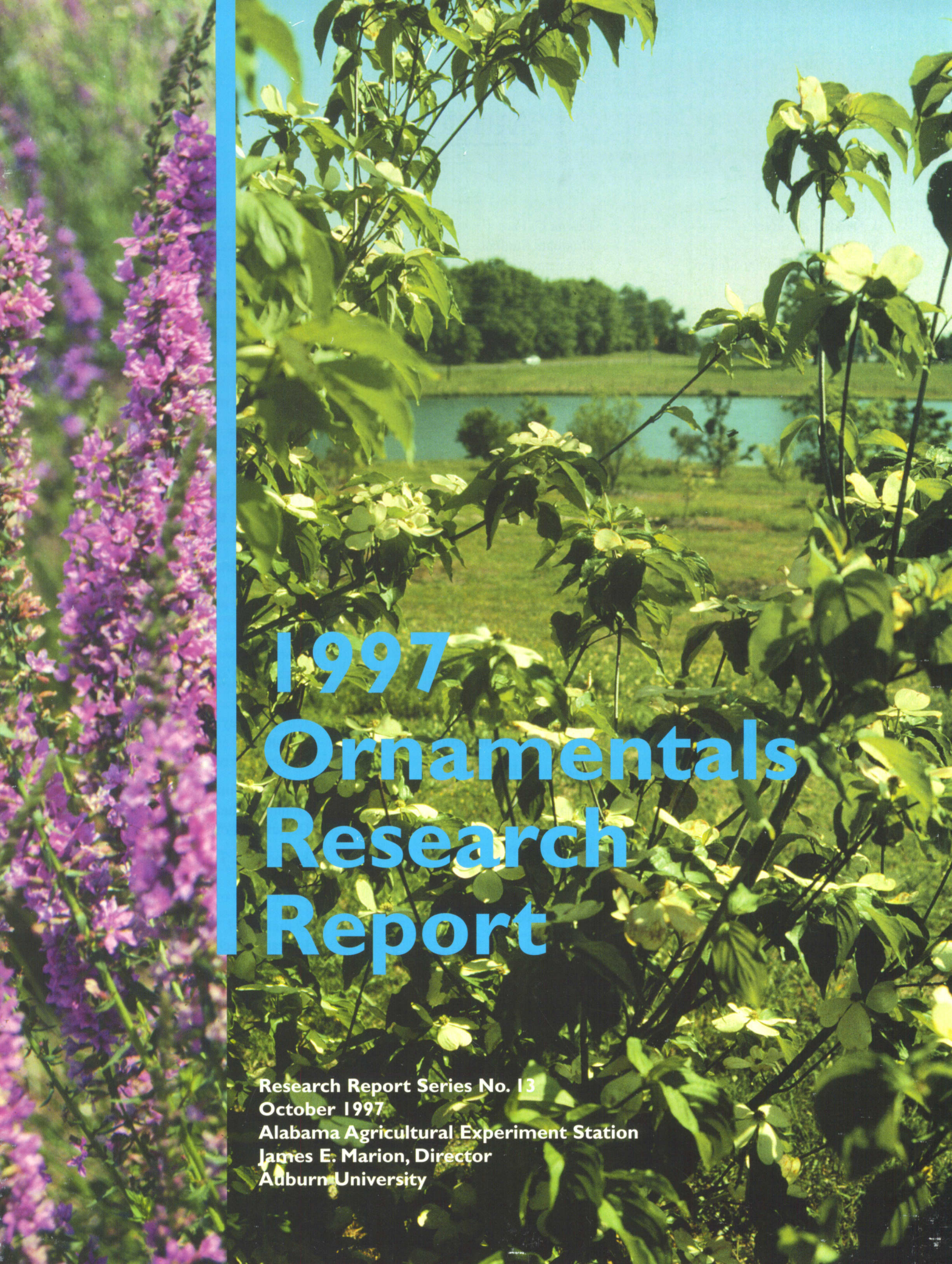

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Alabama Agricultural Experiment Station
James E. Marion, Director
Auburn University

AUTHORS

J. Randall Akridge
Superintendent
Brewton Experiment Station

James S. Bannon
Director
E.V. Smith Research Center

William E. Barrick
Director of Education
Callaway Gardens

Bridget K. Behe
Associate Professor
Department of Horticulture

Kira L. Bowen
Associate Professor
Department of Plant Pathology

Thomas J. Brass
Graduate Student
Department of Horticulture

Arthur H. Chappelka
Associate Professor
School of Forestry

Joseph R. Chamberlin
Field Market Development Specialist
Valent Corp., USA

F. Beth Clendenen
Graduate Student
Department of Horticulture

Cynthia K. Crossan
Graduate Student
Department of Horticulture

William A. Dozier Jr.
Professor
Department of Horticulture

D. Joseph Eakes
Associate Professor
Department of Horticulture

James H. Edwards
Soil Scientist
USDA/ARS

Glenn B. Fain
Research Assistant
Department of Horticulture

Donna C. Fare
Graduate Student
Department of Horticulture

Douglas A. Findley
Graduate Student
Department of Horticulture

Charles H. Gilliam
Professor
Department of Horticulture

James C. Green
Graduate Student
Department of Horticulture

Timothy L. Grey
Graduate Student
Department of Agronomy and Soils

Austin K. Hagan
Professor
Department of Plant Pathology

Ben F. Hajek
Professor
Department of Agronomy and Soils

Brian Hardin
Graduate Student
Department of Horticulture

Charles P. Hesselein
Horticulture Specialist
Department of Horticulture

Jay T. Hudson
Graduate Student
Department of Horticulture

Gary J. Keever
Professor
Department of Horticulture

J. Raymond Kessler Jr.
Assistant Professor
Department of Horticulture

Daniel M. Lauderdale
Graduate Student
Department of Horticulture

Penelope A. Merritt
Graduate Student
Department of Horticulture

John W. Olive
Superintendent
Ornamental Horticulture Substation

Leonard C. Parrott Jr.
Research Technician
Ornamental Horticulture Substation

Harry G. Ponder
Professor
Department of Horticulture

Heath Potter
Graduate Student
Department of Horticulture

Darby M. Quinn
Horticulture Research Specialist
Department of Horticulture

R. Stan Roark
Graduate Student
Department of Horticulture

Laura Sanders-Tucker
Research Associate
Department of Discrete and Statistical Sciences

Jeff L. Sibley
Instructor
Department of Horticulture

Danita R. Smith
Graduate Student
Department of Horticulture

Kenneth M. Tilt
Professor
Department of Horticulture

Catherine M. Walker
Research Technician
Department of Horticulture

Glenn R. Wehtje
Professor
Department of Agronomy and Soils

J. David Williams
Associate Professor
Department of Horticulture

Michael L. Williams
Associate Professor
Department of Entomology

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WOODY LANDSCAPE PLANTS

Styrene Lining and Container Size Affect Substrate Temperature

THOMAS J. BRASS, GARY J. KEEVER, CHARLES H. GILLIAM, AND D. JOSEPH EAKES

Root injury of woody plants may occur when root-zone or substrate temperatures fall below 23°F or rise above 104°F. During the summer, container medium temperatures in the South have exceeded 122°F, while in the winter months ambient air temperatures can fluctuate rapidly or drop below 8°F for short periods of time. Thus, production of container-grown plants requires cultural practices that regulate root-zone temperatures during the summer growing season and during overwintering to ensure adequate growth and plant survival.

One approach for controlling root-zone temperatures is using styrene lining in individual pots. Potential benefits include minimizing the cost and time of applying various production practices to protect plants from extreme temperatures. The objective of this study was to evaluate the influence of container size and styrene lining on substrate temperature patterns in various ambient air temperature regimes.

METHODS

In June 1993, one- and three-gallon containers were filled with a pinebark:sand medium and placed on black polyethylene in full sun. Prior to filling the containers with substrate, 0.1-inch thick, white styrene lining was inserted into half of the containers of each size. Substrate temperatures were recorded hourly from June to August 0.08 inch from the west sidewall. Five clear days with maximum ambient air temperatures of approximately 90°F for a minimum of three hours per day were selected to analyze container substrate temperature patterns during the summer growing season. Temperatures also were recorded from December 1993 to February 1994. Data were analyzed under two conditions when winter injury may occur: days with low ambient temperature throughout the day, and days when wide fluctuations in diurnal temperature occurred. Five days having similar minimum and similar maximum ambient air temperatures were used in each analysis.

RESULTS

SUMMER TEMPERATURES. Substrate temperatures for all treatments showed a similar general response to changes in ambient air temperature. Heating of the substrate in pots of all treatments continued until well after midday when air temperatures began to drop and reached a maximum about 5 p.m. before decreasing (Figure 1). Overall, containers lined with styrene had lower substrate temperatures than unlined containers under ambient conditions in this study. The larger container provided greater buffering of temperatures at the root-zone/container interface than the one-gallon container, regardless of lining treatment, possibly due to the greater substrate volume or thicker sidewalls.

FLUCTUATING WINTER TEMPERATURES. On winter days when wide fluctuations in ambient air temperature occurred over a diurnal cycle, substrate temperature patterns varied with both styrene treatment and container size (Figure 2). When low ambient temperatures occurred, the substrate temperature in styrene-lined containers exceeded that in unlined ones. Also, styrene-lined containers of both sizes had less temperature fluctuation during diurnal cycles compared to unlined containers. These results are significant when one considers that cold hardiness can be lost by brief exposure to mild or high temperatures, rapid changes in temperature can cause more injury than slow changes of a similar magnitude, and roots are more subject to injury from rapid changes in temperature than either stems or leaves.

WINTER TEMPERATURES WITHOUT RAPID FLUCTUATION. When ambient air temperatures lacked wide fluctuations during diurnal cycles, extreme variations in substrate temperatures were not present, and container size had no effect on substrate temperatures (Figure 3). Overall, when low, nonfluctuating temperatures persisted, substrate in lined containers was more insulated against temperature change than that in unlined containers, and substrate temperatures in unlined containers tended to be lower than ambient temperatures.

This study demonstrates potential modification of container substrate temperatures by styrene lining, a material that is lightweight, inexpensive, and easy to install. Styrene lining inserted into black plastic containers insulated the substrate from solar radiation striking the container sidewalls; benefits were most pronounced in smaller-sized containers. Because substrate temperatures in styrene-lined containers were kept from greatly exceeding summer temperatures, higher quality plants and greater growth may be achieved. Lining the container with styrene also reduces heat loss from the container as ambient air temperatures fall, and it insulates against wide fluctuations in substrate temperatures that occur in winter months due to rapidly changing ambient temperatures. Increasing minimum substrate temperatures and reducing temperature fluctuation in styrene-lined containers during winter should decrease low-temperature injury or death of plants. From an applied perspective, inserting a styrene lining at potting may provide much, if not all, of the winter protection needed in the deep South.

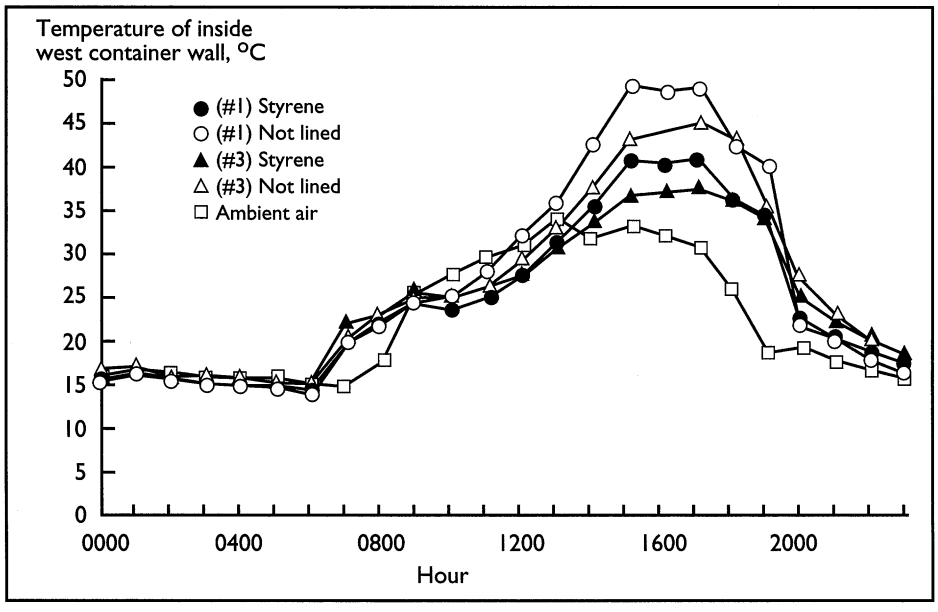


Figure. 1. Summer substrate temperatures adjacent to the west container wall at a four-inch depth; (#1) = one-gallon container; (#3) = three-gallon container.

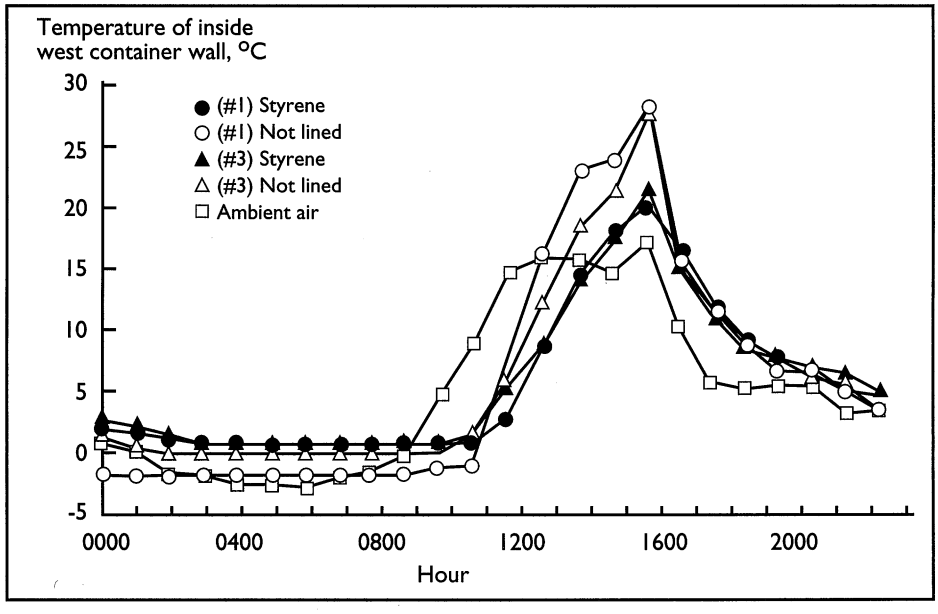


Figure 2. Substrate temperatures adjacent to the west container wall at a four inch-depth with rapidly fluctuating ambient winter temperatures; (#1) = one-gallon container ; (#3) = three-gallon container.

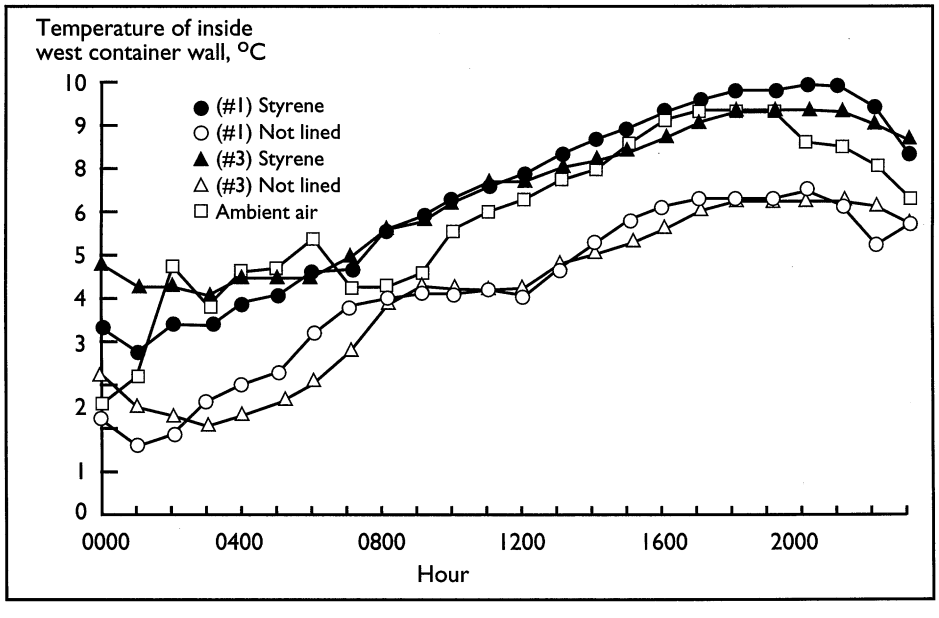


Figure 3. Substrate temperatures adjacent to the west container wall at a four-inch depth without rapidly fluctuating ambient winter temperatures; (#1) = one-gallon container; (#3) = three-gallon container.

Styrene-Lined and Copper-Coated Containers Affect Production and Landscape Establishment of Red Maple

THOMAS J. BRASS, GARY J. KEEVER, D. JOSEPH EAKES, AND CHARLES H. GILLIAM

Densely matted, kinked, and downward-deflected surface roots are common in vigorous plant species grown in containers. Transplanting container-grown stock with poor root development results in poor transplant establishment, increased trunk breakage, poor mechanical stability, and reduced shoot growth. Coating the interior wall of containers with various copper compounds has been effective in limiting root circling and malformation, but this practice is often inconsistent in modifying root growth.

Another problem in container production is high substrate temperatures associated with direct solar radiation striking the container. High temperatures may lead to an increase in water usage, as well as suppressed growth, injury, or dieback of surface roots. A relatively new technique in container production is the use of compressed styrene sheeting inserted into containers to insulate the container medium and possibly alter plant growth. The objective of this study was to determine the effects of copper-coated and styrene-lined containers on root and shoot growth of two bare-root red maple cultivars during production and landscape establishment.

METHODS

In March 1993, an experiment was established with treatments that included all combinations of 'October Glory' and 'Northwood' red maple, with and without styrene lining, and with and without copper coating. Styrene lining, 0.1 inch thick, was cut and inserted to cover pot sidewalls. Copper hydroxide at 13.4 ounces per gallon of latex base (Spin Out) was applied with an electric paint sprayer directly to the containers' interior surfaces or directly to the styrene, which was later inserted into the container. Dormant five-foot-tall whips of each cultivar were planted in seven-gallon containers of amended pinebark:sand medium and grown under nursery conditions. Growth measurements were taken in July and November 1993. Four plants per treatment were left in their original containers during 1994 to determine treatment effects when top growth was disproportionately great relative to container size. In December 1993, six plants in each treatment were repotted into 15-gallon, non-treated black containers. In January 1994, six plants of each treatment were planted in a Marvyn loamy sand soil and watered as needed. Growth of all plants was measured in the summer and fall of 1994.

RESULTS

PLANTS GROWN IN SEVEN-GALLON CONTAINERS DURING 1993. Between summer and fall measurements, 'October Glory' grown in pots with styrene grew more in height than plants in containers without styrene (13.7 inches vs 10.8 inches). At mid-season and at the end of the season, 'October Glory' had thicker trunks than 'Northwood' (Table 1). 'October Glory' was taller than 'Northwood' (8.6 feet vs 8.1 feet) by November. In addition, 'October Glory' had noticeably heavier branching.

Copper-treated containers effectively controlled surface root development, regardless of styrene treatment (83% vs 19% in lined containers; 64.5% vs 17.4% in non-lined containers). In the absence of copper, percent root coverage of the medium-container interface (% MCI) was higher for styrene-lined than for non-lined containers (83% vs 64.5%), which may reflect lower temperatures resulting in less root damage at the medium-container interface. However, in the presence of copper, surface root development was greatly reduced and styrene had no effect. Chemical control of root deflection was achieved for both cultivars using copper hydroxide with or without styrene lining, even though root deflection was greater for 'Northwood.'

There were no styrene or copper effects on dry weight of roots although root systems were visibly more fibrous within the rootball after the primary roots had come in contact with copper-treated surfaces. Dry weight of roots was over 2.5 times higher for 'October Glory' (0.35 ounce) than for 'Northwood' (0.12 ounce).

PLANTS GROWN IN SEVEN-GALLON CONTAINERS DURING 1994. Differences in trunk diameter between 'October Glory' and 'Northwood' were similar to those in 1993. Cultivar plant heights were similar, but branching of 'October Glory' was more extensive than that of 'Northwood,' regardless of copper or styrene treatment. Styrene-lined and copper treated containers had no effect on height or trunk diameter.

Both cultivars had higher % MCI in styrene-lined than in non-lined containers, possibly due to lower surface temperatures in lined containers (Table 2). 'October Glory' had a higher % MCI in non-lined containers than 'Northwood,' while % MCI was similar in styrene-lined containers. Both cultivars had a higher % MCI in containers without copper than in containers with copper (Table 2). Copper was less effective in inhibiting circling roots during the second growing season (60.4%, with copper vs. 81.3%, without) as compared to the first growing season (18.1%, with copper vs. 73.7%, without).

PLANTS REPOTTED INTO 15-GALLON CONTAINERS, 1994. Neither styrene nor copper treatments affected plant height in 1994. However in July and October 1994, trunks of plants originally grown in seven-gallon, copper-treated containers grew less than those never exposed to copper (Table 1). 'October Glory' still had thicker trunks (Table 1), more branching, and denser canopies at the end of the 1994 growing season than did 'Northwood.'

Table 1. Trunk Diameter of 'October Glory' and 'Northwood' Red Maple Grown in Seven-gallon Containers Coated with Copper Hydroxide and Held in Original Pots or Transplanted into 15-gallon Untreated Containers or into the Landscape

Variable	Trunk diameter									
	7-gallon pots (1993)		7-gallon pots (1994)			15-gallon pots (1994)			Field planting (1994)	
	July	Nov.	May	July	Nov.	May	July	Oct.	July	Dec.
	cm	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*
October Glory	2.1	2.8	3.0	3.1	3.1	3.2	3.4	4.6	3.3	3.5
Northwood	1.8	2.1	2.4	2.7	2.9	2.7	3.1	3.4	2.8	3.2
Copper coated	2.1	2.7	2.9	2.9	3.0	2.8	3.0	3.9	3.1	3.4
Non-copper coated	2.0	2.5	2.6	2.7	2.9	2.8	3.4	4.1	3.0	3.3

In the presence of copper, root dry weight was higher for plants previously grown in non-lined containers than for those with styrene lining (Table 3), apparently due to an adverse effect of the styrene-copper combination. In the absence of copper, styrene lining had no effect on root dry weight. Root dry weights in containers originally lined with styrene were less for plants previously grown in containers treated with copper, while in the absence of styrene, root dry weights were higher for plants previously grown in copper-treated containers. After removing root outgrowth from the original rootball, there was a noticeable difference in the original rootball's integrity and root density. When plants were previously grown in copper-treated containers, preservation of the original rootball was maintained by the emergence of a dense network of lateral roots protruding from the rootball which may account for the increased transplant survival and regrowth previously reported. In containers without copper, rootballs tended to fall apart as a result of less root distribution within the original rootball.

LANDSCAPE ESTABLISHMENT. Both cultivars exhibited symptoms of transplant shock. There was little to moderate shoot growth during the growing season, but no leaf drop or stem dieback. Height and trunk diameter for both cultivars previously grown in styrene- or copper-treated containers were not influenced by treatment once planted into the landscape.

'October Glory' had higher regenerated root dry weights than 'Northwood,' regardless of copper treatment (with copper, 10.2 ounces vs. 4.4 ounces; without, 7.4 ounces vs. 4.1 ounces). Additionally, 'October Glory' trees previously grown in copper-treated containers had a higher root dry weight than those grown in non-copper containers (10.2 ounces, with copper vs. 7.4 ounces, without). 'Northwood' had similar root dry weights, regardless of prior copper treatment (4.4 ounces, with copper vs. 4.1 ounces, without).

Regenerated root dry weight, i.e. that after transplanting, also was affected by copper and styrene (Table 3). When containers were treated with copper, plants in styrene-lined containers had produced less root dry weight than those in non-lined containers, while in the absence of copper, styrene lining had no effect on root dry weight. After transplanting, root dry weight for plants previously grown in non-lined containers was higher in copper-treated containers than for plants grown in containers not lined with copper.

This study indicates that the application of copper hydroxide coating to containers can effectively reduce circling of roots along the medium-container interface of bare-root, potted red maple trees. Copper treatment enhanced root regeneration after repotting into larger containers or transplanting into the landscape. The application of copper hydroxide to styrene lining resulted in less root regeneration after transplanting. Copper treatment had no effect on shoot length or trunk diameter of plants grown in containers or transplanted into the landscape during the first year. Styrene lining did not affect shoot length, trunk diameter, or root dry weight of red maple, but higher % MCI was observed. Plant growth was positively influenced by repotting into larger containers, and 'October Glory' performed better than 'Northwood,' regardless of styrene or copper treatment.

Table 2. Percentage of Medium-container Interface Covered with Roots in Seven-gallon Containers, Nov. 1994

Cultivar	Surface covered with roots			
	Styrene lining		Copper coating	
	With	Without	With	Without
	pct.	*pct.*	*pct.*	*pct.*
October Glory	80.7	63.4	57.2	86.8
Northwood	75.6	38.8	55.8	60.0

Table 3. Dry Weight of Red Maple Roots Outside the Original Rootball.

Treatment	Dry weight			
	In 15-gallon containers (Oct. 1994)		Following transplanting (Dec. 1994)	
	Styrene lining		Styrene lining	
	With	Without	With	Without
Copper treated	167	223	177	258
Non-copper treated	194	181	186	157

Use of Composted Organic Waste Products and Fertilizers in Alabama Nurseries

BRIDGET K. BEHE AND CATHERINE M. WALKER

Disposal of organic waste products has come under close scrutiny by government agencies because there is a potential for nitrates to contaminate ground and surface water supplies and to overload landfill capacities. As a result, some industries are seeking new markets in which to distribute wastes. The horticulture industry has the potential to use recycled organic wastes as a growing medium component. Benefits of using composted organic waste products in landscape plant production have been reported.

Composted organic waste can be at least a partial substitute for peat moss in growing media. Poultry waste products in media can reduce fertilizer and water requirements and may improve the quality of water resources. Composted plant and animal waste additives to growing media can potentially reduce nutrient loss in irrigation run-off, thus reducing pollution of water resources by improving media water- and nutrient-holding potential.

METHODS

The objective of this study was to determine how certified Alabama nurseries purchased growing media and fertilizer for their businesses in order to examine the extent of composted waste product use (i.e. animal manures, tree and grass trimmings, etc.) and environmental practices implemented in the horticultural industry. Certified nurseries are container and field producers, wholesalers, and retailers licensed by the state to grow and sell ornamental plant material and represent the population of businesses recognized by the state as nurseries.

Researchers obtained a mailing list of certified nurseries from the Alabama Department of Agriculture in January 1995. A survey with open- and closed-ended questions was designed to ascertain practices related to the use of organic waste products and recycling. Surveys were pre-tested using three Alabama nurseries and modified to clarify responses. Two modified surveys were mailed to each of 648 certified nurseries on Jan. 12 and 26, 1995. Of these, 214 usable responses were returned, yielding a response rate of 33%.

RESULTS

Businesses were first asked what types of plants they produced and marketed in 1994. Of 214 respondents, 37% produced deciduous trees, 43% produced deciduous shrubs, 38% produced perennials, 4% produced Christmas trees, 49% produced evergreens, 37% produced annuals, 5% produced aquatic plants, 33% produced vines and ground covers, and 24% produced other plants not listed. Concerning those plants businesses marketed, 45% sold deciduous trees, 49% sold deciduous shrubs, 47% sold perennials, 19% sold Christmas trees, 58% sold evergreens, 46% sold annuals, 13% sold aquatic plants, 42% sold vines and ground covers, and 23% sold other plants not listed. Plant material grown and sold was quite diverse.

We also asked what percentage of 1994 sales was wholesale and what percentage was retail. The mean percentage of sales that were wholesale was 61%. Thirty-four percent of respondents said 100% of their sales were wholesale, whereas 16% said no sales were wholesale. Twenty percent said 1-49% of their sales were wholesale, and 30% said 50-99% of their sales were wholesale. Nurseries appeared to be vertically integrated with a blend of production and sales functions in the same business.

When asked what percentage of the businesses' 1994 total sales were made outside of Alabama, 43% of respondents said that none of their sales were made outside the state. Twenty-four percent said between 1-49% of sales were out-of-state, and 33% said 50% or more of sales were made outside Alabama. Only one respondent sold all of his or her product outside Alabama. The mean percentage of sales made out-of-state was 29%. Exports caused sales to have regional, if not national, significance.

Businesses were asked how they purchased growing media for plant production. Twenty-one percent bought all their media prepackaged and ready to use. Forty-one percent mixed all their media on-site. Thirty-eight percent bought some media prepackaged and ready to use and mixed some of their own on-site.

Another question concerned the number of cubic yards of media purchased and mixed for plant production in 1994. Twenty-three percent reported they used 50 cubic yards or less, and 18% reported they used 51 to 100 cubic yards. Twenty-nine percent said they used 101 to 500 cubic yards, 11% said they used between 501 and 1,000 cubic yards, 15% said they used between 1,001 and 10,000 cubic yards, and 6% said they used more than 10,000 cubic yards of media in 1994. The average media used by respondents was 28,860 cubic yards.

Respondents were then asked, if they mixed some of their media, which components they used. Sixty-four percent used sphagnum peat moss, 17% used wood chips, 11% used composted animal manure, 13% used sawdust, 27% used vermiculite, and 54% used sand. In addition, 17% used field soil, 81% used bark, 1% used peanut hulls, 2% used rice hulls, 2% used Styrofoam, 36% used perlite, and 13% used other components.

Businesses were also asked the percentage of total media used in 1994 that was comprised of organic components. Two percent of respondents said none of their media was organic, 10% said 1- 49% of their media was organic, 26% said 50-75% of their media was organic, 40% said 76-99% of their media was organic, and 22% said 100% of their media was organic. The mean percentage of media that was organic was 77%.

Businesses also were asked about their environmental practices. Twenty-five percent said they contained irrigation water run-off, 10% said they recycled irrigation water, and 37% said they recycled plastics. Thirty-nine percent of companies said they composted plant material refuse, and 49% said they composted used growing media.

In 1994, Alabama nurseries produced and marketed a diverse product mix of both herbaceous and woody plants, with a large portion of their crop devoted to deciduous shrubs and evergreens. Herbaceous and woody plants often require different growing media and fertilizer schedules, with multiple species further complicating production schedules. A greater percentage of businesses marketed plant material than those that grew it, indicating that at least some businesses purchased plant material for re-sale. A high percentage (61%) offered plants at wholesale; yet, only one-third indicated that their entire stock was sold at wholesale, further indicating the complexity of the businesses. These nurseries operated wholesale and retail operations. A high percentage of nurseries marketed plant material in-state, with only 1% of the participating firms reporting that all their plant material was sold outside Alabama. A large percentage of Alabama nurseries were primarily serving local to regional markets.

Media purchases for plant production were as diverse as the plant material marketed. One-quarter of the firms purchased all of their growing media in a pre-packaged, ready-to-use form, with three-quarters buying some or all of the media components to be mixed on-site. The potential would then exist to market composted waste products to a large percentage of Alabama nurseries for on-site media blending. Amounts of media purchased varied widely, with a mean of 2700 cubic yards.

Media components for on-site blending were even more diverse than plant material sold. Organic components comprised a high mean percentage (77%) of the media components, including peat moss, wood chips, composted animal manure, sawdust, bark, and peanut and rice hulls. Even with a shift in production toward soilless media, 17% of the responding firms used some field soil in their media. Although the use of composted waste products was not overwhelming, the potential exists to develop this market niche.

Using averages, a hypothetical business may use 1,000 cubic yards of media that they blend on-site each year. If 77% of that medium was comprised of organic components (770 cubic yards), perhaps only 25% of the organic components could be substituted with composted waste products (193 cubic yards). No adverse effects on plant production using this rate of composted waste in a growing medium have been shown. Therefore, Alabama could potentially market 194 cubic yards of composted waste material to perhaps half of the certified Alabama nurseries and use nearly 48,000 cubic yards of composted waste annually in plant production. Nursery demand may not be sufficient to use the anticipated 611,680 cubic yards of yard waste compost produced annually in Virginia. Alabamians may find a similar excess in supply.

Alabama currently has no state legislation that is more stringent than EPA guidelines (10 ppm nitrate nitrogen in drinking water). Yet, one-quarter of the certified nurseries contain irrigation water, and 10% recycle it. There is also no legislation regulating plastic disposal, and an even higher percentage of nurseries has taken the initiative to recycle plastics. Some communities regulate the composition of landfills. Apparently, some nurseries have responded by composting both plant material and growing media refuse. These results indicate a proactive strategy in coping with waste disposal. One nursery added, "I would very much like to use composted waste materials if an affordable, consistent source could be located."

Many Alabama nurseries have adopted environmentally conscious practices, including the use of composted organic waste as growing media components, use of controlled-release fertilizers, containment and/or recycling of irrigation water, and composting waste plants and media. The adoption of such practices should put these businesses in a favorable position within the community, and, if legislation is passed, they should be prepared to easily comply with the new regulations. The potential exists to market composted waste products to nursery producers, and they could comprise a substantial segment of the market for disposal of such products. More nurseries may adopt environmentally friendly practices even without legislation.

Production of Six Woody Landscape Plants in Copper-Coated and Styrene-Lined Containers

THOMAS J. BRASS, GARY J. KEEVER, CHARLES H. GILLIAM, D. JOSEPH EAKES AND CHARLES P. HESSELEIN

Because high container temperatures may lead to a reduction in root and shoot growth and death of root tips, many approaches to minimize high temperature root stress have been examined. A recent method using compressed styrene sheeting inserted into containers for insulation reduced maximum growth medium temperatures up to 14°F. However, effects of styrene-lined containers on shoot and root growth have not been evaluated.

An additional problem in container production is circling and matting of roots at the perimeter of the growth medium, which has a negative impact on plant growth and root regeneration. Coating the interior of containers with various copper-containing compounds inhibits root circling and results in a more fibrous root system. The objective of this study was to determine the influence of styrene-lined and copper-coated containers on production and landscape establishment of six woody landscape species.

METHODS

Liners of azalea, Southern magnolia, Blue Princess holly, pittosporum, gardenia, and oleander were potted into one-gallon containers with or without styrene lining and with or without copper coating in April 1993. Styrene, 0.1 inch thick, was cut to cover the interior sidewall but not the bottom of containers. A spray of 3.3 ounces of copper hydroxide per quart of latex base (Spin Out) was applied to the interior surface of the unlined containers or directly to the styrene with an electric paint sprayer. Plants were placed in full sun and watered daily. Shoot growth was determined in July and November 1993 and root growth in November. Six plants per treatment of each species were repotted in December 1993 into three-gallon, non-treated containers and evaluated in May and November 1994. In January 1994, six plants of azalea, gardenia, and holly were field planted in a Marvyn loamy sand soil to determine treatment effects on landscape establishment.

RESULTS

PLANTS GROWN IN ONE-GALLON CONTAINERS IN 1993. Surface root growth of all species measured at the end of the first growing season was effectively controlled by Cu-treated containers (Table 1), while styrene lining had no effect on surface root coverage. Magnolia grown in copper-coated containers were seven inches shorter than those grown in non-coated containers in July and November 1993. Magnolia had less trunk diameter growth between July and November 1993 when grown in copper-coated containers compared to non-coated containers. Styrene lining had no effect on plant height of magnolia or growth index of the remaining species during the first growing season.

PLANTS GROWN IN THREE-GALLON CONTAINERS DURING 1994. Percent surface root coverage of gardenia in May 1994 was higher for plants previously grown in non-coated containers (47%) than for plants previously grown in copper-coated containers (25%). Gardenia also had more surface root coverage in May 1994 when previously grown in styrene-lined containers (46%) than in unlined containers (26%); however, by November 1994 surface root coverage was nearly 100% and was similar for plants regardless of styrene treatment. Copper or styrene had no effect on percent surface root coverage for any other species in May 1994, probably because of the lack of surface root development in all treatments. At the end of the growing season (November 1994), azalea, gardenia, and pittosporum had higher percent surface root coverages when previously grown in non-coated compared to copper-coated containers (Table 3). Azalea and pittosporum previously grown in copper-coated containers had few roots present along rootball surfaces. Percent surface root coverage of holly, oleander, and magnolia in November 1994 was less when previously grown in copper-coated containers compared to non-coated containers, regardless of styrene treatment (Table 4). In the absence of copper, plants previously grown in styrene-lined containers had more surface root coverage than those previously grown in unlined containers. Dry weights of newly generated roots outside the original rootball recorded in May and November 1994 were not affected by treatment except for holly in May. Holly previously grown in copper-coated containers had a lower root dry weight (0.05 ounce) than plants previously grown in non-coated containers (0.08 ounce).

Copper or styrene had no effect on trunk diameter or height of magnolia, or growth index of other species in May 1994. However, by November 1994, growth index of gardenia was five inches less for plants previously grown in copper-coated containers than for those previously grown in non-coated containers. Furthermore, growth index of gardenia previously grown in styrene-lined containers was higher (37 inches) than that of plants previously grown in unlined containers (35 inches).

LANDSCAPE ESTABLISHMENT DURING 1994. Dry weight of newly regenerated roots outside the original rootball was not affected by treatment for either azalea or gardenia. Root dry weight of holly was higher for plants previously grown in non-coated containers (0.2 ounce) than in copper-coated containers (0.06 ounce), a response similar to

Table 1. Percent Surface Root Coverage at the Growth Medium-container Interface for Six Species Grown in Containers With or Without Copper Treatment, November 1993

Species	Copper	
	Coated[1]	Non-coated
	pct.	*pct.*
Azalea	2	65
Gardenia	2	68
Oleander	2	64
Pittosporum	2	40
Holly	2	24
Magnolia	2	24

[1]Coated with copper hydroxide.

Table 2. Percent Surface Root Coverage at the Growing Medium-container Interface for Plants Grown in Containers Coated or Not Coated with Copper Hydroxide in 1993 and Repotted into Three-gallon Containers

Species	Percent root coverage[1]	
	Copper-coated	Non-coated
	pct.	*pct.*
Azalea	5.0	98.1
Gardenia	48.8	53.7
Pittosporum	3.8	82.5

[1]Evaluations made in November 1994.

Table 3. Percent Surface Root Coverage at the Growing Medium-container Interface of Three Species Previously Grown in Containers With or Without a Copper Hydroxide Coating and With or Without Styrene Lining in 1993 and Repotted into Three-gallon Containers in December 1993

Species	Copper treatment	Percent root coverage[1]	
		Styrene lined	Not styrene lined
Holly	Copper-coated	8.8	5.5
Holly	Non-copper coated	85.0	67.5
Magnolia	Copper-coated	22.0	10.3
Magnolia	Non-copper coated	90.4	77.0
Oleander	Copper-coated	7.5	12.5
Oleander	Non-copper coated	98.8	89.8

[1]Evaluations made in November 1994.

that of holly repotted into three-gallon containers.Azalea growth index was higher for plants previously grown in non-coated containers than for plants grown in copper-coated containers (17 inches, non-coated vs. 15 inches, copper-coated).

Coating interior surfaces of containers with copper hydroxide is an effective method of controlling circling roots of many species of woody landscape plants. However, root and shoot growth a growing season after repotting or transplanting into the ground are not always enhanced and, in the case of holly, root growth was less. Lining containers with styrene has little effect on surface root development during the first year of production, but enhances root development in some species in the year following repotting. With a few exceptions, significant benefits in plant shoot growth and root regeneration from copper coating or styrene lining of containers were not realized in this study.

Tree Transplant Size Influences Post-Transplant Growth, Gas Exchange, and Leaf Water Potential

DANIEL M. LAUDERDALE, CHARLES H. GILLIAM, D. JOSEPH EAKES, GARY J. KEEVER, AND ARTHUR H. CHAPPELKA

Water stress of newly transplanted trees has been reported to be a limiting factor in the growth and productivity of urban trees. Water stress is compounded in transplanted trees, since new roots may begin to develop in one to two weeks after digging.

New growth depends on photosynthetic rates high enough to provide carbohydrates for growing tissues and storage for later use. Water stress and/or root removal, which may cause reduced photosynthesis, can result in limited shoot growth. High root to shoot ratios, which occur for small transplant sizes have been shown to encourage shoot growth compared to large transplants.

In the northern U.S., work with a computer model based on tree growth showed that five years after transplanting, the regenerated root system of a tree with a 10-inch trunk diameter will be only about 25% of the original size. A tree with a four-inch trunk diameter transplanted at the same time will replace its root system after about five years. Quicker regeneration of root systems for smaller trees may result in greater top growth than larger trees transplanted at the same time. Limited data are available in the Southeast concerning the influence of tree transplant size on subsequent growth. This study was initiated to evaluate the effects of tree transplant size on performance after transplanting.

METHODS

Two tree species, 'October Glory' red maple and water oak were transplanted in two balled and burlapped tree sizes, 1.5 and three inches caliper, in Mobile at either a park or residential site. The 1.5-inch trunk diameter transplants had root balls 18 inches in diameter, while three-inch trunk diameter transplants had root balls 32 inches in diameter. All trees were hand dug.

Both tree species were planted in Mobile Municipal Park, which consists of playgrounds, picnic areas, and has a history of plant vandalism. This area receives heavy weekend use. Residential plantings included 'October Glory' red maples planted in an older, medium-income area, while water oaks were planted in a nearby, low-income area. Trees were planted in May 1993 by city personnel. Particle size for soil at Municipal Park was 78% sand, 19% silt, and 3% clay in areas where both species were planted. Particle size for soil at the red maple residential site was 80% sand, 18% silt, and 2% clay, while soil at the willow oak residential site consisted of 81% sand, 15% silt, and 4% clay. Soil pH in the park ranged from 5.4 to 7.1, while soil pH in both residential areas ranged from 5.7 to 6.

Planting holes were dug twice the width and the same depth as the root ball. Trees were placed in the planting holes, burlap and cord removed, and two-thirds of the soil was backfilled. Trees were then watered in and the remaining soil was added. Trees were hand irrigated twice per week during the summer of 1993. No irrigation was applied during 1994 other than natural rainfall. During March 1994 all trees were fertilized with 0.4 pounds of 13-13-13 (one pound N per caliper inch measured at six inches above the soil surface).

Growth data collected during the first and second growing seasons included: height increase (determined each year as the increase in height from the previous year on trees with less than 25% crown dieback), trunk diameter increase (determined each year as the increase in trunk diameter from the previous year at six inches above the soil surface), and shoot elongation (based on growth from dormant bud to terminal and taken as an average of three randomly selected shoots).

Red maples were selected for gas exchange and water potential evaluation. Gas exchange on clear to partly cloudy days was monitored on a single, randomly selected, fully expanded leaf from the side of the canopy with LI-COR 6250 Portable Photosynthesis Systems (LI-COR, Inc., Lincoln, Neb.) on Aug. 25-26, 1993; June 13-14, 1994; and Aug. 11-12, 1994. Maples at park and residential sites were monitored over the same period of time by utilizing two LI-COR portable Pn systems. Each tree was evaluated using a different leaf starting at 9 a.m., 11 a.m., 1 p.m., and 3 p.m. for a total of four observations per tree per day.

During the course of this study trees were visually evaluated in August 1993 and September 1994 for general health, as well as specifics such as percent crown dieback and death.

RESULTS

GROWTH. During 1994, an interaction occurred between location and transplant size for maples. Although maple transplant size had no effect at the residential site, small maples at the park site had height increases of 12 centimeters (4.7 inches), compared to two centimeters (0.7 inches) for large maples. Transplant size had no effect on maple caliper increases during 1993, while lateral shoot elongation was greater for small maples (Table 1). During 1994, small maples had height increases six times greater than that of large maples. Trunk diameter increases in 1994 were about twice as great with small maples compared to large maples. Shoot elongation for small maples during 1993 and 1994 was two and four times, respectively, greater than that of large maples. Greater shoot elongation for small maple transplants may indicate that they were under less stress than large transplants.

Small willow oaks had height increases greater than that of large oaks during 1993, but not in 1994. Willow oak shoot elongation and trunk diameter increase were not affected by transplant size in either year (Table 1). These data indicate that field-grown willow oaks can be transplanted in these sizes with similar success.

Greater height increases, trunk diameter increase, and shoot elongation for small maple transplants support other work which showed that 13 years after transplanting, a four-inch trunk diameter tree transplanted at the same time as a 10-inch diameter tree may have a shoot system of similar size. These data also support research which reported that small transplants have better shoot growth after transplanting due to a higher root to shoot ratio compared to large transplants.

GAS EXCHANGE. Small maples had greater net photosynthesis (Pn) rates than large transplants during August 1993, June 1994, and August 1994 observations (data not shown). Greater Pn for small maples indicates that they were under less stress than large maples during the first two growing seasons. Higher Pn for small maples than large maples may partially explain greater shoot elongation. Higher Pn during the first growing season likely contributed to the capacity of smaller trees to store more carbohydrates, which aided growth the second year. Regardless of transplant size maples had greater Pn rates during 1994 than 1993.

Transpiration of small maples was greater than that of large maples on all sampling dates (data not shown). More transpirational water loss by small maples indicate a greater potential for water and nutrient uptake by the root system if they were available. Storage of carbohydrates and nutrients one year may aid growth the following year. Transpiration and photosynthesis, regardless of transplant size during 1994, was greater than in 1993, possibly due to greater rainfall in 1994. Monthly precipitation was 2.03, 1.21, and 3.52 inches below normal in June, July, and August 1993, respectively. However, during the summer of 1994, precipitation was above normal in June and July (0.43 and 3.54 inches), compared to 4.94 inches below normal in August 1994.

WATER POTENTIAL. Mean daily leaf water potentials taken during gas exchange observations and pre-dawn leaf water potentials in August 1993 were greater for small than large maples. These data indicate that small maples rehydrated to a

greater extent overnight from moisture deficits that occurred during the previous day than large trees. These data indicate small maples were under less moisture stress during the first growing season than large maples. Transplant size had no effect on daily leaf water potential during 1994; however, small maples had greater pre-dawn leaf water potential compared to large maples at the August 1994 sampling dates, but not in June 1994.

Data collected in 1993 support the theory that one of the first and most important plant processes adversely affected by moisture stress is gas exchange. Higher leaf water potentials (less negative) or lower levels of moisture stress for small maples during gas exchange observations may have resulted in the higher gas exchange observations when compared to large maples.

Based on gas exchange and leaf water potential data, small transplants of 'October Glory' red maple underwent less transplant shock than larger transplants. These data indicate that smaller red maple trees established more readily in the landscape than the larger transplants.

TREE HEALTH. At the end of the 1993 growing season, large maple transplants at both sites had greater numbers of trees with crown dieback than small trees (data not shown). For example, no crown dieback occurred on small maples at the residential site, while all large maples exhibited some percentage of dieback. At the park planting site one small maple and seven large maples exhibited varying levels of crown dieback. After the 1994 growing season, fewer maples exhibited dieback than during the 1993 growing season. Willow oaks followed a similar trend at the park site. However, oak trees at the lower-income residential site had extensive crown dieback regardless of transplant size. Three small willow oaks had 75-100% crown dieback, while five large willow oaks had 75-100% crown dieback at that site.

Results from this study demonstrate that transplant size is an important variable to consider when planting trees in urban environments. Small maple trees had more growth during the first two years after transplanting due to their ability to overcome transplant stress quicker, as indicated by greater gas exchange and higher leaf water potentials (daily and pre-dawn), than large trees. Smaller transplants may reduce planting cost, maintenance, and replacement costs.

Table 1. Effects of Tree Size at Transplanting on Growth in Mobile, Ala.

Variable	*Acer rubrum* 'October Glory'				*Quercus phellos*			
	1993		1994		1993		1994	
	Small[1]	Large[2]	Small	Large	Small	Large	Small	Large
Height increase (cm)	7.3a[3]	5.3a	34.3a	5.7b	12.5a	1.4b	12.8a	30.2a
Shoot elongation (cm)	11.4a	6.1b	22.4a	5.5b	3.5a	2.1a	10.3a	8.4a
Trunk diameter increase (mm)	4.1a	2.7a	14.1a	7.1b	2.4a	2.8a	17.9a	17.6a
Trees measured	16[4]	16	14	15	13	10	13	10

[1]Small = 3.8-centimeter (1.5-inch) trunk diameter at transplant.
[2]Large = 7.6-centimeter (three-inch) trunk diameter at transplant.
[3]Mean separation by date and species within rows by LSD, P = 0.05. Data followed by different letters are significantly different from other data in the same row.
[4]Number of trees measured out of 16 having less than 25% crown dieback.

Weed Control in Container-Grown Crops With Herbicide-Coated Fertilizers

CYNTHIA K. CROSSAN, CHARLES H. GILLIAM, GARY J. KEEVER, D. JOSEPH EAKES, GLENN R. WEHTJE, AND WILLIAM A. DOZIER, JR.

Weed control is essential in producing high quality container-grown landscape plants. Standard weed control methods include broadcast or spray application of pre-emergence herbicides over container-grown plants. However, previous work has shown that with broadcast herbicide applications nontarget herbicide losses may range up to 86% depending on container spacing and plant growth habit. Nontarget herbicide losses are a primary contributor to herbicides in runoff water from container nurseries.

Numerous techniques have been evaluated to reduce or eliminate chemical losses in container production, including the use of slow-release herbicide tablets, geotextile disks, and geotextile disks containing a slow release formulation of trifluralin. In previous research, Ronstar-coated and Ronstar-blended Nursery Special 12-6-6 provided effective control of prostrate spurge at four, eight, and 16 pounds of active ingredient per acre in container-grown 'August Beauty' gardenia. Weed control was similar to that

obtained with standard application methods (sprayed or broadcast at four pounds of active ingredient per acre), but with substantially less herbicide applied since direct application to individual containers eliminated nontarget herbicide loss.

Since container nurseries top-dress plants with different controlled-release fertilizers, this study was conducted to evaluate several fertilizers to determine if fertilizer carrier affected herbicide activity. The objective of this study was to compare Ronstar 50WP coated on three fertilizer carriers to Ronstar applied by standard methods for control of prostrate spurge and crabgrass.

METHODS

One-gallon containers were filled with a pine bark:sand medium (6:1 by volume), amended with five pounds per cubic yard of dolomitic lime and 1.5 pounds per cubic yard of Micromax on April 14, 1994. Containers were placed in a double-layer polyethylene greenhouse and hand watered as needed. Ronstar 50WP herbicide-coated fertilizer treatments were prepared as previously described with Nursery Special 12-6-6, Polyon 24-4-12, and Osmocote 17-7-12. Calculations were based on the surface area of a trade-gallon container receiving 0.23 ounces (6.5 grams) of Nursery Special or 0.7 ounces (20.0 grams) of either Osmocote or Polyon fertilizer (manufacturer's recommended topdress rates). Ronstar 50WP was coated onto the fertilizer at different concentrations so that applying either 0.23 ounces of Nursery Special or 0.7 ounces of Osmocote or Polyon to a container resulted in the simultaneous application of Ronstar at two, four, eight, and 16 pounds of active ingredient per acre. Fertilizer-herbicide combinations were spread evenly over a the container surface by hand on May 5, 1994. A non-weeded control and a Ronstar 50 WP sprayed treatment applied at the manufacturer's recommended rate of four pounds of active ingredient per acre were included for comparison.

One week after applying treatments, half of the containers were over-seeded with 10 seeds each of prostrate spurge and the other half over-seeded with large-seeded crabgrass. Spurge or crabgrass seedlings were counted 30 days after treatment (DAT). At 60 DAT, weeds were pulled, counted, and fresh and dry weights determined.

The experiment was repeated in March 1995 with some changes. A broadcast application of Ronstar 2G at four pounds of active ingredient per acre was added as an additional control. Untreated controls received either 0.23 ounces (6.5 grams) of Nursery Special or 0.71 ounces (20 grams) of Osmocote or Polyon (not coated with herbicide). Ronstar 50 WP (sprayed) and Ronstar 2G (broadcast) were applied as standard treatments at the manufacturer's recommended rate of four pounds of active ingredient per acre. Each container was over-seeded with 30 prostrate spurge seed one week after treatment.

RESULTS

SPURGE CONTROL. Due to similar results at 30 and 60 DAT, only 60 DAT data are presented. In both experiments, spurge number decreased linearly as the Ronstar concentration in the coated Osmocote increased (Table 1). Ronstar-coated Osmocote rates of four to 16 pounds provided similar spurge control to the spray applied control in Experiment 1. In Experiment 2, where the weed pressure was greater (30 seeds per container), only the two higher rates provided similar control to the spray- or broadcast-applied control.

Table 1. Effects of Ronstar 50WP (Oxadiazon)-coated Fertilizers on Prostrate Spurge Number per Container 60 DAT, Experiments 1 and 2

Treatment	Pounds of active ingredient per acre					
	0	2	4	8	16	Mean[1]
Experiment 1						
Osmocote (O)[2]	4.7	1.6	1.2	0.6	0.2	0.9
O Sprayed	—	—	0.0	—	—	
Polyon (P)[2]	4.1	0.6	0.3	0.1	0.1	0.3
P Sprayed[3]	—	—	0.0	—	—	
Nursery Special (N)2	4.9	1.8	1.6	1.2	0.6	1.3
N Sprayed[3]	—	—	0.1	—	—	
Experiment 2						
Osmocote (O)	5.6	4.3	3.2	1.2	0.0	2.2
Sprayed	—	—	0.0	—	—	
O Broadcast	—	—	0.6	—	—	
Polyon (P)	3.9	0.4	0.0	0.0	0.0	0.1
P Sprayed	—	—	0.0	—	—	
Broadcast	—	—	0.0	—	—	
Nursery Special (N)	5.4	2.4	0.3	2.5	0.0	1.3
N Sprayed	—	—	0.0	—	—	
Broadcast	—	—	0.8	—	—	

[1]Mean of respective fertilizer across rate, 0 rate not included.
[2]Fertilizer coated with Ronstar 50WP (oxadiazon) at the specified rate.
[3]Containers sprayed with Ronstar 50WP (oxadiazon) and top-dressed with the corresponding fertilizer.

Ronstar-coated Polyon provided excellent spurge control at all rates in both experiments. For example, at the lowest herbicide rate, spurge numbers per container were 0.6 and 0.4 in the two experiments. When comparing the fertilizer carriers, spurge control was superior with Polyon in both experiments.

With Ronstar-coated Nursery Special, spurge number decreased linearly in both experiments as the Ronstar rate increased. Spurge control with the two- and four-pound rates of Ronstar-coated Nursery Special was less than with the spray applied control in Experiment 1. Although the eight- and 16-pound treatments had 1.2 and 0.6 spurge plants per container, respectively, both were similar to the Ronstar 50WP spray applied control. In Experiment 2, only the four- and 16-pound treatments provided similar control to the spray and broadcast applied treatments.

While there was no difference in weed number between the sprayed and broadcast Ronstar formulations in Experiment 2, there was a trend for the Ronstar 2G treatment to numerically have more spurge per container. This trend concurs with other work where wettable powder (WP),

emulsifiable concentrate (EC), and granular (G) Ronstar formulations were compared and the WP formulation provided better prostrate spurge control than the G formulation two months after application.

CRABGRASS CONTROL. Germination of crabgrass was low compared to spurge. With Ronstar coated-Osmocote and -Nursery Special treatments all herbicide rates, except the two-pound treatment, provided almost total crabgrass control at both 30 and 60 DAT (data not shown). Ronstar has been reported to be effective in controlling many weed species including large-seeded crabgrass. Fresh and dry weed weights of both crabgrass and spurge followed similar trends to weed numbers.

When comparing fertilizer carriers, Polyon generally provided superior crabgrass control, possibly due to herbicide adhesion or sorption on the fertilizer coating, which may affect herbicide release onto the medium surface after the first irrigation. Other possibilities include oxadiazon binding to the resin coating thus interfering with oxadiazon activity. While the mechanism is unclear, oxadiazon coated-Polyon did provide better weed control in the two studies than herbicide-coated Osmocote or Nursery Special.

These data indicate Ronstar 50WP-coated, controlled-release fertilizers can provide effective weed control in nursery container production. Coated Polyon provided better weed control than coated Osmocote or Nursery Special. Previous research showed that rates higher than the recommended rate may be necessary to achieve satisfactory weed control, while in the current study similar weed control was obtained with the recommended rate coated onto a fertilizer carrier. Even if higher than recommended rates are needed, less total herbicide would be applied per unit area because of application to individual containers. Herbicide-coated fertilizers should be considered as an alternative to the standard spray or broadcast application of pre-emergence herbicides to reduce potential pesticide movement in critical areas where zero pesticide levels must be maintained in runoff water.

Growth of Selected Red Maple Cultivars in Containers

JEFF L. SIBLEY, D. JOSEPH EAKES, AND LAURA SANDERS-TUCKER

Container production of shade and ornamental trees is increasingly important to the horticulture industry. Container production of trees offers numerous advantages over traditional field production, including instant year-round availability. Field studies have shown considerable variation in performance (growth, fall color, regional adaptability) among red maple cultivars; however, there is a lack of adequate information on growth rates during container production.

New red maple cultivars appear almost annually, with about 55 named cultivars currently available in the trade. Red maple cultivars from both the *Acer x freemanii* (red maple x silver maple interspecific cross) and Acer rubrum categories were evaluated in a container study to determine annual growth rates under similar growing conditions. Included were *A. x freemanii* cultivars 'Armstrong,' 'Autumn Blaze' (Jeffersred), and 'Celebration' (Celzam); and A. rubrum cultivars 'Autumn Flame,' 'Fairview Flame,' 'Firedance' (Landsburg), 'Franksred' (Red Sunset), 'Northfire' (Olson), 'Northwood,' and 'October Glory.'

METHODS

Trees liners about six inches tall were obtained in March 1995 and 1996 as acclimated tissue culture liners, rooted cuttings, and bare-root whips from tissue culture origins. All trees were of a similar initial size each year with the exception of 'Northwood' in 1996 (which were approximately 18 inches tall). Trees were planted in three-gallon containers in an amended pinebark/sand (6:1 by volume) growth medium. Trees were grown in full sun from March to December each year under standard nursery practices in Auburn. Overhead irrigation was supplied to each tree twice daily.

Annual Growth Rates in Containers for Selected Red Maple Cultivars

Cultivar	Height 1995	Height 1996	Mean height[1]	Caliper 1995[2]	Caliper 1996[3]
	in.	*in.*	*in.*	*in.*	*in.*
Armstrong	46	41	44	0.47	0.67
Autumn Blaze	—[4]	51	51	—	0.71
Autumn Flame	47	47	47	0.54	0.85
Celebration	49	44	46	0.59	0.69
Fairview Flame	39	41	40	0.47	0.75
Firedance	35	33	34	0.40	0.42
Franksred	44	41	42	0.52	0.60
Northfire	44	45	44	0.49	0.69
Northwood	—	33	33	—	0.57
October Glory	44	43	44	0.65	0.74

[1]From soil line to tip of terminal bud.
[2]Caliper taken six inches above soil line in 1995.
[3]Caliper taken two inches above soil line in 1996.
[4]Autumn Blaze and Northwood not included in 1995.

RESULTS

Growth was similar for individual cultivars both years (see Table). 'Autumn Blaze,' 'Autumn Flame,' and 'Celebration' had height growth of about four feet each year, with most cultivars growing at least three feet each year. Caliper measurements taken at two inches and six inches above the soil line were similar each year.

This information is beneficial for growers selling a finished product to homeowners or shifting up to larger containers. Growth rates for newer introductions 'Firedance' and 'Northwood' were poor in this study, whereas growth rates during production for 'Celebration' and 'Northfire' look promising. For example, the average height increase for 'Northwood' was about 15 inches, as compared with an average height increase of about 40 inches for 'Celebration.' However, longer term evaluations in field studies or urban landscapes to evaluate fall color, limb and scaffold strength, frost cracking, and pest resistance are necessary to present a complete picture of the desirability of newer introductions.

Evaluation of Propagation Method on Performance of Two Red Maple Cultivars

JEFF L. SIBLEY, D. JOSEPH EAKES, CHARLES H. GILLIAM, GARY J. KEEVER, AND WILLIAM A. DOZIER, JR.

Current methods of propagation for cultivars of red maple (Acer rubrum L.) include softwood cuttings, tissue culture, and budding onto seedling rootstocks. Often, losses exceed 50% in the first year, and 10-20% in the second year as a result of bud union incompatibility in selected cultivars.

In a previous red maple evaluation conducted by the AAES, bud union failure was evident in eight of nine cultivars tested within three years after planting. All trees included were budded onto seedling rootstocks. The only cultivar without visible compatibility problems was 'Red Sunset.' 'October Glory' was not included in previous evaluations.

Few studies have reported data from direct comparisons between budded and tissue-cultured microplantlets. However, a field study initiated in 1988 to evaluate the influence of tissue culture and budding propagation systems on the growth of 'Franksred' (Red Sunset) and 'October Glory' is beginning to yield important information for growers of these popular red maple cultivars. Specific characteristics evaluated included mortality and annual growth rates.

METHODS

'Franksred' and 'October Glory' were obtained in March 1988 from A. McGill & Son Nurseries of Fairview, Ore., as tissue-cultured microplantlets, and as budded trees on seedling rootstocks. Trees were containerized and grown for two years in Auburn, Ala. Trees ranged from four to five feet in height when transplanted in March 1990 into a Cecil gravelly sandy loam soil at the Piedmont Substation in Camp Hill, Ala.

The trees were planted on a 30X35-foot spacing and were fertilized in March prior to bud break with one pound of nitrogen (N), phosphorus (P), and potassium (K), as 13-13-13, per one inch of caliper at planting and in subsequent years. Drip irrigation was supplied to each tree through the 1994 growing season. Height and caliper increases were determined by the difference in current and previous year measurements following the 1990 through 1995 growing seasons.

RESULTS

With the exception of 1995 increases for 'October Glory' (Table 1), annual increases in mean height were not different during any of the first six growing seasons for tissue cultured versus budded plants for either cultivar. Mean height growth attained for budded 'Franksred' was four inches greater annually in this study than that reported in previous evaluations at the same substation. Differences may be attributed to trickle irrigation for the current study, and no supplemental irrigation in previous evaluations. Final mean heights for 'Franksred' from tissue culture and budded propagation were 16 feet and 15 feet, seven inches, respectively. No 'Franksred' trees have been lost to date from bud union incompatibility. However, variability in total final height for individual budded trees had a range of five feet, six inches from the smallest to the largest tree. The difference in total final height for the tissue cultured trees was three feet from smallest to largest.

Final mean heights for 'October Glory' from tissue culture and budded propagation were 18 feet and 16 feet, eight inches, respectively. Variability in total final height for individual budded trees was greater than seven-feet, three-inches from the smallest budded 'October Glory' (13 feet, nine inches) to the largest budded tree (21 feet). The difference in total final height for individual tissue-cultured trees was four feet, eight inches. In June 1993, one 'October Glory' died in this study as a result of bud union incompatibility. No physiological or physical evidence of bud union problems were evident prior to the tree breaking off at ground level during heavy winds.

With the exception of 1993 increases for 'Franksred' (Table 1), annual increases in mean caliper were not different

Table 1. Mean Height and Caliper Increases for Select Red Maple Cultivars from Tissue Culture Versus Budded Propagation

Propagation	1991		1992		1993		1994		1995		Avg. annual increase	
	Height	Caliper	Height	Caliper	Height	Caliper	Height	Caliper	Height	Caliper		
	in.	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
'Franksred'												
Tissue culture	31.5	0.51	28.7	0.67	27.6	0.91	28.3	0.83	5.5	0.31	24.4	0.67
Budded	29.1	0.47	28.7	0.75	24.0	0.75	28.0	0.83	4.7	0.28	23.2	0.63
'October Glory'												
Tissue culture	25.6	0.55	34.7	0.79	34.3	1.14	31.2	0.94	11.8	0.84	27.5	0.86
Budded	24.4	0.63	35.8	0.87	37.8	1.02	29.7	0.91	5.6	0.68	26.7	0.82

during any of the six years for tissue cultured versus budded plants for either cultivar. Tissue-cultured 'Franksred' trees had a 21% greater caliper increase than the budded trees in 1993. Annual increases seen in the caliper growth for budded 'Franksred' were again greater under irrigation than those reported in the earlier evaluations. Final calipers for 'Franksred' from tissue-culture and budded propagation were 4.4 inches and 3.9 inches, respectively. Final calipers for 'October Glory' from tissue-culture and budded propagation were 5.5 inches and 4.9 inches, respectively.

Either method of propagation appears to be suitable for 'October Glory' and 'Franksred.' In this ongoing study, losses have been minimal to this point. Therefore, selecting a propagation method based on production costs for a particular method is justified for these two cultivars. Economic concerns for selecting one propagation method over another may be the determining factor for individual nurserymen. In many nurseries, the sequencing of production schedules determines the merit of selecting propagation methods. There are many advantages for growers who bud or graft as a standard means of propagation in a number of species.

Although many red maple cultivars have exhibited bud union incompatibility problems, serious concern for incompatibility problems 'October Glory' and 'Franksred' cannot be substantiated from this study at this time. However, if uniformity is an important factor in a grower's production and marketing plan, tissue-cultured trees offer a better alternative due to variability in trees from budded production.

Fertilizer Placement and Media Influence Azalea Growth

CHARLES P. HESSELEIN, KENNETH M. TILT, AND DONALD J. EAKES

For the past two years, several growers have had large numbers of plants in certain cultivars die in their gallon azalea production. Particularly hard hit were the cultivars 'Snow,' 'Coral Bells,' and 'Pink Pearl.' An AAES study was designed to test the possibility that these problems were related to fertilizer placement or potting media.

The study focused on two media (pine bark:shredded peat moss vs. pine bark:shredded peat moss:wood shavings) in combination with two methods of slow-release fertilizer application (dibble vs. media incorporated). Results demonstrated that neither fertilizer placement nor media were primarily responsible for plant die-off. However, this test shows that fertilizer placement and medium components can influence plant growth and quality.

METHODS

On July 2, 1996, 72 cell pack azalea liners of 'Coral Bells,' 'Snow,' and 'Pink Pearl' were planted in plastic trade-gallon pots. The four treatments consisted of plants planted in amended 3:1 (volume:volume) pine bark:shredded peat moss medium (BP) or in a 2:1:2 pine bark:shredded peat moss:wood shavings medium (BPS). Fertilizer (Osmocote 17-7-12, 12-14 month formulation) was applied either by dibbling beneath the liner at the rate of 0.42 ounces (12 grams.) per pot or incorporated into the media at an equivalent rate (approximately 7.5 pounds per cubic yard). At the end of the growing season each plant's growth index was measured, and a foliar color rating (a within-cultivar comparative scale of 1-5, with 1 = least green plant in each cultivar and 5 = darkest green plant in each cultivar) was performed.

RESULTS

The responses to the different treatments varied with cultivar. Overall, the growth index and foliar color rating of plants in the dibbled fertilizer treatments were higher than or equal to the plants in the incorporate treatments (Table 1, Figure 1). For 'Coral Bells,' dibbled fertilizer increased the growth

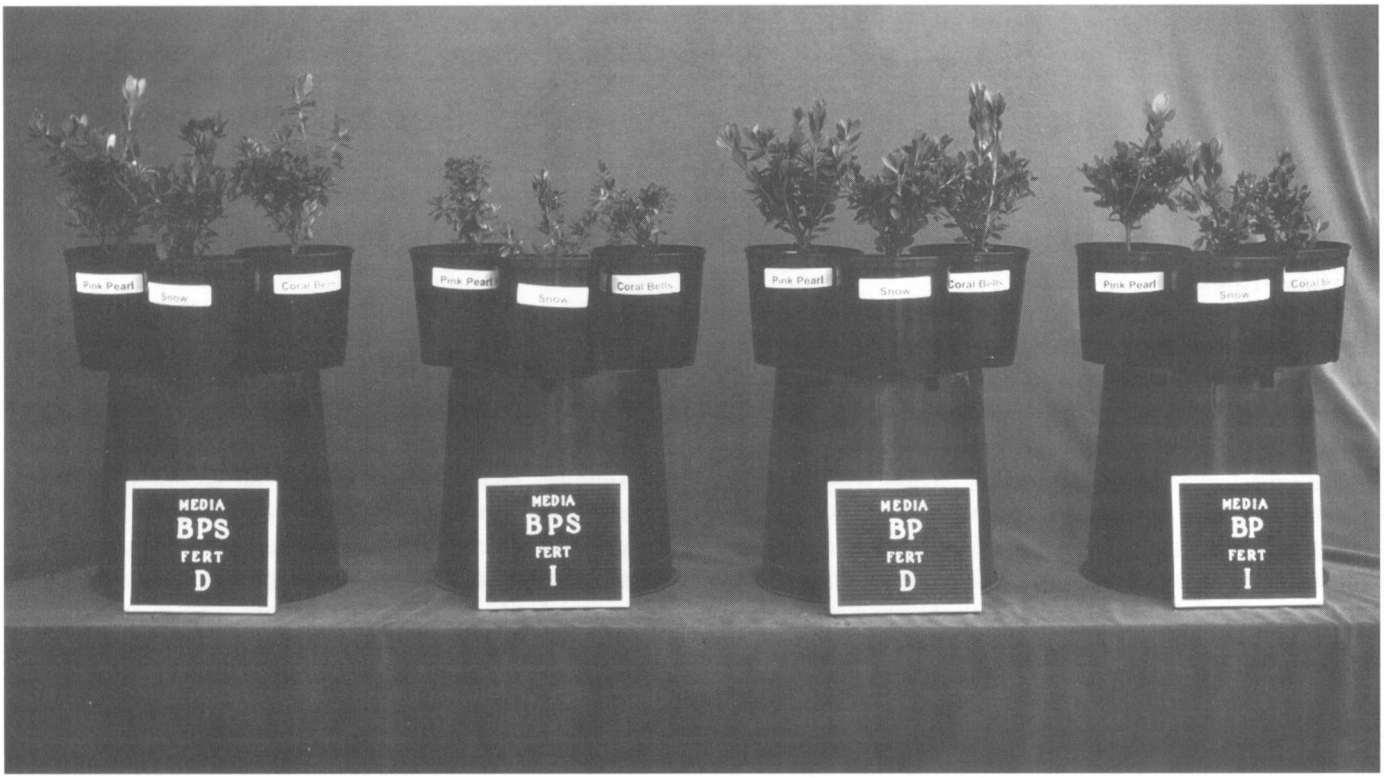


Figure 1. Growth responses of three cultivars of azaleas ('Pink Pearl,' 'Snow' and 'Coral Bells') to fertilizer (dibbled and incorporated) and medium (BP = bark:peat, and BPS = bark:peat:wood shavings).

index by 50% in the BPS medium and 19% in the BP medium. For 'Pink Pearl,' dibbled fertilizer increased the growth index in the BP medium by 63%. For 'Snow,' dibbled fertilizer increased growth index by 27% in the BPS medium and 18% in the BP medium.

Differences in foliar color ratings between the fertilizer treatments were noted in 'Coral Bells' and 'Pink Pearl' in the BPS medium. For 'Coral Bells,' the foliar color rating was 4 for dibbled and 2.9 for incorporated in BPS. For 'Pink Pearl,' the rating was 4.3 for dibbled and 2.4 for incorporated in BPS.

Plants planted in the BP medium had a growth index and foliar color rating higher than or equal to plants planted in the BPS (Table 1, Figure 1). The growth index for 'Pink Pearl' was 44% higher in BP than in BPS for dibbled fertilizer treatments. For 'Snow,' the growth index in BP was 13% higher than BPS in incorporated fertilizer treatments.

Foliar color ratings for 'Coral Bells' were 3.8 in BP and 2.9 in BPS when fertilizer was incorporated. For 'Pink Pearl,' ratings were 3.9 in BP and 2.4 in BPS when fertilizer was incorporated. Some of the differences between media may be the result of incompletely composted shavings and bark in the BPS medium. Bacteria active in the composting process utilize nitrogen, often creating a nitrogen deficiency.

Since different fertilizers, plant species, and even cultivars within species have different characteristics, these results cannot be extrapolated beyond the information presented. However, these results are indicative of how incremental changes in practices applied to specific crops can yield significant beneficial results.

Table 1. Growth Indexes and Foliar Color Ratings of Azaleas as Influenced by Media Composition and Fertilizer Placement

Cultivar	Media[1]	Fertilizer placement	Growth index[2]	Color rating[3]
'Coral Bells'	BPS	Dibble	8.3	4.0
'Coral Bells'	BPS	Incorporated	5.5	2.9
'Coral Bells'	BP	Dibble	7.5	4.3
'Coral Bells'	BP	Incorporated	6.3	3.8
'Pink Pearl'	BPS	Dibble	7.1	4.3
'Pink Pearl'	BPS	Incorporated	6.7	2.4
'Pink Pearl'	BP	Dibble	0.2	4.2
'Pink Pearl'	BP	Incorporated	6.3	3.9
'Snow'	BPS	Dibble	7.5	4.6
'Snow'	BPS	Incorporated	5.9	2.9
'Snow'	BP	Dibble	7.9	4.8
'Snow'	BP	Incorporated	6.7	4.3

[1]Media are 2:1:2 Pine Bark:Shredded Peat Moss:Wood Shavings (BPS), and 3:1 Pine Bark: Wood Shavings (BP).
[2]Growth Index = (height + width1 + width2)/3. Width1 is the widest point; width2 is perpendicular to width1.
[3]Foliar color rating scale is a within cultivar comparative scale of 1-5, with 1 = least green plant in each cultivar and 5 = darkest green plant in each cultivar.

HERBACEOUS LANDSCAPE PLANTS: PRODUCTION AND RETAIL

Pro-Shear-Induced Offset Formation in Hosta Dependent on Cultivar

JAMES M. GARNER, GARY J. KEEVER, D. JOSEPH EAKES, AND J. RAYMOND KESSLER

Previous studies have demonstrated the effectiveness of Pro-Shear in promoting the outgrowth of rhizomic and axillary buds in hosta. Furthermore, offsets formed from Pro-Shear-induced buds can be removed from the mother plant soon after elongation and rooted under intermittent mist. Earlier studies were conducted using blue hosta (*Hosta sieboldiana*) only, yet considerable differences in response to Pro-Shear application are possible due to the large number of recombinations from which cultivars of this genus are derived. The objective of this study was to determine differences in offset production among hosta cultivars in response to Pro-Shear application.

METHODS

Single-eye (no offsets) plants of 10 hosta cultivars (Table 1) were treated with a foliar application of 0, 1,250, 2,500, or 3,750 parts per million (ppm) of Pro-Shear. At 30 and 60 days after treatment (DAT), visible offset counts and a growth index were determined for each plant.

RESULTS

Offset formation in hosta in response to Pro-Shear application was cultivar-dependent. At 30 DAT, more offsets were produced by treated plants than by controls for BD, FR, FW, KR, and RS (see Table 1 for a definition of abbreviations). Compared to controls, increases in offset counts at optimal Pro-Shear rate ranged from 116% (FR) to 3,500% (FW). Offset counts increased with increasing Pro-Shear rate in FR, FW, and RS, but in KR, optimal response to Pro-Shear was achieved at the intermediate rate, 2,500 ppm. For BD the highest number of offsets was formed in plants receiving 3,750 ppm. Offset counts for treated plants were similar to controls in AM, GS, MA, UA, and WB at 30 DAT.

Offset counts generally increased between 30 and 60 DAT, and at 60 DAT, the response of most cultivars (AM, BD, FW, GS, KR, RS, UA, and WB) to Pro-Shear was similar to that observed at 30 DAT. Offset counts for treated plants were higher than those of controls at 60 DAT in BD, FW, KR, MA, and RS. Compared to controls, increases in offset counts at optimal Pro-Shear rate ranged from 150% (RS) to 2,250% (FW).

At 30 DAT, control plants of AM, FR, GS, RS, UA and WB had formed more offsets than other cultivars, indicating that these cultivars readily form offsets in the absence of Pro-Shear. Among treated plants, BD, GS, KR, and RS formed more offsets at 30 and 60 DAT than other cultivars in the study.

The growth index, measured at 30 and 60 DAT, generally increased or was not affected by Pro-Shear rate. Plants displayed no phytotoxic symptoms as a result of Pro-Shear application, and plant appearance was often enhanced by the outgrowth and development of Pro-Shear-induced offsets.

Pro-Shear application to hosta may decrease production time of a wide range of cultivars, including certain cultivars that are otherwise slow to produce offsets, possibly increasing efficiency and decreasing production costs. Among the cultivars evaluated in this study, Pro-Shear application to BD, FR, FW, KR, MA, and RS resulted in the largest increase in offset production. Understanding the cultivar-dependent response to Pro-Shear application appears to be a key factor in capitalizing on Pro-Shear-induced offset formation and development during hosta production.

Table 1. Offset Counts of Hosta Cultivars at 30 and 60 Days after Treatment (DAT) with Four Pro-Shear Rates

Rate	Offset counts for each cultivar[1]									
	AM	BD	FR	FW	GS	KR	MA	RS	UA	WB
30 DAT										
0	2.1	0.4	1.9	0.1	3.9	0.5	0.2	2.9	2.5	3.4
1,250	3.1	4.7	2.5	1.0	5.9	5.2	0.1	6.3	2.2	2.7
2,500	3.2	4.1	2.9	1.6	3.4	6.9	1.5	8.6	2.2	2.7
3,750	2.6	4.8	4.1	3.6	4.6	5.4	0.7	10.4	3.3	2.5
60 DAT										
0	3.4	0.5	3.7	0.2	4.4	0.8	0.5	4.4	4.0	3.7
1,250	3.7	5.4	2.9	0.9	5.6	5.7	0.5	6.7	5.0	2.9
2,500	4.6	4.3	4.6	1.9	4.6	7.7	2.4	9.0	5.5	3.9
3,750	3.0	5.6	4.5	4.7	4.2	5.7	2.1	11.0	5.1	3.1

[1]AM = *Hosta fortunei* 'Aureo-marginata,' BD = *H.* 'Big Daddy,' FR = *H.* 'Francee,' FW = *H.* 'Francis Williams,' GS = *H.* 'Gold Standard,' KR = *H.* 'Krossa Regal,' MA = *H. montana* 'Aureo-marginata,' RS = *H.* 'Royal Standard,' UA = *H. undulata* 'Albo-marginata,' WB = *H.* 'Wide Brim.'

Sequential Pro-Shear Applications Enhance Offset Formation in Hosta

JAMES M. GARNER, GARY J. KEEVER, D. JOSEPH EAKES, AND J. RAYMOND KESSLER

Hostas, herbaceous perennials in the lily family, are conventionally propagated by crown division, but this method yields relatively few plants per clump and is typically accomplished only annually. Rapid increases in plant numbers and the introduction of new cultivars are delayed due to slow multiplication through annual division. Previous studies have demonstrated that application of the synthetic cytokinin Pro-Shear induces the outgrowth of rhizomic and axillary buds in hosta, and offsets formed from Pro-Shear-induced buds can be removed from the mother plant soon after elongation and rooted under intermittent mist. These findings suggest that Pro-Shear-stimulated offsets can provide an effective alternative to conventional propagation methods. Growers propagating hosta in this manner may wish to utilize hosta stock plants as a source for Pro-Shear-stimulated offset cuttings, and harvest cuttings repeatedly over a given season. The objective of this study was to determine the effects of multiple Pro-Shear applications and subsequent repeated removal of Pro-Shear-induced offsets on offset yield from hosta stock plants.

Table 1. Offset Number at 30, 60, 90, and 120 Days after Initial Treatment (DAT) in Two Hosta Cultivars Treated with 0-4 Applications of 3,000 ppm Pro-Shear

DAT	'Francee'					'Francis Williams'				
	0	1	2	3	4	0	1	2	3	4
30	3.7	4.5	—	—	—	0.0	3.9	—	—	—
60	4.9	3.6	5.9	—	—	0.0	2.4	3.7	—	—
90	1.2	1.4	3.5	6.0	—	0.0	0.0	1.0	5.4	—
120	0.0	0.0	0.0	1.0	5.6	0.0	0.0	0.0	1.0	5.2

METHODS

Container-grown, single-eye (no offsets) plants of hosta 'Francee' and 'Francis Williams' were treated with zero, one, two, three, or four foliar applications of 3,000 parts per million (ppm) Pro-Shear. Initially, 40 plants of each cultivar received Pro-Shear treatment and 10 controls of each did not. At 30-day intervals thereafter, offsets were removed from each plant. The number of treated plants was then reduced by 10, and Pro-Shear was reapplied to the remaining plants, resulting at 90 days after initial treatment (DAT) in a total of five treatments. At 30, 60, 90, and 120 DAT, visible offset count and a growth index were determined for each plant.

RESULTS

As in previous studies, Pro-Shear application promoted formation of offsets in hosta. At 30 DAT, offset counts were higher in treated plants of both cultivars compared to untreated controls (Table 1). At 60 DAT, plants of 'Francis Williams' that had been retreated had higher offset counts than controls or plants that received only one Pro-Shear application. In 'Francee' at 60 DAT, sufficient offsets had formed in controls such that offset counts in controls or plants not retreated were similar to retreated plants. At 90 and 120 DAT, plants of both cultivars that were retreated following offset removal had higher offset counts than controls or plants not retreated.

Repeated Pro-Shear application was required to achieve a continued response in offset production, but removal of offsets prior to reapplication of Pro-Shear did not appear to affect subsequent response to Pro-Shear. Total offset yield increased with an increasing number of Pro-Shear applications. Total yield of offsets with zero, one, two, three, or four Pro-Shear applications was 9.8, 9.5, 13.9, 17.4, or 22 for 'Francee' and 0, 6.3, 8.6, 14, or 18.2 for 'Francis Williams,' respectively. Compared to controls, there was a 124% increase in offset counts for plants of 'Francee' that received Pro-Shear applications. With Pro-Shear applications, 'Francis Williams' averaged 18 total offsets per plant, while no offsets formed in controls over the 120-day period.

This study indicates that hosta stock plants could be treated with Pro-Shear at 30-day intervals throughout the growing season to provide greater numbers of offsets than could otherwise be obtained by crown division. A practical system for the accelerated multiplication of hosta could be of benefit to growers by allowing them to propagate hosta efficiently and economically. A propagation system for hosta which employs Pro-Shear application to stimulate the outgrowth of offsets could facilitate rapid multiplication of cultivars that do not readily form offsets. These findings are a significant step in the development of such a system.

The Use of Pistill for Garden Mum Production in South Alabama

CHARLES P. HESSELEIN, J. RAYMOND KESSLER, GARY J. KEEVER, AND LAURA SANDERS-TUCKER

Garden mums are a familiar sight in Alabama nurseries throughout the summer and fall. Traditionally, these crops require removal of growing tips (pinching) to stimulate lateral branching and thus the production of a fuller, more floriferous plant. Pinching garden mums is a time-consuming, labor-intensive procedure.

Two recent developments have called into question the necessity of this practice. The first has been the improvement in the lateral branching of new garden mum cultivars through breeding. The second is the use of the growth regulator, Pistill (ethephon), which stimulates lateral branching of a number of ornamental crops, producing fuller, higher quality plants. This study examined the effects of Pistill on garden mums for the past two years and found that for many growers the practice of pinching or the use of Pistill may not be necessary to produce quality potted garden mums.

METHODS

On July 9, 1996, researchers planted five commonly grown garden mum cultivars ('Bravo,' 'Sarah,' 'Tracy,' and 'Valerie' from Yoder's Prophets series and 'Yellow Jacket') into trade-gallon containers using an amended 3:1 (volume:volume) pine bark:peat potting mix.

The original plan was to include the following six treatments: a single pinch, two pinches, or a single pinch plus one or two applications of Pistill at the rate of 500 or 750 ppm active ingredient. These treatments were used for the cultivar 'Yellow Jacket.' However, because the flower buds of 'Bravo,' 'Sarah,' 'Tracy,' and 'Valerie' appeared to develop sooner, these plants were pinched only once. Thus, the treatments for these cultivars consisted of no pinch, one pinch, or no pinch plus one or two applications of Pistill at the rate of 500 or 750 ppm of Pistill. Plants were pinched or sprayed with Pistill when shoots had about one to 1.5 inches of new growth.

After recording the flowering date, several characteristics of these garden mums were measured and analyzed, including the number of flowers, the date of flowering, the height of the plants, and a growth index. Flowering date was recorded when 75% of the flowers of any plant were fully open.

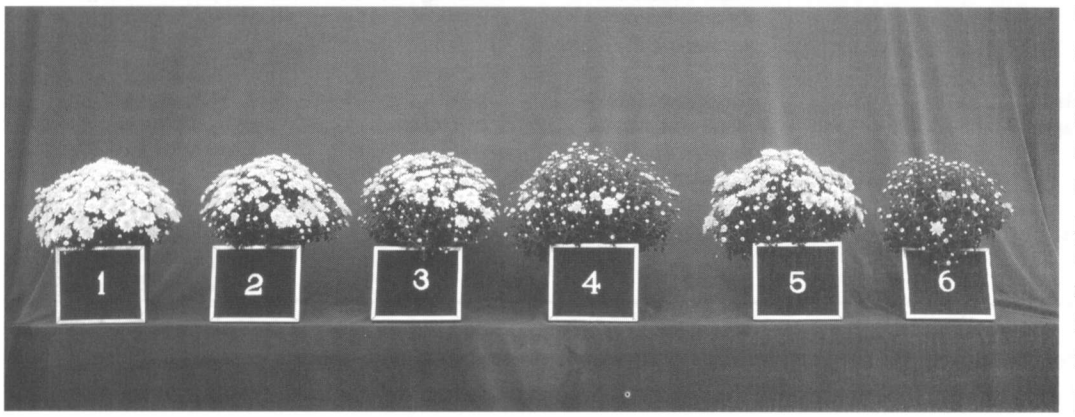


Figure 1. Cultivar 'Yellow Jacket' 1 = 1 pinch, 2 =2 pinches, 3 =1 pinch + 1 spray 500 ppm a.i. Pistill, 4 =1 pinch + 2 sprays 500 ppm a.i. Pistill, 5 = 1 pinch + 1 spray 750 ppm a.i. Pistill, 6 = 1 pinch +2 sprays 750 ppm a.i. Pistill.

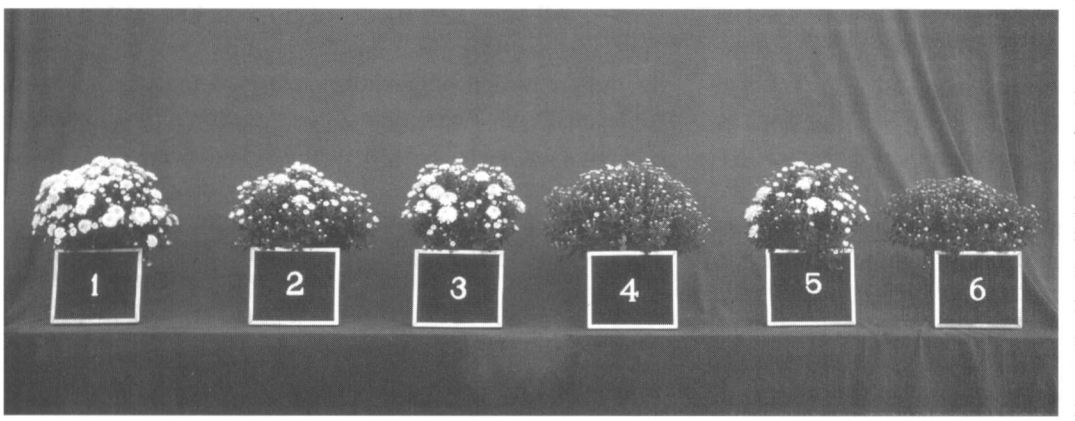


Figure 2. Cultivar 'Tracy' 1 = no pinch, 2 = 1 pinch, 3 = no pinch + 1 spray 500 ppm a.i. Pistill, 4 = no pinch + 2 sprays 500 ppm a.i. Pistill, 5 = no pinch + 1 spray 750 ppm a.i. Pistill, 6 = no pinch + two sprays 750 ppm a.i. Pistill.

RESULTS

The effects of Pistill varied with cultivar and for each characteristic measured. For 'Bravo,' 'Tracy,' and 'Sarah,' single Pistill applications increased flower number by 46%, 46%, and 34%, respectively, when compared to pinched plants (Table 1). For 'Tracy' and 'Sarah,' two Pistill sprays increased flower number 19% and 16% over single sprayed plants.

Flowering delay was noted in at least one cultivar for all treatments (Table 2). An extra pinch caused a three-day delay for 'Yellow

Table 1 The influence of Pistill and Pinching on the Flowering of Garden Mums

Cultivar	No pinch vs. 1 pinch	1 pinch vs. single application Pistill treatments	500 ppm a.i. Pistill vs. 750 ppm a.i. Pistill	1 application vs. 2 applications
'Bravo'	no differences	229 flowers vs. 334 flowers	no differences	no differences
'Tracy'	no differences	224 flowers vs. 329 flowers	no differences	329 flowers vs. 392 flowers
'Sarah'	no differences	137 flowers vs. 184 flowers	no differences	184 flowers vs. 214 flowers

Table 2 The influence of Pistill and Pinching on Garden Mum Flowering Date

Cultivar	No pinch vs. 1 pinch	1 pinch vs. 2 pinches	1 pinch vs. single Pistill applications	500 ppm a.i. Pistill vs. 750 ppm a.i. Pistill	1 Pistill application vs. 2 applications
'Yellow Jacket'	NA	two pinches delayed flowering by approx. 3 days	single application Pistill treatments flowering delayed an average of five days	750 ppm delayed flowering an average of 3 days	2 Pistill applications flowering an delayed flowering an average of 6 days
'Bravo'	no differences	NA	single application Pistill treatments delayed flowering an average of 4 days	no differences	2 Pistill applications delayed flowering an average of 3 days
'Tracy'	no differences	NA	single application Pistill treatments delayed flowering an average of 2 days	750 ppm delayed flowering an average of 2 days	2 Pistill applications delayed flowering an average of 6 days
'Sarah'	one pinch delayed flowering by approx. 2 days	NA	single application Pistill treatments delayed flowering an average of 4 days	750 ppm delayed flowering an average of 1 day	2 Pistill applications delayed flowering by an average of 3 days
'Valerie'	no differences	NA	no differences	no differences	2 Pistill applications delayed flowering an average of 3 days

Jacket' and a two-day delay for 'Sarah.' Single applications of Pistill caused a flowering delay of two to five days beyond the single pinch treatment for 'Yellow Jacket,' 'Bravo,' 'Tracy' and 'Sarah'. Two applications of Pistill caused an average flowering delay of seven to 11 days beyond the single pinch treatment for 'Yellow Jacket,' 'Bravo,' 'Tracy,' and 'Sarah' and only four days for 'Valerie.' Sprays of 750 ppm caused an additional one- to three-day delay in flowering for 'Yellow Jacket,' 'Tracy,' and 'Sarah,' when compared with 500 ppm sprays. Two applications of Pistill delayed flowering an average of three to six days beyond single application treatments for all cultivars. Flowering delay could benefit the grower who wishes to sell a particular cultivar over a greater period of time or it may represent an unwanted delay in flowering.

Pistill treatments increased growth index in 'Yellow Jacket,' 'Bravo,' 'Tracy,' and 'Sarah' an average of 16%, 13%, 7% and 13%, respectively. Two sprays caused an increase in the growth index of 'Yellow Jacket' and 'Bravo' by 17% and 10%, respectively, over single spray treatments.

Treatment-related height differences were only noted in 'Tracy' and 'Sarah,' with Pistill treatments causing a 7% and 13% increase in height, respectively, over unsprayed plants. Several shoots lacking flower buds were observed in plants receiving 750 ppm. These non-flowering shoots detracted from the overall appearance of the plant.

All treatments produced good quality, salable plants. Thus, pinches or applications of Pistill may not be necessary for the production of quality potted garden mums in South Alabama. Depending on the grower's market, the increase in flowering and plant size provided by Pistill sprays may prove cost effective. In addition, the flowering delay demonstrated by the use of Pistill may be a useful tool for manipulating the timing of the final product.

Slag Fiber as a Potting Media Component Affects Growth of Poinsettia

J. RAYMOND KESSLER, JR. AND BRIDGET K. BEHE

Slag fiber is a mineral-based, fibrous material used in the construction industry to fire-proof cement and sound-proof buildings. This light-gray material is composed of loose flocks of small fibers formed by spinning a molten composite of furnace slags and other materials from a coke-fired cupola. Typical chemical composition consists of 45% SiO_2, 35.2% CaO, 9.5% MgO, 7.2% Al_2O_3, and trace amounts of other inorganics. The commercial product is available in several grades based on particle size.

Slag fiber has many of the same properties as granulated rockwool, a material widely used in the greenhouse industry as a potting media component. Rockwool has a total porosity similar to peatmoss but with little water- or nutrient-holding capability. The pH of rockwool is 7, which necessitates a reduction in conventional lime rates to achieve the pH often used in greenhouse pot culture. However, the base mineral used to manufacture slag fiber differs from rockwool, and its utility as a potting media component is unknown. Therefore, a study was conducted to examine the growth response of poinsettia to media amended with slag fiber.

METHODS

Five media containing increasing percentages of slag fiber were developed and compared to two industry standards: a commercially available peat-lite medium, Fafard 3B, and a Cornell Peat-lite Mix B. Slag fiber (Fiberwear G, 90% at least three-eights-inch in diameter) was obtained from Sloss Industries of Birmingham, Alabama. The five peat:slag fiber combinations were 100:0, 75:25, 50:50, 25:75, and 0:100 (volume/volume). Dolomitic limestone application was based on the recommended rate for a Cornell Peat-lite Mix B (eight pounds per cubic yard) with 50:50 peatmoss:perlite. Lime rates were adjusted for each slag fiber medium based on the percent of peatmoss as follows: zero, four, eight, 12, or 16 pounds per cubic yard for peatmoss:slag fiber combinations of 0:100, 25:75, 50:50, 75:25, or 100:0, respectively. Superphosphate at 4.5 pounds per cubic yard and Micromax at 1.5 pounds per cubic yard were added to the Cornell Peat-lite Mix B and all slag fiber media.

Rooted cuttings of the poinsettia cultivars 'Freedom Red,' 'Freedom Pink,' and 'Freedom White' were transplanted into six-inch pots containing the seven media on Aug. 14, 1996, and placed in a polyethylene-covered greenhouse. Fertilization was applied on a constant liquid feed basis using 300 ppm nitrogen from calcium nitrate alternated with 300 ppm nitrogen from 20-10-20. Epsom salt was applied every four weeks at one pound per 100 gallons. Established cuttings were given a soft terminal pinch on Sept. 2, 1996. No plant growth retardant or night-interrupted lighting was used.

Soil tests were performed by the Auburn University Soil Testing Laboratory on samples taken of all slag fiber media and the Cornell Peat-lite Mix B before potting and when flowers were open to a marketable stage in the first week of December. Plant performance was evaluated by measuring plant height, growth index, and the number of flowering shoots on each plant. Each plant was assigned a quality rating (see Table 1 for definition of scale).

RESULTS

Plants of poinsettia 'Freedom Red' grown in Fafard 3B, Cornell Peat-lite Mix B, 100% peat, or 75:25 peat:slag wool were similar in plant height, growth index, and quality rating (Table 1). Those grown in 50:50, 25:75, and 0:100 peat:slag fiber were smaller and of poorer quality. The number

Table 1. Effects of Slag Fiber as a Media Component on Growth of Three Poinsettia Cultivars Compared to Two Industry Standard Media

Medium	Height[1]	Growth index[2]	Flower shoot number	Quality rating[3]
'Freedom Red'				
Fafard 3B	48	55	9.0	4.0
Cornell Peat-lite Mix B	48	54	7.9	3.9
100% peat:0% slag fiber	48	53	8.6	4.1
75% peat:25% slag fiber	46	50	8.6	3.8
50% peat:50% slag fiber	43	45	8.1	3.0
25% peat:75% slag fiber	41	40	6.9	2.2
0% peat:100% slag fiber	35	29	5.2	1.1
'Freedom Pink'				
Fafard 3B	48	53	8.3	4.1
Cornell Peat-lite Mix B	47	51	8.8	3.8
100% peat:0% slag fiber	45	48	8.0	3.2
75% peat:25% slag fiber	43	45	7.3	3.0
50% peat:50% slag fiber	49	50	7.6	3.0
25% peat:75% slag fiber	43	39	6.0	2.4
0% peat:100% slag fiber	31	25	3.2	1.4
'Freedom White'				
Fafard 3B	49	54	8.2	3.6
Cornell Peat-lite Mix B	46	50	8.4	3.6
100% peat:0% slag fiber	44	50	7.0	3.2
75% peat:25% slag fiber	43	43	6.6	3.0
50% peat:50% slag fiber	41	44	6.6	3.0
25% peat:75% slag fiber	45	41	5.6	2.6
0% peat:100% slag fiber	35	30	4.6	1.4

[1]Height and width measurements in centimeters.
[2]Growth Index = (height + width1 + width2)/3 in centimeters. Width1 was at the widest point, and width2 perpendicular to width1.
[3]Quality Rating: 1 = not marketable, 2 = poor, 3 = adequate, 4 = good, and 5 = superior.

of flower shoots was only reduced when plants were grown in 25:75 or 0:100 peat:slag fiber. Poinsettia 'Freedom Pink' and 'Freedom White' grown in Fafard 3B, Cornell peat-lite mix B, and 100:0, 75:25, or 50:50% peat:slag fiber were similar in growth index, flower shoot number, and quality rating. Those grown in 25:75 or 0:100 peat:slag fiber were smaller and of poorer quality. Only 100% slag fiber reduced plant height in both cultivars.

The addition of slag fiber had a marked effect on media pH. Increasing percentages of slag fiber increased the media pH in samples taken before potting (Table 2). This occurred despite the fact that lime rates were decreased with increasing percentages slag fiber. There was no difference in pH between the Cornell Peat-lite Mix B and 100% peat sampled before potting. The same trend was also found in media pH of samples taken at the end of the experiment with the exception of 100% slag fiber.

All three poinsettia cultivars grew well and attained an acceptable market quality when grown in media containing 50% or less slag fiber. Higher slag fiber percentages in the media resulted in reduced growth and quality. This result may, in part, be due to the increase in media pH and its adverse effect on nutrient availability.

Table 2. Effect of Slag Fiber as a Media Component on Substrate pH

Medium	Before potting	Flowering
Cornell Peat-lite Mix B	5.22	4.87
100% peat: 0% slag fiber	5.32	4.74
75% peat:25% fiber	7.54	7.42
50% peat:50% fiber	7.93	7.54
25% peat: 75% fiber	8.45	8.51
0% peat: 100% slag fiber	8.97	6.87

Consumer Perceptions and Expectations of Garden Center Product and Service Quality

JAY T. HUDSON, BRIDGET K. BEHE, HARRY G. PONDER, AND WILLIAM E. BARRICK

Traditional garden centers' (TGC) dominance in the retail landscape horticulture industry is eroding. Competition from non-traditional outlets (NTO), such as home centers, hardware stores, and mass merchandisers, has captured a significant portion of the TGC's sales.

From 1972 to 1977, retail garden center sales grew 129%. However, from 1977 to 1982 sales grew 81%, and from 1982 to 1987 sales grew 88%. Sales from 1987 to 1992 slowed to 17%. The trend for these five-year periods showed a substantial decrease in sales after dramatic growth.

Recent reports show that 32% of American households made a landscape product and/or service purchase from a TGC, compared to 21% from a hardware store, 26% from a mass-merchandiser, and 16% from a home center. Home centers were the only store category that showed a net increase in the percentage of households making a purchase from them in the last five years.

One strategy that could potentially help a business achieve a competitive advantage is delivering high-quality customer service. Previous research has shown that customers are five times more likely to switch venders due to perceived service problems than for price or product quality concerns. One researcher suggested that the key to delivering excellent quality service begins by finding, training, and keeping the best service workers. Clearly, employees are a key link in the chain between business image and customer perceptions.

METHODS

One method for assessing service quality is SERVQUAL, a survey which consists of 22 pairs of questions, half of which measure expectations and half of which measure perceptions of service quality. Questions are asked using a five-point Likert scale where 1 = "strongly disagree" and 5 = "strongly agree." The objective of this study was to adapt SERVQUAL to define consumers' product and service quality perceptions and expectations of traditional and non-traditional retail garden centers.

Expectations are what consumers would expect from an ideal retailer. Perceptions are what consumers felt they got from shopping in their outlet. The level of service quality is defined as the difference between customer perceptions and expectations. A negative service quality gap means the retailer is not meeting customer expectations. A positive service quality gap means the retailer exceeds customers' expectations.

SERVQUAL was divided into five dimensions of service to measure quality: tangibles, reliability, responsiveness, assurance, and empathy. The tangibles dimension was measured with four questions relating to the appearance of

physical facilities, equipment, personnel, and communication materials. Reliability, measured with five questions, was the retailer's ability to perform the promised service dependably and accurately. Responsiveness, measured with four questions, was the willingness to help customers and provide prompt service. The four assurance questions measured the knowledge and courtesy of employees and their ability to convey trust and confidence. Empathy, measured with five questions, was defined as the caring, individualized attention the firm provides its customers.

TGCs were defined as free-standing primarily horticultural retailers offering a full line of products and services, which could include landscape services and delivery. NTOs were defined as a component of a mass-merchandising operation whose product mix was primarily non-horticultural products and offered few or no horticultural services.

Consumers were asked to report how many times they purchased plants from any garden center and their average spending. Participants were also asked how many times they had purchased plants from the particular garden center where the survey was obtained and again their average spending. Demographic questions, including year of birth, gender, income level, and family status, were asked at the end of the questionnaire.

Surveys were distributed on March 31 and April 1, 28, and 29, 1995. Shoppers in the retail outlets were approached by a university student and offered a survey form with a business-reply envelope shown protruding from the center. Each participant was told about the survey and how it could be completed at home, informed of consent to participate, and shown the business-reply, postage-free envelope provided for ease of mailing.

In the first weekend of distribution, 1,465 surveys were distributed among eight outlets, with 518 distributed in TGCs and 947 distributed in NTOs. A total of 2,164 surveys was distributed among seven outlets in the second weekend, with 606 distributed in TGCs and 1,558 given in NTOs. All surveys returned to Auburn University were checked for usability and completeness.

Service quality dimension scores for perceptions and expectations were calculated by averaging individual responses to questions in each dimension. A service quality gap score was calculated for individual respondents by subtracting expectations from perceptions scores for each survey dimension. A positive gap indicated the retailer exceeded customer expectations. A negative gap indicated the retailer fell short of consumer expectations. Perception, expectation, and gap scores for each service quality dimension were calculated for each respondent by averaging responses to the questions or dimensions. An overall measure of service quality was calculated by averaging dimension perception scores and subtracting expectation scores.

RESULTS

TGC customers returned 242 of the 1,124 distributed surveys (21.5% response rate). Only 13.6% of the NTO customers responded as 342 of 2,505 distributed surveys were returned.

There were no differences in mean age (48 years), years of education (15.5), number of household members (2-3), gender distribution (73% female), and marital status of TGC and NTO customers. TGC customers had a 5% higher household income ($45,686) when compared to NTO customers ($43,504). Customers were quite similar demographically, with only a difference observed on one, household income, of six demographic variables.

Of the five dimensions, both TGC and NTO customers ranked assurance and responsiveness as most important and the physical appearance of equipment, personnel, and printed materials as least important (Table 1). TGC customers valued caring, individualized attention more than NTO customers did. These findings suggest that employee knowledge and trust were relatively more important to both groups than the physical condition of facilities.

NTO and TGC customers had similar expectations of their respective retailers but consistently lower perceptions of assurance (Table 2). This service quality gap was nearly three times as large for NTO customers compared to TGC customers, suggesting that TGCs were better at meeting customer expectations and have a potential strength or advantage in this service quality dimension. Some research has shown that technical knowledge, or assurance in the SERVQUAL survey, was an important service the garden center should provide.

NTO customers had a higher expectation of responsiveness when compared to TGC customers, yet TGC customers had a higher perception score (Table 2). The responsiveness gap was more than twice as large for NTOs as the gap calculated for TGCs.

A higher empathy perception score was calculated for TGC customers compared to NTO customers, and an empathy gap was identified for both (Table 2). The TGC customer had only one-quarter the gap calculated for the NTO customer. NTO and TGC customers had similar expectations on the empathy items but had lower perceptions except for convenient operating hours (data not shown).

TGC and NTO customers had similar expectations for reliability, yet TGC customers had a higher perception score. Customers perceived a reliability gap, but the gap for TGCs was one-third less. NTO customers had similar or higher expectations for all questions except showing an interest in solving problems, yet they consistently had lower perceptions on all reliability questions. Other research showed that reliability was the most important service quality dimension for florist and supermarket floral department customers.

Table 1. Relative Importance Ratings and Rankings of Five SERVQUAL Dimensions by Traditional Garden Center (TGC) and Non-traditional Garden Center Outlet (NTO) Customers

Dimension	TGC		NTO	
	Points	Rank	Points	Rank
Assurance	25.6	1	25.5	1
Responsiveness	24.3	2	23.9	2
Empathy	20.5	3	18.6	4
Reliability	17.5	4	17.3	3
Tangibles	12.1	5	14.7	5

Table 2. Summary of the Expectations, Perceptions, and Gap Scores on Combined Items Comprising the Five SERVQUAL Dimensions for Traditional Garden Center (TGC) and Non-traditional Garden Center Outlet (NTO) Customers[1]

Dimension		Expectations		Perceptions		Gap	
		TGC	NTO	TGC	NTO	TGC	NTO
Assurance	mean	4.63	4.63	4.30	3.61*	-0.33	-1.02*
Responsiveness	mean	4.57	4.65*	4.12	3.50*	-0.45	-1.15*
Reliability	mean	4.72	4.72	4.06	3.79*	-0.66	-0.93*
Empathy	mean	4.42	4.39	4.14	3.57*	-0.28	-0.82*
Tangibles	mean	3.59	3.86*	3.67	3.91*	0.08	0.05*
Product	mean	4.49	4.53	3.86	3.52	-0.63	-1.01
SERVQUAL	mean	4.40	4.47*	4.03	3.65*	-0.37	-0.82*

[1]* = Significantly different.

NTO customers had higher expectation of tangibles than TGC customers (Table 2). Tangibles was the only dimension where expectations were met by either retail outlet. This was the only dimension for which NTO customers had higher perceptions than TGC customers.

Because many expectations were similar and perceptions were not, gaps in service quality were determined. Gaps were more numerous and larger for NTOs than for TGCs, clearly giving a competitive advantage to TGCs in service quality. However, gaps were evident for both types of retailers.

If TGCs want to narrow the greatest advantage NTOs have, they should focus on improving the quality of equipment and printed materials, and making operating hours more convenient. NTO customers had higher expectations and perceptions for product guarantees than did TGC customers. NTOs need to improve their customers' perceptions of assurance and empathy. Product and service differentiation are important, but employees should be the primary focus for non-traditional garden centers.

This study demonstrated that customers of NTOs and TGCs have very similar expectations of service quality from their respective retailers. However, TGCs clearly better met customer expectations. Both types of retail outlets had significant product and service quality gaps. Narrowing product and service quality gaps by focusing first on the largest gaps can be a substantial component of a marketing strategy to improve competitiveness.

Summer Annual Performance in the Southern Landscape

DARBY M. QUINN, BRIDGET K. BEHE, J. RAYMOND KESSLER, AND JAMES S. BANNON

In the summer of 1995 and 1996, bedding plant cultivars were evaluated in the All-America Selections (AAS) Display Garden at the E.V. Smith Research Center (EVSRC) located in Shorter, 26 miles east of Montgomery, Alabama. The objective of this study was to determine the heat tolerance and landscape performance of summer-flowering annual plant cultivars.

METHODS

Seeds of the trial entries were donated by several companies and grown by Wrights' Nursery and Greenhouse, a local commercial transplant producer. Beds were located in Norfolk-Orangeburg loamy sand association soil (fine, loamy, siliceous, thermic Typic Kandiudults). Raised beds were tilled and fumigated with methyl bromide two weeks before planting. No other fungicides or insecticides were applied during the trial period. A commercially available slow-release fertilizer (18N-2.6P-10K) was preplant incorporated into the beds as per soil test recommendations. No additional fertilizer was applied during the season.

Transplants of 245 cultivars were planted on May 17, 1995, while transplants of 400 cultivars were planted on June 5, 1996. Twelve plants per cultivar were grown in full sun, with the exception of impatiens, which were grown under aluminum hoop frames covered with 60% black shade fabric. In 1996, begonias, lobelias, and geraniums were grown in both full sun and under 60% shade. Rainfall was

supplemented by overhead sprinkler irrigation to provide an equivalent of one inch of water per week. No maintenance, with the exception of one prune to petunias at mid-season, was performed on any of the cultivars. All petunia cultivars were pruned to approximately one-third their original length on Aug. 8, 1995 and Aug. 15, 1996. No deadheading or other maintenance was conducted.

Eight of 12 plants per entry were evaluated every two weeks from May 31 through Sept. 20, 1995, and from June 13 through Sept. 19, 1996; the outer four plants were used as guard rows. Plants were rated by the same individual using a scale of 1-5. Flowering plants were rated primarily on their floral display, while size, shape, and freedom from insect or disease blemishes were also considered. A rating scale of 1-5 was used, where 1 = small display of foliage with no flowers present; 2 = adequate foliage with one or two flowers showing.; 3 = sufficient foliage and floral display to be attractive in the landscape; 4 = above average floral display and sufficient foliage display; and 5 = superior floral display and sufficient foliage display. A rating of 0 indicated the plant had died. Ratings were made in whole number units.

The average daily air temperatures in 1995 were higher than normal (the average temperatures for the last 30 years), while in 1996 they were not more than four degrees above or below normal. The average monthly rainfall was approximately half the average rainfall for the last 30 years, for June, July, and August, while there was approximately one inch more rainfall than normal in September 1995. In 1996, the rainfall was an average four inches higher than normal each month. In general, it was hotter and dryer than normal during the evaluation period in 1995, and normal temperatures with higher than average rainfall in 1996.

RESULTS

Compared to all other cultivars evaluated in 1995, Vinca 'Blush Cooler' performed best with an average 4.1 rating. 'Pacifica Punch' and 'Pretty in Rose' were among the cultivars with high rating (4.1 and 4, respectively). Salvia farinacea 'Victoria Blue' and petunia 'Fantasy Pink' also performed well, each with a mean rating of 3.5. Celosia plumosa 'Pink Candle' was the best performing celosia (3) and Verbena speciosa 'Imagination' was the best of two verbenas with a 3.4 rating. Of 34 marigold cultivars evaluated, 'Aurora Mixed' (3), had the highest rating; 'Inca Yellow' (2.8) and 'Perfection Gold' (2.8) tied for the second highest rating of the marigolds.

Petunia 'Purple Wave' had a rating of 3.1, but was substantially reduced with a mid-season pruning; the average rating at pruning was 5. 'Purple Wave' did not appear to need pruning nor did it respond well. The best-performing Gomphrena globosa of four cultivars tested was 'Bicolor Rose (2.6) and the best zinnia cultivar was *Zinnia linearis* 'White Star' with an average 2.6 rating. *Melampodium paludosum* 'Derby' and 'Showstar' performed relatively well with 3 and 2.8 mean ratings, respectively.

Of 56 impatiens cultivars, none had a rating of 3 or higher. Due to an early outbreak of pythium root rot, many plants were devastated. There were only three cultivars for which eight or more plants survived. For 16 cultivars, all 12 plants died. Among 56 impatiens cultivars evaluated, 'Novette Pink Star' had the highest rating (2.7) followed by 'Impulse Pink Blush' (2.6).

Of all the cultivars evaluated in 1996, *Gomphrena globosa* "Lavender Lady' and 'Strawberry Fields' performed best with a 4.1 rating. *Verbena speciosa* 'Imagination' was the best of 16 verbenas with a 3.6 rating. *Melampodium paludosum* 'Derby' (3.5) and 'Medallion' (3.5), the only two melampodiums evaluated, both had high ratings. *Ageratum houstonianum* 'Royal Hawaii' (3.3) and 'Blue Hawaii' (3.1) rated the highest of the seven ageratums evaluated. *Begonia semperflorens* 'Baron White' led the 19 begonias evaluated with a 3.2, while *Zinnia elegans* 'Big Red' was the best-performing zinnia (3.2). 'Hero Spry' (3.2) had the highest rating of 35 marigold cultivars evaluated; 'Bonanza Yellow Imp' (3.1), 'Little Hero Flame' (3), 'Hero Flame' (3), and 'Hero Orange' (3) were second third and fourth. Of 21 vinca cultivars evaluated, 'Raspberry Red Cooler' (3.1) had the highest rating. 'Icy Pink Cooler' (3.1) and 'Heat Wave Pink' (3.1) were second and third.

Comparing lobelias, begonias, and geraniums grown in both sun and shade, all three species performed better under 60% shade than in full sun. The tall lobelias performed considerably better than shorter cultivars, which eventually died even under the shade. Begonia 'Baron White' was an exceptional plant under shade conditions, with a larger loose open habit. The two gomphrenas 'Strawberry Fields,' and 'Lavender Lady' were also exceptional performers, covered with flowers and blooming over a long period. *Verbena speciosa* 'Imagination' is a spreading plant that sports many flowers over a long time, and it has rated consistently high. Also performing well on a consistent basis are the vincas. There were no vinca varieties that performed poorly; it is more a matter of color preference when choosing the right one for your landscape. Petunia 'Purple Wave,' an outstanding petunia, is the most reliable performer during the hot parts of the summer. Results show that severe pruning of 'Purple Wave' during the hot part of the summer weakens the plant and may cause death. Other good landscape plants for Zone 8 include the melampodiums and *Salvia farinacea* cultivars, 'Victoria Blue,' 'Victoria White,' and 'Reference.' *Salvia coccinea* 'Lady in Red' along with *Zinnia* 'Big Red' and any of the *Zinnia linearis* cultivars were also worthy of a place in the landscape. Normally, most impatiens cultivars would perform well here in the shade; however, due to an early infestation of root rot, no impatiens performed well.

Employee Training Increases Knowledge: Three Methods Equally Effective

HEATH POTTER, J. DAVID WILLIAMS, BRIDGET K. BEHE, AND HARRY G. PONDER

The success of service-oriented small businesses, such as retail garden centers, is generally believed to be dependent on providing a wide variety of high-quality products, having knowledgeable employees, and providing high-quality customer service that typically cannot be offered by mass merchandisers. Independent garden centers generally provide a wide variety of high-quality products, yet similarly high standards for employee knowledge and customer service have not been established.

People in an organization will help determine that company's ability to grow and expand. If people in an organization help to determine business growth and expansion, then a logical conclusion is that educated and well-trained people are a key to business productivity and profitability. Other studies have shown that employee knowledge and assurance were the most important dimension of service quality. However, both traditional and non-traditional outlets had not met customer expectations of employee knowledge and assurance.

Training can be defined as a set of activities which are designed to improve employee job performance. It differs from education, which is broader in scope, less utilitarian, and centers more on the individual than does training. According to some, the question is never if training should be done, but rather how it should be done.

Among many, three training methods can be used in training employees: personal or small group lecture/ demonstration, videotape, and workbook training manual. Of the garden center employees who received some form of organized or systematic training, Auburn University researchers found that 61% received training on an individual basis. Personal instruction, however effective, is the most expensive form of training in that it involves a significant investment of trainer time; the trainer often is the owner or manager. Training expense can be further increased by a high employee turnover rate.

A combination of videotape and workbook or manual training has been effective for numerous companies and is a powerful training tool that can be used repeatedly by new employees, or as a refresher for long term training. McDonald's, one of the most successful companies in the world, uses videotape, manuals, seminars and one-on-one training. While these are effective for McDonald's, no study has compared effectiveness of methods within the context of training in technical subject matter in horticulture. The purpose of this study was to determine the effectiveness and cost of three training methods.

METHODS

Videotape, workbook, and lecture instruction methods were compared for their effectiveness. A six-page script covering basic principles of selection and installation techniques of woody landscape plants was written by the primary author. Collection of video footage and graphics for video and workbook and materials for lecture illustrations was initiated after script development was complete. A 10-minute video was produced, a nine-page workbook compiled, and a 25-30 minute lecture was prepared based on the same subject matter. An unrelated 10-question Auburn University trivia quiz was developed for a control group.

Training method effectiveness was determined using difference scores for a 10- item pretest-post-test examination. In addition to the examination questions covering the material from the training, the questionnaire requested demographic information that included class, curriculum, year of birth, and gender.

TRAINING EFFECTIVENESS

Student volunteers in the study were compared on six demographic characteristics. Participants were similar with regard to demographic variables which included: classification (freshman, sophomore, junior, senior), student curriculum, type of curriculum (science-based curricula, non-science curricula, horticulture), age, gender, and class hour.

Among the three instructional methods, differences were observed in the mean pretest and posttest scores by training method, and mean change score (posttest - pretest) did not differ. Workbook, videotape, and lecture methods of instruction resulted in increases of 2, 1.9, and 1.9 in mean change in score respectively (Table 1). The control group, which received no horticultural training, had a mean 0.3-point decrease in change in score. The videotape instruction group had a 9 posttest mean score. Lecture and workbook groups followed with posttest means of 8.9 and 8.8 respectively. For the control group, learning decreased 0.3 points. For other methods, the increases of 2 (workbook), 1.9 (video), and 1.9 (lecture) which were significantly different from zero.

Comparison of Mean Pretest and Posttest Scores, and Mean Score Change of Three Training and One Control Group

Instruction group	Participants	Pretest score	Posttest score	Change in score
Video	118	7.0	9.0	1.9
Workbook	114	6.9	8.8	2.0
Lecture	122	7.0	8.9	1.9
Control	128	7.1	6.8	-0.3

ECONOMIC COMPARISON

Since the three training methods were equal, more effective than no training control, the economic comparison of the training methods was important. Training methods, however effective, must be economically feasible to even be a consideration for most independent garden centers. Videotapes can be purchased for $15 each and workbooks for 10 cents per copy from the Alabama Cooperative Extension System. Lecture cost will vary with labor cost or wages of instructor.

Videotape and workbook training allow material to be presented the same each time giving uniformity to instruction between learners. Videotape training presents no recurring cost and can be reused. Workbook training presents no recurring cost, can be reused, and can be personalized by purchasing one for each employee and allowing them to be used at flexible times. Both videotape and workbook present opportunities for employees to refresh themselves easily on certain areas of knowledge or skill. The employee could carry a videotape or workbook home, perhaps receive supplemental pay, consuming less time than on-the-job training. Less on-the-job training translates into more efficient use of time and less distraction on the job if during busy peak season.

Training methods employed need to be effective for each company's specified training objectives. Videotape and workbook should be considered as equally effective training alternatives and more cost effective than one-to-one lecture/demonstration method of training independent garden center employees. Their combination may be even more effective (although not tested here) and still less costly than the one-to-one instruction.

Nontraditional Containers Affect Growth of Wetland Species

D. JOSEPH EAKES, PENELOPE A. MERRITT, GARY J. KEEVER, AND CHARLES H. GILLIAM

In recent years, increased interest in wetland restoration and water gardening has resulted in higher demand for wetland, aquatic, and bog plants. Currently, most plants used in wetland restoration are harvested from native stands. Commercial production of these plants would prevent unnecessary environmental degradation and reduce harvesting stress on native wetlands. There is an opportunity for nurserymen to take advantage of these growing markets through contract-production of wetland plants for restoration and aquatic and bog plants for landscapes.

Although it would appear that cultural practices for container-production of wetland plants should be different from typical container-grown crops, little information exists on wetland plant production. The concept of raised holes on containers is currently marketed as Environmentally Friendly Containers (EFC), which have drainage holes about one inch from the bottom. An AAES study was set up to evaluate the effects of nonconventional containers with various positions of raised-drainage holes, to see if a larger water reservoir would be beneficial to the growth of four wetland plant species.

METHODS

On May 23, 1995, four wetland species, *Canna flaccida Salisb.* (canna), *Iris versicolor L.* (iris), *Spartina alterniflora Loisel* (smooth cordgrass) and *Juncus effesus L.* (soft rush) were planted into trade-gallon containers of Metro Mix 500. The five container types used were: no holes, four holes located at the bottom of the container, four holes half way (3.2 inches) up the side wall, four holes three-quarters of the way (4.7 inches), and pot-in-pot consisting of a trade-gallon growing container with four holes at the bottom placed inside a full-gallon socket pot lined with polyethylene. All plants were fertilized with two Sierra (16-8-12 + minors) tablets (2.39 grams of nitrogen) per pot placed just below each transplant. Plants were watered to 100% container capacity daily and grown in a double poly greenhouse.

Plant growth index [(height + width1 at the widest point + width2 perpendicular to width 1)/3], total shoot number (or leaf number of soft rush), visual shoot rating (a scale of 0-5, with 5 being a large healthy plant and 0 being dead), and medium solution pH and soluble salt concentration were determined 60 days after potting (DAP) for each plant. Due to the rapid growth of canna, visual root rating and shoot dry weight were determined at 60 DAP. At 90 DAP, growth index, total shoot number, and root and shoot visual ratings were determined for iris, rush, and smooth cordgrass. Plants were then harvested to determine shoot dry weights.

RESULTS

Growth index for canna at 60 DAP (Table 1) was greater for pot-in-pot plants and plants produced in pots with holes half way up, while plants produced in containers with holes three-fourths of the way up had the lowest growth index. Plants in the pot-in-pot containers had the highest shoot dry weight, and plants produced in traditional containers with holes at the bottom had the least dry weight. Visual root and shoot ratings for canna were highest in the pot-in-pot treatment and similar for all other treatments.

Table 1. Influence of Container Hole Position on Growth of Canna at 60 DAP

Treatment	Growth index	Shoot rating	Root rating	Top dry weight
	in.			*g/plant*
No holes	23.7	2.4	2.2	57.6
Bottom	23.9	2.7	2.9	47.8
Halfway up	25.3	2.7	2.4	71.3
Three-fourths up	21.0	3.1	2.6	64.5
Pot-in-pot	26.4	4.1	4.6	83.7

Soft rush grown in the pot-in-pot treatment (Table 2) had a higher growth index, leaf and root ratings, and shoot dry weight than plants grown in the other four pot types. There were no treatment differences with any growth parameters for smooth cordgrass or iris.

Table 2. Influence of Container Hole Position on Growth of Soft Stem Rush at 90 DAP

Treatment	Growth index	Shoot rating	Root rating	Top dry weight
	in.			*g/plant*
No holes	29.2	3.0	3.0	52.6
Bottom	26.8	2.7	3.0	40.4
Halfway up	26.0	2.9	3.1	47.0
Three-fourths up	26.8	2.6	3.1	48.3
Pot-in-pot	31.2	4.0	5.0	88.7

Although medium solution pH and soluble salts varied among species, treatment differences were similar. A higher pH and lower salts level were present in the pot-in-pot treatment than in the other treatments. Medium solution pH averaged 5.7 for pot-in-pot soft rush, while the remaining four treatments averaged 5.0 and ranged from 4.6 to 5.3. Soluble salts in containers with no holes, holes half way up, and holes three-fourths of the way up were a minimum of eight times greater than salt levels for containers with holes at the bottom or pot-in-pot.

Growing canna and soft rush in a pot-in-pot system produced larger, more marketable plants than conventional containers regardless of hole position. Container type had no influence on the growth or quality of iris or smooth cordgrass.

INSECTS, DISEASE AND WEED CONTROL

Preemergence-Applied Herbicides Affect Growth of Pampas Grass

JAMES C. GREEN, GARY J. KEEVER, CHARLES H. GILLIAM, JOHN W. OLIVE, AND D. JOSEPH EAKES

In the past two years, several growers in the Southeast have observed midseason lodging of container-grown pampas grass. Most of the herbicides labeled for pampas grass contain a dinitroaniline herbicide which inhibits root formation. A recent trend in the Southeast is to transplant small liners of pampas grass (72-cell pack) into full-gallon containers. In the past, larger-sized liners were used for transplanting. In this study AAES researchers showed that applying certain dinitroaniline preemergent herbicides to these smaller liners at potting results in severe shoot or root inhibition, lodging, or plant death. Injury was less severe with granular formulations of dinitroaniline herbicides than with spray-applied formulations. Nondinitroaniline herbicides (Ronstar and Regal O-O) appeared safe for use on small pampas grass liners at potting.

METHODS

Uniform liners (72-cell packs) of white pampas grass were potted into full-gallon containers of an amended pinebark:peat medium. Two days after potting, nine herbicides were applied over-the-top (Table 1). Granular herbicides were applied with a hand-held shaker, while the three liquid formulation herbicides, Factor 65 WG, Surflan 4AS, and Pendulum 60 WDG, were applied using a backpack sprayer. Data were collected at 45 and 75 days after treatment (DAT).

RESULTS

Surflan 4AS, Rout 3G, and Factor 65 WG all retarded height development at 45 and 75 DAT compared to untreated controls (Table 1). These same three herbicides, plus OH-2 3G, Pendulum 60 WDG, and Pendulum 2G, suppressed upper root development at 45 and 75 DAT. Both Ornamental Weed Grass Control and Regal O-O resulted in less upper root development compared to controls at 75 DAT. Less root development in the lower portion of the container was evident at both 45 and 75 DAT with Surflan 4AS, Rout 3G, Factor 65

Table 1. Height, Root Rating and Foliar Dry Weight of Pampas Grass Treated with Nine Preemergence Herbicides.

Herbicide[1]	Rate	Height		Root rating[2]				Foliar dry weight
				Upper 2 inches		Lower 4 inches		
		45 DAT	75 DAT	45 DAT	75 DAT	45 DAT	75 DAT	75 DAT
	lb. a.i./a.	*cm*	*cm*					*g*
OWGC[3]	3.0	75.2	118.4	2.1	3.1	4.0	4.6	38.93
Pendulum 2G	3.0	71.5	118.5	1.4	3.0	3.9	5.0	39.73
Pendulum 60 WDG	3.0	67.7	112.0	1.0	1.1	2.6	3.0	29.59
OH-2 3G	3.0	74.5	121.9	1.9	3.1	3.8	4.6	35.99
Surflan 4AS	3.0	13.6	—[4]	1.0	1.0	1.0	1.0	—
Rout 3G	3.0	33.2	71.9	1.1	1.1	2.0	1.9	17.63
Factor 65 WG	1.5	46.7	72.7	1.0	1.0	1.0	1.3	10.10
Ronstar	4.0	70.1	118.1	2.5	3.9	4.5	5.0	39.81
Regal O-O	3.0	72.9	119.6	2.5	3.4	4.0	4.5	40.30
Control	—	77.8	121.5	2.6	3.9	4.5	5.0	37.91

[1]All herbicides except Ronstar and Regal O-O contain a dinitroaniline herbicide
[2]1-5 rating scale = 0%, 25%, 50%, 75%, or 100% root coverage at the container-medium interface.
[3]OWGC = Ornamental Weed Grass Control.
[4]All plants had died before 75 DAT.

Table 2. Lodging and Mortality of Pampas Grass Following Application of Selected

Treatment	Preemergence Herbicides		
	Rate	Lodging	Mortality
	lb. a.i./a.	*pct.*	*pct.*
OWGC[1]	3.0	12.5	0.0
Pendulum 2G	3.0	0.0	0.0
Pendulum 60 WDG	3.0	50.0	0.0
OH-2 3G	3.0	0.0	0.0
Surflan 4AS	3.0	—	100.0
Rout 3G	3.0	0.0	12.5
Factor 65 WG	1.5	100.0	0.0
Ronstar	4.0	0.0	0.0
Regal O-O	3.0	0.0	0.0
Control	—	0.0	0.0

[1]OWGC = Ornamental Weed Grass Control.

WG, and Pendulum 60 WDG, when compared to that of control plants.

Foliar dry weights of plants treated with Surflan 4AS, Rout 3G and Factor 65 WG were less than those of plants in all other treatments. Plant mortality was 100% and 12.5% in Surflan 4AS and Rout 3G treatments, respectively (Table 2). Lodging occurred in 100%, 50%, and 12.5% of plants treated with Factor 65 WG, Pendulum 60 WDG, and Ornamental Weed Grass Control, respectively, at 75 DAT (Table 2). The authors observed that aerial support roots of lodged plants were short, stubby, and enlarged at the distal ends. Lack of development of these roots which normally provide support for developing shoots probably contributed to lodging. Pendulum 60 WDG-treated pampas grass generally had less root development than plants treated with the granular formulations of pendimethalin, Ornamental Weed Grass Control and Pendulum 2G; 50% of the WDG- treated plants had lodged compared to 6.3% of plants treated with the granular pendimethalins.

Chemical Control of Cercospora Leaf Spot of Crapemyrtle

AUSTIN K. HAGAN AND J. RANDALL AKRIDGE

Cercospora leaf spot, which is caused by the fungus, *Cercospora lythracearum*, is a common but often unrecognized disease of crapemyrtle in field nurseries and landscapes. Typically, spotting starts on the leaves near the base of the plant in July or August. The most noticeable symptoms of Cercospora leaf spot are yellowing and premature loss of damaged leaves. Although Cercospora leaf spot usually has little impact on the health of crapemyrtle, the spectacular fall color of some cultivars may be ruined by the progressive yellowing of the leaves and defoliation. In an AAES field trial in southwest Alabama, the experimental fungicide ICIA5504 gave effective control of Cercospora leaf spot on crapemyrtle.

METHODS

In March 1996, bare-root crapemyrtle 'Carolina Beauty' were planted in a Benndale fine sandy loam at the Brewton Experiment Field on eight foot centers with 10 feet between rows. Before planting, soil fertility and pH were adjusted according to the results of a soil fertility assay. On March 20 and July 3, half pounds of 16-4-8 and 12-6-6 fertilizers were uniformly distributed around each tree. A trickle irrigation system was installed at planting and trees were watered as needed. A tank-mix of one pound of Gallery and two quarts of Surflan per acre was applied to the plot area twice during the growing season. Hand weeding and directed applications of Roundup herbicide were also employed for weed control. Fungicides were applied between June 7 and Aug. 2 following the schedule found in Table 1 to run-off using an ATV-mounted electric sprayer set at 45 psi with a single nozzle on a hand-held wand. Visual ratings of leaf spot incidence and defoliation were made on Oct. 10. The rating scales used to access disease is listed at the bottom of Table 1.

RESULTS

Light to moderate leaf spotting was seen on all the fungicide-treated crapemyrtle, as well as the unsprayed control. Leaf spot levels were considerably lower on the crapemyrtle treated at two-week intervals with all three rates of the experimental fungicide ICIA5504 or every week with Banner 1.24 MEC, as compared with the unsprayed control. On the ICIA5504-treated crape myrtle, spotting and yellowing of the leaves was confined to the lower 5-10% of the tree canopy. Typical leaf spot symptoms were seen on 25% or more of the leaves of crapemyrtle treated at two- to four-week intervals with Banner 1.24 MEC and the unsprayed control. Defoliation ratings generally mirrored those for leaf spot. The least disease-related defoliation was noted on the crapemyrtle sprayed with ICIA5504. No differences in defoliation were seen across rates of this fungicide. Defoliation was not reduced by any treatment of Banner 1.24 MEC as compared with the unsprayed control.

Table 1. Chemical Control of Cercospora Leaf Spot on Crapemyrtle

Treatment	Rate per 100 gallons	Spray interval	Disease rating[1]	
			Leaf spot	Defoliation
		weeks		
Banner 1.24 MEC	6 fl. oz.	1	3.8	4.0
Banner 1.24 MEC	6 fl. oz.	2	5.0	4.5
Banner 1.24 MEC	6 fl. oz.	3	4.8	4.3
Banner 1.24 MEC	6 fl. oz.	4	5.3	4.7
Eagle 40W	4 oz.	3	4.2	4.0
ICIA5504 80W	4 oz.	2	3.5	3.0
ICIA5504 80W	8 oz.	2	3.3	2.7
ICIA5504 80W	16 oz.	2	3.3	2.7
Unsprayed control	—	5.2	4.5	

[1]Leaf spot and defoliation were assessed using the Barratt and Horsfall System: 1 = 0% of the leaves diseased or prematurely lost due to Cercospora leaf spot, 2 = 0-3%, 3 = 3-6%, 4 = 6-12%, 5 = 12-25%, 6 = 25-50%, 7 = 50-75%, 8 = 75-87%, 9 = 87-94%, 10 = 94-97%, 11 = 97-100%, and 12 = 100%.

Chemical Control of Fireblight on Crabapple

AUSTIN K. HAGAN AND J. RANDALL AKRIDGE

Fireblight, caused by the bacterium *Erwinia amylovora*, is a sometimes damaging disease in landscape plantings of crabapple, flowering pear, and cotoneaster. Despite the widespread distribution of fireblight, few bactericides are registered for the control of this disease on landscape shrubs and trees. In addition, few studies have been conducted to establish the effectiveness of available bactericides against fireblight.

An AAES study was conducted on field-grown crabapple to determine whether fireblight could be controlled with chemical treatments. Results showed that Agri-Strep 21W substantially reduced the severity of fireblight on crabapple.

METHODS

Bare-root 'Snowdrift' crabapples were planted in March 1995 in a Benndale sandy loam soil at the Brewton Experiment Field on 10-foot centers with 10 feet between each row. Before planting, soil fertility and pH were adjusted according to soil assay recommendations. All plants were mulched with aged pine bark. In March and June of 1995 and 1996, approximately 50 pounds per acre of a 16-4-8 analysis fertilizer were broadcast down each row of trees. A tank-mix of one pound of Gallery and two quarts of Surflan per acre was broadcast down each row for weed control. The plots were also hand weeded as needed. All treatments, which are listed in the table, were applied to run-off using an ATV-mounted electric sprayer set at 45 psi using with single nozzle on a hand-held wand. The dormant application of Kocide 101 77W was made on March 1, 1996. All other treatments were applied weekly from March 14 until May 14. Fireblight severity was rated on May 29 using the scale listed below the table.

RESULTS

Among the six treatments, only Agri-Strep 21W substantially reduced the severity of fireblight below levels seen on the unsprayed controls. Severity ratings on the trees treated with the dormant spray of Kocide 101 77W and Phyton 27 were just slightly lower as compared with those of the unsprayed controls. Slight increases in disease were seen on the crabapple treated with the fungicides Fluazinam 500F and Aliette 80W.

Table 1. Chemical Control of Fireblight on 'Snowdrift' Crapapple

Treatment	Rate/100 gal.	Disease Severity[1]
Agri-Strep 21W	0.5 lb.	1.2
Fluazinam 500F	12.0 fl. oz.	2.7
Aliette 80W	2 lb.	2.8
Phyton 27	12.5 fl. oz.	1.9
Kocide 101 77W	12 lb.[2]	1.6
Unsprayed Control	—	2.3

[1]Disease was assessed on a scale of 0-5, with 0 = no disease, 1 = one or few diseased branch tips, 2 = numerous diseased branch tips with a few major branches involved, 3 = considerable dieback, 4 = major portion of tree damaged, and 5 = tree killed.
[2]Single dormant application.

Chemical Control of Phytophthora Shoot Blight of Annual Vinca

AUSTIN K. HAGAN AND J. RANDALL AKRIDGE

Phytophthora shoot blight, which is caused by the fungus *Phytophthora parasitica*, has emerged in recent years as a devastating disease of annual vinca (*Catharanthus roseus*) in both production greenhouse facilities and landscapes across Alabama. This disease has become so widespread and destructive that some landscape contractors have replaced vinca with other summer annuals. So far, no cultivars of annual vinca have been found to have effective resistance to Phytophthora shoot blight.

Few studies have been done to evaluate the effectiveness of fungicides against Phytophthora shoot blight. An AAES field trial was established in Brewton to evaluate the efficacy of selected fungicides for the control of Phytophthora shoot blight in a landscape planting of annual vinca. Effective season-long control of this disease was obtained with bimonthly applications of Aliette WDG.

METHODS

Prior to bed preparation in 1995, a 5-10-50 fertilizer at a rate of 400 pounds per acre was incorporated into a Benndale fine sandy loam soil. Several weeks before planting, the beds were fumigated with 250 pounds per acre of Terr-O-Gas 98 (98% methyl bromide + 2% chloropicrin). Grape Cooler annual vinca were planted on April 20, 1995. Plots were fertilized weekly with approximately 200 ppm of a 20-10-20 analysis fertilizer delivered through a drip irrigation system. Starting on May 5, all fungicide treatments except Subdue 2E were applied to the foliage to run-off at the rates and intervals listed in the table. Subdue 2E was applied as a

soil drench around the base of the plants. The final fungicide applications were made on Aug. 25. The percentage of blighted shoots and plant survival were determined on Aug. 30.

RESULTS

From early May through early August, weather conditions at the test site generally were dry and unseasonably hot. By late July, very little shoot dieback and no plant death had occurred. Disease development followed heavy rains associated with hurricane Erin. Although several fungicide treatments increased plant survival as compared with the unsprayed control, only Aliette WDG applied at two-week intervals prevented the loss of annual vinca due to Phytophthora shoot blight (see table). Also, considerably less shoot blight was seen on the annual vinca sprayed with Aliette WDG at two-week intervals than on plants treated every four weeks with the same fungicide. Aliette WDG applied at two-week intervals also gave much better control of Phytophthora shoot blight than did Phyton 27, Subdue 2E, Pace 77W, Daconil 2787 6F, and the experimental fungicide Fluazinam 500F.

Chemical Control of *Phytophthora* Shoot Blight on Annual Vinca

Fungicide	Rate per 100 gallons	Spray interval	Plant survival	Blighted shoots
		weeks	*pct.*	*pct.*
Aliette WDG	2.5 lb.	2	100	15
Aliette WDG	2.5 lb.	4	56	51
Fluazinam 500F	8 fl. oz.	2	56	60
Phyton 27 40	fl. oz.	2	38	76
Subdue 2E	1.25 fl. oz.	4	31	73
Pace 77W	2 lb.	4	6	95
Daconil 2787	4.17 F	2	6	96
Untreated control	—	2	6	96

In summary, Aliette WDG, when applied at two-week intervals, provided effective control of Phytophthora shoot blight on annual vinca. In the greenhouse production facilities, a preventative program with Aliette WDG for the control Phytophthora shoot blight on flats and pots of annual vinca is strongly recommended. Such treatments should not only prevent costly losses in production greenhouses and retail outlets but also reduce the spread of this disease into the landscape. Such a fungicide program would, however, be highly impractical and too costly in the majority of residential and commercial landscapes.

Resistance of Selected Cultivars of Indian Hawthorn to Entomosporium Leaf Spot

AUSTIN K. HAGAN, J. RANDALL AKRIDGE, JOHN W. OLIVE, AND KENNETH TILT

For generations, Indian hawthorn has been a fixture in landscapes across the Deep South. Its dense, dark green foliage, mounded canopy, and the compact-type growth habit of most cultivars has made this evergreen shrub a popular choice for residential and commercial landscapes. The recent release of a number of new cultivars of Indian hawthorn has renewed interest in this attractive and useful woody shrub.

Entomosporium leaf spot, which is caused by the fungus, *Entomosporium mespili*, is the most common and damaging disease of Indian hawthorn in both the nursery and landscape. Humid, mild weather patterns in the spring and fall favor rapid disease spread. When left uncontrolled, extensive spotting of the leaves and heavy defoliation typically associated with severe leaf spot outbreaks will destroy the market value, aesthetics, and ultimately the health of susceptible Indian hawthorn cultivars.

At a time of increasingly stiffer pesticide regulation in the nursery industry, production of Indian hawthorn can be simplified and costly fungicides sprays eliminated by growing disease-resistant cultivars. In commercial and residential landscapes, where fungicides are not a practical option for controlling leaf spot, disease resistance offers the only real defense against this disease. Unfortunately, little information is available concerning which cultivars of Indian hawthorn are resistant or susceptible to Entomosporium leaf spot. An AAES field study was established to assess the reaction of a wide selection of available cultivars of Indian hawthorn to Entomosporium leaf spot. Not only were a number of leaf spot-resistant Indian hawthorns identified, but those cultivars that proved to be highly susceptible to this disease were also noted.

METHODS

In March 1994, 20 dwarf and a single standard-sized cultivar ('Majestic Beauty') of Indian hawthorn were established in a simulated landscape planting at the Brewton Experiment Field. Two additional cultivars, 'Snow White' and

'Rosalinda,' were added to the study in March 1995. The cultivars evaluated are listed in the table.

Prior to planting, soil fertility and pH were adjusted according to results of a soil test. Plants were grown in beds mulched with aged pine bark and watered as needed with a trickle irrigation system. Twice each year, each plant was uniformly top-dressed with one-half cup of Osmocote 17-7-12 fertilizer. A tank mixture of one pound of Gallery and two quarts of Surflan per acre were sprayed over the beds in March and September each year for weed control. Also, hand weeding and directed applications of Roundup 4L at two fluid ounces per gallon were used to control weeds. A visual rating of Entomosporium leaf spot damage was made on May 28, 1995 and May 29, 1996, using a scale of 1-5.

RESULTS

Leaf spot development occurred in Brewton primarily during the winter and early spring. Frequent showers coupled with persistent cloud cover, and mild temperatures appeared to intensify disease. By summer, little new spotting of any remaining leaves was seen and disease ratings declined (data not shown). Overall, disease ratings for most cultivars were slightly higher in 1996 than in 1995.

Substantial differences in the severity of leaf spot damage were seen among the cultivars tested (see table). Although no cultivar remained completely spot-free in 1995 and 1996, several cultivars suffered only very light and unobtrusive spotting of their leaves while a number of others were severely damaged.

Cultivars of Indian hawthorn with the best resistance to Entomosporium leaf spot included 'Dwarf Yedda,' 'Indian Princess,' 'Olivia,' and 'F1 ' (see table). In 1995, leaves of three of the four above cultivars remained virtually spot-free. Although disease ratings were higher in 1996 on three of these four cultivars, spotting of the foliage generally was very light as indicated by disease ratings of 1.5 to 2. With the exception of the cultivar 'Dwarf Yedda,' disease-related defoliation was not noticeable.

In 1995, the species *R. delacourii* also suffered very little leaf spot damage. Within a few months after hurricane Opal in October 1995, however, nearly all the *R. delacourii* were dying or dead. Although the roots of these plants were badly rotted, no plant pathogenic fungi were isolated. Apparently, *R. delacourii* is much more sensitive than the remaining cultivars of Indian hawthorn to waterlogged or flooded soils. No other cultivars suffered similar damage.

Nine other cultivars of Indian hawthorn had some resistance to Entomosporium leaf spot. Light to moderate spotting of the leaves along with some defoliation was noted both years on the cultivars 'Snow White,' 'Janice,' 'Eleanor Tabor,' 'Majestic Beauty,' 'Jack Evans,' 'F2,' 'F3,' 'Clara,' and 'Rosalinda.' With the exception of 'Rosalinda' and 'F3,' the disease ratings for the above cultivars did not appreciably increase from 1995 to 1996.

The remaining cultivars of Indian hawthorn were highly susceptible to Entomosporium leaf spot. In both years, heavy spotting of the leaves and defoliation were seen on 'Pinkie,' 'Harbinger of Spring,' 'Enchantress,' 'Heather,' 'White Enchantress,' 'Spring Rapture,' 'F6,' and 'Springtime.' In May 1996, several of these cultivars shed nearly all of their leaves. Although all the above cultivars leafed-out both years during the hotter, drier weather in the late spring and early summer, they never produced the dense, spreading, dark-green canopy that was characteristic of the leaf spot-resistant cultivars of Indian hawthorn.

Results of this study clearly identified leaf spot-resistant cultivars of Indian hawthorn that can be maintained in a residential or commercial landscape without any applications of a protective fungicide. Replacement of a leaf spot-susceptible cultivars with disease-resistant cultivars should allow a nursery to produce or maintain an attractive, quality plants for less time, effort, and money. Susceptible cultivars, such as 'Pinkie,' will require an intensive and costly program consisting of numerous fungicide applications in order to produce an attractive, salable product as well as maintain plant aesthetics in the landscape. Even if such plants appear to be disease-free at the time of shipment, disease outbreaks may occur either in retail outlets or later in the landscape.

Leaf Spot Severity on Cultivars of Indian Hawthorn, 1995-96

Cultivar	Disease Ratings[1]		Cultivar	Disease Ratings[1]	
	1995	1996		1995	1996
Springtime	3.9	4.7	F2	2.2	2.6
Harbinger of Spring	3.6	4.0	Jack Evans	2.2	2.6
White Enchantress	3.6	3.9	Eleanor Tabor	2.2	2.5
Pinkie	3.5	4.3	F1	2.0	1.7
Heather	3.5	4.3	Majestic Beauty	2.0	2.7
F6	3.5	3.6	Janice	1.9	2.6
Enchantress	3.3	4.7	Snow White	1.6	3.0
Spring Rapture	3.2	4.7	*R. x delacourii*	1.4	—[2]
Rosalinda	2.5	3.4	Indian Princess	1.1	1.5
Clara	2.3	2.3	Olivia	1.1	1.9
F3	2.3	3.4	Dwarf Yedda	1.0	2.0

[1]Disease was assessed on a scale of 1-5, where 1 = no disease, 2 = 1-25%, 3 = 26-50%, 3 = 51 -75%, 4 = 76-100%, and 5 = 100% of leaves diseased or defoliated due to Entomosporium leaf spot.

[2]*R. x delacourii* succumbed to excess soil moisture levels several months after hurricanes Erin and Opal.

Phytophthora Resistant Annual and Perennial Flowers Found

AUSTIN K. HAGAN, BRIDGET K. BEHE, AND J. RANDALL AKRIDGE

Phytophthora shoot blight and root rot is a devastating disease in landscape plantings of annual vinca or periwinkle (*Cathranthus roseus*) across Alabama. Once introduced into a landscape bed, the causal fungus *Phytophthora parasitica* cannot be eradicated. Annual vinca planted in beds infested with this fungus will quickly succumb to this disease. The foliage, shoots, or roots of other annual and perennial flowers may also be attacked by *P. parasitica.* Preventative sprays of Aliette fungicide, which will control Phytophthora shoot blight and root rot, are considered too impractical and costly to routinely apply to most commercial and residential plantings of vinca and other bedding plants.

Use of Phytophthora-resistant annuals and perennials offers an effective and economical alternative to a costly fungicide treatment program. In an AAES study, selections of annuals and perennials such as ageratum, begonia, celosia, coneflower, geranium, marigold, petunia, salvia, scabosia, sweet basil, thyme, verbena, and zinnia performed well when grown in simulated landscape beds heavily infested with *P. parasitica.*

METHODS

In late March 1996, annual vinca killed the previous year by Phytophthora shoot blight were dried, shredded, and then tilled into raised beds containing a Benndale fine sandy loam soil. At the same time, soil fertility and pH were adjusted according the results of a soil assay. Annual and perennial bedding plants (see Table 1 for list) were planted in a square on one-foot centers on April 20, 1996. The plots were fertilized weekly with approximately 200 ppm of a 20-20-20 analysis fertilizer delivered through a drip irrigation system. Plant survival was assessed on May 29 and July 2, 1996.

RESULTS

Weather conditions from early April through mid-May were unseasonably cool and moist. Temperatures and rainfall were near normal from mid-May through early July. Within one month of planting, nearly all the cultivars of annual vinca had succumbed to Phytophthora root rot (Table 1). In May, a sizable reduction in the stand counts of the impatiens cultivar 'Sun & Shade Red' was also seen. Otherwise, no differences in survival were noted among the remaining annuals or perennials.

By early July, all of the cultivars of annual vinca as well as blue daisy were dead (see the table). Nigella, a short-season annual, flowered, set seed, and died. Noticeable thinning of the stands of all cultivars of impatiens also occurred. *Phytophthora parasitica* was isolated from the roots of symptomatic vinca, blue daisy, and Nigella. Although no stand thinning of any salvia cultivar was seen, growth of two of the four cultivars may have been slowed by Phytophthora root rot. For the remaining annuals and perennials, plant survival ranged from 81% for begonia to 100% for selected cultivars of celosia, geranium, marigold, petunia, salvia, and verbena.

In summary, a number of summer annuals and perennials, that can thrive in *P. parasitica*-infested landscape beds, have been identified. In landscape beds where stands of annual vinca have been decimated by Phytophthora shoot and root rot, establishment of selected cultivars of ageratum, celosia, geranium, marigold, petunia, salvia, scabosia, sweet basil, thyme, verbena, and zinnia is suggested. Outbreaks of this destructive disease may be avoided by rotating annual vinca with one or more of the above annuals and perennials.

Survival of Selective Summer Annuals and Perennials in Simulated Landscape Beds Infested with *Phytophthora parasitica*

Common Name	Cultivar	Survival	
		May 29	July 2
		pct.	*pct.*
Ageratum	Hawaii White	100	94
Begonia	Prelude Pink	94	81
Blue Daisy	Spring Merchen	81	0
Celosia	Prestige Scarlet	100	100
Coneflower	Magnus	100	87
Coneflower	White Swan	94	92
Geranium	Pinto Red Scarlet	100	100
Geranium	Ringo 2000 Light Salmon	100	100
Geranium	Saturn Formula Mix	100	100
Impatiens	Sun & Shade Coral	88	44
Impatiens	Sun & Shade Lavender	88	69
Impatiens	Sun & Shade Neon Rose	75	44
Impatiens	Sun & Shade Violet	100	81
Marigold	American Indian Orange	100	100
Marigold	Girl Orange	94	100
Nigella	Mulberry Rose	100	0
Petunia	Deep Blue	100	100
Salvia	Firecracker Lilac	100	100
Salvia	Firecracker White	94	94
Salvia	Firecracker Salmon	100	94
Salvia	Lady in Red	100	100
Scabosia	Imperial Mix	100	95
Sweet Basil	Siam Queen	94	94
Thyme		94	94
Verbena	Formula Mix	100	100
Vinca	Bikini Formula Mix	6	0
Vinca	Blush Cooler	19	0
Vinca	Grape Cooler	25	0
Vinca	Peppermint Cooler	0	0
Zinnia	Crystal White	88	94

Screening Fungicides for the Control of Leaf Spot on Indian Hawthorn

JOHN W. OLIVE, AUSTIN K. HAGAN, AND L.C. PARROTT JR.

Leaf spot, caused by the fungus *Entomosporium mespili*, is a common and sometimes destructive disease in nursery and landscape plantings of Indian hawthorn (*Raphiolepis sp.*). Typical symptoms of leaf spot on Indian hawthorn include numerous bright red spots on the leaves and tender shoots as well as defoliation and plant death. Nursery stock suffering heavy spotting of the leaves and defoliation are unmarketable. In landscape plantings, leaf spot-damaged Indian hawthorn grow slowly and are unattractive. Although several fungicides are registered for use on Indian hawthorn for the control of leaf spot, their effectiveness has not been thoroughly evaluated under heavy disease pressure.

In an AAES study, effective control of leaf spot on Indian hawthorn was obtained with Daconil 2787 and Daconil Ultrex, when applied on a two-week schedule. Banner 1.24 MEC, Phyton 27, and Bayleton 25W, along with the experimental fungicides fluazinam 500F and Heritage 80DF, failed at the rates evaluated to control leaf spot on Indian hawthorn.

METHODS

In April 1996, trade-gallon containers of Indian hawthorn 'Heather' which were grown in a pine bark medium, were obtained from a nursery. Typical symptoms of leaf spot were seen on the leaves of all the plants included in this study. Prior to the start of the study, each plant was topdressed with 12-6-6 fertilizer followed by weekly applications of 200 ppm of 20-10-20 water soluble fertilizer. Plants were watered daily with overhead irrigation. Disease pressure was maintained by placing leaf spot-damaged Indian hawthorn throughout the block of test plants. Fungicides were applied to run-off at two-week intervals from April 24 through Oct. 7. Disease incidence and defoliation on each plant was rated on Nov. 15 on the scale listed in the table.

RESULTS

The fewest leaf spot-damaged leaves and least defoliation were seen on Indian hawthorn treated with Daconil 2787 and Daconil Ultrex. Of these two, Daconil Ultrex proved slightly more effective against leaf spot than Daconil 2787 6F. Although some reductions in disease as compared with the unsprayed control were obtained with all remaining fungicide treatments, none proved as effective in controlling leaf spot as either formulation of Daconil. None of the fungicides screened were phytotoxic at the rates applied to Indian hawthorn.

Leaf Spot Control on Indian Hawthorn

Treatment	Rate per 100 gallons	Disease incidence[1]	Defoliation[1]
Banner 1.24 MEC	6 fl. oz.	5.5	4.9
Banner 1.24 MEC	12 fl. oz.	6.0	4.5
Daconil 2787 6F	1.3 pt.	3.8	3.2
Daconil Ultrex	1.4 lb.	2.6	2.6
Phyton 27	40 fl. oz.	6.0	4.0
Bayleton 25W	1 lb.	6.3	5.9
Fluazinam 500F	8 fl. oz.	6.1	4.4
Fluazinam 500F	12 fl. oz.	4.9	4.1
Heritage 80DF	1 lb.	6.0	4.8
Unsprayed Control		7.7	6.3

[1]Disease incidence and defoliation were rated using the Barratt and Horsfall rating system: 1 = 0% of leaves diseased or prematurely lost, 2 = 0-3%, 3 = 3-6%, 4 = 6-12%, 5 = 12-25%, 6 = 25-50%, 7 = 50-75%, 8 = 75-87%, 9 = 87-94%, 10 = 94-97%, 11 = 97-100%, and 12 = 100%.

Dogwood Taxa Differ in Their Susceptibility to Powdery Mildew and Spot Anthracnose

AUSTIN K. HAGAN, CHARLES H. GILLIAM, GARY J. KEEVER, J. DAVID WILLIAMS, B. HARDIN, AND D. JOSEPH EAKES

Prior to 1994, powdery mildew was a virtually unknown disease of flowering dogwood (*Cornus florida*). That year, disease, caused by the fungus *Microsphaera penicillata*, appeared in both landscape and nursery plantings of flowering dogwood throughout the eastern U.S. Although damage to landscape trees appears to be largely cosmetic, the slow growth and in some cases death of year-old field-grown nursery stock has been attributed to severe outbreaks of powdery mildew. In Alabama, native flowering dogwoods differ considerably in their reaction to this disease. Trees with heavily colonized leaves may be found adjacent to a mildew-free dogwood. The reaction of cultivars of flowering dogwood to this disease is, however, largely unknown.

Spot anthracnose, caused by the fungus *Elsinoe corni*, occurs wherever flowering dogwood are found and is most prevalent on trees growing in full sun. Although the

Table 1. Response of Dogwood Taxa to Spot Anthracnose and Powdery Mildew

Dogwood taxa	No. cultivars	Powdery mildew[1]		Spot anthracnose		
				Bracts	Leaves	
		1995	1996	1996	1995	1996
Flowering dogwood	26	1.4	0.9	1.5	0.3	1.3
Korean dogwood	3	0.1	0.1	0.0	0.0	0.0
Korean x flowering hybrid	7	0.1	0.0	0.6	0.0	0.3
Pacific x flowering hybrid	1	1.7	0.5	2.0	0.2	1.4
Giant dogwood	1	0.0	0.0	N.R.[2]	0.0	0.7

[1]Severity of powdery mildew and spot anthracnose was assessed on a scale of 0-4, where 0 = no disease, and 1 = 1-25% of leaves damaged, 2 = 26-50%, 3 = 51-75%, 4 = 76-100%.
[2]N.R. = not recorded.

impact of this disease on tree vigor is minor, the bracts and leaves of susceptible trees may be badly defaced and distorted; thereby reducing their landscape value. Some information is available concerning the cultivars sensitivity of flowering dogwood to spot anthracnose. However, the reaction of many newly released cultivars is unknown.

Results of an AAES field study show that flowering dogwood cultivars in a simulated landscape planting differed considerably in their reaction to both spot anthracnose and powdery mildew. Although no cultivars of flowering dogwood were immune to both diseases, several proved to have moderate resistance to both spot anthracnose and powdery mildew. Selections of Korean (*C. kousa*), hybrid Korean x flowering (*C. kousa* x *florida*), and giant dogwood (*C. controversa*) also were resistant to both diseases.

METHODS

Bare-root dogwoods were planted on March 3, 1993 into a Marvyn loamy sand on eight-foot centers in rows spaced 12 feet apart in Auburn, Ala. A trickle irrigation system with two emitters per tree was installed at the time of tree establishment. Twice each spring approximately 0.2 pounds of 13-13-13 analysis fertilizer was uniformly distributed around the base of each plant. Directed applications of Roundup herbicide at recommended rates were made to control weeds. Weeds were also pulled by hand. Alleys between the rows were periodically mown. In 1996, all trees were mulched with aged pine bark. Visual ratings of spot anthracnose and powdery mildew, respectively, were made on April 4 and May 23, 1995, and on April 29 and May 30, 1996.

RESULTS

The flowering dogwood and Pacific x flowering hybrid dogwoods 'Eddie's White Wonder' were more susceptible to both powdery mildew and spot anthracnose than the other dogwood taxa. Overall, disease ratings for powdery mildew across all flowering dogwood cultivars and the pacific x flowering hybrid, 'Eddie's White Wonder,' were lower in 1996 than in the previous year (Table 1). Spot anthracnose incited spotting of the leaves and flower bracts; bract distortion also was considerably heavier across all cultivars of flowering dogwood in 1996 as compared with 1995. In both years, very low spot anthracnose and powdery mildew ratings for the Korean, giant, and Korean x flowering hybrid dogwoods indicate an overall high level of resistance to these two common diseases in these dogwood taxa.

Sizable differences in the level of powdery mildew were seen among the cultivars of flowering dogwood. Among all cultivars of flowering dogwoods, 'Cherokee Brave' consistently remained free of powdery mildew in 1995 and 1996. In both years, the highest powdery mildew ratings were noted on cultivars with either pigmented bracts or

Table 2. Reaction of Cultivars of Several Dogwood Taxa to Powdery Mildew and Spot Anthracnose

Cultivar	Powdery mildew[1]		Spot anthracnose[1]		
			Bracts	Leaves	
	1995	1996	1996	1995	1996
Flowering dogwood					
Dwarf White	3.0	0.0	2.0	0.0	2.0
Autumn Gold	2.9	1.0	N.R[2]	0.7	1.4
Pink Beauty	2.6	1.5	1.6	0.0	1.1
Pink Flame	2.5	1.2	2.0	0.0	1.2
Wonderberry	2.2	0.5	1.8	0.4	0.6
First Lady	2.1	0.6	1.8	0.3	1.5
Rubra Pink	2.0	1.6	0.5	0.3	1.1
Red Beauty	2.0	1.4	1.0	0.3	1.4
Purple Glory	2.0	1.3	1.5	0.0	1.0
Welch's Bay Beauty	1.8	0.0	0.9	0.2	0.4
Ozark Spring	1.8	1.2	2.3	0.2	2.0
Fragrant Cloud	1.8	1.0	1.3	0.0	1.3
Welch's Junior Miss	1.7	0.9	1.3	0.0	2.6
Cloud 9	1.7	1.3	2.6	0.0	2.6
World's Fair	1.6	0.8	1.9	0.0	1.8
Rainbow	1.6	1.3	2.0	2.8	3.0
Barton White	1.5	0.7	3.3	1.0	2.7
Double White	1.5	0.5	0.5	0.5	1.3
Cherokee Princess	1.5	1.1	2.3	0.0	1.3
Stokes Pink	1.5	1.8	1.5	0.0	0.9
Cherokee Sunset	1.4	0.4	0.0	0.2	0.0
Cherokee Chief	1.4	0.6	0.7	0.0	0.6
Weaver's White	1.1	1.0	1.1	0.0	0.8
Cherokee Daybreak	0.9	0.0	3.0	0.5	1.1
Springtime	0.8	0.3	2.3	0.0	2.3
Cherokee Brave	0.2	0.0	1.0	0.0	0.6
Pacific x hybrid dogwood					
Eddie's White Wonder	1.3	0.5	2.0	0.3	1.4
Korean dogwood					
Milky Way	0.3	0.0	0.0	0.2	0.0
Satomi	0.0	0.0	0.0	0.0	0.0
Milky Way Select	0.0	0.3	0.0	0.0	0.0
National	0.0	0.0	0.0	0.0	0.0
Korean x flowering dogwood					
Star Dust	0.2	0.0	0.0	0.0	0.0
Ruth Ellen	0.1	0.1	1.1	0.0	0.3
Galaxy	0.1	0.0	0.0	0.0	0.0
Constellation	0.0	0.1	1.0	0.2	1.1
Stellar Pink	0.0	0.0	0.0	0.0	0.2
Aurora	0.0	0.0	0.0	0.0	0.0
Giant dogwood					
Controversa	0.0	0.0	N.R.	0.0	0.7

[1]Severity of powdery mildew and spot anthracnose was assessed on a scale of 0-4, where 0 = no disease, and 1 = 1 to 25%of leaves damaged or diseased, 2 = 26-50%, 3 = 51-75%, and 4 = 76-100%.
[2]N.R. = not recorded.

variegated leaves such as 'Autumn Gold,' 'Stokes Pink,' 'Rubra Pink,' 'Pink Beauty,' 'Red Beauty,' 'Purple Glory,' and 'Pink Flame.' Noticeable mildew development occurred in 1995 but not in 1996 on a number of other cultivars of flowering dogwood, as well as 'Eddie's White Wonder.' Among this group of flowering dogwoods, the lowest ratings for powdery mildew over both years were seen on 'Cherokee Daybreak,' 'Springtime,' and 'Cherokee Sunset.' Little or no powdery mildew was recorded in either 1995 or 1996 on the foliage of any of the Korean dogwoods, the Korean x flowering hybrids, or the single cultivar of giant dogwood, 'Controversa.'

Among the 26 cultivars of flowering dogwood, only 'Rainbow' suffered severe spot anthracnose-related leaf spotting and distortion in both 1995 and 1996. In 1995, disease intensity on the leaves of most remaining cultivars was negligible. The next year, extensive spotting, discoloration, and distortion of the bracts and leaves were noted on the cultivars 'Cherokee Daybreak,' 'Cloud 9,' 'Springtime,' 'Ozark Spring,' and 'Barton White.' Light to moderate spotting, along with some distortion and discoloration of the bracts, occurred on an additional 16 cultivars of flowering dogwood as well as 'Eddie's White Wonder.' Cultivars of flowering dogwood that had light damage to both the bracts and leaves included 'Cherokee Chief,' 'Cherokee Brave,' and 'Welch's Bay Beauty.' Of all cultivars of flowering dogwood screened, only the leaves and bracts of 'Cherokee Sunset' were free of symptoms of spot anthracnose. With the exception of the cultivar 'Ruth Ellen' in 1996, the remaining Korean x flowering hybrids as well as the cultivars of Korean dogwood cultivars were almost free of symptoms of spot anthracnose on both the leaves and bracts. Some light spotting of the leaves was noted on the giant dogwood 'Controversa' in 1996 but not in 1995.

These data indicate flowering dogwoods are more susceptible to spot anthracnose and powdery mildew than the cultivars of Korean or Korean x flowering hybrid dogwood. However, a few cultivars of flowering dogwood, including 'Cherokee Brave,' 'Cherokee Chief,' and 'Cherokee Sunset' demonstrated good resistance to both powdery mildew and spot anthracnose and any one of them would be an excellent addition to Alabama landscapes. Several others were resistant to either powdery mildew or spot anthracnose. Although the Korean, Korean x flowering hybrids and giant dogwood have superior resistance to these two common landscape diseases, they apparently are much more sensitive to winter kill than the flowering dogwood. After the bitterly cold winter of 1996, nearly all the Korean, Korean x flowering hybrids, and giant dogwoods failed to leaf-out or died shortly thereafter.

In summary, production and establishment of disease-resistant flowering dogwoods makes good sense for both the nursery producer and homeowner. The nursery producer can provide a quality product with fewer costly pesticide and labor inputs. For the consumer, disease resistance translates into attractive, relatively pest-free, low-maintenance flowering dogwood.

Response of Crapemyrtle Cultivars to Powdery Mildew and Cercospora Leaf Spot

AUSTIN K. HAGAN, CHARLES H. GILLIAM, GARY J. KEEVER, J. DAVID WILLIAMS

Brightly colored blooms, brilliant fall color, and a richly colored and textured bark make crapemyrtle a perennial favorite of landscapers and homeowners across Alabama. Within the last two decades, a number of cultivars with a variety of flower colors that vary in size from dwarf shrubs to small trees, have been released into the nursery trade. Two diseases, powdery mildew and Cercospora leaf spot, however, can mar the beauty of crapemyrtle in Alabama landscapes. Both disease may cause discoloration, distortion, and premature leaf loss on crapemyrtle in commercial nurseries. Disease resistance offers effective and pesticide-free control of both powdery mildew and Cercospora leaf spot. An AAES field trial has identified cultivars of crapemyrtle resistant to both of these damaging diseases.

METHODS

Bare-root crapemyrtle (*Lagerstroemia spp.*) were planted in March 1993 in a Marvyn loamy sand soil in Auburn, Ala., on eight-foot centers in rows spaced 12 feet apart. Planting holes were dug to a depth of 24-30 inches. Each plant was watered as needed with a trickle irrigation system. To suppress weeds, aged pine bark was distributed around the base of each plant. Hand weeding and directed applications of recommended rates of Roundup herbicide were also used to control weeds. The alleys between rows were periodically mown. Twice each spring, each tree was topdressed with 3.2 ounces of 13-13-13 analysis fertilizer. Each winter, all plants were lightly pruned. No pesticides were applied to control any insect pests or diseases. Visual ratings of powdery mildew and Cercospora leaf spot were made, respectively, on July 28 and Sept. 15 in 1995 and on June 4 and Sept. 20 in 1996. The rating scales used to evaluate both diseases are listed in the table.

Table 1. Reaction of Crapemyrtle Cultivars to Powdery Mildew and Cercospora Leaf Spot

	Powdery Mildew[1]		Cercospora Leaf Spot[2]	
	1995	1996	1995	1996
County Red	2.8	2.5[3]	4.0	4.6
Caroline Beauty	2.3	1.6	5.8	6.3
Raspberry Sundae	3.1	1.5	4.6	5.7
Wonderful White	2.4	1.5	5.0	6.8
William Toovey	1.9	1.3	3.7	4.4
Regal Red	0.6	1.2	2.1	4.0
Powhatan	1.3	1.1	3.4	5.5
Hardy Lavender	1.1	1.1	4.2	5.1
Majestic Beauty	1.7	1.0	3.7	5.3
Peppermint Lace	1.7	1.0	4.0	5.6
Gray's Red	2.2	0.8	3.5	3.9
Orbin Adkin's	2.4	0.7	5.8	6.7
Velma's Royal Delight	1.2	0.6	2.0	3.3
Glendora White	0.4	0.4	2.3	3.7
Tuskegee	0.1	0.4	1.8	1.5
Biloxi	0.4	0.3	4.4	5.3
Zuni	1.3	0.3	4.8	4.4
Seminole	0.8	0.3	3.3	5.6
Potomac	1.8	0.3	2.7	4.5
Basham's Party Pink	0.2	0.2	2.8	2.5
Dodd #2	0.4	0.2	N.R.	6.3
Catawba	0.7	0.1	3.6	4.6
Natchez	0.0	0.1	4.3	4.6
Choctaw	0.0	0.1	4.5	4.6
Pecos	0.4	0.1	2.8	5.1
Dodd #1	0.1	0.1	3.3	2.7
Acoma	0.0	0.0	5.3	6.3
Hopi	0.2	0.0	3.9	5.7
Comanche	0.0	0.0	5.6	6.6
Lipan	0.3	0.0	2.9	5.1
Osage	0.0	0.0	2.8	4.0
Souix	0.1	0.0	4.3	5.2
Apalachee	0.2	0.0	2.7	2.8
Yuma	0.4	0.0	4.9	5.0
Miami	0.1	0.0	3.5	4.7
Muskogee	0.2	0.0	4.7	4.8
Tuscarora	0.5	0.0	1.7	2.4
Wichita	0.3	0.0	2.8	3.6
Near East	0.3	0.0	5.0	5.4
Centennial Spirit	1.6	0.0	2.2	4.8
Fantasy	0.4	0.0	1.4	1.1
Caddo	0.0	0.0	2.4	2.9
Cherokee	0.0	0.0	2.3	4.0
Sarah's Favorite	0.0	0.0	3.5	3.8
Tonto	0.1	0.0	2.3	1.3

[1]The severity of powdery mildew as assessed on a scale of 0-4, where 0 = no disease, and 1 = 1-25% of the leaves damaged or colonized by E. Lagerstroemia, 2 = 26-50%, 3 = 51-75%, and 4 = 76-100%.
[2]Cercospora leaf spot was evaluated on using the Barratt and Horsfall System: 1 = 0%of leaves diseased, 2 = 0-3%, 3 = 3-6%, 4 = 6-12%, 5 = 12-25%, 6 = 25-50%, 7 = 50-75%, 8 = 75-87%, 9 - 87-94%, 10 = 94-97%, 11 = 97-100%, and 12 =100%.
[3]N.R. = not recorded.

RESULTS

Powdery mildew usually appears on the young leaves and shoots of crapemyrtle in late spring or early summer. On all cultivars except 'Dodd #2,' Cercospora leaf spot did not become noticeable until late August or early September. By early June, heavy spotting of the leaves and some defoliation was seen only on 'Dodd #2.' Spotting of the leaves and the premature leaf drop intensified through late September until the first hard frost. In 1996, the severity of powdery mildew declined while that of Cercospora leaf spot was worse than levels seen in the previous year. The year to year variation in the severity of both diseases may be influenced by summer rainfall or temperature patterns.

Significant differences in the severity of powdery mildew and Cercospora leaf spot were noted among the 45 crapemyrtle cultivars screened (Table 1). Over a two-year period, the cultivars 'Sarah's Favorite,' 'Cherokee,' 'Caddo,' 'Comanche,' 'Osage,' and 'Acoma' remained free of powdery mildew symptoms. An additional 17 cultivars of crape myrtle were disease-free in either 1995 or 1996. When powdery mildew was found on any of the above cultivars, infestations on the leaves, tender shoots, and flower panicles, as indicated by disease ratings of 0.5 or below, generally were very light. In both years, light and unobtrusive mildew infestations were noted on the cultivars 'Dodd #1,' 'Pecos,' 'Catawba,' 'Basham's Party Pink,' 'Biloxi,' 'Tuskegee,' and 'Glendora White.' Light to moderate mildew infestations were noted in both years on an additional seven cultivars.

In 1995, severe mildew infestations, which were characterized by the noticeable and heavy colonization of the leaves and tender shoots, were seen on 'Country Red,' 'Gray's Red,' 'Orbin's Adkins,' 'Raspberry Sundae,' 'Carolina Beauty,' 'Wonderful White,' 'William Toovey,' and 'Potomac' crapemyrtle. With the exception of 'Country Red,' disease ratings of the above cultivars declined in 1996 (Table 1). Year-to-year variations in powdery mildew ratings are due to either differences in rainfall patterns, temperature, or a combination of these two weather parameters.

Several mildew-resistant cultivars of crapemyrtle also suffered from light damage due to Cercospora leaf spot. Spotting of the foliage on the cultivars 'Tuscarora,' 'Tuskegee,' 'Tonto,' and 'Fantasy' was confined to a handful of leaves around the base of each plant. Other mildew-resistant cultivars that suffered from light spotting of the foliage, but no noticeable defoliation were 'Basham's Party Pink,' 'Dodd #1,' 'Apalachee,' 'Glendora White,' and 'Caddo' (Table 1).

Cercospora leaf spot did, however, heavily damage several mildew-resistant cultivars (Table 1). On 'Souix,' 'Hopi,' 'Acoma,' 'Comanche,' 'Near East,' 'Dodd #2,' and 'Yuma' crapemyrtle, heavy spotting of the leaves, which extended well up into the mid-canopy along with considerable early leaf drop, was seen in one or both years. A noticeable but less severe spotting of the leaves, as indicated by Cercospora leaf spot ratings of 4 to 5, was observed on a number of other mildew-resistant crape myrtle cultivars such as 'Natchez,' 'Muskogee,' and 'Miami.' The cultivars 'Caroline Beauty,' 'Wonderful White,' 'Raspberry Sundae,' 'Powhatan,' 'Peppermint Lace,' 'Majestic Beauty,' and 'Orbin's Adkins' were susceptible to both powdery mildew and Cercospora leaf spot.

In summary, excellent resistance to both powdery mildew and Cercospora leaf spot was identified in nine of the 45 cultivars of crapemyrtle screened. The beauty and vigor of these crapemyrtles can be easily maintained in both the nursery and landscape without the need for protective fungicide treatments. For the remaining mildew-resistant, but Cercospora leaf spot-susceptible cultivars, fungicides may be needed to obtain maximum fall color.

Control Of Florida Wax Scale on Dwarf Burford Holly

CHARLES P. HESSELEIN, JOSEPH R. CHAMBERLIN, AND MICHAEL L. WILLIAMS

Florida Wax Scale is a common pest of hollies. Most injury is cosmetic due to excretion of honeydew by the scale and the subsequent growth of sooty mold. However, severe infestations can kill entire branches through direct feeding injury.

This study was conducted to determine the efficacy of two acephate products, Pinpoint and an experimental, 2.5% active ingredient, sand-based granular product, compared to a standard insecticidal oil spray (Sun Spray Ultra Fine Spray Oil) and a water-sprayed control. Sun Spray UFSO and the 2.5% experimental acephate product provided the best control, with Pinpoint providing somewhat less control of Florida wax scale insects.

METHODS

Heavily infested dwarf burford hollies growing in 10-inch pots were placed in a greenhouse. Initially all scale sampled were eggs. Eggs were allowed to hatch and develop into second instars before plants were treated on May 14, 1996. Insecticide efficacy was expressed as the percentage of scale living at the end of the experiment (Final Scale Count/Initial Scale Count).

Treatments consisted of the following: Pinpoint 15 G, half teaspoon per pot; acephate 2.5G, two teaspoons per pot; Sun Spray UFSO 2%, sprayed to runoff, approximately 5.5 ounces of dilute spray per pot; and a water-sprayed control, approximately 5.5 ounces or water per pot.

On the day of treatment and three following days, plants were watered with eight ounces of water per pot. Subsequently, plants were irrigated daily with approximately six ounces water per pot using a drip irrigation system.

RESULTS

Sooty mold ratings were taken at the termination date (July 10). A scale of 1-5 was used, with 1 = 0% of the foliage affected by sooty mold, 2=1-25%, 3=26-50%, 4=51-75%, and 5=76-100%. The average scores for the different insecticide treatments were as follows: Pinpoint, 4.3; acephate 2.5G, 4.7; Sun Spray UFSO, 3.3; and the control, 5. Only the Sun Spray UFSO treatment had a lower sooty mold score compared to all other treatments. In addition to insecticidal properties, oil sprays have the added benefit of loosening sooty mold from the leaf surface, making it easier for the mold to wash or flake off.

Insecticide Efficacy as Measured by the Percent of Living Florida Wax Scale per Sample Area at the Study's Conclusion

Treatment	Pct. of live scale
Control	50
Pinpoint 15G	33
Acephate 2.5G	10
Sunspray UFSO	1

In addition to determining insecticide efficacy, phytotoxicity observations were included as part of the study. Plants exhibited no signs of phytotoxicity or growth stunting as a result of any treatment.

The results of this study show that Sun Spray UFSO and acephate 2.5G were the most effective treatments for controlling second instar Florida wax scale insects. Pinpoint 15G also controlled the scale although not as effectively as the Sun Spray UFSO or acephate 2.5G treatment (see table).

Many pest control manuals recommend using pesticide sprays for scale insects when the insects are in the first instar (crawler) stage. This study demonstrates that it is possible to obtain satisfactory control of Florida wax scale by targeting the second instar stage. The advantages of targeting this stage are two-fold. First, the insects are much easier to see and monitor. Second, the timing of the spray is not as critical as the insect spends more time in the second instar stage than in the crawler stage.

Adult Florida Wax Scale

It is important to realize that insecticidal oil sprays must contact the target pest in order to kill them. Thorough coverage of infested plants by the spray is necessary for satisfactory control.

Barnacle scale crawlers on holly.

Evaluation of Disease Resistant Roses and Alternative Control Treatments

F. BETH CLENDENEN, BRIDGET K. BEHE, AND KIRA L. BOWEN

Roses are among the most popular flowering plants in home or urban landscapes, with at least 10% of American households purchasing rose plants each year. Blackspot, caused by *Diplocarpon rosae* F.A. Wolf, is a serious problem for home gardeners and professional rose growers, causing leaf spots, chlorosis, defoliation, reduced vigor, and plant death.

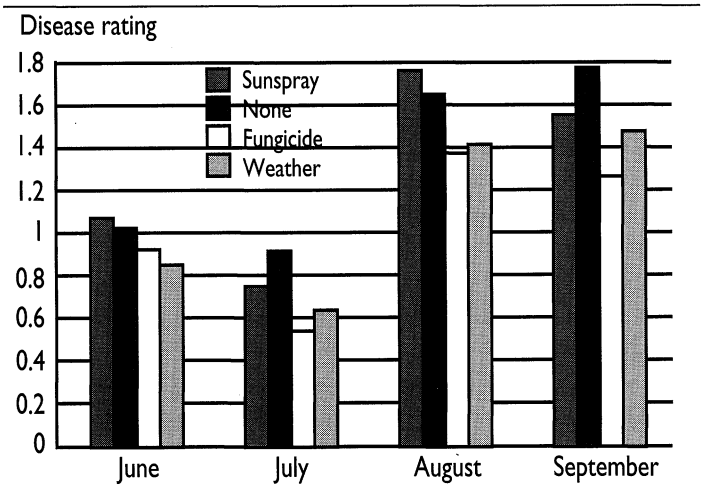
The fungus is especially problematic in the humid South where weather conditions are favorable for the development and spread of the disease and a long growing season extends the problem. The most commonly recommended control for rose blackspot are weekly applications of the fungicide chlorothalonil. Ecological concerns and time considerations associated with frequent fungicide applications can make this an undesirable control option for some homeowners.

Many old, cultivated roses come under the category of old garden roses, a class that may have more natural resistance to blackspot than some of the newer hybrid varieties that are popular today. The possibility of effectively controlling blackspot with horticultural oils or by spraying fungicide around weather events conducive to disease development have also been proposed. The objective of this study was to measure the success of alternative disease control treatments and to identify naturally resistant rose cultivars for the southern landscape.

METHODS

Nine roses compared in this study were either old garden roses or recently released cultivars that were selected for disease resistance. Two additional cultivars used for comparison were a hybrid tea and a floribunda rose. Bare-root roses were planted at E.V Smith Research Center Horticulture Unit, near Shorter, Alabama, in beds receiving full sun. The four blackspot treatments included (1) a no-spray control, (2) bi-monthly applications of chlorothalonil, (3) bi-monthly applications of 1% horticultural oil, and (4) chlorothalonil applied around weather events conducive to disease development.

Weather predictions, rainfall, and temperature data were obtained from the National Weather Service. Soil was tested and amended as recommended by the Alabama Soil Testing Laboratory. Fertilizer equal to 300 ppm N was applied weekly through a drip irrigation system. Rainfall was supplemented with irrigation to one-inch per week. Pine straw mulch was used in conjunction with hand weeding for weed control.



Treatment differences in blackspot disease ratings.

Roses were evaluated weekly using a visual rating scale from 0-5, assessing each rose individually for overall appearance, vigor, and percent disease and defoliation. Monthly counts of flowers and buds were used to compare roses and treatment performance. Monthly lesion counts and number of defoliated leaflets were also taken to assess disease progress.

Vogor Rating for Rose Cultivars

Cultivar	Vigor rating[1]
Belinda's Dream	4.4*
The Fairy	4.3
Red Mediland	3.8*
Carefree Delight	3.5**
Hansa	3.3***
Floral Carpet	3.3**
Seafoam	2.9*
Le Vesuve	2.8*
F.J. Grootendorst	2.4***
Cary Grant	2.4*
Love Potion	2.3**

[1]Scale: 0=appears dead, 1=severely unhealthy appearance, 2=unhealthy appearance, 3=average appearance, 4=pleasing appearance, and 5=overall healthy and vigorous. Phytotoxicity ratings: *= ome residual effects, **=deformation of new growth , and ***=leaf burn.

RESULTS

Throughout the season, chlorothalonil provided the most effective control of blackspot and largely prevented disease-induced defoliation (Figure 1). Fungicide-treated plants also maintained the highest overall quality ratings. No differences in disease control were found between oil-treated plants and untreated plants. Note that high overall ratings did not always reflect low disease incidence. Some cultivars, especially the "old garden roses," maintain their appearance even under significant disease pressure (Table 1). Rose cultivars that maintained high overall ratings throughout the season include 'The Fairy,' 'Belinda's Dream,' and 'Red Mediland.' Cultivars that showed high susceptibility to blackspot include 'Love Potion,' 'Cary Grant,' and 'F.J. Grootendorst.'

While evaluating for the blackspot fungus, another leaf spot disease, *Cercospora rosicola*, was identified. Oil and chlorothalonil both provided disease control, yet both were equally effective in their control of Cercospora. Some phytotoxicity was noticed among cultivars treated with oil (see the table) in mid-August when high temperatures contribute to this effect.

Evaluation of Antitranspirant Materials for Blackspot Control on Roses

R. STAN ROARK, BRIDGET K. BEHE, KIRA L. BOWEN, AND J. RAYMOND KESSLER

The rose is America's national flower and one of our most popular garden flowers. Hybrid tea roses with their long blooming season, wide color range, and attractive fragrance account for three-fourths of all rose sales. Rose blackspot, caused by the fungus *Diplocarpon rosae*, is the most important and destructive disease of hybrid tea roses in the Alabama landscape. Severely diseased roses may be completely defoliated resulting in weaker plants with shorter life.

Recommended control measures include the removal of infected leaves, annual mulch replacement, and weekly applications of a fungicide throughout the growing season. Because of Alabama's long growing season, high annual rainfall, and relatively mild winters, 20-30 fungicide applications are usually required to control blackspot.

Frequent fungicide applications can be neither desirable nor convenient. Concerns have focused on consumer and applicator safety, environmental issues, and the availability of alternative controls which are economically viable and yield high-quality plants. Recently, an AAES study was conducted to evaluate film-forming antitranspirant materials for their effectiveness in controlling rose blackspot. Antitranspirant materials consist of waxes, silicones, latexes, polyterpenes, and high-molecular-weight alcohols. Most film-forming antitranspirants are organically biodegradable and nontoxic to plants and animals. Materials in this study included three pinolene (a highly refined pine oil) products — Wilt Pruf, NuFilm 17, and Vapor Gard; two latex products — Stressguard and Transfilm; and a highly refined paraffinic oil, SunSpray Ultra Fine Horticultural Oil.

METHODS

Eighty plants of each of three hybrid tea cultivars, 'Cary Grant,' 'Princess Monaco,' and 'Dolly Parton,' were established at E.V. Smith Research Center in Shorter, Alabama. The roses were planted in a Norfolk fine sandy loam on three-foot centers in five rows which were 10 feet apart with each row having a trickle irrigation system. Plants were mulched with 2.5 inches of pine straw. Alleys between rows were mowed as needed. Fertilization was applied through the irrigation system as a weekly application of 200 ppm N (Scott's Soluble 20-10-20).

Visual ratings of plants were made weekly, beginning May 3, 1996, and continuing to July 19, 1996, for disease, defoliation, plant vigor, and number of flowers. Ratings for disease were based on a scale of 0 = no disease to 5 = 100% of leaves showing disease. Defoliation ratings were based on a scale of 0 = no defoliation to 5 = 100% defoliated. Vigor was rated from 0 = dead to 3 = a well-formed plant with abundant new growth. The number of flowers and buds showing color was counted weekly for each plant.

Treatments were applied to plants using a CO2 backpack sprayer until material began to drip from the foliage.

Table 1. Blackspot Disease Ratings May 3 to July 19, 1996

Treatment	Applied interval	Total applications	Disease rating[1]
Wilt Pruf 5%	3 weeks	4	1.66
Vapor Gard 2%	3 weeks	4	1.62
Nu Film 17 2%	3 weeks	4	1.61
Transfilm 0.25%	2 weeks	6	1.58
Untreated	—	0	1.46
Stressguard 0.25%	2 weeks	6	1.41
SunSpray Oil 1%	weekly	8	1.37
alternated with chlorothalonil	**[2]	3	
Vapor Gard 1%	2 weeks	5	1.37
alternated with chlorothalonil	**	4	
NuFilm 17 1%	2 weeks	5	1.22
alternated with chlorothalonil	**	4	
Stressguard 0.5%	2 weeks	6	1.19
Chlorothalonil 0.17 oz./gal.	weekly	11	1.07

[1]Disease rating scale: 0 = no disease to 5 = 100% of leaves showing disease.
[2] "**" indicates that application interval was based on the occurrence of rain (> 0.1 inch) following a previous application.

Table 2. Rose Plant Defoliation Ratings May 3 to July 19, 1996

Treatment	Applied interval	Total applications	Defoliation rating[1]
Wilt Pruf 5%	3 weeks	4	1.59
NuFilm 17 2%	3 weeks	4	1.50
Vapor Gard 2%	3 weeks	4	1.48
Transfilm 0.25%	2 weeks	6	1.48
Untreated	—	0	1.38
Stressguard 0.5%	2 weeks	6	1.36
Stressguard 0.25%	2 weeks	6	1.28
NuFilm 17 1%	2 weeks	5	1.02
alternated with chlorothalonil	**[2]	4	
SunSpray Oil 1%	weekly	8	0.99
alternated with chlorothalonil	**	3	
Vapor Gard 1%	2 weeks	5	0.96
alternated with chlorothalonil	**	4	
Chlorothalonil 0.17 oz./gal.	weekly	11	0.73

[1] "**" I Defoliation ratings were based on a scale of 0 =no defoliation to 5 = 100% defoliated. Vigor was rated from 0 = dead to 3 = a well-formed plant with abundant new growth.
[2] "**" indicates that application interval was based on the occurrence of rain (> 0.25 cm) following a previous application.

Applications were made either weekly, biweekly, or every third week. Some treatments were alternated with the fungicide, Daconil 2787/Bravo 4 F (chlorothalonil), based on the occurrence of rain greater than 0.1 inch.

RESULTS

Ratings for the 12-week period showed differences among the treatments for plant disease and defoliation, but not for plant vigor and flowering (Table 1). Two products, Stressguard 0.5% and NuFilm 17 1% alternated with chlorothalonil, produced control of rose blackspot similar to weekly applications chlorothalonil. Stressguard was applied six times and NuFilm 17 five times with four alternate applications of fungicide. For defoliation, only the Vapor Gard 1% alternated with chlorothalonil provided similar control to weekly fungicide applications. Vapor Gard was applied five times and alternated with four applications of chlorothalonil.

Although weekly applications of fungicide gave the best overall control, these results indicate that it is possible to control blackspot with fewer fungicide applications. Stressguard contains no fungicide, and the NuFilm 17 and Vapor Gard treatments used only four applications of fungicide. Alternating antitranspirant materials with chlorothalonil proved only slightly less effective than 11 weeks of chlorothalonil sprays in controlling blackspot. Treatments applied at three-week intervals did not provide effective disease control.

Recycled Waste Paper as Landscape Mulch

DANITA R. SMITH, CHARLES H. GILLIAM, JAMES H. EDWARDS, D. JOSEPH EAKES, AND J. DAVID WILLIAMS

Waste disposal continues to be a critical problem facing municipalities across the U.S. In 1989, the U.S. Environmental Protection Agency (EPA) mandated a national goal for a 25% reduction in landfill disposal effective in 1995 and a total reduction of 75% by the year 2000.

To comply with the goals set by the EPA, many states have enacted laws requiring a 30-60% reduction of municipal solid waste (MSW) entering landfills. Approximately 40% of MSW consists of paper and paper products, which therefore comprise a significant area targeted for reduction and recycling. Recycling of newspaper for the horticulture industry could help reduce the bulk of waste paper entering landfills.

One possibility receiving some attention is the use of recycled newspaper as a landscape mulch. Currently, chopped newspaper has been used successfully for weed control among eggplants, conifer seedlings, sweet corn, soybeans, tomatoes, and strawberries. Chopped newspaper at a four-inch depth suppressed weed germination for two seasons without a negative effect on three species while a fourth plant species had suppressed growth in one year and not the other. One problem encountered with the use of chopped paper was blowing during windy conditions. Rolling the paper with a lawn roller reduced blowing of small pieces of paper; however, the nuisance created from blowing paper was considered unacceptable.

One approach to eliminating windblown paper is reprocessing the paper into a more stable form. Two recent products made from recycled paper have potential for use in the landscape without the nuisance of wind-blown particles previously reported. These products are pelletized recycled newspaper or crumbled recycled newspaper. Newspaper is ground with a hammer mill, then compressed using pelletizing equipment to form pellets about three-sixteenths of an inch by one inch in size. To develop the crumbled product, pellets are put through a granulator with variable pressure plates. Both products are non-composted and have a carbon to nitrogen ratio of about 500:1.

In agronomic studies these products have provided an excellent source of carbon for increasing microbial activity, soil organic matter, water infiltration, and controlling weeds. However, previous work with agronomic crops had suggested that aluminum toxicity created stunting in corn and cotton. Newsprint contains large amounts of aluminum because alum is used during the processing of green logs to remove tars and resins from grinding equipment. Residual alum in the paper reacts chemically, resulting in excess aluminum in the soil and toxicity symptoms in some plants. Al injured roots will appear stunted and shoots are often stunted and chlorotic.

The objective of this study was to compare these recycled newspaper products with traditional landscape weed control methods and to determine effects on growth of annual plants. Pellets and crumble were evaluated in two field studies conducted in Auburn, Ala.

METHODS

EXPERIMENT 1. Beds were amended with two to three inches of pinebark, fertilized with 13-13-13 fertilizer applied at 0.26 pounds of nitrogen per square foot, and tilled prior to planting. Finished plugs of the annual species ageratum, marigold, geranium, and salvia, were planted May 10, 1995. Half of each plot was overseeded with 25 prostrate spurge seed and half overseeded with 25 eclipta seed prior to mulch application. Treatments included the two paper products at three depths — 0.5, 1.0, 2.0 inches; pinebark at two to three inches; pinebark at two to three inches, plus Geogard weedmat; Ronstar 2G pre-emergence herbicide applied at four pounds of active ingredient per acre; and a non-mulched control.

Percent weed control in each plot was determined 30 and 60 days after treatment (DAT). Spurge and eclipta numbers in one square foot were also counted at these times. Shoot dry weights of bedding plants were determined 60 DAT, and soil moisture was determined 32, 39, and 46 DAT.

EXPERIMENT 2. The second study was initiated to determine if the addition of phosphorus would correct the suspected problem of aluminum toxicity observed in the first study. It was theorized that the same situation was occurring with these annual species and based the second experiment on these results. The additional phosphorus would tie up the excess aluminum, eliminating the toxicity.

The same plots were used and were prepared as follows: mulch from the first study was removed, beds were amended with two to three inches of pinebark, fertilized with 13-13-13 applied at 0.26 pounds of nitrogen per square foot, and tilled prior to planting. Finished plugs in 48-count cell packs of three annual species — ageratum, marigold, and geranium — were planted on Sept. 7, 1995. All paper mulches were applied at a depth of one inch. Mulch treatments included either pellets or crumble to which P was added at a rate of 0, 3.75, or 7.5 ppm in the form of triple super phosphate (0-46-0). Triple super phosphate was incorporated into the recycled paper by tumbling it in a revolving mixer into which water was sprayed to encourage contact between the paper and the phosphate. Other treatments included pinebark at a two- to three-inch depth; pinebark at two to three inches plus Geogard weedmat; Ronstar 2G applied at four pounds of active ingredient per acre; and a non-mulched control. Each plot was overseeded with 25 prostrate spurge seed prior to mulch application. Percent weed control was determined 21 and 45 DAT. Spurge plants per plot were also counted 21 and 45 DAT. Growth index was determined by measuring height and two perpendicular widths 45 DAT. At the time of termination, Oct. 30, 1995, volume displacement of roots was determined using a volume displacement technique involving suspending roots in a 10X20-inch cylinder filled with water. Water is displaced via a downspout, allowing for estimation of root volume. Shoot and root dry weights were determined as well as weed dry weights.

Table 1. Experiment 1: Weed Control and Moisture Levels After Various Mulch Treatments

Treatments	Depth	Weed control		Moisture level		
		30 DAT[1]	60 DAT	32 DAT	39 DAT	46 DAT
	in.	*pct.*	*pct.*	*pct.*	*pct.*	*pct.*
Crumble	0.5	95.3	92.3	24.7	24.1	24.5
Crumble	1.0	99.5	99.5	21.6	27.9	25.3
Crumble	2.0	2.0	100	100	22.5	25.1
23.2						
Pellet	0.5	78.8	71.5	20.5	20.0	18.9
Pellet	1.0	84	74.5	21.5	23.9	22.8
Pellet	2.0	97	97.3	21.0	22.3	21.9
PB+m[2]	2-3	99.5	100	20.1	20.8	20.7
PB	2-3	99	99.5	24.9	25.2	22.5
Ronstar[3]	—	85.3	75.8	22.8	20.9	15.4
Control[4]	—	47.5	35	22.5	21.4	17.1

[1]Days after transplant.
[2]Pinebark plus Geogard weedmat.
[3]Ronstar applied at four pounds active ingredient per acre.
[4]No mulch applied.

RESULTS

EXPERIMENT 1. Weed control data at 30 and 60 DAT showed both recycled newspaper products provided effective weed control with the exception of the pellets at the 0.5-inch depth (Table 1). Generally, crumble was more effective then pellets, and an increase in depth gave an increase in weed control. Previous work reported chopped paper provided almost complete weed suppression during the first growing season and acceptable weed suppression during the second season. Pine bark and the pine bark-weedmat combination both provided 99% weed control at both dates. Ronstar, a preemergence applied herbicide, provided 85% and 75% weed control.

Shoot dry weight decreased as crumble mulch depth

Table 2. Experiment 1: Influence of Mulch Type and Depth on Growth of Annual Species[1]

Treatments	Depth	Shoot dry weight			
		Ageratum	Geranium	Salvia	Marigold
	in.	*g/plant*	*g/plant*	*g/plant*	*g/plant*
Crumble	0.5	24.9	15.9	2.3	35.8
Crumble	1.0	12.3	11.6	1.7	27.6
Crumble	0.5	4.1	8.5	1.1	12.8
Pellet	1.0	28.1	19.7	10.3	53.6
Pellet	1.0	16.6	12.5	3.0	40.9
Pellet	1.0	9.8	9.2	1.8	14.5
PB+m[2]	2-3	28.7	21.3	6.4	67.2
PB	2-3	34.0	12.2	4.5	52.1
Ronstar[3]	—	45.9	17.5	7.1	64.8
Control[4]	—	54.8	19.6	5.3	57.8

[1]Experiment 1 terminated 60 DAT (May 10 - July 6).
[2]Pinebark plus Geogard weedmat.
[3]Ronstar applied at four pounds active ingredient per acre.
[4]No mulch applied.

increased with two of the four species (Table 2). With the pellets all four species decreased in shoot dry weight with an increase in mulch depth. Ageratum exhibited the greatest shoot dry weight inhibition. Compared to the control plants, ageratum shoot dry weight was 55%, 78%, and 93% less with crumble mulch treatments of 0.5-, 1.0-, and 2.0-inch depth. Ageratum grown in pellet mulch treatments followed a similar trend to crumble mulch treatments. The three treatments representing industry standards (pine bark mulch, pine bark mulch with weedmat, and Ronstar herbicide) also reduced ageratum shoot dry weight, with the Ronstar herbicide treatment causing the least suppression. These data indicate all mulch treatments reduced ageratum shoot dry weight. With marigold, shoot dry weights were similar among the three industry standard treatments and pelleted recycled newspaper at depths of 0.5 and one inch.

Table 3. Experiment 2: Influence of Mulch Type and P Level on Growth of Annual Species[1]

Treatment[2]	P level	Shoot dry weight		
		Ageratum	Geranium	Marigold
	ppm	*g/plant*	*g/plant*	*g/plant*
Crumble	0.0	6.3	9.6	36.5
Crumble	3.75	19.0	9.8	36.6
Crumble	7.5	12.8	13.2	32.2
Pellet	0.0	5.5	7.5	37.7
Pellet	3.75	12.2	9.7	33.0
Pellet	7.5	10.5	11.0	34.5
PB+m[3]	0.0	10.4	9.6	32.7
PB	0.0	8.8	8.3	36.4
Ronstar[4]	0.0	10.7	10.5	40.7
Control[5]	0.0	12.5	8.5	39.2

[1]Experiment 2 terminated 45 DAT (Sept. 13 - Oct. 30).
[2]All recycled newspaper mulch applied at one inch depth.
[3]Pinebark plus Geogard weedmat.
[4]Ronstar applied at four pounds active ingredient per acre.
[5]No mulch applied.

At termination, the plants were dug and the roots examined. Roots in those plots receiving one or two inches of newspaper mulch exhibited a disruption of root growth. Root systems were stunted and lacking in fine branching.

By 46 DAT all mulched plots had higher moisture levels than the unmulched plots, and all paper treatments with the exception of pellets at 0.5 inch were different from the control (Table 1). Generally the paper mulches had slightly increased or similar moisture levels between the 32 and 46 DAT readings, whereas the unmulched plots had a decrease in moisture levels.

EXPERIMENT 2. When no P was added to the newspaper products, ageratum growth was about half that of the control plants. Addition of P at 3.75 and 7.5 ppm to crumble paper increased ageratum growth 200% and 103% respectively compared to no-P crumble mulched plants. Addition of P at 3.75 and 7.5 ppm to pelleted paper increased ageratum growth 121% and 90% compared to no-P plants. The addition of P did not affect the growth of geraniums or marigolds. (Table 3). These data are consistent with the first study where ageratum was the most sensitive to recycled paper mulches and the other species were less affected at the one-inch depth. Growth index again followed a similar trend to shoot growth data.

Root dry weight of ageratum increased with both levels of P, with the crumble at 3.75 ppm P producing the best growth. Geranium was not affected by the addition of P, but the highest dry weight was produced with the 7.5 ppm with the crumble. Marigold growth was not affected by the addition of P (Table 3).

Ageratum plants grown in the plots with recycled paper treatments exhibited a varying response in the root volume displacement test. The crumble at 3.75 ppm produced the best growth, which was equal to the pinebark plus weedmat. Geranium root volume increased linearly in the paper crumble mulch, but not with the pellets. Mulched plots in general showed better root growth than unmulched plots. Marigolds did not benefit from the addition of P and decreased in root volume with additional P.

All mulch treatments provided effective weed control (90% plus) (Table 4). Ronstar provided about 80% weed control at 45 DAT. Weed dry weight was less for all mulch treatments compared to the Ronstar-treated plot and the nontreated control. For example, weed dry weight for any paper treatment did not exceed 0.85 grams per plot, whereas Ronstar plots had 7.6 grams per plot and the control, 30.2 grams per plot.

These data show paper mulches to be effective in controlling weeds, as well as conserving moisture. Addition of P overcame the negative affects of aluminum in some species, but not in all species. Based on the response to the newspaper treatments, ageratum could serve as an indicator species for plant interactions with the paper.

Table 4. Experiment 2: Weed Control and Weed Dry Weight After Various Mulch Treatments

Treatments[1]	P level	Weed control		Weed dry weight
		20 DAT[2]	45 DAT	(45 DAT)
	ppm	*pct.*	*pct.*	*g/plot*
Crumble	0.0	98.5	97.3	0.4
Crumble	3.75	98.5	93.8	0.9
Crumble	7.5	99.0	96.0	0.4
Pellet	0.0	98.0	97.8	0.4
Pellet	3.75	99.0	98.0	0.2
Pellet	7.5	98.5	97.8	0.7
PB+m[3]	0.0	100	99.5	0.0
PB	0.0	94.8	90.3	1.8
Ronstar[4]	0.0	81.3	78.8	7.6
Control[5]	0.0	58.8	52.5	30.2

[1]All recycled newspaper mulch applied at one inch depth.
[2]Days after transplant.
3Pinebark plus Geogard weedmat.
[4]Ronstar applied at four pounds active ingredient per acre.
[5]No mulch applied.

ENVIRONMENTAL ISSUES

Ozone Sensitivity of Selected Southeastern Landscape Plants

DOUGLAS A. FINDLEY, GARY J. KEEVER, ARTHUR H. CHAPPELKA, CHARLES H. GILLIAM, AND D. JOSEPH EAKES

Since being identified as a phytotoxic, gaseous air pollutant in the 1950s, ozone has progressively become the major air pollutant across the United States. Although ozone is normally associated with urban areas, it is readily transported long distances to non-urban areas. The major effects of ozone on terrestrial vegetation include visible injury, and reductions in growth, productivity, and plant quality. Most of the literature reporting ozone injury has been with plants grown in the Northeast. However, information is needed on ozone sensitivity of landscape plants grown in southern hardiness zones.

Visual appearance is a primary attribute professional and nonprofessional consumers evaluate in the selection and use of landscape plants. Any condition, including exposure to ozone, that adversely alters visual appearance is likely to reduce marketability of a plant. Foliar injury did not occur or was minor for most of the 26 species and/or cultivars exposed to ambient or elevated ozone levels, demonstrating tolerance to elevated ozone in some landscape plants commonly grown in the Southeast. However, of the nine cultivars of buddleia evaluated, 'Black Knight' and 'Royal Red' exhibited minor foliar injury under ambient ozone levels, and severe foliar injury under elevated ozone levels. 'White Star' zinnia also was injured severely under elevated ozone levels. Injury was severe enough to limit selection and use in areas with known elevated ozone levels. Injury observed on the other seven cultivars of buddleia and cultivars of red maple was to less than 9% of the leaves and should not preclude their use in areas with elevated ozone levels.

METHODS

Uniform liners, seedlings, or annual plugs of 26 species or cultivars of plants were transplanted into one- or four-gallon pots containing an amended pine bark and sand medium in March 1994. Plants of each species or cultivar were placed within an open-top fumigation chamber in May 1994 and exposed to various ozone concentrations. The experiment was repeated in June, July, and August 1994 with a new group of plants from the original potting.

Ozone treatments consisted of sub-ambient air, in which air was filtered through activated carbon to reduce ozone to about 50% of ambient levels; nonfiltered ambient air (Auburn, Ala., classified as a rural setting); and air injected with ozone at 2.5 times the ambient level. The latter treatment represents ozone concentrations similar to those reported in urban areas of the Southeast, such as Birmingham or Atlanta.

Plants were evaluated at the end of three weeks for visible injury by estimating the percentage of leaves injured (PLI). Leaves with visible foliar injury were rated further for the percentage of leaf area injured using the Horsfall-Barratt (H-B) rating scale for foliar injury. This rating scale ranges from 1-12, with 1 indicating 0% of the leaf area exhibiting foliar injury and 12 indicating 100% of the leaf area exhibiting foliar injury.

RESULTS

No plants in the sub-ambient treatment exhibited symptoms of foliar injury during the study, and only two cultivars of buddleia, 'Black Knight' and 'Royal Red' developed visible injury symptoms in the ambient ozone treatment. In the ozone-enriched treatment, visible injury was present on all nine cultivars of buddleia, all three cultivars of red maple, and zinnia. No visible injury was apparent on any of the remaining species or cultivars. Visible foliar injury symptoms varied among species but were consistent among the cultivars of a species. Injury was first observed on the oldest foliage of all buddleia and zinnia plants affected, and symptom expression decreased with decreasing leaf age. Injury was first noted on the most recently expanded leaves of the red maple cultivars, indicating that the youngest expanding leaves and the oldest foliage, produced prior to ozone exposure, were more tolerant to elevated ozone concentrations.

Visible injury on buddleia consisted of dark maroon or brown stippling and bronzing on the upper leaf surface. Some of the oldest leaves also developed a general chlorosis as the severity of injury increased. The most severely injured leaves tended to senesce within one week of removal from the chambers. New leaf buds began to break shortly thereafter to replace lost foliage. These symptoms were similar among the buddleia cultivars; only the severity of the injury differed between the ambient and elevated-ozone treatments.

Sensitivity differences among buddleia cultivars were evident based on percentage of the leaves injured and the Horsfall-Barrett rating. PLI increased with increasing ozone concentration for all buddleia cultivars except 'Empire Blue,' 'Opera,' 'Pink Delight,' and 'Sungold' (Table 1). In the ambient ozone treatment, only 'Black Knight' and 'Royal Red' exhibited visible injury with PLI values of 7.2% and 6.8%, respectively. In the elevated-ozone treatment, all cultivars were visibly injured, but the severity varied among cultivars. 'Royal Red' was the most severely injured cultivar

Table 1. Percentage of Leaves Injured (PLI) on Cultivars of Buddleia Exposed to Three Levels of Ozone

Treatment	Cultivar								
	Black Knight	Charming Summer	Empire Blue	Lochinch	Nanho Blue	Opera	Pink Delight	Royal Red	Sungold
Sub-ambient	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ambient	7.2	0.0	0.0	0.0	0.0	0.0	0.0	6.8	0.0
2.5 X ambient	35.0	5.4	3.9	8.3	4.2	2.5	3.6	57.1	4.4

Table 2. Horsfall-Barratt (H-B) Rating of Foliar Injury for Cultivars of Buddleia Exposed to Three Levels of Ozone[1]

Treatment	Cultivar								
	Black Knight	Charming Summer	Empire Blue	Lochinch	Nanho Blue	Opera	Pink Delight	Royal Red	Sungold
Sub-ambient	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Ambient	3.4	1.0	1.0	1.0	1.0	1.0	1.0	3.2	1.0
2.5 X ambient	5.9	2.3	1.7	2.3	2.1	1.5	1.9	6.7	1.9

[1]The H-B rating scale is: 1 = 0% of the leaf area injured, 2 = 1-3%, 3 = 3-6%, 4 = 6-12%, 5 = 12-25%, 6 = 25-50%, 7 = 50-75%, 8 = 75-87%, 9 = 87-94%, 10 = 94-97%, 11 = 97-99%, and 12 = 100%.

with a PLI of 57.1%, followed by 'Black Knight' with a PLI of 35.0%. Injury was present on all but the youngest leaves of these two cultivars. PLI values for the remaining cultivars were less than 10%.

Ratings of visibly injured leaves, using the Horsfall-Barratt (H-B) rating scale, increased with increasing ozone concentrations for all cultivars except 'Empire Blue,' 'Opera,' and 'Sungold' (Table 2). In the ambient ozone treatment, 'Black Knight' and 'Royal Red' had H-B ratings of 3.4 and 3.2, respectively, indicating that between 3% and 6% of the leaf area exhibited visible injury symptoms. In the ozone-enriched treatment, 'Royal Red' was the most severely injured cultivar with a H-B rating of 6.7, which corresponds to 50% to 75% of the leaf area exhibiting visible symptoms. 'Black Knight' had a H-B rating of 5.9, corresponding to leaf area injury of 25% to 50%. All other cultivars had ratings of approximately 2.3, indicating 1% to 3% of the leaf area exhibited injury symptoms.

Although flowering dates were not recorded, the authors observed that flowering was delayed by about three to four days among buddleia cultivars in the ozone-enriched treatment. It was also observed that spider mites appeared to prefer plants exposed to the highest ozone treatment.

Minor visible injury, characterized as a light stippling and slight bronzing on the upper leaf surface, occurred on all three cultivars of red maple, but only in the elevated-ozone treatment (PLI of 4.1% and 1% to 3% of the area of injured leaves exhibiting symptoms).

Visible injury on 'White Star' zinnia was characterized as a uniform light tan stippling on the upper leaf surface. This injury was observed on the lower half of the plant with fewer stipples on portions of leaves shaded by other leaves. The PLI of 40% and H-B rating of 5.9 (25% to 50% of the leaf area injured) were relatively high. Injury severity was similar to that on the most severely injured cultivars of buddleia.

Results herein provide information on the sensitivity to ozone of selected landscape plants grown in southern hardiness zones. Of the 26 species or cultivars, 13 exhibited visible injury symptoms after a three-week exposure to elevated ozone concentrations, indicating both inter- and intraspecific differences in sensitivity to ozone. While all nine cultivars of buddleia exhibited visible injury, the severity of injury differed; most cultivars were tolerant except 'Black Knight' and 'Royal Red'. 'White Star' zinnia also showed extensive visible injury to ozone. Visible injury observed on the other cultivars of buddleia and red maple was minor and should not preclude their use in areas with elevated ozone levels.

Sensitivity of Red Maple Cultivars to Acute and Chronic Exposures of Ozone

DOUGLAS A. FINDLEY, GARY J. KEEVER, ARTHUR H. CHAPPELKA, D. JOSEPH EAKES, AND CHARLES H. GILLIAM

Since being identified as a phytotoxic air pollutant in the 1950s, ozone has progressively become the major air pollutant across the U.S. Tropospheric ozone is associated with urban areas having many automobiles, but it is readily transported long distances to non-urban areas. The major effects of ozone on terrestrial vegetation include visible foliar injury, as well as reductions in growth, productivity, and crop quality. Both acute ozone exposures (the exposure to high concentrations for short periods of time) and chronic ozone exposures (the exposure to low concentrations for long periods of time) can result in injury to sensitive plant species under certain environmental conditions.

Selection of superior species for use as street or landscape trees involves the consideration of numerous qualities such as flowering, fruiting, fall color, and tolerance to air pollutants. Red maple (*Acer rubrum*) is commonly used as a street tree across the U.S., and has the greatest north-south distribution of all tree species along the east coast of the U.S. Variations in sensitivity to ozone have been noted in red maples from different seed sources. Differences in ozone sensitivity among cultivars have also been reported in landscape plants such as azaleas, trembling aspen, and white pine. The objective of this study was to determine the relative sensitivities of several red maple cultivars proven to be good performers in the Southeast to acute and chronic exposures of ozone.

METHODS

ACUTE EXPOSURE. One-year-old liners of 'Autumn Flame,' 'Franksred' (Red Sunset), 'October Glory,' 'Fairview Flame,' and 'Northfire' red maple, as well as 'Autumn Blaze,' a Freeman red maple, were assigned to each of four ozone treatments. Ozone concentrations of 0, 100, 200, or 300 parts per billion (ppb) were applied for four hours on each of two consecutive days in continuously stirred tank reactors located within a walk-in growth chamber.

After exposure, plants were returned to a gravel container area and evaluated two, seven, and 30 days later for percentage of the leaves injured (PLI) and leaf area injured. Leaf area injured was rated for those leaves with visible injury using the Horsfall-Barratt foliar injury scale (H-B rating).

CHRONIC EXPOSURE. One-year-old liners of 'Autumn Flame,' 'Franksred,' 'Fairview Flame,' and 'Autumn Blaze' were exposed to ozone treatments of sub-ambient (CF) air, in which air was filtered through activated carbon to reduce ozone about 50% below ambient level; non-filtered ambient (NF) air (Auburn, Ala., classified as a rural setting); and air injected with ozone at two times the ambient concentration in open-top fumigation chambers. Treatments were applied in fumigation chambers for 12 hours per day, seven days per week.

Plants were evaluated for visible foliar injury at both four and eight weeks after ozone exposure began (WEB). In addition, height and caliper were measured at four, six, and eight WEB, respectively. At eight WEB, all plants of each cultivar were harvested, and roots, stems, and leaves were dried and weighed.

RESULTS

ACUTE EXPOSURE. Minor visible foliar injury was observed on all red maple cultivars following exposure to all ozone concentrations except the control. Visible injury occurred on the oldest leaves only and was characterized by stipples on the upper leaf surface. Injury was minor, involving less than 6.2 PLI, and 2.1% of the total leaf area (H-B rating) (Table 1). Among all cultivars, the PLI observed at the highest ozone concentration was less than 4%. These results are similar to those from other studies conducted in the Northeast, demonstrating the relative high tolerance of red maple cultivars to elevated ozone concentrations.

Table 1. Percentage of the Leaves Injured (PLI) and Horsfall-Barratt (H-b) Rating for Foliar Injury for Six Red Maple Cultivars Exposed to Four Acute Levels of Ozone

Cultivar	Pct. leaf injury	H-B rating[1]
Autumn Blaze	1.9[2]	1.5
Autumn Flame	0.3	1.1
Fairview Flame	3.4	1.6
Franksred	1.8	1.4
Northfire	4.0	1.8
October Glory	2.9	1.6
Ozone Concentration (ppb)		
0	0.0	1.0
100	0.9	1.3
200	2.5	1.6
300	6.2	2.1

[1]H-B ratings: 1 = 0%of the leaf area injured, 2 = 1% to 3%, and 3 = 3% to 6%.

[2]Means for cultivar comparisons are averaged across the three higher ozone concentrations; means for ozone comparisons are averaged across cultivars.

CHRONIC EXPOSURE. Visible foliar injury was not observed on red maples exposed to the three ozone levels. This indicates that the four cultivars evaluated were relatively tolerant to the tested ozone levels in this experiment. As has been reported, red maples are relatively tolerant to ozone, making them ideal trees for areas which experience elevated ozone levels. Also, no differences among the treatments or cultivars were detected for the growth measurements of height, caliper, or leaf, shoot, and root dry weights.

Although ozone sensitivity is an important criterium for selecting many species, red maple's tolerance to ozone exposures indicates there are more important criteria that need to be evaluated for use in a particular area. These include growth rate, form, fall color, and insect or disease resistance. Red maples that perform well in the Southeast, 'Autumn Blaze,' 'Autumn Flame,' 'Franksred,' and 'October Glory,' appear to be relatively tolerant to acute ozone exposures, while all cultivars evaluated appear to be relatively tolerant to chronic ozone exposures.

Using Pine Bark to Filter Out Contaminates in Irrigation Runoff Water

GLENN R. WEHTJE, CHARLES H. GILLIAM, AND TIMOTHY L. GREY

Nurseries and landscape crops can require frequent irrigation and pesticide application. Irrigation runoff from landscape plant production areas and landscape developments has been suggested as a source of pesticide contamination for local water supplies or surrounding bodies of water.

Holding ponds are one method of reducing the amount of pesticide-contaminated water from a container production area. However, when containment ponds are unavailable or not practical, other means of remediation may be required. Filtration of pesticide-contaminated water with commonly used organic container production such as pine park may offer an effective alternative to holding ponds.

Cleansing pesticide-contaminated water may be accomplished by simply allowing container production runoff water to drain through an organic media-filled (pine bark) filter. To test this hypothesis, AAES researchers used the herbicide metolachlor. Metolachlor is commonly used in nursery production under the trade name 'Pennant.' Metolachlor was selected since it's water solubility is fairly high (530 ppm). Removing this compound by filtration would be difficult.

A filtering system requires that all contaminated water pass through the filter. A suitable filter must: (1) not inhibit water flow to unacceptable levels and (2) remove enough of the pesticide residues so as to justify the effort. Since water channeled through a filter would only be in contact with the contents of this filter for only a brief period, adsorption or any contaminates must occur rapidly. Most previous pesticide adsorption studies have been conducted over time frames of one to two days. As a result the first objective was to determine how long pesticide-contaminated water must be in contact with potting media before pesticide adsorption occurs. The second objective was to evaluate the feasibility of cleansing metolachlor-contaminated water by allowing it to drain passively through pine park filters.

METHODS

In the laboratory, pine bark, water and metolachlor were combined. The amount of water was sufficient to bring the pine bark to field capacity (i.e. amount that can be held against gravity for an extended period). The amount of metolachlor was one part per million with respect to the weight of the bark. Water was removed by placing the pine bark-water-herbicide mixture in a specially designed plastic cup. A piston was used to apply pressure and water escaped through perforation in the bottom. The collected water was analyzed for metolachlor. Radioisotope (^{14}C) techniques were used for metolachlor detection. The time allowed for absorption ranged from 1.5 minutes to 24 hours. The minimal time required for a significant amount of metolachlor adsorption to occur would indicate the approximate time that water must reside within a filter in order for filtration to be effective.

Feasibility of this filter concept was evaluated with a controlled experiment. Simulated runoff water was prepared by spiking five gallons of water with metolachlor (10 ppm). This water was allowed to pass through plastic drainage pipe (six-inch diameter), into which a filter was placed. The pipe was placed at a 20-degree angle. Contaminated water entered at the top, passed through the filter midway along the length of the pipe, and was collected at the bottom. The filter was simply an additional section of the pipe which was filled with pine bark. Mesh glued over the openings held the bark within the filter. Filter length ranged from 1.5 to nine inches. Flow of water entering the filter assembly was increased until in-flow equaled out-flow. This rate was noted as the maximum sustainable flow rate for that sized filter. The collected water was analyzed for metolachlor and the amount removed by the filter expressed as a percent.

RESULTS

The time-dependent adsorption study revealed that the adsorption of metolachlor by pine bark occurs very rapidly. Adsorption reached 57% after only a 90-second exposure. Maximum adsorption (approximately 80%) was reached after about 300 minutes.

The ability of a filter to remove water of metolachlor was directly related to filter length (Table 1). Longest filter evaluated (nine inches) reduced the level of metolachlor contamination by 29%; this filter was able to support a flow of 65 gallons per hour.

These results demonstrate that simple filtration by commonly-used organic materials may provide a means of remediating contaminated runoff water. While complete filtration of contaminates may not be achievable by this approach; the potential for using common materials to reduce off-site contamination using this method does exist. Achieving water cleansing in excess of 70% will most likely require more elaborate filter design than simple media-in-a-pipe design used here.

Table 1. Metalachlor Removal from Runoff Water by a Pine Bark Filter as Influenced by Filter Length

Filter length	Maximum flow rate	Metolachlor removed
in.	*gal./hr.*	*pct.*
1.5	160	0
3	150	22
5	110	20
6	100	23
8	85	17
9	65	29

Utilization of Container Media as a Method to Filter Metolachlor (Pennant) from Nursery Runoff Water

TIMOTHY L. GREY, GLENN R. WEHTJE, CHARLES H. GILLIAM, GARY J. KEEVER, AND BEN F. HAJEK

Pesticide-contaminated irrigation or rainfall runoff from landscape plant production areas and landscape developments is a growing concern. When properly managed by use of containment ponds, pesticide-contaminated runoff can be minimized. However, when containment ponds are not available or impractical, then possible filtration of runoff water through media filled filters may offer a viable means of pesticide runoff remediation.

Previous investigations have focused on the adsorption and mobility of herbicides in laboratory settings. Overall, most herbicides exhibit moderate to high adsorption (greater than 90%) to various organic media substrates. Adsorption and mobility of metalachlor, oxadiazon, and oryzalin in both organic media and a mineral soil has been determined. Data from these three studies indicate that herbicide movement is limited through most container medium due to the high adsorptivity of organic media used in container production. Thus, the detection of these herbicides in runoff water results from the material not reaching the media due to method of application.

In a timed-based experiment using ^{14}C-metolachlor (radiolabeled), it was determined that more than 50% adsorption of metolachlor to pine bark occurred after only 1.5 minutes of exposure. Using different length pine bark filled filters, metolachlor-contaminated water was drained through a medium-filled filter which removed approximately 29% of the added metolachlor. Thus, the potential use of medium filters has been established.

Apparent from these studies is that horticultural media are highly adsorptive toward a variety of herbicides, and that they may offer a means of cleansing pesticide-contaminated water. The objective of this study was to determine the potential use of a pine bark-filled-filter for remediation of metolachlor in runoff from a container production area. Metolachlor, with its relatively high water solubility represented a fairly difficult challenge for removal by filtration.

METHODS

One medium component, pine bark, which was typical of those used in container nursery production in the Southeast, was used for the filtration study. Pine bark medium physical properties, cation exchange capacity, bulk density, and organic matter, were characterized. Evaluation of the removal-by-filtration concept was conducted in a field setting. Metolachlor detection was accomplished through enzyme-linked immunoabsorbent assay (ELISA).

Metolachlor removal from water by filtration with pine bark filled filters was tested. To simulate a nursery setting, a 1,300-square-foot area of a nursery container field was bordered with eight-inch-wide metal sheeting buried to a depth of six inches vertically. The area was on a 5% slope so that the border came to a point at the shallow end, in a tear drop fashion. The purpose of the border was to direct runoff originating from irrigation and rainfall to a filter placed at the point at the shallow end. Metolachlor as Pennant 5G was applied to the gravel surface by hand at the recommended field rate of four pounds of active ingredient per acre when no irrigation was applied or rainfall occurred on this day.

The filter was constructed of six-inch diameter PVC pipe 20 inches in length. A 1.5-inch pipe section was cut open vertically and half of the wall removed to form a short trough. This was the front of the filter and was required for pre-filtration water sampling. Pine bark for the filters was pre-sifted through a 0.125-inch round-holed screen with that passing through the screen discarded. Filter sections were filled with five pounds of pine bark. Both ends of the filter section were closed with circular pieces of shade cloth which were glued in place and the final result was a filter 18 inches long.

Irrigation was applied daily beginning on Dec. 12, 1995, (day one), and continued through Jan. 5, 1996 (day 25), at the rate of one acre-inch per day. Total daily irrigation was approximately 820 gallons per replication per day. Rainfall occurred during the time the experiment was conducted and was accounted for (Table 1). Runoff water that was diverted toward the filter was collected prior to entry from the 1.5-inch trough. Water draining through the filter was collected in a 6.8-ounce vial beginning 30 minutes after irrigation had stopped. Total remediation of contaminated runoff was not possible. Metolachlor was quantified in samples taken before and after the filter. The difference between the before and after samples was attributed to the filter.

RESULTS

Metolachlor removal by the pine bark-filled filter fluctuated from -8% to 54% for the entire test period but a general trend was observed (Table 1). Up to day five, more than 23 micrograms per liter were recovered in the runoff. However, after filtration, the amount of metolachlor in the runoff was reduced from 13% to 54% over the first five days. This potentially represents a surge of metolachlor after the initial application. After four days of irrigation day one to day four, and then four days of irrigation and rainfall, day five to day eight, respectively, the metolachlor recovered in the initial runoff dropped to nine micrograms per liter at day eight. This represents a dilution effect of metolachlor in the runoff, but filtration capability was not improved (39% at day eight).

These data concur with other work which indicated maximum isoxaben, oryzalin, and simazine runoff occurs during the first irrigation events following herbicide application.

No rainfall occurred from day nine to 20, and daily irrigation was applied at one acre-inch. Metolachlor levels in the runoff gradually declined from 19 to 14 micrograms per liter from day 11 to 20, respectively. There was fluctuation in the amount of metolachlor removed by the filter during this time ranging from 0% to 33% from day 12 to 20, respectively. No filtration trend was observed.

From day 21 to 23, another rainfall event occurred. During these three days, a negative response was detected as metolachlor filtration dropped to less than -7%. However, the amount of metolachlor recovered in the pre-filtered runoff declined to less than 10 micrograms per liter for this same period. Desorption of metolachlor from the filter may have occurred causing enrichment of the runoff.

Filtration from day one to 10 averaged 31.7% per day. From day 11 to 20 filtration average declined to 15.5% per day and -0.6% per day from day 21 to 25. There was a general decline in metolachlor in the runoff up to day 23 and during rainfall events.

While complete filtration of metolachlor in runoff water was not achievable, the potential for use of filters and using readily available materials, such as peat and pine bark, to reduce off-site movement does exist. Container nursery sites with no capability for retention basins may now consider other alternatives for remediation of herbicide containing runoff water. Further development and testing of filtering systems that are easily constructed and maintained by container nursery producers is achievable.

Table 1. Ability of Pine Bark-containing Filter to Cleanse Metolachlor Contaminated Runoff

Day	Water received		Metolachlor initial runoff	Metolachlor removed by filter
	Irrigation	Rainfall		
	cm	*cm*	*ug/L*	*pct.*
1	23	0	24	31
2	23	0	25	54
3	23	0	23	42
4	23	trace	23	44
5	23	0.8	24	13
6	23	14.9	18	8
7	23	3.3	21	27
8	23	27.4	9	39
9	23	0	15	15
10	23	0	15	44
11	23	0	19	7
12	23	0	17	0
13	23	0	16	18
14	23	0	15	2
15	23	0	14	23
16	23	0	14	2
17	23	0	16	21
18	23	0	16	23
19	23	0	15	26
20	23	0	14	33
21	23	13.9	10	-7
22	23	5.2	9	-7
23	23	4.4	9	-8
24	23	0	17	3
25	23	0	13	16

Cyclic Irrigation and Media: Influence on Container Leachate and Ageratum Growth

DONNA C. FARE, CHARLES H. GILLIAM, AND GARY J. KEEVER,

Nurseries in the Southeast utilize large volumes of water to meet irrigation demands of container-grown plants in pine bark-based media. Environmental awareness has forced nursery producers to look at production practices that will reduce water use, reduce irrigation runoff, and improve water quality of the runoff.

Overhead sprinkler irrigation is the most common application method for producing container-grown plants. It has been reported that about 2.6 million gallons of water are needed to produce an acre of container-grown plants in a growing season. Alternative irrigation systems, such as trickle, ebb and flow, and capillary mat, are more efficient in water use than overhead sprinkler irrigation. However, these are only feasible when used to irrigate high-value greenhouse crops and large-container nursery stock.

Though many growers are voluntarily conserving water in response to drought and increasing water costs, wasteful irrigation practices and excess runoff have been reported in some nurseries. Milled pine bark is the primary component of container media in the Southeast. Many amendments have been evaluated for optimal porosity and water-holding capacity.

Media amendments affect water availability because physical properties are generally altered to increase aeration at the expense of water-holding capacity. An increasing emphasis on water use and water quality, coupled with frequent, high irrigation volume needed to meet irrigation demands of container-grown plants, suggest that media may play a large role in reducing nutrient leaching, such as nitrate-N (NO_3-N) and ammonium-N (NH_4-N).

The benefit of cyclic irrigation on traditional agricultural crops with overhead sprinkler irrigation have been reported. Cyclic irrigation is defined as a series of irrigation cycles, where each cycle includes two phases: (1) the operating phase of the irrigation system, and (2) the phase during which the system is at rest. In practice, cyclic irrigation does not change the amount of water applied in an irrigation cycle, but extends the time of irrigation application.

The objective of this research was to determine the effects of cyclic overhead irrigation and pine bark amended media on container leachate volume, nitrate-N (NO_3-N) and ammonium (NH_4-N) levels in the leachate, and growth of 'Blue Puffs' ageratum.

METHODS

Uniform liners of 'Blue Puffs' ageratum in rose pots were potted in trade-gallon containers and placed in a double layer plastic greenhouse. Container medium in Experiment 1 was a 6:1 pine bark: sand medium (v:v). In Experiment 2, two media were used: a 6:1 pine bark:sand medium (BS) and a 4:1 pine bark:peat medium (BP). In both experiments, media were amended with five pounds of dolomitic limestone and 1.5 pounds of Micromax per cubic yard and top-dressed with five grams of 12-6-6.

Plants were hand watered to saturation at potting. On the following day, plants were hand watered, allowed to drain one hour, then weighed (container capacity). After these initial waterings, plants were watered with overhead irrigation. Plants were weighed each morning to determine gravimetric weight loss. The need to irrigate was based on the weight loss from the original container capacity. Irrigation was applied between 7-10 a.m. when medium moisture reached 80% of container capacity.

Container leachate was collected during an irrigation cycle by elevating the plant over a petri dish. An acetate shield was attached to the container rim and extended 0.5 inch below the container to prevent irrigation water from diluting the container leachate. Container leachates were analyzed for pH, soluble salts, NO_3-N (nitrate), and NH_4-N (ammonium) (data shown for days one, 10, and 25). Leachate pH ranged between 6.2 and 6.4 during the experiments and was not affected by irrigation treatments. Growth indices and shoot and root dry weights were recorded at the end of each experiment.

In Experiment 1, 'Blue Puffs' ageratum were potted in February. Irrigation treatments were applied to all treatments when the irrigation treatment receiving one cycle of continuous irrigation at 0.5 centimeter (0.2 inch) of water (1C.5) reached 80% of the medium water-holding capacity (based on gravimentric weight loss of the potted plant at 7 a.m.) (Table 1).

Irrigation treatments included 0.4 cm (0.16 inch) of water (1C.4) applied either continuously, with a 30 minute resting period (2C.4-30), or with a two hour resting period (2C.4-120). Plants in Experiment 2 were potted in May. Plants potted in each medium received the same irrigation treatments and were designated BS1C.4 (bark:sand, 0.4 cm, applied continuously) and BS2C.4-30 (bark:sand, 0.4 cm, applied in two intervals with a 30-minute resting period) for pine bark:sand medium and BP1C.4 and BP2C.4 for pine bark:peat medium. Potted plants were weighed each morning to determine gravimetric weight loss. Irrigation was applied when the container capacity reached 80% in treatment BS1C.4. Each study was repeated with slight modifications of the irrigation treatments. Due to similar results from the duplicated experiments, only the first study of each experiment is reported.

RESULTS

CONTAINER LEACHATE. In Experiment 1, cyclic irrigation reduced container leachate volume. Container leachate from cyclic irrigation treatments, 2C.4-30 and 2C.4-120,

Table 1. Effects of Cyclic Irrigation on Container Leachate Volume, and Total N Leachate Levels at 1, 10, and 25 Days after Potting and Growth of Ageratum 'Blue Puffs' (Experiment 1)[1]

Treatment[2]	NO_3-N				NH_4-N			Total N[3]			GI[4]	Shoot dry wt.	Total root dry wt.
	Avg.[5]	1	10	25	1	10	25	1	10	25			
	mg/l	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/pot*	*mg/pot*	*mg/pot*	*cm*	*g*	*g*
1C.5	48.2	0.3	30.2	2.7	1.3	15.0	3.0	0.08	2.2	0.28	20.6	12.4	5.2
1C.4	47.7	0.3	32.9	6.6	1.7	9.4	8.6	0.10	2.0	0.73	20.5	12.0	5.2
2C.4-30	27.8	0.5	39.1	5.3	2.0	19.2	8.2	0.07	1.6	0.38	19.9	11.4	5.4
2C.4-120	16.5	0.9	30.2	5.2	1.4	12.9	8.5	0.04	1.7	0.23	18.9	9.1	3.7

[1]Potted Feb. 13, 1991.
[2]Treatment: 1C.5 = one cycle with 0.5 cm continuous irrigation; 1C.4 = one cycle with 0.4 cm continuous irrigation; 2C.4-30 = two cycles with a total of 0.4 cm irrigation and a 30 minutes resting phase; 2C.4-120 = two cycles with a total of 0.4 cm irrigation and a two-hour resting phase.
[3]Total N (NO_2-N, NO_3-N, and NH_4-N).
[4]GI:growth indices=height + width1 + width2(perpendicular to width1)/3.
[5]Average of volumes collected at each irrigation.

averaged 0.9 ounces and 0.5 ounces per pot, respectively, which was a 54% reduction compared to the 1C.4 continuous irrigation treatment (Table 1). Forty-one percent less leachate was collected when the resting phase between cycles was extended from 30 minutes to two hours. These data concur with grower observations that cyclic irrigation does reduce container leachate. Container leachate volumes were similar with traditional irrigation when 0.5 cm (1C.5) and 0.4 (1C.4) cm were applied (Table 1).

In Experiment 2, container leachate was less in cyclic irrigation than continuous irrigation treatments (Table 2) in both pine bark:sand (BS) and pine bark:peat (BP) media. Container leachate volume was reduced by 14% in BS medium when cyclic irrigation was compared to continuous irrigation application. In BP medium, about 40% less container leachate occurred in cyclic irrigation treatments compared to continuous irrigations.

Container leachate volumes were higher in BS medium than in BP medium. Forty-five percent less container leachate volume occurred in BP medium compared to BS medium. These data concur with an experiment where cyclic irrigation reduced container leachate and agreed with other research which reported container media can impact the container leachate volume. Thus, one alternative to improve water application efficiency, is medium selection for higher water-holding capacity.

MEDIA. In Experiment 2, differences existed in physical properties for the two media; however, both media provided acceptable physical properties for container production. The BS medium held less water than BP at moisture tensions ranging from 10 to 100 centimeters. Irrigation was applied when the BS1C.4 reached 80% of the water-holding capacity. Based on the moisture release curve, the BP moisture level was slightly higher than 80% when irrigation was applied.

NITROGEN LEACHED. In Experiment 1, neither cyclic irrigation nor irrigation volume affected NO_3-N or NH_4-N concentrations at most sampling dates (Table 1). One exception occurred at day 25, when NO_3-N and NH_4-N concentration was less in treatment 1C.5 compared to 1C.4. The highest NO_3-N and NH_4-N concentrations among all treatments occurred at day 10 and decreased during the rest of the experiment regardless of the irrigation treatment.

Total N (NO_2-N, NO_3-N and NH_4-N) leached (volume x concentration) was similar among treatments at day one (Table 1). At day 10, total N leached was 42% higher in the continuous irrigation treatment, 1C.4, compared to cyclic treatments, 2C.4-30 and 2C.4-120. There was a substantial reduction in total N leached from the pots when the resting phase was extended from 30 minutes to two hours. These data agree other work which reported higher irrigation volumes can result in higher leachate volumes and leachable NO_3-N from container medium.

Table 2. Effects of Cyclic Irrigation and Media on Container Leachate Volume and Total N Leachate at 1, 10, and 25 Days after Potting (Experiment 2)[1]

Treatment[2]	Total N[3]				GI[4]
	Avg.[5]	1	10	25	
	mg/pot	*mg/pot*	*mg/pot*	*mg/pot*	*cm*
Pine bark:sand (6:1)					
BS1C.4	37.0	4.4	7.5	1.0	21.5
BS2C.4-30	32.2	2.6	5.7	0.6	21.4
Pine bark:peat (4:1)					
BP1C.4	24.1	2.6	4.4	0.2	21.8
BP2C.4-30	14.3	1.2	3.0	0.2	23.1

[1]Potted May 5, 1992.
[2]Treatment: BS1C.4 = pine bark:sand with one continuous irrigation applied at 0.40 cm; BS2C.4-30 = pine bark:sand with two cycles with a 30 minutes resting phase applied 0.40 cm irrigation; BP1C.4 = pine bark:peat with one continuous irrigation applied at 0.40 cm; BP2C.4-30 = pine bark:peat with two cycles with a 30-minute resting phase applied 0.40 cm irrigation.
[3]Total N (NO_2-N, NO_3-N, and NH_4-N).
[4]GI:growth indices=height + width1 + width2 (perpendicular to width2)/3.
[5]Average of volumes collected at each irrigation.

Total N leached during the experiment is important environmentally. For instance, about 47% less total N leached from the cyclic treatments, 2C.4-30 and 2C.4-120, compared to the continuous application, 1C.4.

In Experiment 2, both cyclic irrigation and media affected total N (milligrams per pot) in container leachate (Table 2). Total N leachate levels from BS medium were significantly greater than BP medium leachate. For example, at day 10 in Experiment 1, container leachates from the BS treatments (BS1C.4 and BS2C.4-30) contained 6.6 mg total N, compared to 3.7 mg from the BP treatments (BP1C.4 and BP2C.4-30).

Total N in container leachate from cyclic irrigation treatments (BS2C.4 and BP2C.4) was less at day one than levels in leachate from noncyclic treatments (BS1C.4 and BP1C.4) (Table 2). At day five, the mg total N per pot leached were similar among irrigation treatments.

PLANT RESPONSE. In Experiment 1, plants grown with cyclic irrigation were of acceptable quality (authors observation), except 2C.4-120. Plants grown with cyclic 2C.4-120 had a significant reduction in growth indices compared to treatment 1C.4 (Table 1). When the resting phase was extended to two hours, water-holding capacity of the medium was not recharged as it was with the other treatments. During the last few days of the test, several plants in this treatment (2C.4-120) reached incipient wilt during mid-afternoon, but recovered turgor during the night.

Root distribution was primarily in the upper third of the rootball and less root distribution was present in the lower two-thirds regardless of irrigation application (Table 1). Plants irrigated with 2C.4-120 had less dry root weight in the upper third of the rootball and less total root dry weight than other treatments.

In Experiment 2, plant growth was similar when comparing cyclic irrigation and traditional irrigation. Growth indices were generally 5% larger with plants grown in a BP medium compared to a BS medium.

These data demonstrate cyclic irrigation can reduce container leachate volume and total N leached. From a practical standpoint, these experiments indicate that as irrigation volumes increase, container leachate volumes and total N loss will increase. Cyclic irrigation may become an important production practice to reduce total water applied, reduce irrigation runoff and reduce total N leached.

Effects of Cyclic Micro-Irrigation and Media on Irrigation Application Efficiency and Growth of Sawtooth Oak in Pot-in-Pot Production

GLENN B. FAIN, KENNETH M. TILT, CHARLES H. GILLIAM, HARRY G. PONDER, AND JEFF L. SIBLEY

Irrigation inefficiency in container nurseries is of great concern to the industry. Cyclic, or intermittent, irrigation is a new irrigation practice in container nurseries where plants' daily water allotment is divided up and applied in a series of irrigation and resting intervals throughout the day. Recent studies have shown that cyclic irrigation can improve irrigation efficiency by as much as 38% over irrigation applied once per day. Container media components can also improve irrigation efficiency by increasing water-holding capacity.

The goals of this project were to determine if cyclic micro-irrigation and the amendment of a pinebark medium with coconut coir, an organic byproduct, could effectively reduce the volume of leachate leaving containers and improve irrigation application efficiency. Two fertilizer rates were also evaluated. Each treatment was evaluated for their effects on growth of sawtooth oaks.

Sawtooth oaks were evaluated in a pot-in-pot production system in Auburn, Alabama (Figure 1). Above-ground models were constructed to simulate the pot-in-pot environment in order to monitor each irrigation event. Models were evaluated to determine their effectiveness as a tool for the nursery to monitor irrigation efficiency.

METHODS

Bare-root liners, 18-24 inches tall, of sawtooth oak (Quercus acutissima) were planted in 15-gallon "GripLip" containers (Nursery Supplies of Fairless Hills, Pennsylvania.) in April 1996. Two media were used — 100% pinebark and 80:20 pinebark:coconut coir. Both media were amended with six pounds per cubic yard of dolomitic limestone. Two fertilizer rates were used. Trees were topdressed with either seven ounces or 14 ounces of controlled release fertilizer (Sierra 17-6-10 plus minors). Initial height and caliper were taken upon installation.

Pot-in-pot production system in Auburn, Ala.

Table 1. Irrigation Application Efficiency

Irrigation treatment[1]	Media[2]	Leachate volume[3]	Irrigation efficiency[4]
		liters	*pct.*
1X	100% pb	28.01	72.3
1X	80% pb/20% coir	15.91	84.1
3X	100% pb	2.38	97.7
3X	80% pb/20% coir	1.49	98.5
6X	100% pb	1.05	99.0
6X	80% pb/20% coir	.58	99.4

[1]Irrigation treatments were 2,160 milliliters applied in one application per day (1X), three applications per day of 7,20 milliliters (3X), and six applications per day of 360 milliliters (6X).
[2]Media treatments were 100% pinebark or 80:20 pinebark:coconut coir.
[3]Leachate volumes were total volume (liters) collected from model pots during study.
[4]Irrigation efficiency = [(water volume applied - water volume lost) /water volume applied] x 100.

Table 2. Effects of Irrigation and Media on Height and Caliper Increase[1]

Media	Irrigation treatment[2]					
	1(X)		3(X)		6(X)	
	ht	*cal*	*ht*	*cal*	*ht*	*cal*
100% pinebark	17.17	.43	18.11	.49	20.70	.54
80% pinebark / 20% coir	20.51	.67	22.82	.68	24.77	.75

[1]Height and caliper are measured in inches. Caliper was measured at six inches above soil surface.
[2]Irrigation treatments were 2,160 milliliters applied in one application per day (1X), three applications per day of 720 milliliters (3X), and six applications per day of 360 milliliters (6X).

Above ground plywood boxes were built and insulated to simulate a pot-in-pot environment. A hole was cut in the top of the box for container placement and a access door was built to collect leachates. Six trees were placed in the above ground model pots.

Containers were saturated, allowed to drain, then weighed to determine weight at the maximum water holding level or "container capacity." Weights were then taken prior to an irrigation event to determine pre-irrigation container water level. The weight differences were then used to determine water to apply to reestablish container capacity. This procedure was done monthly during the study to maintain the containers at 70% of container capacity. There were three irrigation treatments: (1) 72 ounces at 10 a.m. (2) 72 ounces divided into three applications of 24 ounces at 10:30 a.m., 1 p.m. and 3:30 p.m., and (3) 72 ounces divided into six applications of 12 ounces at 8 a.m., 9:30 a.m., 11 a.m., 12:30.p.m., 2 p.m., and 3:30 p.m. Irrigation was applied through maxi-jet spray stakes (Acuff Irrigation Company, Cottondale, Fla.) Leachate volumes were recorded from the model pots for each irrigation event. Height and caliper measurements, soluble salts, and pH readings were recorded monthly.

RESULTS

Both irrigation treatment and media had an effect on irrigation application efficiency (Table 1). Irrigation applied once daily had an overall efficiency of 72.3% for trees planted in 100% pinebark and 84.1% for trees planted in 80:20 pinebark:coir. There was little difference between media on irrigation efficiency when irrigation was applied over three and six cycles per day. There was little difference between the three- and six-cycle treatments in irrigation efficiency. Irrigation applications applied over three and six cycles improved efficiency to 98.1% and 99.2%, respectively, compared to 78.2% for the one cycle per day.

There was a significant difference in height and caliper increase between media and irrigation treatments (Table 2). Height increase ranged from 17.2 inches for the one cycle per day irrigation in 100% pinebark to 24.8 inches for the six cycle per day irrigation in 80:20 pinebark:coir. Caliper increase ranged from 0.43 inch for the one cycle per day irrigation in 100% pinebark to 0.75 inch for the six cycle per day irrigation in 80:20 pinebark:coir.

There were no differences in the growth of trees as a result of fertilizer rates. Overall soluble salt levels tended to be higher for the one-cycle irrigation treatment in July and August but lower in September than the other two treatments. However, these differences were not significant and were all within an acceptable range.

In summary, both cyclic irrigation and media can have an effect on irrigation application efficiency as well as growth. Reducing leachate volume is a major concern for the nursery industry now and will be increasingly more important in the future. Most nurseries can apply cyclic irrigation methods without changing existing equipment. Model pots can be an effective tool for monitoring irrigation for pot-in-pot production systems.

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