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Information contained herein is available to all without regard to race, color, sex, or national origin.

ON THE COVER:
Feather Red was one of the best varieties of flowering cabbage grown in Auburn University's All America Display Garden. See article on Page 4 for more information.

GREENHOUSE CROPS

Evaluation of Ancymidol and Paclobutrazol for Height Control of Potted Tulips

C. Frederick Deneke and Gary J. Keever

Potted tulips often become excessively tall either during greenhouse production or in postproduction environments. Therefore, plant growth retardants are commonly used to control plant height and reduce stem topple.

Foliar sprays and drenches are the most common methods of application of plant growth regulators. However, to reduce application costs and to improve the effectiveness of growth regulators, alternative application methods have been investigated, including tablets, gels, encapsulation, granular formulations, and impregnating clay pots. A study was conducted to determine if an ancymidol drench or paclobutrazol applied as a drench or impregnated in a fertilizer spike could effectively control height of tulips.

Results showed that plants receiving 0.25 or one milligram of paclobutrazol per five-inch-diameter pot exhibited acceptable growth with the drench and spike treatments. A 0.25-milligram ancymidol drench also provided acceptable mature plant heights.

METHODS

On Dec. 21, 1987, five bulbs (at least 4.5-inch circumference) of Kees Nelis tulips were potted per 0.8-liter (five-inch diameter) container using a commercial peat moss and perlite growing medium (Pro-Mix BX, Premier Brands, Stamford, Conn.) and placed in a dark cooler at 48°F. When root growth out of the bottom of the pot was evident four weeks later, temperature was decreased to 41°F until the emerging shoots were about 1.5 inches long. Plants were moved to a double polyethylene greenhouse maintained at 64°F during the day and 57°F at night.

Treatments were applied one day after the plants were moved. Rates of growth retardant ranged from 0.06-1.00 milligram per pot for both the drench and spike applications of paclobutrazol. A drench of 0.25 milligram of active ingredient ancymidol per pot was also applied. Drenches were applied using a volume of 75 milliliters per pot. Spikes were identical to Jobe Fertilizer Spikes (10-10-4, Weatherly Consumer Products, Lexington, Ky.) except that the manufacturer incorporated paclobutrazol. One spike was positioned vertically just below the surface of the growing medium in the center of the pot. Spikes used for the control did not have paclobutrazol incorporated.

Plants were fertilized weekly, alternating 200 parts per million (ppm) nitrogen (N) from 20-20-20 and 375 ppm N from calcium nitrate. When flowers first showed color, plant heights were measured. When flowers were fully opened, plant heights and flower diameters were measured.

RESULTS

Time to maturity (time from entering the greenhouse to flowers fully opened) for Kees Nelis tulips was about 21 days regardless of treatment. Heights at first flower color and at maturity were reduced as the concentration of paclobutrazol increased with both methods (see table; Photo 1, Page 18). Paclobutrazol application method did not significantly affect any of the measured variables. Treatments had no effect on flower diameter or uniformity of plants within a pot.

Heights at first flower color and at maturity for ancymidol-treated plants were less than those of either plants receiving the lowest rate of paclobutrazol applied as a drench or spike, or of control plants.

Because height for potted plants should be no greater than two times the diameter of the pot, the maximum acceptable height for plants in a five-inch diameter pot is 10 inches. Therefore, plants receiving a spike or drench of 0.25 or one milligram of active ingredient paclobutrazol per pot or a drench of 0.25 milligram of active ingredient ancymidol per pot had acceptable heights at maturity. In contrast, control plants were 11 inches tall at maturity.

Reduction in Height of Tulips with an Ancymidol Drench or Increasing Rates of Paclobutrazol Applied as a Drench or Impregnated Spike

Treatment	Plant height at:	
	Flower color	Maturity[1]
Paclobutrazol[2]		
Drench		
0.06	9.1	11.4
0.25	8.1	10.0
1.00	6.4	9.4
Spike		
0.06	8.6	10.5
0.25	7.9	9.7
1.00	7.5	9.4
Control	8.5	10.9
Ancymidol[2]		
Drench		
0.25	7.6	9.4

[1]When flowers were fully opened. Plant height was measured in inches.
[2]Treatments measured in milligrams per pot. One gram (g) is .035 ounce. One milligram (mg) is .001 g.

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

Production and Postproduction of Brazilian Verbena as a Cut Flower

Catherine Chege, C. Frederick Deneke, and Bridget K. Behe

Wholesale value of total production of standard cut flowers -- such as roses, carnations, chrysanthemums, and gladioli -- has continued to decline over recent years while total American consumption, importation of cut flowers, and wholesale value of specialty cut flowers have increased. To reduce risks and maximize profits in this ever-changing market, it is necessary to diversify cut flower production. One way of doing this is by growing new varieties of cut flowers.

Brazilian verbena (*Verbena bonariensis*) can be grown as an annual but is a perennial in central and southern Alabama. Its long stems and long-lasting flowers potentially make it a good cut flower. A study was conducted to determine the effect of varying daylength (photoperiodism) on flowering and the effect of stage of development at harvest on vase life of Brazilian verbena as a cut flower.

Results show that Brazilian verbena should be grown under long days for earlier flowering (see Photo 2, Page 18). Harvesting should be done before all of the flower clusters are opened, but after the buds show color for the best quality of cut flowers.

METHOD

In the photoperiod study, Verbena seeds were planted in flats on Sept. 18, 1992, in Pro-Mix media. Seeds were germinated in a greenhouse with 77°F day and 64°F night temperatures and exposed to either long days or short days. All the plants were covered with black cloth from 5 p.m. to 8 a.m. Long days were provided by night-break lighting (10 p.m. to 2 a.m.) using incandescent lamps. Plants under short days were moved two or four weeks after seeding to long days for the remainder of the experiment. Likewise, plants under long days were moved after two or four weeks to short days. Other plants were grown under constant long or short days. Fertilization initially was two times per week with 100 parts per million (ppm) N using 15-16-17 fertilizer. Fertilization was increased to three times weekly after transplanting, which was done on Oct. 21, 1992.

In the stage of development at harvest study, verbena seeds were planted in flats on Sept. 18, 1992, in Pro-Mix medium. The seeds were germinated as described with the photoperiod study. Plants were exposed to long days only. Seedlings were transplanted on Oct. 18, 1992, and grown in Fafard No. 2 medium. Fertilization was as described previously. On Feb. 25, 1993, flowers were harvested at bud-colored stage, two-to-five open-floret stage, and 100% open stage of the first and second pair of inflorescences (flower clusters).

The flowers were then transferred to a simulated consumer environment maintained at 70°F, 12-hour photoperiod, and 60 footcandles of light for postproduction evaluation. They were pulsed with silver thiosulfate for 30 minutes and then placed in deionized water. Color change of the oldest (peripheral) florets from violet-blue to white, bent neck, and weight of cut flowers taken at the same time each day were used to determine the vase life.

RESULTS

Verbena plants grew faster under long days, which resulted in bud formation and flowering. When plants received less than nine hours of light daily, they did not flower. Alternating long or short days had no effect on the flowering date and flower quality. Therefore, long days could be initiated four weeks after seeding instead of at germination to reduce lighting costs. Only one inflorescence (flower cluster) formed per plant. Plants that received short days had more branches. The inflorescence length was good for use as a cut flower.

Flowers harvested at the two-to-five floret-open stage lasted longer than those harvested at bud-colored stage or when 100% of inflorescences were opened. Flowers harvested at the bud-colored stage did not open well and had a faded color. Although flowers harvested at the 100% open stage of the first and second pair of inflorescences had more open flowers at senescence, they suffered from bent neck and lasted only for a short time.

Chege is Graduate Student, Deneke is former Assistant Professor, and Behe is Assistant Professor of Horticulture.

Effects of Daylength on Flowering of Brazilian Verbena

Treatment	Duration[1]		Inflorescence/plant[2]	Branch/plant	Inflorescence length[3]
	To visible buds	To flowering			
	days	*days*	*no.*	*no.*	*cm*
Constant LD[4]	77	87	1.0	2.0	155.0
2 weeks SD[5], then LD	78	87	1.0	1.3	152.0
4 weeks SD, then LD	77	87	1.0	2.0	158.3
Constant SD[6]	-	-	-	3.8	-
2 weeks LD, then SD	-	-	-	5.2	-
4 weeks LD, then SD	-	-	-	4.7	-

[1]Time from seeding (photoperiod treatment).
[2]Flower cluster per plant.
[3]One centimeter (cm) is .3937 inch.
[4]LD = long days (night-break lighting 10 p.m. - 2 p.m.).
[5]SD = short days (no night-break lighting).
[6]Plants did not form buds.

Influence of Subirrigation on Postproduction Longevity of Poinsettias

C. Frederick Deneke, Bridget K. Behe, and John W. Olive

Water quality concerns affect the content of effluent that can be legally discharged from agricultural businesses. Ebb and flow production technology is a closed subirrigation system that prevents water used in irrigating greenhouse crops from being routinely discharged into the environment.

This technology has been adopted in Europe, but few American growers use it. One concern is that subirrigation may reduce the postproduction longevity of plants if excess fertilizer salts are not leached. Previous research indicated that subirrigated poinsettias had lower plant grade than those that were hand irrigated. However, media soluble salts were not closely monitored during production.

A followup study was conducted to determine the influence of hand irrigation or subirrigation on the postproduction quality of Supjibi poinsettia with regular monitoring of media soluble salts. Irrigation method was shown to have minimal impact on overall plant grade and that postproduction quality of subirrigated plants can be at least as good as that produced by hand irrigation if media soluble salts are monitored during production.

METHODS

On Aug. 26, 1991, cuttings of Supjibi were stuck into six-inch azalea pots using a commercial soilless growing medium (Metromix 360, Grace-Sierra). Cuttings were allowed to root under intermittent mist for 14 days. Twelve plants per treatment were fertilized at each irrigation beginning Sept. 9 using equal parts (by volume) of calcium nitrate and 20-10-20 (Peter's Peat Lite, Grace-Sierra). Fertilizer concentration initially was 200 parts per million (ppm) nitrogen (N); from Nov. 11 to Dec. 9, 100 ppm was used. Irrigation method was either hand or subirrigation. Hand irrigation consisted of watering plants with a hose until water began to drip from the bottoms of containers. Subirrigation consisted of flooding watertight benches to a depth of about 3/4 inch for 15 minutes. Media leachates were taken at two-week intervals to determine soluble salts. On Dec. 9, growth was evaluated, and plants were moved to a simulated consumer environment maintained at 70°F and about 75 foot candles of light provide by cool-white fluorescent lamps from 6 a.m. to 6 p.m. (see Photo 3, Page 18).

RESULTS

Media soluble salts for hand-irrigated plants on the first sampling date (Oct. 21) were significantly greater than for subirrigated plants. On the three subsequent samplings, soluble salts were similar regardless of irrigation method. At the time plants entered the postproduction environment, subirrigated plants had greater numbers of bracts (small leaves at the base of flowers or stalks), cyathia (small yellow flowers above bracts), and inflorescences (flower clusters). Plant grade, growth, and the number of leaves were not influenced by irrigation method.

After three weeks in the postproduction environment, leaf drop was greater for subirrigated plants. Irrigation method did not influence bract drop, cyathium drop, or plant grade (see table). From week four to five in the postproduction environment, irrigation method had little influence on any measured variable (data not shown).

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

Plant Grade, and Leaf, Bract, and Cyathium Drop of Supjibi Poinsettia after Three or Four Weeks in a Postproduction Environment

Irrigation method	Three Weeks				Four Weeks			
	Grade[1]	Bract Drop[2,3]	Leaf Drop[2]	Cyathium Drop[2,4]	Grade[1]	Bract Drop[2,3]	Leaf Drop[2]	Cyathium Drop[2,4]
Hand	3.8	2.3	8.5	67.2	2.8	15.0	22.5	100.0
Sub-	3.9	3.7	17.1	32.4	3.2	11.2	26.2	89.9

[1]Rated on a scale from 1 (poor) to 5 (excellent).
[2]Percentages are cumulative leaf or bract drop relative to total number present at Week 0.
[3]Bracts are small leaves that grow at the base of flowers or stalks.
[4]Cyathia are small yellow flowers above the bracts.

Performance Evaluation of Annual Bedding Plants

C. Frederick Deneke, Bridget K. Behe, and Jim Bannon

From November 1991 to March 1992, about 130 entries of cool-season bedding plants were evaluated at the Auburn University greenhouse facilities and E.V. Research Center in Tallassee, an official All-America Selections Display Garden.

Trial gardens are useful for evaluating the performance of new and established plant varieties, but results cannot be viewed as strict recommendations. Weather, hardiness zone, soil, exposure, and cultural practices can greatly affect the growth of plants. Comparison of results from multiple trial sites will increase the reliability of recommendations. (See Photo 4, Page 18.)

METHODS

Seeds were germinated and grown to transplant by commercial growers, who donated their services. Beds in full sun were tilled, covered with a layer of plastic, and fumigated with methyl bromide two weeks before planting. Soil pH was adjusted to about 6.5. Twelve plants per variety were spaced nine inches on center in double rows. Plants were drip irrigated and fertilized as needed.

RESULTS

Viola x *wittrockiana* (pansy)

Generally, no cool season bedding plant can compare with pansies for the diversity of color, duration of flowering, and tolerance to cold and heat. Although all 37 cultivars of pansies flowered, none was spectacular for undetermined reasons. The following cultivars were noticeably superior:

Universal Purple -- slow to start, but good flowering after mid-January;

Maxim Red Yellow -- slow to start, but good flowering after early January;

Melody Yellow Blotch -- very slow to start, but good flowering during March; one of only two entries that completely filled area between plants;

Universal Deep Yellow -- good flowering from late December to early February, then declined;

Universal White -- quick to flower after planting and consistently good thereafter;

Roc White -- almost as good as Universal White; flowering good after mid-December;

Melody White Blotch -- slower to establish but good flowering after late-December, peaking in mid-March (Photo 5, Page 18); completely filled the area between plants; and

Roc Mix -- slow to establish but uniform and good flowering after late December. The good performance of the Rocs was surprising considering that they were selected primarily for the North.

Brassica oleracea (flowering cabbage or kale).

This ornamental vegetable can provide foliage color throughout winter, but its landscape usefulness is limited by flowering (bolting), which can occur in January or February. Also, these plants usually are not as cold tolerant as pansies; plants frequently decline because of leaf browning or rot. Fifteen entries were evaluated. Generally, kale is more cold tolerant than cabbage, and red varieties are more cold tolerant than white or pink. Notable varieties included:

Feather Red -- latest to bolt and minimal cold damage, making it one of the best (see cover); color faded by mid-March;

Color Up Red -- began to bolt by early March, but was the only red cultivar to retain deep, red color until late March when the evaluation was terminated; one of the best-looking entries;

Nagoya Red, Osaka Red -- impressive in January and February, but began to bolt in late February, followed by fading of the leaves and flowering stems;

Feather White -- the only white cultivar that did not have significant cold damage (Photo 6, Page 18) and the last to bolt, making it one of the best selections; also one of the best-looking entries. Other white cultivars began to bolt in late February, about three weeks before Feather White; and

Color Up Pink -- did not bolt until late March, but its landscape usefulness was limited by cold damage; color always appeared faded or bleached.

Dianthus chinensis (china pinks)

Generally, china pinks can overwinter in central and southern Alabama and produce great quantities of flowers by early spring. Flowering in this evaluation generally was minimal until March. However, vegetative growth of most, especially the Charms, would add to an otherwise barren winter landscape. Charms -- Coral, Crimson, Pink, White -- were vegetatively attractive because of their uniform mounding growth and blue-green to green foliage. Little cold damage was noted on any of the 18 varieties. Flowering throughout the evaluation was minimal, except with Charm Scarlet. Notable cultivars included:

Telstar Picotee -- red flowering good beginning in early January and steadily increased after mid-February; the only standout entry when considering earliness and duration of flowering;

Princess Salmon -- better than Charm Coral or Charm Pink, but none of the pink shades flowered well;

Princess Purple -- flowering marginal until early March; appeared more red than purple;

Telstar Purple Picotee -- flowering marginal until early March;

Princess Crimson and Princess Scarlet -- flowering was good after early February;

Charm Scarlet, Telstar Scarlet, and Telstar Crimson -- had begun to shine by early March; and

Telstar White and Princess White -- began to flower well after early March, but none of the whites were exceptional.

Antirrhinum majus (snapdragon)

Similar to China pinks, snapdragons survive mild winters and flower well during early spring. However, many succumbed to the sudden cold temperatures (low 20° F) during early November. Twenty-one entries of snapdragons were evaluated. The performance of the Liberty series (Bronze, Cherry, Crimson, Lavender, Light Pink, Mix, Rose Pink, Scarlet, Yellow, and White) was surprisingly poor since all either died during November and December or had minimal flowering. Floral Carpet Red did not fare much better. However, Liberty snapdragons have performed well in other trial gardens, including the University of Georgia. Notable cultivars included:

Floral Showers Scarlet -- flowering good after early March (Photo 7, Page 18);

Floral Carpet Rose was -- fair flowering;

Floral Carpet Yellow -- good flowering, noticeably better than Floral Showers Yellow; and

Floral Showers White -- flowering good by mid-March; better than the marginal Floral Carpet White.

Deneke and Behe are Assistant Professors of Horticulture; Bannon is Director of the E.V. Smith Research Center.

Note: Complete performance summaries of all varieties from this evaluation and the summer trials are available from the authors. The authors thank Martha and David Wright of Wright's Nursery, Inc., in Plantersville for their significant donations of time, talent, and supplies to produce the plugs and transplants. They also thank American Takii, Ball Seed Co., Goldsmith Seed, George W. Park Co., and Sakata Seed Co. for donating seed.

Perennial Plant Producers Profiled

Bridget K. Behe and Lisa M. Beckett

The U.S. ornamental plant industry is relatively large and growing, with wholesale revenues of slightly more than $4 billion. Herbaceous perennials comprise what is believed to be a significant part of the industry, yet statistics to document production numbers and annual growth of this segment are sparse. The Census of Horticultural Specialties lumped perennials into the category of bedding and garden plants and reported their wholesale value at $21 million. However, estimates show that the value of the herbaceous perennial plant industry was between $78 to $150 million. The industry appears to be under-valued based on production statistics.

Owners and managers have been directing perennial plant businesses through at least a decade of growth with little information about the size and scope of the industry. An AAES study was conducted to establish a base of information about perennial plant producers. More information about these firms may help professionals better understand one facet of this complex industry.

According to study results, perennial plant businesses still appear to be relatively small, but sophisticated businesses managed by highly educated and experienced professionals. Firms produced an average of 30 perennial plant genera, which must require them to have a broad base of production and propagation knowledge. When examining the businesses by the product mix they sell, there are some differences meaning that both newer and more established firms have incorporated perennial plants into their product mix.

METHODS

The AU Horticulture Department and Perennial Plant Association collaborated to develop a survey of herbaceous perennial plant producers. Questionnaires were mailed to 439 members of the Perennial Plant Association classified as "producer/grower" on July 1 and again on July 23 if no response was received. Of those, 150 firms returned forms for a 34% response rate.

RESULTS

Fifty percent of the firms were sole proprietorships, 13% were partnerships, and 34% were corporations. The mean age of participating businesses was 17 years, the median (middle value) was nine years, and the mode (most frequent) was five years. The mean total sales for the perennial plant businesses in 1989 was in the category of $100,000 to $249,000, the median was in the category of $250,000 to $499,000, and the mode was $50,000 to $99,999. Mean wholesale sales were $302,000 and mean retail sales were $63,585. While many were smaller and younger businesses, there were several larger, established firms that increased the averages.

Seventy-one perennial plant genera were listed on the survey form. At least some of the participating firms grew each listed genus. Coreopsis (Photo 8, Page 19) was produced by the largest percentage (66%), followed by Acquilegia (64%), Achillea (62%), Chrysanthemum (excluding garden chrysanthemum) (62%), Echinacea (61%), Hosta (61%), and Dianthus (61%). The mean number of genera produced by each firm was 30.

To see if there were any differences based on how important perennial plants were to the company's sales revenues, each firm was classified by the percentage of the firm's total sales that was accounted for by perennial plants as either (1) totally perennials (100%), (2) primarily perennials (50% to 99%), or (3) secondarily perennials (49% or less).

There was a significant difference in the number of years in operation and the percentage of sales that perennial plants generated (see table). Firms that produced only perennials were in operation an average of 12 years, while primarily perennial firms were in operation an average of 15 years. Firms classified as secondarily perennial producers were in operation an average of 22 years. Businesses that relied totally on perennial plants were relatively young compared with more established firms that apparently added the perennial plant line to broaden already existing product lines.

There was no significant difference in the number of perennial species grown by firms classified as totally, primarily, or secondarily perennials. Each group produced, on the average, near 30 perennial genera.

The difference in sales at the wholesale level for these three types of firms was examined and no significant difference was found. The variation in sales within each type of perennial business classification was too large to see any trends in sales.

There was a distinct difference in the product mix sold by the three types of firms. Businesses that sold perennials only had no sales of annual plants, woody ornamentals, hardwoods, or chemicals. Businesses that sold perennials primarily or secondarily did sell significantly higher percentages of these product lines (see table).

Comparisons of Perennial Plant Firms by Product Mix Sold

Variable	Perennial Product Mix[1]		
	Secondarily	Primarily	Totally
Years in operation	22	15	12
No. species grown	27	33	37
Wholesale sales, 1989 dol.[2]	332M	173M	199M
Wholesale units sold	148M	212M	149M
Pct. annuals sold	19	8	0
Pct. woody plants sold	32	6	0
Pct. hardwoods sold	3	>1	0
Pct. chemicals sold	2	>1	0

[1]Secondarily = 1-49%; Primarily = 50-99%; Totally = 100%.
[2]M = thousands.

Behe is Assistant Professor and Beckett is Research Associate of Horticulture.

Growth and Flowering of Zinnia and Marigold Treated with BAS111

Chia-Lun Chen, Gary J. Keever, and C. Fred Deneke

Plant growth regulators (PGRs) are commonly used in the production of bedding plants to control growth and improve plant appearance and other factors. Once transplanted into the landscape, plants are expected to grow out of the treatments, but the new triazole compounds, such as paclobutrazol and uniconazole, are more active in plants for longer periods of time than daminozide or ancymidol.

BAS111 is a triazole derivative that has been tested as a PGR for fruit trees. Activity and persistence of BAS111 were less than those of uniconazole or paclobutrazol when applied to apple seedlings by injection or soil drench or when applied to zinnia and marigold by foliar spray. No information has been published on the activity and persistence of BAS111 on bedding plants. An experiment was conducted to evaluate the influences of BAS111 dosage and application method (foliar versus drench) on growth and flowering of zinnia and marigold during greenhouse production.

Acceptable height control was obtained with BAS111 when zinnia was treated with a single foliar application of 500 parts per million (ppm) or a medium drench of two or four milligrams (mg) of active ingredient per pot. Desirable height of marigold was obtained with a drench application of two milligrams per pot, but not with any concentration of foliar spray.

METHODS

Seeds of Sunrise Yellow zinnia were direct-sown on May 15, 1990, in one-quart standard pots using a growing medium of 7:1 pine bark:sand (by volume) amended with six pounds dolomitic limestone, 1.5 pounds Micromax micronutrient fertilizer, and 12 pounds Osmocote 14-14-14 per cubic yard. Seeds of Inca Yellow marigold were sown in flats of Metro-mix 360 on July 26, 1990. Marigold seedlings with one pair of true leaves were transplanted on Aug. 3, 1990, into 0.8-quart azalea pots of the same growth medium used with zinnia. After transplanting, seedlings were fertilized weekly with 300 ppm nitrogen (N) from Peters 20-20-20. Plants were grown in a polyethylene-covered greenhouse with a ventilation setpoint of 80°F.

BAS111 was applied to zinnia on May 31 and to marigold on Aug. 16 when the second pair of true leaves had formed. Treatments to zinnia included foliar sprays ranging from 500-2,000 ppm, as well as drenches ranging from two to 10 milligrams active ingredient per pot in a volume of one ounce per container. Treatments to marigold included foliar sprays ranging from 75-300 ppm and drenches ranging from two to eight milligrams of active ingredient per pot in a volume of one ounce per container. Treatments included an untreated control with each species.

Plant height from the growing medium surface to the uppermost growing point was measured when treatments were applied and each week thereafter until flowering. When the first inflorescence (flower cluster) was fully opened, the growth index, height from the surface of the growth medium to the top of the first formed inflorescence, diameter of the first inflorescence, peduncle (stalk) length of the first inflorescence, number of inflorescence buds (bud diameter greater than 0.4 inch), and number of days to flower were determined.

RESULTS

Drench and spray applications of BAS111 were effective in retarding plant height and growth index of zinnia (Table 1). Beginning one week after treatment and continuing through flowering, the height suppression increased as BAS111 concentration increased for both application methods. Compared to control plants one week after treatment, growth decrease ranged from 16-19% with a foliar spray and from 15-27% with a drench. By the third week, heights of plants were reduced from 43-70% by the 500 ppm and 2,000 ppm foliar spray applications, respectively; and 27-61% by the two-milligram and 10-milligram drench applications, respectively. Height suppression was severe and unacceptable with 1,500 and 2,000 ppm foliar sprays, and with eight- and 10-milligram drench concentrations.

Generally, the most desirable height and appearance were obtained with a 500 ppm foliar spray or a two- or four-milligram drench application. BAS111 resulted in 23-46% reductions in growth index by the 500 ppm and 2,000 ppm foliar spray applications, respectively; and 3-50% reductions by the two-milligram and 10-milligram drench applications, respectively.

Table 1. Influence of BAS111 Application Method and Concentration on Height, Growth Index, and Flowering Characteristics of Sunrise Yellow Zinnia

Treatment	Plant height[1,2]			Growth	Days	Peduncle	Height	Inflorescence	Inflorescence
	Week 1	Week 2	Week 3	index[3]	to flower	length[4]		diameter[5]	no.
	cm	*cm*	*cm*	*cm*		*cm*	*cm*	*cm*	
Control									
0	13.8	26.7	47.6	45.1	25.5	8.7	65.9	6.9	4.1
Spray[6]									
500	11.6	17.1	27.0	34.6	27.7	9.0	44.9	6.3	3.2
1,000	12.2	17.2	24.8	31.0	27.9	6.9	34.5	5.7	5.3
1,500	11.6	13.9	17.4	24.6	30.2	6.8	29.0	4.7	3.7
2,000	11.2	13.4	14.4	24.5	33.2	5.2	28.3	5.2	3.5
Drench[7]									
2	11.7	19.5	34.8	43.9	27.9	9.5	56.0	7.0	4.0
4	10.8	16.3	27.2	33.1	26.0	8.6	43.0	6.1	3.8
6	10.7	15.4	25.0	29.2	25.9	6.4	36.8	5.8	3.7
8	11.5	16.1	21.6	28.1	26.7	7.7	36.3	5.4	3.4
10	10.1	13.7	18.6	22.7	27.1	6.5	28.2	5.5	3.1

[1]Data collected weekly beginning one week after treatment.
[2]One centimeter (cm) equals .3937 inch.
[3]Growth index = (height + $width_1$ + $width_2$)/3. $Width_1$ was at the widest point, and $width_2$ was perpendicular to $width_1$. Growth index was determined when the first inflorescence was fully opened.
[4]Peduncle (stalk).
[5]Inflorescence (flower cluster).
[6]Measured in parts per million (ppm).
[7]Measured in milligrams (mg) of active ingredient per pot. One mg is .001 gram; one gram is .035 ounce.

Inflorescence heights of plants treated with BAS111 also decreased with increasing concentrations, from 32-57% with 500 ppm and 2,000 ppm foliar spray applications, respectively; and from 15-57% with the two-milligram and 10-milligram drench applications.

Time to flower of zinnia increased with increasing concentrations of foliar-applied BAS111; the delay in flowering ranged from two to eight days. Drench application had no effect on time to flower. Conversely, peduncle length was not affected by spray application, but decreased with an increase in drench concentration. Inflorescence diameter decreased with increasing concentrations of both foliar spray (maximum decrease of 25%) and drench application (maximum of 20%). Inflorescence numbers were not affected by BAS111 concentration or method of application.

Several plant measurements were less when plants received a foliar spray compared to drench application, including height two weeks after treatment (8.3 versus 9.8 inches), growth index (11.4 versus 12.2 inches), and inflorescence height (13.5 versus 15.8 inches) and diameter (2.2 versus 2.4 inches). Only time to flower was less with the drench application. Greater activity of spray application relative to drench application may reflect a reduced activity of triazole retardants induced by pine bark in the growth medium or more total active ingredient being applied with a foliar application. About 0.2 ounce of spray was applied to the point of runoff to each plant. This volume of a 2,000 ppm solution contains 14 milligrams of active ingredient, four milligrams more than the highest drench concentration. A portion of the foliar spray may have been applied directly to the medium surface or reached the surface as runoff. Solution reaching media by these methods have been shown to increase the efficiency of a PGR.

Heights of marigold receiving a drench application of BAS111 decreased with increasing concentration of BAS111 beginning one week after treatment and continuing until flowering (Table 2). The decrease in height relative to that of control plants was 40% and 43% one week after treatment and 15% and 44% at six weeks after treatment with the lowest and highest drench concentrations, respectively. Height of the first formed inflorescence was 12-20% less than that of control plants. Growth suppression was excessive and unacceptable with four-, six-, and eight-milligram drench applications. Height was initially retarded by foliar application of BAS111 but the effect dissipated over time. Plants were 35% shorter than control plants one week after treatment and 13-26% shorter two weeks after treatment. From four weeks after treatment until flowering, there was no consistent retardation of plant height with foliar application.

Growth index at flowering and inflorescence diameter decreased with increasing concentration of BAS111, regardless of method of application. The decrease in growth index with spray application indicates that plants were not as wide as control plants since heights were similar. Inflorescence diameter was decreased 11-23% and 17-19% with foliar spray and drench applications, respectively. BAS111 did not influence time to flower, peduncle length, or inflorescence number.

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

Table 2. Influence of BAS111 Application Method and Concentration on Flowering Characteristics of Inca Yellow Marigold

Treatment	Days to flower	Peduncle length[1,2]	Inflorescence height[3]	Inflorescence diameter	Inflorescence no.
		cm	*cm*	*cm*	
Control					
0	25.5	8.7	65.9	6.9	4.1
Spray[4]					
500	27.7	9.0	44.9	6.3	3.2
1,000	27.9	6.9	34.5	5.7	5.3
1,500	30.2	6.8	29.0	4.7	3.7
2,000	33.2	5.2	28.3	5.2	3.5
Drench[5]					
2	27.9	9.5	56.0	7.0	4.0
4	26.0	8.6	43.0	6.1	3.8
6	25.9	6.4	36.8	5.8	3.7
8	26.7	7.7	36.3	5.4	3.4
10	27.1	6.5	28.2	5.5	3.1

[1]One centimeter (cm) equals .3937 inch.
[2]Peduncle (stalk).
[3]Inflorescence (flower cluster).
[4]Measured in parts per million (ppm).
[5]Measured in milligrams (mg) of active ingredient per pot. One mg is .001 gram; one gram is .035 ounce.

Production and Postproduction Performance of Sumagic-Treated Bedding Plants

Gary J. Keever and William J. Foster

Triazole-based plant growth inhibitors, which include Sumagic and Bonzi, are active on many bedding plants, including those not affected by other commercially available growth retardants. However, these compounds are active in low dosages and are persistent, which could cause undesirable growth inhibition after plants are transplanted into the landscape.

Limited information is available on postproduction growth and performance of triazole-treated bedding plants. A study was conducted to determine the influence of various dosages of Sumagic on production and post-production performance of several bedding plant species.

Results show that Sumagic is effective in suppressing internode elongation and increasing a plant's tolerance to water stress, both of which should enhance and extend marketability. However, optimum rates are specific to a given species. Growth suppression may continue after plants are transplanted into the landscape, but plants may exhibit an accelerated growth rate after the growth-retarding effect dissipates. Sumagic applied at too high a concentration will suppress growth excessively and delay flowering. The effects may persist for five or more weeks after plants are transplanted into the landscape, depending upon the plant species and the concentration of Sumagic applied.

METHODS

Uniform 0.6-inch plugs (288 cells per tray) of Ringo Deep

Scarlet geranium, Inca Orange marigold, Blue Shades pansy, Zenith New Guinea impatiens, and Victoria Blue salvia were transplanted on Jan. 31, 1989, into pint containers of a peat moss and perlite (1:1, by volume) growth medium. Plants were maintained in a glasshouse with heat and ventilation set points of 60°F and 85°F, respectively, and fertilized weekly with 500 parts per million (ppm) nitrogen from 20-10-20 Peter's Peatlite Special.

The following treatments were applied on Feb. 16, 1989, when geranium, marigold, pansy, impatiens, and salvia were an average of 1.5, 3.7, 1.8, 3.7, and 1.1 inches tall, respectively. Treatments were: single Sumagic sprays of 0-30 ppm (see tables) or a single daminozide spray of 5,000 ppm. Sprays were applied in a volume of two quarts per 100 square feet using a hand-held sprayer to uniformly wet foliage and stems. Ambient temperature was 84°F with 63% relative humidity at time of application.

Plant heights, growth indices, and a foliar color rating were determined four to eight weeks after treatment. Specific dates of data collection were based upon growth and developmental rates of the individual species and are given in the tables. When these data were collected, flowers or inflorescences were counted and peduncle (stalk) lengths of pansy were measured.

To determine treatment effects on water stress tolerance, five plants of each species-treatment combination, except geranium, were placed on a greenhouse bench on April 12 and thoroughly watered. Thereafter, water was withheld from the plants, and time to first signs of wilting was noted by monitoring plants every 30 minutes from 8 a.m. until 6 p.m. Hours between 6 p.m. and 8 a.m. were not counted in determining time to wilting because loss of moisture during this period was considered insignificant. Water was withheld from geraniums beginning on April 24. Following wilting of all plants of a species, shoots were cut at the growth medium surface, dried at 120°F for 72 hours, and weighed.

On April 12 (impatiens, salvia), and April 26 (geranium), five plants from each treatment were planted into the landscape to evaluate post-production growth. Pansies were not transplanted because of their typically poor performance in the south Alabama landscape after early April. Marigolds were not planted into the landscape because of their relatively minor responses to growth retardant treatments. The ground bed consisted of a sandy-loam soil with two inches of amendment grade pine bark tilled into the upper six inches. On May 31, vegetative (to uppermost leaf) and inflorescence heights of salvia and geranium were measured, and shoots of the three species were cut for dry weight determination.

RESULTS

Growth of impatiens, geranium, salvia, marigold, and pansy measured 4.5 to 8.5 weeks after treatment was significantly suppressed by a single foliar spray of Sumagic (Tables 1-5). Plant height, growth indices, and shoot dry weight of all species were lower as concentration of Sumagic increased. Magnitude of suppression varied with species and concentration. Growth indices of impatiens, geranium, salvia, marigold, and pansy treated with five ppm of Sumagic decreased 29.5, 10.2, 5.9, 2.5, and 1.4%, respectively. Shoot dry weights of the same species decreased 52.3, 11.2, 22.2, 12.5, and 10.5%, respectively. Suppression of top dry weight was most pronounced with application of the highest concentration of Sumagic, 30 ppm, and equalled 81.0, 74.8, 44.4, 27.3, and 66.7% with impatiens, geranium, salvia, marigold, and pansy, respectively. Foliar color ratings of impatiens increased with higher concentrations of Sumagic. Foliar color of the other species was not visibly affected by application of Sumagic.

Flowering varied with species used and with the concentration of Sumagic used. Flower number of impatiens, inflorescence number of salvia, and peduncle number of pansy decreased with an increase in the concentration of Sumagic. These reductions in flowering appeared to be due to a delay in floral development rather than an actual suppression of flowering because subsequent observations on flowering in the landscape did not show treatment differences. Flower buds of geranium were first observed on March 29 on plants treated with the three highest concentrations of Sumagic. This trend toward earlier floral development with the highest concentrations of Sumagic continued through April and is reflected in the inflorescence count taken on April 18. Flower bud number of marigold averaged 10 to 12 per plant and was not affected by treatment.

Sumagic had a significant effect on time to wilt of all species except marigold. Time to wilt of impatiens increased from 39% with three ppm of Sumagic to 63% with 30 ppm compared to the control (Table 1). With geranium the increase was from 11% with one ppm of Sumagic to 100% with application of 30 ppm of Sumagic (Table 2). Wilting of salvia was delayed 15% with three ppm of Sumagic and 34% with 30 ppm of Sumagic (Table 3). The delay in wilting of pansy was negligible at concentrations of Sumagic less than 20 ppm, but the time to wilt was increased by 35% with the application of 30 ppm of Sumagic.

As with the production and stress evaluation, plant response to Sumagic five to seven weeks after transplanting into the landscape varied with species and concentration. Plant height of impatiens was suppressed less than 25% with application of one, three, or five ppm of Sumagic compared to the control. Plants treated with Sumagic at these concentrations were of excellent quality. Shoot dry weight was inhibited by 26% with an application of one ppm of Sumagic but increased to 74% with a 20 ppm concentration.

Vegetative and inflorescence heights of geranium five weeks after transplanting were not affected by application of 10 ppm or less of Sumagic; concentrations greater than 10 ppm inhibited plant height as much as 58%. Shoot dry weight of geranium treated with 1, 3, 5, and 10 ppm of Sumagic was 7, 12, 25, and 15%, respectively, greater than that of untreated plants. However, shoot dry weight was suppressed 77% with 30 ppm Sumagic. Vegetative and inflorescence (flower cluster) heights and shoot dry weights of salvia seven weeks after transplanting into the landscape were not affected by Sumagic concentration. Similarity of heights indicates a more rapid rate of growth of Sumagic-treated plants compared to untreated plants. Accelerated growth of triazole-treated plants has been observed after growth suppression effects have dissipated and may relate to the accumulation of large reserves of carbohydrates during the period of growth inhibition that stimulate rapid growth as growth retardation lessens. The high activity and persistence of triazole retardants are well documented and emphasize the importance of applying appropriate concentrations.

Growth and flowering data taken on daminozide-treated plants following production, during the stress evaluation or after five to seven weeks in the landscape, did not differ from values for untreated plants of the five bedding plant species. Therefore, higher concentration and/or repeated application for effective growth suppression are indicated. See Photos 9 and 10 on Page 19.

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

Table 1. Effects of Sumagic Foliar Sprays on Growth and Drought Stress Tolerance of New Guinea Impatiens

Treatment	Growth index[1-3]	Foliar color[4]	Flower no.	Time to wilt	Height	Shoot dry weight[5] 8 WAT[6]	Shoot dry weight[5] 15WAT
ppm	*cm*			*hr.*	*cm*	*g*	*g*
Sumagic							
0	23.7	4.0	4.9	20.5	20.6	4.2	28.2
1	21.6	4.3	3.0	19.4	19.2	3.1	20.9
3	15.6	4.8	2.0	28.5	16.0	1.8	14.5
5	16.7	5.0	3.4	30.5	16.2	2.0	15.9
10	14.8	5.0	2.3	32.2	14.0	1.9	8.0
15	14.9	5.0	2.6	32.8	15.6	1.2	10.2
20	14.2	5.0	0.4	33.5	13.3	0.9	7.4
30	13.8	5.0	0.0	33.5	11.4	0.7	11.5
Daminozide							
5,000	21.2	4.1	3.8	17.2	20.2	3.1	23.4

Table 2. Effects of Sumagic Foliar Sprays on Growth and Drought Stress Tolerance of Geranium

Treatment	Growth index[1,3,7]	Inflorescences[7,12]	Time to wilt	Vegetative ht.[8]	Flowering ht.[8]	Shoot dry weight[5] 10 WAT[6]	Shoot dry weight[5] 15 WAT
ppm	*cm*	*no.*	*hr.*	*cm*	*cm*	*g*	*g*
Sumagic							
0	26.6	1.6	9.7	18.0	28.8	14.3	39.2
1	25.5	1.1	10.8	17.4	28.6	14.0	42.0
3	25.5	1.3	10.5	17.8	28.0	15.0	43.8
5	23.9	1.4	11.4	18.8	29.2	12.7	49.0
10	22.9	1.5	10.9	17.4	27.0	12.6	45.1
15	19.0	1.6	12.5	11.0	19.4	7.8	30.8
20	17.1	1.9	14.8	11.4	18.8	5.2	19.8
30	14.7	2.1	19.4	7.6	12.8	3.6	8.9
Daminozide							
5,000	24.8	1.1	11.4	17.6	28.4	11.2	41.5

Table 3. Effects of Sumagic Foliar Sprays on Growth and Drought Stress Tolerance of Salvia

Treatment	Growth index[1-3]	Inflorescence no.[2]	Shoot dry weight[5,9]	Time to wilt
ppm	*cm*		*g*	*hr.*
Sumagic				
0	30.7	1.9	6.3	14.2
1	28.8	2.1	4.9	13.7
3	29.0	1.3	4.1	16.3
5	28.9	1.1	4.9	15.8
10	29.0	0.5	4.7	16.6
15	26.1	0.2	4.6	18.0
20	26.2	0.3	3.7	18.1
30	23.2	0.1	3.5	19.0
Daminozide				
5,000	28.6	1.1	4.4	16.1

Table 4. Effects of Sumagic Foliar Sprays on Growth and Drought Stress Tolerance of Marigold

Treatment	Growth index[1,3,10]	Shoot dry wt.[5]
ppm	*cm*	*g*
Sumagic		
0	20.1	8.8
1	19.9	8.9
3	19.7	8.7
5	19.6	7.7
10	17.7	8.0
15	17.6	7.5
20	17.4	7.7
30	16.7	6.4
Daminozide		
5,000	19.4	7.0

Table 5. Effects of Sumagic Foliar Sprays on Growth and Drought Stress Tolerance of Pansy

Treatment	Growth index[1,3,11]	Peduncles[11,13]	Time to wilt	Shoot[5,7] dry wt.
ppm	*cm*	*no.*	*hr.*	*g*
Sumagic				
0	20.9	3.7	17.4	5.7
1	22.3	3.6	16.5	5.5
3	21.7	4.0	16.0	5.4
5	20.6	4.2	17.5	5.1
10	18.8	3.7	17.9	4.5
15	16.9	2.7	17.3	3.4
20	14.1	2.7	19.8	2.7
30	11.0	2.2	23.5	1.9
Daminozide				
5,000	20.9	3.9	16.6	4.8

FOOTNOTES: TABLES 1-5

[1]Growth index = (height + $width_1$ + $width_2$)/3. $Width_1$ was at the widest point, and $width_2$ was perpendicular to $width_1$.
[2]This measurement was made 7.5 weeks after treatment.
[3]One centimeter (cm) is .3937 inch.
[4]Foliar color rating: 1, 3, and 5 = light, medium, and dark green, respectively. Foliage was rated 7.5 weeks after treatment.
[5]One gram (g) is .035 ounce.
[6]WAT = weeks after treatment on February 16, 1989. Plants were transplanted into the landscape eight weeks after treatment.
[7]Measurement taken 8.5 weeks after treatment.
[8]Measurement taken 15 weeks after treatment.
[9]Measurement taken eight weeks after treatment.
[10]Measurement taken 4.5 weeks after treatment.
[11]Measurement taken six weeks after treatment.
[12]Inflorescence (flower cluster).
[13]Peduncle (stalk).

Growth and Flowering of Triazole-Treated Zinnia and Marigold

Chia-Lun Chen, Gary J. Keever, and C. Fred Deneke

Triazole-based plant growth inhibitors paclobutrazol and uniconazole are effective on bedding plants at relatively low dosages and persist for a long time. This persistence has some advantages, but it could also result in undesirable growth inhibition during production, marketing or after planting in the landscape.

BAS111 is a triazole derivative previously evaluated as a growth regulator for fruit trees. It appears to have similar regulating activity as paclobutrazol and uniconazole, but it is less persistent, a factor that could be a distinct advantage to bedding plants growers. In an AAES study, paclobutrazol, uniconazole, and BAS111 were evaluated to determine effects on growth and flowering of zinnia and marigold during greenhouse production.

Results showed a single foliar spray of 250-750 ppm of paclobutrazol or uniconazole provided acceptable height control from two weeks after treatment to flowering. Plants flowered earlier, but flower clusters of uniconazole-sprayed plants were smaller. BAS111 temporarily suppressed vegetative growth of zinnia, but at flowering plants were similar in size to untreated plants. Marigold growth and flowering height were not controlled by either paclobutrazol or BAS111, but uniconazole provided acceptable control of plant height. Lack of growth control may be due to paclobutrazol concentration being too low, although other research achieved acceptable control with a similar concentration using a different cultivar.

METHODS

Seeds of Sunrise Yellow zinnia and Inca Yellow marigold were direct-sown in 0.95-quart standard pots and 0.8-quart azalea pots, respectively, on Feb. 1, 1990. The growing medium for the two species was 7:1 pine bark:sand (by volume) amended with six pounds dolomitic limestone, 1.5 pounds Micromax micronutrient fertilizer, and 12 pounds Osmocote 14-14-14 per cubic yard. Seedlings were fertilized weekly with 300 ppm nitrogen from a water soluble 20-10-20 fertilizer. Plants were grown in a polyethylene-covered greenhouse with a ventilation setpoint of 80°F and a heat setpoint of 65°F. Growth retardants were applied at the second-pair true-leaf stage on Feb. 28, 1990, 27 days after sowing. Treatments included a single foliar spray of paclobutrazol, uniconazole, or BAS111 of 250-750 ppm to zinnias and 20-60 ppm to marigolds. An untreated control was included with each plant species.

Plant height from the growth medium surface to the growing point was measured when treatments were applied and each week thereafter until flowering. When the first inflorescence (flower cluster) of each plant was fully opened, the height from the surface of the growth medium to the top of the first inflorescence, growth index (see table footnotes for definition), the diameter and the peduncle (stalk) length of the first opened inflorescence, the number of inflorescence buds (bud diameter greater than 0.4 inch), and days to flower were determined.

RESULTS

By the second week after treatment with paclobutrazol and uniconazole, or the third week after treatment with BAS111, and continuing through flowering, plant height of zinnia was reduced with increasing rates of the compounds (Table 1). Growth suppression, as indicated by plant height, at two weeks after treatment ranged from 7% with the lowest concentration of paclobutrazol and uniconazole to 16 and 20%, respectively with the highest concentration. By week three, growth suppression from the lowest and highest concentrations relative to the control was 27 and 44% with paclobutrazol, 41 and 58% with uniconazole, and 4 and 24% with BAS111.

Growth indices, determined when the first inflorescence of each plant was fully opened, were least when plants were sprayed with uniconazole, ranging from 11-19% less than those of control plants. Growth indices of paclobutrazol-treated plants were 2-

Table 1. Influence of Foliar Application of Paclobutrazol, Uniconazole, and BAS111 on Growth and Flowering of Sunrise Yellow Zinnia

Treatment	Plant height[1]			Growth	Inflorescence	Days	Inflorescence
	Week 1	Week 2	Week 3	index[2-4]	height[1]	to flower[3]	diameter[3]
ppm	*cm*	*cm*	*cm*	*cm*	*cm*		*cm*
Control							
0	6.4	12.6	21.5	31.1	30.7	37.6	6.6
Paclobutrazol							
250	5.9	9.7	15.8	30.4	26.8	36.9	6.1
500	5.1	7.5	12.4	26.7	21.7	26.3	6.2
750	5.4	7.9	12.1	27.4	22.2	26.9	6.1
Uniconazole							
250	5.9	8.4	12.7	27.8	21.2	28.4	6.2
500	5.0	7.0	10.2	27.8	20.6	27.1	5.6
750	5.1	6.9	9.1	25.2	18.2	20.1	5.4
BAS111							
250	5.9	11.8	20.7	30.4	31.3	39.7	6.7
500	5.7	9.8	16.8	31.4	31.5	37.7	6.1
750	6.0	10.3	16.4	30.4	28.9	36.9	6.5

[1]Plant heights were measured weekly beginning one week after treatment; height was measured from the medium surface to the uppermost vegetative part of the plant.
[2]Growth index = (height + $width_1$ + $width_2$)/3. $Width_1$ was at the widest point and $width_2$ was perpendicular to $width_1$.
[3]Data were determined when the first inflorescence was fully opened; height was measured from the medium surface to the top of the inflorescence.
[4]One centimeter (cm) is .3937 inch.

12% less than those of control plants, while growth indices of BAS111-treated plants were similar to those of control plants.

Inflorescence heights were similarly affected by treatments. Heights were less with increased concentrations of paclobutrazol or uniconazole and not affected by BAS111 concentration. Magnitude of suppression was of the following order: uniconazole > paclobutrazol > BAS111. The reduced persistence of growth retardation should ensure that plants resume a normal rate of growth after being planted in the landscape.

Time to flower decreased with increasing concentrations of paclobutrazol and uniconazole to a maximum of 28% and 47%, respectively, with the highest concentration of each growth regulator. BAS111 did not influence time to flower. Inflorescence diameters were affected only by uniconazole, decreasing as concentration was increased. Peduncle lengths or inflorescence numbers were not affected by either treatment or concentration. Leaves of plants sprayed with the compounds and control plants visually appeared similar in color, size, and shape.

Weekly heights of marigold prior to flowering and time to flower were not influenced by treatment or concentration. Growth indices and inflorescence heights and numbers decreased with increasing concentrations of uniconazole, but not with paclobutrazol or BAS111 (Table 2). Decreases in growth indices, inflorescence heights, and inflorescence numbers ranged from 6-9%, 6-19%, and 16-21%, respectively. Peduncle lengths were not affected by concentration, although peduncles of plants sprayed with uniconazole were shorter than those of plants sprayed with other regulators or control plants. Inflorescence diameter decreased with increasing concentrations. Inflorescences were similar in diameter for all treatments.

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

Table 2. Influence of Foliar Application of Paclobutrazol, Uniconazole, and BAS111 on Growth and Flowering of Inca Yellow Marigolds

Treatment	Growth index[2-4]	Inflorescence height[3]	Peduncle length[3]	Inflorescence no.[3]	Inflorescence diameter
ppm	*cm*	*cm*	*cm*		*cm*
Control					
0	24.2	19.9	6.4	13.2	9.1
Paclobutrazol					
20	23.8	19.6	6.6	13.3	8.7
40	24.2	19.1	6.7	12.7	8.4
60	23.4	19.0	6.4	12.1	8.3
Uniconazole					
20	22.7	17.8	6.0	11.1	8.6
40	22.3	17.2	6.1	10.2	8.5
60	22.0	16.2	5.7	10.4	8.4
BAS111					
20	24.3	18.0	5.9	12.1	8.3
40	24.6	19.2	6.7	12.2	8.3
60	23.1	19.1	6.6	12.3	8.4

[1]Plant heights were measured weekly beginning one week after treatment; height was measured from the medium surface to the uppermost vegetative part of the plant.
[2]Growth index = (height + $width_1$ + $width_2$)/3. $Width_1$ was at the widest point and $width_2$ was perpendicular to $width_1$.
[3]Data were determined when the first inflorescence was fully opened; height was measured from the medium surface to the top of the inflorescence.
[4]One centimeter (cm) is .3937 inch.

Chemical Promotion of Axillary Shoot Development of Geranium Stock Plants

James T. Foley and Gary J. Keever

The maintenance of geranium stock plants as a source of vegetatively propagated cultivars requires a continual investment in space and labor. Greater efficiency is possible if the number of cuttings per plant is increased, thus reducing the total number of stock plants maintained. Chemical growth regulators can be used to double or triple branching in geraniums, thereby increasing the number of terminal or single-node cuttings per stock plant.

Florel (ethephon), which is labeled as a branching compound for use on geranium stock plants at a concentration of 500 parts per million (ppm), is well-documented for its promotion of axillary shoot development. Other plant growth regulators, such as the synthetic cytokinins Pro-Shear (BA) and Accel (PBA), reduce apical dominance, promoting the growth of axillary buds. Three experiments were conducted to determine the effectiveness of these three chemicals, plus Promalin (BA + GA^{4+7}), at inducing axillary shoot development of Hollywood Star geranium stock plants for the purpose of increasing the production of cuttings.

In this study, calipers of terminal cuttings were less in Florel-treated plants than in untreated plants. Two applications of Promalin at 75 or 150 ppm increased production of single-node cuttings, without reducing the number or caliper of the terminal cuttings. The use of Promalin is a viable alternative to the industry standard, Florel, for increasing the total number of marketable geranium plants produced from single-node cuttings.

METHODS

Experiment 1. On Nov. 13, 1987, seeds of Hollywood Star geranium were sown in 36-cell flats of Pro-Mix BX. Seedlings were transplanted to six-inch pots of identical growth medium on Jan. 6, 1988. After two days, the following foliar spray treatments were applied to the plants just prior to runoff: Pro-Shear at 75-600 ppm; Accel at 75-600 ppm; or Promalin at 150-1,200 ppm. An untreated control was included for comparison. Buffer-X was added as a surfactant at 0.2% to all chemical solutions in each experiment. Plants were fertilized weekly with 200 ppm nitrogen from 20-10-20 Peter's Peatlite Special. At the termination of the experiment, eight weeks after plant treatment, data collected included the number of axillary shoots, the mean length of three randomly selected axillary shoots, and a growth index (see table footnotes for definition).

Experiment 2. A second study was initiated to determine appropriate concentrations and numbers of applications of the branching compounds Accel, Promalin, and Florel on geranium stock plants. Seeds were sown on April 4, 1988, and the seedlings were grown as in the first experiment. The following foliar spray treatments were applied on June 27, 1988: Accel at 37.5 or 75 ppm.; Promalin at 75 or 150 ppm; or Florel at 500 ppm. A control treatment was included for comparison. Four weeks after initial treatment, terminal and single-node cuttings were taken, and a second application was applied to half of the plants in each treatment group. Plants were then allowed to produce a second crop of cuttings. All side branches were cut from the main leader of each plant and divided into terminal cuttings (about four inches long) and single-node cuttings (with leaf attached). Data collected at the first and second removal of cuttings consisted of lengths and calipers of axillary shoots and numbers of terminal and single-node cuttings. The caliper of each side shoot was taken at the point of detachment from the main leader and the lengths of side branches were also measured from this point to the vegetative shoot apex.

Experiment 3. A third experiment compared the effects of one, two, or four foliar sprays of Promalin at 75-300 ppm or Florel at 500 ppm. An untreated control was included for comparison. Seeds were sown on March 2, 1989, and seedlings were grown as in the first two experiments. The first foliar spray application was on May 4, 1989; additional applications were made at two-week intervals. At time of cutting, the number of terminal and single-node cuttings and lengths and calipers of axillary shoots were recorded.

RESULTS

Experiment 1. As the concentration of Pro-Shear increased, the numbers of axillary shoots decreased (Table 1). When Pro-Shear was applied at 600 ppm, axillary shoot formation was suppressed; there was no effect at lower concentrations. Axillary shoot length increased as concentration of Pro-Shear increased, but the growth index was not affected by application of Pro-Shear. Pro-Shear was not studied further since axillary shoot number was not increased following its application.

Axillary shoot number was increased at lower concentrations of Accel, with no effect thereafter. Axillary shoot length was not affected by Accel application. The growth index increased with Accel up to 300 ppm but declined at higher concentrations.

Axillary shoot number did not differ from the control at the two highest concentrations of Promalin, while numbers increased at the 300 ppm concentration. Although axillary shoot lengths increased linearly as concentration of Promalin increased, lengths did not differ from the control. The growth index increased with increasing concentration of Promalin, with 1,200 ppm producing a growth index greater than the control.

Experiment 2. The first cuttings were harvested four weeks after initial treatment. More terminal cuttings were produced following Florel application than with the other treatments (Table 2). Treatment with Accel at 75 ppm or Promalin at 75 or 150 ppm increased the numbers of terminal cuttings, but the increase was not as great as with Florel. The number of single-node cuttings was not affected by applications of Florel, Accel, or Promalin after the first cuttings had been harvested. Axillary shoot length and caliper of plants treated with Florel were less than all other treated and control plants. When Promalin was applied at 150 ppm, axillary shoot length was increased. Applications of Accel did not affect axillary shoot length. Axillary shoot caliper was not affected by treatment with Promalin or Accel.

After harvesting a second crop of cuttings, number of terminal cuttings did not differ among treatments. The numbers of single-node cuttings increased after a second application of 75 or 150 ppm Promalin. The number of single-node cuttings did not differ from that of control plants with a second application of Accel or Florel. The lengths of axillary shoots were increased with a second application of Promalin at 150 ppm; axillary shoot lengths of plants in other treatments were similar to those of control plants. Calipers of cuttings from plants treated with Florel or one application of Promalin at 75 ppm were reduced. Calipers of plants given other treatments did not differ from those of control plants.

Experiment 3. Application of Florel increased the number of terminal cuttings (Table 3). Foliage of plants receiving four applications of Promalin at 150 or 300 ppm was chlorotic, and isolated marginal leaf necrosis was present. Phytotoxicity possibly contributed to reduced numbers of terminal cuttings. Numbers of terminal cuttings were also decreased by a single application of Promalin at 300 ppm, indicating an excessive concentration was applied. The numbers of terminal cuttings from plants receiving other concentrations of Promalin were similar to those of control plants. The number of single-node cuttings was increased by two applications of Promalin at 75 ppm, while numbers decreased from four applications at 300 ppm. The other application numbers and concentrations of Promalin and Florel had no affect on single-node cutting number.

Table 1. Number and Length of Axillary Shoots and Growth Index of Geranium as Affected by Three Plant Growth Regulators, Eight Weeks After Treatment (Experiment 1)

Treatment	No. shoots	Shoot length[1]	Growth index[2]
ppm		*cm*	*cm*
BA			
75	16.2	9.5	25.1
150	15.6	10.9	24.7
300	14.4	11.1	25.3
600	6.5	13.3	25.6
Accel			
75	17.6	10.3	25.8
150	16.6	11.5	26.5
300	17.0	11.1	28.1
600	13.6	10.2	25.7
Promalin			
150	10.2	8.7	25.8
300	17.2	10.8	25.5
600	14.0	10.2	26.5
1,200	11.4	12.2	28.4
Control			
0	13.6	9.4	24.2

See footnotes on following page.

Table 2. Terminal and Single Node Cutting Numbers and Length and Caliper of Axillary Shoots of Geranium from First and Second Harvests as Affected by Three Plant Growth Regulators (Experiment 2)

Treatment[3]	Terminal cuttings	Single-node cuttings	Shoot length[1]	Shoot caliper
	no.	*no.*	*cm*	*cm*
		First harvest[4]		
Accel				
37.5(1)	9.5	11.3	9.8	0.80
75(1)	10.0	10.5	9.6	0.79
Promalin				
75(1)	9.9	9.6	11.3	0.79
150(1)	10.4	13.6	12.5	0.88
Florel				
500(1)	16.2	10.8	7.3	0.68
Control				
0(0)	8.4	12.3	10.2	0.82
		Second harvest[4]		
Accel				
37.5(1)	9.4	13.4	9.5	0.79
37.5(2)	8.7	19.3	12.8	0.82
75(1)	9.4	18.1	10.7	0.81
75(2)	7.3	16.8	11.2	0.78
Promalin				
75(1)	9.9	8.9	8.1	0.74
75(2)	10.9	25.7	12.7	0.79
150(1)	8.7	17.4	11.5	0.80
150(2)	9.0	27.9	13.5	0.82
Florel				
500(1)	11.0	16.6	9.0	0.68
500(2)	10.2	17.2	9.5	0.69
Control				
0(0)	9.0	16.1	10.1	0.88

Table 3. Terminal and Single Node Cutting Numbers and Length and Caliper of Axillary Shoots of Geranium as Affected by Two Plant Growth Regulators, Seven Weeks after Treatment (Experiment 3)

Treatment[3]	Terminal cuttings	Single-node cuttings	Shoot length[1]	Shoot caliper
	no.	*no.*	*cm*	*cm*
Promalin				
75(4)	11.4	24.4	17.6	0.72
75(2)	12.5	27.4	15.6	0.83
75(1)	12.5	20.5	12.2	0.79
Promalin				
150(4)	10.3	15.7	14.6	0.62
150(2)	11.8	23.1	15.5	0.79
150(1)	13.7	23.6	14.4	0.80
Promalin				
300(4)	9.6	6.2	10.0	0.60
300(2)	11.0	16.9	13.1	0.70
300(1)	10.8	19.5	14.3	0.90
Florel				
500(1)	14.3	14.3	5.7	0.68
Control				
0(0)	12.6	16.5	10.7	0.87

[1]One centimeter is .3934 inch.
[2]Growth index = (height + $width_1$ + $width_2$)/3. $Width_1$ was at the widest point, and $width_2$ was perpendicular to $width_1$.
[3]The first number is the application rate in parts per million, while the number in parentheses is the application number: 1 = monthly; 2 = biweekly; 4 = weekly.
[4]First cut made four weeks after initial treatment; second cut taken nine weeks after second application of treatment.

The lengths of axillary shoots were reduced by application of Florel. One application of Promalin at 150 or 300 ppm or two or four applications at 75 or 150 ppm increased axillary shoot length. Axillary shoot caliper decreased when plants were treated with four applications of Promalin, two applications of 300 ppm Promalin, or with Florel.

Florel produced more terminal cuttings than the other plant growth regulators, but plants had shorter axillary shoots of smaller calipers when compared to the control and Promalin treated plants. Plants treated with Promalin produced longer axillary shoots of increased caliper, resulting in an increased number of single-node cuttings when compared to plants treated with Florel. In addition to an unaltered number of terminal cuttings, the increased number of single-node cuttings produced from stock plants treated with two applications of Promalin at 75 ppm biweekly, doubled or tripled the total number of cuttings produced. This effect would potentially result in a substantial increase in the total number of marketable cuttings produced.

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

WOODY ORNAMENTALS

Comparison of Two Root Control Techniques for the Urban Landscape

Patricia R. Knight, D. Joseph Eakes, and Charles H. Gilliam

Tree root encroachment poses several problems to the landscape industry. Trees planted too close to walks, parking lots, or streets can cause concrete or asphalt to buckle. Root encroachment may also cause aesthetic problems by surfacing in ornamental landscape beds. Current methods of controlling root encroachment, usually involving mechanical removal of the roots, are expensive and tend to provide short-term solutions.

Physical and/or chemical barriers that prevent growth of unwanted roots are being investigated as a more economical and permanent alternative. Based on previous work, Typar Biobarrier (Reemay, Inc., Old Hickory, Tenn.) and DeWitt Pro-5 Weed Barrier (DeWitt Co., Inc., Sikeston, Mo.) were chosen as potential root barriers for an AAES study. Objectives were to evaluate these products in the urban landscape and to determine their influence on the growth of two tree species commonly grown as street trees.

Typar Biobarrier is a time-released material first developed to control root encroachment into hazardous waste burial sites. It is comprised of 0.35-inch spheres that are 24% trifluralin, 18% carbon black, and 56% polyethylene. The herbicide-impregnated nodules are bonded to a permeable geotextile fabric. DeWitt Pro-5 Weed Barrier is a woven polyethylene fabric that provides excellent weed control in the landscape.

Typar Biobarrier effectively controlled root growth for red maple and American sycamore without producing negative effects on tree growth and development during the first two years of this study. In comparison, DeWitt Pro-5 failed to prevent root growth outside the treatment's vertical plane for either species.

METHOD

Two-inch caliper *Acer rubrum* (red maple) and *Platanus occidentalis* (American sycamore) were planted at the E.V. Smith Research Center on March 26, 1990. The planting holes were 8x8 feet and 19 inches deep. Sides of each hole were lined to a depth of 18 inches with either Typar Biobarrier, DeWitt Pro-5, or left unlined as a control. One inch of the fabric was left above the soil surface to prevent roots from growing over the vertical barriers. Trees were placed in the center of the hole, and holes were backfilled. After planting, trees were mulched to a depth of two to three inches with pine bark, watered as needed during the first year, and fertilized annually with one pound of 13-13-13 per inch of caliper. Roundup was used for postemergence weed control around the edge of the planting hole.

Root penetration, height, and caliper were determined following the 1990 and 1991 growing seasons. To determine root penetration through the vertical plane of each treatment, one side of the planting hole (eight feet long) was excavated with a backhoe to within four inches of the vertical plane. The remaining four inches of soil was removed by hand, and all roots penetrating the vertical plane were counted.

RESULTS

There was little or no root penetration by either species beyond the Typar Biobarrier root control treatment following the 1990 or 1991 growing season (see table). At the end of 1990, the untreated control and DeWitt Pro-5 treatments had similar root penetration numbers for both species. In contrast, by the end of 1991 the DeWitt Pro-5 treatment had more roots penetrate the vertical barrier than the control treatment for red maple. Roots that penetrated the DeWitt Pro-5 treatment tended to branch as they penetrated the barrier resulting in small roots that grew along the face of the vertical barrier.

There were no treatment differences in height or caliper for red maple or American sycamore either year. Average height and caliper for red maple across the three treatments were 13.3 feet and 2.2 inches in 1990 and 17.2 feet and 3.5 inches in 1991, respectively. For American sycamore, average height and caliper across the three treatments were 15.6 feet and 2.5 inches in 1990 and 17.8 feet and 3.8 inches in 1991, respectively.

In May 1991, soil samples were taken horizontally from the area surrounding a Typar Biobarrier treatment to evaluate trifluralin movement in the soil. Trifluralin levels were highest, 24.1 parts per million (ppm) up to 1/8 inch from the Typar Biobarrier, and concentration decreased as distance from the Typar Biobarrier increased. At a distance of two inches from the Typar Biobarrier, the trifluralin concentration had decreased to 0.1 ppm. The nodule trifluralin concentration was comparable to the original herbicide content of the nodule.

Root Penetration Through Vertical Plane of Root Control Treatments

Treatment	Number of roots			
	Red Maple		American Sycamore	
	1990	1991	1990	1991
Typar Biobarrier	0.0	0.0	0.0	1.0
DeWitt Pro-5	11.7	58.7	16.3	58.0
Untreated Control	17.0	28.3	22.0	53.7

Knight is Graduate Research Assistant, Eakes is Assistant Professor, and Gilliam is Professor of Horticulture.

Influence of Subirrigation and Container Size on Growth of Two Tree Species

Ken M. Tilt, Ronald L. Shumack, and John W. Olive

Overhead irrigation of a container nursery requires about 20,000 to 40,000 gallons of water per acre each day. Some 70-80% of this water falls between or passes through the containers and runs off the nursery. There is strong concern for preventing ground water contamination that could be caused by runoff of pesticides and fertilizers in the wasted irrigation water.

Some nurseries have already implemented conservation measures to address these concerns. One method has been to channel runoff to holding ponds where it is filtered and recycled. Another production technique is to use drip irrigation where each container has its own water source. This method prevents tremendous loss of water but is only economically feasible in larger containers and can still result in runoff.

AAES research evaluated the effects on growth of live oak (*Quercus virginiana*) and Shumard oak (*Quercus shumardii*) as a result of catching the leachate or water passing through the container and holding it in reserve in a saucer. A second objective was to determine whether a constant water level maintained in the saucer beneath the containers would be detrimental to or enhance growth compared to allowing the saucer to dry out between irrigations.

This study proved that equal or better growth of the trees can be obtained using subirrigation while eliminating any water runoff. Proper selection of container size for the plant being grown can increase growth and profits. These results represent positive implications for further research to increase or maintain production efficiency while increasing the commitment toward conservation and preservation of natural resources.

METHODS

Trees were planted Jan. 18, 1988, and were analyzed separately. Fifteen- and 30-gallon containers were used to determine the size of containers needed to facilitate optimum growth. Some trees were given a "subirrigation-wet" treatment, in which a 1.5-inch saucer was placed under the container and maintained filled with water at all times. Other trees received a "subirrigation-dry" treatment, in which the saucer was filled with water as it dried out. A control group of both species was given traditional drip irrigation. All plants received the same cultural care throughout the experiment, except for the irrigation treatments. The height and caliper of each tree was measured on Oct. 10, 1989.

RESULTS

Live oaks had greater caliper and height for either subirrigation treatment compared to the control drip irrigation treatment (Table 1). There were no differences in growth for Shumard oak due to the irrigation treatments.

There was a clear growth benefit to growing the trees in 30-gallon containers over 15-gallon containers for the two-year study. Live oak and Shumard oak grown in 30-gallon containers were 0.8 foot and 1.6 feet taller than 15-gallon container trees, respectively (Table 2).

Table 1. Effect of Subirrigation on Growth of Two Tree Species

Irrigation	Live Oak		Shumard Oak	
	Height	Caliper	Height	Caliper
	ft.	*in.*	*ft.*	*in.*
Control	5.1	1.4	5.5	1.0
Dry[1]	7.2	1.9	6.1	1.0
Wet[2]	6.7	1.9	5.4	1.0

[1]1.5-inch saucer was filled with water after it dried out.
[2]1.5-inch saucer was maintained filled with water at all times.

Table 2. Effect of Container Size on Growth of Two Tree Species

Irrigation	Live Oak		Shumard Oak	
	Height	Caliper	Height	Caliper
	ft.	*in.*	*ft.*	*in.*
15 gal.	5.8	1.5	5.0	1.1
30 gal.	6.6	1.9	6.6	1.0

Tilt is Associate Professor and Shumack is Department Head and Professor of Horticulture; Olive is Superintendent of the Ornamental Horticulture Substation.

Effects of Water Reservoirs on Growth of Container-Grown Pecan and Pear Trees

Ken M. Tilt, William D. Goff, Ronald L. Shumack, and John W. Olive

Despite research on efficiency of water use for container-grown plants, nursery practices for scheduling irrigation to container-grown woody ornamentals is often imprecise and subjective. The nursery industry is under pressure and is cooperating to make sure its management practices do not adversely affect the environment.

Commonly, nursery producers will examine the moisture in the top inch of medium; if it is dry, they apply sufficient irrigation to thoroughly rewet the medium. This system can result in fluctuating levels of excessive and deficient moisture. Excessive moisture results in inadequate root aeration and can contribute to increased incidence of root-rot diseases. Deficient moisture can also stress plants and result in disease and loss of growth. Improved water management is necessary not only for plant growth but also to reduce the impact of excessive water runoff.

One possible way to improve water management for container trees is to adapt the principles of subirrigation to container production. In subirrigation, a water table is maintained at a certain depth beneath the soil surface. Capillary action ensures sufficient water is readily available to plant roots. Roots also move down to the water table. An AAES study examined the effect of growing pecan (*Carya illinoensis* Melrose) and pear (*Pyrus calleryana* Bradford) trees in containers with a water-holding reservoir at the container base.

Results of the study show equal or better tree growth can be realized through subirrigation or water reservoirs. Data suggest that improved growth is related to continuous root access to water. If these methods are economically feasible to implement, then an opportunity exists for improving profits while acting as responsible role models in preserving natural resources.

METHODS

Thirty-six, three-gallon Melrose pecan trees and 36 field-grown Bradford pear trees were selected for uniformity in March 1991 to be used in the experiment. The trees were subjected to two treatments plus a control: raised holes, subirrigation, and traditional containers. The raised hole (EFC) treatment had trees grown in 20-gallon containers, but with the drainage holes located 2.5 inches from the container bottom (distance measured from bottom of container to bottom of the drainage holes). The drainage holes were the same in size as in the standard containers and distributed evenly around the container. Spot-spitter irrigation was used as described for the control treatment. This system was developed and patented by Robert Rigsby of Rigsby Nursery, Ft. Myers, Fla. The containers are sold under the name Environmentally Friendly Containers™ (EFC).

The subirrigation treatment was provided by constructing water-holding frames from wood lined with plastic, and placing the containers in the frames. No surface irrigation was provided for these containers, except for rainfall. The frame dimensions were 3x3 feet and 2.5 inches deep. Control treatment trees were grown in 20-gallon traditional polyethylene containers with four one-inch drainage holes at the bottom of the container. Irrigation was provided by two spot-spitter emitters. The emitters used a semi-circular spray pattern sufficient to wet the entire surface of the medium. Plants were irrigated when the upper one inch of medium was dry.

The frames were filled with water to the full depth, and were refilled whenever the level of water in the frame dropped to half-full. Water entered the container through the drainage holes in the bottom, and saturated the medium in the lower part of the container.

Trees were transplanted in March 1991 into the three containers containing milled pine bark:sand (6:1) medium amended with 11 pounds Osmocote 18-6-12, 1.5 pounds Micromax micronutrients, and six pounds dolomitic limestone per cubic yard. Supplemental Osmocote 18-6-12 was topdressed at the same rate in April 1992.

Plant height and trunk caliper were measured at transplanting, and on Aug. 23, 1991, and Nov. 18, 1992. Of the 12 trees in each treatment, four were randomly selected for shoot fresh weight determination.

RESULTS

Shoot growth measurements of pear trees were significantly greater when trees were grown in EFC (raised hole) containers, although plant height was not affected by container treatment. Subirrigation and control treatments were similar for all variables measured with both tree species. With pecan trees, the EFC containers had greater caliper and shoot fresh weight than the control treatments (see table).

When plants were removed from the containers and root systems were examined, it was obvious that roots were absent in the poorly-aerated layer where water stood at the bottom of the containers with water reservoirs. The absence of roots in the lower layer of medium in the treatments with water reservoirs contrasted sharply with the proliferation of roots at the bottom of containers in the treatments with free drainage. No pathological study of root microorganisms was done. If pathogenic fungi such as Phytophthora were present in the containers with water reservoirs, their influence was not detrimental to top growth or was overridden by other favorable conditions. There were no difference in dry weight of roots among the three container treatments. Plants in containers with reservoirs compensated for loss of root growth in the bottom of the containers by increasing root mass in the tops of the containers. See Photos 11-13 on Page 19.

Effect of Irrigation Treatments on Growth of Pecan and Pear Trees[1]

Treatment	Caliper	Caliper increase	Height	Shoot weight
	in.	*pct.*	*ft.*	*lb.*
Pear				
Raised holes	1.8	305	8.2	9.5
Subirrigation	1.5	246	7.9	6.2
Control	1.4	219	7.9	5.5
Pecan				
Raised holes	1.7	138	7.9	4.2
Subirrigation	1.5	116	8.2	3.5
Control	1.3	91	7.2	2.4

[1]Percent increase is from treatment initiation at repotting in March 1991 until Nov. 18, 1992, when growth measurements were made. Measurements were made after two seasons of growth.

Tilt and Goff are Associate Professors and Shumack is Department Head and Professor of Horticulture; Olive is Superintendent of the Ornamental Horticulture Substation.

Growth of Container-Grown Trees Transplanted from the Field or Grow-Bags

Kenneth M. Tilt, Charles H. Gilliam, John W. Olive, and Emmett L. Carden

Root Control Bags, produced by Root Control of Oklahoma City, can help nursery producers save more of a tree's roots at harvest, but consumers prefer traditional plastic containers over these "grow-bags." Some producers transplant trees from grow-bags to containers to provide a more desirable product, but limited data are available on how such transplants affect the trees.

With traditional field production, 92 to 98% of the root system is reportedly lost when plants are harvested. Reports indicate that more roots are harvested from a grow-bag. The grow-bag system constricts the root tips as they penetrate through the small holes in the fabric, resulting in root pruning and root branching. As with a container, grow-bags confine a large portion of the roots within a limited space. This positive aspect of grow-bags for some trees facilitates year-round harvesting. Landscaping has become a year-round business with demand for plant materials that will tolerate transplanting during extremely stressful conditions.

AAES research compared tree growth of traditional field production and grow-bag systems in the sandy soils of south Alabama where traditional field-harvesting methods are more difficult. Performance of trees transplanted from the two field production systems to 20-gallon containers in March (dormant trees) and July (actively growing trees) also were compared.

The study indicated that grow-bags offer an alternative to producing more difficult-to-transplant species, especially in sandy soils where traditional field production is not practiced. Advan-

(Continued after photo section)

Photo 1. Reduction in height of Kees Nelis tulip with an ancymidol drench or increasing rates of paclobutrazol in an impregnated spike. See article on Page 2.

Photo 2. Brazilian verbena grown under long days, left, or short days 92 days after sowing. See article on Page 3.

Photo 3. Simulated consumer environment for the postproduction evaluation of poinsettias. See article on Page 4.

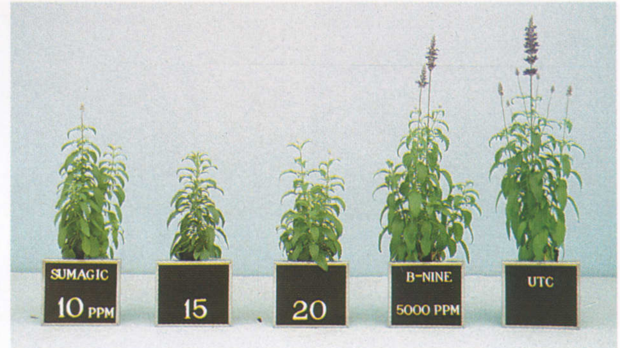
Photo 4. Pansies in the All-America Display Garden at the E.V. Smith Research Center in Tallassee. See article on Page 4 for more information about Photos 4-7.

Photo 5. Superior performance of pansy Melody White Blotch in foreground, compared to Roc White in background.

Photo 6. Flowering kale Feather White had minimal cold damage in February 1992, compared to the other white varieties.

Photo 7. Superior performance of snapdragon Floral Showers Scarlet in March 1992; most Floral Carpet Red (background) died in early November.

Photo 8. Coreopsis was produced by the greatest number of perennial plant producers who responded to a national survey. See article on Page 6.



Photos 9, 10. Above left to right, salvia treated with 10, 15, and 20 ppm Sumagic; 5,000 ppm B-Nine; and an untreated control. Below left to right, marigold treated with 10, 15, and 20 ppm Sumagic; 5,000 ppm B-Nine; and an untreated control. See article on Page 8.

Photo 11. Subirrigation of pear and pecan trees. See article on Page 16.

Photo 12. Raised-hole container, sold under the name Environmentally Friendly Container (EFC). See article on Page 16.

Photo 13. Bradford pear trees in, left to right, traditional drip, raised hole (EFC), and pan subirrigation. See article on Page 16.

Photo 14. All field-dug live oak, left, died when transplanted in July, compared to bag-transplanted trees (right) which survived and grew. See article on Page 18.


Photos 15, 16. In the photo at left are Bradford pears treated with 150, 300, and 450 ppm BA and an untreated control (left to right). In the photo at right are Bradford pears treated with 300, 600, and 1,200 ppm Promalin, and an untreated control (left to right). See article on Page 22.

Photo 17. Peppermint Cooler vinca growing on an ebb and flow bench; closest row inoculated with *Phytophthora parasitica*. See article on Page 30.

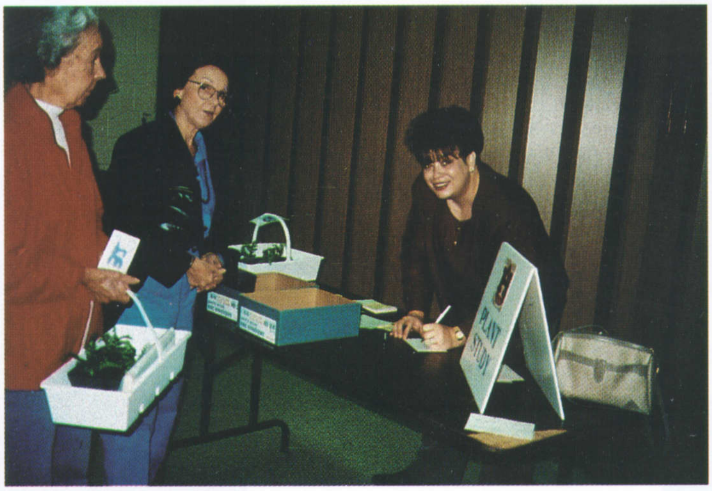


Photo 18. Consumers participating in the potting mix evaluation select their plants at the beginning of a study of a new potting media that contains composted chicken litter. See article on Page 40.

tages gained from using the grow-bags vary with the species grown. One major limitation to the system is that no standards or specifications for grow-bags have been developed by the American Association of Nurserymen for landscape architects and designers to use in their plans. This failing hinders the market potential of grow-bags.

METHODS

Liners of *Lagerstroemia* x Natchez (Natchez crape myrtle), *Pistacia chinensis* (Chinese pistachio), and *Quercus virginiana* (live oak) were transplanted on March 24, 1988, into the 20-gallon containers. Live oak was selected because of its reputation for being difficult to transplant, while crape myrtle is a tree that traditionally transplants easily.

Tree liners were planted in a fine sandy loam soil at the Gulf Coast Substation in Fairhope. Crape myrtles and live oaks were planted in either 18-inch diameter grow-bags, backfilled with native soil or by direct planting in the field. Holes were dug using a 20-inch auger. Each tree was topdressed with one tablespoon (18 grams) of Osmocote 17-7-12 (Grace-Sierra Horticultural Products Inc., Milpitas, Calif.) at planting and again on April 13, 1989. On July 21, 1988, and May 12, 1989, one tablespoon of 12-6-6 was applied. Plants were watered every 28 hours for two hours with drip irrigation emitters supplying two gallons of water at each irrigation. Irrigation was turned off during rainy days.

A three-foot-wide weed-free strip was maintained around the trees using metolachlor (Dual, Ciba-Geigy, Greensboro, N.C.) and simazine (Princep, Ciba-Geigy, Greensboro, N.C.) at labeled rates in April of each year. Spot-spraying as needed with glyphosate (Round-up, Monsanto, St Louis, Mo.) and hand weeding around the trunks of trees completed the weed control program. Plants were spaced six feet within rows and 10 feet between rows.

Height and caliper were measured on Oct. 17, 1988, and March 1, 1990. Calipers for crape myrtle were measured and reported by taking the average of the largest three trunks of the multi-stemmed trees. On March 17, 1990, one tree from each block and treatment (24 trees, 12 of each species) was selected at random and harvested. A 20-inch diameter root ball was hand-dug for 5.8-foot crape myrtles and 1.4-inch caliper live oaks. Grow-bag-grown trees were removed from the field in their bags. The 24 trees were cut at ground level and fresh top weight was determined. Root balls were washed, roots were severed from the original root ball, and fresh root weight was recorded.

Two additional trees from each block and treatment (24 trees of each species) were hand-dug and transplanted to 20-gallon containers filled with a 100% pine bark medium (grow-bags were removed from trees). Trees were fertilized by topdressing with 5.3 ounces per pot of Osmocote 17-7-12 plus minor nutrients. Trees were placed under 50% shade, syringed three to four times a day for one week, and then moved to the production area under overhead irrigation.

On July 11, 1990, four months after transplanting, containerized trees were measured for caliper, height, and fresh weight. Twelve root balls of each species were slipped from the containers and the percent of the root ball surface covered with roots was evaluated. Root balls were given ratings from 1 to 5 (see tables). Oak roots were washed, and root growth extending into the pine bark from the severed roots of the original root ball were cut and weighed. Crape myrtle root systems were too dense to separate the container medium from the roots.

On July 11, the remaining 24 trees (12 of each species) were measured, dug, and transplanted to 20-gallon containers using the same procedures described earlier. This step was used to evaluate transplanting success during stressful conditions. The July-planted containerized trees were harvested Oct. 3, 1990, and fresh weight and root ratings were recorded.

RESULTS

Growth was similar for both tree species grown in both tree production systems (see tables on next page). Exceptions were 1990 live oak height and 1988 live oak caliper where trees (60 measured) in traditional field production were seven inches taller than trees grown in grow-bags and 0.04 inch larger in caliper, respectively. However, this difference was not reflected in the other growth variables, and the difference was very small. This agrees with most other research on grow-bags.

Neither caliper nor top weight of crape myrtles or live oaks differed as a result of transplanting the dormant trees to containers in March, 1990. However, live oaks and crape myrtles produced without bags, dug by hand, and grown in containers for nine months were 16.5 and 6.7 inches taller, respectively, than trees grown in grow-bags. Live oak root regeneration expressed by the root rating was enhanced when plants were grown in grow-bags.

Growth was similar for March-transplanted/July-harvested and July-transplanted/October-harvested crape myrtles when comparing grow-bag and traditional field production. Live oaks produced by traditional field production and transplanted to the 20-gallon containers in July died. Live oaks grown in grow-bags survived and continued to grow until the October harvest. Additional root growth was exhibited by trees grown in grow-bags which were March-transplanted/July-harvested (root rating 3.5) over traditional field-produced trees harvested and transplanted on the same dates (root rating 2.6). This result may help explain the survival of July-transplanted live oaks from grow-bags in October and the death of traditional field-produced trees.

A niche has been established in the industry for the production and use of plants produced in grow-bags. Grow-bags meet a need for trees by landscapers in mid-summer. As evidenced by the results from transplanting crape myrtles, all trees may not benefit from the grow-bag system. The system is a hybrid between traditional field production and container production and requires developing cultural and marketing practices that are significantly different from the other two systems. This research and that of others shows that many plants can be grown as well in grow-bags as by traditional field production methods. Live oaks and possibly other difficult-to-transplant trees can have increased success in the landscape when produced in grow-bags, especially where sandy soil conditions prevail. See Photo 14 on Page 20.

Tilt is Associate Professor and Gilliam is Professor of Horticulture; Olive and Carden are Superintendents of Ornamental Horticulture and Gulf Coast Substations, respectively.

Table 1. Effects of Production System on Crape Myrtle Harvested from the Field and Transplanted to Containers

Field

	Caliper[1]		Height[1]		Top fresh weight[1]	Root weight[1]
	1988	1990	1988	1990	1990	1990
	mm	*mm*	*cm*	*cm*	*kg*	*g*
Field	-[2]	23	105	175	2.4	276
Grow-Bag	-	28	105	176	2.6	353

Container

	Caliper[1]		Height[1]		Top fresh weight[1]		Root Rating[3]	
	July	Oct.	July	Oct.	July	Oct.	July	Oct.
	mm	*mm*	*cm*	*cm*	*kg*	*kg*		
Field	29	32	206	193	3.9	4.7	4.3	4.1
Grow-Bag	29	31	189	178	4.1	3.3	4.1	4.0

Table 2. Effects of Production System on Live Oak Harvested from the Field and Transplanted to Containers

Field

	Caliper[1]		Height[1]		Top fresh weight[1]	Root weight[1]
	1988	1990	1988	1990	1990	1990
	mm	*mm*	*cm*	*cm*	*kg*	*g*
Field	16	36	132	211	2.2	262
Grow-Bag	15	36	127	193	2.0	260

Container

	Caliper[1]		Height[1]		Top fresh weight[1]		Root Rating[3]	
	July	Oct.	July	Oct.	July	Oct.	July	Oct.
	mm	*mm*	*cm*	*cm*	*kg*	*kg*		
Field	47	-[2]	252	-	3.1	-	2.6	-
Grow-Bag	43	44	210	211	3.3	2.5	3.5	2.5

[1]One millimeter (mm) is .0394 inch. One centimeter (cm) is .3937 inch. One kilogram (kg) is 1,000 grams (g). One gram is .035 ounce.
[2]Data not available.
[3]Trees were transplanted to 20-gallon containers from the field in March and July, 1990 and harvested in July and October. Root rating: 1= No roots on outside of container rootball, 5= matted (24 trees each species, each transplant date).

Increasing Crotch Angles and Lateral Shoot Numbers of Bradford Pear with BA or Promalin

Gary J. Keever, William J. Foster, and John W. Olive

Bradford pear, a widely planted ornamental tree, is characterized by an oval-to-pyramidal form and dense, ascending branches. With age, many symmetrical specimens split, presumably due to narrow, bark-embedded crotches that are structurally weak compared to crotches with connective wood. Pruning during production in the nursery to remove narrow crotches and increase branch spacing has met with limited success in alleviating splitting.

Growth regulators, such as the cytokinin benzyladenine (BA) used alone or in combination with gibberellins$_{4+7}$ (Promalin), have improved plant structure of several fruit tree species by stimulating branching and increasing the crotch angles of primary branches. An AAES study was conducted to determine the effects of foliar-applied BA and Promalin on branching and crotch angles of Bradford pear.

Results support previous research findings with fruit tree species, where increased lateral shoot development and crotch angles and reduced lateral shoot length resulted from BA or Promalin treatment. This work indicates that BA and Promalin can increase crotch angles of Bradford pear, which potentially could lessen the splitting of older trees. Increased lateral development may require selective pruning to avoid crowding of branches as trees mature.

METHODS

Liners (nine inches tall) of Bradford pear were transplanted on March 22, 1988, into three-gallon pots of 3:1 pine bark:peat moss (by volume) amended with six pounds dolomitic limestone, two pounds gypsum, 1.5 pounds Micromax, and 14 pounds Osmocote 17-7-12 per cubic yard. Plants were placed outdoors in full sun in Mobile and maintained under overhead irrigation. On Sept. 20, 1988, plants were pruned to 51 inches in height, and leaves were left on only the uppermost 10 nodes. The following foliar spray treatments were applied to the upper 12 inches of shoots: 150-450 milligrams of BA per liter or 300-900 milligrams of Promalin per liter with Buffer X surfactant at 0.2% by volume. An untreated control was included for comparisons. Plant height, lateral shoot numbers (greater than 0.8 inch in length) and lengths, and crotch angles were recorded on Nov. 18, 1988. The experiment was repeated in 1989 with the following changes: liners were transplanted on April 20, treatments were applied Sept. 12, only the upper three inches of terminal shoots were removed, BA at 600 milligrams per liter and Promalin at 1,200 milligrams per liter were included as additional treatments, and data were collected in December 1989.

RESULTS

Lateral shoot numbers and crotch angles were increased in both years with increasing concentrations of BA or Promalin (see table). The increase in shoot number was 65-440% (1988) and 43-174% (1989) with BA concentrations greater than or equal to 300 milligrams per liter, and 240-490% (1988) and 43-239% (1989) with Promalin concentrations greater than or equal to 300 milligrams per liter. Almost all new lateral shoots developed from the 12-inch section of shoot treated with BA or Promalin. Crotch angles were increased 26-30% (1988) and 10-26% (1989) with BA and 26-34% (1988) and 6-38% (1989) with Promalin. Promalin resulted in greater shoot numbers (9.6 versus 5.3, 1988; 4.9 versus 3.9, 1989) and crotch angles (58° versus 52°, 1988) than did BA. Mean lateral shoot lengths decreased linearly in 1989 with increasing concentrations of the growth regulators, from 9-23% with BA and 15-57% with Promalin. The reduction was most evident for BA and Promalin at concentrations greater than or equal to 450 milligrams per liter and 900 milligrams per liter, respectively. Mean shoot lengths of BA- and Promalin-treated trees were 3.6 inches and 3.1 inches, respectively, while lateral shoot length of control plants averaged 4.4 inches. Plant heights were not affected by any treatments. (See Photos 15-16, Page 20)

Effects of BA and Promalin on Primary Shoot Development of Bradford Pear Trees

Treatment[1]	Lateral shoots[2]		Crotch angle		Shoot length[3]
	1988	1989	1988	1989	1989
mg/l	*no.*	*no.*			*cm*
Control					
0	2.0	2.3	45°	46°	11.1
BA					
150	1.8	2.3	42°	51°	10.1
300	3.3	3.3	57°	50°	10.7
450	10.8	3.5	58°	59°	6.9
600	-	6.3	-	58°	8.6
Promalin					
300	6.8	3.3	57°	49°	9.4
600	10.3	2.8	58°	49°	10.8
900	11.8	6.0	60°	61°	6.1
1,200	-	7.8	-	63°	4.8

[1]One milligram (mg) is .001 gram; one gram is .035 ounce. One liter (l) is 1.0567 liquid quarts.
[2]Shoots greater than 0.8 inch in length were counted.
[3]One centimeter (cm) is .3937 inch.

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

Response of Established Landscape Plants to Uniconazole

Gary J. Keever

Much of the millions of dollars spent each year on landscape maintenance and tree-trimming under power lines could be saved through the use of the right plant growth regulator. Many of these compounds have been evaluated for retardation of woody plant growth, but most are not economical or cause undesirable side effects.

Uniconazole (Sumagic), a triazole-based growth regulator, has shown promise for being very persistent in retarding growth without harming the plant. It is labeled for use on bedding plants and several potted crops, but not on woody landscape plants. Research indicates that uniconazole is effective in suppressing growth of container-grown woody landscape plants, but its influence on field-grown landscape plants had not been studied.

Another concern was that the previous studies with container-grown woody ornamentals were done with "angiosperms," such as maple, oak, and holly. However, growth retardants are generally less effective or harmful to "gymnosperms," such as pines, cedar, and juniper.

AAES research was conducted to determine the influence of soil- and foliar-applied uniconazole on two established, field-grown woody landscape species under simulated low maintenance landscape conditions. Both species, *Elaeagnus pungens* Fruitlandii (thorny elaeagnus), an angiosperm; and X *Cupressocyparis leylandii* (leyland cypress), a gymnosperm, exhibit very fast growth rates. Preliminary tests were performed to establish approximate rates of uniconazole for gymnosperms.

Drench-applied uniconazole was shown to be effective in retarding growth of in-ground thorny elaeagnus for at least two growing seasons under landscape conditions. This material could offer those involved in landscape maintenance an additional tool for managing this vigorous species. Regular, but less pruning will still be required to remove rank shoots. Foliar spraying of uniconazole to established thorny elaeagnus was ineffective in retarding shoot growth. Uniconazole was effective in retarding growth of young, container-grown leyland cypress, but it was not effective when applied as either a foliar spray or drench to established plants under landscape conditions.

METHODS

To establish rates of uniconazole for gymnosperms, uniform liners of leyland cypress in four-inch containers were potted into No. 1 gallon containers using a pine bark:sand (7:1, by volume) growth medium amended per cubic yard with five pounds dolomitic limestone, 14 pounds Osmocote 17-7-12, and 1.5 pounds Micromax in Jan. 1989. Plants were grown in a heated (minimum 68°F) double polyethylene greenhouse. On March 31, 1989, uniconazole was applied as a foliar spray or drench. Single foliar sprays of 10-500 milligrams per liter was applied using a hand-held sprayer to uniformly wet foliage and stems. Single medium drenches of 1-15 milligrams of active ingredient per pot was applied in a volume of one ounce.

Growth indices (see table footnotes for definition) measured six weeks later were inversely proportional to uniconazole rates, regardless of application method. Growth indices of plants sprayed with the 200 or 500 milligrams per liter rate of uniconazole were 18% and 37% smaller, respectively, than those of control plants. Reduction in growth indices with drench application ranged from 7% with the five-milligram drench treatment to 48% with the 15-milligram drench treatment. Based on these results, rates higher than those that suppressed shoot growth were selected for the in-ground experiment to test if older, well-established landscape plants would be less responsive to uniconazole.

The experimental site for the field test consisted of a Marvyn loamy sand soil of pH 5.5. Based on soil test recommendations, dolomitic limestone was broadcast over the planting area at 2,000 pounds per acre. The area was subsoiled to an 18-inch depth in the rows, and planting holes were cored to 24 inches with a 24-inch auger. Uniform No. 1 gallon plants of thorny elaeagnus and leyland cypress were planted on Dec. 4, 1988. Plants were spaced four feet apart within rows, and rows were six feet apart. Plants were pruned for shape on May 3, 1989, and for uniformity (24x24 inches) on April 12, 1990. Osmocote 17-7-12 at one tablespoon per plant was topdressed around the base of each plant on May 18, 1989, and April 16, 1990. Area between plants was maintained by periodic mowing and the use of glyphosate (Roundup). No supplemental irrigation was provided.

On April 12, 1990, the following uniconazole treatments were applied to both species: single drench applications of 15-45 milligrams of active ingredient in 17 ounces of distilled water applied around the base of each plant; single foliar sprays of 500-1,500 milligrams per liter solution applied to uniformly wet foliage and stems; and an untreated control. Spray treatments were applied using a CO_2 sprayer with a No. 3 conical head nozzle. Tank pressure was 20 pounds per square inch, and about six ounces of solution were applied to each plant. Climatic conditions when treatments were applied were clear, 55°F, and 76% relative humidity.

Growth indices were measured on July 18, 1990; Dec. 6, 1990; and Dec. 10, 1991 (leyland cypress only). On Dec. 18, 1991, half of the thorny elaeagnus in each treatment were cut at ground level, chipped using a portable shredder, and placed in a 158°F drying oven for 21 days before being weighed. Shoot dry weights of leyland cypress were not determined because plants appeared uniform in size and density.

RESULTS

Growth indices of elaeagnus were not affected by uniconazole rate when measured in July 1990, although there was a slight downward trend with increasing drench rates (see the table). Mean growth indices of drench-treated plants (90.0) were significantly less than those of sprayed (102.5) or untreated plants (97.7). By December 1990, growth indices were similar among plants treated by the different application methods.

Shoot growth of thorny elaeagnus plants was relatively uniform during the two months following pruning. Plants developed vigorous, rank shoots during the latter part of the 1990 growing season and the entire 1991 growing season that made growth indices a poor indicator of vegetative growth after mid-summer 1990, hence shoot dry weights were determined in December 1991. Shoot dry weight of thorny elaeagnus decreased with increasing rates of drench-applied uniconazole. Weight of plants receiving 15, 30, or 45 milligrams of active ingredient per plant were 16, 37, and 61%, respectively, less than those of control plants. Drench application resulted in significantly lower mean shoot dry weight than spray application (six pounds versus 9.2 pounds) or than no treatment (9.7 pounds). Weights were not affected by increasing rates of foliar-applied uniconazole. Growth indices of leyland cypress were not influenced by application method or rate on any of the sampling dates. All plants were densely pyramidal in form and uniform in appearance.

No phytotoxicity or foliar color differences were observed on plants of thorny elaeagnus or leyland cypress in any treatment during the experiment. Flowering of elaeagnus in fall 1990 appeared heavier on plants receiving a drench application of uniconazole compared to those sprayed, and heavier on plants sprayed with 1,500 milligrams per liter than on those sprayed with a lower rate or not treated. No quantitative measurements of flowering were made.

Effectiveness of uniconazole in controlling vegetative growth of elaeagnus was greater with drench application than with foliar application. This is likely due to differences in root and foliar uptake of uniconazole or differences in the compound's ability to be moved in different parts of the plant.

Shoot growth of leyland cypress, a gymnosperm, was not affected by uniconazole applied as either a spray or a drench. Shoot dry weight of thorny elaeagnus, an angiosperm, was reduced as much as 61% with a single drench application.

In a short-term test with recently-potted liners of leyland cypress, plants were as much as 37% or 48% smaller than control plants when treated with a foliar spray or drench application, respectively, of lower concentration than that used in the field test. Differences in effectiveness may relate to plant age, growing environment, or both. In other research, young gymnosperm seedlings responded to drench application of several growth retardants, while older plants (three to nine years old) were not affected by soil drench or stem injection of the growth regulator. Plants in this field test were well-established, having been planted 16 months prior to treatment. Soil-applied triazole retardants are relatively immobile and are most efficiently taken up by plants when both roots and inhibitor are localized in the same area. Essentially the entire root systems of container-grown leyland cypress were exposed to uniconazole, while a relatively smaller portion of the root systems of field-grown plants were treated.

Response of Thorny Elaeagnus to Drench or Foliar Applied Uniconazole (Sumagic)

Treatment	Growth index[1,2]		Shoot dry wt.[3]
	7/18/90	12/6/90	
	cm	*cm*	*kg*
Drench[4]			
15	92.3	150.6	3.68
30	93.2	174.2	2.76
45	87.2	154.0	1.71
Foliar[5]			
500	98.1	153.6	4.32
1,000	106.8	158.0	4.08
1,500	102.5	153.2	4.17
Control			
0	97.7	151.3	4.38

[1]Growth index = (height + $width_1$ + $width_2$)/3. $Width_1$ was at the widest point, and $width_2$ was perpendicular to $width_1$.
[2]One centimeter (cm) is .3937 inch.
[3]One kilogram (kg) equals 2.205 pounds. Weight was measured on Dec. 18, 1991.
[4]Sumagic measured in milligrams of active ingredient per plant. One milligram is .001 gram; one gram is .035 ounce.
[5]Sumagic measured in parts per million.

Keever is Professor of Horticulture.

Controlled Release Fertilizers Influence Container-Grown Azaleas

D. Joseph Eakes, John W. Olive, and Patricia R. Knight

Resin-coated controlled release fertilizers (CRFs) are generally formulated to operate in temperatures much lower than those actually measured in the South during summer. Higher temperatures hasten the release of nutrients with possible negative consequences for plants.

Release of nutrients from these materials is controlled by the resin coating thickness, medium moisture content, and most importantly, medium temperature. Manufacturers generally document nutrient release characteristics for their CRF products at temperatures ranging from 68 to 77°F. However, container temperatures often exceed 95°F for during the summer. An AAES study compared 12- to 14-month CRFs at four rates on growth of three azalea species.

Greatest shoot dry weights for the three species occurred with the highest N application rate, three pounds of N per cubic yard, regardless of CRF product applied. Coral Bells azalea was the only species influenced by CRF product 360 days after treatment. Greatest shoot dry weights occurred for the Nutricote- and Osmocote-treated plants.

METHODS

Uniform liners of *Rhododendron obtusum* Coral Bells (kurume type), *R. indicum* Formosa (southern indian type), and *R. eriocarpum* Pink Gumpo (Satsuki type) were potted May 2, 1990, in a 3:1 pine bark:peat moss medium in trade gallon containers. Fertilizer treatments were Osmocote 17-7-12, Sierra 16-6-10, High-N 24-4-7, Sierrablen 17-7-10, and Nutricote 16-10-10 (Type 360) preplant incorporated from 1.5 to three pounds of nitrogen (N) per cubic yard. All media were amended with six pounds of dolomitic limestone, two pounds of gypsum, and 1.5 pounds of Micromax per cubic yard, with the exception of the Sierra 16-6-10 medium where no Micromax was added.

Medium leachates were collected at 30-day intervals up to 360 days after treatment using the Va. Tech. Pour-through Extraction Procedure to determine medium solution electrical conductivity (EC). On Jan. 4, 1990, half the plants were harvested to determine shoot dry weight. The remaining plants were harvested to determine shoot dry weight on May 6, 1991.

RESULTS

Shoot dry weights increased as N rate increased for the three azalea species in 1990 and 1991, regardless of CRF applied. Greatest shoot dry weights for Coral Bells azalea were produced by the Osmocote and Sierrablen treatments during the 1990 growing season (see table). Following the 1991 spring flush of growth, Nutricote plants had the greatest shoot dry weights compared to the other CRF treatments, while shoot dry weights for Sierrablen treated plants were the least.

Formosa azalea shoot dry weight was greatest for Sierrablen-treated plants in 1990, regardless of application rate. Osmocote-, High-N-, and Sierrablen-treated plants were similar in size to Sierrablen-treated plants, while Nutricote-treated plants had the smallest shoot dry weight when compared to other CRF treatments. Following the 1991 spring growth flush, there was no difference in shoot dry weight due to CRF for Formosa azalea.

Greatest shoot dry weight for Pink Gumpo azalea in 1990 occurred for Osmocote- and High-N-treated plants, regardless of fertilizer rate. As with Formosa azalea following the 1991 spring flush of growth, CRF product had no influence on shoot dry weight for Pink Gumpo azalea.

Electrical conductivity is a measure of the quantity of fertilizer salts in the soil; as EC drops, fertilizer quantity declines. Thirty days after treatment, Nutricote had the greatest medium solution EC level with a mean EC of 0.60 decisiemens (dS) per meter. The lowest EC levels were observed for Osmocote and Sierrablen with EC levels of 0.24 and 0.21 dS per meter, respectively. From 30 to 60 days after treatment, medium solution EC increased for all CRF treatments with the exception of Nutricote. Medium solution EC was greatest for the High-N and Sierra products 60 days after treatment, while Nutricote had the lowest EC; a sharp decrease from 30 days after treatment. Medium solution EC levels increased from 60 to 90 days after treatment for the Osmocote and Sierra products, while Nutricote, High-N, and Sierrablen all had decreases in EC. Medium solution EC declined for all CRFs from 90 through 360 days after treatment.

Medium solution EC levels began to drop sharply 90 days after treatment for all treatments. Medium solution EC increased as application rate increased. Following observations 90 days after treatment, EC declined for all fertilizer rates. By 150 days after treatment, mean medium solution EC across all treatments and rates was 0.14 dS per meter and continued to decline to 360 days after treatment.

Eakes is Assistant Professor and Knight is Graduate Research Assistant of Horticulture; Olive is Superintendent of the Ornamental Horticulture Substation.

Shoot Dry Weight for Three Azalea Species in Response to 12- and 14-Month Controlled Release Fertilizers and Rate of Application

Treatment	Shoot dry weight[1]					
	1990			1991		
	Coral Bells	Formosa	Pink Gumpo	Coral Bells	Formosa	Pink Gumpo
	g	*g*	*g*	*g*	*g*	*g*
Fertilizer						
Osmocote	42.6	70.5	36.7	48.1	80.5	58.2
Sierra	34.6	72.8	33.3	41.4	80.8	52.9
High-N	35.2	68.1	36.9	45.8	77.6	54.9
Sierrablen	38.3	68.7	34.7	44.2	78.9	49.8
Nutricote	36.2	64.9	31.5	50.7	77.2	53.3
Rate[2]						
1.5	30.5	54.3	29.9	38.1	60.2	42.5
2.0	36.8	62.3	32.3	43.7	76.3	50.7
2.5	37.4	75.3	37.9	49.5	88.2	58.3
3.0	44.9	84.1	38.3	52.9	91.4	63.8

[1]One gram is .035 ounce.

[2]The rates of application are measured in pounds of N per cubic yard.

CRF Type, Rate, and Placement Influence Growth of Container-Grown Ornamentals

D. Joseph Eakes, John W. Olive, and Charles H. Gilliam

Controlled release fertilizers (CRFs) are an integral part of the fertilization programs of many container-grown nurseries. Plant growth and nutrient release characteristics vary depending on method of fertilizer application, CRF product, fertilizer rate, and plant species grown.

Effects of applying CRFs at three nitrogen (N) rates on the growth of juniper and azalea were assessed in an AAES study. Research showed that CRF type had little effect on the growth of juniper, but best results were obtained when CRF was preplant incorporated at 2.5 pounds of N per cubic yard. However, dibble fertilizer placement of more than 1.5 pounds appeared to injure roots, reducing growth of juniper. In contrast, dibble and topdress applied Osmocote and Nutricote, at the rate of 2.5 pounds per cubic yard, produced the greatest azalea shoot dry weight. CRF type and rate did not affect azalea root ratings.

METHODS

Uniform liners of *Juniperus conferta* Blue Pacific (juniper) and *Rhododendron* x Coral Bells (azalea) were potted May 16 in trade gallon containers of a 3:1 pine bark:peat moss medium. The medium was amended with six pounds of dolomitic limestone, two pounds of gypsum, and 1.5 pounds of Micromax per cubic yard. Fertilizer treatments were Osmocote 18-6-12, Nutricote 16-10-10 (Type 270), and High-N 24-4-8. All CRFs are eight- to nine-month formulations. Application methods were preplant incorporated, dibbled, or topdressed at 1.5, 2.0, or 2.5 pounds of N per cubic yard. In November, juniper and azalea shoot dry weights and relative root densities were determined.

RESULTS

Shoot dry weights and root ratings for juniper receiving dibble-applied fertilizer were greatly reduced as N rate increased regardless of the CRF used (Figures 1 and 2). Dibble placement of CRFs at the rate of 1.5 pounds of N per cubic yard produced plants that had 57% and 38% more shoot dry weight than those receiving two and 2.5 pounds of N per cubic yard, respectively. In contrast, when fertilizer was incorporated into the medium or topdressed, shoot dry weights and root ratings of juniper generally increased as N rate increased. Shoot dry weights and root ratings were not influenced by CRF type.

Azaleas that were topdressed or dibbled with CRFs had 31% and 27% greater shoot dry weights than those receiving preplant incorporated fertilizers, respectively (Figure 3). Both Osmocote 18-6-12 and Nutricote 16-10-10 resulted in greater azalea shoot dry weights than plants receiving the High-N 24-4-8 fertilizer. Shoot dry weights of azalea increased as N rate increased for all CRF products and method of application.

Root densities were rated on a scale of 1-5, with 1 = no visible roots and 5 = 100% of the root ball medium-container interface covered with roots. Root ratings of azalea were 3.9 and 3.8 with dibbled and medium incorporated fertilizer placement, respectively (Figure 4). In comparison, plants receiving topdressed fertilizer placement had a mean root rating of only 3.5. Root ratings were not affected by CRF type or rate.

Eakes is Assistant Professor and Gilliam is Professor of Horticulture; Olive is Superintendent of the Ornamental Horticulture Substation.

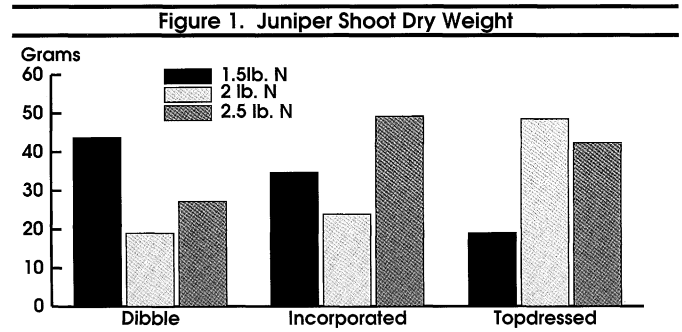


Fig. 1. Shoot dry weight of juniper as influenced by controlled release fertilizer rate and placement.

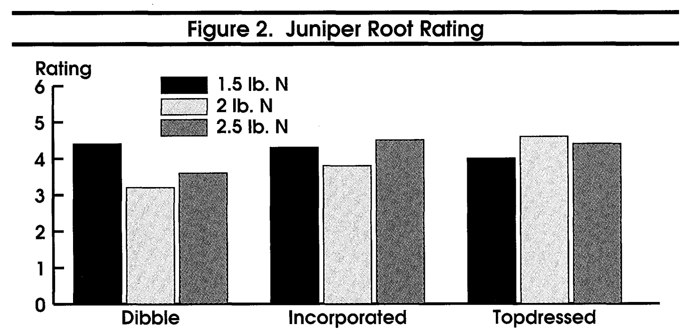


Fig. 2. Root quality rating of juniper as influenced by controlled release fertilizer rate and placement.

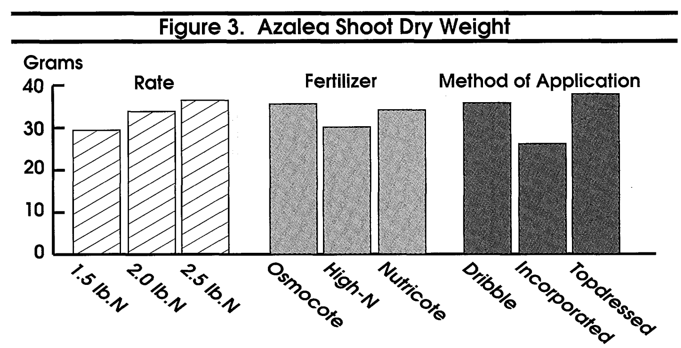


Fig. 3. Shoot dry weight of azalea as influenced by controlled release fertilizer rate, type (Osmocote 18-6-12, Nutricote 16-10-10, or High-N 24-4-8), and placement.

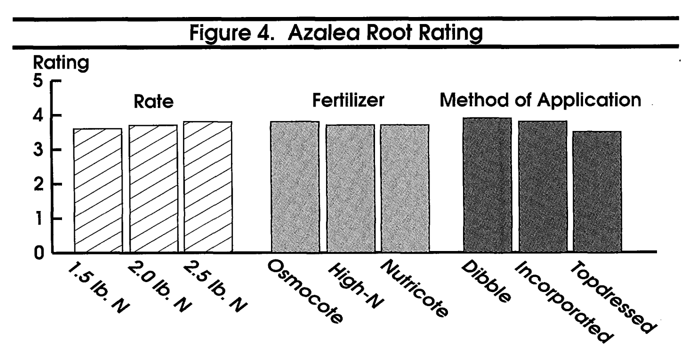


Fig. 4. Root quality rating of azalea as influenced by controlled release fertilizer rate, type (Osmocote 18-6-12, Nutricote 16-10-10, or High-N 24-4-8), and placement.

INSECT, DISEASE, AND WEED CONTROL

Evaluation of Postemergence-Applied Herbicides on Ornamental Grass

Charles H. Gilliam, Gary J. Keever, Donald J. Eakes, and Donna C. Fare

Demand for ornamental grasses in landscaping in on the rise, but competition from annual and perennial grasses can cause problems. Ornamental grasses are tolerant to some postemergence-applied herbicides, though tolerance varies among species. A study was conducted to evaluate the effects of two registered postemergence-applied herbicides, Poast (sethoxydim) and Fusilade (fluazifop), for over-the-top application on ornamental grasses.

Poast and Fusilade have undergone extensive evaluation for use in landscape plantings and are registered for a wide range of landscape plants for the control of annual and perennial grasses. In addition, Poast is registered for selective use in some turf species. Neither Poast nor Fusilade is registered for use on ornamental grasses, and information is lacking on the response of ornamental grass species to these herbicides.

Data from the study show that use of these herbicides will injure ornamental grasses. The extent of injury varies with species and with choice of herbicide. In extreme situations weed pressure may dictate use of a postemergence-applied herbicide. Growers and landscapers should evaluate the tolerance of ornamental grasses on a small scale before adopting widespread use of a particular herbicide. These data indicate that Poast was generally the least injurious to ornamental grasses. Use of Fusilade was injurious to all grasses tested.

METHOD

Liners of four ornamental grasses: dwarf fountain grass (*Pennisetum alopecuroides* Hameln); pampas grass (*Cortaderia selloana*); maiden grass (*Miscanthus sinensis* Gracillimus); and purple maiden grass (*M. sinensis* Purpurescens) were potted into #1 plastic containers on May 23, 1990. The medium was pinebark/sand (6:1, by volume) amended per cubic yard as follows: 14 pounds of Osmocote 18-6-12, five pounds of dolomitic limestone, and 1.5 pounds of Micromax. All plants were grown in full sun and irrigated as needed. Various herbicide treatments were applied on June 19 to all four ornamental grasses (see tables). An untreated weeded control treatment was included with each ornamental grass for comparison. Broadleaf weeds were removed by hand from all herbicide treatments. Herbicides were applied in 20 gallons of water per acre with a backpack CO_2 sprayer using a 8004 nozzle operated at 30 pounds of pressure per square inch. Ambient air temperature was 87°F with 75% relative humidity at the time of application. Grass control data are not presented since the activity of these herbicides is well documented.

In 1991, the study was repeated with the same species to collect additional data, including flower number at the peak of flowering 120 days after treatment for pampas, maiden, and purple maiden, and 60 days after treatment for dwarf fountain grass. Liners were potted in May, with medium and cultural practices similar to the 1990 test. The same treatments used in the first experiment were applied on May 16, 1991 (see tables). Plants were larger in 1991 due to larger liners being planted.

RESULTS

Some injury occurred with both postemergence-applied herbicides on all grass species tested at some point in the two-year evaluation (Table 1). In 1990, pampas grass displayed no difference in plant injury when comparing the unsprayed control plants and plants treated with Poast at the low rate. Injury was generally greater with the higher rates of the two herbicides and with Fusilade compared to Poast. In both years, greater than 50% injury occurred with both Fusilade 2000 rates on all four grasses 30 days after treatment. With Poast, maiden grass (1990) and purple maiden grass (1990 and 1991) had greater than 50% injury at the low rate, while at the higher rate both miscanthus species and dwarf fountain grass had greater than 50% injury 30 days after treatment. Fusilade 2000 caused greater than 50% injury on all four grasses 30 days after treatment when applied at the low rate.

These data concur with other reports that have shown Fusilade causes injury to most grass species. By 60 days after treatment in both years, most plants that survived the herbicide treatments had initiated new growth and exhibited normal growth through the remainder of the growing season.

Although initial growth was delayed or damaged, many of the plants caught up with the untreated control plants before the end of the growing season. These data concur with previous reports of maximum injury occurring four weeks after application. Growth indices of all grasses (both years), except purple maiden grass and maiden grass in 1990, treated with .25 pound per acre of Poast were similar to the untreated control grasses (Table 2). See Table Footnote 6 for a definition of growth index.

Growth indices of all grasses treated with .50 pound per acre of Poast tended to be smaller than the untreated control plants but similar to or larger than growth indices of Fusilade-treated plants. Fusilade 2000 limited growth of all grass species at the lower rate except dwarf fountain in 1991, and the higher rate had lower growth indices with all grasses.

Flowering in three of the four grasses was adversely affected by all postemergence herbicide treatments in 1991 (data not shown). The fourth grass, pampas, did not flower during the 1991 growing season. Poast at the low rate had a limited effect on growth indices and reduced flowering 82% and 61%, respectively, for maiden grass and purple maiden grass.

EDITOR'S NOTE: This paper reports the results of research only. It does not imply registration of a pesticide. Before using any of the products mentioned in this research paper, be certain of their registration by appropriate state and/or federal authorities.

Gilliam is Professor, Keever is Professor, Eakes is Assistant Professor, and Fare is former Senior Research Associate of Horticulture.

Table 1. Injury Caused by Selected Herbicides to Ornamental Grasses 15 and 30 Days After Treatment in 1990 and 1991

Treatment[2]	Pct. visual injury[3]															
	Pampas grass				Dwarf fountain				Maiden grass				Purple maiden			
	1990		1991		1990		1991		1990		1991		1990		1991	
	15	30	15	30	15	30	15	30	15	30	15	30	15	30	15	30
Poast +.25% COC[4] 0.25	10	0	8	26	35	9	46	45	22	71	42	36	61	66	50	63
Poast +.25% COC 0.50	34	34	26	34	53	48	54	56	51	93	59	56	72	81	67	78
Fusilade +.25% X-77[5] 0.25	46	89	50	61	56	76	29	52	30	92	50	61	69	79	50	73
Fusilade +.25% X-77 0.50	69	69	97	31	60	69	94	46	73	41	98	58	81	91	61	86
Weeded check 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2. Effects of Herbicides on Growth Indices of Ornamental Grasses in 1990 and 1991

Treatment[1,2]	Growth indices[6,7]							
	Pampas grass		Dwarf fountain		Maiden grass		Purple maiden	
	1990	1991	1990	1991	1990	1991	1990	1991
	cm	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*
Poast +.25% COC[4] 0.25	85.2	136.8	49.8	100.4	56.0	124.5	34.8	69.6
Poast +.25% COC 0.50	62.9	130.2	38.0	103.4	45.0	115.9	30.2	62.0
Fusilade +.25% X-77[5] 0.25	34.1	112.2	31.5	95.4	46.3	68.4	28.7	64.2
Fusilade +.25% X-77 0.50	24.8	61.2	26.6	50.5	44.7	54.6	23.1	51.4
Weeded check 0	88.1	137.3	53.0	106.3	85.6	115.1	42.3	80.6

[1]Treatments were applied on June 19, 1990, and May 16, 1991. Data were collected 15 and 30 days after treatment.
[2]Rates are measured in pounds of active ingredient per acre.
[3]Visible injury was rated on a scale of 0-100% with 0% = no injury and 100% = dead plant.
[4]COC = crop oil concentrate (Prime Oil).
[5]Ortho X-77, a nonionic surfactant.
[6]Growth index = (height + $width_1$ + $width_2$)/3. $Width_1$ was at the widest point, and $width_2$ was perpendicular to $width_1$. Data were taken 60 days after treatment (July 24) in 1990 and 90 days after treatment in 1991 (Aug. 21).
[7]Growth index is measured in centimeters (cm). One cm is .3937 inch.

Evaluation of Preemergence-Applied Herbicides on Selected Hardy Ferns and Hosta

Daniel M. Lauderdale, Charles H. Gilliam, and John W. Olive

In the past few years, several herbicides have been registered for use in nursery crop production. Some of these new herbicides have been reported to be safer on container-grown crops than some of the standard chemicals used in nursery production. A study was conducted to compare several of the new products with standard herbicides in terms of growth and injury to herbicide-sensitive plants.

Results showed that the newly registered herbicides tested -- including Pennant 5G, Derby 5G, Dimension 0.25G, and Snapshot 2.5TG -- were safe on Albo-marginata and Meta Peka hosta. No significant injury or growth reduction was seen with either plant when treated with these herbicides. However, autumn fern and holly fern exhibited significant injury and suppressed growth when treated with Dimension 0.25G or Snapshot 2.5TG. Of the commonly used preemergence-applied herbicides, Rout 3G, OH-2 3G, and Ronstar 2G caused the most injury and growth inhibition.

These data show that potential exists for use of these newly registered preemergence-applied herbicides on some sensitive crops. However, users must be aware of current labeling and only use pesticides on crops for which they are labeled.

METHOD

In March of 1991 and 1992, *Hosta fortunei* Albo-marginata, *Hosta fortunei* Meta Peka, *Dryopteris erythrosora* (autumn fern), and *Cyrtomium falcatum* Rochfordianum (holly fern), which are all sensitive to the standard herbicides currently used, were potted in three-quart (trade gallon) containers. A pinebark and peat moss medium (3:1, by volume) amended with 14 pounds of Osmocote 17-7-12, six pounds of dolomitic limestone, two pounds of gypsum, and 1.5 pounds of Micromax per cubic yard was used. Treatments included ten herbicides and a unweeded check for comparison (see tables). Treatments were applied on April 14, 1991, and April 17, 1992. All treatments were placed under 47% shade cloth and irrigated as needed with overhead impact irrigation.

RESULTS

With both hosta cultivars, Rout preemergence-applied herbicide caused the greatest injury, while OH-2 and Ronstar also caused significant damage (Table 1). By 60 days after treatment, plants had grown past injury symptoms, and no injury was noted. With the recently registered herbicides, no injury occurred to either hosta cultivar at any time. Plants of both cultivars treated with Rout generally had the least growth. Generally, there was no growth suppression with any of the recently registered herbicides to the hosta cultivars.

In both years, the greatest injury to both hardy fern species resulted when Dimension was applied (Table 2). The remaining treatments caused no significant injury to autumn fern. However, holly fern exhibited injury symptoms with other treatments, including Ronstar, OH-2, and Rout at 30 days after treatment, and Snapshot 2.5TG at 60 days after treatment.

After Dimension, Snapshot 2.5TG generally suppressed growth of both fern species the most in both years. In 1991, liners were about one inch tall when treated, while in 1992 the liners were about two inches tall when treated. Application of herbicides to younger and smaller plants may explain why growth of the two ferns was reduced more in 1991. Autumn fern growth was suppressed by SWGC, Rout, OH-2, and Ronstar in 1991. But in 1992 no growth reduction occurred with any of these treatments, perhaps relating back to the size of the liner at potting. Holly fern treated with Ronstar and SWGC in 1991 had growth indices of about seven inches; significantly lower when compared to the check.

Lauderdale is a Graduate Research Assistant and Gilliam is Professor of Horticulture; Olive is Superintendent of the Ornamental Horticulture Substation.

Table 1. Effects of Preemergence-Applied Herbicides on Two Hosta Cultivars

Treatment	Albo Marginata			Meta Peka		
	Growth Index[1]		Injury[2]	Growth Index[1]		Injury[2]
	1991	1992		1991	1992	
	in.	*in.*		*in.*	*in.*	
Devrinol[3]	19.8	17.5	2.5	20.1	22.6	0.0
Pennant[3]	20.5	18.2	0.0	19.6	16.7	0.0
Derby[3]	18.8	17.9	0.0	20.6	15.7	0.0
Dimension[4]	19.8	18.2	0.0	19.6	15.4	0.0
Snapshot[3]	18.5	18.0	0.0	20.0	17.2	0.0
SWGC[3]	18.6	16.5	0.0	18.2	16.6	0.0
Rout[5]	13.4	16.7	37.5	16.8	16.3	32.5
OH-2[5]	16.0	18.0	23.8	17.1	16.4	22.5
Ronstar[5]	17.8	18.1	25.0	18.1	18.1	17.5
Prodiamine[3]	18.4	16.8	2.5	19.9	16.6	0.0
Unweeded	19.0	16.0	0.0	19.4	18.5	0.0

Table 2. Effects of Preemergence-Applied Herbicides on Two Hardy Ferns

Treatment	Autumn fern				Holly fern			
	Growth Index[1]		Injury[2]		Growth Index[1]		Injury[2]	
	1991	1992	30 DAT	60 DAT	1991	1992	30 DAT	60 DAT
	in.	*in.*			*in.*	*in.*		
Devrinol[3]	19.8	13.7	0.0	0.0	16.9	19.6	3.8	0.0
Pennant[3]	19.8	16.4	0.0	0.0	22.9	19.1	0.0	0.0
Derby[3]	17.9	14.5	0.0	0.0	15.0	18.4	0.0	0.0
Dimension[4]	1.3	1.0	0.0	40.0	0.0	5.4	15.0	67.5
Snapshot[3]	7.3	14.4	0.0	0.0	4.8	11.8	5.0	27.5
SWGC[3]	10.0	14.0	0.0	0.0	7.1	16.1	0.0	0.0
Rout[5]	12.2	14.0	0.0	3.8	12.1	19.0	13.8	0.0
OH-2[5]	11.8	13.8	0.0	0.0	14.2	18.8	18.8	0.0
Ronstar[5]	10.5	10.9	0.0	5.0	7.4	17.0	27.5	0.0
Prodiamine[3]	17.2	16.8	0.0	0.0	13.5	22.0	0.0	0.0
Unweeded	20.0	14.8	0.0	0.0	16.3	20.2	0.0	0.0

[1]Growth index = (height + $width_1$ + $width_2$)/3. $Width_1$ was at the widest point; $width_2$ was perpendicular to $width_1$.
[2]Injury ratings: 0 = no injury, 100 = dead. Plants were rated 30 days after treatment (DAT) to derive the data in Table 1. Plants were rated 30 and 60 DAT to derive the data in Table 2. Only the 1992 injury ratings are presented.
[3]Four pounds of active ingredient per acre.
[4]Two pounds of active ingredient per acre.
[5]Three pounds of active ingredient per acre.

Transmission of *Phytophthora parasitica* in an Ebb and Flow Subirrigation System

Stephen S. Strong, C. Fred Deneke, Kira L. Bowen, Bridget K. Behe, and Gary J. Keever

Ebb and flow subirrigation is a closed production system that recirculates a water/nutrient solution and collects its own runoff. Water pumped from a storage tank floods the surface of a leak-proof floor or bench, where the solution flows around and beneath potted plants. Water is transported up through the growing media by capillary action. After a predetermined time, water flow is terminated and the remaining solution allowed to drain back to a tank or collecting pond. The system conserves water and fertilizer, decreases groundwater contamination, and reduces foliar disease.

However, ebb and flow may spread plant pathogens in the recycled nutrient solution. Bacteria and fungi can move freely in water and possibly cause large crop losses. Research was conducted to determine the rate of transmission of the root rot pathogen *Phytophthora parasitica* from diseased to healthy plants in an ebb and flow system.

Results from this study showed that root pathogens can be spread up to 23 inches on recirculating subirrigation bench, and approximately 36% of the plants exhibited severe root injury at close spacing. Wider plant spacing may be an important factor in reducing the severity of disease spread. This research was partially supported by the Bedding Plants Foundation.

METHODS

Five-week-old seedlings of annual vinca (*Catharanthus roseus* Peppermint Cooler) were transplanted into three-inch pots containing Fafard No. 2 peat:perlite medium. The Canadian sphagnum peat:perlite medium used in this study was steam pasteurized to allow for more accurate detection of *Phytophthora* by eliminating existing pathogens. However, pasteurization of peat is not recommended in commercial production because beneficial microorganisms are destroyed that may suppress root diseases caused by *Phytophthora* and *Pythium*.

Six rows of seven plants were placed on 4x6-foot ebb and flow benches (Photo 17, Page 20). The first row placed closest to the drain end of each bench was inoculated with *Phytophthora parasitica*. These treated plants served as an inoculum source for the rows of untreated plants. Plants were spaced at a distance of 7/16 inches between pots on two benches (Group 1), and a distance of 1 5/8 inches between pots on two other benches (Group 2). Plants were harvested from each of the untreated rows at two-week intervals, and root samples were tested for evidence of *Phytophthora*. The crop was grown for six weeks on the benches and was fertilized at each irrigation with a solution of 100 parts per million (ppm) nitrogen from Peters 20-10-20. Samples from the irrigation tanks were tested for the presence of pathogen spores at two-week intervals.

RESULTS

Monitoring of pathogen movement showed spread from the inoculated row to the fifth untreated row of plants on all benches by the sixth week. *Phytophthora* had spread across the benches a total distance of 17 inches in Group 1 and 23 inches in Group 2. However, only 13% of infected Group 2 plants exhibited severe root injury (up to 25% root system injured), compared to 36% of those infected at the closer spacing. See the table for an analysis of the rate of *Phytophthora* infection. All the inoculated plants from both groups died by week six, and the pathogen was recovered from all samples. Sampling of the irrigation solution revealed the presence of the pathogen in one of the Group 1 tanks at week six.

Sanitation of production areas and disinfection of equipment reduce the chances of a disease outbreak, but other measures may be necessary once a pathogen becomes established in an ebb and flow system. Chemical pesticides are commonly applied in conventional production systems. However, there are currently no fungicides or pesticides registered for recirculation.

Movement of *Phytophthora parasitica* to Non-inoculated Plants Spaced at Two Distances on Ebb and Flow Benches

Spacing	Non-inoculated Plants Infected		
	Week 2	Week 4	Week 6
in.	*pct.*	*pct.*	*pct.*
Group 1 .... 7/16	6	23	60
Group 2 .... 1 5/8	0	10	30

Strong is former Graduate Assistant, Deneke is former Assistant Professor, Behe is Assistant Professors, and Keever is Professor of Horticulture; Bowen is Associate Professor of Plant Pathology.

Chemical Control of Azalea Lace Bug

James C. Stephenson, Michael L. Williams, and John W. Olive

The azalea lace bug, *Stephanitis pyrioides*, is a common economic pests in azaleas, one the primary nursery crops in south Alabama. Until recently, the insect had not been difficult to control.

This insect is often present year-round, but greatest abundance occurs during the warmer months. Lace bugs are very mobile and are commonly found on lower leaf surfaces. Injury results from insect feeding that produces chlorotic spotting on the upper leaf surface. Numerous cast skins and circular black fecal spots usually are present on the lower leaf surface.

AAES tests indicated a number of labeled insecticides provide good azalea lace bug control when properly applied. Thorough coverage of foliar sprays remain one of the most important factors in controlling the azalea lace bug. The incorporation of Orthene 15G at higher rates may also prove useful in the future.

METHODS

Test 1 evaluated foliar application of three relatively new materials or formulations and four common ornamental-labeled insecticides. *Rhododendron* x Treasure grown in three-gallon containers of an amended pine bark:peat moss medium were treated with a single foliar spray to all leaf surfaces until run-off. No spray adjuvants were included. Treatments were replicated and plants placed under 47% shade cloth. Evaluation was conducted seven days after treatment using a modified beat-sheet method to count live adult lace bugs.

Test 2 evaluated the efficacy of a pre-plant incorporation of Orthene 15G as a preventative treatment. *Rhododendron* x Christmas Cheer liners were potted in trade gallon containers of an amended pine bark:peat moss (3:1) medium. Orthene 15G was pre-plant incorporated at several different rates into the media. A foliar-applied treatment of Orthene 75S was included as a standard for comparison. Treatments were replicated and plants placed in close proximity to azaleas heavily infested with lace bugs.

RESULTS

In Test 1, good control was observed with all materials tested when compared to the untreated check (Table 1). Treatments included two formulations of Talstar, Dycarb 76W, Mavrik 2F, Margosan O, Orthene 75S, and Diazinon AG-500.

In Test 2, lace bug feeding damage was observed within 36 hours after treatment on most plants. At the first evaluation seven days after treatment, little difference in lace bug numbers was observed. However considerably less feeding damage was observed with the single foliar application of Orthene 75S (Table 2). At 21 days after treatment, the two highest rates of Orthene 15G and the Orthene 75S foliar spray provided control (Table 2). The plants receiving the foliar spray had the least amount of feeding damage. At 21 days after treatment, similar results were observed (data not presented). In the final count, 35 days after treatment, only the standard foliar-applied Orthene 75S provided some control (data not presented). No phytotoxicity was observed in either test.

Table 1. Chemical Control of Azalea Lace Bug Seven Days After Treatment

Treatment[1]	Application rate[2]	Live bugs[3]
Talstar 10WP	12.8	3.5
Talstar 80 g/lF	15.3	0.5
Dycarb 76W	16	0.3
Mavrik Aquaflow 2F	5	2.3
Morgasan O 0.3%	80	3.0
Orthene 75S	10.6	0.5
Diazinon AG-500	16	1.8
Control	0	43.3

Table 2. Preventative Treatment for Azalea Lace Bug

Treatment[1]	Rate[4]	Live bugs[3]	
		7 DAT[5]	21 DAT
Orthene 15 G	0.11	2.5	12.3
Orthene 15 G	0.23	3.3	12.3
Orthene 15 G	0.45	4.0	5.3
Orthene 15 G	0.66	3.0	3.3
Orthene 75 S	1	2.3	0.8
Control	0	5.5	17.5

[1]Treatments applied July 17, 1991.
[2]Talstar 80 g/1F, Mavrik Aquaflow 2F, and Morgason O 0.3% are measured in fluid ounces per 100 gallons of water; others are measured in ounces per 100 gallons.
[3]Mean number of live lace bugs per container.
[4]Orthene 75 S is a foliar spray and was applied at the rate of one pound per 100 gallons of water. All other treatments were applied on the basis of pounds per cubic yard.
[5]Days after treatment (DAT).

Stephenson is Associate Superintendent and Olive is Superintendent of the Ornamental Horticulture Substation; Williams is Associate Professor of Entomology.

Fungicidal Control of Southern Blight on Aucuba

Austin K. Hagan and John W. Olive

Southern blight, which is caused by the soil fungus *Sclerotium rolfsii*, is a destructive disease of aucuba, ajuga, and other woody ornamentals. It has usually been seen in field and landscape beds but considerable damage has been reported on container-grown aucuba. Terraclor fungicide has been used to control southern blight, but there are some questions concerning its effectiveness on ornamentals. Also, several experimental fungicides active against the southern blight fungus have been identified.

An AAES study was conducted to evaluate several of these new fungicides for the control of southern stem rot on aucuba. Two of the new products, Prostar and ASC66825, completely protected aucuba from southern blight.

METHODS

Aucuba cv. Golddust liners were potted in one-gallon containers in a pine bark-peat moss media 3:1 (by volume) amended with 14 pounds of Osmocote (17-7-12), six pounds of dolomitic limestone, two pounds of gypsum, and 1.5 pounds of Micromax per cubic yard of medium. Plants were located in partial shade and watered daily with overhead sprinklers. Fungicides were applied on Sept. 2 as a heavy spray/drench using a CO_2-pressurized backpack sprayer. All treatments, with the exception of the noninoculated control, were inoculated with sclerotia of *S. rolfsii*, and then held for several days in a hot, humid enclosed area. Plant mortality was determined on Sept. 30.

RESULTS

All plants treated with Prostar and ASC66825 appeared healthy. Folicur and Terraclor gave some protection from southern blight but neither fungicide proved as effective as Prostar and ASC66825. Plant mortality of the Terraguard and Curalan-treated aucuba was similar that of the inoculated controls. None of the noninoculated controls died from southern blight.

Effects on Plant Mortality of Fungicidal Control

Fungicide[1]	Plant mortality
Folicur 3.6F (8 fl. oz.)	20
Prostar 50W (2 lb.)	0
ASC66825 500F (32 fl. oz.)	0
Terraguard 50W (1 lb.)	60
Terraclor 75W (1.25 lb.)	30
Curalan 50DF (8 oz.)	70
Inoculated control	80
Noninoculated control	0

[1]Application amount is given in parenthesis; rate is per 100 gallons of water.

Hagan is Professor of Plant Pathology and Olive is Superintendent of the Ornamental Horticulture Substation.

Use of Selected Pesticides And Pesticide Combinations Against Sweetpotato Whitefly on Container-Grown Ornamentals

Michael L. Williams and James C. Stephenson

Southern growers are desperate for new ways to control the sweetpotato whitefly, *Bemisia tabaci*, the most troublesome and difficult to manage of the whiteflies. Its potential for damaging greenhouse-grown ornamental plants in Alabama is great because of its amazing ability to tolerate pesticides, adapt to new host plants, and reproduce rapidly.

Whiteflies, a common ornamental plant pest, cause damage by sucking out plant juices and spreading diseases. Their nymphs secrete honeydew, a growth medium for black sooty mold which detracts from a plant's appearance and can interfere with photosynthesis. There are several species of whiteflies, but the sweetpotato whitefly causes the most problems with indoor plants.

Sweetpotato whitefly resistance is broadbased, spanning at least four classes of insecticides -- organochlorines, organophosphates, carbamates, and pyrethroids. Resistance in some populations of sweetpotato whitefly has been documented at the 54-fold level. Some growers have turned to unlabeled products and application methods in an effort to control the pest. In the interior environment, the arsenal of pesticides available for use against sweetpotato whitefly is limited. Because of human exposure problems, highly toxic and long-lasting materials cannot be used inside. For these reasons, AAES researchers are evaluating both traditional and new materials for use against this pest in greenhouses and shadehouses.

Several pesticide combinations, soap, and oil sprays evaluated in these tests provided good to excellent control and offer additional materials to use in rotation with other pesticides to help control and manage pesticide resistance in sweetpotato whitefly populations.

METHODS

In 1991 nine pesticides and/or pesticide combinations were evaluated for control of sweetpotato whitefly on container-grown Chinese hibiscus, *Hibiscus rosa-sinensis* L., growing in the greenhouse. Test materials were applied on Aug. 19 and 25, to 40 plants, potted in three-gallon containers, that were heavily infested with whiteflies. The foliar sprays were applied to run-off using hand held compressed air sprayers. Care was taken to thoroughly cover undersides of leaves. Granular materials were sprinkled on the soil surface and watered in. Efficiency of materials tested was evaluated seven and 14 days post-treatment.

In 1992, additional tests were conducted against sweetpotato whitefly infesting container grown althea, *Hibiscus syriacus* L. Test materials were applied on Sept. 2 and 9 to two-foot-tall plants growing in one-gallon containers and heavily infested with sweetpotato whitefly. Efficacy of the materials tested was evaluated seven and 14 days post-treatment.

RESULTS

Best results in 1991 were obtained with combinations of Tame 2.4 EC + Orthene 75 S and Orthene 75 S + Sunspray Ultrafine Spray Oil. Both combinations provided 100% control of sweetpotato whitefly infesting hibiscus after two applications applied at a seven-day interval (Table 1). No plant damage, or phytotoxicity, was observed.

Only Sunspray Ultrafine Spray Oil and pesticides used in combination with Sunspray Ultrafine Spray Oil provided control significantly better than the untreated control plants in the 1992 test. The Tame + Orthene combination that was so effective in the 1991 test was ineffective in the 1992 test. The only explanation for its failure in 1992 is that the population of whiteflies tested against in 1992 came from a greenhouse where previous attempts to control them had failed, suggesting that pesticide resistance in the test whitefly population may have been the reason for the lack of control.

Table 1. Control of Sweetpotato Whitefly on Hibiscus, 1991

Treatment[1,2]	Mean pct. mortality[3]	
	7 DAT[4]	14 DAT
Tame 2.4 EC		
0.20 lb.	31	42
Orthene 75 S		
0.25 lb.	29	47
Tame 2.4 EC+Orthene 75 S		
0.20 lb.+0.25 lb.	80	100
Orthene 15G		
1.5 g	44	76
Orthene 75 S+Sunspray Oil		
0.25 lb.+2 gal.	72	100
Talstar 10W		
0.20 lb.	44	55
Talstar 80F		
0.20 lb.	38	64
Attack Soap		
4 gal.	68	76
Avid 0.15 EC		
8 oz.	39	84
Control		
0	22	12

Table 2. Sweetpotato Whitefly Control on Althea, 1992

Treatment[1,2]	Mean pct. mortality[3]	
	7 DAT	14 DAT
Tame 2.4EC+ Orthene 75s		
0.2 lb.+0.25 lb.	13.50	11.75
Tame 2.4EC		
0.2 lb.	11.25	17.50
Tame 2.4EC		
0.3 lb.	9.25	14.50
Orthene 75s		
0.25 lb.	5.00	8.75
Sunspray 6E		
2.0 gal.	90.00	98.25
Tame 2.4EC+ Sunspray 6E		
0.2 lb.+2.0 gal.	95.25	98.00
Talstar 80F		
2.0 lb.	6.50	8.25
Orthene 75s+ Sunspray 6E		
0.25 lb.+2.0 gal.	86.75	97.25
Dibeta ABG-6320		
0.225 gal.	8.25	8.25
Control		
0	5.50	11.00

[1]Treatments applied Aug. 19 and 25, 1991.
[2]These rates are the amount of insecticide added to 100 gallons of water, except for Orthene 15 G, which was applied at the rate of 1.5 grams per three-gallon pot.
[3]Mortality determined Aug. 25 and Sept. 2, 1991.
[4]Days after treatment (DAT).

Williams is Associate Professor of Entomology and Stephenson is Associate Superintendent of the Ornamental Horticulture Substation.

Chemical Control of Two-spotted Spider Mite on Golden Euonymus

William H. Reynolds, James C. Stephenson, and Michael L. Williams

The two-spotted spider mite is a widespread pest species of many ornamentals and is frequently encountered in landscapes, interiorscapes, greenhouses, and nursery operations. Mild spider mite infestations are characterized by a yellow or white stippling of leaves. Chlorosis and leaf death accompanied with fine webbing both under the leaves and at the leaf bases indicate heavy mite infestations.

Adult spider mites are small (less than 1/50 inch), yellow to green in color, and have two dark spots on the body. The average female spider mite produces 100 to 200 eggs with oviposition occurring on all plant surfaces. Under favorable conditions, the entire life cycle requires little more than a week (eight to 12 days). High humidity and poor air circulation provide favorable conditions for spider mite outbreaks.

Nine pesticides and/or pesticide combinations were evaluated for control of two-spotted spider mites within a shadehouse facility in Mobile in September 1992. Of the nine treatments, Attack Soap at four gallons per 100 gallons of water and DiBeta 5 AS at two and four pints per 100 gallons provided best control. Plant damage was not observed in any of the treatments.

Control of Two-spotted Spider Mite

Treatment[1,2]	Mites per sample[3]
Tame 2.4 EC+ Orthene 75S (.20 lb.+0.25 lb.)	21.50
Tame 2.4 EC (0.20 lb.)	25.75
Tame 2.4 EC (0.30 lb.)	50.25
Orthene 75S (0.25 lb.)	26.75
Sunspray 6E (2.0 gal.)	24.25
Attack Soap (4.0 gal.)	10.00
DiBeta 5 AS (2.0 pt.)	7.00
DiBeta 5 AS (4.0 pt.)	4.50
Talstar 80F (0.20 lb.)	32.75
Control (0)	23.00

[1]Treatment applied September 9, 1992
[2]Amount of pesticide per 100 gallons of water.
[3]Samples consisted of four terminal leaves per plant from four plants. Samples were taken seven days after treatment.

METHODS

Heavily infested golden euonymus shrubs, *Euonymus japonica* Aureomarginata, in trade gallon pots were selected for treatment. Test materials were applied to upper and lower leaf surfaces with hand-held compressed air sprayers on Sept. 9, 1992. Seven days after treatment, terminal shoots bearing four leaves were removed from each plant. Terminals were brushed with a mite-brushing machine onto a counting disc and the number of living mites counted. Due to mite damage and overall decline of the plants, the test was terminated after one week.

Reynolds is Graduate Research Assistant and Williams is Associate Professor of Entomology; Stephenson is Associate Superintendent of the Ornamental Horticulture Substation.

Chemical Control of Spot Anthracnose of Dogwood

Austin K. Hagan, John W. Olive, and Leonard C. Parrott

Spot anthracnose, caused by the fungus *Elsinoe corni*, is a common foliar disease of flowering dogwood. On leaves, flower bracts, berries, and young stems, numerous small circular spots with reddish purple margins and a tan or grey center may be seen. Severe infections can cause distorted and tattered leaves.

Several non-registered compounds and labeled fungicides were evaluated for control of this disease on flowering dogwood. Of the fungicides screened, only Daconil 2787 4.17F and Daconil 2787 WDG are currently registered for use on dogwoods, but not specifically for the control of spot anthracnose. Based on the successful control of this disease in these trials, spot anthracnose could be included on the Daconil 2787's 1994 label.

METHODS

White seedling dogwoods, infested with *E. corni*, were potted in three-gallon containers in February 1991 and 1992. The potting medium was milled pine bark and peat moss (3:1, by volume) amended with six pounds limestone, two pounds gypsum, 1.5 pounds Micromax, and 14 pounds Osmocote 17-7-12 per cubic yard. Fungicides were applied at seven-day intervals from May 28 to July 22, 1991, and 14-day intervals from April 4 to May 22, 1992. Spray treatments were applied to run-off. Disease severity was determined on June 30, 1991 and May 23, 1992.

RESULTS

In 1991 and 1992, all fungicide treatments were effective in reducing the severity of spot anthracnose on dogwood foliage, and similar control was observed with all fungicides evaluated. Results indicate that a 14-day spray interval may be sufficient to control this disease with the fungicides evaluated in 1992.

Hagan is Professor of Plant Pathology; Olive is Superintendent of Ornamental Horticulture Substation; Parrott is Research Technician IV.

Table 1. 1991 Evaluation of Fungicidal Treatments for Control of Spot Anthracnose of Dogwood (Seven-Day Spray Schedule)

Fungicide[1]	Disease severity[2]
Daconil 2787 4.17 F (2 pt.)	1.5
Daconil 2787 4.17 F (4 pt.)	1.3
Daconil 2787 WDG (1.25 lb.)	1.4
Daconil 2787 WDG (2.5 lb.)	1.2
ASC 66791 (32 oz.)	1.3
ASC 66791 (64 oz.)	1.6
Rally 40W[3] (5 oz.)	1.6
Benlate 50W[4] (8 oz.)	1.4
Folicur 3.6F (4.5 fl. oz.)	1.6
Non-sprayed control (0)	2.8

Table 2. 1992 Evaluation of Fungicidal Treatments for Control of Spot Anthracnose of Dogwood (14-Day Spray Schedule)

Fungicide[1]	Disease severity[5]
Daconil 2787 4.17 F (2 pt.)	2.3
Daconil 2787 4.17 F (4 pt.)	2.0
Daconil 2787 WDG (1.25 lb.)	1.5
Daconil 2787 WDG (2.5 lb.)	2.0
Rally 40W (35 oz.)	1.7
Folicur 3.6F (4.5 fl. oz.)	1.3
Non-sprayed control (0)	5.2

[1]Rate is per 100 gallons of water.
[2]Disease severity scale used in 1991: 1 = 0%, 2 = 25%, 3 = 50%, 4 = 75%, and 5 = 100% of new foliage affected.
[3]Federal registration of Rally 40W on some ornamentals is expected in 1993, but it may not be cleared for use on dogwoods.
[4]Benlate's registrations on all ornamentals were withdrawn by the manufacturer.
[5]Disease severity scale used in 1992: 1 = 0, 2 = 0-3%, 3 = 3-6%, 4 = 6-12%, 5 = 12-25%, 6 = 25-50%, 7 = 50-75%, 8 = 75-88%, 9 = 88-94%, 10 = 94-97%, 11 = 97-100%, and 12 = 100% of new growth affected.

Dogwood Anthracnose on Dogwood in Alabama: Its Distribution and Severity

Austin K. Hagan and Jackie M. Mullen

Dogwood anthracnose poses a significant threat to the health of flowering dogwood in Alabama's forests. The destructive disease has recently been found on flowering dogwood (*Cornus florida*) in forested and landscape sites in Appalachian Mountains and nearby uplands in the Southeast. In Alabama, this disease has been found in four northern counties and in Lee County, but the distribution and extent of damage to dogwoods in the state are not known.

Stands of native flowering dogwood in state parks and national forests in north Alabama were checked in the late spring, 1991 and 1992, to determine the distribution and severity of dogwood anthracnose. Trees found along one or more sites at each location were examined for symptoms of the disease.

Death of understory trees was seen at one location and considerable foliage damage was seen at several others across extreme northeast Alabama. Continued intensification of this disease, particularly on seedling and young trees, will eventually result in elimination of dogwood from some Alabama forests. The appearance of this disease at lower elevations shows that dogwood anthracnose may also spread over a much wider area of the state than originally thought. Problems with this disease also are likely in the next few years on dogwood growing on shaded areas in home and commercial landscapes across much of north Alabama.

Controls for dogwood anthracnose include planting healthy trees, avoiding dogwoods transplanted from the forest, pruning surrounding trees to improve sunlight penetration and air circulation, maintaining good soil fertility, light pruning to open the tree canopy and remove dead wood, establishing new trees on sites open to sunlight, surface watering weekly during drought, mulching trees, and fungicide sprays. No flowering dogwoods resistant to this disease have been found.

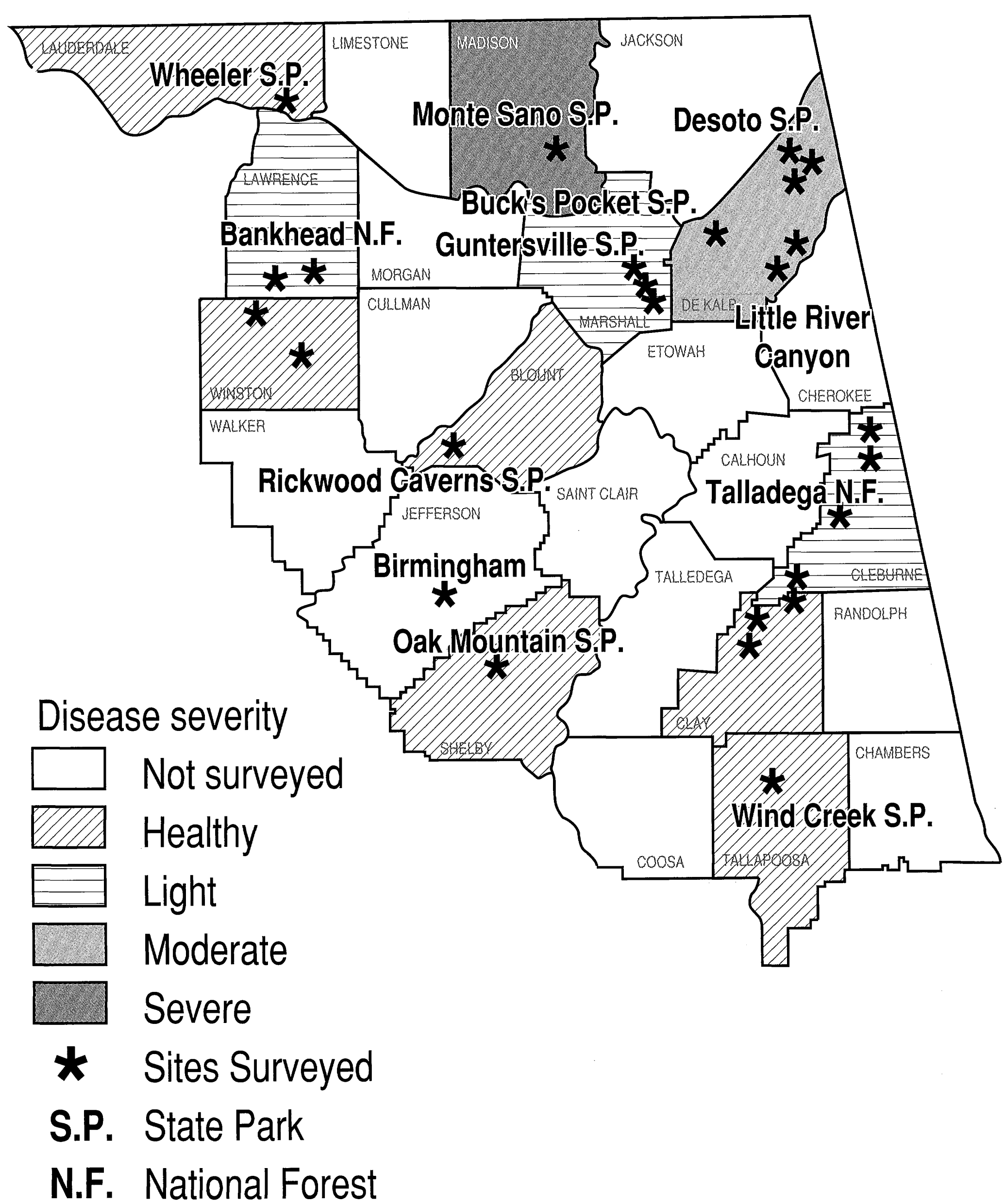
METHODS

Disease occurrence and severity at each site were recorded. In 1992, disease severity was assessed on each tree by a modified Miekle-Langdon scale (see table footnote for description). Disease severity was not determined using this scale in 1991. Leaves from trees with typical disease symptoms were examined for the presence of the causal fungus, *Discula destructiva*.

RESULTS

In 1991, typical leaf spot and blight were seen on nearly all dogwoods examined in Monte Sano State Park in Madison County and Desoto State Park in DeKalb County. Twig dieback and tree

Dogwood Anthracnose in Alabama, 1992



death, which are associated with severe anthracnose injury, were not seen in either park, but few healthy trees were found. Symptoms were lighter on the taller dogwoods than on the smaller understory trees. Elevation of sites surveyed in both parks was 1,600 to 1,700 feet.

Some leaf spotting was seen on a few scattered trees near the lodge in Lake Guntersville State Park in Marshall County and along the north rim of the Little River Canyon in DeKalb County (elevation 1,000 feet). No dogwood anthracnose was found on trees along several lake-front trails in Lake Guntersville State Park. One dogwood with typical leaf spot symptoms was found in Buck's Pocket State Park in DeKalb County and in the Talladega National Forest in Calhoun County. No diseased trees were found at two other locations in the Talladega National Forest in Cleburne County, or several sites in Cheaha State Park in Clay County. Also, dogwood on several sites in Wheeler State Park in Lauderdale County, Wind River State Park in Tallapoosa County, and Oak Mountain State Park in Shelby County were healthy.

Favorable weather conditions in summer 1991 resulted in an increase in the range and severity of dogwood anthracnose in 1992 (see table). Some shoot dieback along with the typical leaf spot and blight was seen on all dogwoods examined in Monte Sano and Desoto state parks. On a few trees, death of the lateral branches was followed by the appearance of numerous water sprouts along the main trunk. Tall dogwoods in direct sunlight suffered less damage than the smaller, shaded understory trees.

Serious leaf blight and limb dieback occurred on dogwoods along the north rim of the Little River Canyon and Coleman Lake in Talladega National Forests in Cleburne County. Spread of the disease to previously healthy dogwood stands was seen in Lake Guntersville, Buck's Pocket, and Brymer Mountain and Horseblock Mountain in Talladega National Forest in extreme southwest Cleburne County. Dogwood anthracnose also was identified at one site in Bankhead National Forest between Lawrence and Winston counties. At several of these locations, diseased dogwood were found at elevations down to 600 feet. Also, one symptomatic dogwood was found in Birmingham in Jefferson County near Legion Field.

Trees at two sites south and west of Cheaha in the Talladega National Forest in Clay County were healthy. The same was true with all trees checked in Wind River, Oak Mountain, Wheeler state parks and three sites in the Bankhead (Sipsey Wilderness) in Winston and Lawrence counties.

Other foliar diseases of dogwood identified during the course of this survey were spot anthracnose and botrytis blight. Of the two diseases, spot anthracnose, which was found on dogwood in partial to full sun, was the most common. The most extensive outbreak of this disease was found on dogwood growing along the rim of the Little River Canyon in Desoto State Park. Botrytis blight, a disease that exhibits symptoms similar to dogwood anthracnose, was rare.

Hagan is Associate Professor and Mullen is Plant Pathologist of Plant Pathology.

Distribution and Severity of Dogwood Anthracnose in Alabama on Flowering Dogwood in 1992

State Park or National Forest	County	Incidence	Disease rating[1]
		pct.	
Rickwood Caverns	Blount	0	5.00
Talladega	Clay	0.8	4.99
Talladega	Cleburne	40.1	4.40
Desoto	DeKalb	91.5	3.20
Buck's Pocket	DeKalb	37.2	4.50
Little River Canyon	Dekalb	88.5	3.70
Bankhead	Lawrence	0.9	4.95
Wheeler	Lauderdale	0	5.00
Monte Sano	Madison	100.0	2.10
Lake Guntersville	Marshall	12.1	4.74
Oak Mountain	Shelby	0	5.00
Wind River	Tallapoosa	0	5.00
Bankhead	Winston	0	5.00

[1]Disease severity was evaluated on each tree using a modified Mielke-Langdon scale: 0 = dead tree; 1 = 75-100% leaves diseased with numerous water sprouts; 2 = 50-75% leaves diseased with extensive twig dieback; 3 = 25-50% leaves diseased with some twig dieback; 4 = 1-25% of leaves diseased; and 5 = healthy tree.

ENVIRONMENTAL PROTECTION

Nontarget Herbicide Losses from Application of Granular Ronstar to Container Nurseries

Charles H. Gilliam, Donna C. Fare, and Alan Beasley

Weed control is essential in container production, but increasing concerns about water quality dictate that herbicide use must be environmentally safe. Three main concerns regarding herbicides in nursery runoff water are the location of container nurseries in relation to surface water, potential plant injury from recycled runoff water, and possible ground water contamination.

Granular herbicides are normally used to control weeds in container nurseries. These herbicides are usually broadcast using a cyclone-type spreader with up to five applications a year. When applied to round nursery containers, 20% or more of the herbicide falls directly to the ground between the containers. Previous studies indicated that little leaching of chemicals occurs from potting media when normal rates are used. These results suggest that the greatest potential for water contamination is from the grains of herbicide that fall to the ground.

A study was conducted to determine how these nontarget losses are influenced by container spacing and plant species. It revealed that nontarget granular herbicide loss from broadcast application ranges from 23-30% when three-quart pots are spaced adjacent to one another. Increasing plant spacing progressively increases nontarget loss. From a practical standpoint, herbicide applications should be made before spacing of containers if possible. Furthermore, this work points out the need to develop more refined granular herbicide application techniques to reduce nontarget loss.

METHOD

A rectangular frame (7.5x4.2 feet) was constructed and covered with a plastic sheet to allow recovery of the applied herbicide. Ronstar 2G was applied at the manufacturer's suggested rate of 200 pounds per acre. A hand-held shaker can was used to apply the herbicide to empty three-quart containers. Three spacings evaluated were container-to-container, and pots spaced on eight- and 12-inch centers (1.5 and five inches between containers, respectively). Each pot was lined with a plastic bag to collect the herbicide going into the container. Herbicide falling inside the containers was pooled and weighed, and herbicide falling on the plastic sheet under the containers was weighed.

The test was repeated with containers of Trouper azalea (*Rhododendron* x Trouper), representing a dense canopy plant, and Crimson Pygmy barberry (*Berberis thunbergii* Crimson Pygmy), representing an open canopy plant. Trouper azaleas averaged 16.4 inches in height and 15.5 inches in width. Barberry plants averaged 9.7 inches in height and 14.9 inches in width. These container-grown plants were placed in a plastic bag to cover the outside of the container and prevent container media from falling onto the plastic sheet. Container size and spacing were similar to the empty container test.

RESULTS

Canopy density appeared to have little influence on nontarget herbicide loss. When spaced container-to-container, the nontarget losses were 23%, 30%, and 27% for the empty pots, azalea-planted pots, and barberry-planted pots, respectively. See the table for other results.

Nontarget Loss of Ronstar 2G Herbicide with Broadcast Applications as Affected by Pot Spacing and Plant Canopy

Container	Spacing	Pct. herbicide loss
Empty	pot to pot	23
	8 in.	51
	12 in.	80
Azalea	pot to pot	30
	8 in.	55
	12 in.	79
Barberry	pot to pot	27
	8 in.	54
	12 in.	80

Gilliam is Professor, Fare is former Senior Research Associate, and Beasley is former student of Horticulture.

Monitoring Irrigation at Container Nurseries

Donna C. Fare, Charles H. Gilliam, and Gary J. Keever

Water use and runoff in container nurseries are major concerns to U.S. nursery operators. Improving water management is the first strategic step in improving water quality and reducing water usage and surface runoff from container nurseries.

Overhead irrigation is the primary irrigation method in Southeast container nurseries. Growers generally irrigate one hour a day during the growing season, assuming an application of one inch of water per hour. Overhead irrigation may apply 40,000 gallons per acre daily, with losses of 16,000 to 36,000 gallons through evaporation and runoff. In Alabama, total water used for irrigation was reported at 77,000 acre-feet per year; the container nursery industry uses up to 50,000 of that amount.

As a baseline, improving water management practices requires an understanding of current irrigation procedures employed in container nurseries. A two-year survey was conducted to determine irrigation distribution at Alabama container nurseries. The survey reflects current production irrigation application volumes in the state and is probably indicative of the South. The amount of irrigation applied varied with each nursery sampled, but averaged 0.6 inch per hour, or about 40% less than most nursery operators assumed was being applied. Despite differences in irrigation output, plants grown in the six nurseries surveyed were of consistently uniform marketable quality.

Based on this survey, potential ways for improving irrigation delivery include careful monitoring of output throughout the year with adjustments to ensure uniform delivery, especially when using overwintering structures. Most of the irrigation systems were not checked for proper irrigation output or distribution, but the growers assumed the system to deliver one inch of water per hour.

The survey also emphasizes the need for uniform initial design. Poor water distribution could have been improved with a properly designed irrigation system. Output and distribution of water from overhead systems are dependent upon many variables, including wind, operating pressure, pipe size and spacing, nozzle size and type, and plant size and spacing. These variables must be considered in designing an irrigation system.

METHODS

Six container nurseries were monitored in 1989 and 1990 to determine the amount and distribution of irrigation water applied to container-grown nursery crops using overhead impact nozzles. Irrigation systems were designed by the nursery operators or by professional irrigation specialists. Growers at these nurseries typically watered for about one hour. Four of the nurseries surveyed (1-4) were located in central or south Alabama. Production in these nurseries consisted mostly of trade- and full-gallon plants potted in April or May, grown for one season, placed pot-to-pot during the winter (November-March) and marketed during the following spring. In the two north Alabama nurseries (5, 6) and one nursery in south Alabama (3), plants were placed pot-to-pot in polyethylene-covered overwintering houses during the winter. All irrigation nozzles at these nurseries were located within the overwintering structures. In the spring, the polyethylene was removed and plants were spaced in the overwintering houses and adjacent areas. These plants were marketable after a growth flush.

Taylor rain gauges were placed in plant containers to collect irrigation water over a one-hour period. Fifteen gauges were located in a grid system between or around irrigation risers within a container block in each nursery. When plants were spaced in Nurseries 3, 5, and 6, gauges were spaced further apart. Gauges were placed at the same locations at each sampling in Nurseries 1, 2, and 4. With all nurseries, similar grid patterns for gauge location were used, even though each nursery had a different irrigation system design, including varied riser heights, riser spacing, and nozzle types (see table). Calm conditions generally prevailed during sampling.

RESULTS

Results were similar for the two years of the survey, so only data from 1990 are reported. Average irrigation volumes applied varied widely from nursery to nursery (see figures). For example, the average irrigation collected during a one-hour period in nurseries for the six sampling times ranged from 0.3 inch in Nursery 5 to 1.3 inches in Nursery 6, a four-fold difference. Excluding Nursery 6, the average irrigation collected over the remaining five nurseries was 0.6 inch, or slightly more than half of the one inch that most growers assumed they were applying in an hour. An average of less than a half inch of water was applied at Nurseries 2, 4, and 5, while an average of 0.7 inch was applied in Nurseries 1 and 3. Variation in irrigation volume among the sampled nurseries may relate to differences in nozzle type, delivery pressure, riser height, and spacing, as shown in the table.

Irrigation distribution varied widely over sampling times within some nurseries, while the irrigation volumes collected from other nurseries were relatively consistent. In Nursery 1, 0.9 inch was collected in June, but only 0.4 inch was collected in November. In Nursery 3, the average irrigation collected ranged from 0.6 inch in May to 0.8 inch in November. In contrast, the hourly irrigation averages for Nurseries 2 and 4, were between 0.3 and 0.4 inch for all of the sampling times. These data demonstrate that uniform irrigation distribution can be achieved. Furthermore, careful monitoring of the irrigation system is needed to ensure efficient water use and to minimize potential water runoff.

Temporary covering of winter protection structures altered irrigation volumes measured. Nursery 6 used polyethylene-covered overwintering structures that confined irrigation to a smaller area and resulted in almost three times the irrigation applied in March as in the other five months of sampling -- 2.7 inches versus one inch. A similar situation occurred in Nursery 5 where irrigation from the November sampling (overwintering structures were covered) averaged 0.8 inch, while the other five sampling dates averaged 0.4 inch.

Irrigation distribution varied widely in the overwintering structures. For example, at Nursery 6 during March (covered structure), irrigation ranged from 0.8 inch to 4.3 inches. During the growing season when the polyethylene was removed and plants were spaced (May-September), the irrigation distribution range was less, ranging from 0.5 inch to 2.1 inches among the 15 gauges. Most of these systems were designed to accommodate the expanded growing areas. In most parts of the U.S., overwintering structures (hoop houses) are a critical component of nursery production. These data indicate that poor irrigation distribution and utilization may occur in covered houses if the system is designed for irrigating adjacent areas.

Uneven water distribution within a block of plants occurred in all nurseries on at least one sampling date. Variations in irrigation volumes were not confined to overwintering structures, but due to other unidentified factors. Within-block variations were relatively low in Nurseries 2 and 4 during May through September, but in August at Nursery 3, irrigation ranged from 0.5 inch to 2.6 inches.

Fare is former Senior Research Associate, Gilliam is Professor, and Keever is Professor of Horticulture.

Characteristics of Irrigation Systems at Six Wholesale Container Nurseries in Alabama

	Nurseries					
	1	2	3	4	5	6
Nozzle types[1]	Rain Bird 40 Rain Bird 35	Rain Bird 30 Rain Bird 35 Nelson 631 A	Rain Bird 25	NAAN 30 NAAN 35	Rain Bird 30	Rain Bird 25
Operating pressure (psi)	30-80	30-80	30-70	25-65	30-80	30-70
Riser spacing (ft.)	40x40	48x48	102	40x40	152	152
Riser height (ft.)	6	5	5	3	4	3
Container size (gal.)	23	1	1	33	23	1
Delivery pressure at pump (psi)	75	60	60	45-65	80	85-90

[1]Manufacturer of Rain Bird nozzles is Rain Bird International, Inc., Glendora, Calif.; manufacturer of NAAN nozzles is NAAN Sprinklers and Irrigation Systems, Inc., Cerritos, Calif.; manufacturer of Nelson nozzles is R.L. Nelson, Inc., Orlando, Fla.
[2]Single-row spacing inside overwintering structure.
[3]Trade size (three quarts).

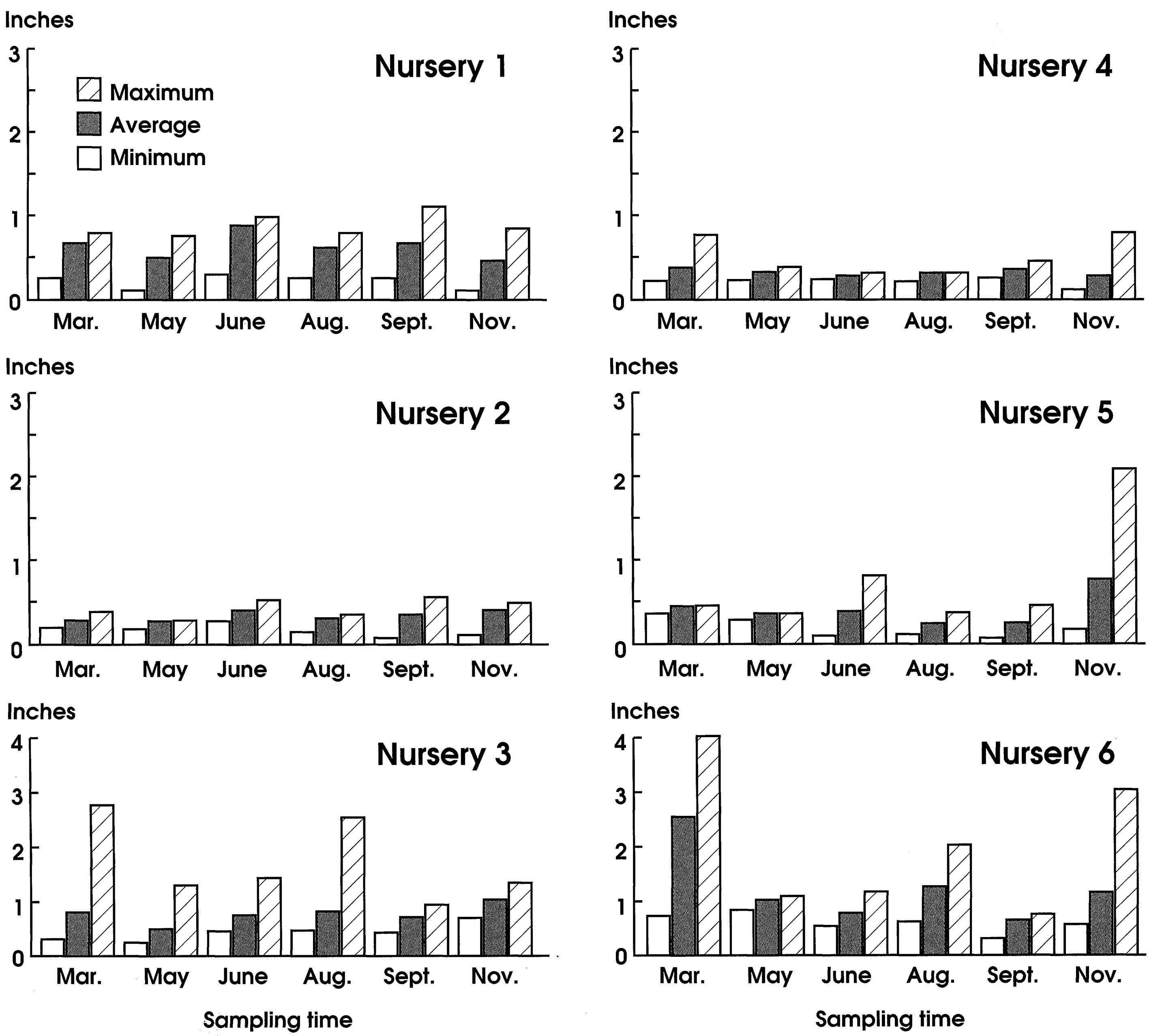


Figure. These graphs show the minimum, average, and maximum irrigation volumes applied at six Alabama nurseries, March-November 1990.

Agricultural Waste Products as Composted Soil Conditioners

D. Joseph Eakes, Ronald L. Shumack, Charles H. Gilliam, and James O. Donald

Disposal of large quantities of waste products is one of the largest problems facing agriculture today. These byproducts could be turned into a valuable resource for the ornamental plant industry as potting media and landscape soil amendments.

Peat moss was once considered the industry standard for landscape soil amendments or conditioners, but its cost and availability have made composted pine bark mixes more popular. Some producers have expressed interest in mixing other composted organic materials with pine bark, which could improve pine bark soil amendments. It could also encourage conversion of agricultural byproducts from potential pollutants to valuable resources.

An AAES study was conducted to evaluate cotton gin waste and broiler litter as additives to composted pine bark soil amendments or conditioners for herbaceous ornamentals in the landscape. It revealed three important facts about using these byproducts with bark. First, composting foul-smelling material, such as broiler litter, with cotton gin waste eliminated the odor. Second, plant growth in compost-amended plots was equal to or better than growth in peat moss-amended plots. Third, composted waste soil conditioners did not provide adequate nutrition, so additional fertilization is needed.

METHODS

Various combinations of cotton gin waste, broiler litter, and pine bark were thoroughly mixed and placed into piles containing about 12 cubic yards (Table 1). The piles were turned every three weeks. The material composted rapidly. There was no detectable broiler litter odor in any of the treatments where cotton gin waste was incorporated into the compost.

Raised beds of pine bark-amended sandy loam soil were treated with one of the compost treatments on Sept. 25 and planted with Fizzy White kale and Orange Boy marigold. Treatments were applied on a dry matter basis at the rate of 20 tons per acre to 6.25x7-foot plots, and tilled in to a depth of two to four inches. Half of the treatments received a commercial fertilizer application at the recommended rate of 120 pounds of nitrogen (N) per acre (Table 1). The two control treatments, peat moss-amended and nonamended, also received the commercial fertilizer application.

RESULTS

Foliar color ratings were similar for Fizzy White kale when comparing the composted treatments with the peat moss-amended treatment where both received the recommended rate of fertilizer (Table 2). All fertilizer-amended compost treatments provided greater plant dry weight than peat moss, as shown in Table 2.

Kale composted treatments not receiving additional fertilizer were smaller and off color compared to the treatments that did receive the recommended fertilizer application. One component of this test was to evaluate whether or not sufficient nutrients would be available to the plants from the composted materials for acceptable plant growth. These data indicate that even though high nutrient levels are in the soil conditioners, they do not provide adequate nutrition for immediate plant needs. Along with the gin waste-broiler litter (1:1) treatment, about 800 pounds of N per acre were applied. Perhaps the release rate of the organic N was too slow for plant needs.

Orange Boy marigold was less responsive to the compost treatments than Fizzy White kale. Color ratings and plant dry weight were similar when comparing the composted treatments plus fertilizer to the peat moss plus fertilizer treatment (Table 3). The gin waste-broiler litter-pine bark (1:1:1) treatment produced slightly larger plants than the peat moss plus fertilizer treatment (7.3 versus 6.1 grams, respectively).

Table 1. Composition of Soil Conditioning Treatments Used

Components[1-3]	Ratio	Pct. N	N lb./a.
GW-PB[4]	1:1	1.0	400
GW-BL-PB	1:1:1	1.6	640
GW-BL-PB[4]	1:1:4	1.3	520
GW-BL-PB	1:2:7	1.2	480
GW-PB[4]	1:4	0.8	320
GW-BL	1:1	2.0	800
Peat moss[4]	-	-	-
None[4]	-	-	-

Table 2. Effects of Soil Conditioners on Growth of Fizzy White Kale

Components[1]	Ratio	Foliar color[5]		Dry weight[7]
		30 DAP[6]	60 DAP	g
GW-PB[4]	1:1	3.8	4.8	32.1
GW-BL-PB	1:1:1	2.3	2.9	4.3
GW-BL-PB[4]	1:1:4	4.0	4.8	33.1
GW-BL-PB	1:2:7	1.5	1.6	2.9
GW-PB[4]	1:4	3.8	4.8	28.3
GW-BL	1:1	2.0	3.1	4.2
Peat moss[4]	-	4.1	4.5	21.7
None[4]	-	3.3	4.5	19.4

Table 3. Effect of Soil Conditioners on Growth of Orange Boy Marigold

Components[1]	Ratio	Foliar color[5]	Dry weight[7]
			g
GW-PB[4]	1:1	3.8	6.1
GW-BL-PB	1:1:1	2.2	7.3
GW-BL-PB[4]	1:1:4	4.2	2.6
GW-BL-PB	1:2:7	2.0	1.6
GW-PB[4]	1:4	3.5	6.5
GW-BL	1:1	2.0	1.8
Peat moss[4]	-	4.4	6.1
None[4]	-	3.2	4.5

[1]GW = gin waste, BL = broiler litter, PB = pine bark.
[2]All combination treatments were applied at 20 tons per acre on a dry matter basis.
[3]Peat moss was added to plats at about a one-half to one inch depth.
[4]These treatments received a commercial fertilizer application at the recommended rate of 120 pounds of N per acre.
[5]Foliar color rating scale: 1 = chlorotic, 3 = light green, and 5 = dark green.
[6]DAP = days after planting.
[7]One gram (g) is.035 ounce.

Eakes is Assistant Professor, Shumack is Department Head and Professor, and Gilliam is Professor of Horticulture; Donald is Professor of Agricultural Engineering.

Consumers Favorably Evaluate a Growing Medium Containing Broiler Litter Compost

Bridget K. Behe, Lillie V. Purvis, Lisa M. Beckett, James O. Donald, and Charles H. Gilliam

In 1991, Alabama's poultry industry produced 3.76 billion pounds of broiler chickens, but it was also left with the challenge of disposing of millions of tons of broiler litter without harming the environment. Composted litter can be used in potting media, as a soil amendment, and as a fertilizer, but consumer perceptions of its odor may limit marketability of the byproduct in horticultural products.

An AAES study assessed consumer acceptance of a growing medium amended with litter compost. It was conducted in consumer homes to provide a realistic setting and compare a litter-based product, AUmix, with two commercial alternatives, Baccto and Hyponex. AUmix was comprised of broiler litter compost; aged, amendment-grade pine bark; and horticultural-grade perlite (by volume, 10:10:1).

Determining a perception of an unpleasant odor was the study's primary concern. Few participants noticed any unpleasant odor, and only a minimal amount was detected. Therefore, AUmix odor perceptions should not limit its marketability. On other factors -- water requirements, frond color, and plant health -- AUmix was rated higher than one of the commercial alternatives and about on par with the other. These results indicate that a growing medium amended with broiler litter compost could be acceptable for use in consumer homes.

METHOD

On Oct. 17, 1990, commercially grown two-inch liners of Dallas Jewel fern were transplanted into four-inch diameter plastic containers with one of the media and grown for one week in a fiberglass covered greenhouse. Between Oct. 24 and Nov. 1, consumers randomly chose a set of three ferns that included an instruction sheet, six color-coded forms for weekly evaluations, and six postage-paid envelopes. Containers were labeled as either A, B, or C, and media order was randomly varied in each fern set. Care instructions were provided on commercially-produced tags. Participants were told that the purpose of this study was to evaluate a new potting mix. They were not told that one medium contained broiler litter compost. (See Photo 18, Page 20.)

Consumers included 119 members of Lee County garden and homemaker clubs. Participants ranged in age from 33-85, and 87% had completed some college or earned a college degree. Average per capita income was $21,502, and the average household had 2.5 residents; 88% were female and 12% were male.

From Nov. 2 through Dec. 7, consumers evaluated each fern on four attributes (water required, frond color, plant health, and mix odor), comparing the plant being rated to the other two plants. Ninety-four percent of the consumers completed the study. Consumer ratings were averaged and compared.

RESULTS

Over the six-week evaluation, ferns in Hyponex required the most water (see table). For weeks two through six, ferns in AUmix required an amount of water intermediate to ferns in Hyponex and Baccto. Ferns grown in Hyponex were perceived to be a lighter green when compared to plants in AUmix and Baccto, with similar mean color ratings. Ferns in Hyponex were perceived as less healthy than fern plants in AUmix or Baccto, which received similar mean health ratings. Consumers noticed minimal unpleasant odor from Baccto and Hyponex, less than was noticed from the AUmix (see table). No more than 13% of the participants rated AUmix unpleasant odor a two or higher during the evaluation, and it was judged to be only slightly more unpleasant.

Behe is Assistant Professor, Purvis is former Graduate Student, Beckett is Research Associate, and Gilliam is Professor of Horticulture; Donald is Professor of Agricultural Engineering.

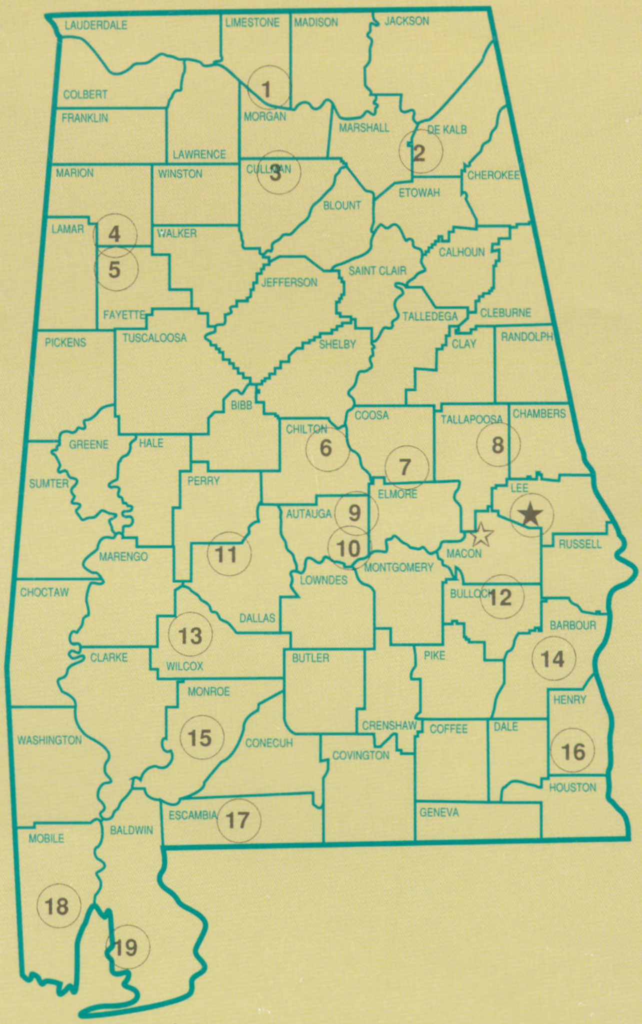
Average Consumer Ratings of Three Media Attributes for Three Media with Dallas Fern Over Six weeks of In-home Evaluations

Medium	Water[1]	Color[2]	Health[3]	Odor[4]
Baccto	3.3	3.7	3.7	1.1
Hyponex	2.2	3.0	3.1	1.1
AUmix	2.3	3.6	3.6	1.2

[1]Water required was rated from 1 = little water required to 5 = a great deal of water required.
[2]Fern frond color was rated from 1 = light green to 5 = dark green.
[3]Fern health was rated from 1 = fair health to 5 = excellent health.
[4]Odor of media was from rated 1 = no unpleasant odor to 5 = strong unpleasant odor.

Alabama's Agricultural Experiment Station System
AUBURN UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the state has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.

☆ E. V. Smith Research Center, Shorter.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Chilton Area Horticulture Substation, Clanton.
7. Forestry Unit, Coosa County.
8. Piedmont Substation, Camp Hill.
9. Foresty Unit, Autauga County.
10. Prattville Experiment Field, Prattville.
11. Black Belt Substation, Marion Junction.
12. The Turnipseed-Ikenberry Place, Union Springs.
13. Lower Coastal Plain Substation, Camden.
14. Forestry Unit, Barbour County.
15. Monroeville Experiment Field, Monroeville.
16. Wiregrass Substation, Headland.
17. Brewton Experiment Field, Brewton.
18. Ornamental Horticulture Substation, Spring Hill.
19. Gulf Coast Substation, Fairhope.