SECTION 1

DR. BRYSON L. JAMES STUDENT COMPETITION

Edward Bush
Section Editor and Moderator

Dolomitic Lime and Micronutrient Rates Affect Container Plant Growth and Quality

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Nature of Work: Pre-plant incorporation of dolomitic limestone and micronutrients as amendments to container media is a common industry practice. However, research indicates that plant response to these amendments can be beneficial, detrimental, or have no effect based on the rate applied and the species produced (1, 2, 3, 4). The objective of this work was to determine the effects of dolomitic limestone and micronutrient rate on the growth and quality of 7 container-grown species, and the container medium solution pH.

On May 31, uniform liners of azalea (Rhododendron indicum 'Formosa'), Japanese holly (Ilex crenata 'Greenluster'), Burford holly (Ilex cornuta 'Burfordii'), Chrysanthemum (Dendranthemum x morifolium 'Yellow Jacket'), dwarf nandina (Nandina domestica 'Wood's Dwarf'), hosta (Hosta japonica 'Meta Peka'), and red maple (Acer rubrum 'October Glory') were potted in a 3:1, by volume, pine bark:peat moss medium amended with 14 pounds of Osmocote 17-7-12 per cubic yard. The six treatments were a factorial of three dolomitic limestone rates (0, 5, and 10 pounds per cubic yard of medium) and two micronutrient rates (0 and 1.5 pounds per cubic yard of medium) as Micromax (Scotts Co. Marysville, Ohio) pre-plant incorporated. All plants were produced under overhead impact irrigation in trade gallon containers with the exception of the red maples which were grown in 10 gallon containers receiving drip irrigation.

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

Results and Discussion: Foliar color ratings were similar among treatments within each species 30 DAP. However, by 60 DAP dolomitic limestone and micronutrient rates affected both red maple and dwarf nandina FCR. Best FCR for red maple occurred with plants receiving Micromax regardless of dolomitic limestone rate, and for plants produced with no dolomitic limestone and no Micromax plants (Table 1). Dwarf nandina produced with 5 or 10 pounds of dolomitic limestone and 1.5 pounds of Micromax had the best FCR compared to plants in the remaining treatments. Within each of the other species, FCR were similar among treatments. At 120 DAP, red maple, dwarf nandina, and hosta FCR increased as dolomitic limestone rate decreased when no Micromax was supplied. When Micromax was added plants in all dolomitic limestone rates had similar FCR and were similar to FCR of no dolomitic limestone, no Micromax plants. Although there was no interaction between dolomitic limestone and micronutrient rates for azalea, FCR increased as dolomitic limestone rate decreased (a rating of 4.1 for no dolomitic limestone to 3.5 for 10 pounds of dolomitic limestone) or when Micromax was supplied (4.0 with Micromax and 3.5 without). No other plant species FCR were affected by dolomitic limestone or micronutrient rate 120 DAP, and FCR for plants in all treatments were similar within species 360 DAP.

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

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

Significance to the Industry: The addition of dolomitic limestone to the potting medium increased the size of nandina, hosta, dendranthemum, and both holly species, while it had no affect on azalea or red maple. However, the quality of red maple, dwarf nandina, and hosta species declined with increasing amounts of dolomitic limestone when micronutrients were not supplemented in the potting medium.

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Table 1. Influence of dolomitic limestone and micronutrient rates on foliar color rating of container grown plants.[1]

Lime-stone rate	Micro-max rate	Foliar color rating[2]				
		60 DAP[3]		120 DAP		
(lbs/yd^3)	lbs/yd^3)	Red maple	Dwarf nandina	Red maple	Dwarf nandina	Hosta
0	0.0	4.7a[4]	3.5b	4.3ab	4.0a	4.0a
5	0.0	3.3b	3.4b	4.0b	3.4b	3.9ab
10	0.0	3.1b	2.7c	3.0c	2.2c	3.7b
0	1.5	5.0a	3.6b	4.5a	4.0a	4.0a
5	1.5	4.7a	4.1a	4.2ab	4.0a	4.0a
10	1.5	4.7a	3.9a	4.3ab	4.1a	3.9a

[1] Medium was 3:1 by volume pine bark: peat moss.

[2] Foliar color rating from 1 to 5 with 1 being bleached foliage, 2 being chlorotic, 3 being light green, 4 being medium green, and 5 being dark green.

[3] DAP = days after potting.

[4] Means within columns followed by the same letter are similar (LSD, $p \leq 0.05$).

Influence of Black Locust and Contorted Willow Water Diffusate on Rooting Stem Cuttings

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Nature of Work: Due to the tremendous number of plants, especially ornamentals, that are propagated by cuttings, there is great interest among plant propagators and nursery professionals in the rooting of cuttings (Davis *et al.,* 1988). Treatments with aqueous diffusates from Salix species and other easy-to-root plants have promoted adventitious rooting of certain stem cuttings (Girouard *et al*., 1964; Kawase, 1970,1971,1972; LeClerc *et al*., 1983). This study investigated the use of aqueous diffusates of both contorted willow (*Salix* x*erythroflexuosa* RAG.) and black locust (*Robinia pseudoacacia* L.) as sources of root promoting substances on stem cuttings of chinese fringetree (*Chionanthus retusus* Lindl. & Paxt.) and mung bean (*Vigna radiata* L.). The effects of leaching stem cuttings of chinese fringetree in water as a pretreatment were also investigated.

On 8 July 1996, water diffusates were prepared from freshly chopped terminal stems (112.0 g) of both black locust and contorted willow that were steeped in 4 liters of tap water for 24 hours. Sixty stem cuttings of chinese fringetree were leached in running tap water (1 liter/15 minutes) for 24 hours. All cuttings were then double wounded. Twenty cuttings were then treated with 3.0% IBA in talc and immediately inserted in medium. The remaining cuttings were divided into two groups of twenty and placed in either locust or willow diffusate for 24 hours. All cuttings were then treated with 3.0% IBA in talc and inserted in medium.

On 9 July 1996, an additional sixty stem cuttings of chinese fringetree were collected and double wounded. Twenty cuttings were treated with 3.0% IBA in talc and immediately inserted in medium. The other forty cuttings were divided into two groups of twenty and placed in locust or willow diffusate for a 24-hour soak (these cuttings shared the same diffusate bath as the previous cuttings). After soaking, all cuttings were treated with 3.0% IBA in talc and inserted into the medium.

Cuttings were propagated in Dyna-flats with holes containing a mixture of 3 peat : 1 sand (by volume) to a depth of approximately 7 cm. Cuttings were randomly inserted in flats which were placed under intermittent mist. A tent made of 3 mm clear polyethylene plastic was used to cover the cuttings. Cuttings received ambient light and temperatures were maintained at 18C at night, with day temperatures not exceeding 30C.

Three mung bean bioassays were used to partially characterize and verify the effects of the diffusates. The first tested the effects of either locust or willow diffusate (5 ml) with 10 ml deionized water containing 8 ppm IBA on rooting of mung bean cuttings. A second test used ethyl acetate extracts of each diffusate at pH 3.0 and 7.0 to determine the polar nature of the diffusates. A silica gel thin-layer chromatography of locust and willow diffusates and their extracts at pH 3.0 were tested for indole acetic compounds served as a third test.

Mung bean seeds were grown in flats (F-1020-no holes) containing moistened Pro Mix BX in a growth chamber at 28C with an 18 hour photoperiod for seven days. On the seventh day, cuttings were harvested by cutting off the seedlings' root systems 4.0 cm below the cotyledon node. The mung bean bioassay consisted of one mung bean cutting and the test solution per test tube. The bioassay was maintained in a growth chamber at 28C with an 18 hour photoperiod. A 15 ml liquid level was the standard solution total per test tube. This was monitored daily and replenished with deionized water as needed. After the fourth day, all solutions were discarded and replaced with fresh deionized water. Diffusates were made from chopped, frozen locust or willow terminal stems placed in water (10g/300 ml H_2O), and stirred for 24 hours. The number of roots were counted and recorded on the tenth day.

After 71 days, chinese fringetree cuttings were harvested and roots were evaluated based on five classes: 5=heavily rooted; 4=above average; 3=average rooting; 2=poorly rooted; and 1=no roots. Nonleached cuttings treated with willow diffusate followed by 3.0% IBA produced the highest mean class of roots (mean 4.1, SD 1.2) and were significantly different from all other treatments. Leached cuttings treated with locust diffusate produced the second highest mean class of roots (mean 3.5, SD 1.0). Willow and locust diffusate, whether leached or nonleached, produced significantly more roots than the standard IBA treatment (mean 2.4, SD 1.4) in this experiment. The diffusate treatments also had a higher percentage of rooted cuttings. In a similar experiment willow diffusate combined with IBA had a positive effect on rooting white fringetree (*Chionanthus virginicus* L.).

All mung bean bioassays were replicated three times and their averages reported. Mung bean cuttings treated with locust or willow diffusate, both with IBA, stimulated the production of roots more than IBA or either diffusate alone. Ethyl acetate extracts of each diffusate at pH 3.0 produced more roots than extracts at pH 7.0. Silica gel thin-layer chromatography of locust diffusate and locust extract at pH 3.0 showed no detectable color spots when tested for indoles. Willow diffusate showed five detectable color bands, which were pink and rose in character at Rf 0.05, 0.25, 0.35, 0.68, and 0.93. Willow extract at pH 3.0 showed four similarly colored bands at Rf 0.24, 0.38, 0.54, and 0.73. These colors indicated the presence of indoles in the willow diffusate and willow extract at pH 3.0.

Results and Discussion: The use of easy-to-root plant diffusates followed by IBA to increase rooting of moderately to very difficult-to-root plants such as chinese fringetree. The mung bean bioassay demonstrated that root promoting substances existed in both locust and willow diffusate and their pH 3.0 ethyl acetate extracts. Both willow diffusate and willow extract at pH 3.0 tested positive for indoles but these were unidentified. Easy-to-root plant diffusates as postulated by Hess (1959) and Kawase (1970,1971,1972) may be the missing ingredients needed to help overcome rooting failure in difficult-to-root plants.

Significance to Industry: Chinese fringetree is one of many highly sought-after, moderately difficult-to-root plants. These plants have responded favorably to easy-to-root plant diffusate treatments. The results of this research indicate the possibilities of expediting the production process--a critical need in the industry. Further research is being conducted in this area at the University of Tennessee-Knoxville.

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Effects of Cyclic Micro-Irrigation and Media on Irrigation Application Efficiency and Growth of Quercus acutissima in Pot-in-Pot Production

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Nature of Work: The quality and quantity of water used, along with the effluent leaving container nurseries, are of great concern to nurseries in the United States (9,15,17). Increasing irrigation application efficiency [((water volume applied-water volume lost)/ water volume applied) x 100] by reducing leachate volume is important from an economical and environmental standpoint. Pot-in-pot production, introduced around 1990, is where a 'socket' pot is permanently placed in the ground. A container plant is then placed inside the 'socket' pot (12). With cyclic irrigation, a plant's daily water allotment is subdivided into more than one application with prescribed intervals between applications, contrasted with conventional irrigation practices whereby the daily water allotment is applied in a single (continuous) application (5,6,11). Little research has been done on cyclic irrigation in pot-in-pot production.

Increased awareness for proper water use within an ecologically managed environment has stimulated interest in the development of improved water use techniques (3). With increasing emphasis on water quality, commercial nurseries are being targeted as a potential source of ground and surface water contamination (2). Container-grown landscape plants are usually irrigated with overhead sprinklers. Yet, overhead irrigation is inefficient, especially for larger plants (1,16). Overhead irrigation may apply 40,000 gal of water per acre daily, with losses from 40 to 90% through evaporation during application and runoff (2). Selecting irrigation systems, schedules, and growth media are major parameters affecting plant growth. A more efficient alternative to the standard practice of overhead irrigation is intermittent (cyclic) irrigation through a spray stake in each individual container (7,8). Cyclic irrigation may improve irrigation application efficiency by allowing time for water to move through the micropore system of a container substrate (4). Irrigation application efficiency was improved 38% with cycled irrigation over one time applications (14). Growers that use cyclic irrigation can expect greater plant utilization of applied N as well as reduced water and nutrient loss from containers (4). Few nurseries monitor evapotranspiration or moisture levels of the growing medium to determine plant water requirements and increase irrigation efficiency. Applying irrigation based on daily water loss (DWL= plant transpiration plus evaporative loss from substrate) from the container may further improve irrigation application efficiency (13).

The goals of this project were to determine if cyclic micro-irrigation and pinebark medium amended with coconut coir effectively reduce the leachate volume leaving containers and improve irrigation application efficiency. Media and irrigation were evaluated for their effects on growth of *Quercus acutissima*, in a pot-in-pot production system.

Eighteen to 24" bare root trees were planted in 15 gallon "GripLip" containers (Nursery Supplies of Fairless Hills, PA) in April 1996. Two media were used, 100 percent pinebark and 80/20 pinebark/coconut coir. Both media were amended with 6 pounds per cubic yard of dolomitic limestone. Trees were topdressed with either 6.3 or 12.6 ounces of controlled release fertilizer (Sierra 17-6-10 plus minors). Initial height and caliper were taken after the 96 trees were planted and final measurements in September, 1996. Above ground insulated 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 an access door was built to collect leachates. Six trees representing each irrigation and media treatment 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 difference in weights were then used to determine water to apply to re-establish container capacity. This procedure was done monthly during the study to maintain the containers above 70% of container water holding capacity. There were three irrigation treatments. Treatment one applied 72 ounces at 10:00am, treatment two applied 72 ounces divided into 3 applications of 24 ounces at 10:30am, 1:00pm and 3:30pm, and treatment three applied 72 ounces divided into 6 applications of 12 ounces at 8:00am, 9:30am, 11:00am, 12:30pm, 2:00pm, and 3:30pm. Irrigation was applied through maxi-jet spray stakes supplied by Acuff Irrigation Company of Cottondale Fla. Leachate volumes were recorded from the model pots for each irrigation event.

Results and Discussion: Results indicate that cyclic irrigation and media affect irrigation application efficiency. In model pots irrigation applied once per event had an overall efficiency of 72.3% for trees planted in 100% pinebark compared to 84.1% for trees planted in 80/20 pinebark/coir. Irrigation applied in one cycle had an efficiency of 78.2% compared to 98.1 and 99.2% for the three and six cycle respectively.

There was a significant difference in height and diameter increase between media (p= 0.05). Mean height increase ranged from 18.5 inches for the 100% pinebark to 22.8 inches for the 80/20 pinebark/coir. Mean diameter increase ranged from 0.47 inches for 100% pinebark to 0.70 inches for 80/20 pinebark/coir. There was a significant difference in height and diameter increase between irrigation treatments (Table 1) .

Mean height increase ranged from 18.8 inches for the 1(X) treatment to 22.8 inches for the 6(X) treatment. Mean diameter increase ranged from 0.51 inches for the 1(X) treatment to 0.64 inches for the 6(X) treatment. There were no differences in the growth of trees as a result of fertilizer rates.

Significance to the Industry: In summary, preliminary results indicate that both cyclic irrigation and media have an effect on irrigation application efficiency by reducing leachate volume. Cyclic irrigation produced growth of *Quercus acutissima* compared to a single irrigation event. Most nurseries can apply cyclic irrigation methods without changing existing equipment.

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Table 1. Effects of irrigation and media on height[1] end diameter[2] increase.

Media[1]	**height**[4]	**diameter**[4]
100% pinebark	18.5a	0.48a
80/20 pinebark/coir	22.8 b	0.70 b
Irrigation Treatment[2]		
IX	18.8a	0.51a
3X	20.5ab	0.58ab
6X	22.8 b	0.65 b

[1] Height in inches.

[2] Diameter in inches at 6 inches above soil surface.

[3] Irrigation treatments were 2160ml applied in one application per day (1X), 3 applications per day of 720ml (3X), and 6 applications per day of 360ml (6X).

[4] Means in the same column followed by the same letter(s) are not significantly different at the P=0.05 level.

Shredded Tire Rubber as a Media Amendment in the Production of Fall Chrysanthemums

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Nature of Work: In recent years research has been conducted using shredded automobile tires as a potting media amendment (Bowman et al., 1994; Handreck, 1996; Harkess et al., 1995; Newman et al., 1997). Zinc oxide which is added as a strengthening agent during the vulcanization process is found tire rubber in large amounts (Handreck, 1996). As much as 13,000 ppm zinc have been found in shredded tire rubber by the Mississippi State Chemical Laboratory using an acid digestion extraction. Zinc absorption in poinsettia has been reported to be decreased by adding calcium carbonate to the media (Harkess, 1996).

Two hundred rooted cuttings of *Dendranthema* x *grandiflora* ‘Anna’ and ‘Encore’ were potted on 17 July 1996 in 5 inch pots. They were potted in media containing shredded tire rubber at 0, 25, 50, or 75% by volume mixed with peat moss. Dolomitic lime was added at 0, 4.4, 8.8, or 13.2 lbs/yd3 in a complete factorial design. A 2-6.3 mm particle size shredded tire rubber (Rouse Rubber Industries, Vicksburg, MS) was used. Micromax (The Scotts Co, Marysville, OH) was added to the media at 1.5 lbs/yd3. The cuttings were fertilized with Peter’s Pot Mum Special 15-20-30 (The Scotts Co, Marysville, OH) at 250 ppm continuous liquid feed. The chrysanthemums were scheduled as a fast crop and required no pinching or disbudding. A growth index based on plant width and height was recorded every two weeks. A visual quality rating, dry weight, and a tissue analysis were collected at harvest.

Results and Discussion: Tissue analysis of ‘Encore’, showed no significant difference in calcium and magnesium content in relation to the amount of rubber or lime in the media (Table 1). Tissue nitrogen and phosphorus levels were highest in plants grown in 50% rubber and lowest in those grown in media with 13.2 lbs/yd^3 lime added. Potassium was lower in plants grown in 75% rubber, but was unaffected by the amount of lime added. Iron and magnesium were noticeably higher in plants grown in 25 and 50% rubber. Manganese was unaffected by the lime, while iron content was lower with increased lime. Zinc concentrations were significantly lower in plants grown in media with no rubber and was unaffected by the amount of lime added. Copper concentrations increased when plants were grown in 25 or 50% rubber with lower levels of lime added.

In ‘Anna’, the amount of rubber had no affect on the uptake of magnesium, but magnesium levels were higher in the media containing 13.2 lbs/yd^3 lime (Table 2). Tissue levels of nitrogen, phosphorus, and copper were slightly increased in plants grown in 25 or 50% rubber. While nitrogen was only slightly affected by the amount of added lime, copper was significantly lower in plants grown in media with 4.4 lbs/yd^3 lime added. Phosphorus was unaffected by lime rate or concentration of rubber in the media. The potassium concentration was significantly higher in plants grown in the 50% rubber medium but was unaffected by the addition of lime. The highest level of calcium was observed in plants grown in 25% rubber but was lowest in 0% rubber. The tissue calcium concentration decreased with decreasing amounts of lime added to the media. Iron was significantly lower in ‘Anna’ when grown in 25% rubber and was unaffected by the lime rates. Manganese and zinc levels were found to be higher in the plants grown in media containing rubber than those grown in peat. Zinc and manganese were present in higher concentrations at increased lime additions.

There was a considerable decrease in dry weight, visual rating and growth index as the amount of rubber increased. ‘Anna’ had a significantly higher dry weight, visual rating and growth index than ‘Encore’ (Table 3).

Significance to Industry: The results indicate that there is a cultivar dependant response to shredded tire rubber used as a media amendment for the production of fall chrysanthemums. While shredded rubber has worked well for other species, chrysanthemums appear to be particularly sensitive to this media amendment. Growers need to be aware of these specie and cultivar specific responses to new media amendments.

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Table 1. Main effects of chrysanthemum 'Encore'tissue analysis of plants grown in media containing shredded tire rubber at 0, 25, 50, or 75 % and amended with lime at 0, 4.4, 8.8, or 13.2 lbs/yd^3 in a complete factorial experiment.

% Rubber	N %	P %	K %	Ca %	Mg %	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
0	2.1b^z	.4b	3.0a	.4a	.1a	170bc	113c	363b	6c
25	2.1b	.4b	3.0a	.5a	.1a	341a	201a	1390a	15a
50	2.7a	.5a	3.4a	.5a	.1a	254ab	163b	1606a	12b
75	2.1b	.3b	2.5b	.5a	.2a	113c	132c	1005a	6c
Lime lbs/yd^3									
0	2.5a	.4a	3.0a	.5a	.2a	271a	164a	1423a	13a
4.4	2.2a	.4a	3.1 a	.4a	.1 a	232ab	145a	891 a	1 Ob
8.8	2.3a	.4a	3.0a	.5a	.1a	222ab	144a	992a	8bc
13.2	1.8b	.4a	3.0a	.5a	.1a	145b	145a	619a	7c

[z] Mean separations within columns using Student-Newman-Kuels' $P_{\propto}$=0.05.

Table 2. Main effects of chrysanthemum 'Anna' tissue analysis of plants grown in media containing shredded tire rubber at 0, 25, 50, or 75 % and amended with lime at 0, 4.4, 8.8, or 13.2 lbs/yd^3 in a complete factorial experiment.

% Rubber	N %	P %	K %	Ca %	Mg %	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
0	2.4b^z	0.4b	3.7b	0.5c	0.2a	194b	146c	63d	7c
25	2.8a	0.5a	3.6b	O.9a	0.2a	433a	360a	2492a	22a
50	2.8a	0.5a	4.4a	0.6b	0.2a	184b	243b	2171b	12b
75	2.7ab	0.4b	3.4b	0.7b	0.2a	147b	207b	1747c	7c
Lime lbs/yd^3									
0	2.9a	0.4a	3.6a	0.5c	.14b	259a	197b	1321b	13a
4.4	2.6ab	0.4a	3.7a	0.6b	.17b	174a	192b	1116b	8b
8.8	2.7a	0.4a	3.5a	0.8a	.18ab	259a	244ab	1745a	13a
13.2	2.4b	0.4a	4.1a	0.8a	.2a	236a	268a	1464ab	11a

[z] Mean separations within columns using Student-Newman-Kuels' $P_{\propto}$=0.05.

Table 3. Dry weight, visual rating, growth index measurements from chrysanthemums grown in shredded tire containing media amended with dolomitic lime. Growth index = (((2nr)h)/1000). Visual ratings were from 1 to 5 with 5 being superior.

		'Anna'			'Encore'		
% Rubber	Lime lbs/yd^3	dry weight	visual rating	growth index	dry weight	visual rating	growth index
0	0	75bc^z	2.6abc	1335b	63c	1.7b	755b
0	4.4	95ab	4.4a	2247a	94b	4.2a	2200a
0	8.8	81 abc	3.4abc	1268bc	109a	4.6a	2503a
0	13.2	102a	4.2ab	2084a	112a	4.8a	2629a
25	0	57c	1.0c	166c	57c	1.3b	306b
25	4.4	59c	1.0c	297bc	59c	1.0b	2087b
25	8.8	57c	1.0c	202c	59c	1.5b	355b
25	13.2	60c	1.5c	400bc	69c	3.0b	983b
50	0	57c	1.0c	196c	57c	1.Ob	236b
50	4.4	55c	1.0c	251 bc	56c	1.Ob	562b
50	8.8	58c	1.4c	263bc	55c	1.0b	287b
50	13.2	60c	1.7c	499bc	60c	2.0b	403b
75	0	60c	1.7c	497bc	59c	1.8b	471 b
75	4.4	58c	2.0c	491 bc	56c	1.Ob	159b
75	8.8	58c	1.3c	320bc	62c	2.2b	606b
75	13.2	61c	2.4bc	718bc	62c	2.0b	483b

[z] Mean separations within columns using Student-Newman-Kuels' $P_{\propto}$=0.05.

The Effects of Photoperiod on the Growth and Development of Dahlia 'Sunny Rose' Plugs

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Nature of Work: Currently, growers producing dahlia plugs for late Winter and early Spring sales are growing them under the naturally occurring short days. Short daylengths, under approximately 11 hours, promote tuberous root formation to the extent that the tuberous roots may begin to outgrow the plug cells themselves. Tuberization inhibits shoot growth and fibrous root development (Zimmerman and Hitchcock, 1929), however the extent of this inhibition in plug production has not been investigated. The energy being allocated for tuberization may be better utilized to produce a more desirable plug while reducing production time. Plugs may benefit both physiologically and aesthetically from long days (night interruptions) throughout production. It was the objective of this study to determine the effects of daylength on the growth and development of Dahlia 'Sunny Rose ' plugs, and to determine if night interruptions will be cost effective in plug production. Plug trays (8x10") containing eighty 1x1" cells were filled with Fafard Superfine Germinating Mix (Fafard, Inc., Anderson,SC.). Seeds were not sown in the outer rows of the experimental trays, while the remaining 48 cells were sown with Dahlia 'Sunny Rose' seeds (Ball Seed Co., West Chicago IL.) Plugs were double sown (Feb. 7,1995) to ensure a full stand. The 10 flats were placed in a growth chamber with fluorescent lighting at 18 C (64.4 F). Germination occurred in approximately 4-5 days. Exactly one week after sowing, stands were thinned to 1 seedling per plug section and flats were moved to a glass greenhouse for photoperiod treatments. Maximum greenhouse temperatures were approximately 27 C day and 17 C night. During the second week of production flats were irrigated and fertilized with a 50 ppm solution of Peters Professional Peat-Lite Special 20-10-20 (Grace-Sierra Horticultural Products Co., Milpitas, CA.). Fertilizer concentrations were increased to 150 ppm N and K at each watering after the second week of production . Weekly applications of a 33 ppm ancymidol spray (A-Rest) were made beginning on Feb. 28, a standard practice in dahlia plug production for effective height control (De Hertoph and Blakely, 1976). The 10 flats were placed on a bench as shown in fig. 2-1. The 1 6x4 foot bench was divided in half by a blackcloth partition that could be raised and lowered as needed. All the flats received 9 hours of the same photosynthetically active radiation (PAR) from 9 a.m. to 6 p.m.. The entire bench was covered by the blackcloth curtain from 6 p.m. to 9 a.m. Plugs under long day treatments were given a night interruption provided by two 60 watt incandescent bulbs approximately 4 feet above the bench and 3 feet apart. The lights were controlled with a timer and turned on between 10 p.m. and 2 a.m. According to Moser and

Hess (1969), night interruptions were most effective on dahlias if given in the middle of the night cycle. Five flats were placed under long days (9 hours + night interruption) while the other five received short days (9 hours), resulting in 5 repetitions for each treatment. Each flat was randomly divided into three 2x8 cell sections to be harvested following 2, 4, and 6 weeks of photoperiod treatments. Five plugs were harvested per repetition from the corresponding section depending on the week of harvest. Excessively large or stunted plugs were not harvested. After each harvest the flats were randomized on the bench. Plug height, shoot and root (fibrous and tuberous) dry weight and leaf area were determined. Root tissue was frozen in liquid nitrogen and freeze dried for carbohydrate analysis.

Results and Discussion: Following 6 weeks of photoperiod treatment long day plugs showed a 73% increase in shoot dry weight over short day plugs, while short day plugs showed a 50% increase in root dry weight over long day plugs (figure 1). Statistically significant differences in shoot fresh weight were observed after 4 weeks of photperiod treatment. Tuberous root formation was not evident until plugs recieved 4 weeks of photoperiod treatment, and by week 6 of treatment, short day plugs showed a 140% increase in tuberous root dry weight over long day plugs, while long day plugs showed a 72% increase in fibrous root dry weight over short day plugs (figure 2). The ratio of fibrous root dry weight to tuberous root dry weight (FR/TR) at week 6 was 0.13 for SD plugs and 0.64 for LD plugs. Fresh and dry weight increases in fibrous roots were linear while increases in tuberous roots were exponential from week 2 through week 6. There was no statistically significant difference in total plug dry weight throughout the experiment (figure 3) indicating that differences in shoot and root dry weight is a result of assimilate partitioning due to photoperiod. Short day tuberous roots showed a 156% increase in storage carbohydrate (fructan) concentration over long day plugs following 6 weeks of photoperiod treatment (figure 4). Long day plugs showed a 40% increase in leaf area and 37% increase in height over short day plugs following 6 weeks of photoperiod treatment (figures 5 and 6). Increases in leaf area in LD plugs may be partially attributed to increased exposure to far-red light emitted by the incandescent bulbs during the night break. Far-red light has been shown to increase leaf surface area without increasing leaf dry weight. However the fact that LD plugs show a 73% increase over SD plugs in shoot dry weight by week 6 infers that the majority of the increase in leaf area is a result of increased assimilate partitioning to the shoots. It would be interesting to see if the same results are achieved using a fluorescent light source during the night break, as it would emit very little far-red light. Increased plug height under long days may not be considered a benefit, as a shorter, more compact plug is more appealing to the plug finisher. Once again, this long day increase in plug height may be partly attributed to increased exposure to far red light which has been shown to encourage stem elongation or "stretching". The use of fluorescent light sources may produce a shorter plug.

Significance to the Industry: Major differences in LD and SD plugs occurred between weeks 4 and 6. It is the authors opinion that neither LD or SD plugs were of salable quality by week 4. By week 5 LD plugs were of salable quality while SD plugs were not salable until week 6. LD plugs at week 5 exceeded SD plugs at week 6 in the following categories; Shoot dry weight, fibrous root dry weight, leaf area, and height. The benefits of night interruption during dahlia plug production include increased shoot growth, increased fibrous root production, smaller tuberous roots, and increased leaf area. One possible downside is increased "stretching" which may be alleviated by the use of fluorescent lighting or increasing PGR concentrations. Another alternative is to plant the plugs a little deeper upon transplanting to a larger pot. LD plugs at week 5 were superior in quality to SD plugs at week 6 Following transplanting to 4" pots, LD (9.7 g) plugs showed a 68% increase in shoot fresh weight over SD plugs (5.7 g). Our results show that a superior quality plug can be produced in a shorter amount time and plugs produced under night interruptions show a superior growth response following transplanting to 4" pots. Shorter production times will allow for more crops to be produced throughout the year.

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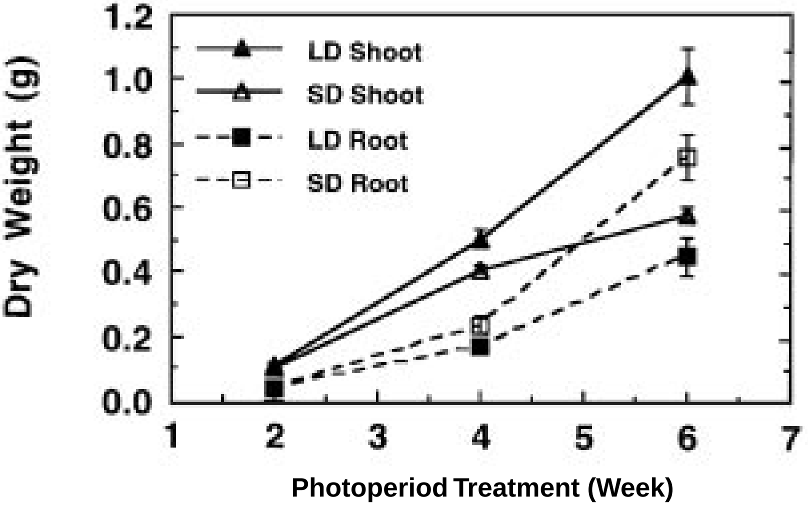

Figure 1. Dry weight of roots and shoots for weeks 2 thru 6 following start of photoperiod treatment. Values are means of 5 replications per treatment ± standard error. If standard error bar is not visible, it falls within the dimensions of the symbols.

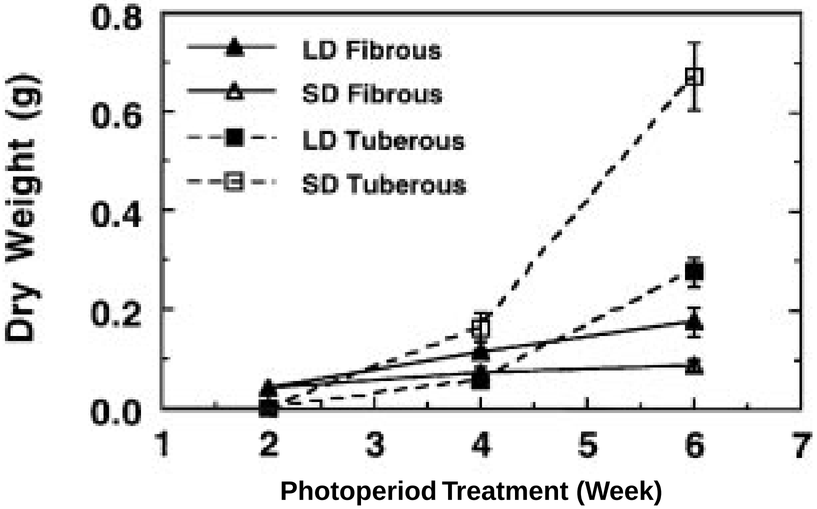

Figure 2. Dry weight of fibrous and tuberous roots for weeks 2 thru 6 following start of photoperiod treatment. Values are means of 5 replications per treatment ± standard error. If standard error bar is not visible, it falls within the dimensions of the symbols.

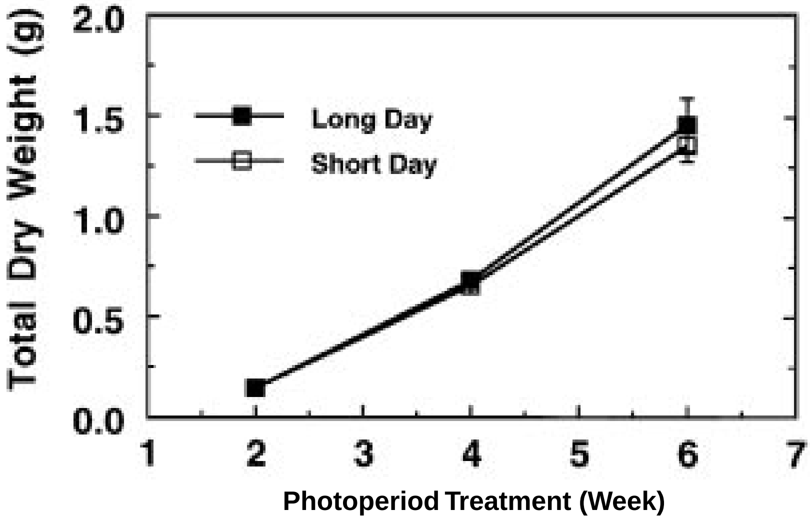

Figure 3. Total dry weight for weeks 2 thru 6 following start of photoperiod treatment. Values are means of 5 replications per treatment ± standard error. If standard error bar is not visible, it falls within the dimensions of the symbols.

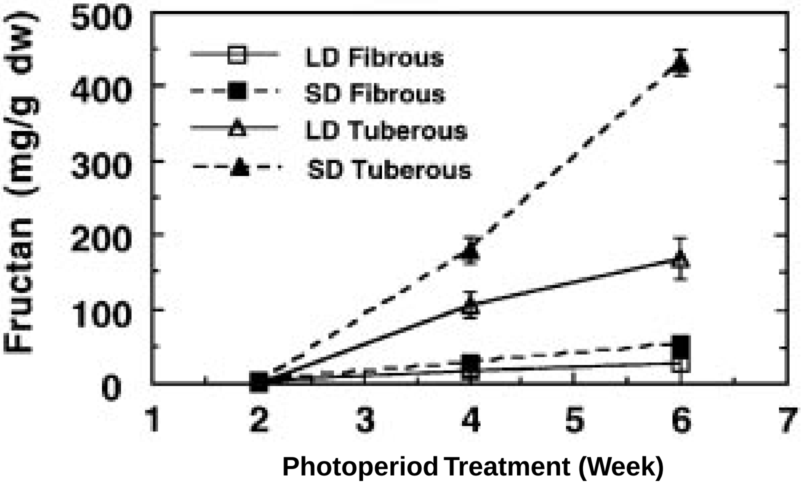

Figure 4. The effects of photoperiod on fructan concentration in fibrous and tuberous roots. Values are means of 5 replications per treatment ± standard error. If standard error bar is not visible, it falls within the dimensions of the symbols.

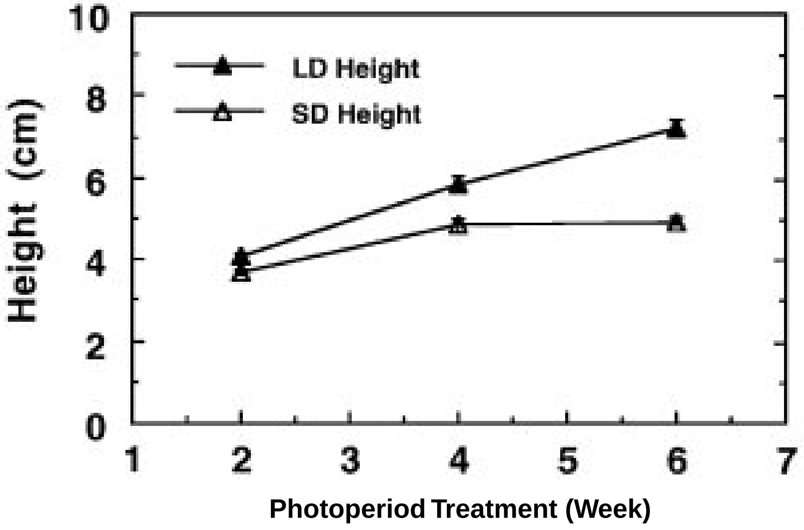

Figure 5. Plug leaf area for weeks 2 thru 6 following start of photoperiod treatment. Values are means of 5 replications per treatment ± standard error. If standard error bar is not visible, it falls within thc dimensions of the symbols.

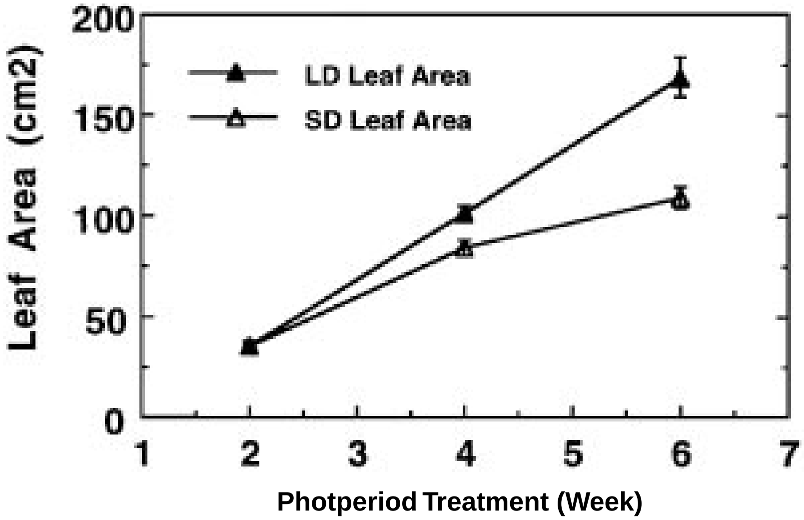

Figure 6. Plug height for weeks 2 thru 6 following start of photoperiod treatment. Values are means of 5 replications per treatment ± standard error. If standard error bar is not visible, it falls within the dimensions of the symbols.

Growth and Flowering of *Lagerstroemia* in Response to Photoperiod and Fertilization Rates

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Nature of Work: The introduction of new dwarf and semi-dwarf forms has lead to an increased interest in greenhouse forcing of crapemyrtle. A survey conducted on crapemyrtle as a forced crop for indoor use found the top color preferences to be red and purple with the number one recommended holiday as Mother's Day (Guidry and Einert, 1975).

Crapemyrtle blooms in the summer on current season's growth. Vegetative growth and flowering are thought to be regulated by several factors including: photoperiod, accumulated light intensity, and temperature (Stimart, 1986). Guidry (1977) reported that forcing of crapemyrtle requires multiple pinches, and long photoperiods for vegetative growth. Rapid flowering was achieved using high temperatures (70%F night/ 84%F day) and 16 hour photoperiods. High fertility rates consisting of surface applied Osmocote 18-9-13 supplemented with a liquid feed of 20-20-20 at 700 ppm were used in the forcing process (Guidry, 1977; Einert, 1976). The present study was conducted to further define the fertilizer and photoperiod requirements of crapemyrtle during greenhouse forcing.

On 3 January 1997, actively growing liners of *Lagerstroemia* Victor, red, and Zuni, purple, (The Liner Farm, Inc., St. Cloud, FL) were planted with either one or three liners per 6 inch standard container in Sunshine Mix 1 (Sun Gro Horticulture, Bellevue, WA). Before planting, the liners were pruned to a uniform size about 4 inches from the soil line leaving from one to three primary branches. Two experiments were conducted.

Photoperiod Experiment. Treatments consisted of either one or three liners per pot, and 0, 4, 8, or 12 weeks of short days before being moved to long days. One group of plants was held under continuous short days as a control. Long days were provided by a 4 hour night interruption from 2000 to 0200 HR. Short days were maintained by covering the plants with black cloth from 1700 to 0800 HR. A minimum night temperature of 68%F was maintained during the experiment. All plants were fertilized with Osmocote 15-11-13 (The Scotts Co., Marysville, OH) at 6 g/6 inch pot and 200 ppm N liquid feed once per week from Peter's peat lite 20-10-20 (The Scotts Co., Marysville, OH). Five replications were used. The number of days until plants reached 75% full bloom, height, width, and visual quality ratings on floral display and on branching/plant form were recorded.

Fertilizer Experiment. Treatments consisted of either one or three liners per pot, Peter's peat lite 20-10-20 weekly liquid feed at 0, 200, 400, 600, or 800 ppm N, and Osmocote 15-11-13 surface applied at either 0 or 6 g/ 6 inch pot. Treatments were arranged in a complete factorial and were blocked in the greenhouse by liquid fertilizer rate. There were four replications per treatment. All plants were pruned to provide a better shape and more uniform flowering on 15 March 1997. Data was collected 2 May 1997 when 90% of the plants had reached at least 75% full flower opening. Data was collected on plant height, width, dry weight, and visual quality ratings on floral display and on branching/plant form were recorded. Visual ratings were from 1 to 5 with 5 being the best.

Results and Discussion: The number of liners per pot did not affect the overall size of Victor as indicated by the growth index (Table 1). However, in comparing height and width, the pots with three liners were shorter and wider than those with only one liner. Victor planted three liners per pot were also wider than with only one liner. Zuni grown three liners per pot had a significantly greater growth index as well. While flowering in Victor was not affected by liners, Zuni had significantly better floral rating with three liners per pot. For both varieties, branch ratings indicating plant form were greater with three liners per pot. The number of liners did not affect the number of days to flower.

Continuous short days (SD) prevented vegetative growth and floral development in both cultivars (Table 2). The best growth index ratings were measured on plants having received either 4 or 8 weeks of SD for Victor or 8 weeks of SD for Zuni before being moved to long days (LD). While there was no difference in floral ratings in Zuni, Victor flowered best after receiving 8 weeks of SD before moving to LD. Victor tended to branch heavier than Zuni and received consistently higher ratings on plant form. When Victor did not receive any SD, plant form was rated lowest. Zuni, however, had better plant form when moved directly to LD for growth and flowering. Victor and Zuni both took longer to flower with increasing numbers of SD weeks. If the SD weeks are subtracted from the number of days to flower, the length of time to flower in LD was almost equal until reaching 12 weeks when they flowered quicker. In the fertilization experiment, liner number had little effect on most parameters measured. Liner number did significantly affect the growth index of Zuni where measurements of 67 and 89 were recorded for one and three liners respectively. For all parameters measured except dry weight of Victor and branch rating of Zuni, there was a significant liquid fertilizer by Osmocote interaction (Table 3). The application of Osmocote did not significantly enhance the growth of Victor or Zuni if the plants were supplemented with liquid feed. Victor and Zuni both responded variably to the fertilizer rates but no improved plant size or dry weight resulted from high nutrient levels. Floral ratings were improved in Victor when fertilized at 200 ppm N with 6 g Osmocote applied. Plant form indicated by branch rating increased slightly with the addition of Osmocote but this increase was not statistically significant. From these results, crapemyrtle did not respond to the high fertility levels previously reported (Guidry, 1977; Einert, 1976) to be needed for forcing crapemyrtle.

Significance to Industry: High fertilization rates are not needed in forcing crapemyrtle. Photoperiods have been shown to have a significant affect in regulating vegetative growth. Since crapemyrtle bloom on current season's growth, good vegetative growth is needed for a good floral display. Early flowering could be used to increase sales during the spring planting season which could include markets where crapemyrtle are not winter hardy and can be grown as a summer annual.

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Table 1. The effects of liner number per 6 inch pot on growth of crapemyrtle Victor and Zuni. Growth index = 3.14 (width/2)^2 height. Visual ratings are on a scale of 1 to 5 with 5 being best.

No. Liners	Width (cm)	Height (cm)	Growth Index	Floral Rating	Branc Rating	Days to Flower
Victor						
1	129b[z]	73a	456678a	2.6a	3.1 a	11 0a
3	157a	60b	539300a	2.9a	4.3b	106a
Zuni						
1	61b	95a	161835b	1.6b	1.0b	101a
3	113a	86a	361478a	2.1 a	2.1a	104a

[z] means separation within column by cultivar using Student-Newman-Kuels' $P_{\propto}$=0.05.

Table 2. The effects of number of weeks of short day before placing in long days on growth of crapemyrtle Victor and Zuni. Growth index = 3.14 (width/2)^2 height. Visual ratings are on a scale of 1 to 5 with 5 being best.

Weeks of Short days	Width (cm)	Height (cm)	Growth Index	Floral Rating	Branch Rating	Days to Flower
Victor						
0	150b[z]	56b	414147b	3.8ab	2.9b	73c
4	179a	66b	762880a	3.4b	3.7ab	114b
8	167ab	69b	698119a	4.3a	4.0ab	115b
12	118c	90a	446129b	2.3c	3.6ab	134a
CSD	98c	55b	175232c	--	4.3a	--
Zuni						
0	95b	59b	213100b	2.0a	1.9a	64a
4	90bc	67b	208141b	2.2a	1.7ab	98b
8	125a	83b	520276a	2.2a	1.5ab	119c
12	65c	174a	268921b	2.7a	1.2b	130d
CSD	62c	67b	90731 b	--	1.7ab	--

[z] means separation within column by cultivar Student-Newman-Kuels' $P_{\propto}$=0.05.

Table 3. Interactive effects of fertilization with a weekly liquid feed and surface applied Osmocote on crapemyrtle Victor and Zuni. Growth index =3.14 (width/2)^2 height. Visual ratings are on a scale of 1 to 5 with 5 being best.

	Growth Index		Dry Weight (g)		Floral Rating		Branch Rating	
	Osmocote		Osmocote		Osmocote		Osmocote	
Fertilizer rate (ppm)	0g	6g	0g	6g	0g	6g	0g	6g
Victor								
0	13842b[z]	45036a	17c	28ab	0.6c	4.3ab	2.0b	3.8a
200	31998b	29681b	29ab	30ab	3.8ab	4.8a	3.3a	3.9a
400	47628a	26640b	34a	30ab	3.8ab	4.0ab	3.4a	3.8a
600	22313b	24517b	24b	29ab	3.0b	3.1b	3.4a	3.4a
800	22503b	25000b	24b	30ab	3.5ab	3.4a	3.3b	4.0a
Zuni								
0	9228b	28622a	17c	23a	1.0b	2.6a	1.9a	2.3a
200	30045a	19960ab	23a	21ab	3.0a	3.5a	2.7s	2.5a
400	15783ab	18876ab	21abc	23a	3.0a	3.2a	2.7a	2.2a
600	14052ab	12494ab	19abc	18bc	2.7a	2.9a	2.2a	2.3a
800	13781ab	13501ab	20abc	18bc	3.3a	3.3a	2.8a	2.3a

[z] Means separation using Student-Newman-Kuels $P_{\propto}$=0.05.

The Effect of Temperature on Pansies Inoculated with *Thielaviopsis basicola*

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Nature of Work: Black root rot, caused by T*hielaviopsis basicola*, is reported as the most destructive crown and root disease of pansies in the state of Alabama (1). High temperatures that prevail in Alabama are thought to promote black root rot in pansy (5). The development of black root rot on other crops, such as poinsettia, sesame, and chickpea, is reported to be influenced by temperature (2,3,4). For example, the optimal temperature for development of black root rot in poinsettia is poinsettia is 62°F and is 86°F in chickpea (2,4). To test the effect of temperature on black root rot development in pansies, three week old pansies (Crystal Bowl primrose) were transplanted into peat based medium and placed in growth chambers set at differing temperatures (59°F, 68°F, 77°F, 86°F). Half of the pansies in each chamber were inoculated with *T. basicola* using a root dip method; the other half were uninoculated controls. Plants were destructively sampled weekly for four weeks. Data were collected on relative quality of roots and shoots, as well as root and shoot fresh and dry weights of each plant. Data analyses included analysis of variance, and because of the quantitative nature of temperatures, linear regression analysis. Measured plant parameters for each temperature were regressed over sampling dates for model comparisons.

Results and Discussion: Models describing temperature effects on fresh and dry weights of both roots and tops over sampling dates were developed. Models for inoculated plants compared to those for uninoculated control plants were approximately parallel (Figs. 1-4) indicating that growth was affected by inoculation, but temperature did not influence damage due to disease. Pansy growth is affected by temperature but black root rot damage is neither enhanced nor reduced at any particular temperature. Temperature may play a role in black root rot development in pansy but was not the major factor influencing disease development.

Significance to Industry: Most commercial pansy producers have sizable investments in environmental controls for the production of high quality plants. If the environmental factors that promote or suppress black root rot were better understood, the grower's disease and plant management strategies may be appropriately amended. Our results indicate that temperature may not solely be responsible for black root rot disease development but additional research is needed on the interrelatedness of environmental factors affecting black root rot development in pansy.

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Figure 1. Inoculated and uninoculated fresh root weights over time when pansies are grown at 59^{0}F.

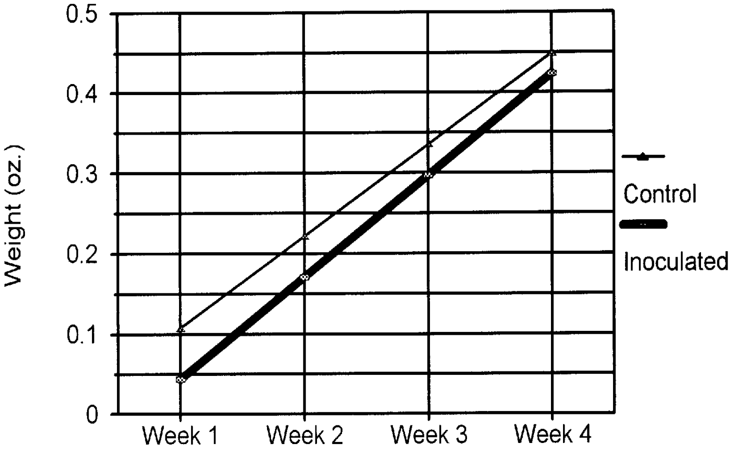


Figure 2. Inoculated and uninoculated fresh root weights over time when pansies are grown at 68^{0}F.

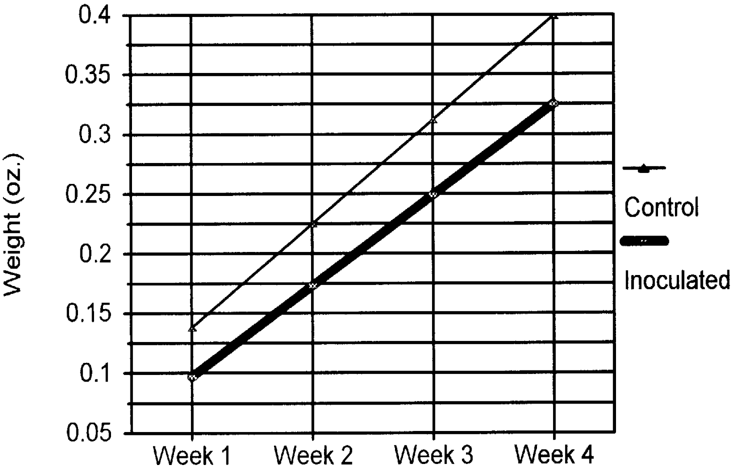


Figure 3. Inoculated and uninoculated fresh root weights over time when pansies are grown at 77^0F.

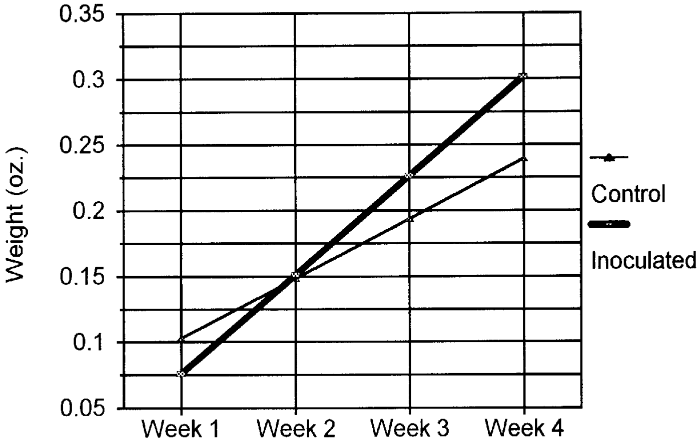
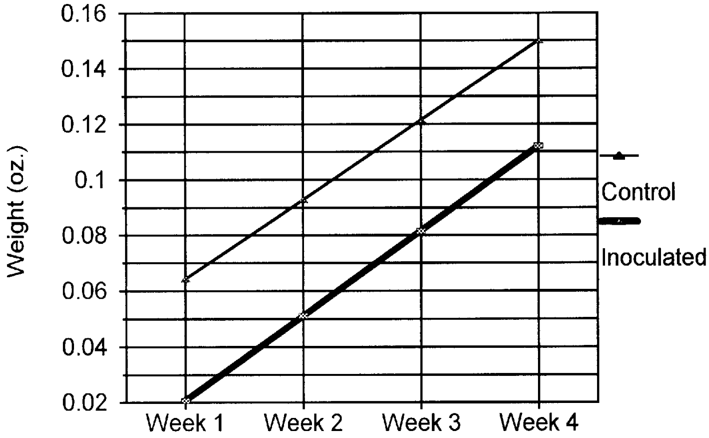


Figure 4. Inoculated and uninoculated root weights over time when pansies are grown at 86^0F.



Repellency of *Allium* Extracts on Two-Spotted Spider Mites

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Nature of Work: Two-spotted spider mites, Tetranychus urticae Koch, feed on many host plants in nurseries and greenhouses, and may be considered the most serious pest of ornamentals in the southeastern United States (1). Nurserymen and greenhouse growers usually rely on pesticide applications for mite control.

As an alternative to synthetic chemicals, *Allium* (garlic, onions, and chives) and its extracts have been suggested anecdotally in the popular press as a repellent for many arthropods (2-4). Volatiles from the bulbs of *Allium sativum* were shown to have adverse affects on certain insect eggs associated with cotton (5). The object of this research was to assess the repellent effects of garlic extract on two-spotted spider mites.

Allium extracts used in these bioassays were Garlic Barrier® Ag, a commercial insect repellent of 100% garlic juice, and a modified recipe of a suggested organic spray (2) in which 60 ml (2 fluid ounces) mineral oil was added to 125 grams (4 ounces) of garlic powder, then allowed to adsorb for 24 hours. The garlic-oil mixture was then added to a solution of 500 ml (16.5 fluid ounces) water and 15 ml (0.5 fluid ounces) fish emulsion, stirred, and drained through cheese cloth. The Garlic Barrier® Ag and garlic mixture were used in concentrations of 100%, 50%, 20%, and 10%. Water was used as the control. Mature leaves from a lima bean plant (*Phaseolus*) were dipped, one each into each concentration and allowed to dry for two hours. The leaves were then placed on a thin layer of cotton saturated with water in petri dishes. An untreated leaf disc, 14 mm (9/16 inch) in diameter, was positioned in the middle of each leaf, and 10 adult female mites were placed on each disc. Mites remaining on the leaf disc were counted at 15 minutes, 30 minutes, 45 minutes, 1 hour, 2 hours, 3 hours, and 4 hours. The assays were replicated three times on consecutive days.

Results and Discussion: Garlic Barrier® Ag treatment showed significant repellent effects and rate response only at 100% concentration ($P<.002$), with the exception that the 50% concentration was significantly different ($p<.05$) than the control at 30 and 45 minutes (Figure 1). The garlic mixture treatment showed significant repellent effects at all concentrations (Figure 2). Mites preferred to stay on the untreated leaf disc when the garlic mixture was applied at any tested concentration on the treated leaf, demonstrating that the mixture or one of its components repelled them. This is the first scientific evidence that demonstrates the effectiveness of the extracts of *Allium* as a repellent of two-spotted spider mites.

Significance to Industry: Reducing chemical control in the nursery and greenhouse is desirable to conserve costs, natural enemy populations, and environmental quality. *Allium* extracts may be useful in pest management programs by alleviating the need for repeated pesticide applications and aiding biological control by concentrating mites into biologically active areas. Expectations for field effectiveness are positive.

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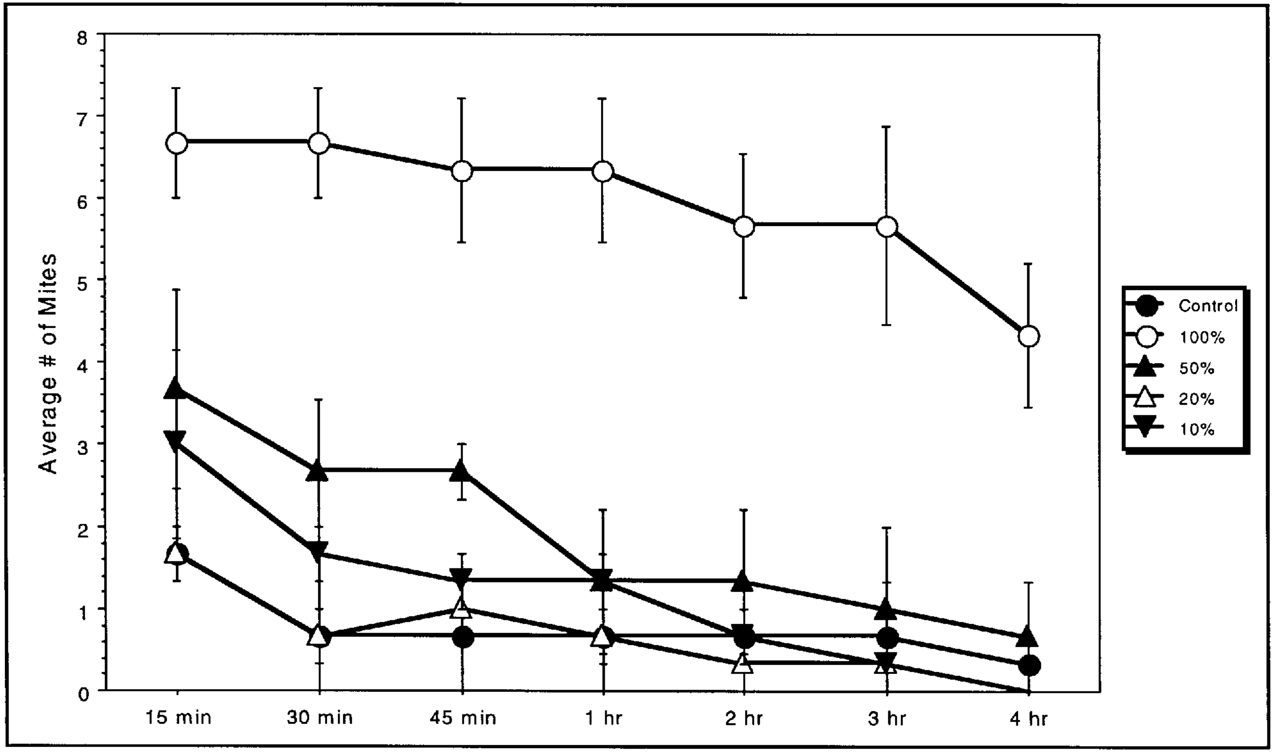

Figure 1: Repellency of Garlic Barrier® Ag on two-spotted spider mites. Values indicate number of mites remaining on untreated leaf discs placed on bean leaves treated with Garlic Barrier® Ag concentrations.

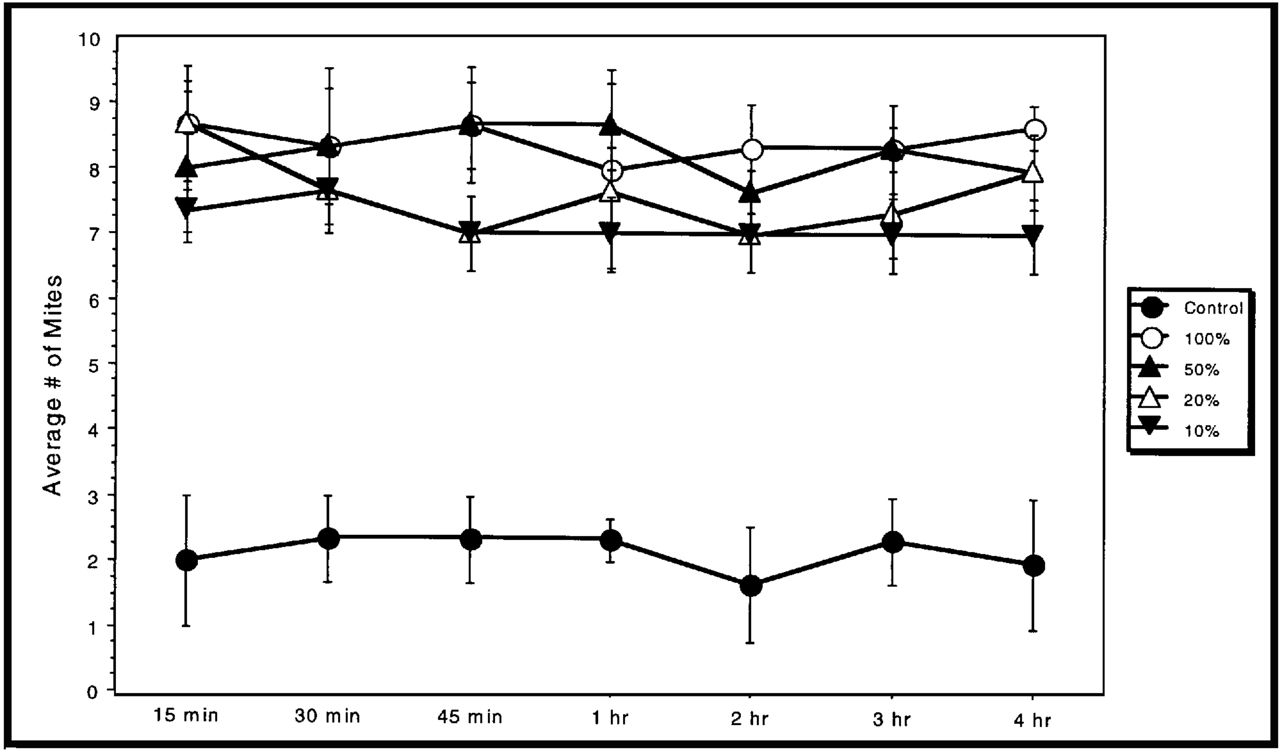

Figure 2: Repellency of the garlic mixture on two spotted spider mites. Values indicate numbers of mites remaining on untreated leaf discs placed on bean leaves treated with the garlic mixture concentrations.

Pampas Grass: Timing of Herbicide Application After Transplanting

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Nature of Work: In the southern United States many nursery growers produce pampas grass (Cortaderia selloana) in small cell packs. Reduced growth and lodging of pampas grass have been observed in nurseries using preemergence herbicides that contain a dinitroalanine herbicide. Recent work has demonstrated that application at potting of herbicides containing a dinitroalanine herbicide causes these observed effects(1). These effects were attributed to a high percentage of the small root system being within the zone of herbicide activity. One strategy that may lessen injury is to delay herbicide application for 2 to 4 weeks after potting to allow root growth below the zone of herbicide activity. Therefore, the objective of this study was to determine if time of herbicide application affected root and shoot growth of pampas grass.

Uniform liners (36-cell packs) of white pampas grass were potted on June 19, 1996 in trade gallon containers of a 4 pinebark : 1 sand medium amended with 12.5 lbs of 12-month Polyon 24-4-14, 5 lbs dolomitic lime, and 1.5 lbs Micromax/yd^3. The study consisted of 13 treatments: 4 herbicide treatments, 3 application dates and a non-treated control. Herbicides and their rate in lbs ai/A were Ronstar 2G (4.0), Pendulum 2G (3.0), Factor 65 WG (1.5), and Pendulum 60 WDG (3.0). The 3 applications were made at potting, 2 weeks after potting, and 4 weeks after potting. Each treatment consisted of 7 single-plant replications. Plant height was recorded 15, 30, 45, 60, 75, and 90 days after potting. Roots in the upper 2 inches and lower 4 inches of the container were rated separately on a scale of 1-5 where 1=0%, 2=25%, 3=50%, 4=75%, and 5=100% root coverage at the medium-container interface. Root rating and lodging were recorded at 30, 45, 60 days after treatment (DAT). The number of club roots was also recorded at 90 days after potting. Treatment means were compared using LSD test at ($P< 0.05$).

Results and Discussion: There was an interaction between herbicides and time of application with club root numbers. Control and Ronstar 2G treated plants had few if any club roots regardless of time of application (Fig. 1). There was a trend for Pendulum 2G treated plants to have fewer club roots when application was delayed until 4 weeks after potting. Pendulum 60WDG treated plants also tended to have the most club roots when applied at 4 weeks after potting. Pendulum 60WDG treated plants had 2 to 3 times more club roots then Pendulum 2G treated plants. Plants treated with Factor 65WDG had the most club roots over all times of herbicide application except when compared to

Pendulum 60WDG when applied at 4 weeks after potting. These data concur with our earlier test which showed that Factor and Pendulum WDG caused the most club root development when applied to container grown pampas grass at potting.

Lodging followed a similar trend to club root development in lodging did not occur in the control plants or Ronstar treated plants did not lodge, but did in all other herbicide treatments did cause lodging (Fig. 2). With Pendulum 2G, none of the plants lodged when applied at potting, 28.6% lodged when applied 2 weeks later, and none lodged when applied 4 weeks after potting. The most lodging occurred with Factor and Pendulum WDG and did not appear to be affected by time of application. At the end of the study there was no herbicide effects on plant height; however, plants treated at 2 and 4 weeks after potting were taller than plants treated at potting. Also, Factor treated plants generally had the lowest upper and lower root ratings (least roots) compared to all other herbicide treatments.

Significance to Industry: Our results show that delaying herbicide application for 2 or 4 weeks after potting pampas grass does not reduce the injury potential expressed by lodging and club root formation for spray applied herbicides (Pendulum and Factor). When granular-applied Pendulum was applied 4 weeks after potting there was no lodging and the least club root numbers of any herbicide treatment except Ronstar. Ronstar, a non-dinitroalanine herbicide, applied at potting caused no lodging or club root formation.

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Figure 1. Number of club roots in container-grown pampas grassfollowing herbicide application 0,2, or 4 weeks after potting; data collected 90 days after potting.

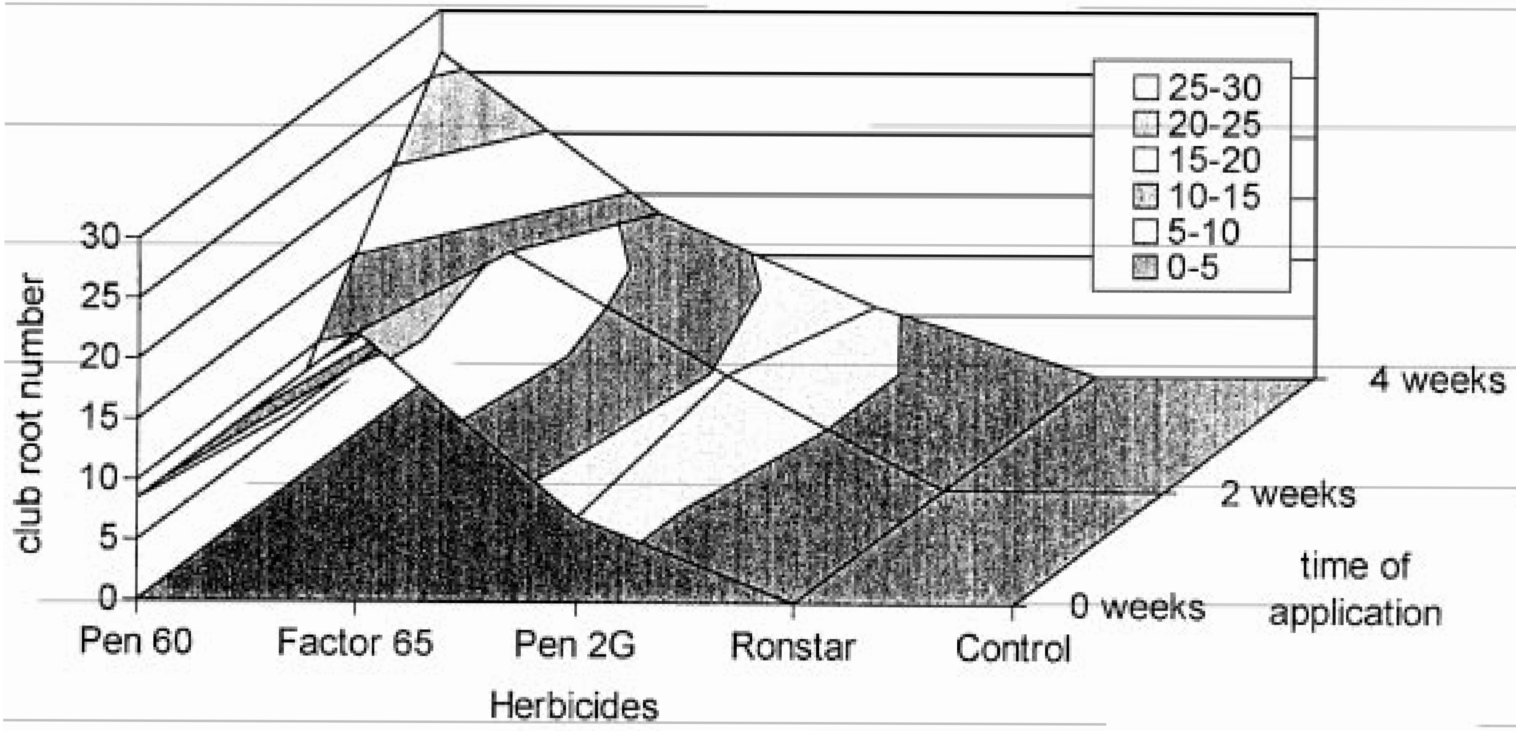
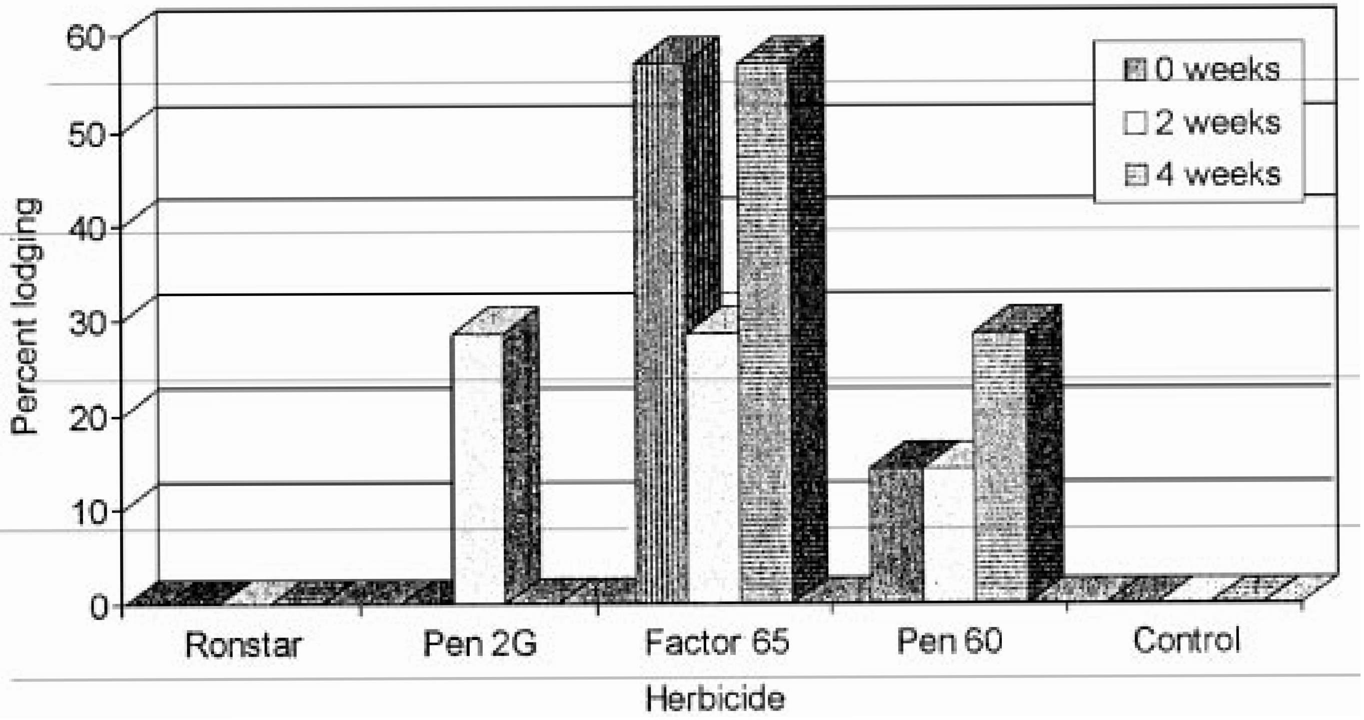


Figure 2. Percentage lodging in container-grown pampas agrass following herbicide application 0, 2, and 4 weeks after potting; data collected at 60 days after potting.



Early Rooting-out Response of Two Landscape Trees in a Pot-in-pot Production System

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Nature of Work: In-ground pot-in-pot (PIP) production of landscape trees alleviates several problems associated with conventional container production such as supra-optimal root-zone temperatures and blow-downs (2-5). In-ground PIP production utilizes a permanent socket container placed in the ground and a growing container placed in the socket container and removed with the tree at sale. However, growth of roots out of the socket container and into the native soil is a problem with PIP production.

Research indicates that methods of controlling rooting-out utilizing Biobarrier is effective for some trees species (2,4,5). However, the effectiveness of Biobarrier may be reduced if a tight seal between the growing container and the socket container does not exist (5). Long-term use of a PIP system in a nursery may result in difficulties in achieving adequate closure. Additional research indicated that copper-coated pots resulted in reduced root elongation and increased root branching in the interior of the root ball (1). The objective of this experiment is to evaluate early plant growth and rooting-out response for two tree species when treated with various rooting-out control methods in conjunction with copper-coated containers.

The experiment is being conducted at GreenForest Nursery (Perkinston, MS) in an established pot-in-pot nursery block. Little gem magnolia (*Magnolia grandiflora* ‘Little Gem’) and Natchez crape myrtle (*Lagerstroemia indica x faurei* ‘Natchez’) liners were transplanted into 57 l (#15) containers in 1996. Plants were grown in a pine bark:grit:sand (6:3:1 v:v:v) substrate. Fertilizer and micronutrients were applied based on nursery practices. Treatments were begun on May 14, 1997 before roots began to circle in the growing container. Treatments were initiated with one-year-old plants with intact root balls being transferred into Spin-out™-coated containers (The Lerio Corporation, Mobile, AL) with the exception of a control. After plant transfer into treated containers, plants were placed in socket containers treated with 32 or 64 nodule Biobarrier (Reemay, Inc., Old Hickory, TN), a single-nodule wide Biobarrier ring covering the side drainage holes in the socket pot, or Trialin 10G (The Griffin Corp, Valdosta, GA), a trifluralin-based herbicide. Additional treatments included a container rotated 1/4 clockwise turn every 3 weeks or a growing container with two rows of 3/32" drain holes 1 1/2” above the container bottom. Trees were irrigated with low volume emitters based on nursery practices.

Growth measurements were taken monthly for both species. Height and caliper (15.2 cm (6 in) above the soil line) were measured for magnolia, and growth indices [(height+width1+width2 (perpendicular to width1))/3] were measured for crape myrtle. Means are reported as the increase in growth since experiment initiation. Phytotoxicity and rooting-out rating were also taken monthly. The experiment was arranged in a randomized complete block design with four single plant replications. Each species was analyzed as an individual experiment using the general linear models procedure of SAS (SAS Institute, Cary NC).

Results and Discussion: Crape myrtle-Increases in growth indices were similar for all plants regardless of treatment 30 and 60 DAT (Table 1 and 2). Crape myrtles exhibited no phytotoxicity symptoms 30 or 60 DAT. Control, 32 and 64 nodule Biobarrier, Trialin 10G, rotated pot, and Biobarrier ring treatments were similar in plant rooting-out response 30 DAT. Plants in growing containers with 3/32" holes exhibited the lowest rooting out rating, and rotated pot treatments were similar to all other treatments excluding the control. Control, 32 and 64 nodule Biobarrier, Trialin 10G, and rotated pots treatments resulted in plants with the highest rooting-out rating while the 3/32" drilled hole treatment resulted in plants with the lowest rooting-out rating 60 DAT (Table 2). Plants grown using a Biobarrier ring were similar to all other treatments.
Magnolia-Increases in both height and caliper were similar for all treatments 30 days after treatment initiation (DAT)(Table 3). After 60 days, there were no differences in plant height, but caliper was higher for plant grown using Trialin 10G and lower for plant grown using 64 nodule Biobarrier or rotated pots (Table 4). All other treatments were similar. Additionally, no phytotoxicity was observed for any treatment 30 or 60 DAT. Control, 32 and 64 nodule Biobarrier, Trialin 10G, and rotated pot treatments had similar rooting-out ratings 30 DAT (Table 3), but 60 DAT there were no differences in rooting-out ratings for any treatment (Table 4). Growing containers with 3/32" holes had a rooting-out rating of zero, and treatments utilizing a Biobarrier ring were similar to all other treatments during the first evaluation.

Significance to Industry: All treatments provided adequate rooting-out control after one month without reducing plant growth or resulting in phytotoxicity. However, Biobarrier concentrations sufficient to reduce long-term rooting-out response in crape myrtle have reduced plant growth (5) and little research exists concerning rooting-out control for magnolia. Additionally, inadequate sealing between the growing container and the socket container reduces the long-term efficiency of Biobarrier. A method of reducing root diameters of escaping roots such as 3/32" drainage holes may provide long-term rooting-out protection, and, based on its early performance in this experiment, merits further study.

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Table 1. Influence of rooting-out treatments on growth, rooting-out, and phytotoxicity for crape myrtle[z].

Treatment	Phytoxicity[y]	Rooting-out rating[x]	ΔGrowth indices
Control	0a[w]	2.25a	0.71a
32 nodule Biobarrier	0a	1.75ab	0.25a
64 nodule Biobarrier	0a	1.75ab	0.25a
3/32" holes	0a	0.38c	0.35a
Trialin IOG	0a	1.50ab	0.47a
Rotated pot	0a	1.13bc	0.10a
Biobarrier ring	0a	1.63ab	0.62a

[z] 6/16/97. 30 DAT.

[y] 5-death, 3-moderate damage, 0=no damage.

[x] 5=heavy rooting-out, 0=no roots growing from container.

[w] Means followed by the same letter within a column are not different according to LSD ($p<0.05$).

Table 2. Influence of rooting-out treatments on growth, rooting-out, and phytotoxicity for crape myrtle[z]

Treatment	Phytoxicity[y]	Rooting-out rating[x]	ΔGrowthindices
Control	0a[w]	4.5a	1.92a
32 nodule Biobarrier	0a	3.9a	01a
64 nodule Biobarrier	0a	4.3a	0.86a
3/32" holes	0a	I.9b	1.75a
Trialin IOG	0a	4.1a	1.22a
Rotated pot	0a	3.8a	1.03a
Biobarrier ring	0a	3.0ab	1.89a

[z] 7/14/97. 60 DAT.

[y] 5=death, 3=moderate damage, 0=no damage.

[x] 5=heavy rooting-out, 0=no roots growing from container.

[w] Means followed by the same letter within a column are not different according to LSD ($p<0.05$).

Table 3. Influence of rooting-out treatments on growth, rooting-out, and phytotoxicity for magnolia[z]

Treatment	Phytoxicity[y]	Rooting-out rating[x]	AHeight (ft)	A Caliper(in)
Control	0a[w]	0.38a	0.10a	0.10a
32 nodule Biobarrier	0a	0.50a	0.23a	0.02a
64 nodule Biobarrier	0a	0.50a	0.15a	0.03a
3/32" holes	0a	0.00b	0.15a	0.06a
Trialin IOG	0a	0.50a	0.33a	0.08a
Rotated pot	0a	0.38a	0.23a	0.03a
Biobarrier ring	0a	0.25ab	0.30a	0.08a

[z] 6/16197. 30 DAT.

[y] 5=death, 3=moderate damage, 0=no damage.

[x] 5=heavy rooting-out, 0=no roots growing from container.

[w] Means followed by the same letter within a column are not different according to LSD ($p<0.05$).

Table 4. Influence of rooting-out treatments on growth, rooting-out, and phytotoxicity for magnolia[z]

Treatment	Phytoxicity[y]	Rooting-out rating[x]	AHeight (ft)	∆Caliper(in)
Control	0a[w]	0.8a	1.15a	0.15ab
32 nodule Biobarrier	0a	1.0a	0.95a	0.15ab
64 nodule Biobarrier	0a	0.8a	I.11a	0.12b
3/32" holes	0a	0.4a	1.05a	0.14b
Trialin IOG	0a	I.0a	0.90a	0.21a
Rotated pot	0a	I.0a	0.98a	0.13b
Biobarrier ring	0a	0.6a	1.10a	0.16ab

[z] 7/14/97. 60 DAT.

[y] 5=death, 3-moderate damage, 0=no damage.

[x] 5=heavy rooting-out, 0=no roots growing from container.

[w] Means followed by the same letter within a column are not different according to LSD ($p<0.05$).

Eastern Redbud (Cercis canadensis) Toxicity with Increasing Rates of Sulfentrazone

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Nature of Work: Sulfentrazone, an experimental herbicide from the FMC Corporation, has shown promising results for long-term weed control in field trials with ornamentals by controlling weeds that are difficult to manage with currently labeled products, such as morningglory and yellow nutsedge (Collins et al., 1996). This compound has recently been labeled for use in both soybeans and tobacco. A possible hindrance to the labeling of sulfentrazone for use in ornamentals is the phytotoxicity that occurs in certain sensitive ornamental species.

Sulfentrazone works by inhibiting protoporphyrinogen oxidase in the chlorophyll biosynthetic pathway in susceptible plants. As a result, a phytodynamic toxicant (protoporphyrin IX) builds up, leading to membrane disruption. Sulfentrazone is absorbed by both the roots and shoots of plants, which turn necrotic and die shortly after exposure to light. Postemergence application of sulfentrazone resulting in foliar contact of weeds can cause rapid dessication and necrosis in affected weeds, particularly smaller ones (Theodoridis et al., 1992, Van Saun et al., 1991).

In a field trial using sulfentrazone during 1996, Cercis canadensis exhibited foliar damage, but phytotoxicity ratings were not noted because the damage resembled Botryosphaeria canker, a common disease of redbuds in this area. After much discussion about that trial, an experiment was conducted to determine if sulfentrazone has detrimental effects on Cercis canadensis, and if increasing rates are more detrimental.

Cercis canadensis liners measuring 18-24" were planted in 3 gallon containers in April 1997 using a medium consisting of pine bark and expanded shale (2:1 by volume). The plants were allowed to leaf out completely and establish new roots. Sulfentrazone 80WP was applied in May 1997 at increasing rates for a total of 6 treatments (0.125, 0.25, 0.375, 0.5, and 0.625 lb ai/A, plus a control). Ten single plant reps were used for each treatment, arranged in a completely randomized design of 60 plants. Plants were watered using trickle irrigation. Treatments were applied using a CO_2 pressurized backpack sprayer calibrated to 26 GPA using 8004 nozzles at 30 lbs psi at the boom. Plant phytotoxicity ratings were taken weekly after herbicide application, measured on a scale from 0 to 10 (0 representing no phytotoxicity and 10 representing plant death). Plants were harvested 6 WAT (weeks after treatment). At that time, a visual root rating was taken on a scale from 0 to 10 (0 representing no root damage compared to the control and 10 representing plant death). Shoot and root dry weights were determined after drying for 2 days in a 40°C oven.

Results and Discussion: Phytotoxicity ratings are reported in Table 1 and Figure 1. Phytotoxicity appeared as a reddish-brown necrotic area around the leaf margin, eventually spreading throughout the whole leaf. A more severe form of phytotoxicity was exhibited as current season stem death in some plants. At 1 WAT, phytotoxicity increased with increasing sulfentrazone rates as expected. At 2 WAT, we observed increasing phytotoxicity with increasing rates, but this response was not as linear or exponential with increasing rate. This phenomenon was due to the fact that the more severely damaged plants were producing new growth which was undamaged, while the plants that initially had less damage were exhibiting increasing toxicity. By 4 WAT, response was similar among all treatment combinations, with a difference of only 1.2 between the lowest and highest rates. The higher rates had a considerable amount of new growth by this time, thereby negating some of the initial negative effects of sulfentrazone. An explanation for the continued decline of the plants sprayed with lower rates could be that the higher rate effects were initially so severe that the plant was caused to be stressed and temporarily shut down growth and translocation processes, no longer absorbing the herbicide, while the plants sprayed with lower rates continued to absorb the herbicide readily, allowing continued translocation throughout the plant. By 5 and 6 WAT, there were no significant differences among the rates of sulfentrazone. The phytotoxicity ratings were slightly higher at 6 WAT, due to abnormal growth noticed on the new leaves of plants in all treatments, indicating sulfentrazone phytotoxicity persisted 6 weeks after treatment from visual analysis.

At 6 WAT, plants were harvested and a visual root rating was given to each plant (Table 2). Roots were then separated from shoots and placed in a drying oven for 2 days. At this time, root and shoot dry weights were measured in grams (Table 2). The visual root rating increased with increasing sulfentrazone rates, but dropped at the highest rate. The shoot dry weight followed a similar trend, decreasing with increasing sulfentrazone rates, but increased again at the highest rate. These observations could be attributed to the fact that the plants sprayed with the highest rate of sulfentrazone started to show new growth earliest after the initial treatment, and had the most time to regenerate. The root dry weights showed no significant difference among sulfentrazone treatments, although there were differences visually. Future experiments could utilize more replications to evaluate treatment effects.

Significance to Industry: Sulfentrazone, an experimental herbicide by the FMC Corporation, shows promise for long term weed control in ornamentals. However, the phytotoxicity it causes in some plants is a hindrance to labeling for use on ornamentals. Continued research on the phytotoxicity of sulfentrazone could eventually lead to the release of a dependable, long term herbicide with low toxicity for use in the nursery industry.

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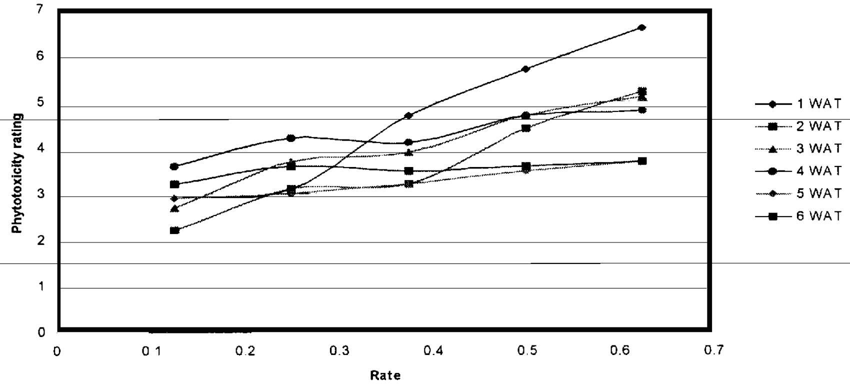
Table 1. Phytotoxicity ratings

Treatment	Rate	1 WAT	2 WAT	3 WAT	4 WAT	5 WAT	6 WAT
Sulfentrazone 80WP	0.125	2.9c	2.2c	2.7c	3.6b	2.9a	3.2a
Sulfentrazone 80WP	0.250	3.1 c	3.1 c	3.7bc	4.2ab	3.0a	3.6a
Sulfentrazone 80WP	0.375	4.7b	3.2bc	3.9abc	4.1ab	3.2a	3.5a
Sulfentrazone 80WP	0.500	5.7ab	4.4ab	4.7ab	4.7a	3.5a	3.6a
Sulfentrazone 80WP	0.625	6.6a	5.2a	5.1 a	4.8a	3.7a	3.7a
Control	0.000	0.0d	0.0d	0.0d	0.0c	0.0b	0.0b
LSD	--	1.54	1.29	1.28	0.95	1.04	0.92

Table 2. Root and shoot evaluation

Treatment	Rate	Root rating	Root dry weight	Shoot dry weight
Sulfentrazone 80WP	0.125	5.4c	7.86b	13.76ab
Sulfentrazone 80WP	0.250	6.0bc	7.86b	11.19bc
Sulfentrazone 80WP	0.375	7.3ab	4.65b	7.85cd
Sulfentrazone 80WP	0.500	7.7a	3.88b	6.02d
Sulfentrazone 80WP	0.625	6.4abc	6.75b	9.17bcd
Control	0.000	0.0d	13.88a	17.97a
LSD	--	1.64	4.40	4.87

Figure 1. Sulfentrazone Toxicity on *Cercis canadensis*



Natural Occurrence of *Microsphaera Pulchra* and *Phyllactinia Guttata* on two Cornus Species

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Nature of Work: Powdery mildews of *Cornus* L. species were rarely reported before 1994, but have since become a common foliar disease (4,6,7,8). Dogwood leaves infected with powdery mildew become distorted, have an increase in red pigmentation, and develop lesions that eventually become necrotic. Infected flowers typically fail to develop normally and become misshapened and nonfunctional (6). The disease may cause stunting of young seedlings and slow growth in older trees (8). Two powdery mildew species have been reported to infect dogwoods in eastern North America, *Microsphaera pulchra* Cooke and Peck (1,3,7) and *Phyllactinia guttata* (Wallr.:) Lev. (2,3,6). The asexual stage of *Microsphaera* species (*Oidium*) was reported on flowering dogwood (3,4), whereas *Ovulariopsis*, the asexual stage of *Phyllactinia* species, was reported on various *Cornus* species (1). The purpose of this study was to identify the powdery mildew species infecting a red-fruited dogwood, *C. florida* L. 'Cherokee Brave', and a blue-fruited species, *C. amomum* Mill. based on ascocarp characteristics.

Leaves were collected from ‘Cherokee Brave’ and C. a*momum* in August of 1996 on the Agricultural Campus of the University of Tennessee. Diseased leaves were viewed with a stereo dissecting scope at 40-70X magnification and then dried in a plant press. Ascocarps from both dogwood species were mounted in lactophenol and examined with a compound microscope. The diameters of ascocarps and length of 4-5 appendages of each ascocarp were measured. Powdery mildew species were identified using the form and length of appendages and ascocarp diameter.

Leaf were cut from dried leaves using a 12 mm diameter cork borer and examined using scanning electron microscopy. Disks, without fixation and dehydration, were mounted on aluminum stubs with double sided tape, sputter-coated with gold-paladium and viewed with an ETEC Autoscan operated at 20 kV.

Results and Discussion: Dichotomously branched appendages and the occurrence of many asci in each ascocarp identified one of the powdery mildew genera as *Microsphaera*. The ratio of ascocarp diameter (92-(107)-128 μm) to appendage length (117-(134)-160 μm) of 1:13 (Table 1), identified the species as M. *pulchra* (1). Host and ascocarps with bulbous based appendages identified the second powdery mildew species as *Phyllactinia guttata* (1). Ascocarps of both *P. guttata* and *M.*

pulchra were observed on the same dogwood leaves. *Microsphaera pulchra* ascocarps were randomly distributed on the abaxial surface of ‘Cherokee Brave’ leaves. Signs of this fungus were found in higher densities on these leaves than were signs of *P. guttata*. *Phyllactinia guttata* ascocarps were mixed with and in close association with the *M. pulchra* ascocarps on these leaves. In contrast, ascocarps of *P. guttata* were commonly found on C. amomum leaves in close association with the less frequent *M. pulchra* ascocarps.

Significance to Industry: Many fungi have been reported as the causal agents of powdery mildew on *Cornus* species in North America. The family Cornaceae is the host of 7 *Erysiphe*, 15 *Microsphaera*, and 20 *Phyllactinia* species in the northern hemisphere, and seven hosts are infected by two or more powdery mildew species (5). This study provides documentation of both *M. pulchra* and *P. guttata* occurring simultaneously on both *C. florida* and *C. amomum*. However, the predominant powdery mildew of 'Cherokee Brave' was *M. pulchra*, whereas guttata occurred more frequently on *C. amomum*.

Observations of two powdery mildew species on one dogwood tree warrants caution. Resistance breeding and disease control requires a positive identification of the causal agent. Differences in the disease processes of *Microsphaera* and *Phyllactinia* may have implications to breeding programs as they search for a general resistance mechanism. Resistance to one pathogen species may not necessarily correlate with resistance to another (9). Dogwood cultivars may need to be reassessed for resistance against both species of powdery mildew. Identification of powdery mildews based on previously documented reports of host-pathogen relationships and distributions should be supplemented with asexual identification and when possible, verification by ascocarp morphology.

Table 1. The ratio of *Microsphaer*a species ascocarp diameter to appendage length to identify the powdery mildew species.

Ascocarp diameter (,µm)	Appendage length (,µm)*	Ratio (length/diameter)
110	160	1.5
97	133	1.4
97	119	1.2
93	117	1.3
97	120	1.2
114	140	1.2
119	136	1.1
128	145	1.1
107 ±12..9	134 ± 14.9	1.3 ± 0.14

* mean of 4-5 appendages per ascocarp.

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The Role of Endogenous Phenolics in Host Plant Resistance Among *Malus* Taxa to Japanese Beetles

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Nature of Work: Japanese beetles (JB), *Popillia japonica* Newman, are destructive, highly polyphagus herbivores that show a general preference for plants in the Rosaceae family. Although *Malus* taxa are often found to be susceptible to JB, there are substantial differences in resistance among *Malus* species and cultivars (1,2). In a prior study, total phenolic levels in Malus were not correlated with JB resistance (2). The objectives of this study were to compare natural resistance to JB among *Malus* taxa and to evaluate the role of individual phenolics in host plant resistance.

The choice feeding assay was conducted with field grown trees, n=3. Defoliation ratings were done on August 14, 1995 and were conducted by two independent observers. No-choice feeding assays were conducted using the methods given by Fulcher et al. (2). After a 24 hour feeding period, conducted in a growth chamber, leaf area consumption was calculated to document host plant resistance. Beetles for artificial diets were handled according to Fulcher et al. (2). Artificial diets were made of sucrose, cellulose, agar, and one of the eight test compounds: phloridzin, phloretin, naringenin, kaempferol, rutin, quercetin, catechin, and chlorogenic acid (Sigma Co., St. Louis, MO) in 0, 1.0, 3.2, 10.0, 31.6 and 100.0 mM. Ten replications of a compound at each concentration were used. One female beetle was placed in each petri dish with a plug of diet and was set randomly in the growth chamber. After 24 h beetles were removed and fecal matter was collected and dried for 24 h at 70°C (Isotemp Oven 665F Fischer Scientific, Pittsburgh, Pa.) and weighed.

Endogenous levels of individual phenolics were analyzed by a reversed phase HPLC method adapted from Hunter et al. (3). Standard curves were prepared of phloridzin, phloretin, kaempferol, naringenin, chlorogenic acid, and catechin from standards (Sigma Co., St. Louis, Mo.). An isocratic solvent system of 75 water:25 methanol and 0.1% phosphoric acid was used. The column was an adsorbospere C18, 250 x 4.6 mm, containing a 5 um C18 bonded phase (Alltech Associates Inc., Deerfield, Ill). Compounds were detected at 254 nm with a UV detector (Millipore Corp., Bedford, Mass.).

Results and Discussion: Feeding injury in the choice test varied from 0 to 73 percent defoliation (Table 1) Under these conditions 8 taxa were resistant with less than 10% defoliation. Feeding under no-choice conditions ranged from 1.0 cm^2 to 7.6 cm^2 (Table 1). Under this intense feeding pressure M. Golden Raindrops™, *M.* baccata 'Jackii', and *M.* Harvest Gold™ were highly resistant with less than 2 cm^2 leaf area consumption. Six taxa were intermediate and *M.* 'Radiant' was statistically the most susceptible with 7.6 cm^2 leaf area consumption.

Although total phenolic content can sometimes influence insect feeding, the presence and concentration of specific phenolic constituents can be more important than total phenolic content (4). Phloridzin, and its hydrolysis product phloretin, were highly effective at deterring JB when present in artificial diets. The effective dose to reduce feeding by 25% (ED_{25}) for phloridzin was 3.2 mM. Phloretin had an ED_{25} of 2.9mM. Conversely, rutin increased feeding by 174% of the control at the 100mM concentration.

HPLC analysis revealed a wide range in the concentration of different endogenous phenolics among taxa. Using stepwise multiple regression analysis, phloridzin was the only endogenous phenolic significantly related to feeding from either the choice or no-choice feeding assays ($p<0.05$). These data implicate phloridzin as an important endogenous feeding deterrent for the JBs. Although some resistant plants had low total phenolic contents (e.g. *Malus* baccata 'Jackii'), they appeared to have adequate levels of phloridzin to deter beetles from feeding (Table 1).

Significance to Industry: This research documented a broad range of natural resistance to feeding by adult JBs among taxa of *Malus*. Greater use of pest resistance plants will reduce the need for chemical controls, reduce production and maintenance costs, and aid in the development of more sustainable landscapes. In addition, identification of resistant genotypes provides the basic information needed for breeding new plants with enhanced pest resistance.

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Table 1. Resistance to Japanese beetle as measured by leaf area consumption, percent defoliation, and endogenous levels of phloridzin among crabapples *(Malus* spp.).

	No ChoiceTest	Choice Test	Phloridzin
Taxon	Leaf area consumed (cm^2)	Percent Defoliation	mM/kg fresh weight
M. x'Schmitcutleaf Golden Raindrops™	0 99	1	154
M. baccata 'Jackii'	1.07	0	144
M. x'Hargozam' Harvest Gold™	1 83	1	143
M. x'Branzam' Brandywine™	3.29	1	177
M. floribunda	3.61	0	146
M. x'Naragansett'	3.63	3	80
M. x 'Robinson'	4.19	2	170
M. x 'Red Splendor'	4.84	26	34
M. x'Baskatong'	5.05	9	96
M. x 'Radiant'	7.62	73	34
^{LSD}0.05	2.01	10	36

Amending Pine Bark with Lime and Micronutrients Affects Growthof Nine Landscape Tree Species

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Nature of work: Amending a pine bark (PB) container medium with lime and micronutrients is a common practice in the nursery industry. Little, if any, information is available on the effects of these PB amendments on the growth of container-grown landscape trees. In 1941, Spurway (5) listed definite and specific pH preferences for a wide range of plant species including many landscape trees, but these recommendations were for mineral soils. Most work has investigated responses of shrub species to lime and micronutrient additions to PB. For example, adding lime to PB reduced the growth of some species such as *Ilex crenata* Thunb. and *Rhododendron obtusum* Planch. (2) and improved growth of others including *Juniperus chinensis* L. (2). Growth responses to micronutrient-amended PB have also been variable (3,7) The objective of this experiment was to determine the lime and micronutrient preferences of nine species of landscape trees grown in pine bark.

Lime and micronutrient treatments were in a two by two factorial arrangement. The four preplant incorporated PB treatments were: unamended (control), lime only (6lb. / cu. yd.), micronutrients only (1.5 lb. Micromax / cu. yd.), and lime plus micronutrients (previously stated rates). The lime source was dolomitic limestone (21% Ca, 10% Mg) with a calcium carbonate equivalency of 100%. The micronutrient source was Micromax (Scotts-Sierra, Marysville, Ohio). The source of PB was Summit Bark Plant (Waverly, Va.). Initial PB pH was 4.7. Treatments were organized in a completely randomized design with three single-container replications. Seeds of each of nine tree species (Table 1) were sown (40 seeds per species per container) just beneath the substrate surface of PB-filled three-gallon containers (11.4 liters) on January 17, 1997. Seeds germinated in one to two weeks and were thinned at week six leaving 10 to 15 seedlings per container. Trees were grown on raised benches in a greenhouse until May 29 (week 19). Seedlings were fertilized as needed with 500 ml of a solution composed of 300 mg/liter N (ammonium nitrate), 45 mg/liter P (phosphoric acid), and 100 mg/liter K (potassium chloride). The PB solutions were extracted using the pour-through method (6) on March 6 (week 7) by applying 500 ml water to the substrate surface one hour after irrigation. Solutions were analyzed for Ca, Mg, Fe, Mn, Cu, and Zn. At week 12, all plants except one per container were harvested, and shoot height was determined. The remaining plant per container was allowed to grow until May 29 (week 19), at which time final shoot height was measured. Data were analyzed using SAS PROC ANOVA (4).

Results and Discussion: Adding micronutrients to PB increased height for some species by week 12 and for all species by week 19. Height data for *Acer palmatum* (Japanese maple) are presented in Table 2 as a representative treatment response. Adding lime either had no effect on height or suppressed height (Table 2). There were no significant interactions between lime and micronutrients for height. Adding micronutrients to PB without lime increased the PB solution concentrations of Ca, Mg, Fe, Mn, Zn, and Cu compared to those found in the control, but these increases were diminished in the presence of lime, except Mg for which lime increased its concentration (Table 3). The decrease in micronutrient concentrations in the presence of lime was most likely due to the increase in pH which can cause increased cation adsorption or precipitation (1). In the absence of micronutrients, adding lime decreased Fe concentration; all other micronutrient concentrations were unaffected (Table 3).

Our findings indicate that under the conditions of this experiment, addition of micronutrients was necessary for optimal growth of a wide variety of landscape tree species. However, under other conditions, e.g., a lower pH, amendment requirements may be different.

Significance to Industry: The practice of growing landscape trees in PB in containers is becoming more common throughout the nursery industry. Our data indicate that under pH conditions similar to those of this experiment (initial pH 4.7) adding micronutrients but not lime is necessary to optimize growth. Lime did not increase the height of any of the species used in this work, and in some cases decreased growth. PB having a pH different from that used in this experiment may require alternative lime and micronutrient additions. We conclude that the lime and micronutrient requirements are the same for a wide range of landscape tree species.

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Table 1. Landscape tree species used in experiment.

Species	Common name
Acer palmatum Thunb.	Japanese maple
Acer saccharum Marshall.	sugar maple
Cercis canadensis L.	redbud
Cornus florida L.	flowering dogwood
Cornus kousa (Buerger ex Miq.) Hance.	kousa dogwood
Koelreuteria paniculata Laxm.	goldenraintree
Magnolia x *soulangiana* Soul.-Bod. 'Lennei'	saucer magnolia
Nyssa syhatica Marshall.	black gum
Quercus palustns Munchh	pin oak

Table 2. Japanese maple height as affected by lime and micronutrient additions to pine bark (week 19).

Treatment	Plant height (cm)
Lime[z]	77.3
No lime	94.5
Micros[y]	129.2
No micros	42.6
Significance[x]	
Lime	*
Micros	***

[z] Lime and no lime treatments were averaged over micronutrient treatments.

Micros and no micros treatments were averaged over lime treatments.

[x] *,***significant at $p \le 0.05$ and 0.001, respectively, according to ANOVA.

Table 3. pH and nutrient concentrations of pine bark solution as influenced by lime and micronutrient additions (week 7).

		Concentration (mg/liter)					
Treatment	pH	Ca	Mg	Fe	Mn	Cu	Zn
Control	4.8	35.3	8.3	0.08	0.47	0.012	0.127
Lime	5.6	28.4	17.3	0.04	0.09	0.007	0.102
Micros	4.6	97.4	27.1	0.13	5.07	0.023	0.725
Lime + Micros	5.2	82.3	47.4	0.06	1.75	0.016	0.165
Significance[z]							
Micros	**	***	***	**	***	***	***
Lime	***	NS	***	***	***	**	***
Lime x micros	NS	NS	*	NS	**	NS	***

[z] ***, **, *, Ns-significant at $p \le$ 0.001, 0.01, 0.05, or not significant, respectively, according to ANOVA.

The Influence of Ontological Age on Adventitious Bud and Shoot Formation in North American Pawpaw [*Asimina Triloba* (L.) Dunal] Nodal Explants

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Nature of Work: Current clonal propagation methods for the North American pawpaw [*Asimina triloba* L. Dunal] are limited to budding and grafting techniques (4). No work has been published detailing a micropropagation system for the pawpaw, but Callaway (1) indicated limited success in regenerating shoots using leaf tissue. Successful micropropagation systems have been developed for related *Annona* species (2).

The ease with which a plant can be established in culture is often a direct result of ontogenetic age. Ontogenetic maturity is reached when a plant obtains the ability to flower, but for many species flowering is accompanied by a reduction in juvenile characteristics making mature source explants more difficult to stabilize in culture than juvenile source explants (3).

The objective of this research was to observe the effect of ontological age on adventitious bud and shoot development of pawpaw nodal explants in culture. Explants from a juvenile source (seedlings), mature sources (forced stems) and from shoots produced on root pieces were used to study the effect of ontogenetic age during the establishment phase.

Stratified seeds were germinated in a 25°C growth chamber. Approximately 12 weeks after planting, seedlings had 6-10 nodes. Mature wood explants were obtained from dormant stems (10-40 cm in length) collected from 26 genetically different mature, flowering trees. Stems were forced in beakers in a 25°C growth chamber. After 6 weeks, shoots had expanded to ≥ 10 cm. Explants were also obtained from shoots produced on root pieces. Root pieces (≥ 5 mm diameter, 10-12 cm length) were obtained from mature trees. Shoots were forced on root pieces kept in a 22°C greenhouse and after 20 weeks shoots had expanded to ≥ 10 cm.

Single node explants were excised from each source, washed and surface disinfested. After rinsing, single explants (1-3 cm) were inserted vertically and cultured on 20 ml of MS medium supplemented with 10 µm BA and 0.1 µm TDZ in 25 x 150 mm test tubes closed with polypropylene caps. Medium pH had been adjusted to 5.8 Å 0.1 prior to autoclaving and solidified with 6% Bacto-agar (Difco Laboratories, Detriot, MI).

Culture tubes were kept in racks on shelves in a culture room under 16 hrs of 20 $\mu mol \bullet sec^{-1} \bullet m^{-2}$ of light provided by cool white fluorescent bulbs. Culture room temperature was 25°C.

Explant transfer and data evaluation occurred at 2 week intervals and the percentage of explants with elongating axillary shoots was recorded. Axillary shoots were determined as the number of shoots (> 2 mm in length) arising from a leaf axil. Formation of adventitious buds (<0.5 cm) and shoots (≥ 0.5 cm) was also recorded at each transfer interval. Adventitious buds and shoots were determined as buds and shoots arising at any location on the explant other than in a leaf axil.

Results and Discussion: Within 4 weeks, 60% of the seedling explants had expanded axillary buds (Table 1), but no axillary bud elongation was observed on explants from mature stems or shoots from root cuttings. After 6 weeks in culture, 72% of the seedling explants had expanded axillary buds and 88% of the expanded shoots (≥ 3 cm) were suitable for subculture (data not shown). At 8 weeks, axillary buds elongated on all seedling nodal explants and multiple adventitious buds and shoots formed. At this same time, axillary shoot elongation occurred in 42% of the explants from shoots produced on root cuttings. Mature source explants had no axillary shoot elongation or adventitious bud formation and many explants darkened in culture. Adventitious bud or shoot formation was not observed on explants from shoots produced on root cuttings or explants from mature stems. Mature source explants were maintained in culture and after nearly 7 months, axillary bud expansion occurred in 4% of the explants (data not shown).

The effect of ontogenetic age on explant performance was seen with the inability of explants from the 26 mature sources to respond in culture. Of the 551 mature explants, 72% were successfully disinfested, but only 4% survived in the culture environment. Most of the mature explants turned black and lost tissue integrity. Only the small percentage of explants from mature sources that survived showed some axillary tissue proliferation after approximately 7 months in culture. Shoots produced on root cuttings did not respond as rapidly or at the high percentages of the seedling explants, but the explants did respond in culture. Seedling explants, an ontologically juvenile source, responded rapidly *in vitro.*

Discoloration of the medium was observed for all explant sources. Explant exudation caused a reddish-brown discoloration of the medium at the basal end of the explants. However, the apical portion of most explants appeared healthy. Explant exudation has been documented in many species, including other Annonaceae members, and has been attributed to phenolics and polyphenoloxidase in the medium (4).

Significance to Industry: Although tissue from mature sources is difficult to establish in culture, this study indicates that a successful micropropagation system can be developed for pawpaw. The ontological age of the explants must be considered. When using explants from mature sources, additional time is required to induce explant responses. In addition, shoots produced on pawpaw root cuttings provide an alternative explant source for tissue culture studies. Seedling tissue can be used for preliminary dose response, rooting and acclimatization studies and is quickly and easily obtained at any time of the year. This study provides preliminary information about the effect of ontological age on establishment of explants, but additional research is needed addressing the subsequent stages of micropropagation in developing a system for the North American pawpaw.

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Table 1. Percentage of North American pawpaw (*Asimina triloba*) explants showing axillary bud elongation of seedling, shoot produced from root and mature source nodal explants after 4, 6 and 8 weeks of culture on an MS medium with 10 µM BA and 0.1 µM TDZ.

	Weeks in culture		
Explant source	4	6	8
Seedling (n=25)	60%	72%	100%
Root shoot (n=42)	0%	0%	42%
Mature(n=551)	0%	0%	0%

Evaluation of Disease Resistant Rose Varieties for the Southern Landscape

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Nature of Work: Blackspot, caused by *Diplocarpon rosae* F.A. Wolf, is a fungal pathogen specific to roses. The disease causes black spots and chlorotic lesions on foliage, which may lead to defoliation, reduced plant vigor, and even plant death. The fungus is especially problematic in the humid south where weather conditions are favorable to disease development and spread. The most commonly recommended control practice for blackspot is a weekly application of chlorothalonil. Economic, ecological, and time considerations associated with frequent fungicide applications can make this an undesirable option (1). Researchers have noted that some cultivated roses in the “old garden” rose class have more resistance to blackspot fungi than some more popular, modern hybrids (2). The possibility of effectively controlling blackspot by making applications of compounds with fungicidal activity, spraying fungicides less frequently, or applying them around weather events conducive to disease development have been proposed (3). The purpose of this study was to evaluate disease resistant rose cultivars for use in the southern landscape with reduced chemical applications and fungicide alternatives.

Nine of 11 roses compared in this study are classified as “old garden roses,” including some recently released cultivars that were bred for and are marketed as disease resistant. Two cultivars used for comparison are a modern hybrid tea (‘Cary Grant’) and a floribunda (‘Love Potion’). Bare root roses were planted at E.V Smith Horticultural Research Unit, near Shorter Alabama, in newly tilled beds receiving full sun in 1996. The four blackspot treatments include: 1) a no treatment control, 2) bi-monthly fungicide application of chlorothalonil (Bravo), 3) bi-monthly application of 1.0% Sunspray Ultra-Fine Horticultural Oil, and 4) chlorothalonil application based on rainfall.

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 to equal one-inch per week. Pine straw mulch was used in conjunction with hand weeding for weed control. Visual evaluations of the performance of each plant was made weekly. Roses were evaluated using a rating scale (0 to 5), assessing each plant for overall appearance, vigor, percent disease, defoliation, and flower production.

Results and Discussion: Data taken from June through September, 1996, wereanalyzed (LSD, Duncan's Multiple Range Test). Throughout the season, chlorothalonil applied on a 14 day schedule provided the most effective control of blackspot and least defoliation. Fungicide-treated plants also maintained the highest overall cultivar ratings. Figure 1 shows the monthly progression of blackspot, as well as disease treatment differences.

Rose cultivars that maintained high overall ratings throughout the season include 'The Fairy,' 'Belinda's Dream,' and 'Red Meidiland' (Table 1). Cultivars that showed high susceptibility to blackspot include 'Love Potion,' 'Cary Grant,' and 'F.J.Grootendorst.' Cultivars with low blackspot disease ratings were 'Floral Carpet,' 'Le Vesuve,' 'Belinda's Dream', 'Carefree Delight,' and 'The Fairy'. Cultivars with low defoliation ratings were 'The Fairy,' 'Belinda's Dream,' 'Floral Carpet,' and 'Le Vesuve.' While we saw a relationship between disease and defoliation ratings, we noted that high overall vigor ratings did not always reflect low disease incidence. Some cultivars, especially the old garden roses, flowered well and maintained a very good appearance even under significant disease pressure.

While evaluating for the blackspot fungus, another leaf spot fungus, *Cercospora rosicola*, was identified. The *Cercospora* leaf spot appeared as small tan lesion with a red margin, although it does not appear to cause defoliation as blackspot does. The *Cercospora* was more prevalent among old garden rose varieties than modern hybrids. 'Seafoam' and 'Red Meidiland' maintained the highest *Cercospora* disease ratings throughout the season. Sunspray and chlorothalonil controlled *Cercospora* equally more effective than the untreated control. Some phytotoxic effects were noticed on Sunspray treated plants. Fungicide residue was also apparent on some cultivars (Table 1). Phytotoxicity ratings were taken in mid-August during high temperatures known to be conducive to damage.

Significance to Industry: Integrated Pest Management (IPM) strategies are becoming more common in the horticultural industry, generating alternative disease management options, including the utilization of disease resistant varieties and reduced chemical inputs. Professional horticulturists and homeowners may consider choosing rose cultivars that can be grown and enjoyed with less maintenance. These may include 'Belinda's Dream,' 'Floral Carpet,' 'The Fairy,' and 'Le Vesuve.' We found that effective blackspot control can be achieved on these cultivars with bi-monthly applications of chlorothalonil and bi-monthly Sunspray applications may provide some *Cercospora* control.

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Figure 1. Treatment differences for four alternative blackspot controls on roses.

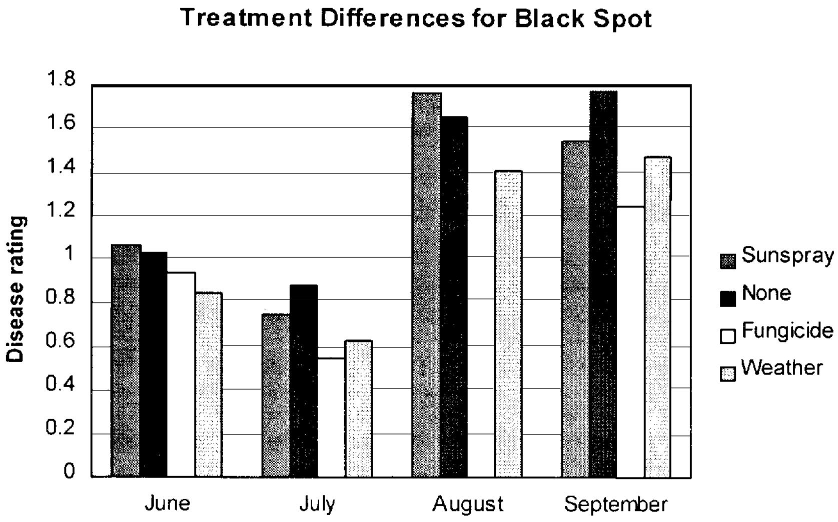

Table 1. Evaluation of rose cultivars for vigor, defoliation, and other effects of treatments.

Cultivar	Vigor Rating[1]	Defoliation Rating[2]	Disease Rating[2]	Notes[3]
Belinda's Dream	4.4	0.7	0.8	a
The Fairy	4.3	0.6	1.0	
Red Meidiland	3.8	1.3	2.0	a
Carefree Delight	3.5	1.4	1.0	b
Hansa	3.3	1.3	1.3	c
Flora Carpet	3.3	0.5	0.8	b
Seafoam	2.9	1.9	1.8	a
Le Vesuve	2.8	1.0	0.8	a
F.J. Grootendorst	2.4	2.1	2.7	c
Cary Grant	2.4	2.1	2.0	a
Love Potion	2.3	2.0	2.8	b

[1] Scale: 0=appears dead, 1=very unhealthy appearance, 2=unhealthy appearance, 3= average appearance, 4=good appearance, 5= overall healthy and very good appearance.

[2] Disease and defoliation ratings indicate percent of plant affected was O=less than 20%, 1=20% to 39%, 2= 40% to 59%, 3=60% to 79%, and 4=80% to 99%, 5=100%.

[3] Notes: a=some residual effects, b=deformation of new growth, c=leaf burn or phytotoxicity.

Bittercress Control in Gravel Beds with Preemergence Herbicides

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Nature of the Work: Bittercress can produce as many as 5000 seeds per plant and shoot out these seeds as far as 42 inches (Bachman and Whitwell 1995). Bittercress weed infestations in the production of landscape plants usually start from seeds remaining in the media residues of reused pots and from seeds that splash into pots from surrounding beds. Bittercress also becomes established in gravel beds and infests nearby containers with seed. Weed control on gravel beds is essential to maintaining weed free container-grown plants.

Preemergence herbicides are used to control weeds in containers and as much as 80% can reach gravel beds to control bittercress but the persistence and longevity of control is considered to be relatively short (Gilliam et al 1992). Herbicides are adsorbed by media or soil for residual activity against germinating weeds. Gravel has few adsorption sites and herbicides may leach or breakdown to inactive components resulting in shorter persistence and shorter periods of weed control. Herbicides vary in solubility and other chemical characteristics that affect weed control longevity on gravel beds. Formulations of herbicides also may determine activity on gravel beds. Granular herbicides may release their products slowly over time providing longer control than sprayable formulations. The objective of this research was to evaluate several preemergence herbicides, sprayable and granular formulations, for bittercress control on gravel production beds.

Gravel beds inside Clemson's research area at Carolina Nurseries were selected and sprayed with Finali (a non selective, non residual herbicide) to kill existing weeds. Pots containing bittercress outlined the 3 ft x 3 ft plots to keep a constant supply of bittercress seed infesting the gravel plots. Excellent bittercress germination and population were maintained in the untreated plots during the study.

Twelve herbicide products (Table 1.) were applied at four times the normal use rate on October 24, 1995. The granular formulations were applied with a shaker can and the sprayable formulations were applied with a Co^2 back pack sprayer calibrated to deliver 40 gallons per acre. Plots were replicated twice. Irrigation and fertilization were used in the gravel beds on the same frequency as on the other production beds.

As the result of the first study, a larger experiment with more replications were initiated in the fall of 1996. Sprayable formulations of eight herbicides (Table 2.)were evaluated at 2 rates (2x and 4x label rates). Gravel bed plots were 3 ft x 5 ft and treatments were replicated 4 times. Herbicides were sprayed using a backpack sprayer calibrated to deliver 40 gallons per acre. Pots infested with bittercress were placed around the plots to keep a constant supply of bittercress seed entering the gravel plots. Crepe Myrtle plants were placed in each plot to evaluate treatment effects on plants rooting into the gravel. Irrigation and fertilization were applied to the beds as normal for container production.

Bittercress control was rated visually monthly on a scale of 0 to 100 with 0 = no control and 100 = complete control. Data were subjected to analysis of variance and means separated using least significant difference at *P*=0.05.

Results and Discussion: After 3 months, excellent bittercress control (100%) was observed from all treatments in the first study except Gallery WG which only controlled bittercress 85 % (Table 1). Treatments were applied in October and by May (7 mot later) control had declined to unacceptable levels for all treatments except Factor (>90%), Rout (87%), Dimension (100%), Pendulum (82%), Goal (87%) and Ronstar (85%). In general, the sprayable forms were more effective than the granular formulations.

Factor, Dimension, and Goal EC controlled bittercress (>80%) 8 months after application but only Factor and Dimension controlled bittercress > 80% control by 8.5 months (257 days) after application. Dimension (dithiopyr) is a turfgrass herbicide that is not available to the nursery industry.

Treatments which provided excellent bittercress long term control (8.5 mot) bittercress control in 1995 were also evalauated in 1996 along with other preemergence herbicides (Table 2.). Al1 herbicides controlled bittercress at 3 months after application. Surflan (both rates), Predict (5.0 lb) and Princep (8.0 lb) were ineffective at 5 months. At 6 months, both rates of Factor and Dimension controlled bittercress (>81%). The highest rate of Goal also gave 90% bittercress control. However at the last evaluation 8 months after application, only Factor at 4.0 lbs/A effectively (88%) controlled bittercress.

Significance to Industry: Factor, Dimension and Goal EC (high rate) were effective in controlling bittercress in gravel beds under the conditions of this study for time period of 6 to 8 months. No injury was observed to Crepe Myrtle plants placed in the plots. Additional research is needed to determine other products, effective rates and the impact of plants rooting out of the pots into Factor and Goal treated gravel. Both of these products are labeled for use in nurseries, therefore, minimal crop damage should be observed from these herbicides.

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Table 1. Bittercress control in gravel beds months following herbicide application.

		% Bittercress Control				
Herbicide	rate lb ai/A	1 mo[a]	3mo	7mo	8mo	8.5 mo
Factor WGC	4.0	100[b]	100	100	95	90
Factor GR	4.0	100	100	90	85	85
Rout GR	12	100	100	87	30	35
Dimension GR	4	100	100	100	85	80
Snapshot TG	10	100	100	0	7	17
Pendulum EC	8	100	100	82	32	25
Pendulum GR	8	100	100	82	65	65
Gallery WG	4	100	85	0	0	10
Gallery -GR	4	100	100	35	15	10
Goal GR	8	100	100	87	60	42
Goal Ec	8	100	100	100	82	65
Ronstar Gr	8	100	100	85	15	7
LSD (0.05)	-	0	12	31	33	28

[a] Months after herbicide application.

[b] Visual control ratings on a scale of 0 witncontrol and 100 = complete control.

[c] GR and TG = granular formulations; EC and WG = sprayable formulations Table 2. Bittercress control in gravel beds with preemergence herbicides.

		% Bittercress Control				
Herbicide	rates lbs ai /A	3 mo [a]	4 mo	5 mo	6 mo	8 mo
Factor [c]	2.0	100 [b]	97	95	85	57
Factor	4.0	100	100	97	92	88
Goal	4.0	100	99	91	62	27
Goal	8.0	100	100	100	90	43
Ronstar	4.0	100	96	84	45	0
Ronstar	8.0	100	97	92	69	0
Predict	5.0	95	89	52	25	0
Predict	10.0	97	96	87	50	17
Princep	4.0	92	80	82	45	0
Princep	8.0	92	71	66	35	20
Dimension	2.0	100	100	96	81	0
Dimension	4.0	100	100	100	95	50
Pendulum	4.0	100	96	81	47	0
Pendulum	8.0	100	100	95	75	27
Surflan	4.0	92	86	46	22	0
Surflan	8.0	94	87	30	20	0
LSD (0.05)		5	16	29	38	33

[a] Months after herbicide application.

[b] Visual control ratings on a scale of O to 100 with 0 = no control and 100 = complete control.

[c] All formulations were sprayed on the gravel beds.

Influence of Propagation Substrate and Auxin Treatment on the Rooting of *Ceratiola Ericoides* (Rosemary)

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Nature of Work: Rosemary (*Ceratiola ericoides* Michx.) is a woody, evergreen, dioecious shrub of the Empetraceae (Crowberry family) endemic to the coastal and xeric areas of Florida, Georgia and South Carolina (2). Rosemary is a dominant dune binding species of the barrier islands of Florida and has been the subject of an extensive population structure study to determine the spatial pattern, age, sex and size structure of four populations in Florida (1). These populations were shown to have a male to female sex ratio of 1:1 and the mean age of reproductive individuals was 13 to 16 years for coastal populations. The uniform, globose canopy and dark, evergreen foliage of rosemary make it extremely desirable as a home landscape plant in the barrier island communities. Rosemary production has not been possible on a commercial scale because seed germination is slow and difficult and no vegetative propagation information is available (3). The objectives of this research were to 1) evaluate the effectiveness of common auxin sources on the rooting of rosemary, 2) evaluate the influence of two propagation substrates on the rooting response of rosemary and 3) determine if the sex of the cutting influences rosemary rooting response.

Softwood cuttings of rosemary were collected on 23 July, 1996 from the eastern end of Santa Rosa Island, a coastal barrier island (30° 18'N, 87° 16'W). Cuttings were segregated by sex, placed in plastic bags, and stored in a cooler for transport. Prior to treatment cuttings were recut to a length of 9 cm (3.6 in) and the foliage removed from the basal 4 cm (1.6 in) of each cutting. Auxin treatments included Hormodin 1 and Hormodin 3, commercially available talc formulations containing 3,000 and 8,000 ppm Indole-3-butyric acid (IBA), respectively; IBA at 1,000 or 5,000 ppm; 1-Naphthaleneacetic acid (NAA) at 1,000 or 5,000 ppm; Dip'N Grow (10,000 ppm IBA and 5,000 ppm NAA stock solution) diluted with distilled water at three ratios: 1:5 (1666.66 ppm IBA and 833.33 ppm NAA), 1:10 (909.09 ppm IBA and 454.54 ppm NAA), and 1:20 (476.19 ppm IBA and 238.09 ppm NAA), and a nontreated control. Both NAA and IBA were each dissolved in isopropyl alcohol. Dilution ratios of Dip'N Grow were selected on the basis of label recommendations. The basal 1 cm (0.4 in) of each cutting was treated with an auxin solution for 1 sec followed by 15 min of air drying prior to insertion to a 2 cm (0.8 in) depth in a 10 cm (4 in) deep nursery flat containing a medium of perlite:vermiculite (1:1 by volume) or 0.625 cm (0.25 in) pinebark:sand (6:1 by volume). Intermittent mist operated 6-8 sec every 10 min from7 a.m. to 8 p.m. daily and cuttings were maintained under natural photoperiod. Cuttings were sprayed on a biweekly schedule with Daconyl to control fungal diseases. The experimental design was a split, split plot arranged in a randomized complete block with six cuttings per auxin treatment (a total of 40 treatments) and ten replications. The experiment was terminated after 12 weeks and percent rooting, root number, and length of the 5 longest primary roots≥1 mm (0.01 in) recorded. Mean separation within main effects of propagation substrate, sex and auxin treatment were determined using the least significant difference test at an alpha level of 5%.

Results and Discussion: Percent rooting. The initial analysis indicated only the main effect of propagation substrate was significant and there were no significant interactions between the main effects of propagation substrate, sex and auxin treatment. The propagation substrate did have an effect on the percentage of cuttings that rooted (p= 0.0001) with cuttings propagated in perlite:vermiculite rooting at 97.8% and cuttings propagated in pinebark:sand rooting at 85.4%. The coarse texture of the pinebark:sand may have a particle size too great for the fine textured roots of rosemary. The pinebark:sand also retained a greater quantity of water than did the perlite:vermiculite. In addition, the texture and water holding capacity of the perlite:vermiculite more closely resembles the fine textured sand found in the native habitat of rosemary.

Root number. The initial analysis indicated the main effects of substrate (p= 0.0001), auxin (p= 0.0001), and sex (p= 0.007) were significant. A substrate by auxin interaction (p= 0.01) was also present; therefore, results for each substrate are presented independently. Cuttings propagated in the perlite:vermiculite substrate produced a mean of 13.1 roots per cutting while cuttings propagated in the pinebark:sand substrate produced a mean of 7.04 roots per cutting. Cuttings from male plants produced more roots than cuttings from female plants with males producing 10.68 and females 9.71 roots. Auxin application also influenced root numbers but the response to auxin differed with the propagation substrate (Table 1). The greatest number of roots per cutting for cuttings propagated in the perlite:vermiculite substrate were achieved with NAA at 1,000 or 5,000 ppm and the Dip'N Grow (1:5) which contained NAA at a concentration of 833.33 ppm. While NAA treatments appeared to increase the number of roots per cutting compared to the control, root number did not improve with liquid formulations of IBA. In addition, the higher concentration of IBA may have reduced root number. For cuttings propagated in the pinebark:sand substrate the number of roots per cutting was lower than for cuttings propagated in the perlite:vermiculite substrate. The greatest number of roots for cuttings propagated in the pinebark:sand substrate occurred with Dip'N Grow (1:20) with 9.06 roots per cutting; the lowest value among cuttings propagated in the perlite:vermiculite substrate was 9.40 roots per cutting. Liquid formulations of IBA at 1,000 and 5,000 ppm resulted in the fewest roots per cutting. Among cuttings propagated in the pinebark:sand substrate, no auxin treatment resulted in a greater root number than the nontreated control.

Root length. The initial analysis indicated the main effects of substrate (p= 0.002) and sex (p= 0.04) were significant. Substrate by auxin (p= 0.0001) and substrate by sex (p= 0.009) interactions were also present; therefore, results for each substrate are presented independently. Cuttings propagated in the perlite:vermiculite substrate produced roots with a mean length of 2.35 cm (0.94 in) while cuttings propagated in the pinebark:sand substrate produced roots with a mean length of 2.82 cm (1.13 in). Root length of cuttings from male and female plants differed only for the cuttings propagated in the perlite:vermiculite substrate with root length of female cuttings an average of 2.04 cm (0.82 in) and root length of male cuttings and average of 2.67 cm (1.07 in). Mean root length for cuttings propagated in the pinebark:sand substrate was 2.82 cm (1.13 in). Auxin application also influenced root length but the response to auxin differed with the propagation medium (Table 1.). For cuttings propagated in the perlite:vermiculite substrate, root length was increased over that of the nontreated control with the application of auxins containing NAA. The greatest root length for cuttings propagated in the perlite:vermiculite substrate was achieved with all three concentrations of Dip'N Grow and NAA at 1,000 ppm. Root length of cuttings receiving auxin treatments containing IBA alone did not differ from the control. Treatment with IBA would therefore not offer any benefit over nontreated cuttings. For cuttings propagated in the pinebark:sand substrate the root length did not differ from that of the control. Root lengths were equal to, or greater than, those of cuttings rooted in the perlite:vermiculite substrate. This response was not unexpected since the cuttings propagated in the pinebark:sand substrate also had fewer roots per cutting which would allow for more carbohydrates to be allocated to root length.

Significance to Industry: These data demonstrate that rosemary can be successfully propagated from softwood cuttings using a perlite:vermiculite substrate. Nurserymen should expect lower rooting percentages and lower root numbers per cutting when using a pinebark:sand substrate. Nurserymen can also expect to see slight differences in root system quality among cuttings from male and female plants. In addition, nurserymen can achieve an improvement of root quality by increasing root number and root length with the application of a synthetic auxin containing 1,000 to 5,000 ppm NAA.

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Table 1. Influence of auxin treatment on root number and root length of Ceratiola ericoides (Rosemary) rooted in two propagation substrates.

Auxin treatment	Perlite:vermiculit e		Pinebark:sand	
	Root number	Root lengh	Root number	Rootlength
Hormodin 1	12.31cde	1.85de	8.88ab	3.69 a
Hormodin 3	12.96 bcde	1.89 de	6.65 bc	3.19 abc
Dip'N Grow (1 :20)	13.57 bcd	2.60 bc	9.06 a	3.20 ab
Dip'N Grow (1:10)	14.33 b	2.91 ab	7.38 abc	2.89 abc
Dip'N Grow (1:5)	16.25 a	3.45 a	7.98 abc	2.38 bc
NAA 1,000 ppm	14.21 bc	2.41 bcd	6.64 bc	2.33 bc
NAA 5,000 ppm	14.78 ab	2.82 ab	6.26 bc	2.22 c
IBA 1,000 ppm	11.25e	1.59 e	5.57 bc	3.10 abc
IBA 5,000 ppm	9.40 f	2.11 cade	5.26 c	2.70 abc
Nontreated control	11.92 de	1.86 de	7.00 abc	2.55 abc
LSD alpha = 0.05	**1.90**	**0.63**	**3.73**	**1.21**

Means within a column followed by the same letter do not differ (LSD alpha = 0.05).

Usefulness of the Cellugro® System as a Nursery Production Method for Woody Wetland Plants

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Nature of Work: Survivability of woody plants used in constructed wetlands or in poorly-drained landscapes has historically been poor (2). This low survivability has led regulators and designers to require that plants grown under mesic conditions be acclimated to a wet environment prior to transplanting into wetland construction sites.

Species that grow in both wetlands and uplands develop anatomical and metabolic adaptations that are different for each site (2,3). In wetlands, these adaptations allow the plant to survive in the anaerobic environment of saturated soils. Research using troughs filled to varying heights of water to acclimate woody wetland species in pots has shown that some species benefit from this treatment, but some species do not survive even partial flooding (5).

Research using Environmental Friendly Containers (EFC™ , IEM Plastics, Reidsville, NC) with raised drain holes and subirrigation of regular pots in a trough of water showed an increase in trunk diameter and height of Melrose pecan and Bradford pear trees when compared to controls grown under normal mesic conditions (8). Pot-in-pot treatment of herbaceous wetland plants increased growth indices for the species tested when compared to regular nursery pots with bottom drainage holes, pots with no holes and pots with holes half way or _ way up the side (7). Neither of these studies included a transplanting component to test survivability. Preadapting container-grown woody plants for wetland acclimation by partial submergence of the root zone did not appear to increase survivability (4). A recent study by Environmental Concern, St. Micheals, MD showed that transplant survival to wetland sites can be significantly increased by using nursery stock grown in shallow containers (3 inches deep) that restrict depth of root growth when compared with those grown in regular one gallon or five gallon pots (6). Since differing acclimation results have been obtained using a variety of production methods, additional investigation of this acclimation problem seemed warranted.

The Cellugro® System (ACF Environmental, Richmond, VA) is a new concept for nursery stock production which may be beneficial for wetland species. The system is installed in the ground to a depth of approximately eight inches. A liner, drain board and pipe allows water recycling or drainage. In ground installation and the compact design of production cells act to conserve water and also reduces root temperature variation to provide more natural in-ground growing conditions (1). Less irrigation is needed to maintain vigorous growth. The drain pipe can be modified to maintain a perched water level at the bottom of the planting medium.

The purpose of this research was to evaluate the use of the Cellugro® System to produce healthy woody wetland species in planting medium that is maintained wet via unit drainage modification. Six mini Cellugro® units, cut to 4’ x 8’ from the normal 8’ x 20’ Cellugro® units were installed by the manufacturer at the Hampton Roads Agricultural Research and Extension Center in March, 1996. One unit of each pair had the drain pipe raised 1 - 2 inches higher to create a perched water table at the bottom of the planting medium to simulate saturated conditions. The other units were installed with their drain pipe for normal drainage. All units were filled with a standard nursery mix consisting of milled pine bark and sand (4: 1, v/v) amended with 8 lb. Osmocote 22-4-7 (The Scotts Company, Marysville, OH), 4.5 lb. lime and 1.5 lb. Micromax (Scotts) per cubic yard.

Each mini Cellugro® unit holds 88 plants with individual offset rows holding either 5 or 6 plants. The units were planted with four species of woody wetland plants: *Ilex verticillata* (winterberry), *Fraxinus pennsylvanica* (green ash), *Betula nigra* (river birch) and *Cephalanthus occidentalis* (button bush). Plants were installed in the Cellugro® units on April 9, 1996. The green ash and river birch were year old seedlings, while button bush and winterberry were rooted cuttings. Considerable size variation existed within each species. The plants were sorted by

The Effect of Early Radicle Pruning of Root and Shoot Development in a Red (*Quercus Falcata Pogodifolia*) and White Oak (*Quercus Bicolor*) Species

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Nature of Work: Oak species are a popular and useful ornamental in the home and commercial landscape. There is a need for growers to produce oaks efficiently and quickly. Oaks possess a dominant tap root that can grow in circles when produced in containers (Hathaway, 1977). The capability to produce a vigorous root system is needed to support vigorous shoot growth and leaf area expansion (Farmer, 1975).

The objective of this study was to determine if removing the radicle tip could induce new lateral root growth at the point of pruning and produce a more fibrous root system.

Two species of oaks with notable differences in growth patterns were compared to observe if radicle pruning induced root regeneration in a species dependent manner. White oak acorns (*Quercus bicolor*) were collected and directly sown into flats containing MetroMix 360 (Scottís) and put under greenhouse conditions to germinate. Red oak acorns (*Quercus falcata* pogodifolia) were collected and stratified in the refrigerator (5°C) for 4 months prior to planting in a medium of MetroMix 360 (Scottís). Red oak acorns were also placed under standard greenhouse conditions to germinate.

After germination, radicles were measured and grouped according to length (cm) for both species. The tips were either removed from radicles measuring to 4cm, 7cm and 10cm. Uncut radicles of the same corresponding length served as controls. Acorns were replanted in 12” Anderson-band containers and placed back in the greenhouse under standard conditions. Overhead irrigation was applied as needed with Peterís 15-5-15 fertilizer in solution at 200ppm.

Both species were evaluated for root dry weight, shoot dry weight, shoot height, number of new-branched roots at the cut surface and leaf area. Samples for each treatment ranged from 4-8 plants.

Results and Discussion: Swamp white oak increased in leaf area, shoot height and dry weight when the radicle was pruned to 7cm and 4 cm compared to their uncut controls of the same length (Table 1). Root dry weight decreased suggesting that the tap root was not as prominent and that a more branched root system was produced. Radicles pruned to 10cm showed no improvement over the control.

Cherrybark oak increased in leaf area, shoot height and shoot dry weight with the radicle tips removed at 10cm and 7cm (Table 1). Root dry weight also decreased as with the white species. Radicles pruned to 4cm showed no significant increase in measurements.

Removing the radicle tip increased shoot biomass and substantially reduced the root to shoot ratio especially in the swamp white oaks (Table 2). This reflected a reduction in tap root size in favor of a more branched root system. This type of root structure could be more capable of further regeneration producing a better quality transplant (Kazmarek, 1993).

Swamp white oak and cherrybark oak reacted differently to the pruning treatments. The white oak type responded to the removal of the radicle tip more than the red oak type (Table 3). A larger number of branched roots were formed at the removal point on the swamp white oaks as compared to the smaller number generated on the cherrybark oaks. This would suggest that the impact of radicle pruning was species dependant.

Significance to the Nursery Industry: Pruning of the radicle tip increased root regeneration especially in the white oak type. These preliminary data suggest that treatments to remove the radicle (like physical removal, copper treatment or air-pruning) could be effective tools for producing container-grown oak liners with a more fibrous root system.

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Table 1. Biomass in two oak species after removal of the radicle tip at 10, 7 or 4 cm.

Swamp white oak		Leaf area (cm^2)	Shoot drywt. (grams)	Shootheight (grams)	Rootdrywt. (grams)
10 cm	Intact	761.0	6.7	30.0	4.7
	Removed	525.9	4.5	24.0	2.6
7 cm	Intact	344.5	3.31	7.3	3.3
	Removed	538.9	5.0	30.0	2.6
4 cm	Intact	460.0	4.6	21.3	3.7
	Removed	644.9	6.7	31.5	3.4
Cherrybark oak					
10cm	Intact	350.7	3.4	31.0	2.3
	Removed	538.0	4.9	32.3	1.9
7cm	Intact	305.7	3.2	28.3	1.8
	Removed	460.0	4.4	31.0	2.3
4cm	Intact	543.4	4.5	32.3	1.8
	Removed	331.3	2.9	30.8	1.5

Table 2. Branch root formation at the site of tip removal in two oak species cut at 10, 7 or 4 cm.

		Number of branch roots	
Treatment		Swamp white oak	Cherrybark oak
10cm	Intact	0.70	0.68
	Removed.	0.58	0.39
7cm	intact	1.0	0.56
	Removed	0.52	0.52
4cm	Intact	0.80	0.40
	Removed	0.51	0.52

Table 3. Branch root formation at the site of tip removal in two oak species cut at 10, 7 or 4 cm.

	Number of branch roots	
Treatment	Swamp white oak	Cherrybark oak
10cm	5.7	4.0
7cm	9.0	2.7
4cm	8.3	3.3

Purchasing and Pest Treatment Trends in Azaleas: A Survey of Georgia Ornamental Growers and Consumers

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Nature of Work: Purchase and treatment trends of growers and consumers of ornamental plants were investigated using azaleas damaged by adult lace bug feeding. Growers and consumers were surveyed individually during the 1996 Southern Nurseryman's Association Wintergreen Trade Show and the 1997 Atlanta Botanical Garden's Southeastern Flower Show. Respondents inspected 12 'Delaware Valley White' (DVW) azaleas which exhibited a range of chlorotic stippling due to azalea lace bug (ALB) feeding. Survey participants were asked to indicate which plants they would be inclined to purchase and which plants, if found within their landscape, merited the application of a pesticide control. In addition, participants completed questions regarding pesticide use, pest and beneficial organisms, and willingness to consider pesticide alternatives. A final section allowed the respondent to contribute biographical information.

Results and Discussion: Floral and trade show participants responded well to the surveys. Landscape professionals and growers returned 121 useful surveys at the "Wintergreen" trade show in Atlanta, GA. Consumer survey participants at the Southeastern Flower Show completed 239 surveys. Biographically, homeowners were dominant in both grower and consumer surveys. The majority of respondents in both surveys were graduates of college or technical school. A large proportion of the consumers had received graduate degrees. Few consumer respondents were represented in the lower income ranges. The majority of consumers reported annual household incomes ranging from $51,000 to $100,000.

Survey participants were also asked a series of questions revealing the general range of knowledge and illustrating behavioral trends in pest scouting and pesticide use. Respondents of both surveys strongly valued the appearance of their yard and landscape plantings. Growers reported a greater ability to recognize pests, diseases, and beneficial insects associated with ornamental plants. Consumer abilities in these skills varied considerably. Both growers and consumers reported a large readership of grower and gardening publications.

Interest in hiring an ornamental pest scout varied widely. Growers appear to prefer self-reliance in scouting. Many of the consumers indicated a large neutral response to hiring a pest scout. This may indicate a cost-dependent interest among these respondents. Few reported scouting more than once a week with the majority of both groups scouting less frequently. The majority of growers and consumers appear to check their landscape plantings either monthly or every few months.

Both growers and consumers were highly interested in reducing the amount of pesticides applied to ornamentals. For both groups surveyed, pesticide use is greatest when pests are noticed or when damage becomes visible. The extremes of pesticide use, either never or as a preventive measure against plant pests, were only moderately represented by the respondents in each group.

A hypothetical question was posed to survey participants asking how much damage would be acceptable to landscape plants in order to avoid using a pesticide control. Trends of both consumer and grower were very similar. The majority of both groups tolerated a hypothetical level of 6-10% damage. To more accurately assess this level, the survey included purchase and treatment decisions based on 12 live azaleas damaged to differing degrees by ALB feeding. Growers exhibited a purchase threshold at damage levels as low as 3.5%. Treatment decisions increase relatively uniformly as damage levels increase. Consumers demonstrated a sharp drop in acceptance of azaleas having greater than 1.2% damage to the shrub. Consumer treatment trends increase stepwise in response to the level of ALB damage. Both grower and consumer groups had an increase in the purchase of plant damaged at levels above the apparent thresholds. There was also a corresponding reduction in the decision of respondents to treat these plants for pests. The selection of plants damaged above the apparent thresholds may be indicative of a greater value placed by the consumer or grower on plant form, color, or texture at point-of-purchase. The aesthetic characteristics of the survey plants were not assessed.In conclusion, ALB populations can often be effectively controlled with chemical pesticides including Orthene (acephate), Merit (imidachloprid), Sevin (carbaryl), Dursban (chlorpyrifos), and Cygon (dimethoate) (1,4). Control costs escalate, however, when individual applications are made to a few, or single, plants. The cost of treating a single infested azalea can often be as much as 33% of its replacement cost (3). This, coupled with mounting public concerns about pesticide use and growing awareness of potential chemical interactions with the environment has prompted an interest in effective pest management alternatives among landscape professionals, growers, and consumers.

Integrated pest management (IPM) options for nursery grown azaleas and established azalea plantings should include traditional chemical pest control strategies including selection of pest resistant plant varieties, knowledge of pest biology, pest monitoring, phytosanitary practices, and avoidance of plant stress with biological controls (2). Effective ALB management should also target damage thresholds of less than 3% for point-of-purchase sales. Treatment thresholds in established plantings are likely to be higher in indirect proportion to the number of azaleas requiring treatment.

Significance to Industry: The high costs of managing azaleas for azalea lace bug infestations may be reduced by planting azaleas in groups and by keeping ALB-induced chlorotic stippling below 10% of the total leaf area of the shrub. Consumers and growers reported a hypothetical acceptance of 10-15% ALB feeding damage in exchange for a reduction in pesticide use. In practice, both consumers and growers demonstrated an acuity for detecting damage. Point-of-purchase decisions are likely to be based on a 1-3% level of visible damage. In some cases, plant form, texture, or color may prompt a purchase despite a higher level of visible damage.

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Influence of Stratification, Temperature, and Light on Seed Germination of Selected Provenances of Atlantic White Cedar

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Nature of Work: Atlantic white cedar [*Chamaecyparis thyoides* (L.) B. S. P.] has a wide distribution occurring in a narrow belt along the northeastern and southeastern coasts of the U. S. extending west to the Gulf Coast (6). This evergreen tree with highly prized wood also has the potential for wetlands reclamation, as an ornamental and Christmas tree, and as an understock to graft superior cultivars of other species of *Chamaecyparis* Spach. Throughout its range, natural stands of Atlantic white cedar are diminishing rapidly. Acreage of white cedar in North Carolina alone has declined by as much as 90% within the last 2 centuries (4). White cedar usually fails to regenerate naturally after logging when no measures are taken to control competing vegetation.

Due to extensive reclamation efforts, there is increasing demand for transplants of Atlantic white cedar. However, little research has been reported on propagation and establishment of the species. Therefore, the objectives of this research were to examine the influence of stratification (moist-prechilling), temperature, and light on seed germination of selected provenances of Atlantic white cedar.

Mature cones of six provenances (Escambia Co., Ala., Santa Rosa Co., Fla., Wayne Co., N.C., Burlington Co., N.J., New London Co., Conn., and Barnstable Co., Mass.) of Atlantic white cedar were collected Fall 1994 (Ala., N.C., N.J., and Conn.), Winter 1995 (Mass.), or Fall 1995 (Fla.) from open pollinated trees. Cones were dried for 2 months, followed by seed extraction and storage in sealed glass bottles at 4°C (39°F).

In July 1996, seeds were removed from storage and graded initially with the use of an air column (General Seed Blower-Model ER, Seedburo Intl. Equip. Co., Chicago, Ill.). Abnormal, damaged, undersized or discolored seeds and other large debris, not eliminated by the air column, were removed manually. Graded seeds selected for the research were firm with a dark brown color.

Graded seeds of each provenance were then stratified (moist pre-chilled) for 0, 30, 60 or 90 days at 4°C (39°F). Following stratification, seeds were sown in covered, 9-cm (3.5 in) glass petri dishes containing two prewashed (rinsed) germination blotters moistened with tap water. Following placement of seeds in the dishes, half were designated for germination at 25°C (77°F) and the other half to be germinated at an 8/16 hr thermoperiod of 30°/20°C (86°/68°F). All dishes were placed in double layer, black sateen cloth bags and the seeds allowed to imbibe overnight at 21°C (70°F). The next day, bags were randomized within two growth chambers [C-chambers (3)] set at the appropriate temperatures. Chamber temperatures varied within ± 0.5°C (0.9°F) of the set point.

Within each temperature regime, seeds were subjected daily to the following photoperiods with a photosynthetic photon flux (400-700 nm) of 34 $\mu mol{\cdot}m^{-2}{\cdot}s^{-1}$ (2.6 klx) provided by cool-white fluorescent lamps: total darkness, 1 or 24 hr. Light was measured at dish level with a cosine corrected LI-COR LI-185 quantum/radiometer/photometer (LI-COR, Lincoln, Neb.). Photoperiod treatments were regulated by removal and placement of the petri dishes in black sateen cloth bags. Regardless of temperature, the 1 hr photoperiod was administered the same time each day and for the alternating temperature of 30°/20°C (86°/68°F), it began with the transition to the high temperature portion of the cycle. For the 24 hr photoperiod treatment, the petri dishes remained continuously unbagged in open chamber conditions. Temperatures in the petri dishes never deviated from ambient temperature by more than 1°C (2°F) as measured by a thermocouple. The constant darkness treatment was maintained by keeping the petri dishes in the black cloth bags throughout the duration of the experiment. Seeds maintained in darkness were examined under darkroom conditions utilizing a green safelight.

For each provenance, all temperature, photoperiod, and stratification treatments were replicated four times and a replication for a provenance, with the exception of Mass., consisted of a petri dish containing 100 seeds. A replication for the Mass. provenance utilized 40 seeds per dish. Germination counts were recorded every 3 days for 30 days. A seed was considered germinated when radicle emergence was ≥ 1 mm (0.04 in). Decayed seeds were removed promptly from the dishes.

Percent germination was calculated as a mean of four replications per treatment. Data were subjected to analysis of variance procedures and regression analysis.

Results and Discussion: Stratification, temperature, and light had significant effects on seed germination of Atlantic white cedar. However, responses to these factors varied according to provenance. Averaged over all treatments, the Alabama provenance exhibited the greatest germination (61%) followed by the Florida provenance (45%) with the remaining provenances ranging from 20%-38%. However, there were specific treatments for each provenance which resulted in germination >

50%. Seed germination of various species of *Chamaecyparis* has been reported to be inherently low, due in part to poor seed quality and also to various degrees of embryo dormancy (5).

Regardless of stratification, germination was generally lower at 25°C (77°F) than at 30°/20°C (86°/68°F) for each provenance (31% vs. 43%, respectively). However, germination was not significantly different between these two temperatures for four of the provenances (Conn., Mass., N.J., and N.C.) when germinated in the absence of light. Similarly, Bianchetti et al. (1) reported greater germination of stratified seeds of Atlantic white cedar at an alternating temperature of 30°/20°C (86°/68°F) versus constant temperatures of 23°C (73°F) or 26°C (79°F).

With regard to light, Little (7) "reported a fair amount of light, probably to provide heat, is desirable for obtaining good seed germination of white-cedar." In the present study, seeds of the Ala. and Fla. provenances of white cedar did not exhibit an obligate light requirement. However, a daily photoperiod of 1 hr and 30 days stratification increased germination greatly of these provenances in comparison to stratified seeds germinated in darkness (48% vs. 76%) (Fig. 1).

In contrast, the N.C., N. J., Conn., and Mass. provenances had an obligate light requirement. When subjected to continuous light, these provenances only required 30 days stratification for maximum germination. When subjected to a 1 hr photoperiod, seeds from these provenances required longer durations of stratification for maximum germination. Regardless of the length of stratification, the N.J. provenance needed a 24 hr photoperiod to maximize germination (63%). This is similar to data reported by Boyle and Kuser (2) where seeds of white cedar from N.J. provenances exhibited greater germination under a 16 hr photoperiod (32%) in comparison to negligible germination under a 10 hr photoperiod (0.7%).

Significance to Industry: Data indicate that seed germination requirements of Atlantic white cedar depend on the provenance. Thus, stratification, temperature, and light treatments needed to maximize germination will vary depending on the provenance. The Ala. and Fla. provenances required 30 days stratification, alternating temperatures of 30°/20°C (86°/68°F), and photoperiods $\geq$ 1 hr for maximum germination. In contrast, the N.C., N. J., Conn., and Mass. provenances required 30 days stratification and continuous light for maximum germination. However, if photoperiods were $<$ 24 hr, stratification for 60 to 90 days was necessary to maximize germination. When averaged over all treatments, total germination for each provenance was greater at 30°/20°C (86°/68°F) than at 25°C (77°F). Seed viability of Atlantic white cedar is inherently poor, thus requiring rigorous seed grading prior to sowing.

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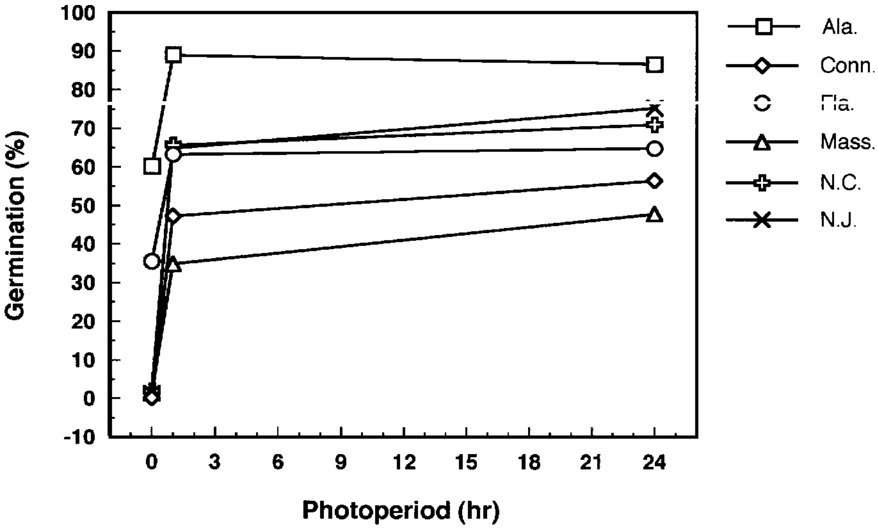

Figure 1. Seed germination of six provenances of Atlantic whit cedar as influenced by photoperiod. Seeds were stratified for 30 days followed by germination at 30/20C (86/68)with daily photoperiods of 0,1 or 24hr.

Fungal Associates of the Asian Ambrosia Beetle, *Xylosandrus crassiusculus*

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Nature of Work: During the past fifty years, there have been at least seven new species of ambrosia beetles introduced into the continental United States from Asia (Hoebeke, 1991). The Asian ambrosia beetle, *Xylosandrus crassiusculus* (Motschulsky) (Coleoptera: Scolytidae), was first documented in the southeastern United States in 1974 (Anderson, 1974). The most recent distribution report indicates that the current range of the beetle extends north to Maryland, land and west to Texas (Ree and Hunter, 1995; Ree, 1994). The beetle has a wide host range including 124 tree species worldwide (46 families) and seventeen families in the continental United States (Atkinson et al., 1988; Ree and Hunter, 1995). Unlike most ambrosia beetles, *X crassiusculus* can attack apparently healthy trees (Atkinson et al., 1988; Davis and Dute, 1995). Individual nursery losses have been reported up to $24,000 annually (Ree and Hunter, 1995). Trees that are infested with *X. crassiusculus* or similar ambrosia beetles may wilt rapidly and die back to the point of infestation (Davis and Dute, 1995; Larsen et al.,1994; Meshram et al., 1993; Hoebeke,1991; Atkinson et al., 1988). The beetles introduce symbiotic ambrosial fungi into their galleries and beetle larvae will feed on the fungal hyphae (Kajimura and Hijii, 1994a). Ambrosia beetles have distinctive adaptations for transporting fungal spores. *X. crassiusculus* and other ambrosia beetles have a pouch-like structure (mycetangium) underneath the posterior portion of the thorax which is used to store fungal inoculum. Likewise, some species of fungi are specifically adapted for beetle dispersal (Kinuura, 1995; Kajimura and Hijii,1994b; Carpenter, 1988). However, these mutualistic relationships between the beetles and their associated fungi may allow the introduction of pathogenic wilt fungi into host trees (Kile et al., 1991; Davidson, 1979; Anderson and Hoffard, 1978; Faulds, 1977; Kessler, 1974). *X. crassiusculus* has been reported to vector the sap stain fungus, *Botryodiplodia theobromae* into coffee plants in India (Sreedharan et al., 1991). In a previous study, wood response in *X. crassiusculus-* infested Kwanzan cherN, (Prunus serrulata'Kwanzan') and eastern redbud *(Cercis canadensis)* trees indicated that a fungal pathogen might be partly responsible for rapid dieback and subsequent death of the host (Davis and Dute, 1 996).

Xylosandrus -infested Japanese pagoda trees *(Sophora japonica)* were harvested in April 1996. Trees that were infested with beetles were dead or dying. These trees also had powdery-vermilion pustules on their trunks. Only trees with beetle infestations had bark cankers. Neighboring trees that were not beetle-infested had no bark cankers. Using inoculum from pustules and beetle entry holes, a fungus, identified as *Nectria cinnabarina,* was isolated and grown on potato- dextrose agar (PDA). This species of *Nectria is* largely saprophytic therefore it is probable that the fungal infection appeared after the beetle damage had occurred. However, it was not known if *N. cinnabarina* could have caused the observed rapid wilt and die-back. To determine the effects of beetle damage and *N. cinnabarina* damage, artificial beetle entry tunnels were created in the trunks of seven healthy trees using a cordless drill. In late April, each tree received five to ten “tunnels” that were 2 mm (0.08 in) in diameter and 10 mm (3.94 in) deep. These drilled holes were made between 0.5 and 1.0 m (~ 20 - 40 in) from the ground. The drill tip was sterilized by flaming with 70 % ethanol before and after each hole was drilled. Conidia from diseased trees were used to inoculate four of these trees. The other three trees received no inoculum. Inoculum was placed into drilled holes using a sterile needle. Portions of the trunks that received artificial galleries were wrapped in a layer of organdy fabric to exclude contamination from beetles. Observations were made every two weeks until June and monthly thereafter until September.

Beetle infested samples of *Zelkova serrate* and *Cercis canadensis* were obtained from a commercial nursery in McDuffie County, Georgia. Cultures from galleries, entry tunnels, and beetles were isolated and grown on acidified PDA at 26°C (78.8°F).

Galleries in an infested redbud from a previous study (Davis and Dute, 1995) and galleries from recently infested (March 1997) redbuds were examined with a scanning electron microscope (SEM). The focus of this portion of the study centered on tracking progression of fungal hyphae in the vascular systems of the hosts.

Results and Discussion: This study was directed towards identifying possible fungal pathogens that could be introduced during infestations by *Xylosandrus crassiusculus .* At least four genera of fungi were found to be associated with beetle infestations. Trees that were inoculated with *Nectria* were expected to show symptoms of infection. A similar study using a pathogenic ambrosia beetle associate, *Sporothrix,* resulted in wilting of red beech, *Nothofagus fusca* (Faulds, 1977). However, none of the seven trees showed any signs of *Nectria* infection nor any decline in health from the tunnels themselves. In the beetle infested *Sophora* trees, *Nectria* infection was severe, but evidence suggests that it is not the primary cause of decline of these trees.

Two possible pathogenic cultures were obtained from entry tunnels and the cankers present around the entry points of *Zelkova* samples. The cultures were identified as species of *Phomopsis* and *Fusarium.* Identification to species is still ongoing. No viable cultures were isolated from the beetles. Prior to this report, *Phomopsis* spp. had not been reported as an associate of X *crassiusculus. Phomopsis is* associated with stem cankers of many trees, but it is typically not a wilt fungus (Agrios, 1988). In fact, *Phomopsis* has been shown to inhibit larval growth of another ambrosia beetle species, *Scolytus,* in England (Webber, 1981). Nevertheless, *Phomopsis was* not isolated from the beetles, therefore, it is premature to assume that this fungus is vectored by *Xylosandrus crassiusculus.* In contrast, *Fusarium is* commonly associated with other ambrosia beetles (Anderson and Hoffard, 1978; Kessler, 1974). Several species of *Fusarium* are considered to be wilt fungi (Agrios, 1988). *F. laferitium* and *F. oxysporum* have been associated with *Xylosandrus germanus,* an ambrosia beetle that attacks black walnut (Kessler, 1974), and *F. solani* has been documented in tulip poplars infested with X. *germanus* and *Xyleborus sayi* (Anderson and Hoffard, 1978). Therefore, it is not surprising to find a *Fusarium* species associated with *Xylosandrus crassiusculus.*

Generally there were two types hyphae present in the redbud samples examined with the SEM. Hyphae that invaded the vascular tissue were typical of Ascomycete or Deuteromycete fungi. The pattern of septation and high incidence of vacuolization were the strongest evidence for this conclusion. In samples collected from beetle-infested redbuds in March of 1997, hyphae were found in water conducting tissue 10 cm (3.94 in) above and 5 cm (1.97 in) below beetle galleries, confirming that fungi are invading tissues surrounding galleries. In both old and new samples, hyphae that remained in the gallery formed conidia. The shape and number of conidia indicate that this is a species of *Ambrosiella,* probably *A. macrospora* or *A. hartigli* (Batra, 1967). *Ambrosiella is* commonly associated with ambrosia beetles (Kovach and Gorsuch, 1988; Roeper and French, 1981; Batra, 1967), however it is not known to be pathogenic (Batra, 1967).

In conclusion, the rapid wilt and subsequent death of trees that are attacked by *X. crassiusculus* could be correlated with the presence of one or more species of pathogenic wilt fungi. At least three possible pathogens were identified in trees infested with Asian ambrosia beetles. There is evidence that the tunnels of the beetles themselves would not elicit the wilt response observed in infested trees (Faulds, 1977). It is also probable that the presence of ambrosial fungi will not induce rapid wilting (Kovach and Gorsuch, 1988). Interruption of water transport in the xylem can be caused directly by mechanical damage or by occlusion of vessel elements with hyphae. Indirect responses to wounding can also impede water transport. For instance, wilt fungi can induce a host tree to occlude its own sapwood with resins (Parmeter et al., 1992), gums (Rioux and Ouellette, 1991; VanderMolen et. al., 1977) and/or tyloses (Mace, 1978). Substances secreted by some wilt fungi may induce xylem embolisms (Sperry and Tyree,1988) which may also interrupt water transport. Evidence supports the possibility that at least one fungal pathogen would have to be present in order to produce the symptoms present when trees are infested with Asian ambrosia beetles. However, further studies need to be directed at isolating these pathogens and re-infecting healthy trees. Also possible pathogens need to be isolated from the beetles themselves. Evidence suggests that X. *crassiusculus* is a vector of pathogenic wilt fungi. To be certain, however, a direct correlation needs to made between the beetles and the possible pathogen(s).

Significance to the industry: To date, there is not an effective chemical control for wilt fungi in field nurseries. The best way to avoid contamination is by observing sanitary culture practices. Upon detection, removal and destruction of possible fungal reservoirs are the best ways to control wilt fungi. Regular removal of dead or dying trees from fencelines and woodland borders will also help to keep fields sanitary. Current control of the Asian ambrosia beetle with pesticides has been ineffective. *Xylosandrus compactus,* a similar beetle that attacks mahogany plantations in India has been controlled by spraying with monocrotophos 0.05% (Nuvacron EC). However, monocrotophos is highly toxic and is not labeled for nursery use. In addition, Nuvacron is not available in the United States. Dursban WSP 50 is labeled for ambrosia beetles (not *Xylosandrus* specifically), but the rate is an astonishing sixteen pounds per acre. Not only is this expensive, but such concentrated tank mixtures often clog filters and nozzles *(personal communication,* Garry Agan). Safety and cost dictate that removal and destruction of infested trees are still the best ways to control *Xylosandrus crassiusculus.*

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Integrated Plant Health Management Pilot Project

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Nature of Work: The intent of this two year study is to reduce pesticide use while maintaining or improving current aesthetic standards in the landscape. The cooperating landscape managers receive training in the proper identification of pests, diseases, and turf problems. Pest thresholds, proper timing of pesticide applications to coincide with the most vulnerable stage of the pest, and the identification and impact of beneficial insects are also being emphasized. Cooperators are learning the proper use of non-chemical control methods (biological, cultural, and mechanical), and the use of safer pesticides that are less damaging to the environment. Thus, at the end of this pilot study, the cooperators will have hands-on experience using cost effective pest management techniques that reduce the potential pesticide toxicity for both the applicator and the client. County Extension Agents assisted in selecting nine sites that met the following criteria. First, the sites had to be established landscapes installed at least one year ago and contain a high level of plant diversity. Sites or portions of sites that were approximately one half acre in size were used in the study. Last, all the sites were required to have a documented history of pesticide use. The cooperators agreed to attend the three training sessions (in April, June, and Fall) held by the Ornamentals Working Group (OWG) and to be present when the entire OWG visited the sites in early May. In addition, the cooperators agreed to provide the OWG with the site's history of pesticide use and to meet with the landscape monitor (C. Stewart) at the site every two weeks for no more than one hour. Scouting began on April 19-20, and will continue until August 25-26, 1997. The cooperators were also asked to follow the OWG's recommendations and to provide the OWG with information regarding any actions that were taken in response to these recommendations. In return, the OWG will provide training, a set of scouting tools, a reference guide to pests and diseases, and pocket-sized pest and disease identification cards for use in the field. The monitor is working with each cooperator, pointing out what he's looking for and why, and noting numbers of pests and baneficials present. At this time the monitor is showing the cooperator how to quantitatively assess the severity of the pest problem, evaluate any recommended control measures, and discussing the idea of pest thresholds. Initially it was thought that scouting could be done in 30 minutes, or, at most 45 minutes. It has been determined (from April to June 4-5, 1997) that 45 to 60 minutes is the ideal time allotment. The observations from all of the sites are pooled and sent out to all cooperators. At the end of the season, observations on the pests and beneficials will be converted into growing degree days. The scouting report and recommendations from the individual cooperator are faxed (where possible) to both the cooperator and the County Extension Agent. The monitor is also making insect collections containing pests and beneficial insects (collected from all of the sites) and giving one collection to each cooperator at the end of the season. During the second year of the program the cooperator will be monitoring the sites and the OWG will serve as technical support for the cooperator by answering questions or making management recommendations. All of the above services that the University of Georgia OWG provides are free of charge to the cooperator. At the end of the first year, pesticide records from this year and the previous year will be compared. A questionnaire will also be distributed to the cooperators to evaluate the success of the program and to find ways to improve it.

Results and Discussion: A number of pests have been identified on the sites that may require treatment if populations increase or when vulnerable stages of the pests such as scale crawlers are detected. These include (with hosts on which they have been detected in parentheses): aphids (various hosts except those listed in Table 1 which required treatment), boxwood mites (boxwood), camellia scale (holly), cottony maple scale (maple), gloomy scale (maple), green June beetles (turf), leafhoppers (maple), mealybugs (pyracantha), root weevil damage (holly), tulip poplar scale (tulip poplar), two-lined spittlebug (turf), Indian wax scale (yaupon holly),whitefly (holly). The following pests and diseases have been identified for which no control measures are expected: black rot (Boston ivy), fusiform rust (oak), many types of insect and mite galls, leaf spots (birch, maple, oak, spirea), needle rust (pine), planthoppers (numerous), powdery mildew (dogwood), shothole (skip laurel), ringspot virus (camellia), spittlebugs (Leyland cypress), spot anthracnose (dogwood), thrips (azalea, juniper, skip laurel), yaupon psyllid galls (yaupon holly), and yellow poplar weevil (tulip poplar). geneficial insects that have been detected at the sites include: assassin bugs (all stages, many types), azalea plant bugs (nymphs), dusty wings (adults), lacewings (eggs, nymphs, adults), and lady beetles (all stages and many types).

Table 1. Pests and Diseases for Which Control Measures Have Been Recommended

Pest or Disease	Common Name of Plant(s!	Nature of Control*
aphids	blueberry, juniper	chemical
adelgids	pinep	physical
azalea lace bug	azalea	chemical
azalea leaf gall	azalea	physical
bacterial canke	rcherry	cultural
black spot	ros	physical, chemical
borers	maple, dogwood	chemical
Botryosphaeria canker	deodar cedar	physical
brown patch	turf	chemical
clover mites	holly	chemical
cottony camellia scale crawlers	holly	chemical
eriophyid mites	wax myrtle	chemical
euonymus scale (crawlers)	camellia	chemical
fire ants	turf	chemical
fire blight	Bradford pears	physical
Japanese beetles	cherry, crepe myrtle, rose	chemical
powdery mildew	crepe myrtles holly	chemical, physical
Lecanium scale (crawlers)	oak	chemical
nutritional problems	holly, junipers	cultural
seiridium canker	Leyland cypress	physical
twospotted spider mites	juniper, skip laurel	chemical
woolly alder aphids	maple (over a driveway)	chemical
weeds	turf	chemical, physical
whitefly	gardenia	chemical

* Chemical- Except for mites (on juniper), fire ants, Japanese beetles, and preventive sprays for borers on severely stressed maples and dogwoods, horticultural oil or insecticidal soap was used on the pests. In a single instance, after oil failed to control azalea lace bugs, acephate was applied.
Cultural: soil amendments, fertilizer applications
Physical: pruning, hand picking. Note: due to the small size of the pine (2' high) it was possible to crush the adelgids by hand.

Significance to Industry: It is hoped that this program will reduce pesticide use on landscape ornamentals and turf while maintaining or improving high aesthetic standards on commercial, municipal, and residential properties.

Potential Pesticide Phytoremediation using *Canna hybrida* 'King Humbert'

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Nature of Work: Organic pesticide use is essential for controlling many disease, insect, and weed problems associated with high quality turfgrass and nursery environments. Workers, wildlife, and human populations may be exposed to significant quantities of these pesticides due to the common practice of washing pesticide application equipment after use. This research focuses on the use of *Canna hybrida* 'King Humbert' in constructed wetlands for the removal of pesticides found in equipment washings. In such systems, it is essential that pesticide concentrations not exceed the tolerance levels of the occupant plants. The objective of this experiment was to determine the tolerance levels of *C. hybrida* 'King Humbert' to simazine, metolachlor, and metalaxyl concentrations in water. Simazine and metolachlor are the active ingredients present in the commercial herbicide formulations of Princep™ and Pennant™, respectively. Metalaxyl is the active ingredient present in the commercial fungicide formulation, Subdue™. These pesticides are labeled for use on turfgrass and nursery crops. *C. hybrida* 'King Humbert' was selected as a test species based on its ornamental character, vigorous growth, and tolerance for wet conditions.

Plants were grown and propagated in a greenhouse using Fafard Germination Mix as a substrate. Approximately 2 weeks before tests were initiated, plants were transferred from potting media in the green-house to hydroponics in the lab. Plants were grown and tested in the lab under metal halide lamps with a light intensity of 375 $\pm$ 25 μmol/m^2•sec and a 16 h light: 8 h dark photo-period. Each pesticide was dissolved in 10% Hoagland's nutrient media (Hoagland and Arnon, 1950) at the following concentrations: metolachlor @ 0, 1.0, 3.0, 6.0, 12.0, 25.0, and 50.0 mg/l; metalaxyl @ 0, 1.0, 5.0, 10.0, 25.0, 50.0, and 100.0 mg/l; and simazine @ 0, 0.01, 0.03, 0.1, 0.3, 1.0, and 3.0 mg/l. Individual plants were exposed to 200 ml of each pesticide concentration for 7-d. After 7-d exposure, plants were placed in "clean" nutrient media and allowed to grow for an additional 7-d in order to observe any latent effects or recovery. Fresh masses were recorded before exposures, after 7-d exposure, and after the 7-d recovery period. Maximum and minimum chlorophyll fluorescence quantum yields for dark-adapted leaves were also measured using an OPTISCIENCES OS-500 modulated Fluorometer. These yields were used to calculate Fv/Fm ratios as, Fv/Fm = (Fm-Fo)/Fm, where Fm and Fo are maximal and minimal fluorescence yields, respectively. This ratio is a measure of the efficiency of photosynthetic electron transport. A completely randomized statistical design with 4 replications for each exposure concentration was used. Fresh-mass gains were ranked by the Wilcoxon rank-sum test and analyzed by ANOVA at $P = 0.05$. Fluorescence measurements were analyzed by ANOVA at $P = 0.05$.

Results and Discussion: 'King Humbert' canna showed varying degrees of tolerance for each pesticide respective to each measured endpoint. No significant reductions in 7-d fresh mass production were observed for plants exposed to metalaxyl or metolachlor. Likewise, no latent effects were observed after the 7-d recovery period in which plants were placed in "clean" nutrient media. This is in spite of obvious phytotoxicity symptoms displayed by plants exposed to 25, 50, and 100 mg/l metalaxyl. These symptoms were manifested as leaf-tip chlorosis that lead to leaf tip and marginal necrosis. No plants exposed to metolachlor exhibited symptoms of phytotoxicity. Plants exposed to simazine displayed a dose-dependent reduction in fresh mass production after 7-d exposure. Seven-day fresh mass production for plants exposed to 0.01, 0.03, 0.1, and 0.3 mg/l were comparable to the controls. Fresh mass production for those exposed to 1.0 and 3.0 mg/l was reduced 85 and 89%, respectively, relative to the controls. Plants exposed to 3 mg/l had senesced by the end of the 7-d recovery period, while those exposed to 1 mg/l recovered to approximately 24% of the controls. No latent effects were observed for plants exposed to 0.01, 0.03, 0.1, and 0.3 mg/l after the 7-d recovery period. Effected plants were chlorotic with necrotic lesions.

Chlorophyll fluorescence measurements with dark-adapted leaves showed no effects for plants exposed to metolachlor and metalaxyl. This was expected since neither compound exerts direct action on the photosystem of the plant. However, these results also indicate that there were no indirect effects on the functionality of the plant's photosystems. Conversely, plants exposed to simazine for 7-d displayed a dose-dependent reduction in Fv/Fm ratios. These reductions commenced at the 0.3 mg/l treatment concentration. Fv/Fm ratios were reduced to 90, 66, and 40% of the control levels for the 0.3, 1.0, and 3.0 mg/l exposure concentrations, respectively. The decrease in Fv/Fm ratios at higher simazine concentrations result from increased base-line (Fo) fluorescence associated with the blockage of the electron transport chain. Under normal conditions, approximately 2-5% of the light energy absorbed by a thylakoid is re-emitted as fluorescence (Karukstis, 1991). Simazine blocks electron transport between Q- and cytochrome b559 LP (Goodwin and Mercer, 1990), thus increasing the normal background fluorescence and lowering the Fv/Fm ratio. Fv/Fm ratios were restored to control levels after placement in "clean" nutrient media for 7-d, indicating that the simazine was no longer inhibiting electron transport.

Table 1 summarizes the No Observable Effects Concentrations (NOEC's) and the Lowest Observable Effects Concentrations (LOEC's) for each pesticide and measured endpoint. Maximum pesticide concentrations in sprayer rinsates were calculated based on 1 - 5 gal. residual volumes between tank rinses and low application rates. These concentrations are: metalaxyl, 4.6 - 23.4 mg/l; metolachlor, 3.5 - 17.8 mg/l; and simazine, 9.2 - 46.2 mg/l. Based on these calculated maximum concentrations, it is apparent that concessions must be built into the design of a constructed wetland for the removal of simazine from contaminated rinsates. These concessions may include built-in dilution factors and biological stratification with other plant species. Furthermore, these results represent a worst-case scenario where root contact with the contaminated water is maximized. As a result, they may over-estimate the actual effects experienced in the field where solid substrates are present. Likewise, fairly juvenile plants were tested for logistical reasons. It is very likely that mature plants will tolerate higher concentrations of each pesticide.

Significance to Industry: Pesticide use by the ornamental horticulture and turfgrass industries is often necessary for the production of pest-free, high quality, premium return ornamental crops and turfgrass areas. Establishment of constructed wetlands in areas subject to high pesticide loadings (such as at pesticide sprayer wash stations) may reduce environmental threats to human and wildlife populations that might otherwise be exposed. *Canna hybrida* 'King Humbert' appears to be a good candidate for establishment in these constructed wetlands based on its tolerance and vigorous growth. In addition to filtering waste-water generated by spraying pesticides, the nursery industry may also benefit from increased interest in and production of this crop under a new marketing strategy.

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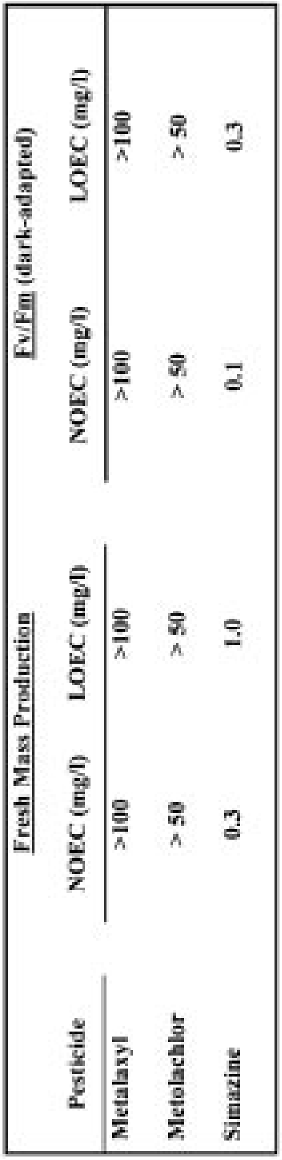
Table 1. Plant toxicity threshold summary. The first number in each column is the No Observable Effects Concentration (NOEC); the second number is the Lowest Observable Effects Concentration (LOEC).



	Fresh Mass Production		Fv/Fm (dark-adapted)	
Pesticide	NOEC (mg/l)	LOEC (mg/l)	NOEC (mg/l)	LOEC (mg/l)
Metalaxyl	>100	>100	>100	>100
Metolachlor	> 50	> 50	> 50	> 50
Simazine	0.3	1.0	0.1	0.3