that they could tell the difference between a healthy and an unhealthy plant.

Respondents were then asked to choose which pansy on display they would purchase if making a purchase for themselves that day. Of those responding, 51 percent chose the plants in the bag, 28 percent chose the plants in the cell packs, and 19 percent chose the plants in the 6-inch pots.

Price did not appear to be a concern to these consumers, yet purchasing a high quality plant was. Health is one measure of plant quality, and it is one characteristic respondents believed they were able to recognize. Plants in the grow-bag may have appeared to grow larger than plants in the cell pack or pots. Consumers may have equated larger sized or more colorful plants with higher quality plants. The plants may have grown larger because the grow bags held more soil, retained more moisture, or provided some nutrition.

Results of this study offer helpful information for marketing bedding plants. Larger plants or those with a more colorful display are preferred by consumers. Optimum container size for greenhouse production may not be the optimum size container in which to market plants. Annual plants could be transplanted into larger containers prior to retail sales, which could result in more visual appeal. While many plants would still be purchased in traditional cell pack containers, suggesting uses to the consumer may stimulate additional sales. Displaying mature plants in large containers, or a variety of containers, may suggest additional uses.

The container does not appear to play a significant role in the consumer purchase decision directly. However, it may influence the consumers' perception of quality, most likely by influencing the growth and development of the plant itself. Therefore, the container selection should be given further consideration by producers and retailers of annual bedding plants.

Behe is Assistant Professor, Purvis is Graduate Student, and Gilliam is Professor of Horticulture.

Hardy Chrysanthemum Trial

Bridget K. Behe, C. Fred Deneke, Art McDow, and Dan Land

HARDY CHRYSANTHEMUMS, ones which should overwinter outdoors from year to year, are popular flowering plants for fall gardens in Alabama. Hardy chrysanthemums are available in a wide range of colors and forms, some of which bloom earlier or longer than others. To evaluate new varieties, a study was initiated to determine the date the first flower opened and the date of peak flowering for new chrysanthemum cultivars.

Uniform unrooted cuttings of 19 cultivars of chrysanthemums were treated with a basal dip of Hormodin #2, and directly stuck into trade gallon containers on June 28, 1990. The medium contained 4:1:1 (by volume) of composted bark, sand, and peat moss. Incorporated into the medium were 1.5 pounds dolomitic limestone, 10 ounces superphosphate, 10 ounces gypsum, and 2 ounces Micromax® minor elements per cubic yard. Cuttings were placed under mist for 3 days. Fifty plants of each cultivar were planted in ground beds on August 26 and visually evaluated weekly until October 31. Plants were fertilized with a liquid feed of 200 p.p.m. nitrogen using a 20-10-20 formulation on July 9, August 31, and September 28.

Results of the trial are shown in table 14. The color of the petals is shown followed by the form of the flower. Daisy-form flowers have two colors indicated: the color of the ray flowers (petals) followed by the color of the disc flowers (center). The flowering mechanism in chrysanthemums is regulated by the photoperiod; thus, date when the first flower opened is important in determining when the floral display will begin. Date of first flowering was recorded as the date of peak flowering, when a majority of blooms

TABLE 14. EVALUATION OF 19 HARDY CHRYSANTHEMUM VARIETIES ON COLOR, FORM, DATE OF FIRST FLOWER, AND DATE OF PEAK FLOWER

Variety	Color[1]	Form[2]	Flowering	
			First	Peak
Allure	Y/Y	Daisy	9/19	9/30
Bravo	Red	Cushion	9/19	10/12
Dark Grenadine	Red	Cushion	9/19	10/12
Debonair	Pink	Cushion	9/3	10/7
Donna	Y/Y	Spoon/Daisy	9/8	9/30
Grace	B/Y	Daisy	8/31	10/11
Hekla	W/Y	Daisy	8/31	9/30
Illusion	W/Y	Quilled/Daisy	9/15	9/30
Jessica	Y	Cushion	9/7	9/23
Legend	Y	Pompon	9/18	10/12
Minnigopher	R	Pompon	9/19	10/7
Naomi	P&W/Y	Daisy	9/27	10/12
Red Remarkable	R	Cushion	10/1	10/14
Sandy	B/B	Daisy	9/28	10/12
Sarah	B	Cushion	10/4	10/21
Sundoro	P	Cushion	10/1	10/21
Target	Y	Cushion	9/23	10/12
Tolima	W	Cushion	9/16	10/12
Volunteer	W	Cushion	9/16	9/19

[1]Flower colors: Y=yellow, R=red, P=pink or lavender, W=white, and B=bronze.
[2]Forms were daisy, cushion, and pompon.

on each plant were fully open. Notes were made on bloom fading and susceptibility to Botrytis blight (grey mold) on the blooms.

The white varieties included Hekla, Illusion, Tolima, and Volunteer. Of these, Hekla was the first to flower, on August 31, a desirable characteristic in garden performance, and also the first to reach peak flowering, on September 30. This variety did, however, grow taller than the other white varieties evaluated. The bloom color of Hekla discolored early, turning purple soon after opening. Volunteer appeared to be highly susceptible to Botrytis blight in this trial.

The red varieties included Bravo, Dark Grenadine, Minnigopher, and Red Remarkable. All of the red cultivars except Red Remarkable showed their first flower on September 19. Red Remarkable showed first flower on October 1, nearly 2 weeks later. Minnigopher reached peak flowering before the other three red varieties on October 7. Bravo retained its petals quite well in the evaluations.

The yellow varieties included Allure, Donna, Jessica, Legend, and Target. Jessica was the first of the yellow varieties to flower, on September 7, and one of the first of all variety colors to flower. Jessica was also the first to reach peak flowering, while Legend and Target were the last yellow varieties to reach peak flowering, on October 12. Donna appeared to be more susceptible to Botrytis grey mold on the blooms, and the blooms faded quickly after opening.

Three pink varieties were evaluated: Debonair, Naomi, and Sundoro. Debonair was the first pink to flower, on September 3. It appeared to be one of the top performers in the evaluation as it faded slowly and appeared to be resistant to Botrytis blight. Naomi had an interesting color pattern, bright pink ray petals with white near the bottom and yellow center disc flowers. Naomi reached first flower on September 27 and peaked on October 12. Naomi also seemed less resistant to Botrytis blight, and the petals appeared to fade more quickly than other colors.

The bronze varieties included Grace, Sandy, and Sarah. Grace flowered first of the bronze varieties, on August 31, while the last bronze variety to flower was Sarah on October 4. Grace, photo 5 (page 18), performed well early in the study and kept a high rating into the final week of the study.

Overall, Grace performed the best of all 19 varieties. It flowered very early, only 1 week after being planted in the ground beds, the blooms faded little, and it appeared to be resistant to Botrytis blight. Other top performing varieties included Hekla, a white petal and yellow center daisy form, Bravo, a red cushion, and Legend, a yellow pompon form chrysanthemum.

Behe is Assistant Professor, Deneke is Assistant Professor, McDow is undergraduate student, and Land is Greenhouse Supervisor of Horticulture.

Profile of the Perennial Plant Industry

Bridget K. Behe and Lisa Beckett

ONE OF THE FASTEST growing categories for sales of horticultural products recently has been herbaceous perennials. Businesses which market perennials often handle a tremendous variety of species from which their clients may choose. Little information is available to current industry members and to firms considering entering this lucrative market. What little information is available on the size of the perennial industry is found in the U.S. Agricultural Census of Horticultural Specialties publication. It contains information on only the wholesale value of a wide variety of plants, including annuals and herbaceous perennials. The census information is further limited by its publication once every 10 years. The annual USDA Floriculture Crops Summary shows the wholesale value of selected florist crops and bedding plants in 28 states, but excludes perennials. Thus, reliable information on important characteristics of the perennial plant industry is lacking.

In an effort to provide perennial plant growers and marketers with additional information, research by the Alabama Agricultural Experiment Station, in cooperation with the Perennial Plant Association (PPA), investigated characteristics of the perennial plant industry in the United States. PPA members who grew perennials in 1989 were used as the sample for the study.

In July, 1990, 439 surveys were mailed to perennial businesses across the country. Two surveys were mailed to each business to encourage a response. A total of 146 surveys was returned, for a 33 percent return rate.

Characteristics of Perennial Plant Businesses

Many members of the industry think of perennial plants as newcomers, and that perhaps the businesses which sell these plants are newcomers as well. The perennial plant firms responding to this study were not newcomers, however, having been in business from 1 to 75 years, or an average of 16 years.

The legal form of businesses can add another facet of information to the perennial plant industry. Forty-seven percent of the businesses were sole proprietorships, 12 percent were partnerships, 39 percent were corporations, and 2 percent had adopted some other business form. This meant that almost half of the firms were owned and operated by one person. Over half of the businesses (57 percent) had two or fewer full-time year-round employees and 76 percent had one or more seasonal employees.

The total sales for each company in 1989 was requested. This total included wholesale and retail sales of items which may have included more products than strictly perennial plants (many businesses sold annuals, woody plants, hard goods, florist crops, and fertilizers). Thirty-four percent of the businesses had total revenues of $50,000 or less in 1989, while 14 percent had revenues of $1 million or more. These results showed that many of the firms selling perennial plants are relatively small.

Market Area

Respondents to the survey came from 31 states. Many indicated that over half of the plants they marketed went to buyers in the state where their business was located. In fact, 78 percent of the plants were sold in the state where the business was located; 21 percent were sold out of the state and 1 percent were sold out of the country.

Responses to a question about method of sale revealed that telephone sales accounted for an average of 25 percent of revenues, mail sales 14 percent, and walk-in or drive-in sales 42 percent of total sales.

Methods of Propagation

Results indicated that, on average, 30 percent of plants propagated by the businesses are propagated from seed, 14 percent are propagated from plugs, 27 percent are from division of plants or root cuttings, and 29 percent are propagated by other vegetative methods, including stem cuttings and tissue culture. These results show that over half of the perennial plants produced in the United States are propagated vegetatively, from cuttings or division. This means that stock plants must be maintained, or a source of cuttings located. Vegetative propagation is also more expensive than seed propagation, increasing the costs of production for perennial plants.

Implications

The size of the perennial industry is estimated to be between $66 and $150 million, although the 1990 Census of Horticultural Specialties has not yet been published. The information examined thus far shows that perennials are a sizeable component of the horticultural industry. Perennial plant growers and marketers are most likely sole proprietors who operate businesses which sell more than one type of plant (i.e., perennials and annuals, woody plants, or florist crops). Most perennials are propagated vegetatively, adding considerably to the cost of production for these plants. These relatively small businesses utilize a number of methods to sell their plants, but the majority are sold when the customer visits the operation.

Perennial growers are not large businesses with the financial resources to obtain sophisticated marketing studies; rather, they rely on government or other researchers to compile information for them. The few studies published thus far support the widely held notions that perennials have earned a substantial portion of the horticulture industry and have grown markedly in the past 10 years. The results of this study should provide those business managers with useful information to help them formulate marketing strategies for the next decade.

Behe is Assistant Professor and Beckett is Graduate Student of Horticulture.

Influences of Subirrigation on Postproduction Longevity of Poinsettias

C. Fred Deneke, Bridget K. Behe, and John Olive

INCREASING CONCERN for Alabama's water quality has focused much attention on businesses that use nitrate fertilizers and pesticides. Ebb and flow production technology is a closed subirrigation system which prevents water used in irrigating greenhouse crops from being routinely discharged into the environment. This technology, developed in the early 1950's, has been only recently adopted in Europe but only infrequently adopted by American producers. In an ebb and flow system, plants are grown in a trough. Water and fertilizer from an enclosed tank are pumped into the trough where the plants are watered from below. Water that is not absorbed by the media after a few minutes drains back into the tank for recirculation.

One concern expressed by many growers and researchers is that subirrigation may reduce the postproduction longevity of plants. The objective of this study was to compare the postproduction longevity of poinsettias grown with traditional irrigation and subirrigation.

On September 12, 1990, rooted cuttings of Pink Peppermint, Supjibi, V-10 Amy, and V-14 Glory were stuck in 6-inch azalea pots using a 3:1 milled pine bark:peat moss medium amended per cubic yard with 6 pounds dolomitic lime, 2 pounds gypsum, and 1.5 pounds Micromax®. Plants were pinched to four nodes on September 25. A drench of Dexon®, Benlate®, or Truban® was applied four times.

Plants were watered with either drip irrigation or subirrigation. Plants on drip irrigation were fertilized about twice per week beginning September 19 with 300 p.p.m. N from 20-10-20. This fertilization rate was gradually reduced to 200 p.p.m. by November 20. Similarly, the conductivity of the irrigation water of subirrigated plants was monitored so that fertilization rates were gradually reduced from 300 to 200 p.p.m.

TABLE 15. EFFECTS OF IRRIGATION METHOD ON POSTPRODUCTION LONGEVITY OF FOUR POINSETTIA CULTIVARS 6 WEEKS AFTER PLACEMENT IN A SIMULATED CONSUMER ENVIRONMENT

Cultivar	Irrigation method	Plant grade[1]	Leaf drop	Bract drop	Flower drop
			Pct.	*Pct.*	*Pct.*
V-10 Amy	drip	2.0a[2]	19a	24b	77a
	sub-	1.0b	4b	55a	76a
V-14 Glory	drip	2.6a	6a	4a	52b
	sub-	2.0b	3a	6a	59a
Pink Peppermint	drip	2.8a	7b	3b	86a
	sub-	1.8b	24a	10a	91a
Subjibi	drip	2.0a	20a	14b	72a
	sub-	1.0b	14a	50a	65a

[1]Rated from 5 (excellent, no discoloration and no bract or leaf drop) to 1 (poor, faded bracts and leaves, or leaf and bract drop).
[2]Means followed by the same letter within cultivars are not significantly different (Duncan's multiple range test, 5 percent level).

N. Plants in both irrigation methods were irrigated with water only after November 20.

On November 29, plants were moved to a simulated consumer environment to evaluate postproduction quality. After 3 and 6 weeks in the postproduction environment, data were taken on plant grade and leaf, bract, and flower (cyathium) drop.

There were no differences in plant grade among cultivars and treatments when plants were placed in the postproduction environment. After 3 weeks, plant grade significantly declined and leaf drop significantly increased only for subirrigated V-10 Amy as compared to the drip irrigation treatment. After 6 weeks, plant grade for all cultivars and treatments had declined; this decline was greater in subirrigated plants, table 15. Similarly, the numbers of leaves and bracts dropped were greater in subirrigated plants. Flower abscission of subirrigated V-14 Glory was greater than with drip irrigated plants.

Regardless of the irrigation method, V-14 Glory and Pink Peppermint had the highest plant grades. Also, these two cultivars retained their bract coloration. V-10 Amy dropped bracts sooner than the other cultivars; other researchers have noted that this cultivar is subject to severe leaf and flower abscission. Supjibi, because of its large brightly colored bracts, was the most striking cultivar when plants were moved to the postproduction environment and also 3 weeks later. However, after 6 weeks in the postproduction environment, extensive leaf and bract drop and bract discoloration greatly detracted from its appearance.

The differences in postproduction longevity observed in this research were surprising. These experiments will be replicated in 1991 to verify these results. Also, additional data will be taken on media and root system characteristics to possibly explain any differences in postproduction longevity.

Deneke is Assistant Professor and Behe is Assistant Professor of Horticulture; Olive is Superintendent of the Ornamental Horticulture Substation.

Effects of Sumagic on Seed-Propagated *Physostegia virginiana* Alba

C. Fred Deneke, Patricia F. Thomas, and Gary J. Keever

IN THE LAST several years, herbaceous perennials have increased in popularity. The market for perennials could be expanded by using them in the home for several weeks before planting in the landscape. However, many herbaceous perennials are too tall for use as potted plants, and they also have the problem that many do not come true from seed.

Physostegia virginiana (obedient plant or false-dragon head) is a herbaceous perennial that was judged to have potential for use as a potted plant. A member of the mint family, *P. virginiana* is native to the Eastern United States and is cultivated in wildflower gardens and for cut flowers. White or pink florets are arranged on a densely flowered raceme in summer on plants 2 to 4 feet tall. The florets are unusual in that they can be repositioned on the raceme, which is beneficial in cut flower arrangements and interesting to flower enthusiasts. Plants have few disease or insect problems but can be invasive in the landscape.

Floricultural crops are often treated with plant growth retardants to control height. Uniconazole (Sumagic®), which is a member of the triazole family of growth retardants like Bonzi®, has not yet been registered for use on horticultural crops. No plant growth regulators have been extensively used on herbaceous perennials. The objective of this research was to evaluate drench applications of Sumagic® in restricting vegetative growth in *P. virginiana* Alba.

Seeds of *P. virginiana* Alba were sown on January 12, 1990, transplanted into cell packs on January 30, and repotted into 5-inch pots on February 19. A soilless medium of 7 pine bark:1 sand amended per cubic yard with 6 pounds dolomitic limestone, 2 pounds superphosphate, 1.5 lb. of Micromax®, and 6 pounds Osmocote® 14-14-14 was used. Plants were maintained in a greenhouse with a minimum night temperature of 70°F. Night-break incandescent lighting from 10:00 p.m. to 2:00 a.m. was used since long-day photoperiods enhance flowering. On March 6, Sumagic was applied as a drench of 0, 0.75, 1.50, 2.25, 3.00, or 3.75 mg active ingredient (a.i.) per pot.

Drench applications of Sumagic effectively controlled excessive vegetative growth, table 16. Plant height decreased linearly as drench rate increased. Time to flower was not affected by application rate. Most plants flowered within 14 weeks of treatment, and no plants exhibited phytotoxicity symptoms. Increasing drench rates decreased the number of lateral shoots, and thereby decreased the number of lateral inflorescences. The highest application rate of 3.75 mg a.i. per plant was judged to result in plant heights proportional to the 5-inch container size; however, flowering quality was reduced. A drench application of 2.25 mg a.i. per plant was judged to be the best treatment for controlling plant height without adversely affecting flowering quality. There was noticeable variation within all treatments

TABLE 16. RESULTS OF DRENCH RATES OF SUMAGIC ON *PHYSOSTEGIA VIRGINIANA* ALBA, TAKEN WHEN THE FIRST FLORET OPENED ON THE INFLORESCENCE

Drench rate, mg/pot	Flowering[1]	Days to flower	Plant height	Lateral shoots
	Pct.	*No.*	*In.*	*No.*
0	100	69	28	6
0.75	90	69	30	4
1.50	90	72	26	3
2.25	100	68	21	2
3.00	80	73	19	1
3.75	90	73	13	1
Significance[2]		ns	l***	l*

[1]Percentage of plants to flower within 14 weeks after treatment.
[2]ns = not significant; l = linear; *** and * = significant at 0.001 and 0.05 levels, respectively.

for time to flowering and plant height. A problem with producing *P. virginiana* from seed, as well as many other species of herbaceous perennials, is the large variation in a number of plant characteristics assumed to be genetically influenced.

Deneke is Assistant Professor, Thomas is former Graduate Student, and Keever is Associate Professor of Horticulture.

Branching of *Vinca minor* Increased by Growth Regulators

James T. Foley and Gary J. Keever

THE COMMON VINING groundcover *Vinca minor* is characterized by long runners and little lateral shoot development. *Vinca* is typically sold by the number of runners on the plant. Crops are potted several plants per pot or pruned repeatedly during production to produce well-branched, high-quality plants. The first approach requires more plant material than using one plant per pot, while the latter is labor intensive. A study was instituted to determine the effectiveness of several plant growth regulators in inducing lateral budbreak and elongation of *V. minor.*

Cuttings of *Vinca* were stuck in 36-cell flats of Pro-Mix BX® medium and placed in a double polyethylene greenhouse under intermittent mist (5 seconds/10 minutes) for 11 weeks. Rooted cuttings were transferred to 4-inch pots and pruned to three nodes each; all side and basal shoots were removed. The following foliar spray treatments were then applied to the plants: Promalin® at 125, 250, and 500 p.p.m.; Atrinal® at 1,000, 2,000, and 3,000 p.p.m.; BA at 62.5, 125, and 250 p.p.m.; and Accel® at 62.5, 125, and 250 p.p.m. Sprays were applied just prior to runoff in a volume of about 2.0 ml per plant. Buffer-X® was added as a surfactant at 0.2 percent to BA, Promalin, and Accel. Plants were fertilized weekly with 200 p.p.m. N from Peters Peatlite Special® 20-10-20. A pruned control was included for comparison.

Promalin treatments up to 250 p.p.m. increased runner number and runner length. Atrinal delayed runner production through week 4, but numbers increased thereafter and runner length decreased as Atrinal rate increased. BA did not increase runner number, and increased rates of BA tended to increase runner length. Accel did not increase runner number, and increased rates of Accel decreased runner length.

TABLE 17. PRIMARY RUNNER NUMBER AND LENGTH OF *VINCA MINOR*

Treatment	Final runner number[1]	Final runner length
		In.
Promalin		
250 p.p.m.	4.2	14
500 p.p.m.	5.1	12
1,000 p.p.m.	7.1	12
Atrinal		
250 p.p.m.	3.3	14
500 p.p.m.	2.3	14
1,000 p.p.m.	3.0	14
Control	2.5	15

[1]Runners produced from a 3-node cutting.

Based on results of the first experiment, a second test was initiated to determine appropriate rates of the most effective branching compounds from the initial test. Foliar spray treatments consisted of Promalin and Atrinal at 250, 500, and 1,000 p.p.m. Treatments were applied a second time without pruning 6 weeks after the initial application. Data were taken at 2-week intervals and included primary runner number and length, secondary runner number (from primary runners), and basal runner number (from the growth medium). Final data included a node count of primary runners and a measure of the three longest secondary runners.

The results of the second study showed that Promalin increased primary runner number from the three-node cutting, increased secondary and total runner number, and decreased primary runner length. Secondary runner length was found to increase as rate of Promalin increased. Atrinal did not promote runner production or runner elongation.

Treatment with Promalin resulted in light to severe chlorosis, especially at higher rates. Plants eventually developed normal foliar color and the majority of secondary runners survived. These results indicate that two applications of Promalin at 500 or 1,000 p.p.m. at about 6-week intervals effectively induce lateral branching of runners of *V. minor.*

Foley is Graduate Student and Keever is Associate Professor of Horticulture.

PHOTO 1. Alice du Pont *mandevilla* is a popular greenhouse or horticultural annual crop.

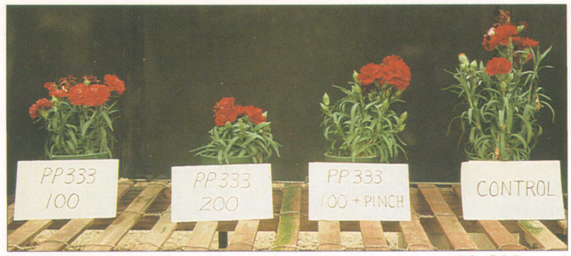

PHOTO 2. Carnations treated with (left to right) 100, 200, and 200 p.p.m. paclobutrazol + pinch and untreated control.

PHOTO 3. Garden pinks treated with (left to right) 100, 200 + pinch, and 200 p.p.m. paclobutrazol and untreated control.

PHOTO 4. Containers for annual bedding plants used in study: grow-bag, cell packs, and round pots.

PHOTO 7. Effect of (left to right) 0, 500, and 1,000 p.p.m. BA, and pruning on branching of Helleri holly.

PHOTO 8. Infestation of obscure scale, *Melanaspis Obscura* (comstock), on pin oak.

PHOTO 9. An adult jumping tree bug, *Lidopus heidemanni* Gibson, probing beneath the cover of an adult obscure scale.

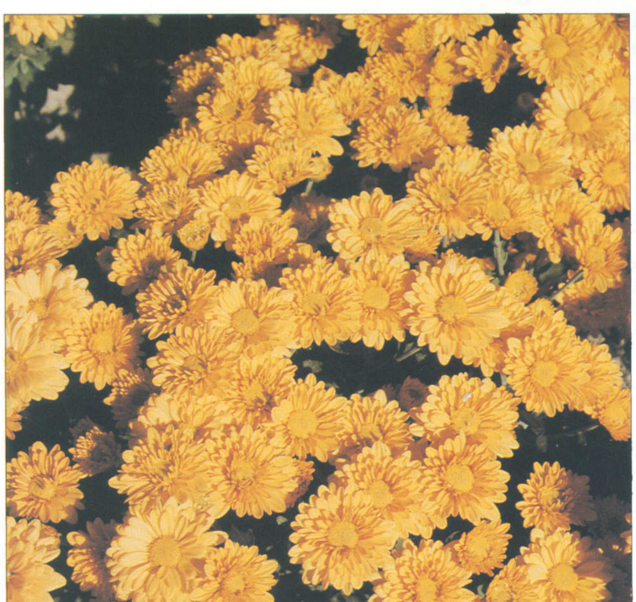

PHOTO 5. Grace, a bronze daisy form, was the top performer in the 1990 chrysanthemum trial.

PHOTO 6. Fireblight damage on Autumn Blaze callery pear.

Fireblight Susceptibility of Ornamental Pears in Southern Conditions

Donna C. Fare, Charles H. Gilliam, and Harry G. Ponder

RELEASE of Bradford pear by the USDA in the early 1960's has led to extensive plantings along streets, highways, and urban landscapes in many Middle Atlantic and Southeastern States. Seasonal contributions of spring flowering, summer shade, and fall leaf color have led to Bradford pear being ranked among the "Ten Most Recommended Trees" in several states. However, maturing Bradford trees have exhibited robust growth, causing overcrowded conditions in some landscapes. Also, trunk and canopy splitting of older trees has been reported in the Southeast. Splitting is often reported as storm damage, but is likely caused by unnoticed splitting prior to storms caused by acute branch angles. These problems plus the success of Bradford have led to the release of 12-15 other selections of *Pyrus calleryana*.

Since 1980, *P. calleryana* and nine ornamental pear cultivars have been evaluated for tolerance to fireblight (*Erwinia amylovora*), a bacterial leaf and stem blight. All trees were planted as bare root whips in a grid spacing of 30 feet. During May 1988, 1989, and 1990, fireblight injury was assessed by counting the number of infected shoot tips per tree. Also, three infected shoots per tree were chosen at random to measure the length of the fireblight dieback. At this stage of infection, shoots were darkened as if scorched by fire. Measurements were taken to the base of the dieback, though some fireblight cankers were observed below the dieback on what appeared to be healthy branches. No selective pruning or preventative (or corrective) spray program was employed to reduce fireblight pressure.

Fireblight development is enhanced by warm, moist weather conditions, particularly during flowering. Blight development can occur at temperatures between 65 and 95°, but the 75-81°F range is most favorable. Rain is critical to the development and spread of fireblight. Warm, cloudy weather following a rain, as often occurs in the Southeast, promotes the growth and spread of causal bacterium. Other environmental factors, such as frost, high winds, and hail, create wounds through which the bacteria can enter the plant. Weather conditions in 1988 and 1989 in central Alabama mimic the favorable weather description for disease development. In 1990, flowering occurred about 1 month earlier than in previous years, due to unseasonably warm temperatures and less rainfall as compared to the previous years; consequently, disease severity was greater in 1988 and 1989 than 1990.

Prior to the spring of 1988, the incidence of fireblight infection was insignificant. In 1988, Aristocrat and Redspire trees had 112 and 40 fireblight damaged shoots, respectively. *P. calleryana* and other cultivars had fewer than 12 diseased shoots per tree, figure 2. The number of infected shoots of Aristocrat (208) and Redspire (70) was higher in 1989 than in previous years. These data concur with a report from Kentucky that Aristocrat and Redspire were more susceptible to fireblight than Bradford, Capital, Fauriei, and Whitehouse. Their data were based on a survey of four sites where cultivars were growing in proximity to each other.

In 1988, the average length of dieback per infected shoot was greatest on Redspire (19 inches), Autumn Blaze (17 inches), Aristocrat (15 inches), and Earlyred (14 inches), figure 3. In 1989, Autumn Blaze was severely infected with fireblight (209 infected shoots per tree averaging 78 inches dieback per infected shoot), photo 6 (page 18). Autumn Blaze trees died during the winter of 1989-90, following 2 years of intense fireblight-related damage. Bradford had the least dieback per infected shoot, with the dieback averaging 3, 8, and 5 inches in 1988, 1989, and 1990, respectively.

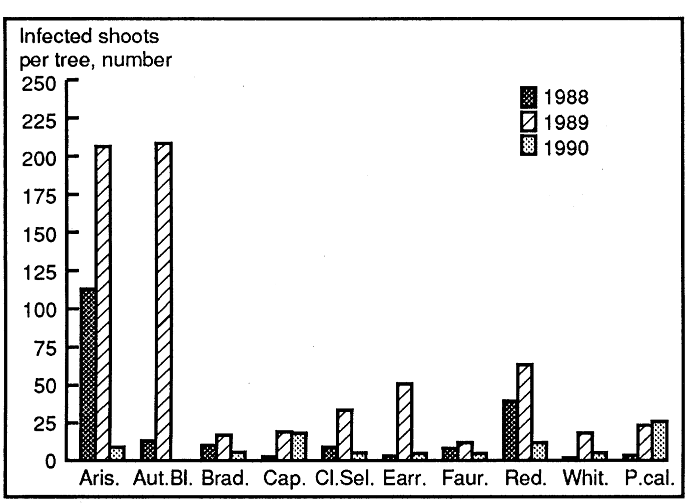

FIG. 2. Number of infected shoots per tree.

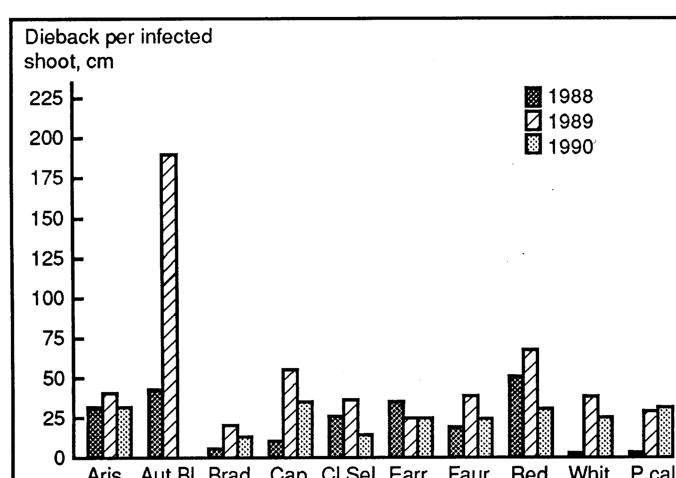

FIG. 3. Length of dieback per infected shoot.

The selection of callery pear for use in southern landscapes will be strongly dependent on varietal reaction to fireblight. Fireblight from plant species in the native habitat in the South will maintain constant pressure in cultivated landscapes, therefore the success of any cultivar may be largely determined by fireblight tolerance. Callery pears most susceptible to fireblight in this study were Autumn Blaze, Aristocrat, Redspire, and Earlyred. The least susceptible cultivars were Bradford, Capital, Fauriei, and Whitehouse.

Fare is Research Associate, Gilliam is Professor, and Ponder is Professor of Horticulture.

Growth of Five Shade Trees as Influenced by Trickle Irrigation Based on Net Evaporation

Donald J. Eakes, Charles H. Gilliam, Harry G. Ponder, William B. Webster, and Clyde E. Evans

PREVIOUS RESEARCH has shown trickle irrigation to enhance growth of field-grown nursery stock. Most research to date has been conducted to evaluate irrigation rates delivering a fixed amount of water on a daily basis during the growing season regardless of environmental conditions. In the Southeastern United States, summers are characterized by prolonged drought periods with occasionally widely scattered, afternoon thunderstorms, causing soil moisture to vary from day to day. Since trickle irrigation is generally considered as the daily maintenance of adequate soil moisture to at least 25 percent of the root system to prevent moisture stress, water requirements will vary on a daily basis. A fixed irrigation rate may cause overwatering on cloudy, overcast days and may not provide adequate moisture for optimum growth during drought periods. The purpose of this experiment was to evaluate the effects of trickle irrigation rates based on net evaporation from a class A pan on five field-grown shade tree species.

On March 29, 1-year-old liners of river birch, flowering dogwood, green ash, Bradford pear, and pin oak were planted in a Decatur silt loam soil at the Tennessee Valley Substation, Belle Mina, Alabama. All plants were 18- to 24-inch bareroot liners, except Bradford pear had been potted in #1 containers after rooting the previous season. Rows were 6 feet apart, and plants were spaced 4 feet within rows. Four irrigation rates based on 0, 25, 50, and 100 percent replacement of net evaporation from a class A pan were evaluated. The five shade tree species were measured for height and caliper at 6-week intervals.

Trickle irrigation was installed on May 13. One Rain Bird EM-J10® series 1-gallon-per-hour pressure compensating emitter was inserted into the 1/2-inch black polyethylene pipe adjacent to individual plants receiving 25 percent and 50 percent replacement of net evaporation. Irrigation was supplied to plants receiving 100 percent replacement of net evaporation with Rain Bird EM-J20 2-gallon-per-hour pressure compensating emitters. Emitters were placed within 6 inches of the plant's base.

Rainfall and net evaporation from a class A evaporation pan were recorded daily throughout the experiment. Plants were irrigated from May to October, when net evaporation reached or exceeded 1/2 inch. Irrigation prior to May was not necessary due to rainfall distribution and lower daily temperatures. Daily water replacement was based on each plant occupying a space of 1.5 square feet.

Results varied according to species and irrigation rate. Trickle irrigation on flowering dogwood resulted in greater caliper and height growth when compared to nonirrigated trees. Irrigated flowering dogwood had greater caliper by the end of the first growing season, and the differences continued through the second year, table 18. Treatments of 50 percent and 100 percent replacement of the net evaporation produced the greatest height. Both caliper and height of green ash responded in a quadratic manner to irrigation rates. Caliper of river birch responded in a linear and quadratic fashion to increasing irrigation rates, table 18. Maximum caliper size occurred with application of 50 and 100 percent replacement of net evaporation. Height of river birch was not affected by irrigation. Pin oak and Bradford pear growth was not influenced by irrigation.

While these data do not demonstrate a positive response for all five tree species to trickle irrigation, they do support the concept that trickle irrigation is not

TABLE 18. EFFECTS OF TRICKLE IRRIGATION ON CALIPER AND HEIGHT OF FIVE WOODY TREE SPECIES AFTER TWO GROWING SEASONS

Irrigation rate, percent replacement of net evaporation	Dogwood		Green ash		River birch		Pin oak		Bradford pear	
	Caliper	Height	Caliper	Height	Caliper	Height	Caliper	Height	Caliper	Height
	cm	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*
0	2.2	134.1	3.8	244	4.4	261	3.6	169	3.3	237
25	2.5	141.7	3.9	252	4.1	250	3.6	177	3.4	231
50	2.7	150.4	4.1	258	4.6	242	3.5	170	3.5	231
100	2.7	147.8	4.2	264	4.8	257	3.9	178	3.5	226
Significance										
Irrigation rate-linear	*[1]	ns	ns	ns	*	ns	ns	ns	ns	ns
-quadratic	**	**	*	*	**	ns	ns	ns	ns	ns

[1]Nonsignificant (ns) or significant at the 5 percent (*) or 1 percent (**) level.

economically beneficial for all field-grown nursery stock. This may be particularly true for silty loam soils which have a high water holding capacity and typically produce excellent nursery stock.

Eakes is Assistant Professor, Gilliam is Professor, and Ponder is Professor of Horticulture; Webster is Superintendent of the Tennessee Valley Substation; Evans is Professor of Agronomy and Soils.

Chemically Induced Branching of Woody Landscape Plants

Gary J. Keever and William J. Foster

REPEATED PRUNING of many woody landscape species is a labor-intensive practice required to produce well-branched, marketable materials. Shoot tip pruning removes the source of apical dominance, a process controlled by a balance between auxin and cytokinin levels, and stimulates lateral bud development. Exogenously applied cytokinins, including BA, promote axillary bud growth and branching of woody plants. Synthetic cytokinins may induce only a partial release from apical dominance; further growth of released axillary buds requires treatment with a synthetic auxin or gibberellin. Two experiments were conducted to determine if axillary growth of several woody landscape species could be promoted by exogenous cytokinin and gibberellin application. Species used in the tests typically require multiple prunings during production for the development of a well-branched, compact plant.

In experiment 1, uniform liners of Helleri holly, Stoke's Dwarf holly, Fraser photinia, Indian hawthorn, Formosa azalea, and cleyera were grown in 3-inch-square containers in a glass greenhouse. Growth medium was amended milled pine bark-peat moss (4:1, by volume). On March 7, 1986, a single spray of BA at 0, 125, 250, 500, and 1,000 p.p.m. was applied to the foliage of all species. Foliar sprays included 0.2 percent (by volume) Buffer X®, an ionic surfactant. A pruned control in which plants were cut 2 inches above the growth medium also was included. On April 29, 1986, newly developed lateral shoots longer than 0.4 inch were counted.

Due to a minimal response to BA, the experiment was terminated in June 1986 for all species except Helleri and Stoke's Dwarf hollies. On June 9, 1986, Helleri and Stoke's Dwarf hollies were repotted into #1 containers of amended 100 percent milled pine bark. Plants were moved from the greenhouse to an outdoor production area in full sun, and treatments were reapplied. Growth indices [(height + width + width)/3] were measured on November 18, 1986. On January 28, 1987, lateral shoot length (five longest shoots per plant), plant height, and relative root rating (1 = no roots on rootball surface; 2-5 = 25, 50, 75, and 100 percent coverage of rootball, respectively) were determined.

Because several species were not responsive to the BA rates applied, a second experiment was conducted using higher BA rates and several rates of Promalin. Promalin is a mixture of equal parts by weight of BA and GA_{4+7}. Species evaluated included Fraser photinia, cleyera, Formosa azalea, Indian hawthorn, and Harbour Dwarf nandina (Harbour Dwarf nandina has little or no lateral branching and does not readily respond to mechanical pruning). Uniform liners were grown in 3-inch containers of the same amended liner growth medium as in the first experiment. On November 4, 1987, BA treatments of 0, 1,000, 1,500, 2,000, and 2,500 p.p.m. and Promalin® treatments of 0, 2,000, 3,000, 4,000, and 5,000 p.p.m. were applied. A pruned control was included for comparison. Plants were maintained in a glass greenhouse.

On January 26, 1988, plant height and axillary budbreak were determined, and on February 8, treatments were reapplied. Plant height and axillary budbreak data were collected on April 1 from all species except Indian hawthorn, which was collected on May 13. On May 24, apical and subapical single-node cuttings were taken from Harbour Dwarf nandina to determine treatment effects on cuttage; cuttage production limits the availability of Harbour Dwarf nandina.

Experiment 1

Induction of axillary budbreak in response to BA application was species-dependent, table 19. Budbreak of cleyera, Formosa azalea, and Indian hawthorn was marginally or not affected by BA, whereas hand pruning induced equal or greater branching than all rates of BA. Axillary budbreak of Helleri and Stoke's Dwarf hollies and Fraser photinia increased with increasing rates of BA and resulted in a greater number of new shoots at 1,000 p.p.m. than did hand pruning, photo 7 (page 18).

Six months after repotting and a second BA application, little visual response was evident in the relative root rating for Helleri and Stoke's Dwarf hollies. Growth indices, shoot length, and plant height measurements

TABLE 19. EFFECT OF BA FOLIAR SPRAYS AND HAND PRUNING ON AXILLARY BUDBREAK OF FIVE WOODY NURSERY CROPS, EXPERIMENT 1

Treatment	Average number of new shoots/plant				
	Cleyera	Formosa azalea	Helleri holly	Fraser photinia	Stoke's Dwarf holly
	No.	*No.*	*No.*	*No.*	*No.*
BA[1]					
125 p.p.m.	6.3*[2]	11.2	11.5*	1.5	39.4
250 p.p.m.	6.8	10.6*	14.7	1.5	45.2
500 p.p.m.	6.5*	10.6*	20.9	4.4	35.0
1,000 p.p.m. ..	5.9*	9.9*	42.1*	7.3*	63.4*
Control	6.7	9.9*	6.8*	1.7*	29.7
Hand pruned	9.5	13.7	19.1	2.5	35.4
Significance[3]	q	c	c	c	l

[1]Applied as a foliar spray with 0.2 percent Buffer X, a surfactant, added.

[2]Dunnett's test for least significant difference; means within a column followed by an asterisk differ from the mean of the pruned treatment, 5 percent level.

[3]q = quadratic; c = cubic regression response; l = linear; 1 percent level.

TABLE 20. GROWTH INDEX, SHOOT LENGTH, AND PLANT HEIGHT OF HELLERI AND STOKES'S DWARF HOLLIES TREATED WITH BA, EXPERIMENT 1

Treatment	Growth index[1]		Shoot length[2]		Plant height	
	Helleri	Stoke's Dwarf	Helleri	Stoke's Dwarf	Helleri	Stoke's Dwarf
	cm	*cm*	*cm*	*cm*	*cm*	*cm*
BA						
125 p.p.m. ..	28.8	27.6*[3]	6.9	7.3	19.9	25.5*
250 p.p.m. ..	26.9	29.2*	4.7*	7.3	19.4	25.2*
500 p.p.m. ..	29.8	27.2	6.1	7.9	19.3	26.5*
1,000 p.p.m.	27.2	24.6	5.4	6.9	18.7	22.4
Control	30.4	26.9	7.6	7.7	20.6	26.5*[3]
Hand pruned ...	27.1	25.5	7.4	6.9	18.2	22.2
Significance[4]	ns	c	c	q	ns	c

[1]Growth index = (height + width + width)/3.
[2]Shoot length = mean of 5 longest shoots/plant.
[3]Dunnett's test for least significant difference; means within a column followed by an asterisk differ from the mean of the pruned treatment, 5 percent level.
[4]ns = not significant; c = cubic regression response; q = quadratic; 1 percent level.

tended to decrease with increasing BA rates, table 20. BA application, especially at the higher rates, resulted in dense and compact plants of Helleri and Stoke's Dwarf hollies. Phytotoxicity was not observed on any species.

Experiment 2

Axillary shoot number taken when treatments were first applied did not differ among treatments, so subsequent budbreak data were not adjusted. As in the first experiment, species responded differently to growth regulator application. Neither axillary budbreak nor plant height of cleyera was affected by BA or Promalin foliar sprays.

Axillary budbreak of Formosa azalea, determined in January 1988, decreased at the lower BA rates before increasing at the highest rate, table 21. By April, budbreak was positively correlated with BA rate, increasing from 9.1 breaks per plant for the unpruned control to 14.1 breaks per plant receiving 2,000 p.p.m. BA. Budbreak was not affected by Promalin in January, but by April 1988, budbreak increased linearly with increasing Promalin rate, from 9.1 breaks on the unpruned control to 22.1 breaks on plants treated with 5,000 p.p.m. Pruning induced greater budbreak than all plant growth regulator (PGR) treatments except 2,500 p.p.m BA in January and the lower two BA rates in April. Only the highest Promalin rate promoted greater budbreak than pruning. There was a decrease in plant height with increasing plant growth regulator rate; this trend was particularly evident in April.

Indian hawthorn responded minimally to both plant growth regulators. With increasing BA and Promalin rates there was a slight increase in budbreak noted in January 1988, however this response was not evident in May. Budbreak of pruned plants was significantly less in January than budbreak of plants treated with three rates of BA and Promalin and less in May than that of plants treated with all rates of both materials. Budbreak of pruned plants also was less than that of unpruned plants in May.

Axillary budbreak of Fraser photinia was promoted by BA and Promalin on both sampling dates, table 22.

TABLE 21. EFFECTS OF BA AND PROMALIN ON AXILLARY BUDBREAK AND HEIGHT OF FORMOSA AZALEA, EXPERIMENT 2

Treatment	Axillary budbreak		Plant height	
	Jan. 26, 1988	Apr. 1, 1988	Jan. 26, 1988	Apr. 1, 1988
	No.	*No.*	*cm*	*cm*
BA				
1,000 p.p.m.	5.5*[1]	8.1*	29.0*	49.7*
1,500 p.p.m.	4.9*	8.7*	31.9*	53.3*
2,000 p.p.m.	5.1*	14.1	28.9*	51.7*
2,500 p.p.m.	6.1	13.6	27.1*	42.8*
Promalin				
2,000 p.p.m.	5.5*	13.7	33.9*	46.4*
3,000 p.p.m.	5.9*	15.9	28.6*	41.7*
4,000 p.p.m.	5.5*	16.2	28.0*	37.6*
5,000 p.p.m.	6.0*	22.1*	29.5*	38.4*
Pruned	7.7	15.3	16.0	14.5
Unpruned	6.9	9.1*	30.7*	49.3*
Comparison				
BA vs. Promalin[2]	ns	**	ns	**
Sign of rate[3]				
BA	q	q	q	q
Promalin	ns	l	c	l

[1]Dunnett's test for least significant difference; means within a column followed by an asterisk differ from the mean of the pruned treatment, 5 percent level.
[2]ns = not significant or significant at the 1 percent (**) level.
[3]q = quadratic; ns = not significant; l = linear; c = cubic regression response; 1 percent level; unpruned control included in regression analysis.

TABLE 22. EFFECTS OF BA AND PROMALIN ON AXILLARY BUDBREAK AND HEIGHT OF FRASER PHOTINIA, EXPERIMENT 2

Treatment	Axillary budbreak		Plant height	
	Jan. 26, 1988	Apr. 1, 1988	Jan. 26, 1988	Apr. 1, 1988
	No.	*No.*	*cm*	*cm*
BA				
1,000 p.p.m.	3.8	11.5*[1]	22.3*	33.7*
1,500 p.p.m.	4.7	15.3*	25.7*	40.7*
2,000 p.p.m.	4.9	18.1*	22.1*	32.2*
2,500 p.p.m.	6.9*	23.8*	24.5*	36.0*
Promalin				
2,000 p.p.m.	4.7	20.7*	29.3*	42.6*
3,000 p.p.m.	5.9*	24.7*	29.3*	41.5*
4,000 p.p.m.	6.3*	24.6*	30.3*	40.9*
5,000 p.p.m.	9.6*	28.7*	36.9*	43.5*
Pruned	3.6	3.7	14.5	12.8
Unpruned	1.8*	11.0*	23.5*	38.1*
Comparison				
BA vs. Promalin[2]	**	**	**	**
Sign of rate[3]				
BA	q	l	ns	ns
Promalin	c	l	c	ns

[1]Dunnett's test for least significant difference; means within a column followed by an asterisk differ from the mean of the pruned treatment, 5 percent level.
[2]ns = not significant or significant at the 1 percent (**) level.
[3]q = quadratic; ns = not significant; l = linear; c = cubic regression response; 1 percent level; unpruned control included in regression analysis.

In January, budbreak of BA-treated plants increased from 1.8 for the unpruned treatment to 6.9 breaks with 2,500 p.p.m. BA. In April, the increase was from 11.0 to 23.8 breaks per plant. Budbreak increased to 9.6 in January and to 28.7 in April with the highest Promalin rate. Budbreak of pruned plants was twice that of unpruned plants in January but less in April. Pruning was less effective in inducing axillary budbreak than 2,500 p.p.m. BA and the three highest Promalin rates in January and all rates of both in April. Plant height, measured in January, was promoted by Promalin, but was not evident in April.

BA and Promalin increased axillary budbreak of Harbour Dwarf nandina compared to unpruned plants, table 23. The BA-induced increase was from 1.1 breaks for unpruned plants to 3.9 breaks with 2,000 p.p.m. in January and from 1.3 to 7.4 breaks with 2,000 p.p.m. in April; Promalin promoted budbreak to 3.3 breaks in January and 5.5 breaks in April with 5,000 p.p.m. Pruning induced more budbreaks compared to the unpruned control and was more effective than the two lowest Promalin rates in January but less effective than the three highest BA rates and the highest Promalin rate in April. Plant height of Promalin-treated plants was greater than height of unpruned plants on both sampling dates.

TABLE 23. EFFECTS OF BA AND PROMALIN ON AXILLARY BUDBREAK AND HEIGHT OF HARBOUR DWARF NANDINA, EXPERIMENT 2

Treatment	Axillary budbreak		Plant height	
	Jan. 26, 1988	Apr. 1, 1988	Jan. 26, 1988	Apr. 1, 1988
	No.	*No.*	*cm*	*cm*
BA				
1,000 p.p.m.	2.0	3.6	12.6	16.9
1,500 p.p.m.	3.9	5.8*[1]	11.4	17.3
2,000 p.p.m.	4.1	7.4*	13.1	18.6
2,500 p.p.m.	3.8	7.4*	13.3	18.2
Promalin				
2,000 p.p.m.	1.6*	3.5	18.0	27.2*
3,000 p.p.m.	1.3*	2.4	18.5*	26.9*
4,000 p.p.m.	1.9	3.5	22.4*	36.8*
5,000 p.p.m.	3.3	5.5*	21.6*	43.3*
Pruned	3.4	2.9	11.3	15.7
Unpruned	1.1*	1.3	12.1*	16.8
Comparison				
BA vs. Promalin[2]	**	**	**	**
Sign of rate[3]				
BA	c	l	ns	ns
Promalin	l	c	l	l

[1]Dunnett's test for least significant difference; means within a column followed by an asterisk differ from the mean of the pruned treatment, 5 percent level.
[2]ns = not significant or significant at the 1 percent (**) level.
[3]c = cubic regression response; 1 percent level; l = linear; ns = not significant; unpruned control included in regression analysis.

More single-node apical and subapical cuttings were taken from Promalin-treated Harbour Dwarf nandina and more apical cuttings were taken from BA-treated plants than from unpruned plants, table 24. This increase represents an important source of propagation material for the grower from a cultivar that does not naturally branch or form multi-node shoots.

TABLE 24. NUMBER OF CUTTINGS TAKEN FROM HARBOUR DWARF NANDINA SPRAYED WITH BA OR PROMALIN, EXPERIMENT 2

Treatment	Cuttage[1]		
	Apical	Subapical	Total
	No.	*No.*	*No.*
BA			
1,000 p.p.m.	1.6	0.0	1.6
1,500 p.p.m.	3.0	.0	3.0
2,000 p.p.m.	3.4	.0	3.4
2,500 p.p.m.	4.8	.4	5.2
Promalin			
2,000 p.p.m.	1.8	2.2	4.0
3,000 p.p.m.	2.0	1.2	3.2
4,000 p.p.m.	2.2	2.4	4.6
5,000 p.p.m.	3.2	4.6	7.8
Pruned	1.4	.0	1.4
Unpruned	1.0	.0	1.0

[1]Means of five single-plant replicates.

BA promoted axillary budbreak of Fraser photinia, Harbour Dwarf nandina, Helleri holly, Stoke's Dwarf holly, and Formosa azalea, while budbreak of Harbour Dwarf nandina, Fraser photinia, and Formosa azalea was stimulated by Promalin. These responses were species and rate-dependent, with higher rates generally inducing more lateral budbreak than lower rates. Branching of cleyera and Indian hawthorn was not influenced by BA or Promalin application. BA and Promalin generally induced equivalent or greater numbers of axillary shoots compared to mechanical pruning. Plant height of all species and root rating, growth index, and shoot length of Helleri and Stoke's Dwarf hollies were minimally influenced by PGR application.

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Plant Response to Planting Method and Media

Gary J. Keever and Gary S. Cobb

CONTROLLED-RELEASE granular fertilizers are typically applied either uniformly incorporated into container growth media or surface-applied as a topdressing. Incorporation has proven successful in a wide range of applications, but uniform blending is essential and subsequent storage for more than a week is not recommended due to the potential release of fertilizer salts. Longer storage necessitates leaching prior to planting to avoid phytotoxicity, but this wastes fertilizer and could result in undesirable pollution of the surrounding area. Intermittent drying of surface-applied fertilizer slows release due to a lack of continuous moisture, and fertilizer may be lost if the container is overturned or rapidly flooded.

Placement of the fertilizer directly under the liner at transplanting (dibbling) is a third method that presents no storage, mixing, drying, or spilling problems. In some cases, dibbling has resulted in more growth or superior-quality plants compared to incorporation.

In other studies, either no benefit or a negative response to dibbling was observed. A possible explanation for the poor results with dibbling is that compaction of the growth medium at planting restricts root growth. The objective of this research was to compare dibbling with excavating (removal of a core to form the planting hole without compaction of the growth); media effects on planting method were also evaluated.

Aged pine bark was mixed with a sandy loam soil in 4 ratios (1 pine bark:1 soil, 4:1, 9:1, 1:0, by volume). Media were amended by preplant incorporation of 6 pounds dolomitic limestone, 2 pounds gypsum, and 1.5 pounds Micromax® per cubic yard. Osmocote® 17-17-12 at 0.63 ounce per #1 container was placed under each liner at planting. Bulk densities, particle size distributions, water holding capacities, and air porosities were obtained for each growth medium.

Uniform liners of Compacta holly and Hino Crimson azalea were transplanted into #1 containers of the four growth media on March 28, 1984. Two planting methods were compared: (1) compression to form the planting hole (dibbling), and (2) removal of a core to form the planting hole (excavating). Compressed hole and core were similar in size to a linear rootball. Plants were grown in full sun. Plants within media treatments were irrigated as needed by overhead impact sprinklers. After 7 months, growth index [(height + $width_1$ + $width_2$)/3], shoot dry weight, and relative root density were determined.

In a second experiment, liners of Helleri holly and Trouper azalea were transplanted on April 12, 1985, into #1 containers, by either dibbling or excavating. Growth media included four media commonly used in the Southeastern United States: 100 percent milled pine bark; pine bark:sandy loam soil (4:1, by volume); pine bark:peat moss (3:1, by volume); and peat moss:softwood shavings (1:1, by volume). Media were amended as in the first experiment, and 0.67 ounce of Osmocote 17-7-12 was placed under each holly and azalea liner, prior to transplanting. Plants were grown in full sun and watered as needed by overhead irrigation. After 7 months, growth index, shoot dry weight, and relative root density were determined.

Experiment 1

Physical properties varied greatly among the four media. For example, the higher the percent bark in the pine bark:soil media the higher the percentage of coarse material and the higher the air porosity. Conversely, the higher the percent soil in the media the greater the fraction of fine material, and the greater the bulk density. Water-holding capacity was not greatly influenced by media; however, irrigation frequency was increased 23.4, 29.8, and 44.7 percent with 4:1, 9:1, and 1:0 pine bark:sandy loam soil media, respectively, compared to the 1 bark:1 soil growth medium.

Planting method influenced shoot growth and root density of both holly and azalea, tables 25 and 26. Shoot dry weight of holly and azalea averaged 0.17 and 0.13 ounce, respectively, more when media were excavated at transplanting compared to dibbled. Root densities also were greater with excavating. Growth indices of the two species were not influenced by planting method.

Growth index and relative root density of holly increased as the percentage of sandy loam soil in the media decreased from 50 percent (1:1) to 20 percent (4:1); there were only minor differences in these measurements among the three media with lower percentages of soil. Shoot dry weight was similar among treatments, except holly growth was greater in the 9:1 growth medium.

Growth index, shoot dry weight, and root density of azalea increased with increasing percentages of pine bark up to 90 percent; there was little change in measurements as the percentage of pine bark increased

TABLE 25. EFFECTS OF PLANTING METHOD AND GROWTH MEDIA ON GROWTH OF COMPACTA HOLLY 7 MONTHS AFTER TRANSPLANTING

Comparison	Growth index[1]	Shoot dry weight	Relative root density[2]
	cm	*Grams*	
Method			
Dibble	35.7a	33.3b	3.2b
Excavate	36.1a[3]	38.1a	3.5a
Pine bark:sandy loam ratio			
1:1	33.7	34.5	2.3
4:1	36.6	35.5	3.7
9:1	37.0	38.3	3.6
1:0	36.4	34.7	3.8
Significance[4]	q**	c*	c**
Method x ratio of pine bark: sandy loam[5]	ns	ns	ns

[1]Growth index = (height + $width_1$ + $width_2$)/3, in centimeters.
[2]Relative root density: 1 = few surface roots on root ball; 3 = moderate root density over entire rootball; 5 = dense matting over entire rootball.
[3]Mean separation within columns by Duncan's multiple range test, 5 percent level.
[4]Quadratic (q) or cubic (c) regression response significant at 5 percent (*) or 1 percent (**) level.
[5]Plant method x media interaction not significant (ns).

TABLE 26. EFFECTS OF PLANTING METHOD AND GROWTH MEDIA ON GROWTH OF HINO CRIMSON AZALEA 7 MONTHS AFTER TRANSPLANTING

Comparison	Growth index[1]	Shoot dry weight	Relative root density[2]
	cm	*Grams*	
Method			
Dibble	31.1a	39.9b	3.2b
Excavate	31.8a[3]	43.7a	3.4a
Pine bark:sandy loam ratio			
1:1	28.6	38.9	2.3
4:1	30.9	38.9	3.2
9:1	33.3	44.0	3.9
1:0	33.0	45.5	4.0
Significance[4]	c**	q*	c**
Method x ratio of pine bark: sandy loam[5]	ns	ns	*

[1]Growth index = (height + $width_1$ + $width_2$)/3, in centimeters.
[2]Relative root density: 1 = few surface roots on root ball; 3 = moderate root density over entire rootball; 5 = dense matting over entire rootball.
[3]Mean separation within columns by Duncan's multiple range test, 5 percent level.
[4]Cubic (c) or quadratic (q) regression response significant at 5 percent (*) or 1 percent (**) level.
[5]Plant method x media interaction not significant (ns).

TABLE 27. EFFECTS OF PLANTING METHOD AND GROWTH MEDIA ON GROWTH OF HELLERI HOLLY 7 MONTHS AFTER TRANSPLANTING

Growth media	Growth index[1]		Shoot dry weight		Relative root density[2]	
	Dibble	Excavate	Dibble	Excavate	Dibble	Excavate
	cm	*cm*	*Grams*	*Grams*		
Pine park (100 percent)	38.9a(b)[3]	39.3a(b)	30.4b(c)	34.7a(b)	2.2ab(ab)	2.4a(ab)
Pine bark-sandy loam (4:1)	35.5b(c)	41.5a(ab)	25.4b(c)	41.0a(a)	2.0b(b)	2.5a(a)
Pine bark-peat moss (3:1)	42.5a(a)	43.2a(a)	39.1a(b)	42.3a(a)	2.4a(a)	2.4a(ab)
Peat moss-shavings (1:1)	44.6a(a)	43.1a(a)	49.2a(a)	45.5a(a)	2.2a(ab)	2.2a(b)

[1]Growth index = (height + $width_1$ + $width_2$)/3, in centimeters.
[2]Relative root density: 1 = few surface roots on rootball; 3 = moderate root density over entire rootball; 5 = dense matting over entire rootball.
[3]Mean separation within planting method made using LSD at 5 percent level; mean separation within growth media ( ) by Duncan's multiple range test, 5 percent level. All planting method x media interactions were significant.

from 90 to 100 percent. Root density was greater with excavation than with dibbling in the 4:1 and 9:1 media, but similar for plants in the other two media transplanted by the two methods.

Experiment 2

Excavation resulted in a higher growth index than dibbling in the pine bark-sandy loam growth medium and a greater shoot dry weight and relative root density in 100 percent pine bark and pine bark-sandy loam media, table 27. Planting method did not affect measurements of plants grown in other media.

Growth index and shoot dry weight of dibbled hollies were greater when plants were grown in media containing peat moss compared to media without peat moss. Plants of the excavation planting method had the lowest growth index and shoot dry weight when grown in 100 percent pine bark, possibly because of less water retention compared to the other media. Root density of dibbled hollies was greater in a pine bark medium when peat moss was a component compared to sandy loam soil. Excavation resulted in less root growth in a peat moss-shavings medium than in the pine bark-sandy loam medium.

Neither growth index, shoot dry weight, nor relative root density of azalea was influenced by planting method. Growth index and shoot dry weight were greater in peat-based media than in media not containing peat moss. Root density of plants grown in pine bark + sandy loam soil or peat moss was greater than root density in 100 percent pine bark or peat moss-shavings medium.

Shoot and root growth of two species in two experiments were either greater or not influenced when the planting hole was excavated rather than dibbled. This response was media-dependent, occurring in media with a range of pine bark:sandy loam ratios but not in peat-based media. Alterations in the physical properties of the media during formation of the planting hole or differences in moisture-holding capacity of excavated and dibbled media may explain growth differences.

Placement of controlled-release fertilizer directly under the liner at transplanting is an effective method of fertilization that avoids media storage and mixing problems. However, plant growth may be adversely affected if the planting hole is formed by compression (dibbling) rather than removal of a core (excavating). This effect is more likely to occur in pine bark-based media that do not contain peat than in peat-based media.

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Paclobutrazol Inhibits Growth of Woody Landscape Plants

Gary J. Keever, William J. Foster, and
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MECHANICAL PRUNING to control excessive vegetative growth and improve plant form is a major expense in the production and maintenance of some woody landscape plants. Over time, numerous compounds have been used to retard woody plant growth, but most remain uneconomical or cause undesirable side effects. Currently, chemical growth inhibitors are being actively evaluated by the electric utility industry, which spends an estimated $800 million per year on tree trimming.

Paclobutrazol, registered as Clipper®, is an inhibitor of gibberellin biosynthesis and is used to suppress regrowth of pruned trees along utility rights-of-way. Clipper is labeled for trunk injection of trees, which avoids chemical contact with nontarget plants and reduces environmental residues. Paclobutrazol also is labeled as Bonzi® for use on poinsettias, bedding plants, chrysanthemums, geraniums, and potted freesias. Little published research is available on the potential uses of paclobutrazol in the production of woody landscape plants. The objectives of this research were to evaluate the magnitude and duration of growth inhibition by media- and foliar-applied paclobutrazol for eight woody landscape species.

Uniform liners of eight species were potted March 27, 1986, in an amended 100 percent milled pine bark growth medium. Plant species and container sizes included euonymus, dwarf Burford holly, compacta holly, juniper, Hino Crimson azalea, photinia, and Formosa azalea in #1 gallon containers and privet in #3 containers. Plants were placed outdoors in full sun or under 47 percent shade (euonymus and azaleas) and maintained following typical nursery cultural practices. On July 23, 1986, the following treatments were applied: paclobutrazol sprays of 0, 250, 500, 1,000, and 2,000 p.p.m. and drenches of 6.3, 25, and 100 mg active

TABLE 28. GROWTH INDICES OF EIGHT WOODY LANDSCAPE SPECIES DRENCHED OR SPRAYED WITH PACLOBUTRAZOL, NOVEMBER 19, 1986 (17 WAT)

Treatment (a.i.)	Index[1] by species							
	Euonymus	Compacta holly	Dwarf Burford holly	Juniper	Privet	Photinia	Formosa azalea	Hino Crimson azalea
Drench								
6.3 mg/pot	33.8	42.4	24.0	44.5	76.0	50.8	49.8	38.8
25.0 mg/pot	32.8	39.7	25.6	42.9	75.2	47.0	53.8	37.7
100.0 mg/pot	30.4	38.5	25.8	36.6	68.5	43.5	49.9	38.8
Control	44.3	45.5	28.1	52.2	100.5	78.2	62.6	41.8
Significance[2]	c**	q**	c*	c**	c**	c**	c**	c**
Spray								
250 p.p.m.	45.1	46.9	25.0	47.5	91.3	63.3	56.7	38.5
500 p.p.m.	45.0	41.5	24.1	50.0	89.5	56.0	55.3	38.7
1,000 p.p.m.	41.5	42.3	24.7	45.9	82.6	55.4	54.1	39.4
2,000 p.p.m.	40.7	40.3	27.1	44.5	74.9	50.7	53.4	38.5
Control	44.3	45.5	28.1	52.2	100.5	78.2	50.7	41.8
Significance	c*	l**	q**	l**	l**	c**	q**	c*
Drench	32.3*[3]	40.2*	25.1	41.3*	73.2*	47.1	51.1*	38.4
Spray	43.1	42.8	25.2ns	47.0	84.6	56.4	54.9	38.8ns

[1]Growth index = (height + $width_1$ + $width_2$)/3 in centimeters, where $width_1$ = width at the widest point and $width_2$ = width at a right angle to $width_1$.
[2]Significant at the 5 percent (*) or 1 percent (**) level; c = cubic; l = linear, q = quadratic. Zero rate included in regression analysis.
[3]Significant (*) or not significant (ns) at the 5 percent level; zero rate not included in mean determination

ingredient (ai) in a volume of 8.5 ounces per container. (A dosage of 100 mg = 0.0035 ounce.)

On November 19, 1986, 17 weeks after treatment (WAT), growth indices and foliar color ratings were determined for all species. On March 27, 1987 (35 WAT), flowers on five plants of Formosa azalea were counted and the diameter of 10 flowers each on four plants of Hino Crimson azalea was measured. Growth indices were taken again on June 19 (48 WAT) and December 1, 1987 (71 WAT); foliar color was rated on December 9, 1987 (72 WAT), and fruit of dwarf Burford holly was counted on January 18, 1988 (78 WAT). On March 8, 1988 (84 WAT), root systems of all species were rated for density, foliage color was rated, and shoots were severed at the container medium surface for dry weight determination.

By November 19, 1986 (17 WAT), significant differences in growth indices had occurred in response to both concentration and application method, table 28. In general, growth indices of all species decreased with increasing drench and spray concentrations. Drench treatments were more active than spray treatments for six species, while two species (dwarf Burford holly and Hino Crimson azalea) responded similarly, regardless of the application method. Similar trends in growth indices to those on November 19 were observed on June 19, 1987 (48 WAT), and December 1, 1987 (71 WAT). Growth indices for all species decreased with increasing paclobutrazol concentrations except for spray-treated euonymus (both dates) and juniper (June date only). Drenches again were more effective than sprays in suppressing growth indices for all species on both sampling dates.

For most species, foliar color ratings taken November 19, 1986 (17 WAT), were not influenced by treatment. By December 9, 1987 (72 WAT), foliar color ratings of most species were influenced by paclobutrazol, Foliar color ratings for six of eight species drenched and four of eight species sprayed with paclobutrazol improved with increasing concentration, while foliar color ratings of drench-treated dwarf Burford holly and Hino Crimson azalea were greatest at the low concentrations.

Flower number for Formosa azalea increased dramatically in response to paclobutrazol, with as much as a 360 percent and 238 percent increase in flower number with sprays and drenches, respectively, compared to nontreated plants, table 29. Flower diameter of Hino Crimson azaleas drenched or sprayed was reduced as much as 46 and 11 percent, respectively, compared with the control. Flowering of drench-treated plants of both cultivars was delayed about 3 weeks.

TABLE 29. FLOWERING OR FRUITING OF THREE WOODY LANDSCAPE SPECIES DRENCHED OR SPRAYED WITH PACLOBUTRAZOL

Treatment (a.i.)	Formosa flowers[1]	Hino Crimson flower diameter[2]	Dwarf Burford holly fruit[3]
	No.	*cm*	*No.*
Drench			
6.3 mg/pot	—	2.9	239.6
25.0 mg/pot	189.1	2.1	73.0
100.0 mg/pot	153.0	1.9	1.5
Control	79.2	3.5	40.2
Significance[4]	q**	q**	c**
Spray			
250 p.p.m.	119.2	3.3	40.2
500 p.p.m.	238.6	3.2	208.4
1,000 p.p.m.	287.6	3.1	159.5
2,000 p.p.m.	274.4	3.3	272.5
Control	79.2	3.5	275.0
Significance	q**	q**	q**
Drench	171.1**[5]	2.3**	104.7
Spray	230.0	3.2	228.9

[1]Means of five single-plant replicates, March 27, 1987. Due to a delay in flowering, data on drench-treated plants were taken April 20, 1987. Data for the 6.25 mg a.i. drench not available.
[2]Means of 10 flowers per plant, 4 single-plant replicates, March 27, 1987. Due to a delay in flowering, data on drench-related plants were taken April 20, 1987.
[3]Means of 10 single-plant replicates, January 18, 1988.
[4]Significant at the 1 percent level; q = quadratic, c = cubic. Zero rate included in regression analysis.
[5]Significant at the 1 percent (**) level.

Fruit number of dwarf Burford holly increased with increasing spray concentrations compared to nontreated plants, while drench-treated plants increased in fruit number at the lowest concentration and decreased to essentially zero at the highest concentration.

Terminal data collected on March 8, 1988 (84 WAT), were root density and shoot dry weight. Roots of most species covered the entire rootball surface and were densely matted, regardless of treatment. However, differences among treatments were evident with the two azalea species and dwarf Burford holly. Root density of Formosa azaleas treated with the highest drench concentration was less than plants in other treatments, whereas root density of Hino Crimson azalea decreased with increasing drench concentration. Root coverage of sprayed and control plants was similar for both azalea cultivars. Root coverage of dwarf Burford holly was highest for nontreated plants and decreased with increasing paclobutrazol concentration, with drenches suppressing root growth more than sprays.

Twenty months after paclobutrazol was applied, shoot dry weight was suppressed on all species drenched and on six of eight species sprayed, table 30. Only dry weight of spray-treated dwarf Burford holly and juniper was not affected by treatment. Growth retardation was greater for seven of eight species drenched compared to sprayed.

In addition to quantitative differences among treatments, visual or aesthetic changes were observed with paclobutrazol-treated plants. Generally, plants responded to increasing drench and spray concentration by producing shorter internodes and smaller leaves. Axillary buds began to develop on several species, but these buds seldom elongated more than 0.8-1.6 inches. Foliage of some species was darker green when treated with paclobutrazol; with other species, treatment had no effect on foliar color. Relatively high concentrations of paclobutrazol generally do not cause phytotoxicity. However, in this test several species exhibited phytotoxicity symptoms in response to the highest paclobutrazol concentrations; for example, foliage of dwarf Burford holly developed tip and marginal chlorosis while new foliage of photinia and the two azalea cultivars curled downward. As a result of excess internode suppression, other species developed dense clusters of leaves closely adpressed along the stems.

Paclobutrazol is a powerful inhibitor of internode elongation. Growth inhibition was detected as early as 4 months after paclobutrazol was applied and persisted for at least 20 months. Generally, the magnitude and duration of growth suppression was greater when paclobutrazol was applied as a drench than as a spray, as exemplified by the growth indices, table 28, and shoot dry weight, table 30. Foliar color ratings generally increased when paclobutrazol was applied as a drench; response to sprays varied among species. Paclobutrazol promoted flowering and fruiting, table 29, of several species.

Paclobutrazol is an effective growth retardant on a wide range of woody landscape plants when applied as either a drench or spray. This may offer growers an additional management tool; for example, its use offers the ability to retard growth during a depressed market or avoid transplanting. Due to the magnitude and persistence of growth suppression, drench applications during production are probably not practical and spray concentrations should be carefully chosen. Drench and spray application methods have potential for the landscape industry, however established plants may respond differently than container-grown plants to paclobutrazol concentration and application method due to differences in growth medium or other factors. Sensitivity to paclobutrazol varied greatly among species, and appropriate concentrations are likely to be highly species-dependent; hence, paclobutrazol should first be tested on a small group of plants before committing to large scale application.

Keever is Associate Professor of Horticulture; Foster is former Superintendent and Stephenson is Associate Superintendent of the Ornamental Horticulture Substation.

TABLE 30. SHOOT DRY WEIGHT OF EIGHT WOODY LANDSCAPE SPECIES DRENCHED OR SPRAYED WITH PACLOBUTRAZOL, MARCH 8, 1988 (84 WAT)

Treatment (a.i.)	Dry weight, by species							
	Euonymus	Compacta holly	Dwarf Burford holly	Juniper	Privet	Photinia	Formosa azalea	Hino Crimson azalea
	Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
Drench								
6.3 mg/pot	52.2	82.6	45.0	161.9	172.2	111.4	129.6	67.9
25.0 mg/pot	47.9	81.0	26.0	182.4	181.1	95.2	116.7	46.2
100.0 mg/pot	37.0	63.9	21.7	112.9	144.5	43.9	32.4	27.3
Control	83.8	119.2	63.4	171.2	277.9	164.0	242.6	102.6
Significance[2]	c**	c*	q**	q*	c**	c**	c**	c**
Spray								
250 p.p.m.	77.2	127.9	65.8	164.3	232.3	162.5	248.3	96.3
500 p.p.m.	82.3	106.7	70.6	151.5	235.5	128.0	255.8	74.8
1,000 p.p.m.	78.7	102.5	57.0	166.1	182.8	110.6	213.9	69.4
2,000 p.p.m.	67.3	88.4	61.3	1,710.6	200.6	164.0	174.1	64.2
Control	83.8	119.2	63.4	171.2	277.9	92.9	242.6	102.6
Significance	l**	l**	ns	ns	q**	l**	c**	q**
Drench	45.7	75.8*	30.9*	152.4	165.9*	83.5*	128.4	47.1*
Spray	76.4	106.4	63.7	163.1ns	212.8	123.5	223.0	76.2

[1]Significant or not significant (ns) at the 5 percent (*) or 1 percent (**) level; q = quadratic, c = cubic; l = linear. Zero rate included in regression analysis.
[2]Significant (*) or not significant (ns) at the 5 percent level; zero rate not included in mean determination.

INSECT, DISEASE, AND WEED CONTROL

Herbicide Effects on Rooting and Root Growth

Mack Thetford, Charles H. Gilliam, and D. Joseph Eakes

MANY GROWERS propagate cuttings by placing the cuttings in small containers (rose pots) under mist in greenhouses or outdoor groundbeds. Weed control in these areas is a recurring problem currently addressed by hand weeding. Use of herbicides to control weeds in these areas would be beneficial; however, information is limited on how herbicides affect rooting and subsequent root growth of woody cuttings. Previous work has demonstrated that suppressed rooting and lower root quality occurred when herbicides were broadcast over the top of cuttings during propagation. Defoliation of some species was also observed.

In commercial production, cuttings are stuck directly into individual pots, pots are filled with media, placed in flats, and the flats are moved to the propagation house 1-2 days prior to sticking the cuttings. During this time, the pots are watered to thoroughly wet the medium. Preemergence application of herbicides to the pots before sticking the cuttings may avoid the direct herbicide injury previously reported. The objective of this study was to determine if pre-propagation application of preemergence applied herbicides would affect rooting and subsequent root growth of selected woody plants.

Experiment 1 was initiated in November 1986, when 3-inch-square pots were filled with a pinebark and sand medium (1:1, by volume) amended per cubic yard with 6 pounds Osmocote® 18-6-12, 3 pounds dolomitic limestone, and 1.5 pounds Micromax®. Treatments included five herbicides and a nontreated control. The following four herbicides were applied at 3.0 pounds a.i. per acre: Rout 3G®, OH-2 3G, Surflan 4AS®, and Prowl 4L®. Ronstar 2G® was applied at 4.0 pounds per acre. These herbicides were selected for evaluation because (1) Rout, OH-2, and Ronstar are the three major herbicides used in container production, (2) Surflan is one of the most widely used herbicides in ornamental crops, and (3) Prowl has recently received an ornamental label. Granular formulations were applied with a hand-held shaker; Surflan and Prowl were applied with a CO_2 sprayer at 29 p.s.i. with 20 gallons of water per acre.

All herbicides were applied to the medium prior to sticking cuttings. The base of each cutting was dipped in a 5,000 p.p.m. K-IBA solution prior to sticking and placed under intermittent mist (2.5 seconds per 5 minutes from 8 a.m. to 5 p.m.) in a 50 percent shade glass house. Two species, *Ilex* × *attenuata* Fosteri (Foster holly) and *Juniperus horizontalis* Wiltoni (Blue Rug juniper) were used. Data collected included rooting percentage, root number, and root rating scale: 1 = distorted roots < 0.4 inch, 2 = 1-4 roots 0.4-2.0 inches long, 3 = 5-10 roots 0.4-2.0 inches long, 4 = 10-15 roots 0.4-2.0 inches long, 5 = 16+ roots 0.4-2.0 inches long.

Experiment 2 was initiated in June 1987. Species used were: *Abelia* × *grandiflora* (abelia), *Buxus microphylla* Koreana (Korean boxwood), and *Ilex crenata* Compacta (Compacta holly). Procedures and treatments were identical to those in experiment 1. Rooting data were collected 8 weeks later (August), and growth indices and root density ratings were measured in December 1987 [4 months after potting (4 MAP)], March 1988 (7 MAP), and September 1988 (13 MAP). Cuttings were maintained in the greenhouse until May 1988 in the original 3-inch pots when they were potted into 1-gallon containers using the medium previously described, except that the Osmocote rate was 14 pounds per cubic yard, and moved to an outdoor container-growing area. The root density rating scale was: 1 = no roots visible on outer edge of rootball, 3 = root development to outer edge of rootball, and 5 = total root coverage of rootball. Due to a lack of roots on the outer edge of the rootball in September 1988, root fresh weights were collected on the Japanese holly.

In experiment 1, rooting percentage, root number, and root ratings of Blue Rug juniper were not affected by any herbicide treatment. In contrast, rooting percentage (3 percent vs. 36 percent) and root ratings (1.0 vs. 2.3) of Foster holly were severely suppressed with Surflan compared to nontreated controls. None of the other herbicide treatments affected Foster holly rooting percentage or root quality.

In experiment 2, Korean boxwood rooting percentage and root ratings 8 weeks after sticking were suppressed with Surflan compared to all other treatments, table 31. Growth index measurements indicated shoot growth suppression continued up to 14 MAP with Surflan, compared with the nontreated control. Korean boxwood root growth suppression also continued throughout the test with Surflan. These data support previous findings that reduced root growth of Japanese holly liners occurred with Surflan-treated plants. There were no measurable effects with the other treatments until 13 MAP, when root density ratings were suppressed with Rout, OH-2, and Prowl. These data indicate potential long-term effects from using products containing dinitroaniline herbicides (Rout and OH-2) in the propagation of woody plants. Both Rout and OH-2 are commonly used in commercial production of container nursery crops and producers may consider their use in propagation since these products would be available at the nursery. Ronstar and nontreated plants were sim-

TABLE 31. ROOT AND SHOOT GROWTH RESPONSE OF KOREAN BOXWOOD PROPAGATED IN HERBICIDE-TREATED MEDIUM, EXPERIMENT 2

Treatment/rate per acre	Rooting[1]	Root rating[2]	Results, by months after potting				
			Growth index[3]			Root density rating[4]	
			4	7	14	4	14
	Pct.						
Rout, 3.0 lb.	82a	2.7a	10.0abc	20.2ab	19.5abc	4.0a	2.3bc
OH-2, 3.0 lb.	92a	2.6a	10.0abc	20.6ab	20.0ab	4.0a	2.6b
Ronstar, 4.0 lb.	92a	2.8a	10.2abc	20.8ab	21.4a	3.9ab	2.8ab
Surflan, 3.0 lb.	75b	1.2b	9.2c	17.4b	17.6c	3.7b	2.0c
Prowl, 3.0 lb.	83a	2.7a	10.9ab	21.9a	21.6a	4.1a	2.5bc
Nontreated	90a	3.1a	11.3a	20.1a	20.5ab	4.2a	3.2a

[1]Rooting percentage measured August 1987, 8 weeks after sticking.
[2]Root rating scale: 1 = distorted roots < 1 cm, 2 = 1-4 roots 1-5 cm, 3 = 5-10 roots 1-5 cm, 4 = 10-15 roots 1-5 cm, 5 = 16+ roots 1-5 cm; August 10, 1987.
[3]Growth index: (height + width at widest point + width perpendicular to widest point)/3.
[4]Root density rating scale: 1 = no roots visible on outer edge of rootball, 3 = root development to outer edge of rootball, 5 = total root coverage of rootball.
[5]Mean separation within columns by Duncan's multiple range test (5 percent level).

ilar throughout the test with respect to all data collected.

Compacta holly rooting percentage was suppressed with Surflan and initial root ratings were lower with Surflan and Rout. Root density ratings 4 MAP showed that all treatments resulted in less root growth, compared with nontreated plants. At the end of the study (13 MAP), root fresh weights were less with Surflan than with the nontreated control (57.6 vs. 94.9 grams); shoot fresh weight was not affected by Surflan application. All other treatments had similar root and shoot fresh weight, compared with the nontreated plants.

Initial abelia root ratings were lower with Rout and Surflan, while rooting percentage was lower with OH-2; however, at 4 MAP, root and shoot growth were similar among all treatments.

This study demonstrates several important considerations when using preemergence-applied herbicides in propagation of woody plants. First, plant response varies with herbicide application. In experiment 1, Blue Rug juniper rooting percentage was not affected by any preemergence herbicide application, while in experiment 2, both Korean boxwood and Compacta holly rooting percentage was less with Surflan.

The results also demonstrate that herbicide application may inhibit root growth for varying lengths of time depending on the plant species. In experiment 2, abelia root growth was suppressed initially with Rout and Surflan; however, by 4 MAP, treatment effects on abelia root growth were not significant. With Korean boxwood, root suppression continued for 13 MAP. Dinitroanaline herbicides (Surflan and Prowl) were involved in all cases of extended suppression of root growth. Since root inhibition of annual crops is a major characteristic of dinitroanaline herbicides and in consideration of previous work with woody plants, strong evidence is provided against the use of Surflan or Prowl and their combination products during propagation.

Thetford is former Graduate Student, Gilliam is Professor, and Eakes is Assistant Professor of Horticulture.

Landscape Fabrics Suppress Growth of Weed Species

Chris A. Martin, Charles H. Gilliam, and Harry G. Ponder

MULCHING LANDSCAPE planting beds may enhance aesthetic value, reduce soil temperature fluctuations, and increase resistance to weed pressure. Laying plastic underneath an organic mulch is a common landscape installation practice. Previous work evaluating mulching with pine bark over black polyethylene concluded that the presence of black polyethylene made little difference in controlling weed growth, while winter kill of landscape plants was increased by 60 percent compared with bark mulch alone.

An alternative to black polyethylene is polypropylene fabrics now on the market. Two types of fabrics available are the woven and nonwoven polypropylene polymers. Polymers of nonwoven fabrics are spun-bound or meshed, while polymers of woven fabrics are generally of thicker diameter and tightly woven. Most polypropylene polymers are readily oxidized when exposed to ultraviolet light and are limited for use as an undercover supplemental mulch under a surface component such as pine bark. However, some fabrics, such as the Dewitt Pro 5 Weed Barrier® (woven), are surface-coated with carbon black, conferring a degree of resistance to degradation from ultraviolet light and therefore may be used singly as a mulching material.

Unlike polyethylene sheets, polypropylene landscape fabrics are permeable to water. This is an advantage in facilitating improved soil aeration and reducing root growth at the plastic-soil interface. However, the principal purpose of mulching is to suppress weeds. This study was designed to compare the effectiveness of several polypropylene landscape fabrics in suppressing the emergence and growth of selected weed species.

Two separate 30-day experiments were conducted in an unshaded double polycovered greenhouse with a daily temperature range of 66° to 88°F. Rectangular plastic flats 11 × 20.5 inches were filled with pine

TABLE 32. AVERAGE COUNT (CNT) AND SHOOT DRY WEIGHT (SDW) PER FLAT OF WEEDS PENETRATING UP THROUGH SIX LANDSCAPE MATS 30 DAYS AFTER SOWING, EXPERIMENT 1

Mat type	Yellow nutsedge		Bermudagrass		Johnsongrass		Pigweed		Sicklepod		Smallflower morningglory	
	CNT	SDW	CNT	SDW	CNT	SDW	CNT	SDW	CNT	SDW	CNT	SDW
	No.	*Grams*	*No.*	*Grams*	*No.*	*Grams*	*No.*	*Grams*	*No.*	*Grams*	*No.*	*Grams*
Dewitt Landscape Fabric	1.3ab[1]	1.5a	0.0a	0.0a	0.8a	0.7a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a
Geoscape Landscape Fabric	.3a	.1a	7.0ab	3.7b	1.7a	11.4ab	.0a	.0a	.0a	.0a	.0a	.0a
Amoco Rit-a-Weed	2.5bc	.2a	11.3b	7.3b	7.5a	40.7c	5.3ab	7.5b	.0a	.0a	.0a	.0a
Phillips Fibers Duon	1.3ab	.4a	13.8b	5.2b	8.0a	42.6c	12.5b	9.6b	.0a	.0a	.0a	.0a
Weedblock Fabric	3.8c	9.8b	92.3c	22.3c	5.3a	31.7bc	110.7c	24.7c	.0a	.0a	.0a	.0a
Control	11.8d	44.5c	126.1c	25.9c	21.0b	70.3d	139.0c	27.2c	33.3b	18.7b	15.5b	13.2b

[1]Mean separation within columns by Duncan's multiple range, 5 percent level.

bark:sand:sandy loam (1:1:1, by volume) amended with 2 pounds of Osmocote® 18-6-12 per cubic yard. Two weed species were sown separately on opposite halves of each flat, covered with vermiculite, and irrigated. After 2 days, flats were covered with polypropylene fabric with overlapping fabric tucked underneath the flats. A 2-inch-deep mulch of landscape bark nuggets was placed on top of all flats to simulate typical landscape practices. At the end of 30 days, weeds emerging through the fabric were counted. Shoots were subsequently clipped at the fabric surface, dried, and weighed.

In experiment 1, the following six weed species were used: pigweed (*Aranthus* sp.); sicklepod (*Cassia obtusifolia*); bermudagrass (*Cynodon dactylon*); yellow nutsedge (*Cyperus esculentus*); small flower morningglory (*Jacquemontia tamnifolia*); and johnsongrass (*Sorghum halepense*). Approximately 0.3 tablespoon of weed seed were sown per half flat for all species, except for yellow nutsedge where 15 tubers were planted in each flat. The five polypropylene landscape fabrics used to cover the flats included: Dewitt Weed Barrier® woven; Amoco Rit-a-Weed® heavy-meshed nonwoven; Phillips Fiber Duon® 2.5-ounce meshed nonwoven; Geoscape Landscape Fabric® meshed nonwoven; and Weedblock Fabric® perforated-polyethylene nonwoven. The control treatment consisted of flats without fabric coverings.

In experiment 2, the same weed species were used, except sicklepod and smallflower morningglory were omitted. These two species were completely inhibited by all fabrics in experiment 1. Weed seeds were sown or planted as in experiment 1. Polypropylene fabrics used included five fabrics listed previously plus three additional fabrics: Weed Barrier Mat® woven; Dupont Typar 307® spunbound nonwoven; and Typar 312® spun-bound nonwoven. The control treatment consisted of flats without mat coverings.

In experiment 1, shoot emergence of sicklepod and smallflower morningglory, both species with broadleaf cotyledons, was completely suppressed by all landscape fabrics, table 32. Shoot emergence of pigweed was completely suppressed by the Dewitt and Geoscape Landscape fabrics, while Amoco Rit-a-Weed and Phillips Fibers Duon provided partial suppression, compared with the control. Shoot emergence of bermudagrass was completely suppressed by Dewitt, whereas bermudagrass shoots emerged through the Weedblock fabric in numbers equivalent to the control. All other treatments provided similar control of bermudagrass shoot growth. Johnsongrass shoot emergence was suppressed by all treatments, but the greatest suppression was achieved with the Dewitt and Geoscape fabrics. Johnsongrass growth after emergence through all fabrics was altered in that aerial adventitious roots developed immediately above the fabric surface, while not developing the caliper of the portion of stem which initially emerged through the landscape fabric. These weeds were easily rouged by hand.

All landscape fabrics partially suppressed the emergence of yellow nutsedge compared to the control; however, yellow nutsedge dry weights were greater with

TABLE 33. AVERAGE COUNT (CNT) AND SHOOT DRY WEIGHT (SDW) PER FLAT OF WEEDS PENETRATING UP THROUGH NINE LANDSCAPE MATS 30 DAYS AFTER SOWING, EXPERIMENT 2

Mat type	Yellow nutsedge		Pigweed		Bermudagrass		Johnsongrass	
	CNT	SDW	CNT	SDW	CNT	SDW	CNT	SDW
	No.	*Grams*	*No.*	*Grams*	*No.*	*Grams*	*No.*	*Grams*
Dupont Typar 307	0.0a[1]	0.0a	0.0a	2.5a	2.9ab	2.9ab	0.0a	0.0a
Dupont Typar 312	.0a	.0a	.3a	.8a	.9a	.9a	.0a	.0a
Weed Barrier Mat	.3ab	1.4ab	.0a	.0a	.0a	.0a	.3a	.3a
Dewitt Pro 5	1.0ab	3.6ab	1.9a	1.5a	3.0ab	3.0ab	2.3a	5.8ab
Geoscape Landscape Fabric	.8ab	4.6b	.0a	9.3a	4.4b	4.4b	.3a	4.3ab
Amoco Rit-a-Weed	2.5b	4.0b	5.0b	17.5a	5.2b	5.2b	7.0b	9.7bc
Phillips Duon Fiber	3.3b	3.6ab	6.6b	12.0a	5.1b	5.1b	6.5b	13.4cd
Weedblock Fabric	1.8ab	3.8ab	12.1c	72.6b	10.3c	10.3c	8.0b	10.4bc
Control	8.3c	23.1c	13.2c	112.8c	12.8c	12.8c	12.8c	19.7d

[1]Mean separation within columns by Duncan's multiple range test, 5 percent level.

the Weedblock Fabric compared to the other landscape fabrics and less than the control, table 32. The elasticity of the Weedblock fabric, a polyethylene derivative, appeared greater than the other polypropylene fabrics and may have facilitated yellow nutsedge penetration.

In experiment 2, shoot emergence of yellow nutsedge and johnsongrass was completely suppressed by the spun-bound nonwoven fabrics from Dupont, table 33, although etiolated growth of yellow nutsedge was observed underneath the Dupont landscape fabrics. All treatments provided partial control of yellow nutsedge compared with the control. Johnsongrass dry weights with Phillips Fiber Duon were similar to the control; however, the number of weeds emerging was reduced, suggesting that weeds that penetrated the fabric were able to grow to a larger size.

Pigweed was completely suppressed by Typar 307, Geoscape Landscape Fabric, and the Weed Barrier Mat, and growth was inhibited by Typar 312 and Dewitt Pro 5, table 33. Bermudagrass was best controlled by the Dupont Typar fabrics, the Weed Barrier Mat, and Dewitt Pro 5, while bermudagrass growth with the Weedblock Fabric was similar to the control.

Use of landscape fabrics by American Woven Fabrics, Dewitt Co., Dupont Corp., and Innovative Geotextile resulted in the best overall suppression of emergence and growth inhibition of the weed species tested. Results indicate that weed suppression may not be correlated to polypropylene polymer type; however, weed suppression using spun-bound nonwoven fabrics was superior to meshed nonwoven fabrics. This research would also tend to agree with earlier findings that some hand weeding and herbicide application may be necessary when landscape fabrics are used.

Martin is former Graduate Student, Gilliam is Professor, and Ponder is Professor of Horticulture.

Weed Control In Field-Grown Holly

Glenn R. Wehtje and Charles H. Gilliam

WEED CONTROL in field-grown nursery crops and landscape beds generally requires the application of herbicide combinations, as well as multiple applications of these combinations during a growing season. In Maryland, herbicides applied twice per season to field-grown azaleas controlled greater than 99 percent of the weeds at the end of the growing season. In contrast, a single application provided only 63-77 percent weed control. In Illinois, Roundup® applied preplant, followed by Princep® alone or in combination with either Surflan®, Enide®, Lasso®, or Devrinol®, resulted in season-long weed control in field-grown nursery crops. In Connecticut, November applications of Princep alone at 1.5 to 2.5 pounds a.i. per acre or at 1.0 pound per acre when in combination with other herbicides provided over 95 percent control of weeds as rated in late May of the following year.

Information on the use of herbicides in nursery crop production in the Southeastern United States is limited. Compared to northern locations, achieving satisfactory weed control is more difficult in the Southeast because the growing season is longer and the warmer soil temperature may hasten herbicide dissipation. Previous work in Alabama evaluated several herbicide combinations applied twice annually and reported that Surflan + Princep at 2.0 + 0.75 pounds a.i. per acre provided acceptable weed control in field-grown photinia and boxwood. The first objective of this research was to examine how time of Surflan + Princep application affected weed control in field-grown *Ilex*.

Goal® has been demonstrated to provide excellent weed control in selected woody crops. The 2 percent granular formulation has been evaluated extensively in container production and reported to be safe to a wide range of woody plants. Comparison of the 2E and 2G formulations has shown the 2E formulation to be significantly more injurious to woody plants. Other work has reported injury from application of Goal 2E to 3 of 13 plant species, however three *Ilex crenata* cultivars were not injured. Previous work has showed mid-summer application of Goal to be noninjurious when applied over the top of four field-grown woody plants. This lack of injury was attributed to the semi-dormant state that plants enter during an environmentally stressful period of the year. The second objective was to evaluate multiple applications of Goal on three species of field-grown Ilex for efficacy and weed control.

Two experiments with separate objectives were conducted simultaneously. The first examined the effect of herbicide application timing, and the second evaluated the performance of various herbicide combinations.

Three *Ilex* cultivars were chosen for these experiments because of large acreage plantings in north Alabama. Uniform liners of: *I.* x *meserveae* China Girl, *I.* x *aquipernyi* San Jose, and *I. aquifolium* x *cornuta* Nellie R. Stevens were planted on March 12, 1985, in a Hartsells fine sandy loam soil at the Sand Mountain Substation, Crossville, Alabama. The research area was uniformly infested with large crabgrass (*Digitaria sanquinalis*), entire leaf morningglory (*Ipomoea hederacea*), and prickly sida (*Sida soinosa*).

Herbicides were applied with a tractor-mounted, compressed-air boom-type sprayer operating at 32 p.s.i. and delivering 15 gallons of water per acre. Initial herbicide treatments were applied over the top 2 weeks after the March 28 planting. Treatments were reapplied according to the pertinent treatment schedule.

Data collected included crop injury (0 = no effect, 100 = death) and percentage weed control (0 = no control, 100 = total control); hand hoeing times were determined in mid-July just prior to the second application and in early October at the end of the growing season. Plots were uniformly weed-free prior to the second application. Growth indices [(height + width + width)/3] were taken in early October each year.

Both experiments had two control treatments. The first was hand weeded in July just prior to the second herbicide application, and again at the end of the grow-

TABLE 34. WEED CONTROL AS INFLUENCED BY TIMING OF SURFLAN + PRINCEP[1] (2.0 + 0.75 POUNDS PER ACRE) TO THREE FIELD-GROWN *ILEX*, EXPERIMENT 1

Time of application	Broadleaf weed control						Grass weed control					
	1985		1986		1987		1985		1986		1987	
	7/18	9/19	7/15	10/7	7/1	9/20	7/18	9/19	7/15	10/7	7/1	9/30
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
March	78ab[2]	78bc	80ab	88abc	100a	95ab	74a	71b	100a	100a	98a	100a
Mar.-July	76ab	90a	84ab	97ab	100a	100a	80a	96a	100a	100a	100a	100a
Mar.-July-Nov.	84a	88a	93a	99a	100a	99a	84a	97a	100a	100a	100a	100a
Mar.-Nov.	70ab	68bc	93a	78c	100a	95ab	90a	81b	100a	100a	96a	100a
July-Nov.	0c	85ab	60bc	95ab	100a	100a	0c	90a	85a	99a	100a	100a
Hand weeded	63b	64c	49c	84bc	36b	90b	20b	70b	24b	58b	88b	30b
Nonweeded	0c	0d	0d	0d	0c	0c	0c	0c	0c	0c	0c	0c

[1]Rates were 2.0 and 0.75 pounds per acre.
[2]Means within columns followed by the same letter are not significantly different at the 5 percent level as determined by Duncan's multiple range test.

ing season in early October. The second control was hand weeded only at the end of the growing season.

Experiment 1

Surflan® + Princep® at 2.0 + 0.75 pounds a.i. per acre were applied with five treatment schedules: March; March + July; March + July + November; March + November; and July + November, table 34.

In 1985, maximum season-long broadleaf weed control was obtained with all treatments that contained a minimum of two Surflan + Princep applications that included the March + July treatments. An additional herbicide application in November (i.e., a total of three applications) offered no further improvement in broadleaf weed control. Other treatments that had two applications (i.e., March + November or July + November) also provided maximum control at one or more of the rating periods. However, only the March + July application obtained maximum control for the duration of the growing season.

Broadleaf weed control in 1986 and 1987 exhibited a similar trend to that which was established in 1985, table 34. However, treatments that were marginal in performance in 1985 tended to be more effective in 1986 and 1987. This may be attributable to increased crop competition and residual herbicide effects. These data also show that during the first year in production, when crop competition is minimal, maximum herbicide inputs are necessary. Furthermore, the data indicate that during the second and subsequent years, herbicide inputs may be decreased.

Grass control followed a similar pattern to that observed with broadleaf control. In 1985, two applications of Surflan + Princep resulted in maximum grass control. A third application of Surflan + Princep in November did not improve control when compared to the March + July application. In all years, all herbicide treatments were effective in providing the maximum level of grass control.

Hoeing times were generally reflective of weed control ratings, table 35. Application of Surflan + Princep in March + July resulted in minimum hoeing times. Hoeing time, as averaged over all treatments, decreased each year. This trend probably reflects increased crop competition and residual herbicide activity.

Maximum growth indices of China Girl holly occurred when Surflan at 2.0 pounds and Princep at 0.75 pound per acre were applied in March. Applying Surflan + Princep in July + November resulted in reduced growth indices throughout the study. These data demonstrate the importance of early season weed control in reducing weed crop competition. Similar plant size among March-based treatments during the third year tends to confirm that if adequate weed control practices are maintained, fewer herbicide applications are necessary in the later crop years.

Experiment 2

Six different herbicide combinations were evaluated under a common schedule (March + July), table 35.

Across all years, all herbicide combinations provided equivalent maximum levels of both broadleaf and grass weed control. No differences between individual treatments were detected. The only exception was Goal + Princep (low rate), in which grass control at the first

TABLE 35. TIME REQUIRED TO REMOVE REMAINING WEEDS FROM PLOTS AT THE END OF THE GROWING SEASON, EARLY OCTOBER

Treatment	Time required/plot, by year		
	1985	1986	1987
	Min.	*Min.*	*Min.*
Exp. 1: Timing of application[1]			
March	7.8b[2]	2.2bc	0.6
Mar.-July	2.9c	.4c	.2c
Mar.-July-Nov.	2.6c	.2c	.2c
Mar.-Nov.	6.5b	3.0bc	.7c
July-Nov.	4.1bc	.9c	.3c
Hand weeded	10.7ab	7.7b	5.2b
Nonweeded	29.1a	38.2a	11.1a
Exp. 2: Herbicide combinations			
Surflan + Princep (2.0 + 0.75 lb.)	2.9c	0.4c	.2c
Surflan + Princep (3.0 + 1.0 lb.)	1.1c	.1c	.2c
Goal + Princep (1.0 + 0.75 lb.)	1.5c	.4c	.3c
Goal + Princep (2.0 + 0.75 lb.)	1.6c	.0c	.3c
Surflan + Goal (2.0 + 1.0 lb.)	2.5c	.0c	.3c
Surflan + Goal (2.0 + 1.0 lb.)	1.3c	.1c	.2c
Handweeded	10.7b	7.7c	5.2b
Nonweeded	29.1a	38.2a	11.1a

[1]Surflan + Princep, 2.0 + 0.75 pounds/acre.
[2]Means within columns followed by the same letter or letters are not significantly different at the 5 percent level as determined by Duncan's multiple range test.
[3]Applied March-July.

rating in 1985 was less than the other treatments. This was expected since both of these herbicides are primarily active against broadleaf species.

No crop injury resulted from the mid-season applications of Goal, which agrees with earlier results. *Ilex* typically exhibits episodic growth patterns characterized by periodic stem elongation. Less than ideal conditions (nonirrigated field conditions during the summer months) may reduce shoot growth until satisfactory conditions prevail. Elongated stems harden off and remain in that condition until favorable conditions occur. The application of Goal-containing herbicide combinations during this summer dormant period (July) caused no injury over the 3-year test to the three field-grown *Ilex*. Other woody crops have responded similarly in the Southeast.

Data from both experiments indicate that application timing is of greater importance than herbicide selection. Provided the combination contains both a broadleaf and grass-active herbicide and rates are sufficient, acceptable weed control can be obtained. The critical factor was time of application. None of the herbicides evaluated had sufficient residual activity to provide control for the entire season with a single application. An initial application in March served to eliminate much of the weed competition during spring growth. A second application extended control through the remainder of the season. These data also suggest that chemical weed control needs are greatest during the first year following planting.

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Jumping Tree Bugs Are Important Natural Enemies of Obscure Scale Infesting Landscape Plantings of Pin Oak

Michael L. Williams and Harlan J. Hendricks

THE PIN OAK, *Quercus palustris*, is one of the most widely used landscape trees on home grounds, parks, golf courses, and street borders in Alabama. Obscure scale, *Melanaspis obscura*, is the primary insect of pin oak, causing rapid decline in plantings in the South, photo 8 (page 18). A survey of the Auburn University campus, where pin oak is one of the most common shade trees, revealed that more than 90 percent of 305 pin oaks were infested with obscure scale. Obscure scale infestations seldom kill the tree, but can cause extensive dieback of branches and make the tree more susceptible to secondary infestation by other insects and diseases. Pesticide sprays applied to kill the obscure scale have generally proved unsuccessful and may have a detrimental effect on its natural enemies as well.

Biologically, there are several predators and parasites that have an important impact on obscure scale populations. In a study of the bionomics of obscure scale and its natural enemies on the Auburn Campus during 1985-88, 21 species of insects and mites were observed preying on or parasitizing obscure scale. The most important predators were four species of predaceous plant bugs in the family Miridae. Included were the jumping tree bugs *Corticoris signatus* (Heidemann), *Lidopus heidemanni* Gibson, photo 9 (page 18), and *Myiomma cixiiforme* (uhler). Jumping tree bugs are predaceous plant bugs that are difficult to detect because of their small size, cryptic coloration, and secretive habits. These three species were the most frequently encountered predators and were observed on all areas of infested trees sampled, particularly in cracks and crevices of the trunk. Immature stages were more common on the undersides of branch bases. Both adults and immature stages of all three species were observed feeding on obscure scale.

The active searching behavior, aggressive feeding habits in the laboratory, and large populations of these jumping tree bugs associated with obscure scale in this study suggest that these predators play an important role in regulating obscure scale populations. Feeding observations and those conducted in a similar study in Pennsylvania strongly suggest that jumping tree bugs may well be specialized scale feeders. Knowing and understanding the natural enemy complex of a pest species are of utmost importance in managing a pest population, particularly when chemical controls are ineffective.

Williams is Associate Professor and Hendricks is former Graduate Student of Entomology.

Evaluation of Labeled Miticides for Control of Southern Red Mite on Azaleas

Michael L. Williams, James C. Stephenson, and Gary L. Miller

A PERSISTENT nursery pest of azaleas is the southern red mite, *Oligonychus ilicius* (McGregor). Although this mite can be found throughout the year, greater numbers are found during cooler weather when damaging populations can build up quickly. Mite populations often fluctuate dramatically on their host. This fluctuation may be due in part to the host's poor foliage condition during the cooler part of the year. This test was initiated as a single curative treatment to determine the efficacy of many currently labeled miticides.

Eight pesticides were selected for application on mite-infested White Gumpo azaleas. Plants were grown in trade gallon plastic containers with amended pine bark-peat moss medium. Miticides were applied to upper and lower leaf surfaces using a CO_2 pressurized test plot sprayer at 35 p.s.i. No spray adjuvant was included in the test. Four single-plant replicates were

TABLE 36. CONTROL OF SOUTHERN RED MITE ON *RHODODENDRON* × WHITE GUMPO

Treatment, rate/100 gal.[1]	Mean no. of mites/sample, by days after treatment[2,3]	
	7	21
Talstar 10WP®, 1 lb.	7.8a	1.3a
Vendex 50WP®, 1 lb.	12.5a	1.0a
Avid 0.15 EC®, 4 fl. oz.	39.5b	21.0bc
Morestan 25WP®, 1 lb.	10.3a	.0a
Pentac Aquaflow 4F®, 16 fl. oz.	5.0a	.3a
Mavrik 2F®, 10 fl. oz.	.0a	.0a
Omite 30W®, 1 lb.	8.5a	1.3a
Safer's Ins. Soap®, 128 fl. oz.	12.0a	8.5ab
Untreated check	48.5b	31.0c

[1]Treatments applied January 18, 1989. Dry bulb 58.5°F, wet bulb 56°F.
[2]Evaluation January 25 and February 8, 1989.
[3]Values followed by the same letter are not significantly different at the 5 percent level by Duncan's multiple range test.

randomized and held in an open, unheated glass greenhouse for the duration of the study. Evaluations were conducted 7 and 21 days after treatment.

Seven days after treatment, all materials except Avid® provided significant control when compared to the untreated check, table 36. Even 21 days after treatment, excellent control was observed with most miticides when compared with the untreated check. As with the 7-day evaluation, Avid did not provide good control.

Most of the labeled miticides evaluated in this test provided adequate control of southern red mite populations. Because this mite is often found on the underside of foliage, it is most important to achieve full coverage of the leaf surface. It is also good policy to rotate various compounds in a spray program to reduce chances for pesticide resistance.

Williams is Associate Professor of Entomology; Stephenson is Associate Superintendent of the Ornamental Horticulture Substation; Miller is Research Associate of Entomology.

Chemical Control of Powdery Mildew on Miniature Roses

Austin K. Hagan and John Olive

POWDERY MILDEW, caused by the fungus *Sphaerotheca pannosa*, is a common disease on field- and greenhouse-grown roses. In Alabama, this disease is particularly troublesome on greenhouse-grown miniature roses. Although the damage is largely cosmetic, powdery mildew-damaged miniature roses often appear unsightly and may be unmarketable. In this study, the efficacy of Spotless fungicide for the control of powdery mildew on miniature rose was compared with that of several registered fungicides.

Red miniature rose (*Rosa* spp.) liners were planted in a pine bark:peat moss medium (3:1, by volume) 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 of media. Plants were maintained in the greenhouse and watered daily using drip irrigation. Disease incidence, as indicated by an estimate of the percentage of diseased shoot tips, and canopy height and width were recorded on January 3. The growth index was calculated as follows: (height + width 1 + width 2)/3. Widths were measured perpendicular to each other.

In 1989, the fungicide Spotless 25W at 0.2, 0.3, and 0.4 pound per 100 gallons of water was compared with Benlate 50DF® at 0.25 pound per 100 gallons of water, Bayleton 25W® at 0.25 pound per 100 gallons of water, and Rubigan A.S. 1.0E® at 8 fluid ounces per 100 gallons of water for the control of powdery mildew on miniature roses. All rates of Spotless were applied with and without 1 pint of Agrioil AG-98® crop oil concentrate surfactant. Treatments were applied with a CO_2 pressurized sprayer every 2 weeks from October 4 to December 12.

TABLE 37. POWDERY MILDEW CONTROL OF MINIATURE ROSES FROM DIFFERENT FUNGICIDE TREATMENTS, 1989

Treatment, rate/100 gal.	Growth index	Disease incidence
		Pct.
Spotless 25W		
0.2 lb.	35.2	35.5
0.3 lb.	31.6	4.0
0.4 lb.	30.5	2.0
Spotless 25W + Ag-98 (0.5% volume)		
0.2 lb.	19.4	.0
0.3 lb.	22.4	.0
0.4 lb.	18.4	.0
Benlate 50W		
0.25 lb.	31.2	28.1
Bayleton 25W		
0.025 lb.	28.7	37.9
Rubigan A.S. 1.0 E		
8 fl. oz.	33.0	3.6
Non-sprayed control	33.4	60.9

[1]Growth index = (height + width 1 + width 2)/3.

All fungicides reduced disease incidence, but considerable differences in controlling powdery mildew on rose were seen among the fungicide treatments, table 37. Spotless and Rubigan generally gave the best disease control. Only the lowest rate of Spotless applied without the AG-98 surfactant failed to provide good disease control. Addition of AG-98 improved the effectiveness of the lowest rate of Spotless against powdery mildew, but not the two higher rates of the same fungicide. Benlate and Bayleton reduced disease incidence, but were not as effective in controlling powdery mildew as Rubigan and the two higher rates of Spotless.

Although some improvement in powdery mildew control was obtained by adding AG-98 surfactant to the lowest rate of Spotless, 40-50 percent reductions in shoot growth were associated with the use of this tank-mix combination. Brown necrotic spots were also seen on the leaves of the roses sprayed with all three Spotless

+ Agrioil AG-98 tank-mix combinations. Surprisingly, the surfactant-free spray mixes of Spotless had no effect on plant growth, nor did any of the other fungicides screened.

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Effect of Nova Fungicide on Entomosporium Leaf Spot on Photinia

Austin K. Hagan, John Olive, and William J. Foster

ENTOMOSPORIUM LEAF SPOT is a destructive disease on red tip photinia in production and landscape settings across Alabama. Control of existing disease outbreaks often depends on an intensive fungicide spray program. Previous Alabama Agricultural Experiment Station trials have clearly shown that the registered fungicides Daconil®, Zyban®, and Triforine® will give good control of this disease. The objective of this trial was to determine whether the experimental fungicide Nova would provide better control of Entomosporium leaf spot on photinia than registered fungicides.

Healthy red tip photinia (*Photinia fraseri* Birmingham) liners were potted in a pine bark medium amended with 12 pounds of 17-7-12 Osmocote®, 6 pounds of limestone, 2 pounds of gypsum, and 1.5 pounds of Micromax® per cubic yard in trade gallon containers. The plants were watered daily with overhead impact sprinklers. Inoculum pressure was maintained by placing diseased photinia within the blocks of fungicide-treated plants. Nova 40W® fungicide was applied from May 9 to July 28 at the rates listed in table 38 at 1-, 2-, and 4-week intervals. Weekly applications of label rates of Daconil 2787 4.17F and Triforine 1.6E were also included. A Penetrator 3® spray adjuvant was added to all Nova tank-mixes. Disease incidence was evaluated using the Horsfall and Barratt rating system. Plant dimensions were recorded on July 31. The growth index was calculated using the formula (height + width 1 + width 2)/3.

All rates of Nova applied on a 1- and 2-week spray schedule gave excellent control of Entomosporium leaf spot, table 38. No spotting of the leaves was seen across all application rates at these spray schedules, except for plants treated every 2 weeks with the lowest rate of Nova. Disease incidence increased sharply as interval between applications of all rates of Nova was lengthened from 2 to 4 weeks. Applied weekly, all rates of Nova gave disease control similar to that obtained with Daconil 2787. Weekly applications of the 12-fluid-ounce rate of Triforine failed to control Entomosporium leaf spot.

TABLE 38. IMPACT OF SPRAY SCHEDULE AND APPLICATION RATE ON THE CONTROL OF ENTOMOSPORIUM LEAF SPOT AND GROWTH OF PHOTINIA

Fungicide rate/100 gal. water	Disease incidence[1]	Growth index[2]
		cm
Nova 40W 2.5 oz.		
Sprayed weekly	1.0	56.4
Sprayed every 2 weeks	1.8	59.3
Sprayed every 4 weeks	5.3	60.4
Nova 40W 5.0 oz.		
Sprayed weekly	1.0	49.6
Sprayed every 2 weeks	1.0	50.7
Sprayed every 4 weeks	3.0	60.4
Nova 40W 10.0 oz.		
Sprayed weekly	1.0	40.1
Sprayed every 2 weeks	1.0	62.4
Sprayed every 4 weeks	4.1	54.9
Daconil 2787 4.1F 2 pt.		
Sprayed weekly	1.3	57.8
Triforine 1.6E 12 fl. oz.		
Sprayed weekly	4.1	57.0
Nonsprayed control	7.1	58.8

[1]Disease incidence was measured on a scale of 1-12 (1 = no disease, 2 = 0-3 percent, 3 = 3-6 percent, 4 = 6-12 percent, 5 = 12-25 percent, 6 = 25-50 percent, 7 = 50-75 percent, 8 = 75-87 percent, 9 = 87-94 percent, 10 = 94-97 percent, 11 = 97-100 percent, and 12 = 100 percent of leaves diseased).
[2]Growth index = (height + width 1 + width 2)/3.

Plant growth reductions were seen on photinia treated with the two higher rates of Nova applied on a 1- and/or 2-week spray schedule. The 10-ounce rate applied weekly had the greatest impact on plant growth. The lowest rate of Nova, Daconil 2787, and Triforine did not have an adverse impact on plant growth.

Nova fungicide across a range of application rates provided excellent control of Entomosporium leaf spot on photinia. Applied on a 1- or 2-week spray schedule, little if any disease was seen on the Nova-treated photinia. The level of disease control with Nova was comparable to that obtained with Daconil 2787 and superior to that from Triforine. Previous results have shown that Nova may prove more effective in controlling Entomosporium leaf spot under heavy disease pressure than Daconil 2787. Unfortunately, reductions in shoot growth were seen on photinia treated with high rates of Nova on short spray schedules. Similar reductions were not recorded in the previous Nova spray trial. Further work must be done to identify application rates of this fungicide that will give good disease control without appreciable reductions of plant growth.

Hagan is Associate Professor of Plant Pathology; Olive is Superintendent and Foster is former Superintendent of the Ornamental Horticulture Substation.

Evaluation of Stirrup M as a Tank-Mix Addition to Miticides for Control of Spider Mites on Roses

James C. Stephenson

MITES CONTINUE to be a concern for many nurserymen in Alabama. The ineffectiveness of some compounds, plus problems of spray coverage in dense plant canopies, close plant spacing, and environmental conditions, complicates control measures. There are several mites which are economic pests in Alabama nurseries. The twospotted spider mite, *Tetranychus urticae* Koch, continues to be one of the most serious and widespread. Damaging populations can build rapidly and under favorable conditions take as little as 5 days to develop from egg to adult.

One recent approach to offset some spray coverage problems is to bring the pest into contact with a toxicant by the addition of a pheromone. A pheromone is a substrate produced by one individual that induces a specific reaction by others of the same species. It is a means of communication. In this case, Stirrup M®, a sex pheromone, reportedly results in mites moving around within the plant canopy out of the more sheltered areas. This improves the chance and length of time a mite contacts the miticide. This new approach has been reported to be successful in the Western United States on fruit trees and in the desert Southwest on cotton. This study was initiated as a preliminary evaluation of Stirrup M as a tank-mix addition to miticides for use on ornamentals.

Mite-infested miniature roses growing in a glass greenhouse were selected for treatment. Good spray coverage on this plant is difficult due to its waxy leaf surface. Treatments were applied to run-off using a hand-held compressed air sprayer to upper leaf surfaces. No spray adjuvant was included in the first trial. Chevron X-77® at the rate of 8 fluid ounces per 100 gallons of water was added in the second trial.

TABLE 39. EVALUATION OF STIRRUP M FOR SPIDER MITE CONTROL ON ROSES

Treatment[1], rate/100 gal.	Mean number of mites/sample[2], by days after treatment 7	21
Pentac Aquaflow®, 16 fl. oz.	10a	8a
Pentac Aquaflow + Stirrup M, 16 fl. oz. + 2 fl. oz.	38a	18ab
Morestan 4F® 8 fl. oz.	51ab	63bc
Morestan 4F + Stirrup M, 8 fl. oz. + 2 fl. oz.	23a	41abc
Vendex 50 WP®, 1 lb.	13a	35ab
Vendex 50 WP® + Stirrup M, 1 lb. + 2 fl. oz.	13a	41abc
Stirrup M, 2 fl. oz.	134c	87c
Untreated check	91bc	66bc

[1]Treatments applied March 5, 1990.
[2]Mean separation within columns by Duncan's multiple range test, P=0.05.

In the first trial, there was a high degree of variability within treatments and an apparent lack of control. This prompted the addition of a spray adjuvant to insure better coverage of the leaf surfaces in the second trial.

In the second trial, table 39, good control was observed with most miticide treatments compared to the untreated check 7 days after treatment. In this test, there was no advantage gained by adding Stirrup M to the spray tank. In a final evaluation 21 days after treatment, the same conclusion concerning Stirrup M was reached.

In summary, these two trials indicate that no clear advantage is gained by adding Stirrup M to the spray tank for control of the twospotted spider mite on miniature roses. However, there are other factors which affect pheromone use, such as rate, specificity, and environmental conditions, that must be addressed before a definite conclusion can be reached. No incompatibility or phytotoxicity was observed.

Stephenson is Associate Superintendent of the Ornamental Horticulture Substation.