SECTION 1
DR. BRYSON L. JAMES
STUDENT COMPETITION

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Control of Bittercress in Container-Grown Plants

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Nature of work: Weed control in container nurseries is a serious management concern. Several preemergence herbicides are used to control oxalis, eclipta, prostrate spruge, hairy bittercress, and purple and yellow nutsedge in commercial nurseries. Of these *Cardamine hirsuta*'s ballistic seed dispersal mechanism creates a tremendous problem with container nursery stock, launching up to 50,000 seeds per plant (1). In a previous study, Ronstar was reported to be the most effective herbicides evaluated for bittercress control (2). Due to the vigorous nature of bittercress, multiple applications of Ronstar are required for effective control (3). Since his previous work, several new herbicides have been registered for nursery and landscape crops. The objective of this study was to evaluate several of these new herbicides for control of bittercress in container grown nursery crops.

Two experiments were conducted. In experiment one, 10 herbicides were evaluated in the fall of 1994 in Mobile, AL. The test was split between a greenhouse location and a field location. In subsequent test 5 herbicides demonstrating potential for bittercress control were evaluated in trade gallon containers with a 6:1 pinebark to sand medium amended with 10 lbs osmocote 17-7-12, 5 lbs dolomitic lime and 1.5 lbs micromax/ yd^3. Five herbicides evaluated at 3 rates each (1/2X, X, and 2X recommended rate) were Rout 3G, Snapshot 80DF, Surflan 4AS, Stakeout .1G, Gallery 75DF and Ronstar 2G was evaluated only at the recommended rate 4 lb ai/A. The study consisted of 17 treatments conducted in Mobile and Auburn with 7 single plant replicates and a nontreated control. One week after treatment, 20 bittercress were sown over each container. Data collected 30 days after treatment (DAT) included the number of bittercress weeds per pot and at 60 DAT number and dry weight of the weeds was determined.

Results and Discussion: In the initial test conducted in Mobile, AL 10 herbicides applied at the recommended rates provided control of bittercress in the following order of decreasing control: Snapshot 80DF, Stakeout 0.1G, Rout, OH-2, Ronstar, Snapshot 2.5TG, Factor, SouthernWeedGrass Control, Pennant, and Derby 5G. In both locations, Stakeout .1G and Snapshot 80DF provided excellent control while Derby 5G, Pennant and SouthernWeedGrass Control provided little control.

In the second test, limited weed pressure occurred, probably due to containers being in full sun. All herbicides at all rates provided excellent control, with the exception of Surflan 4AS at the 2 and 4 lb ai/A rate. In general, the 1/2X herbicide rate provided the least control. At the Auburn location, weed pressure was greater (containers were under 47% shade). Only Rout(X and 2X), Stakeout(2X), and Ronstar(X) provided acceptable control of bittercress. These data demonstrates that bittercress control can be achieved with some of the newer herbicides, and that Ronstar is still a viable alternative for bittercress control.

Signficance to the Industry: If left untreated, bittercress can become a serious weed problem especially in late winter to early spring. This research demonstrates that bittercress can be effectively controlled through the use of Rout 3G, Ronstar 2G, Stakeout 0.1G, and Snapshot 80DF.

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Table 1. Effects of selected herbicides on bittercress control.

		Mean weed #	
Treatments	lbs. ai/A	60 DAT Mobile	60 DAT Auburn
Rout 3G	1.5	0.3b	0.7gh
Rout 3G	3.0	0.3b	0.0h
Rout 3G	6.0	0.0b	0.0h
Snapshot 80 DF	1.5	0.1b	6.7bc
Snapshot 80 DF	3.0	0.0b	6.4bcd
Snapshot 80 DF	6.0	0.0b	4.7fecd
Surflan 4AS	2.0	0.6b	8.3ab
Surflan 4AS	4.0	0.7b	3.4fegd
Surflan 4AS	8.0	0.0b	6.9bc
Stakeout 1G	1.0	0 . Ob	2. Of gh
Stakeout 1G	2 . O	O . 0b	2. 8fegh
Stakeout 1G	4 . O	O . Ob	O.6gh
Gallery 75 DF	0.5	O . Ob	10.7a
Gallery 75 DF	1.0	0 . Ob	4.7gh
Gallery 75 DF	2 . 0	o . Ob	5 . 4becd
Ronstar 2G	4 . O	O . 0D	0. 7gh
Control	O . O	8 . 3a	8. Oab

Mean seperation within treatments by Duncan's multiple range test.

Light Degrades Iron-Chelates in Fertilizer Solutions, Affecting Physiology of Iron Acquisition in Marigold (*Tagetes erecta* L.)

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Nature of Work: In tissue culture, plants are typically grown on a translucent, gel-like agar incorporated with nutrients often containing [iron (Fe)]-chelates such as Fe-EDTA. Recent work has shown that Fe-EDTA in the agar degrades when exposed to light (irradiated), resulting in the precipitation of Fe (1). Precipitated Fe in the agar is insoluble and unavailable to the plant, and limited soluble Fe significantly reduces plant growth (2). Many plants respond to Fe-deficiency stress by modifying root physiology (3). These modifications include root induced acidification of the media to increase Fe solubility in the root zone, and an enhanced ability to reduce, or chemically convert, Fe^{3+} (ferric iron) to Fe^{2+} (ferrous iron), the form of Fe that plants take up. These physiological reactions are collectively referred to as Fe-efficiency. Research has shown that Fe-efficient plants grown on tissue culture agar low in soluble Fe have greater tissue callus growth than plants that do not modify root physiology under Fe-deficiency conditions (Fe-inefficient) (2).

Although research has demonstrated that Fe-chelate degradation by light is a problem in tissue culture, the significance of this phenomenon to the ornamental horticulture industry is unknown. Iron-chelates are common components of many commercially produced nursery and greenhouse fertilizers. Therefore, studies were initiated to determine if (A) Fe-chelates incorporated into commercial fertilizers degrade in light, and (B) to determine if the use of such fertilizers exposed to light affect plant physiology associated with Fe acquisition.

Commercially produced soluble 20-10-20 (N-P-K) fertilizers that contain Fe-EDTA (Brand 1 and Brand 2) were prepared as 100X stocks based on a 100 ppm N (1X) concentration. Samples of the fertilizer solutions were then kept dark (1.1 qt. containers covered with aluminum foil) or irradiated with 500 $\mu mol \bullet m^{-2} \bullet s^{-1}$ (approximately 3,500 foot candles.) from fluorescent and incandescent light sources for 10 days. Chelated Fe was separated from unchelated Fe in samples taken daily by centrifugation (spinning) at 6,000 X g for 20 minutes. Using this method, insoluble or unchelated Fe would precipitate and form a solid pellet, leaving only soluble, chelated Fe in the supernatant (solution). Iron in the supernatant was determined directly by atomic absorption spectrophotometry (AA). The pellet was dissolved in acid (1 N HCl) prior to Fe determination by AA.

Twenty-four day old ‘First Lady’ marigold (*Tagetes erecta* L.) plants were hydroponically grown in a greenhouse under supplemental lighting (HID) to deliver 12 hour photoperiods. Heating/venting temperatures in the greenhouse were 65/80°F. Treatments (hydroponic solutions) consisted of 1X concentrations (100 ppm N) of the fertilizer solutions treated as described in the previous study, consisting of both irradiated and dark-kept solutions of brand 1 and brand 2 fertilizers. Plants were grown in treatment solutions adjusted to pH 5.8 for 8 days with one solution change on day 4. The experiment was a completely randomized design with 8 replications per treatment. At the termination of the experiment, hydroponic solution pH was determined using a pH probe. Root-associated Fe^{3+} reduction was determined by placing excised whole roots in an assay solution containing Fe^{3+}-DTPA (Fe-chelate) and BPDS (an Fe^{2+} indicator), and determining the formation of Fe^{2+}-BPDS (a stable, pink-colored compound) spectrophotometrically (4). This is an indirect method of determining the rate that roots convert Fe^{3+} to Fe^{2+}.

Results and Discussion: Soluble Fe in the irradiated commercial fertilizer solutions decreased 85% in 10 days (Fig. 1). In conjunction with the decrease in soluble Fe in the irradiated fertilizer solutions was the formation of a tan precipitate. Analysis of the precipitate revealed that it was composed of Fe in an amount that was equivalent to 90% of the soluble Fe lost by irradiation (data not shown). There was no loss in soluble Fe in treatments kept dark (Fig. 1). These findings indicate that light levels in the greenhouse are sufficient to degrade Fe-chelates in commercially produced fertilizers, rendering Fe unchelated and readily unavailable to the plant.

Roots of marigold grown hydroponically in the irradiated fertilizer solutions had Fe^{3+}-DTPA reductase activity, on average, 3.5-times greater than roots of plants grown in fertilizer solutions kept dark (Table 1). Plants grown in irradiated fertilizer solutions acidified the root zone more than plants grown in fertilizer solutions kept dark (Table 1). The increase in Fe reductase activity and root zone acidification are Fe-efficiency reactions of marigold responding to the degradation of Fe-chelates by light and subsequent decrease in soluble Fe in the commercial fertilizer solutions. These findings indicate that the use of irradiated commercial fertilizers containing Fe-chelates can affect plant physiology associated with Fe acquisition.

Significance to Industry: Iron-chelates in commercially produced soluble fertilizers are vulnerable to light degradation. Therefore, a grower not only has to consider fertilizer formulation and application frequency in crop production, but also must consider how the fertilizer stock solution is stored. Using irradiated Fe-chelate containing fertilizer solutions in plant production can establish Fe-deficiency conditions in the root zone, inducing the plant into an Fe-efficiency mode. Plants under such stress may be lower in quality, and may be predisposed to other nutritional disorders. For example, a grower prepares a soluble fertilizer stock solution that is vulnerable to light (i.e., stored in a translucent or a lidless container). Over a period of time, the Fe-chelates in the fertilizer stock solution are degraded by light and with each subsequent fertilizer application, the plants become more Fe-efficient. Eventually, the fertilizer stock solution is depleted and a fresh batch is prepared. Plants physiologically conditioned to scavenge Fe are then suddenly supplied with soluble Fe upon the first application of the freshly prepared fertilizer stock solution. The possibility then exists that massive Fe uptake occurs, leading to Fe toxicity. Through proper storage of fertilizer stock solutions in opaque containers, degradation of Fe-chelates by light can be avoided.

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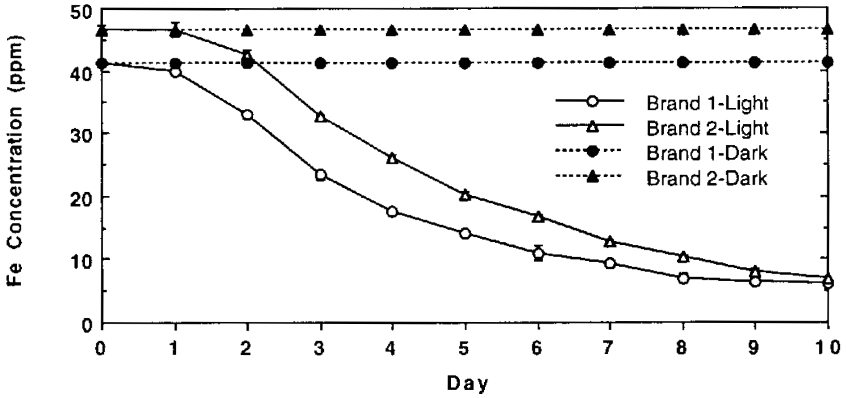

Figure 1. Soluble Fe in commercially produced (Fe-EDTA)-containing 20-10-20 fertilizers (Brand 1 and Brand 2), prepared as 100X stocks and irradiated (Light) with 500 $\mu mol \cdot m^{-2} \cdot s^{-1}$, or kept dark (Dark) in a growth chamber for 10 days. Values represent the mean of 3 replications. The vertical bars represent the standard error of the mean.

Table 1. Root associated Fe^{3+} reduction and root zone acidification of marigolds grown hydroponically for 8 days in (Fe-EDTA)-containing commercial fertilizers (Brand 1 and Brand 2), irradiated (Light) or kept dark (Dark). Values represent the mean of 8 replications ± standard error.

	Fe^{3}+-DTPA reduction (µmol•gFW -1 •h-1)		Root Zone Acidification (pH of the hydroponic solution)	
Fertilizer	Light	Dark	Light	Dark
Brand 1	0.2 ± 0.06	0.04 ± 0.01	4.47 ± 0.04	4.67 ± 0.02
Brand 2	0.07 ± 0.01	0.04 ± 0.01	4.46 ± 0.02	4.65 ± 0.03

The Effect of Grassed Waterways in Reducing Pesticide Levels in Runoff Water of a Container Plant Nursery

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Nature of Work: Container plant nurseries employ frequent applications of pesticides to control weeds, insects, and pathogens, resulting in a high quality product. Granular formulations are commonly utilized due to ease of handling and enhanced applicator safety. Up to 80% of the pesticide can fall directly onto the production surface (4), often a ground cover of fabric, gravel or plastic. Overhead irrigation generates runoff water which may transport the pesticides off site. Herbicides have been detected in both the runoff water and the containment pond water and sediment of container plant nurseries in South Carolina (2,5,6). Following a granular application of a preemergent herbicide at a container nursery, 10.3% of applied isoxaben moved from the site in the runoff water within five days of treatment (7). Concerns are that container nurseries may introduce pesticides onto the crop through recycling of water, and pesticides may be a source of pollution for adjacent or neighboring waters. Grassed filter strips and waterways have been used extensively for the reduction of sediments and nutrients in runoff waters from livestock feedlots and agricultural lands (3). The objective of this research was to ascertain if grassed waterways would reduce pesticide levels of runoff water at a container nursery.

Research was conducted at a container nursery in northwestern South Carolina. Runoff water from a four hectare growing bed was diverted into equal halves and channeled into either a hybrid bermuda grass (*Cynodon dactylon x C. transvaalensis*) waterway (100 m long by 2 m wide), or an existing gravel and clay reference waterway of equivalent dimensions. Snapshot TG (2% trifluralin, 0.5% isoxaben), a preemergent herbicide formulation, was broadcast applied at the recommended rate, and Cleary's 3336-F fungicide (46.2% thiophanate-methyl), and Dursban 50 W insecticide (50 % chlorpyrifos), were sprayed onto the container beds at recommended rates. Weirs were installed at the termination of the waterways to facilitate sampling and to determine runoff volumes. A ninety minute overhead irrigation event followed pesticide application, and six 500 ml samples of runoff were collected from each waterway at equivalent time intervals after runoff began. Samples were collected on the day of application and 1,2,8, 15 and 22 days after application. Runoff volumes were calculated by Bernoulli's equation. The pH of water samples was adjusted to 2.2 -2.3, duplicate 200 ml fractions were filtered through Whatman #5 qualitative filter paper, and pesticides were extracted using solid phase C_{18} columns (500 mg). Pesticides were eluted with 2 ml acetone. Analysis of duplicate samples was by high performance liquid chromatography (HPLC) using a Hewlett Packard 1090 HPLC equipped with a C_{18} reverse phase column (3 μ), diode array detector set at 206 nm, a mobile phase of 50:50 acetonitrile:water to 70:30 over 22 minutes, and a flow rate of 0.5 ml/min. Retention times and percent recoveries are shown in Table 1.

Table 1: Retention times and percent recoveries for the pesticides.

Pesticide	Thiophanate-methyl	Isoxaben	Chlorpyrifos	Trifluralin
Retention time	3.4	8.6	18.8	19.4
% Recovery	42	119	83	64

Results and Discussion: Isoxaben was detected through 8 days after pesticide applications in all samples. Trifluralin was detected on the day of application (DOA) in the grassed and reference waterways, and at 1 day after application (DAA) in only the reference treatment. The highest concentration detected was 0.28 ppm. Chlorpyrifos and thiophanate-methyl were detected only on the DOA with concentrations ranging from 4.70 to 0.04, and 2.08 to 0.38 ppm respectively. Runoff volumes averaged 47,138 L for the reference waterway, and 64,456 L for the grassed ditch, with 70% of applied amount of irrigation water recovered. Detected isoxaben concentrations were lower from the grassed waterway when compared to the reference waterway on the DOA and at 1 DAA (Table 2). At 2 and 8 DAA (Table 2), concentrations of early runoff samples were lower, but middle and final samples were higher. Results are consistent with our previous findings in which model grassed waterways demonstrated a release of trapped herbicides over time (1). Chlorpyrifos concentrations were also reduced by the grassed waterway (Figure 1) with detected ppm's ranging from 1.19 to 0.04. Reference waterway concentrations were 4.70 to 0.04 ppm. Trifluralin and thiophanate-methyl levels were not consistently reduced by the grassed treatment.

Significance to Industry: The fate of pesticides applied to ornamental nurseries is extremely important both to the nursery industry and adjacent property owners. Our preliminary study suggests that the use of grassed waterways will reduce the pesticide levels in runoff water generated during container nursery production. Pesticide movement into containment ponds and/or offsite could be minimized by grassed waterways as could the potential for introduction of pesticides onto nursery beds in recycled irrigation water. Further work is presently being conducted utilizing cattails (*Typha latifolia*) to reduce pesticide levels in runoff water.

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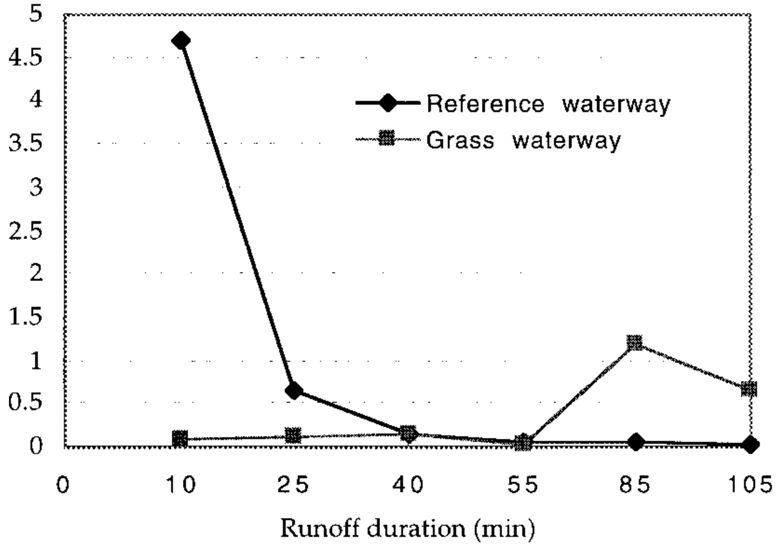
Table 2: Isoxaben concentrations (ppm) by runoff duration (minutes) in the reference and grassed waterways for day of application (DOA) and 1 and 8 days after application (DAA).

	DOA		1 DAA		8 DAA	
Runoff duration (minutes)	Reference	Grass	Reference	Grass	Reference	Grass
10	1.49	0.94	0.64	0.53	0.36	0.23
25	1.23	0.98	0.55	0.39	0.15	0.22
40	0.93	0.98	0.47	0.43	0.13	0.29
55	0.65	0.53	0.39	0.40	0.14	0.21
85	0.63	0.49	0.34	0.35	0.10	0.15
105	0.53	0.59	0.32	0.39	0.17	0.09

Figure 1: Chlorpyrifos concentration in ppm for the reference and grass waterways on the day of application.



Ozone Sensitivity of Buddleia Cultivars

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Nature of Work: Ozone is considered to be the most phytotoxic pollutant in the southeastern United States. It can cause visible injury to foliage, reductions in growth and productivity, and predispose plants to other biotic and abiotic stresses. No prior studies have been done to determine the sensitivity of buddleia to ozone. Ozone studies with forest trees demonstrated potential reductions in both growth and yield across the United States (Pye, 1988). Davis et al.(1981) and Umbach and Davis (1984) investigated the severity and frequency of ozone injury on many tree and shrub species growing in Pennsylvania. They reported a wide variation in the severity of injury with a majority of the species exhibiting an intermediate sensitivity to ozone. Buddleia is a popular summer blooming shrub used in perennial gardens or as butterfly attractants. It is both drought and heat tolerant making it well suited for the Southeast. No prior studies have determined the sensitivity of buddleia to ozone.

Nine buddleia cultivars were evaluated for foliar injury to three ozone regimes: *Buddleia davidii* 'Empire Blue', 'Black Knight', 'Royal Red', 'Opera', Charming Summer' and 'Pink Delight'; *Buddleia davidii nanhoensis* 'Nanho Blue'; *Buddleia fallowiana* 'Lochinch'; and *Buddleia x weyeriana* 'Sungold'. Uniform liners were transplanted into trade gallon pots containing a medium of amended pine bark and sand (7:1, v/v) on April 23, 1994. The treatments consisted of 1) charcoal-filtered air (CF), to reduce ozone approximately 50% below ambient level; 2) non- filtered ambient air (NF), and 3) air injected with ozone at 2.5X NF. The high ozone level is similar to levels found in large urban areas such as Atlanta or Birmingham. Three plants per cultivar were exposed to each treatment using open-top chambers. Treatments were replicated over time with each of four exposure periods lasting twenty-one days. After the exposure period, plants were evaluated for foliar injury by estimating the percent of the leaves damaged (PLD) and the leaf area injured (LAI). The LAI is a scale from 0 to 5 where 0:0%, 1:>0% <10%, 2:>10% <25%, 3: >25% <50%, 4:>50% <75%, 5:>75% of the leaf area injured.

Results and Discussion: No plants in the CF treatment developed signs of foliar injury during the study. Two cultivars developed signs of injury in the NF treatment. 'Royal Red' had 6.8% of the leaves damaged and a LAI rating of 2.1. 'Black Knight' had a higher PLD, 7.6%, but a lower LAI of 1.3. Injury to plants in the NF treatment was confined to the oldest leaves and was characterized as bronzing on the upper leaf surface. All cultivars were injured in the 2.5X treatment, the most severely being 'Royal Red' with a PLD of 57.1% and a LAI of 3.7 and the least being 'Pink Delight' with a PLD of 2.9% and a LAI of 0.4. Signs of ozone injury ranged from a light bronzing on the upper leaf surface of slightly injured cultivars to chlorotic leaves with dark red to purple blotches for the most severely injured cultivars. The most severely injured plants exhibited symptoms on all but the youngest leaves. Response to CF and NF treatments was similar for all cultivars when compared for PLD. For LAI the only cultivar that had a significant difference was 'Royal Red'. When comparing the 2.5X treatment and the CF or NF treatment 'Royal Red', 'Black Knight', 'Charming Summer', and 'Nanho Blue' all showed significantly more injury in the 2.5X ozone treatment. Potential increases in insect infestations may accompany ozone injury since after removal from the chambers spider mites preferred plants that had been exposed to the 2.5X treatment.

Significance to the Nursery Industry: The rapid growth in the nursery crop and landscape industries in the Southeast may be impacted by increasing ozone levels. Information is needed on the sensitivity of landscape plants grown in the southern hardiness zones, including symptoms of ozone injury, and the identification of sensitive and tolerant plant species. This study shows that cultivar differences exist among *Buddleia*. Two cultivars showed signs of injury at ambient levels and all showed that elevated ozone levels have the potential to cause visible injury. Two cultivars, 'Royal Red' and 'Black Knight', appear to be extremely sensitive to ozone. This could mean lower quality plants for consumers since injured plants were not as aesthetically pleasing.

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Table 1. Ozone sensitivity of *Buddleia* cultivars.

		PLD[Z]			LA[Y]	
Cultivar	CF[X]	NF[X]	2.5X[X]	CF	NF	2.5X
Royal red	0 b[W]	6.8 b	57.1 a	0 b	2.1 a	3.7 a
Black Knight	0 b	7.6 b	35.0 a	0 b	1.3 b	3.2 a
Charming Summer	0 b	0 b	5.4 b	0 b	0 b	0.9 b
Nanho Blue	0 b	0 b	4.2 b	0 b	0 b	1.0 b
Lochinch	0 b	0 b	4.4 b	0 b	0 b	0.6 b
Sungold	0 b	0 b	4.4 b	0 b	0 b	0.6 b
Empire Blue	0 b	0 b	3.9 b	0 b	0 b	0.4 b
Pink Delight	0 b	0 b	2.9 b	0 b	0 b	0.4 b
Opera	0 b	0 b	2.5 b	0 b	0 b	0.3 b

[Z] Percent of the leaves damaged.

[Y] Leaf area injured scale form 0- to 5 where 0:0%, 1:>0%<10%, 2:>10%<25%, 3:>25%<50%, 4:>50%<75%, 5:>75% of the leaf area injured.

[X] CF + charcoal-filtered air, NF = non-filtered air, 2.5X = ozone at 2.5X NF.

[W] Means within a row and category separated by single degree of freedom orthogonal contrasts, $p \leq 0.05$.

Initial Seedling Growth of Atlantic White Cedar as Influenced by Temperature and Photoperiod

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Nature of Work: Atlantic white cedar [Chamaecyparis thyoides (L.) B. S. P.], also known as Southern white cedar or swamp juniper, is an evergreen tree indigenous to a narrow coastal belt, 80-209 km (50-130 miles) wide from southern Maine to Mississippi (5). The species has soft, blue-green leaves that are four ranked, scale-like, aromatic when crushed, and reaches a height of 12-22 m (40-75 ft). The narrow, conical form of the tree supports slender, horizontal to pendulous branches with descending terminal shoots. The durable wood is used for house siding, boat construction, fencing, furniture, telephone poles, railroad ties, pilings, and waterfowl decoys Atlantic white cedar also has potential for wetlands reclamation and as an ornamental and Christmas tree.

Although Atlantic white cedar occurs over a large area, pure stands are relatively small (6). The species occurs on wet sites in acidic, fresh-water swamps and bogs near sea level and along stream banks and usually grows on hummocks slightly elevated above the forest floor. Throughout its range, natural stands are diminishing rapidly. This destruction has been followed by inadequate regeneration measures. Acreage of white cedar in North Carolina alone has declined by as much as 90% in the last 2 centuries due to extensive drainage, agricultural clearing, wildfires, and logging (2).

Due to accelerated loss of natural stands and efforts directed at wetlands reclamation, there is currently great interest in propagation, culture, and field establishment of Atlantic white cedar. However, little research has been reported regarding the aforementioned. Therefore, the objective of this study was to determine the optimum photoperiod and day/night temperature for initial seedling growth.

On Mar. 24, 1994, uniform seedlings of a Bladen Co., N. C. provenance were transplanted individually into RLC-4 Ray Leach Cone-tainers containing a medium of 1 peat: 1 perlite: 1 vermiculite (v/v) amended with Osmocote 18-6-12 at 2.1 kg m-3 (3.6 lb yd-3) and were grown under greenhouse conditions for 1 month. On April 19, 1994, uniform seedlings were then transferred to the Southeastern Plant Environment Laboratory (Phytotron) and the experiment was initiated. At treatment initiation, plant heights and stem diameters were recorded from the base of the lowest needle on the main stem. In addition, six plants were harvested to determine total root lengths and root areas utilizing a Monochrorne Agvision System 286 Image Analyzer. Initial top and root dry weights [dried at 70°C (1 58°F) for 72 hrl were also recorded. Temperature treatments were then initiated using controlled environment A-chambers (1).

The study was a completely randomized design with a 4 x 4 x 2 factorial arrangement of treatments consisting of four, 9-hr day temperatures of 18°, 22°, 26°, or 30°C (64°, 72°, 79°, or 86°F), four, 16-hr night temperatures of 14°, 18°, 22°, or 26°C (57°, 64°, 72°, or 79°F) and two photoperiods [a short day (9-hr) and a long day (9-hr day with a 3-hr daily night interruption from 11:00 PM to 2:00 AM]. There were 10 single plant replications per treatment. Plants were moved between chambers at 7:30 AM and 4:30 PM daily to maintain appropriate day/night temperatures. Seedlings were fertilized twice weekly with the standard Phytotron nutrient solution (1) and watered with deionized water on remaining days. Plant heights were recorded every 2 weeks.

Seventy-eight days after treatment initiation, needle gas exchange was measured with a LI-COR LI-6200 closed portable infrared gas exchange system. Photosynthetically active radiation (PAR), air and needle temperatures, and relative humidity inside a 0.25 liter (0.27 qt) leaf chamber were measured concurrently with gas exchange for 30 sec. Net needle photosynthetic rates (PN)S were calculated from

Results and Discussion. Data were recorded approximately 5-10 cm (2-4 in) from the terminal portion of a lateral branch on each of three plants per long day temperature treatment. Seventy-nine days after treatment initiation, final heights and stem diameters were recorded in addition to crown width which consisted of two branch measurements at a 90° angle. Roots were washed free of medium and seedlings were separated into tops and roots. Before drying at 70°C (158" F) for 72 hr. total root length, and root area of three plants per treatment grown under long days were measured. Roots were first stained with 1% methylene blue for 48 hr and were then measured utilizing a Monochrome Agvision System 286 Image Analyzer. Data were subjected to analysis of variance procedures (ANOVA) and regression analysis. Results and Discussion: Dry matter production was influenced by day and night temperatures and photoperiod. Significant day temperature x photoperiod interactions occurred for caliper, crown width, and top dry weight. There were no significant interactions for root dry weight, root area, or root length. Optimum day temperature for top and root dry weight was 30°C (86°F) whether seedlings were grown under short or long days (Fig. 1). Root area and total root length were also maximized at days of 30°C (86°F) for long day seedlings. This is in contrast to data reported for Fraser fir [Aties fraseri (Pursh) Poir.] as days/nights of 30°/26°C (86°/79°F) resulted in death of some seedlings with the remaining seedlings being spindly with poorly developed root systems (4). Greatest caliper and height were also realized at days of 30°C (86°F). Long day plants had greater values for all growth measurements than short day plants except for caliper ($P < 0.05$) Short day plants had slightly greater caliper growth at 26°C (79°F) than long day plants ($P < 0.05$). A quadratic response to increasing day temperatures was noted for crown width for plants grown under long days with a maximum at days of 22°C (72°F). A similar response was observed for short day plants with a maximum at 26°C (79°F).

Significant night temperature x photoperiod interactions occurred for crown width and top dry weight. Optimum night temperature for top and root dry weight of seedlings was 26°C (79°F) whether grown under short or long days (Fig. 2). Similarly, Hellmers (3) reported when nights were warmer than days, dry-weight production in seedlings of red fir (Abies magnifica A. Murr.) was favored. Regardless of night temperature, top and root dry weights were lowest at days of 18°C (64° F) (Fig. 1). Greatest caliper, height, root area, and root length were also realized at night temperatures of 26°C (79°F). With regard to crown width, long day plants had a quadratic response to increasing night temperatures as a maximum occurred at nights of 22°C (72°F). A linear response was noted for short day plants with maximum crown width at nights of 26°C (79°F). A significant day x night temperature interaction occurred for net leaf photosynthetic rates.

Significance to Industry: here is currently great demand for transplants of Atlantic white cedar for reclamation efforts. Data indicate that optimal seedling growth of Atlantic white cedar can be achieved by utilizing a day/night cycle of 30°/26°C (86°/79°F) with long day conditions.

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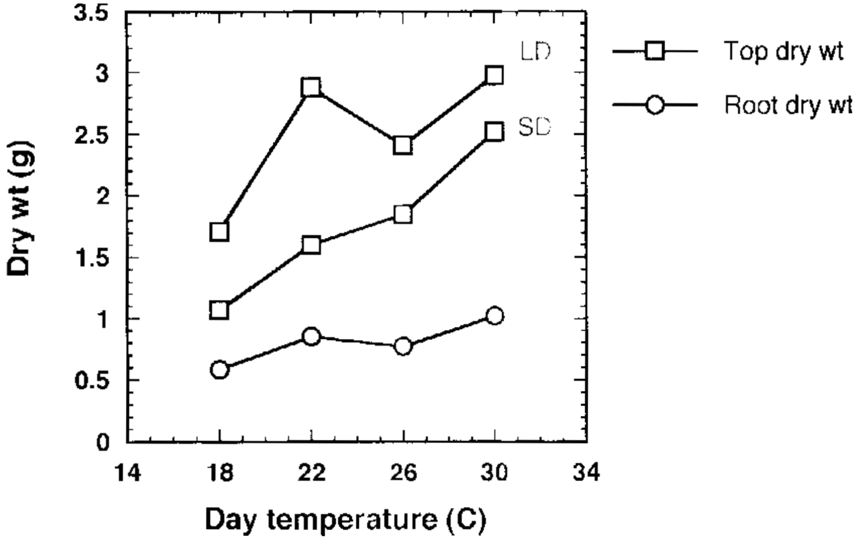

Fig. 1. Effects of day temperatures averaged over all night temperatures for top and root dry weight during initial seedling growth of Atlantic white cedar. For top dry weight, each symbol is a mean of 40 observations and for root dry weight, each symbol is a mean of 80 observations combined over photoperiods. LD = long days and SD = short days.

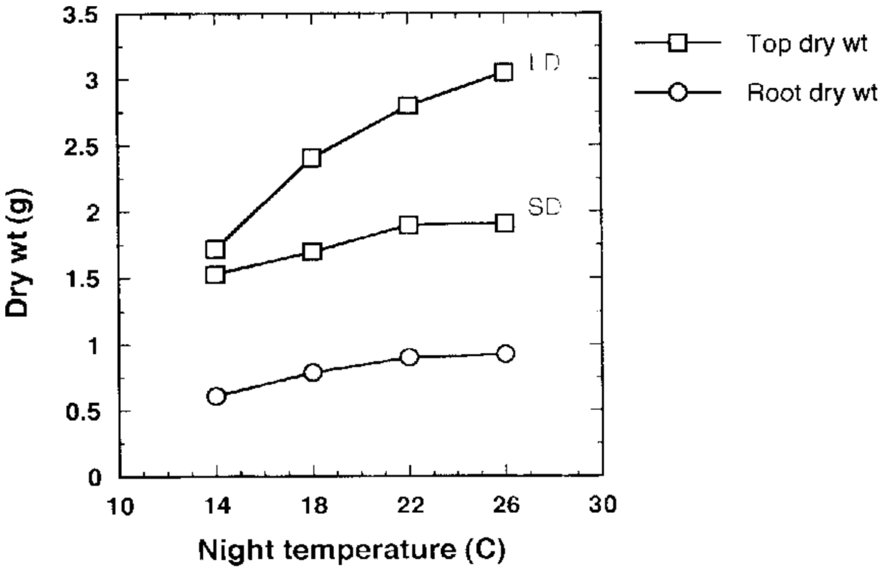

Fig. 2. Effects of night temperatures averaged over all day temperatures for top and root dry weight during initial seedling growth of Atlantic white cedar. For top dry weight, each symbol is a mean of 40 observations and for root dry weight, each symbol is a mean of 80 observations combined over photoperiods.

Effect of Horticultural Oil and Pruning on Crapemyrtle Aphid Eggs

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Nature of Work: Crapemyrtle (*Lagerstroemia* spp.), an ornamental tree frequently used in southern landscapes, requires little maintenance and is relatively pest free. The crapemyrtle aphid, *Tinocallis kahawaluokalani* (Kirkaldy) is the primary insect pest. Crapemyrtle aphids are host specific and exist as non-sexual adults giving birth to live young throughout the spring and summer months. Should a resistant aphid appear, asexual reproduction would favor a rapid shift from susceptible to resistant aphids when sprayed. Feeding aphids also excrete honeydew which serves as a source of food for various sooty molds. The sooty molds form a black film on the leaves which reduces plant vigor, reduces aesthetic quality, and causes leaf drop. The objective of this experiment was to evaluate the effects that horticultural oil and pruning have on overwintering crapemyrtle aphid eggs.

On May 20, 1994, one gallon 'Acoma' crapemyrtles were transplanted into three gallon containers containing an 8:1 pine bark:sand (by vol.) substrate, and two ounces of Osmocote High N 24-4-7 was surface applied. Trees were arranged in a randomized complete block design with six blocks and twelve trees per block. Water was supplied at two quarts a day via Robert's Spray Stakes. In July 1994 adult and immature crapemyrtle aphids were introduced. Crapemyrtles were 30 to 36 inches tall at treatment initiation on March 27 , 1995. Treatments consisted of a 2% and 4% (by vol.) SunSpray Ultra-Fine Spray Oil, pruning and an untreated control. Oil sprays were applied with a backpack sprayer as a fine mist at 60 psi until tree surfaces were wet. Pruning consisted of a 30% reduction of shoot length with a heading back cut. Treatments were applied in late winter as susceptibility of overwintering eggs to petroleum oil treatments increases the closer the eggs are to hatching (Chapman and Pearce, 1949), and cold hardiness increases in crapemyrtles pruned in late winter (Haynes et al., 1993). Immature aphids were observed in mid-April, and aphid counts were made before immature aphids reached the winged adult stage. For aphid counts the trees were divided into four quadrants and lateral branches were randomly removed from each quadrant. A total of 20 lateral branches were examined from each plant with each branch containing six to eight leaves. Treatment means were subjected to an analysis of variance (ANOVA) and compared using least significant difference with a P = 0.05.

Results and Discussion: Oil treatments significantly reduced aphid populations compared to the untreated control (Table 1). However, there was no difference between the 2% and 4% oil treatments, and the pruning treatment was not different from the control or oil treatments.

Alverson and Allen (1992) found 35% of crapemyrtle aphid eggs were within 8 inches of limb terminals and 54% of aphid eggs within 16 inches of limb terminals on 40 inch stems. In this experiment, the pruning treatment removed 10 to 12 inches from the stems of each tree which was not long enough to significantly reduce the initial aphid population. Pruning may not be a viable option for young or small crapemyrtles since a large percentage of the tree would have to be removed to effectively reduce the number of aphid eggs. These data in conjunction with Alverson and Allens' (1992) suggest that a 30% heading back may reduce the number of aphids if crapemyrtles are larger than three feet. Thus, pruning six to eight foot crapemyrtles with a 30% heading back might reduce the number of overwintering aphid eggs.

Significance to Industry: The first generation of aphids can be reduced using oil applications to aphid eggs. Smaller first generation populations delay and reduce the need to spray. They may also reduce the risk of aphid resistance to pesticides used during the growing season, and may delay sooty mold build up by reducing the number of aphids excreting honeydew.

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Table 1. Effect of horticultural oil and pruning on crapemyrtle aphid eggs.

Treatment	Aphid no.
Untreated	3.25 a[z]
Pruned[y]	2.00 ab
2% Oil (by vol)	1.33 b
4% Oil (by vol)	0.75 b

[z]Means followed by the same letter are not significantly different as determined by least significant difference at 5%.

[Y]Trees were pruned to remove 30% of existing growth.

Use of Recycled Newspaper as a Container Medium Amendment

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Alabama

Nature of Work: On average, 67% of MSW (municipal solid waste) in the U.S. goes to landfills, 23% is recycled, and 10% is incinerated. Average cost of disposal of MSW in landfills in the U.S. ranged from a low of \$8 $tons^{-1}$ in New Mexico to \$75 ton^{-1} in New Jersey in 1994 (1). In addition to the high cost of MSW landfill disposal, the U.S. Environmental Protection Agency (EPA) has established a national goal of reducing the nation's dependence on landfill disposal by source reduction or recycling. By adopting this as a national goal, EPA has emphasized the need for a change in the nation's approach to producing, packaging and disposing of consumer goods. Numerous studies have been conducted with organic waste by-products as a soil amendment, surface mulch, or a residue cover during fallow periods with agronomic crops (2). Organic waste by-products, when applied properly, have increased soil organic matter content, total soil N, reduced soil erosion, wind erosion, and increased crop yields of soybean, cotton, and corn (3). The nursery industry utilizes large volumes of organic products as media or media amendments in the production of container grown crops. Thus, our objective was to evaluate recycled newspaper products as a medium amendment for annual bedding plants. Three experiments were conducted in this study. In experiment 1, four bedding plants: dusty miller, impatiens, celosia, and pansy, were grown in one of four recycled paper media (7:1; 3:1; 2:1; and 1:1 pine bark/recycled newspaper, v:v) with 2 Osmocote rates (14-14-14) (10 and 14 lbs/yd^3) and two standard medium (7:1 pine bark/sand, 3:1 pine bark/peat v:v). Plants were potted on November 18, 1994. On January 23, 1995, data was collected and included plant dry weight. In experiment 2, pansy and snapdragons were grown with 3:1 pine bark/newspaper medium amended with either 10, 20, or 30 lb/yd3 of Osmocote 14-1414 with the C:N ratio adjusted to 30:1 with either poultry litter, ammonium nitrate or urea. Data collected included: flower number, shoot dry weight, and nutrient concentration. In experiment 3, impatiens were grown in the 3:1 pine bark/newspaper medium with the C:N ratio adjusted to 30:1 with poultry litter (2.8%N) in a 3x2x2 factorial of Osmocote (0, 10, or 20 lblyd3); dolomitic lime (0 or 5 lblyd3); and Micromax (0 or 1.5 lb/yd^3). Data collected included medium pH soluble salts flower number, and shoot dry weight at the end of the study.

Results and Discussion: In experiment 1, there was no C:N ratio adjustments of the pelletized recycled newspaper. Shoot dry weight and N concentration of dusty miller and pansy decreased with increasing rates of recycled newspaper used in the growth media. Growth media pH was in the range of 6.9 to 7.5 at harvest and may have contributed to growth reduction. Increasing the rate of Osmocote from 10 to 14 lbs/yd3 in the growth media did not eliminate the nutrient deficiencies. In experiment 2, C:N ration of the recycled newspaper was adjusted to 30:1 with different forms of N (urea, NH4NO3, and poultry litter) in combination with rates of P (O and 16.5 lb/yd3 in the growth media with 10, 20 or 30 lb/yd3 of Osmocote 14-14-14. The different forms of N used to adjust C:N ratio did not affect plant growth. Increasing P levels in the growth medium decreased shoot dry weight of pansies but no affect was observed with snapdragrons. Increasing the Osmocote rate in the growth medium from 10 to 30 lb/yd3 did not affect shoot dry weight of either plant species. In experiment 3, recycled newspaperamended media produced the largest plants compared to the standard control treatment. Impatiens shoot dry weight was increased with Osmocote rates, but the addition of lime and micromax micronutrients did not benefit plant growth in the newspaper amended medium.

Significance to Industry: The nursery industry utilized large volumes of peat moss, a nonrenewable resource, in the production of ornamental plants. These data demonstrate recycled newspaper has potential for used as a medium amendment and/or possible replacement for peat moss. The newspaper product has uniform consistency and will be widely available.

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Table 1. Effects of osmocote, lime and micromax on impatiens shoot dry weight and media pH and soluble salts at 2 week intervals.

Media	Osmocote	Lime	Micromax	Shoot Dry Wt	Media pH				Soluble salts			
composition		lb/yd^3		g/pot	Initial	2 wk	4 wk	6 wk	initial	2 wk	4 wk	6 wk
3:1 PB/NP[1]	0	0	0	9.56	5.1	6.8	6.7	6.4	2.38	1.04	0.32	0.07
	0	5	0	9.59	5.5	6.9	6.9	6.8	2.38	1.23	0.51	0.14
	0	5	1.5	10.99	5.3	6.8	6.8	6.7	2.97	1.58	0.49	0.11
	0	5	1.5	9.72	5.0	6.6	6.6	6.6	2.55	1.26	0.45	0.10
	10	0	0	12.57	4.5	6.6	6.5	6.3	6.03	1.42	0.54	0.11
	10	5	0	12.19	5.0	6.8	6.9	6.7	5.35	1.31	0.38	0.09
	10	5	1.5	12.04	4.7	6.6	6.7	6.7	6.12	1.04	0.40	0.14
	10	0	1.5	10.17	4.3	6.5	6.5	6.4	6.24	0.72	0.35	0.09
	20	0	0	14.07	4.4	6.8	6.7	6.4	10.88	1.03	0.68	0.09
	20	5	0	15.13	4.5	7.1	6.7	6.6	7.29	1.23	0.61	0.12
	20	5	1.5	13.88	4.6	6.8	6.7	6.6	8.70	1.37	0.59	0.09
	20	0	1.5	12.38	4.2	6.5	6.5	6.4	5.23	1.08	0.45	0.09
7:1 PB/S[2]	10	5	1.5	8.8	5.2	6.3	6.3	6.5	1.36	0.61	0.31	0.08

[1] 3:1 Pine bark/newspaper with C:N ratio adjusted to 30:1 with poultry litter.
[2] Control 7:1 Pine bark/sand medium.

Irrigation Volume and Controlled Release Fertilizers Influence Plant Growth

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Nature of Work: Water quality and quantity are becoming the number one environmental concern in the horticulture industry (Urbano, 1989). Irrigation and fertilization practices directly affect the quantity of water and nutrient content lost from the container substrate. Current production practices involve the excessive use of water and fertilizer in order to maximize plant growth. By determining the amount of water necessary to optimize plant growth, water resources can be used more efficiently. As irrigation application efficiency increases, volume of water needed may be reduced since more water is retained in the substrate and the amount of water and nutrients leached decreases. Controlled release fertilizers (CRF) are efficient (Warren et. al., 1995) and are designed to release nutrients slowly over a period of time as plants need them which could potentialy reduce the amount of nutrients lost (Warren et. al., 1995). This research was conducted to determine the effects of reduced irrigation volume and CRF on plant growth.

The experiment, a randomized split plot design with 3 replications was conducted on a gravel pad. Main plots were irrigation volumes of 200 ml (0.3 in), 400 ml (0.6 in), 800 ml (1.1 in), and 1200 ml (1.7 in) applied once a day and the same volumes applied in two applications with a two hour rest interval between irrigation allotments. Irrigation was applied via pressure compensated spray stakes at a rate of 200 ml/min (0.3 in/min). Within each main plot, subplots consisted of one of five fertilizers: Meister 21-7-14 (Helena Chemical Co., Tampa, Fla.) composed of 0.5% NO3, 0.7% NH4, and 19.8% polymer coated urea (hereafter referred to as polymer coated urea); Osmocote 24-4-7 (The Scotts Co., Marysville, Ohio) made up of 6.6% NH4, 5.9% NO3, and 11.5% urea (hereafter referred to as resin coated NH4NO3); Scotts 23-4-8 (Experimental fertilizer #S5037, The Scotts Co.) composed of urea (hereafter referred to as polymer coated N); Sustane 5-2-4 (Sustane Corp., Cannon Falls, Minn.) consisted of 0.8% NH4 and 4.2% organic N and organic P (hereafter referred to as composted turkey litter); and Woodace 21-6-12 (Vigoro Industry, Inc., Fairview Heights, III.) composed of 1% NO3, 16.5% urea, and 3.5% water insoluble N (hereafter referred to as urea). Cotoneaster dammeri 'Skogholm' plants were potted into 3.8 liter (4 qt) containers in a pine bark: sand (8:1 by vol) substrate amended on a m3 (yd3) basis with 1.8 kg (4 Ibs) dolomitic limestone and 0.9 kg (1.5 Ibs) micronutrient fertilizer. Each plant was fertilized at potting (May 23, 1994) to acheive 3.5 9 N per container. All fertilizers were incorporated. Irrigation treatments were initiated on day 0 (May 30, 1994) and the study was terminated 120 days later. At harvest, shoots (aerial tissue) were removed and roots were placed over a screen and washed with a high pressure water stream to remove substrate. Plant tissues were dried at 62C (144F) for 5 days and weighed.

Results and Discussion: Composted turkey litter had the lowest dry weight of all fertilizers at all irrigation volumes and was not affected by irrigation volume (Table 1). Dry weight of plants fertilized with polymer coated urea, resin coated NH4NO3 and urea increased quadratically with increasing volume; while dry weight increased linearly with increasing irrigation volume when plants were fertilized with polymer coated N. Greatest dry weight occurred with 400 (0.6 in), 800 (1.1 in), 800 (1.1 in), and 1200 ml (1.7 in) for polymer coated urea, resin coated NH4NO3, urea and polymer coated N respectively, which suggests that lower volumes of water could be used with polymer coated urea, resin coated NH4NO3, and urea in order to maximize plant growth. Resin coated NH4NO3 and polymer coated N resulted in dry weight greater than urea at all volumes except 200 ml (0.3 in).

At 200 ml (0.3 in) all fertilizers except composted turkey litter yielded similar results with regard to total plant dry weight (Table 1). At 400 ml (0.6 in) polymer coated urea, resin coated NH4NO3 and polymer coated N resulted in greater total plant dry weight than composted turkey litter and urea. At 800 and 1200 ml (1.1 and 1.7 in) resin coated NH4NO3 and polymer coated N produced greater total plant dry weight than urea which was greater than polymer coated urea and composted turkey litter.

Significance to the Nursery Industry: Optimal plant growth was achieved by using reduced volume of irrigation in combination with some CRFs in this experiment. In some cases 0.6 or 1.1 in. of irrigation per day produced a larger plant that 1.7 in. per day which indicates that lower volumes of irrigation water are adequate for optimal plant growth thus improving water efficiency. Understanding how CRFs respond to decreased irrigation volumes can be beneficial in selecting irrigation and fertilization regimes to maximize plant growth.

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Table 1. Effect of irrigation volume and fertilizer Cotoneaster dammeri 'Skogholm' total plant dry weight.

	Total plant dry weight (g)				
	Fertilizer				
Irrigation volume (mls)	Polymer coated urea	Resin coated NH_4NO_3	Polymer coated N	Composted turkey litter	Urea
200	75.7 a[z]	79.5 a	73.4 a	54.1 b	73.0 a
400	104.7 a	106.7 a	108.0 a	55.1 c	90.1 b
800	87.1 c	119.5 a	118.4 a	49.7 d	98.5 b
1200		78.7 c	117.3 a	123.4 a	40.4 d
96.9 b					
Significance[y]					
Linear	0.021	0.001	0.001	NS	0.011
Quadratic	0.013	0.001	0.001	NS	0.039

[z] Means withina row (irrigation volume) followed by the same letter or letters are not significantly different as determined by LSD, $p = 0.05$.

[y] Regression analysis of irrigation volume, NS = $p > 0.05$.

Alternative Utility Line Plants

Barbara Touchette and Bonnie Appleton
Virginia

Nature of Work: Trees are valuable assets contributing to increased property values. Trees also help conserve energy, screen less aesthetic views, help wildlife, and provide enjoyment because of their form and seasonal interest.

Unfortunately, trees can be an expensive public relations problem resulting in increased trimming costs for utility companies trying to maintain a reliable source of power (10).

Issues utility companies must deal with include: 1) Trim cycles - on an average, trees are trimmed every 3 years; 2) Limiting the number of power interruptions; 3) Keeping labor costs down; 4) Trimming more trees in less time; 5) Controlling faster growing species which demand trimming more frequently than the normal 3 year cycle; 6) Generating satisfaction amongst customers; 7) Maintaining healthy trees; and 8) Searching for more effective tools to complete their job (6).

Native forest trees with heights in excess of 100 feet line many of our older city streets (8). As utilities were erected, these trees often proved too tall to fit under the utility lines. Service access was provided to utility customers by cutting through these magnificent old giants. This process of severely pruning or topping trees permits disease or insect entry, and removes valuable food/shade producing canopy (1). Eventual health decline often leads to fallen limbs during heavy winds or ice storms, frequently causing power outages.
Customers often express dissatisfaction with the appearance of trees that utility companies have trimmed. To minimize dissatisfaction with this perceived mutilation of trees, utility companies use natural, lateral, or directional pruning methods. Developed by arborists and arboriculture association members, these methods encourage new limbs to grow away from power lines (2).

Trimming, however, is expensive, repetitive and dangerous work for utility companies. As an alternative, companies such as Dow Elanco have created tree growth regulators (TGRs) which chemically suppress gibberellin and thereby reduce overall tree growth (4). This reduction helps to decrease the national annual average $3-5 million tree trimming cost, and the disposal of 13 million tons/year of chipped biomass (10).

Research published in 1995 by Mann et.al. indicated a 58% reduction in job site time needed for drop crotch trimming (V-trim) of TGR-treated silver maple trees under three phase conductors (9). This data is comparable to a 59% reduction in trim and chip time for the same species as reported by Redding et.al. in 1994 (10). 1995 test results published by Sterrett and Dow Elanco showed a 30-50% biomass growth reduction in American sycamore, red oak, white ash and tulip tree with the use of flurprimidol or Cutless tree implants (5).

Early TGR problems associated with pressure injection methods caused wound weeping, trunk splitting (above and below the injection site), wound compartmentalization extending from root flare to crown, and ring shake or internal separation of tree growth rings (4). Newer methods of tree implants, and especially basal drench, are less injurious and only slightly less effective. Species sensitivity to chemicals and method of application must be considered (10).

One of the best solutions to expensive utility line maintenance lies in the selection of alternative plants for use under or near utility lines. These plants, both small trees and large shrubs, require little or no trimming or TGR use.

The use of alternative trees and/or shrubs was the subject of a survey conducted in 1993 (3). Arborists and horticulturists responded with comments on street plants currently used under or near utility lines. They also listed preferred characteristics of trees and shrubs for street utility locations, and potential alternative plants to use.

Results and Discussion: A demonstration Utility Arboretum has been established at the Hampton Roads Agricultural Research and Extension Center (HRAREC), Virginia Beach. Funding has been provided by numerous grants from the Urban and Community Forestry Grant Assistance Program (Virginia Department of Forestry) and the Virginia Nurserymen's Association for the purchase of plants. In addition, Virginia Power erected 3 utility poles and 2 spans of uncharged wire on the arboretum site.

The purpose of the Utility Arboretum is to trial many of the above suggested species, along with other alternative selections. A total of 97 small trees and large shrubs have been planted (Table 1). In addition, two inappropriately tall trees - *Acer rubrum* (red maple) and *Platanus x acerifolia* (London planetree) have been planted for height comparisons.

Yearly growth measurements (height and caliper) are being taken to determine whether these small trees and large shrubs will require too much pruning from an economic stand point to train into street tree forms. We are also studying appropriate timing of pruning and limbing up (basal branch removal) to reduce the incidence of suckering.

Significance to Industry: The goal of the HRAREC Utility Arboretum is to provide suggestions of alternative small trees and large shrubs for incorporation into future utility designs, either during initial installation, or when changes to existing utility infrastructures need to be made (7).

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Table 1. Small trees and large shrubs being trialed under utility lines at the Hampton Roads Agricultural Research and Extension Center, Virginia Beach, VA.

Small Trees

Acer buergeranum
Acer ginnala 'Flame'
Acer griseum
Acer palmatum
Aesculus pavia
Alnus glutinosa
Amelanchier laevis 'Cumulus'
Aronia sp.
Betula nigra (dwarf form)
Carpinus caroliniana
Carpinus japonica
Catalpa x Chilopsis
Cercidiphyllum japonicum
Cercis canadensis
Cercis canadensis 'Forest Pansy'
Cercis canadensis 'Silver Cloud'
Cercis 'Texas White'
Cercis mexicana

Chioanthus virginicus
Chioanthus retusus
Clethra acuminata
Cornus x 'Stellar Pink'
Cornus alternifolia
Cornus kousa angustata
Cornus mas
Cornus mas 'Spring Glow'
Cornus officinalis
Crataegus crusgalli var. inermis
Crataegus mollis
Davidia involucrata
Eriobotrya japonica
Franklinia alatamaha
Gordonia lasianthus
Halesia carolina
Ilex decidua 'Council Fire'
Koelreuteria paniculata
Lagerstroemia indica 'Miami'
Maackia amurensis
Magnolia x 'Galaxy'
Magnolia grandiflora 'Little Gem'
Magnolia kobus
Magnolia sieboldii
Magnolia stellata
Magnolia virginiana
Magnolia virginiana var. australis
Malus 'Centurion'
Malus 'Indian Magic'
Myrica cerifera
Oxydendrum arboreum
Parrotia persica
Photinia davidsonian
Prunus cerasifera 'Thundercloud'
Prunus mume 'Bonita'
Prunus mume 'Peggy Clark'
Prunus x yedoensis
Quercus myrsinifolia
Rhus copallina
Sinojackia rehderana
Sophora affinis
Stewartia pseudocamellia
Styrax japonicus
Styrax japonicus 'Issai'
Styrax japonicus 'Sohuksan'
Styrax obassia
Syringa reticulata (S. amurensis)
Ulmus parvifolia (small-leaved clone)

Large Shrubs

Amorpha fruticosa
Caragana arborescens
Cotinus coggygria 'Royal Purple'
Daphniphyllum macropodum
Exochorda racemosa
Hamamelis x intermedia 'Arnold Promise'
Hamamelis x intermedia 'Diane'
Hamamelis virginiana
Heptacodium miconodes
Hibiscus syriacus
Hydrangea paniculata 'Grandiflora'
Ilex x 'Nellie R. Stevens'
Myrica cerifera
Photinia x fraseri
Photinia villosa
Pseudocydonia sinensis
Syringa villosa
Syringa vulgaris
Viburnum awabuki 'Chindo'
Viburnum maresii
Viburnum opulus
Viburnum prunifolium
Viburnum rhytidophyllum
Viburnum x rhytidophylloides
Viburnum tinus
Viburnum trilobum
Vitex agnus-castus

Extraction and Partial Purification of *Discula destructiva* Phytotoxins from Culture Filtrates

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Nature of Work: Dogwood anthracnose is caused by Oiscula destructiva Red. and is a serious disease for many members of the genus Cornus L. The major symptoms of dogwood anthracnose are rapidly developing blight of leaves and shoots, characterized by a browning and shriveling of young leaves during leaf expansion; large irregular necrotic areas on distorted leaves that otherwise remain green; and small necrotic spots on mature leaves (1). Necrosis was shown to occur in leaves with few visible hyphae suggesting the involvement of a toxin (6). The overall purpose of this research was to isolate fungal toxins, demonstrate their involvement in disease symptoms and determine specific response of various Cornus spp. to the toxins.

Discula destructiva conidia at a rate of 5 x 1 o6 conidialml were used to inoculate a basal Murashige-Skoog medium (4) modified with 30 9 sucrose. Cultures were grown as still cultures for 10 months at 23i2°C and 12 hr photoperiod. Extraction and separation protocol was a modification of procedures used to study Pythium spp. (2) which included ultrafiltration through 100,000 and 3,000 molecular weight membranes followed by Iyophilization. High performance liquid chromatography (HPLC) was used to further separate the culture filtrate. HPLC conditions were as follow: Hewlett-Packard 1090 HPLC equipped with a diode array detector, solvent of 100:0 water with 2% acetonitrile:acetonitrile for 10 min., followed by gradient 100:0 to 85:15 for 10 min, and 0:100 for 10 min, flow rate 0.4 ml/min for first 10 min then 0.5 ml/min for remainder of run, reverse phase C,8 column (3 p) and 250 pl injection. HPLC fractions were collected and Iyophilized for testing for toxic activity. HPLC fractions were obtained from two samples of the HPLC filtrate at the 23.5-24.5 min interval for 100 MS. MS broth similarly treated was used as a control.

Demonstration that D. destructiva toxins have a significant role in disease symptom expression in dogwood anthracnose was accomplished using a modification of a leaf-puncture bioassay (3, 4). Toxicity was demonstrated using a dose-response format with a leaf puncture-wound overlay technique. Leaves in the second leaf pair were wounded with a 26 ga. needle and each puncture site was overlaid with 10 pl of a 1:2 dilution of HPLC fractions or water control.

Cornus florida, C. controversa, C. alba, C. nuttallil, C. kousa, C. kousa Chinensis, C. candensis, C. amomum, C. racemosa, and C. angusfata were grown in GA7 magenta jars (Sigma) and used to observe the response in Cornus spp. to the partially purified toxins (PPT). Necrotic leaf area was measured over seven days.

Results and Discussion: Initial responses were observed in all Cornus spp. within 24 hr (Figures 1-3). The response observed was a necrotic lesion which continued to expand over seven days and between three and seven days the formation of a purplish red margin occurred. Young leaves became blighted while older leaves developed a more centralized lesion. Upward translocation was observed in C. canadensis and translocation to the leaf margin was observed with C. alba resulting in a secondary necrotic lesion. These in vivo symptoms are consistent with those seen in forested settings and may explain the losses of canopy in flowering dogwood and sensitivity of young seedlings to D. destructiva.

Significance to Industry: This study has demonstrated that Discula destructiva has toxins which are associated with symptom expression. The isolation of these toxins could lead to their usage in tissue culture resistance selection and to select toxin insensitive Cornus spp. Such selection is extremely important in the development of a management scheme for the control of dogwood anthracnose and in the idenfffficaffon/ development of resistant dogwood for the nursery industry

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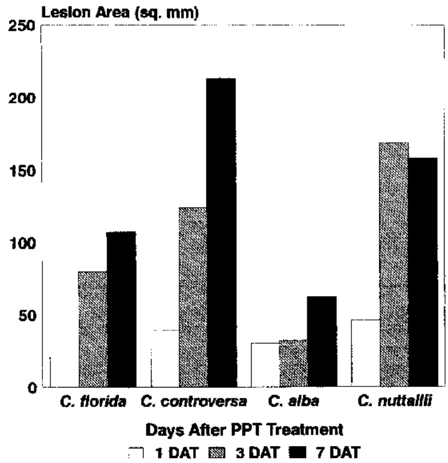

Figure 1: Relative necrotic lesion size on various *Cornus* spp.

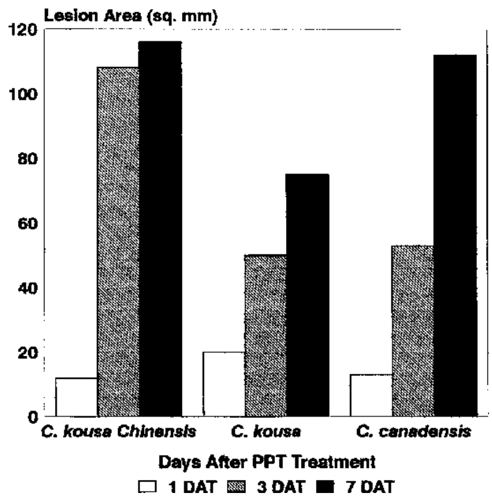

Figure 2: Relative necrotic lesion size on various *Cornus* spp.

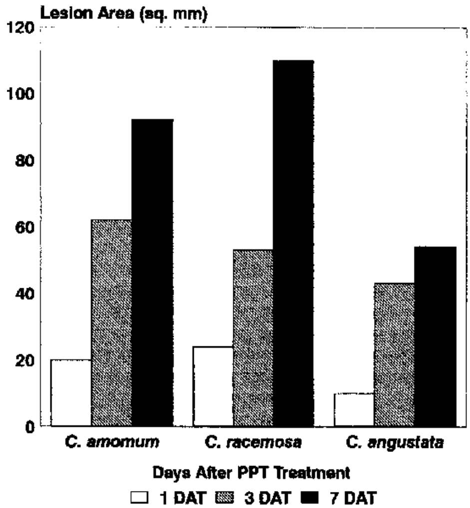

Figure 3: Relative necrotic lesion size on various *Cornus* spp.

Lawn Maintenance Expenditures of Texas Single-Family Households

Clarinda L. Smith and Dr. Charles R. Hall
Texas

Nature of Work: A research study to determine the total economic impact of the turfgrass industry in Texas is being conducted by the Texas Agricultural Experiment Station in association with the Texas Agricultural Extension Service and the Department of Agricultural Economics at Texas A&M University. Following are preliminary results of analysis of one sector, single-family households.

Economically, turfgrass provides an asset to homes by increasing property values and aesthetic appeal. Many households consider a well maintained lawn to be a vital part of a pleasant environment in which to live, work, and play. But how much do they spend in order to reap benefits of a well maintained lawn? In addition, who primarily maintains the lawn, and what are their predominant lawn care practices? These are the kinds of information that firms in the turfgrass industry must know in order to effectively satisfy turf-related needs of household consumers.

As stated by James B. Beard, "the turfgrass industry can be evaluated in three basic ways: (a) the initial capital investment required to develop and establish turfs, (b) the annual cost for maintenance of turfs, and (c) the turfgrass acreage" (1). Two of these are related to the economics of the industry which emphasizes the need for this type of research. Single-family households were evaluated in terms of their annual cost for maintenance of turf.

The main objective of the study was to determine Texas single-family households total expenditures on lawn maintenance in 1993 as well as their predominant lawn care practices.

Survey schedule development was assisted by the Texas Turfgrass Advisory Committee, a committee of selected members of the Texas Turfgrass Association. Following approval, copies of the questionnaire were sent to the Texas Agricultural Statistics Service, who was subcontracted to conduct telephone interviews of households. A statistically representative sample was surveyed utilizing an area frame sample scheme across three strata: (1) large MSA's (urban), (2) intermediate MSA's, and (3) rural areas. Six hundred two completed surveys were received, of which, 601 were usable.

Edits made before data analysis included the conversion of household lot size from square feet to acres, and questions that were interrelated were checked for accuracy to ensure internal consistency. With some variables, missing values were replaced with the sample mean. Mean expenditures per household and the number of single-family households in the state were used to expand data to state totals. In 1993, there were approximately 4.9 million single-family households (e.g. 1, detached and 1, attached) in

Texas (2). The 1990 Census of Population and Housing estimates were adjusted for the projected percentage increase in population from 1990 to 1993.

Results and Discussion: The average lot size of a single-family house was 0.802 acres encompassing 0.413 acres of turf area. Bermudagrass (57.8%) and St. Augustine (51.2%) were the most common types of grass grown in Texas lawns. Several climatic and agronomic factors have "forced" many Texas homeowners to rely on these "proven" turfgrasses. However, some homeowners did report growing other turfgrasses, including Fescue (2.2%), Rye (2.2%), Buffalograss (1.7%), Zoysiagrass (0.5%), and Centipedegrass (0.5%).

On the average, the family adult was the one primarily responsible for mowing and trimming (83.5%) as well as watering the lawn (94%). The most common lawn practice was irrigation (94%) followed by the application of fertilizers (79%) and the use of insect control (62%). Half of the households practiced weed control, and only 1 in 17 households tested the soil and/or renovated their lawn.

In terms of equipment, the most commonly used mower by Texas households was push (37%) or self-propelled (30%). Only twenty-seven percent of the respondents used a riding mower and six percent of the respondents did not own a mower. A majority of the households did not own an edger (57%); however, those owning an edger mainly used one that was gas-powered (25%) or electric (16%) as opposed to a hand edger (2%). Nearly all of the participants, who watered their lawn, used hoses and sprinklers (90%), while the remaining 10% utilized an installed irrigation system, a majority of which were automatic as opposed to manual. The main source of water was municipal water systems (78%) followed by the household's own well (19%).

Over one-half of Texas single-family households left clippings on their lawn, while only eighteen percent chose to bag clippings from their yard. This may reflect the effectiveness of the "Don't Bag It" program implemented by the Texas Agricultural Extension Service, which recommends leaving the clippings on the lawn, providing benefits to the lawn itself and reducing the amount of yard waste in municipal landfills. Others chose to compost clippings (7%) or use the clippings as mulch (19%).

All expenses reported were out-of-pocket costs excluding all opportunity and imputed costs. As outlined by Table 1, the average single-family household in Texas spent $515.08 on lawn maintenance in 1993. Equipment was the main expense at $251.04. The cost of water was $111.00, while labor & lawn service expense totaled $54.64 (see Table 1). Fertilizers and chemicals were an estimated $46.66 and $40.45, respectively. All other items totaled approximately $11.29. Of these, the greatest cost was seed & sod ($5.15), followed by mulch ($2.20), soil ($1.48), turf repair ($1.21), excavating/grading ($0.29), and other items such as organic and biological materials ($0.96) (see Table 1).

An estimated 4.9 million single-family households spent approximately $2.5 billion maintaining their lawns (see Table 1). Over $1.2 billion was spent on equipment, and the cost of water totaled an estimated $544 million. Fertilizers and chemicals were the next largest expense items totaling $229 and $198 million, respectively. All other items, including seed and sod, mulch, soil, turf repair, excavating/grading, and other items, cost households an estimated $55 million (see Table 1).

Table 1. Breakdown of Lawn Maintenance Expenditures of Texas Single-family Households, 1993.

Item		Expense per Household		State Total (millions)	
Equipment			$251.04		$1,230
Water Cost			111.00		544
Fertilizers			46.66		229
Chemicals			40.45		198
Labor & lawn service			54.64		268
Other items:	Seed & sod	5.15		25	
	Mulch	2.20		11	
	Soil	1.48		7	
	Turf repair	1.21		6	
	Excavating/grading	0.29		1	
	Other items	0.96		5	
Total other items			11.29		55
Total			515.08		2,524

Significance to Industry: In 1993, approximately 4.9 million single-family households in Texas spent an estimated $2.5 billion maintaining their lawns. The typical single-family household maintained 0.413 acres of turf, mainly Bermudagrass or St. Augustine grass. On the average, the family adult mowed the lawn with a push or self-propelled mower, leaving grass clippings on the ground, and irrigated the lawn with hoses and sprinklers drawing water from a municipal water system. These type of data assist horticultural firms in developing marketing strategies for products and services, effectively satisfying the turf-related needs of household consumers.

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Accelerated Flowering of Foxglove

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Nature of Work: Foxglove (*Digitalis purpurea)* is a biennial which self sows and remains in the garden year after year. It is known for its stately spires of color which remind us of the "old- fashioned" garden. 'Foxy' is a dwarf selection that begins to flower when about 18 inches high; inflorescences elongate to about 3 feet as flowers continue to open. 'Foxy' typically flowers its first year from seed making it very attractive to growers. However, it usually flowers after the peak marketing period for herbaceous perennials. Gibberellic acid has previously been used to promote earlier flowering in numerous crops (1,2); however, no previous research has examined GA_3 effects on foxglove. This study was conducted to stimulate earlier flowering in 'Foxy', hopefully making it more marketable.

Uniform liners of 'Foxy' were potted in 5-inch pots on May 23, 1994. On July 1, 1994, a single foliar spray of 10, 25, 50, 75, 100, 125, 250, 500, 750, or 1000 ppm GA_3 was applied to runoff. An untreated control was included for comparison. Buffer-X at 0.1% was added as a surfactant to solutions. Plants were maintained in a double poly greenhouse under 47% shade. Days to flower, inflorescence height, growth index, and foliar color rating were determined when the first flower on each plant opened. Treatments were completely randomized with 10 single-plant replicates.

Results and Discussion: The percentage of plants that flowered increased with the application of GA_3. 30% for the control, 89% with 10 ppm, and 100% for all other treatments. Days to flower decreased numerically as concentrations increased up to 100 ppm (Table 1); however, regression was not significant. Inflorescence height increased slightly up to 50 ppm and was considered proportional to plant size. Inflorescences of plants treated with higher concentrations of GA_3 were excessively elongated, and malformed flowers developed on plants treated with concentrations _ 100 ppm GA_3. There appeared to be fewer flowers per inflorescence, and flowers seemed to senesce sooner on plants treated with concentrations greater than 100 ppm.

Distinct differences in appearance occurred between plants treated with_ 50 ppm and _ 75 ppm. Lower concentrations produced compact plants with thick, coarse leaves. Higher concentrations produced less compact plants with thinner, more elongated leaves. Plants treated with 25-100 ppm GA_3 were darker green than those treated with lower or higher concentrations.

Significance to Industry: Rates of 10-50 ppm GA_3 promoted flowering (89-100%) compared to 30% for untreated controls. In addition, these plants were compact with attractive foliage and were considered highly marketable. Foxglove treated with higher rates of GA_3 flowered but many of the flowers were malformed. Leaves also were thinner and strap-like and the plants were noticeably lighter green in color.

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Table 1. Response of Foxglove to Gibberellic Acid.

GA3 Rate (ppm)	Days to Flower	Inflorescence Height[z] (cm)
Control	61	25.2
10	56	29.2
25	58	32.3
50	57	35.8
75	50	50.9
100	49	48.8
125	53	48.4
250	49	51.8
500	54	48.1
750	52	52.7
1000	55	49.0
Significance[y]	NS	L***Q***

[z] Inflorescence height measured from medium surface to top of inflorescence.
[y] NS, L, Q: nonsignificant, linear, or quadratic, respectively at the 0.1% level (***); control included in regression analysis.

Identification of Azalea Genotypes Resistant to Azalea Lace Bug and Possible Resistance Mechanisms

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Nature of Work: Azalea lace bug is a key pest of azaleas. Management of this pest currently depends on chemical control although natural control by predators and parasitoids has been demonstrated(1,2). Another important pest management strategy is the identification and incorporation of resistant plants into landscapes. Results of recent research demonstrated that *R.canescens* and *R.prunifolium* were the least susceptible of five deciduous species tested and all deciduous species were less preferred than the evergreen control (Delaware Valley White)(3). Schultz observed that the evergreen cultivar 'Macrantha' was the most resistant of 20 azalea cultivars(4). The susceptibility of deciduous species and related mechanisms of host plant resistance to azalea lace bug requires further investigation. The objective of this study is to identify native deciduous species resistant to azalea lace bug and determine related resistance mechanisms.

Laboratory Bioassays. Seventeen genotypes of deciduous azaleas were obtained in 1994. Eleven of these are native to Georgia. The range in plant susceptibility was evaluated in the laboratory by quantifying feeding injury (leaf area damaged), oviposition (number of eggs deposited), and adult and nymphal survival and development in the following manner. One cutting with 2 leaves was removed from 12 plants of each genotype on August 5, 1994 and again on May 5, 1995. Each cutting was placed in a 32 ml water-filled vial and was infested with 2 female lace bugs. These cuttings were incubated for 5 days in a growth chamber at 24_C and 15:9 (L:D) photoperiod. Following the exposure period, adults were removed and cuttings with eggs were maintained in the growth chamber until eggs hatched. To examine nymphal survival and development, fifty newly emerged nymphs were transferred, 10 per dish, into 5 petri dishes for each plant genotype. The nymphs were fed using newly excised leaves until the adult stage. Damaged leaf area was evaluated using a 0-10 scale from 0: no damage; 1: 10% damaged; ......to 10: 100% damaged.

Potential mechanisms. Water content was calculated using the formula (fresh weight - dried weight)*100/fresh weight. Five leaves from 5 plants of each genotype were randomly selected to measure the lower leaf surface hair number. Under 25X magnification, the hair number was counted along a 1 cm length of midvein and branch vein, and 1 cm^2 interveinal area. Leaf surface lipids were extracted by chloroform (30-60 seconds), dried by liquid nitrogen (N_2), derivatized with N,O-bis (trimethylsilyl) acetamide at 110_C for 10 minutes and again dried with N_2, then dissolved in hexane and analyzed by combined gas chromatography/mass spectrometry. Individual components were characterized by their mass spectra which were compared to standards and matched by computer search of the NIST/EPA/NIH Mass Spectral Database. Quantitation was based upon the integration of total ion chromatograms. All variables (e.g., egg and nymphal number, development rate, etc.) and their correlation with potential mechanisms were analyzed using SAS GLM and stepwise regression models. Mean separation was accomplished using LSD.

Results and Discussion: Laboratory Bioassays. The susceptibility to azalea lace bug of 17 genotypes differed significantly (Table 1). *R. canescens* in both years had the lowest number of eggs(0.7-1.6) and least leaf area damaged(Table 1). The number of nymphs (0.1-0.8), egg hatch rate (8.3-12.2%), and nymphal survival (0%) also were all significantly lower than most other species. Several native species were as or more susceptible than the evergreen standard Delaware Valley White. Our data indicate that the species *R.canescens*, *R.periclymenoides* and *R.prunifolium* are the most resistant of the selections studied and may prove valuable in landscape design and replacement. Potential mechanisms. Leaf moisture and leaf surface lipids were related to resistance to lace bug. The leaf hair density of *R.canescens* was 3 to 4 times higher than all susceptible genotypes, though relationship to resistance is inconclusive. Water content was significantly positively correlated to oviposition, egg and nymphal development, and damaged leaf area. Some leaf surface lipid compounds appear to function in host plant resistance. Eicosanoic acid had a significantly positive effect on the nymph development. Ursolic acid, hexacosanoic acid, octacosanoic acid, and 2 unknows had significantly negative effects on oviposition egg hatch, and/or nymphal feeding and development. Some surface lipids may act as deterrents for oviposition and feeding or as toxic compounds which interfere with the development of nymphs.

Significance to Industry: These results indicate that the susceptibility of native deciduous azaleas to lace bug differs. *R.canescens*, *R.periclymenoides,* and *R.prunifolium* were the most resistant of the tested genotypes. The use of such resistant species in landscape design and replacement will reduce the use of pesticides. Furthermore, the susceptibility to lace bug should be a factor in the development of desirable hybrids. The identified resistant species can be used to cross with others to develop new cultivars which combine resistance with other desirable traits.

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Table 1. Egg number and damaged leaf area(%) in cuttings of 17 azalea species and cultivars

Species and cultivars	Eggs/cutting 1994	Eggs/cutting 1995	Damaged leaf area(%) 1994
'Buttercup'	27.4bcd	39.7 ab	50.8bc
'Nacoochee'	24.5cde	14.4 efg	40.0de
'Delaware valley white'	35.3ab	36.0 abc	60.8ab
R.arborescens	23.5de	21.0 def	40.4de
R.atlanticum	37.9a	11.2 fg	56.7abc
R.calendulaceum	17.3e	12.6 efg	30.4e
R.serrulatum	33.4abc	44.2 a	62.9a
R.viscosum	38.9a	29.1 bcd	62.9a
R.roseum	25.7cde	13.6 efg	50.0cd
R.periclymenoides	3.1f	2.8 g	16.3f
R.japonicum	26.1cde	38.0 abc	36.7e
R.canescens	0.7f	1.6 g	9.6f
R.alabamense		47.4 a	
R.austrinum		26.0 cde	
R.prunifolium		14.7 efg	
'My Mary'		28.8 bcd	
R.oblongifolium		42.4 ab	

Means within a column followed by the same letter are not significantly different.

Influence of Storage Conditions on Long-Term Seed Viability of *Rhododendron catawbiense*, *Rhododendron maximum* and *Leucothoe fontanesiana*

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North Carolina

Nature of Work: Many woody ericaceous species native to North Carolina are highly desirable landscape plants, including *Rhododendron catawbiense* Michx. (catawba rhododendron), *R. maximum* L. (rosebay rhododendron), and *Leucothoe fontanesiana* (Steud.) Sleum (drooping leucothoe). Most of these species are currently produced by “cutbacks” harvested from public and private lands (1). However, native stands are finite. Production by seed represents an alternative system for producing high quality plants. Because viable seeds are not always available on a yearly basis, growers attempt to collect large quantities of seeds during bountiful years and store them for future use. Unfortunately, there is no quantitative information on proper storage techniques for various ericaceous species which is essential to maintain long-term viability. Therefore, in Fall 1990 a study was initiated to provide such information.

In November 1990, mature seed capsules from native populations of open pollinated plants of *R. catawbiense*, *R. maximum*, and *L. fontanesiana* were collected in Buncombe, Avery, and Henderson County, North Carolina at elevations of 1860, 950, and 640 m (6100, 3100, and 2100 ft), respectively. Capsules were stored in paper bags at 20C (68F) for 30 days. Seeds were then removed from the capsules, the seeds placed in glass bottles, and the bottles sealed. At this time seed moisture content of each species was as follows: *R. catawbiense* = 6%, *R. maximum* = 5%, and *L. fontanesiana* = 7%.

Following drying and moisture determinations for all species (2, 3), two viability (germination) studies were conducted, a preliminary study followed immediately by a more rigorous germination test conducted at the Southeastern Plant Environment Laboratory (Phytotron) (4). Results of the studies were in agreement and indicated that seeds of *R. catawbiense*, and *R. maximum* were capable of high germination (approximately 85%) whereas, moderate germination (approximately 55%) was possible for seeds of *L. fontanesiana*.

Once the more rigorous germination test was initiated, seeds of each species were divided into three equal lots and the lots (seeds in sealed bottles) placed under the following storage conditions: -18, 4 or 21C (0, 39 or 70F). These storage conditions were selected because storage at -18, 4 or 21C (0, 39 or 70F) is analogous to storage in a home freezer, a refrigerator or at room temperature, respectively. The initial Phytotron germination studies were conducted in the following manner and have been repeated yearly since the seeds were placed in storage. Yearly tests for each species have included seeds stored at -18, 4 or 21C (0, 39 or 70F).

Seeds of each species were sown in covered 9-cm (3.5 in) glass petri dishes containing germination blotters (two per dish) moistened with tap water. Following placement of the seeds in the dishes, half were designated for germination at 25C (77F) and the other half to be germinated at an 8/16 hr thermoperiod of 25/15C (77/59F). All dishes were placed in double layer, black sateen cloth bags and the seeds allowed to imbibe overnight at 21C (70F). The next day, bags were randomized within two growth chambers [C-chambers (4)] set at the appropriate temperatures. Chamber temperatures varied within _ 0.5C (0.9F) of the set point.

Within each temperature regime, seeds were subjected daily to the following photoperiods with an irradiance of approximately 42 _mol_m^{-2}_s^{-1} (3.1 klx) provided by cool-white fluorescent lamps: total darkness, 1 or 24 hr. Light was measured at dish level with a cosine corrected LICOR LI-185 quantum/radiometer/photometer. Photoperiod treatments were regulated by removal and placement of the petri dishes in black sateen cloth bags. Each photoperiod treatment was replicated four times and a replication consisted of a petri dish containing 100 seeds. Data were recorded every 3 days for 30 days. Seeds maintained in darkness were examined under a green safelight. A seed was considered germinated when radicle length was _1 mm (_0.04 in). Decayed seeds were promptly removed from the dishes. Percent germination was calculated as a mean of four replications per treatment. Data were subjected to analysis of variance procedures (5).

Results and Discussion: Throughout this study seeds of each species required light for germination regardless of temperature. These findings strongly suggest that the light requirement for germination does not disappear with dry storage.

For both temperatures a 1 hr photoperiod was not sufficient to elicit maximum germination of any species. However, for either temperature, maximum germination of all species was noted for seeds subjected to constant light. All of the aforementioned agree with previous reports (2, 3).

Cumulative (30-day) germination for a species exposed to constant light was always similar regardless of temperature. Thus, germination percentages discussed represent a mean response of the two temperatures.

At the time the seeds were placed in storage, initial germination for *R. catawbiense*, *R. maximum*, and *L. fontanesiana* was 90%, 89%, and 56%, respectively. After 1 year of storage at -18, 4 or 21C (0, 39 or 70F), seed germination for *R. catawbiense*, *R. maximum*, and *L. fontanesiana* was 88%, 92%, and 62%; 88%, 88%, and 53%; and 58%, 54%, and 15%, respectively. Thus, viability after 1 year for all species remained constant for seeds stored at -18 (0F) or 4C (39F) whereas a significant decrease in viability was noted for seeds stored at 21C (70F). The decrease in viability for seeds stored at 21C (70F) continued with each passing year.

By the year 4, seed viability of the three species stored at -18C (0F) or 4C (39F) remained relatively unchanged in comparison to total loss of viability for seeds stored at 21C (70F). After 4 years, seeds of *R. catawbiense*, *R. maximum*, and *L. fontanesiana* stored at -18, 4 or 21C (0, 39 or 70F) had germination percentages of 92%, 89%, and 1%; 87%, 90%, and 0%; and 51%, 48%, and 0%, respectively. Since seed viability of each species remained generally unchanged after 4 years storage at -18C (0F) or 4C (39F), these data strongly suggest that viability for periods greatly exceeding 4 years is possible.

Significance to Industry: Long-term seed storage of *R. catawbiense*, *R. maximum*, and *L. fontanesiana* is possible provided seeds are first dried to moisture contents of 5% to 7% and then stored in sealed containers at -18C (0F) or 4C (39F). Room temperature storage [approximately 21C (70F)] should be avoided as viability is lost rapidly.

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An Innoculation Technique for Dogwood Anthracnose

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Nature of Work: Dogwood anthracnose is a fungal disease threatening dogwoods in natural settings, nurseries and cultivated landscapes. Researchers have experienced difficulty in inciting the disease in the laboratory or greenhouse (1). The objective of this study was to find a reliable inoculation technique for dogwood anthracnose to aid in future studies of the disease.

Two isolates were used as inoculum. One was obtained in 1993 from the Catoctin Mountains (CM). The other isolate was collected from Great Smoky Mountain National Park (GSMNP) in 1994. Both were kept in serial transfer on growth media until inoculation in February 1995.

Forty flowering dogwood seedlings approximately two years from seed were grown in a pine bark mix amended with macro and minor nutrients. Twenty trees were placed in an environmental growth chamber with the following conditions: air temperature 18-20C; 14 hour photoperiod; light intensity about 100 _mol m^{-2} s^{-1}; and relative humidity about 75%. The remaining twenty trees were placed into a plastic-enclosed bench in a greenhouse. This plastic chamber was equipped with a window air conditioner unit and three humidifiers. Daily light intensity averaged about 20 _mol m^{-2} s^{-1} and photoperiod was just under 14 hours. The temperature remained near 20C day and night and relative humidity was approximately 93%. Environmental conditions were continuously logged using a 21X datalogger (Campbell Scientific, Logan, Utah) in the growth room and a CR10 datalogger (Campbell Scientific) in the greenhouse.

Leaves of the experimental trees were wounded with a floral frog (several closely spaced steel needles in a steel base, formerly used for floral arrangements), and inoculum was rubbed into the wounds. After inoculation, leaves were enclosed in a plastic bag for 0, 2, 4, or 7 days. Length and width of any lesions resulting from inoculation were measured at the end of the bagged incubation period. These numbers were multiplied to achieve a rough estimate of lesion area. Measurements were recorded weekly for five weeks.

Trees were randomly placed within repetitions in either the greenhouse chamber or the growth room. Treatments formed a 2x2x4 factorial, with 2 isolates (CM and GSMNP), 2 inoculum types (spores and hyphae), and 4 lengths of time leaves were in bags. These 16 treatment combinations were run using a 4x4 balanced lattice design. Data were analyzed using Proc Mixed (2). Treatment means found to be different were compared using pairwise t-tests. There were 5 repetitions of each treatment combination in each location.

Results: The lesions that developed in the greenhouse chamber were larger than those in the environmental growth room. The lower light levels and higher relative humidities in the greenhouse probably accounted for the increased disease in the greenhouse chamber. Neither the type of inoculum (hyphae vs. spores) nor the inoculum source (CM vs. GSMNP) caused differences in the lesion sizes. However, the length of the bagged period did affect the lesion size. The longer the inoculated leaves were bagged, the larger the lesions which developed. The treatment that caused the most disease was the GSMNP hyphae bagged for 7 days in the greenhouse. The most consistent treatment between locations, however, was CM hyphae with a bagged period of 7 days.

Significance to the Industry: Before large numbers of dogwood germplasm can be evaluated for resistance to dogwood anthracnose, a reliable inoculation technique must be developed. This study provides evidence that dogwood trees can be consistently infected with dogwood anthracnose, using different inoculum sources and fungal organs. It is important, however, to enclose the inoculated leaf in a plastic bag to provide the fungus with a very moist environment for at least the first week after inoculation.

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Cyclic Irrigation Increases Irrigation Efficiency and Ammonium Retention

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Nature of Work: Concerns such as water-use, nutrient contaminated runoff, and potential pollution of ground water have forced many nurseries to search for "best management practices" to improve irrigation and fertilizer efficiency (Williams, 1990). Limited research has suggested that intermittent or cyclic irrigation, where the daily water allotment is applied in a series of cycles of an irrigation and a resting interval, can improve irrigation efficiency and nutrient efficacy. Lamack and Niemiera (1993) reported that cyclic irrigation improved irrigation efficiency by 24% compared to applying the same volume of water allotment in one application. Concurrent with the increased irrigation efficiency, working in a laboratory, Karam (1994) reported a 30% decrease in NO3-N and NH4-N leached with cyclic irrigation compared to a single application. This research was conducted to evaluate the effects of cyclic irrigation on irrigation efficiency, nutrient efficacy, and plant growth in a simulated nursery. The experiment, a RCBD with 4 replications, consisted of 4 irrigation treatments: 900 ml (1.2 in) of water applied once a day [900 (1 x)], 450 ml (0.62 in) of water applied in two cycles [450 (2x)], 300 ml (0.41 in) of water applied in three cycles [300 (3x)], and 150 ml (0.21 in) of water applied in six cycles [150 (6x)]. A cycle consisted of a one hour rest interval between each irrigation allotment. Irrigation water was applied via pressure compensated drip emitters at a rate of 150 ml/min (0.21 in/min).

A container-grown plant production area was constructed and subdivided into 16 separate plots which allowed for the collection of all irrigation water leaving each plot. Plants were potted into 3.8 liter (#1) containers in a pine bark:sand (8:1 by vol) substrate, top dressed with 13 g (0.46 oz) of and experimental, polymer coated, urea fertilizer, 23N - 2.6P - 8.4K (23-6-10), and amended on a m3 (yd3) basis with 1.8 kg (4 Ibs) dolomitic limestone and 0.9 kg (1.5 Ibs) micronutrient fertilizer. Uncoated monoammoniun phosphate served as the P source. Fertilizer applications resulted in 3.0 g N and 0.34 g P205 applied to each container. At 8:00 AM daily, volume of effluent from each plot was measured and a sub-sample of the effluent was collected, filtered, and frozen for future NO3-N, NH4-N, and P analyses. Fertilizer was topdressed at initiation (Day 0; June 1, 1993) and the study was terminated 100 days later. Irrigation efficiency was defined as the difference between irrigation volume applied and volume leached divided by the volume applied and relates to the percentage of irrigation water retained by the container substrate to the volume of irrigation applied.

Results and DIscussIon: The 900 (1x) treatment produced higher volume of effluent, lower irrigation efficiency, and higher NH4-N losses compared to the cycled irrigation applications (Table 1). Cycled irrigation (2x, 3x, 6x) did not differ in volume of effluent or irrigation efficiency; however, the 450 (2x) treatment had higher NH4-N losses than the 300 (3x) and 150 (6x) treatments. Irrigation efficiency over the course of the experiment averaged 52% for the cycled irrigation, an improvement of 38% over the 900 (1 x) standard, one time application. However, irrigation efficiency was not constant and improved over the 100 days, averaging 38% during the first 30 days, increasing to 61% during the next 30 days, and averaged 71% for the remainder of the study for the 450 (2x) and 300 (3x) cycled irrigation treatments. Applying irrigation based on the quality of water lost from the substrate may further improve irrigation efficiency. Irrigation treatment did not affect cumulative NO3-N or P effluent losses.

There was a linear response in cumulative NH4-N in runoff water for each treatment over the 100 days suggesting that rates of fertilizer release always exceeded plant uptake (data not shown). Slopes of regression lines describing the effects of each irrigation treatment on daily NH4-N content in the effluent were not significantly different (data not shown). This indicates that regardless of irrigation treatment, rates of NH4-N lost were equivalent on a daily basis. However, when the daily mg NH4-N/ day losses were summed over the 100 days, the 900 (1 x) resulted in a greater quantity of NH4-N in effluent than the cycled applications (Table 1).

Significance to the Nursery Industry: Cycled irrigation improved irrigation efficiency and NH4-N retention in the container-grown plant production system used in this experiment. Irrigation efficiency was improved 38% with cyclic irrigation over the standard, one time application. Dividing the plant's water allotment into two cycles of irrigation maximized irrigation efficiency. Nutrient contamination effluent leaving a nursery site can be reduced with the use of cyclic irrigation. However, irrigation efficiency may be further improved by reducing the volume of irrigation water applied to match plant water use as it increases over the course of a growing season.

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Table 1. Effect of irrigation treatment on cumulative effluent losses per 318 1iter container and irrigation efficiency after 100 days.

Irrigation treatment	Effluent[z] Volume (liters)	NH4-N (mg)	Irrigation Efficiency[y] (%)
900 (1x)	43.9	51.2	37.5
450 (2x)	33.8	32.1	51.9
300 (3x)	31.8	26.0	54.7
150 (6x)	36.1	25.6	48.6
Contrast[x]			
900 vs. 450	0.002	0.001	0.002
900 vs. 300	0.001	0.001	0.001
900 vs. 150	0.009	0.001	0.009
450 vs 300	NS	0.05	NS
450 vs. 150	NS	0.04	NS
300 vs. 150	NS	NS	NS

[z]Average of 30 containers.

[y][(ml applied - ml lost) / ml applied] x 100.

[x]Treatment comparisons made by single degree of freedom linear contrast tests. Considered significant at $p < 0.05$, NS = $p > 0.05$.

Propagation of Sweetgum by Stem Cuttings

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Nature of Work: Studies were conducted to investigate the effects of nitrogen, photoperiod, and chilling on root and shoot growth of sweetgum [*Liquidambar styraciflua* (L.)] rooted cuttings.

Cuttings were collected May 17, 1994. They were prepared and set in 10 cubic inch (64.5 cm^3) containers with 1:1 peat : perlite media composition. Chilled cuttings were prepared and set in June after one month of chilling at 4C (38F). All cuttings remained under intermittent mist for ten weeks. They received 6 seconds of mist every 20 minutes from nozzles that delivered 8 1/2 gallons (70 liters) of water per hour. After 10 weeks, the cuttings were moved to a standard greenhouse bench where nitrogen and photoperiod treatments were imposed.

A Nitrogen/Photoperiod Study was designed to determine if such treatments could increase root and shoot size of rooted cuttings. There were five nitrogen levels (0, 25, 50, 100, 200 ppm N) and four clones over five replications. Photoperiod was the whole plot treatment in this split-plot design. The two photoperiod treatments were ambient and a three-hour night interruption with incandescent lights. The nitrogen treatment was applied once a week and the photoperiod treatment was daily for 16 weeks. Each treatment/replication combination consisted of 5 cuttings for a total of 1000 cuttings.

The one-month chilled cuttings were compared to cuttings set in May with the same media composition and fertilizer application. They were fertilized weekly (starting at the 11th week after setting) with Peter's 9-45-15 (for the first 3 weeks) then with Peter's 20-20-20. Both studies were terminated in December, 1994 and new shoot growth and root dry weights [dried at 70C (150F) for 48 hr.] were determined.

Results and Discussion: These results are preliminary and based on mean statistics only; analyses of variance are currently underway. As nitrogen levels increased, shoot growth increased. Thus, the larger shoots were on cuttings receiving 200 ppm N, while root growth peaked at 25 ppm nitrogen. Larger shoots were also evident on the cuttings receiving the 3-hour night interruption, but root growth was unaffected by photoperiod. Cuttings chilled for an additional month had greater shoot and root growth than cuttings in the control.

Significance to Industry: These data indicate that the root:shoot ratio of sweetgum rooted cuttings depends on the nitrogen level. Therefore, decisions on nitrogen application will depend on what growth characteristics are most important to the grower. Our data also indicate that a night interruption promotes shoot growth. An additional chilling treatment appears promising, but further investigation is needed.

Dissemination of *Thielaviopsis basicola* and *Fusarium proliferatum* by Fungus Gnats

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Nature of the Work: Fungus gnat larvae, *Bradysia* spp., are capable of feeding on root hairs and larger roots. Such damage is not obvious in established plants until substantial root loss has occurred. Plant material in propagation, however, may be lost quickly by the feeding of larval fungus gnats on the limited root systems of these plants (1). In addition, fungus gnats often have been associated with outbreaks of disease (2). This association has been considered secondary, in that the disease appeared first followed by the insects. Current research, however, is demonstrating that fungus gnats may actually dissiminate several serious fungal plant pathogens (3,4).

Infection by Thielaviopsis *basicola*, the fungus that causes black root rot, can result in extensive plant loss (5). Outbreaks of this disease often occur when infestations of fungus gnats are present, however, the role these insects may play in the development of disease is unclear. Therefore, the purpose of this research was first to determine if fungus gnats can dissiminate *T. basicola* to healthy plants and second, to determine the possible means of dissemination. In addition, the fungus *Fusarium proliferatum* was assessed for potential as a biological control agent of *T. basicola*.

A laboratory colony of the fungus gnats, *Bradysia coprophila*, was established and exposed to cultures of *T. basicola* to provide insects contaminated with the plant pathogen. Pansy seedlings (Universal Orange Hybrid Pansy, Park Seed, Greenwood, SC) were utilized as the susceptible host plant. Seeds were surface sterilized, geminated, and grown under sterile conditions at 72°F in plastic Petri dishes (90 x 15 mm) containing tissue culture media (Murashige and Skoog Basal Salt Micro- and Macronutrient Solutions, [Sigma Chemical Co., St. Louis, MO]). Treatment inocula were placed in the tissue culture plates alongside the main seedling root. Five means of phytopathogen dissemination by fungus gnats were evaluated: 1) on the surfaces of adults, 2) within the digestive tracts of adults, 3) on the surfaces of larvae, 4) within the digestive tracts of intact larvae, and 5) in larval frass. Two weeks following inoculation, seedling roots were microscopically examined for *T. basicola* chlamydospores which indicate infection. Roots were also evaluated for any indication of infection by *F. proliferatum*. The experiment was repeated twice and the data pooled and analyzed using the Statistical Analysis System procedure CATMOD which performs a chi-square analysis of binomial categorical data (6).

Results and Discussion: All seedlings exposed to the contaminated adults, larvae, larval digestive tracts, and larval frass became infected with *T. basicola*. Only inoculations with the adult digestive tract failed to result in 100% infection of the exposed seedlings. This suggests that the most common means by which adult *B. coprophila* can dissiminate *T. basicola* is via surface contamination. Adult fungus gnats may easily become contaminated when visiting plants infested with *T. basicola*, a phytopathogen which has been shown to exhibit extensive above ground sporulation (7).

The percentage of seedlings infected by *T. basicola* was reduced for every means of inoculation when *F. proliferatum* was simultaneously inoculated. *F. proliferatum* is a known pathogen of monocotyledonous plants such as corn and asparagus, however, it has never been reported infecting any dicotyledonous plants. None of the antagonistic fungi currently in use for disease suppression, such as species of *Trichoderma* or *Gliocladium* are effective against *T. basicola*. The results of this study indicate the use of *F. proliferatum* as a potential alternative to chemical control of the pathogen that causes black root rot.

Significance to Industry: These dissemination tests clearly demonstrate the ability of both larval and adult stages of fungus gnats to carry phytopathogens to susceptible plants. Fungus gnat larvae, which can move from one container to an adjacent container, are capable of spreading black root rot locally in a production environment. More important, however, are the highly mobile adult fungus gnats that should be considered potential carriers of phytopathogens. Control of fungus gnats may aid grower efforts to control recurring disease problems.

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Potential of Southeastern Wildflower Seed Production

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Nature of Work: Wildflower plantings installed by state transportation departments (DOTs) as part of roadside beautification programs, are usually established by direct seeding (1). Most seed purchased for use in the southeast is grown in western states, such as Texas and Oregon. Having a quality wildflower seed source in the southeast would provide purchasers such as DOT's, with the economical option of obtaining regionally grown seed. Limited information is available on seed yields, percent germination, and seed maturation for species that may have potential for seed production in the southeast (2, 3).

The objective of this study was to evaluate 29, native and non-native perennial and annual wildflower species for seed production in a southeastern environment. Production potential criteria for these species were based on yield of viable seed per acre, percent germination shortly after harvest, and seed maturation rates.

Species were selected for evaluation based on regional performance and potential for wildflower sod production (4). The experiment was arranged in a complete randomized block design with 4 replications of each treatment. Research plots were located in coastal South Carolina in a Goldsboro sandy loam. Soil pH was 5.0, N was low, P very high , and K medium. Individual species were mixed with clean contractors sand and broadcast seeded using a shaker jar. Seeds were sown at the supplier's recommended rates (between 1 lb. / A and 15 lbs. / A), into shallow tilled 10.8 ft^2 plots, separated by 10.8 ft^2 buffers. Seeds were lightly raked into the soil to a depth of 0.18 in., then rolled with a turf roller to ensure good seed to soil contact. Overhead irrigation was used to maintain soil moisture. Three months after planting, all plots received an application of 16-4-8 slow release fertilizer at a rate of 136.25 lbs. / A.

For each species, data were collected on the number of seeds produced per ft^2, grams per 100 seeds, germination percentages, lbs. of viable seed per acre , seed maturation rate, and date of seed harvest. The number of seeds produced per ft^2 was determined by the amount of seed-bearing structures present in each plot. If few mature seeds were present, all seeds in a ft^2 area were collected and counted. If many mature seed-bearing structures were present, four representative samples were collected from a ft^2 area, and the number of seeds per ft^2 was extrapolated from the samples. Pounds of live seed per acre for each species was determined by the weight in grams of 100 seeds x the number of seeds per ft^2 x the percent germination.

Seed maturation was determined by observing the rate at which seeds matured over time. One of 5 ratings was assigned to each species based on seed color, seed softness when pinched, and percent of mature seed structures present compared to immature seed structures present.

Seed Maturation Rating (SM)

1 = 85% to 100% of seeds mature at one time.

2 = 60% to 84% of seeds mature at one time.

3 = Seeds mature over a period of weeks, seed heads remain intact until plant senescence.

4 = Seeds mature and shatter over a period of 2 to 4 weeks.

5 = Seeds mature and shatter over a period of 1 to 2 months as plant produces inflorescence and vegetative growth.

Approximate date of seed harvest was based on observations of maximum amount of mature seed present at a given time.

Seed germination tests were conducted 4 to 6 weeks after harvest. Seeds were surface sterilized in a 5% bleach and deionized water solution followed by 3 rinses in deionized water. Seeds were placed on moistened Whatman's #5 filter paper in petri dishes and sealed with paraffin wrap. All treatments were exposed to continuos fluorescent light for two weeks at 73°F. Prior to testing, seeds were stored without light in airtight containers at 44°F and 33% RH . This procedure was followed for all treatments.

A second germination test was conducted for *Bidens aristosa* due to poor initial results. *B. aristosa* seeds were moist-stratified in damp, whole sphagnum moss and stored in plastic freezer bags inside sealed plastic containers at 45°F and 33% RH for 120 days. Seeds were surface sterilized then sown in river sand at a 0.13 in. depth. Flats were placed under mist irrigation for 3 weeks. Average greenhouse high temperature was 82°F and low was 63°F.

Results and Discussion: At the termination of the evaluation all species in the study were grouped into 3 categories or eliminated from the study due to poor establishment or insufficient flowers. Species eliminated from the study were *Chrysanthemum maximum* (Shasta Daisy), *Echinacea purpurea* (Purple Coneflower), *Lobularia maritima* (Sweet Alyssum), *Oenothera missouriensis* (Missouri Primrose), *Ratibida columnaris* (Mexican Hat), *Rudbeckia amplexicaulis* (Clasping Coneflower), and *Solidago rugosa* (Rough-leafed Goldenrod).

Criteria for each category were based on percent germination and seed maturation rating. Pounds of live seed per acre and harvest dates are given but do not affect the categorization of the individual species. A Spearman's Rho Correlation Coefficient Test was conducted to determine a relationship between the seed maturation rating and percent germination. There was not evidence of a correlation at the P=0.05 level.

Species placed in Category I and II (see Tables 1 and 2), had maturation habits conducive to a uniform harvest of mature seed as well as good germination percentages. These species may warrant further large scale field evaluation. Species in category III (see Table 3) were not selected for further study due to poor germination percentages and / or difficulty in harvesting seed due to prolonged periods of seed maturation and shattering. Though germination percentages were low for some species at the time of testing, seeds may have still been viable, as requirements for breaking dormancy may not have been met in these initial tests.

Significance to Industry: Regionally grown wildflower seeds could be an economic benefit to the southeastern ornamental industry. A regional seed source would also provide purchasers with southeastern native species less commonly found in the seed trade and more easily grown in the southeast. This may be advantageous for highway departments and other organizations requiring wildflowers that are well adapted to regional conditions.

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Table 1. Category I Species with excellent seed production potential based on seed maturation and germination percentages. Criteria: Seed Maturation Rating (SM) 1 or 2, and Germination > 75%

Species		SM	% germ	lbs./A	lbs. of viable seed / A	Date of harvest
Hesperis matronalis	Dame's Rocket	2	98%	2,660	2,607	1-July
Monarda citriodora	Lemon Mint	1	78%	1,428	1,114	18-July
Silene armeria	Catchfly	1	100%	78.3	78.3	26-May

Table 2. Category II species with moderate seed production potential based on seed maturation and germination percentages. Criteria: Seed Maturation Rating (SM) 1, 2, 3 or 4, and Germination 45% to 75%

Species		SM	%germ.	lbs./A	lbs. of viable seed / A	Date of harvest
Bidens aristosa	Bur Marigold	1	59%	69.3	40.9	20-October
Centaurea cyanus	Cornflower	2	50%	1,648	824	9-June
Chrysanthemum leucanthemum	Ox-Eyed Daisy	4	88%	31	27	18-May
Coreopsis tinctoria	Plains Coreopsis	1	63%	292	184	21-June
Gypsophila muralis	Baby's Breath	2	68%	177	120	21-June
Ipomopsis rubra	Standing Cypress	1	45%	5,117	2,302	2-September
Rudbeckia hirta	Black-Eyed Susan	1	53%	945	501	26-July

Table 3. Category III Species with low seed production potential based on seed maturation and germination percentages. Criteria: Seed Maturation Rating (SM) 5, and / or Germination < 45%

Species		SM	% germ.	lbs./A	lbs. of viable seed / A	Date of harvest
Achillea millefolium	Yarrow	2	10%	169	16.9	1-July
Coreopsis lanceolata	Tickseed	4	43%	325	140	5-June
Cosmos bipinnatus	Cosmos	5	0%	936	0	12-August
Cosmos sulphureus	Yellow Cosmos	5	48%	230	110	26-July
Eschscholzia californica	California Poppy	4	28%	131	37	5-June
Gaillardia aristata	Blanketflower	3	14%	227	31.8	10-September
Gaillardia pulchella	Firewheel	3	20%	784	157	24-June
Oenothera speciosa	Showy Primrose	2	0%	270	0	26-May
Papaver rhoeas	Corn Poppy	1	0%	55	0	9-June
Phlox drummondii	Drummond Phlox	5	68%	413	277	5-June
Salvia coccinea	Scarlet Sage	5	8%	249	18.7	2-September
Verbena tenuisecta	Moss Verbena	5	5%	42	2.1	18-May

Initial Offset Number Affects Hosta's Responses to BA

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Nature of Work: Growth of rhizomic buds in hosta is inhibited by apical dominance, but application of the cytokinin, BA, has been shown to release these buds from apical control and stimulate bud outgrowth (Keever, 1994). Furthermore, it has been demonstrated that BA stimulated buds can be removed from the mother plant and rooted under intermittent mist (Keever, et al., 1995).

Initial studies involving the induction of hosta buds with BA were conducted using uniform plants that possessed only one growing point. Nurserymen would likely produce offsets for propagation from stock plants that display a number of offsets, however, and the initial number of offsets present may affect the production and development of offsets following BA treatment. To develop a practical system for the rapid multiplication of hosta that employs BA application, it is necessary to determine not only optimum application rate, but also optimum stage of development for stock plants. The objective of this study was to determine the effect of the presence of stock plant offsets on the plant's response to a range of BA rates.

One-gallon plants of H. sieboldiana (Lodd.) Engl., grown in a standard amended nursery medium under 47% shade, were selected according to the number of offsets present. Plants were divided into three groups: those with no offsets present, those with only one emerged offset, and those with two or three offsets. Eight single plant replicates from each group were assigned to an application rate of either 0, 1250, 2500, or 3750 ppm BA, for a total of 12 treatments in a completely randomized design.

Treatments were applied as a single foliar spray on 17 July 1994, using a CO_2 sprayer fitted with a cone nozzle. Each treatment was applied as a full coverage spray, up to the point of run-off. Buffer-X was added to each treatment solution as a surfactant at the rate of 0.2%.

At the commencement of this study, a growth index (height + width at widest point + width 90_ to first width) was calculated for five plants from each group of offset criteria. At 30, 60 and 90 days after treatment (DAT), measures for overall plant height and growth index were taken again and offset counts were recorded for each plant.

Results and Discussion: Offsets generally increased with increasing BA rate (Table 1). The greatest relative increase in offsets following treatment with BA was achieved with 3750 ppm among plants with no visible offsets at the time of treatment. This trend was evident at 30, 60 and 90 DAT, with the highest relative increase in offset numbers measured at 90 DAT. Change in Offset number 90 DAT, averaged across initial offset number, increased from -0.3 for the control to 2.4 for plants treated with 3750 ppm BA (Table 2). Within the plants receiving 3750 ppm BA, those with no initial offsets gained an average of 70% more offsets than those beginning with one offset and 75% more than plants with two to three initial offsets, over the 90 day test period (data not shown). Change in offset number at 90 DAT, averaged across BA rate, was 31 or 143% greater for plants with no initial offsets compared to those with one or two to three initial offsets, respectively (Table 2).

Data support the use of stock plants without visible offsets present at the time of BA treatment. These results are consistent with the primagenic dominance hypothesis (Bangerth, 1989), which states that an earlier developed organ creates a metabolic sink that inhibits development of later initiated organs by suppressing auxin export from the inhibited organ.

Significance to Industry: Hosta are perhaps the most widely used herbaceous perennials for the shaded landscape, and market demand is strong for new cultivars. Hosta are conventionally propagated by annual division or crowns, or by tissue culture techniques. Division yields a relatively small number of plants per clump, however, and tissue culture explants are not only expensive, but also may not come true to type. Economical introduction of new cultivars to the market is often impeded due to these factors. An integrated system for the rapid multiplication of hosta which employs BA application to induce offsets could be of benefit to growers by allowing them to efficiently produce and market new cultivars which are otherwise slow to produce offsets. The results of this study suggest that plants without visible offsets would provide the best stock plants for this type of production program.

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Table 1. Change in initial offset number of *Hosta sieboldiana* stock plants treated with 0, 1250, 2500, 3750 ppm BA[z].

	Change in offset number					
	30 DAT			60 DAT		
Initial offset number	0	1	2-3	0	1	2-3
BA rate (ppm)						
0	0.1a[y]	-0.8b	-1.4c	0.1a	0.1a	-0.7b
1250	1.5a	2.3a	-0.4b	2.3a	2.8a	0.3b
2500	1.3a	1.3a	1.4a	0.9a	1.4a	1.7a
3750	3.1a	2.4a	1.1b	3.0a	2.1a	1.9a
Significance[z]	L***	L***	L***	L***	L*Q*	L***

[x] Initial offset number x BA rate significant.
[y] Means within rate and time separated by single degree of freedom orthogonal contrast.
[z] L, Q: linear or quadratic response, respectively, at the 0.05(*) or 0.01(***) level; control included in regression analysis.

Table 2. Change in initial offset number of *Hosta sieboldiana* stock plants treated with 0, 1250, 2500, or 3750 ppm BA, 90 DAT.

BA rate (ppm)	Change in offset number
0	-0.3
1250	1.5
2500	1.4
3750	2.4
Significance[y]	L***
Initial offset number	
0	1.7a[z]
1	1.3ab
2-3	0.7b

[y] L: linear response at the 0.05(*); control included in regression analysis.
[z] Means within rate and time separated by single degree of freedom orthogonal contrast.

Cost Comparison of Pot-in-Pot Production to Above-Ground and In-Field Production Methods

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Nature of Work: Pot-in-pot production is an interesting alternative production method for large plant material because it combines the advantages of both above-ground and in-field production methods. The objective of this study was to determine cost of production of *Lagerstroemia indica* under three alternative production methods: in-field production, above-ground container production and pot-in-pot production. Cost were assessed for a ten acre nursery with a five acre production area on a three year growing cycle. In this study nurseries were not actually constructed; however, model nurseries were synthesized using the guidelines of economic engineering where the "best management practice" was included in each model. We chose a ten acre nursery for the model because it was a suitable size for comparison of production methods and a potential starting point for implementing new technology. Estimated cost of production was gathered from growers and researchers in the southeastern United States or modified from existing budgets from container nurseries (2). All cost and hourly labor requirements were estimated in a conservative manner to accurately represent actions that most likely may be taken by production managers and to factor in the effects of inflation over time.

In-field production for the three species began with the primary and secondary tillage of five production acres followed by the incorporation of nutrients based on recommendations of typical soil analyses. Plants were bought as bare root liners and planted. A drip irrigation system was added for fertigation. We planned to harvest plants in the winter months of the third growing season. Capital requirements for an in-field nursery included $1200 for improvements of the five acre production area, including grading, tree removal, building of access roadways and waterways, and pond construction to prevent runoff. Buildings included an office, machinery storage and supply storage. Most equipment (tractors, trucks, sprayers, etc.) was held constant for all three production methods. Essential equipment for in-field production are a moldboard plow, disking harrow, single row transplanter and tree spade.

Above ground container production for the three species began with the propagation of cuttings in one gallon containers. The cuttings were grown for one year in polyethylene covered greenhouses. After one year, the plants grown in one gallon containers were transplanted into three gallon containers and moved outside. All outside above-ground container production was irrigated by an overhead system. After one year, the plants in a three gallon container were transplanted into a ten gallon container. Plants were staked using a three foot section of rebar. Other cultural practices were the same for ten gallon production as for three gallon production. Plants were harvested in the spring after one year of growth in ten gallon containers.

Pot-in-pot production began with the propagation of cuttings under the same cultural practices and cost of cuttings propagated for the use of above-ground container production. However, instead of the one gallon containers being stepped up to three gallon containers, they were transplanted directly into ten gallon containers. This allowed for a larger number of plants to be produced due to the fact that there was no allocation of land for three gallon container production such as there was in above-ground container production. The plants were irrigated and fertilized by drip irrigation. No rebar stakes were needed to hold the containers upright. All other cultural practices were the same for the pot-in-pot production method as with above-ground container production. Plants were harvested in the spring after the second year of growth in ten gallon containers.

Results and Discussion: Total capital requirements for in-field production were $194,837, where land and improvements represented 13%, buildings comprised 18%, and machinery and equipment represented 69% (Table 1). Annual fixed cost for this nursery was $114,653 which averaged $12.07 per plant. Equipment cost totaled $13,183 over the three year production period which equaled $1.39 per plant. Total variable cost was $54,591 for the three year production period and $5.75 per plant. Total cost per finished plant was $17.82.

Total capital requirements for above-ground production were $194,822. Representation of capital for land and improvements, buildings, and machinery and equipment was 20%, 25%, and 55%, respectively. Annual fixed cost for an above-ground container nursery was $116,869 which equaled $10.23 per plant. Equipment cost totaled $8,277 for the three year production period which equaled $.72 per plant. Total variable cost was $87,676 for the three year production period and $7.67 per plant. Total cost per finished plant was $17.90.

Estimated capital requirements for pot-in-pot production totaled $207,177. Representation of capital to land and improvements, buildings, and machinery and equipment were 14%, 23%, and 63%, respectively. Annual fixed cost was $121,595 and equaled $10.64 per plant. Machinery and equipment cost for the three year production period was $7,848 which totaled $.60 per plant. Total variable cost was $74,021 or $5.66 per plant. Total cost per finished plant was $14.96.

In-field production was the method with the highest total cost. This was due to the fact that it was a five acre production area and this size area is considered relatively small for the in-field production method. The buildings and machinery used in these models are sufficient to support a much larger production area. If a larger number of plants were produced, the total cost per plant would decrease. This is economies of size or economies of mass production. With economies of size, average total cost decreases as the size of an operation grows. This is due to the specialization of labor, specialization of management and efficient capital utilization (1). In addition, spacing requirements for in-field production are greater due to extra space between rows needed for equipment allowing fewer plants to be produced per acre. In the models, a five acre production area allowed for only 9,494 plants to be produced with in-field production (due to spacing requirements which are greater for in-field production), as opposed to 11,425 plants with above-ground container or 13,060 for pot-in-pot production methods. Fixed cost per plant is lower when spread across a greater number of plants. Fixed cost per plant for in-field production were tremendously high because a small number of plants were produced in the models with high capital requirements. However, variable cost is comparable to those of the other two production methods due to less labor intensive cultural practices. If these fixed cost were allocated over a production area one acre larger, then fixed cost per plant would be comparable to those of both pot-in-pot and above-ground container production utilizing a five acre production area.

Significance to Industry: Pot-in-pot production had a high initial capital investment. This made the fixed cost per plant higher than that of above-ground container production. However, the total cost per finished plant was the lowest of the three production methods, because of less intensive cultural practices, which was a great advantage of pot-in-pot production. There were also a greater number of plants to spread the cost over. Even though the spacing for above-ground container production and pot-in-pot production are the same, Pot-in-pot production does not have an area set aside for three gallon production. This means that a larger area is being utilized for the production of ten gallon plant material.

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Canopy Density Influences Herbicide Effectiveness

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Nature of Work: Weed control in container nursery production has always been a major concern. The growth of 1 weed can significantly reduce woody plant growth in containers (1). Plants must compete with weeds for water, nutrients, sunlight, and space. Fretz (2) stated plant size can be reduced as much as 50% by just 2 weeds per pot. Due to the costs of herbicide and their application and concern for the environment, nursery owners must continually consider ways to reduce herbicide use without sacrificing weed control. One important factor that has not been considered is container plant size versus weed growth. Large plant canopies should shade the container medium surface reducing sunlight for weeds as well as the root system competing better for water and nutrients.

This experiment was done to test the theory that plants with large canopies have less need for weed control and can therefore be treated with lower herbicide rates, and still have acceptable weed control. On August 20, 1993, 2.25 inch liners and 1 gallon pots of Japanese holly (*Ilex crenata* 'Greenluster') were transplanted into 3 gallon containers. One week later these containers as well as finished 3 gallon containers were treated with 1/3X, 2/3X, and 1X the recommended rate of Snapshot 2.5 TG. Control containers for each initial plant size with no herbicide treatment were also included. On August 31, 1993, all containers were over seeded with prostrate spurge (*Euphorbia humistata*). Thirty days after treatment (DAT) with herbicide, number of weeds per pot, plant growth index (GI) [(height + width1 + width 2)/3], and photosynthetically active radiation (PAR) at the container medium surface were determined. PAR was determined using the LICOR 188B Integrating quantum/radiometer/photometer. Pots were centered under a mercury vapor lamp (approximately 3 feet above medium surface). The light sensor was placed 1 inch from the container side wall at 90 deg. intervals based on pot center for a total of 4 observations per pot. The PAR values per pot were averaged to estimate plant canopy density. At 60 DAT, number of weeds per pot, weed dry weights, percent weed control, and plant GI were determined.

Results and Discussion: Weed number at 30 DAT, and weed number, percent weed control, and weed dry weight at 60 DAT were effected by the combination of herbicide application rate and initial plant size for 3 gallon container grown holly (Table 1). As herbicide application rate increased weed control for all initial plant sizes increased, with the exception of the finished 3 gallon plants where there were no weeds in pots for any treatment on either date. Growth indices (30 and 60 DAT) of holly plants increased and PAR levels decreased as initial plant size increased (data not shown). Mean GIs were 15.5, 30.1 and 52.3 cm, and PARs were 241.2, 107.4 and 13.3 $umol \cdot m^{-2} \cdot sec^{-1}$ for the initial plant sizes of 2.25 inch liner pot, 1 gallon and 3 gallon plants, respectively.

Significance to the Nursery Industry: These data demonstrate the potential to reduce herbicide application rates for large, dense canopied container grown plants such as Japanese holly. Weed control was enhanced at lower herbicide rates as initial plant size increased. A 95% weed control rating or better was obtained for all 3 gallon plants regardless of herbicide treatment while rates of 2/3X and 1X were required for 1 gallon and liner, respectively.

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Table 1. Effects of herbicide application rate and initial plant size on prostrate spurge control for 3 gallon container grown Japanese holly.

Application rate of Snapshot 2.5TG[y]	Initial plant size[x]	Weed number/pot 30DAT	Weed number/pot 60DAT[z]	Percent weed control[w]	Weed dry weight (g)
1/3X	liner	4.1c[v]	6.7c	49.9d	5.1c
2/3X	liner	1.8cd	2.3cd	77.7c	1.3d
1X	liner	0.3d	0.3d	98.2ab	0.2d
controlliner	14.5a	27.5a	5.0f	19.5a	
1/3X	1 gallon	1.9cd	2.7cd	81.8bc	1.3d
2/3X	1 gallon	0.8d	1.2d	95.1ab	0.4d
1X	1 gallon	0.3d	0.4d	92.4abc	0.5d
control	1 gallon	8.5b	14.3b	31.5e	8.6b
1/3X	3 gallon	0.0d	0.0d	100.0a	0.0d
2/3X	3 gallon	0.0d	0.0d	100.0a	0.0d
1X	3 gallon	0.0d	0.0d	100.0a	0.0d
control	3 gallon	0.0d	0.0d	100.0a	0.0d

[z]DAT = days after treatment with herbicide.
[y]Rates were 1/3X, 2/3X and X-recommended rate. An untreated control for each initial plant size was included (-).
[x]Initial plant sizs were 2 1/4" liner and 1 gallon pots each transplanted to 3 gallon containers, and finished 3 gallon plants.
[w]Percent weed control and weed dry weight were determined 60 DAT.
[v]Mean separation within columns by LSD, P = 0.5.

Flood Tolerant Hollies: Qualifiers for Quagmires

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Nature of Work: Hollies (Ilex spp.) represent one the most commercially important groups of landscape plants in the United States. Within this genus, there are species native to a diversity of climates and habitats that range from arid alpine conditions to warm wetlands (3). Landscape sites are often characterized as having compacted, clay soils resulting in poor drainage and low aeration that subsequently limit plant growth and survival. The objective of this study was to evaluate and compare relative tolerance to root-zone inundation among a diverse collection of holly taxa.

The taxa used in this study included: Ilex rugosa, Ilex x meserveae (rugosa x aquifolium) 'Blue Princess', I. aquifolium 'Sparkler', I. crenata 'Convexa', I. opaca 'Satyr Hill', I. rugosa x cornuta 'China Girl', I. x attenuata (opaca x cassine) 'Foster's #2', I. aquifolium x cornuta 'Nellie R. Stevens', I. cassine, I. cornuta 13urfordii', I. decidua 'Warren Red', I. verticillata 'Winter Red', I. vomitoria 'Stokes', and I. glabra. Plants were propagated from stem cuttings in 1993 and potted into two quart pots in a composted pine bark mix. In September 1994 plants were placed into twenty randomized complete blocks with each block containing one control and one flooded plant from each taxa. The flooded plants were placed in one-gallon plastic buckets and the water level was maintained one inch above the root crown. Photosynthetic rates were measured biweekly using a portable gas exchange system (LI-COR, Model LI-6200, Lincoln, Neb.). After eight weeks of flooding and two weeks after draining visual evaluations of root and leaf appearance were made. An I I point, pretransforrned rating scale was used that corresponded to the percent of root ball having live roots, with zero being no live roots and ten being 100% covered (1). A similar scale was used for evaluating shoots with zero indicating no leaf drop or discoloration and ten indicating that all of the leaves showed discoloration or had abscised. In mid-November the hollies were placed into a walk-in cooler kept at 40°F with an 8-hour photoperiod for over-wintering. In mid-March the plants were placed back into the greenhouse to conduct survival ratings.

Results and Discusslons: Photosynthesis is often found to be a sensitive indicator of plant response to stress, and the capacity to maintain photosynthesis during flooding is an effective measure of a plant's tolerance to flooding (2). Following eight weeks of flooding, net photosynthetic rates of flooded plants ranged from 60% of the control for I. cornuta 'Burfordii' to 6% of the control for I. rugosa (Table I). Two weeks after the flooded plants were drained, photosynthetic rates recovered for some plants and ranged from l 37% of the control for I. cassine to -5% of the control for I. aquifolium ' Sparkler' . Visual ratings for root systems following flooding ranged from 92% of the control for I. cornuta 'Burfordii' to 60% of the control for I. crenata 'Convexa'. Visual ratings of the shoots (flooded-control) ranged from 0% deterioration for I. cornuta 'Burfordii' to 93% deterioration for I. rugosa Survival of flooded plants, measured the following Spring, ranged from 100% for eight of the taxa to 6% for I. rugosa. Overall, four of the taxa: I. cornuta 'Burfordii', I. x 'Nellie R. Stevens', I. cassine, and I. x attenuata 'Foster's #2' performed remarkably well during and after flooding with photosynthetic rates greater than 40% of the controls after eight weeks of flooding, root ratings greater than 75% of the controls, less than 5% of the foliage showing deterioration, and 100% survival. At the other end of the spectrum I. crenata 'Convexa', Ilex x meserveae 'Blue Princess', 1. rugosa and 1. aquifolium 'Sparkler' did not tolerate flooding well as indicated by severely depressed photosynthetic rates, deterioration of foliage and roots, and decreased survival. The remaining taxa, I. x 'China Girl', I. glabra, 1. verticillata 'Winter Red', I. decidua 'Warren's Red', I. vomitoria 'Stokes', and I. opaca 'Satyr Hill' were intermediate but still relatively tolerant of the flooding stress as indicated by survival rates of 95-100%.

Significance to the Industry: This study demonstrates considerable variation in tolerance to root-zone flooding arnong different hollies. When selecting hollies for poorly drained conditions, consideration should be given to their relative tolerance to inundation and appropriate taxa should be utilized. The considerable variation in tolerance to inundation also suggests the potential for enhancing adaptability through selective breeding or use of more adaptable taxa for rootstocks in grafted plants.

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Table 1. Comparison of net photosynethesis (µmol•m-2•s-1) among flooded and control treated plants of 14 taxa following 8 weeks of treatment at 2 weeks after the flooding treatments were ceased.

	8 weeks of Treatment			2 Weeks Following Treatment		
Taxa	Control	Flooded	% of Control	Control	Flooded	% of Control
Burfordii'	10.2	6.1	60	10.3	10.3	100
'Nellie R. Stevens'	11.5	6.2	53	8.8	6.6	75
cassine	4.4	2.2	50	3.8	5.2	137
'Foster's #2'	7.2	3.1	43	9.4	5.5	59
'China Girl'	11.1	4.0	36	10.8	1 1.4	105
glabra	12.5	4.4	35	13.6	12.7	93
'Winter Red'	7.4	2.6	35	11.5	11.0	96
'Warren's Red'	12.0	2.3	19	8.1	2.1	25
'Stokes'	10.5	3.5	33	8.3	7.1	85
'Satyr Hill'	7.7	2.9	37	7.3	4.2	58
'Convexa'	14.2	2.6	18	14.3	2.5	17
'Blue Princess'	6.2	1.3	21	6.3	0.9	15
rugosa	3.2	0.2	6	3.0	0.3	10
'Sparkler'	12.3	1.5	12	10.2	-0.6	-5

Statistical Analysis[Z]				
Taxa	**	**	**	**
Treatment	**	NA	**	NA
Taxa x Treatrnent	**	NA	**	NA
LSDo05	2.4	20	2.7	30

[Z] NS, *, and ** indicate that treatments were not significant or significan at P=0.05 and P=0.01, respectively.

Table 2: Visual ratings of root and shoot quality following 8 weeks of treatment and survial after overwintering.

	Root Rating[W]			Shoot Rating [X]			Survival (%)	
Taxa	Control	Flooded	% of Cont.[Y]	Control	Flooded	Flood-Control[Y]	Control	Flooded
'Burfordii'	25	20	89	0	0	0	100	100
'Nellie R. Stevens'	44	35	87	0	1	1	100	100
cassine	12	6	67	2	11	4	100	100
'Foster's #2'	21	10	67	0	0	0	100	100
'China Girl'	44	29	78	0	4	4	100	100
glabra	39	18	64	0	37	37	100	100
'Winter Red'	81	55	75	8	18	2	100	100
'Warren's Red'	29	16	74	2	55	41	100	100
'Stokes'	38	25	79	0	1	1	100	95
'Satyr Hill'	43	19	64	0	4	4	100	95
'Convexa'	19	4	46	0	21	16	100	90
'Blue Princess'	11	4	59	0	67	65	100	40
rugosa	10	4	57	0	93	93	100	15
'Sparkler'	3	1	55	0	91	91	100	6
Statistical Analysis[Z]								
Taxa		**	*		**	**		**
Treatment		**	**		**	**		**
Taxa x Treatment		**	*		**	**		**
$LSD_{0.05}$		25.0	12.3		3.0	3.0		9.5

[W] % of root ball covered with live roots (values were backtransformed to percentages following statisitics).
[X] % of foliage area that were dead, discolored or abscised (values were backtransformed to percentages following statisitics).
[Y] Values were calculated on from original data and thus will not equal the percent or difference of means.
[Z] NS, *, and ** indicate that treatments were not significant or significan at P=0.05 and P=0.01, respectively.

Adsorption, Mobility, and Filtration of Herbicides by Container Media

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Nature of the Work: Granular herbicides are often broadcast applied three or four times annually over container areas due to the continuous emergence of weeds. Broadcast spreaders are used and herbicide loss can be significant due to granular herbicide falling outside the pot. Loss can range from 23% to 80% depending on the pot spacing and plant architecture. This nontarget loss is considered as a point-source for herbicide contamination in nursery runoff (2). Frequent irrigation can produce runoff from landscape plant production areas and landscape developments and has been suggested as a source of pesticide contamination for local water supplies or surrounding bodies of water (3).

Ronstar 2G (oxadiazon) and Surflan (oryzalin) are essentially completely adsorbed by media containing peat, bark, and/or rice hulls (6, 7). The proportion of Ronstar 2G and Surflan adsorbed by various combinations of these media were 98 and 94%, respectively. In the same studies, column leaching data revealed that mobility was similarly limited. It was concluded that the detection of either Ronstar 2G or Surflan in runoff water would have to be the result of these materials not reaching the medium due to nontarget losses.

Pennant 5G (metolachlor) is commonly used in nursery production for the control of annual grasses (1). Mahnken et al. (4) examined the leaching of metolachlor through various media and determined that maximum adsorption of metolachlor occurred with hardwood plus pine bark and pine bark plus sand. The generally high adsorptive nature of horticultural media to herbicides has been observed by others (5). Media may offer a means of cleansing pesticide-contaminated water. This could be accomplished by simply allowing pesticide-contaminated water to drain through a media filter. Metolachlor, with its relatively high water solubility and its established precedent to be leached through media, would probably represent a difficult challenge for removal by filtration. The first objective of this study was to evaluate both the adsorption and mobility of metolachlor in container media. In previous studies, which established the high adsorptivity of media toward herbicides, at least a day was allowed for the adsorption to occur. However, for removal-by-filtration to be effective, adsorption would have to occur in a much shorter period. Consequently, time was included as an experimental variable in the adsorption studies. The second objective was to evaluate the feasibility of cleansing of metolachlor-contaminated water by allowing it to drain passively through pine bark filters.

Adsorption, mobility, and filtration ability of organic media toward metolachlor were evaluated in a series of laboratory experiments. Experimental variables included media type, metolachlor concentration, and equilibration time. Media evaluated included peat, pine bark, 3 pine bark: 1 peat, 5 pine bark: 1 peat, and 5 pine bark: 1 sand. Adsorption of metolachlor was determined by a soil solution technique by which media were brought to field capacity with water containing 0.01, 0.1, 1.0, or 10.0 ppm metolachlor spiked with ^{14}C metolachlor and allowed to equilibrate for 48 hours. Adsorption isotherms for each medium were determined from the adsorption data by application of the log form of the Freundlich equation, $\log S = \log K + (1/n) \log C$; where S = adsorbed-phase concentration, C = equilibrium solution-phase concentration, and K and 1/n = Freundlich adsorption constants. Adsorption of ^{14}C-metolachlor at a single concentration (1 ppm) as a function of time was also measured. The equilibration time progressed downward in a geometric manner from 24 h to 1 m 30 s. A relationship between equilibration time and adsorption was determined. Mobility was evaluated using glass columns filled with media that were then surface spiked with metolachlor and then leached once a day, 10 consecutive times. Filtration of commercially formulated metolachlor from contaminated water (1 ppm) passed through differing-length, bark-filled filters was evaluated using an enzyme linked immunosorbant assay. All experiments were replicated at least three times and conducted twice.

Results and discussion: Peat, bark, combinations of these two media and the mixture of bark and sand, adsorbed >90% of the ^{14}C metolachlor (Table 1). From the Freundlich equation, the values for K, the index of the quantity adsorbed per gram of media, were 10.9, 18.2, 13.4, 14.2, and 11.0 for bark, peat, 5 bark: 1 peat, 3 bark: 1 peat, and 5 bark: 1 sand, respectively (Table 1). In a timed exposure experiment using bark, minimum metolachlor adsorption, 57%, was at 90 seconds and maximum adsorption, 82%, required at least 1440 minutes (Figure 1). Indications of the highly adsorptive nature of organic media for the herbicide metolachlor were expressed by these results. In column leaching studies, data for all media indicate that metolachlor is relatively immobile through these substrates. An initial pulse, or break-through event, of metolachlor, <1.0 ppb, was detected with each medium up to the third wetting event with a subsequent decline, > 0.5 ppb for each media, in the metolachlor recovered. In the bark filled filter experiment, general adsorption of metolachlor varied from 0, 17, 20, 22, 23, and 29% for filters 1.57, 7.87, 4.72, 3.15, 6.30, and 9.45 inches in length, respectively. While no metolachlor was filtered with the 1.57 inch filter, adsorption similarity was consistent in filters 3.15 to 7.87 inches in length. The 9.45 inch filter exhibited the highest adsorption, 29%, which may be contributed to the increased exposure time of water to the bark. These results support the contention that such filtration would be effective provided the residence time of water within the filter was sufficient for adsorption of the contaminate to occur by the media.

Significance to Industry: Results from Freundlich isotherms, adsorption, and mobility data show that media are very adsorptive and confirm the suspicion that contaminant in nursery runoff is largely attributable to a herbicide not reaching the pots during the application. Conversely, media are so adsorptive that they may offer merit as filters for herbicide contaminated runoff. While complete filtration of contaminates in runoff water may not be achievable, the potential for use of existing grower materials (such as peat and pine bark) to reduce offsite movement does exist. Development of filtering systems that are easily constructed and maintained by container nursery producers is achievable.

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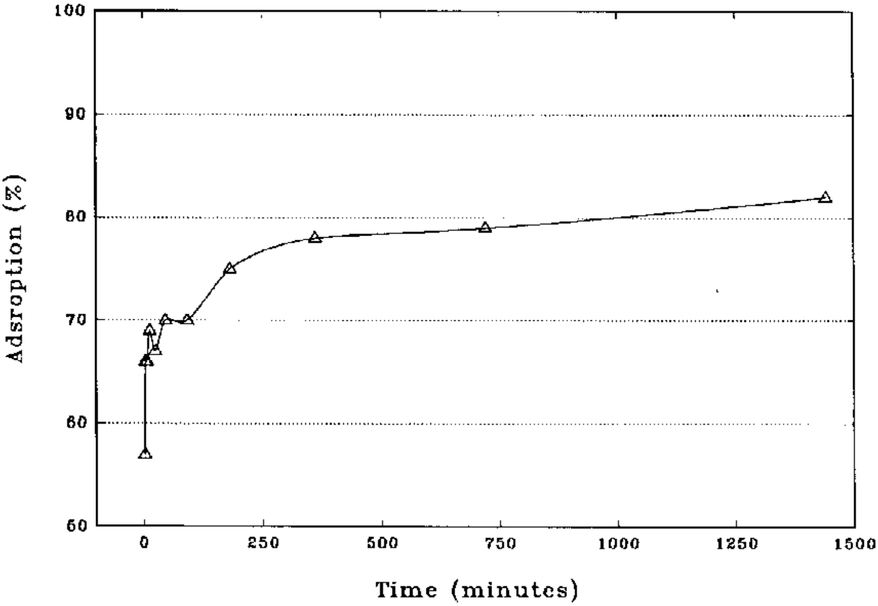
Table 1. Sorption of 14C-metolachlor and Freundlich constants in five different media.

	Metolachlor concentration (ppm)					Freundlich constants		
	0.01	0.10	1.00	10.00	LSD			
Media	------------- % in solution -------------					K	1/n	r2
bark	11.5	9.1	8.6	8.6	NS	10.9	1.03	0.995
peat	7.6	5.3	5.8	5.6	0.7	18.2	1.04	0.997
3 bark: 1 peat	7.0	6.6	8.2	5.9	0.9	14.2	1.01	0.999
5 bark: 1 peat	8.1	6.7	8.1	6.7	NS	13.4	1.05	0.999
5 bark: 1 sand	9.3	7.5	7.0	9.2	NS	11.0	0.99	0.994

Figure 1. Metolachlor adsorption in pine bark over time.



Selected Preemergence Herbicides for Weed Control in Four Annual Bedding Plants

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Nature of Work: Many preemergence ornamental herbicides are not labeled for use on bedding plants (1). Researchers have determined the efficacy of many of these preemergence herbicides for weed control, however; phytotoxicity on annuals has not been extensively examined. Metolachlor and oryzalin are the only products labeled for use on annual bedding plants in this study; *Impatiens wallerana* and *Tagetes ssp*. Our objectives were to evaluate herbicide efficacy and phytotoxicity of selected ornamental herbicides on four species of common bedding plants.

On July 5, 1994, *Begonia x semperflorens-cultorum* 'Encore Red', *Catharanthus roseus* ' Grape Cooler', *Impatiens wallerana* 'Showstopper Tropical Punch', and *Tagetes* 'Discovery Orange' were transplanted into field beds. Plots were irrigated as needed and ammonium nitrate (112 kg/ha) was applied. Each plot was 3.1 m by 6.1 m and contained 20 of each species. Plots were set up in a randomized block design with three replications.

On July 11, 1994, herbicides were applied to the plots post-transplant. The granular materials (Derby 5G, Snapshot 2.5G, and Ronstar 5G) were applied using a calibrated rotary spreader. Other materials (Pennant 7.8L, Gallery 75DF, Dimension 1EC, Predict 80WG, Surflan 80 WG, Barricade 65 WG, and Snapshot 80 DF) were applied using a CO_2 pressurized backpack sprayer calibrated at 26 GPA using 8004 nozzles with 28 psi.

Plots were rated visually for herbicide efficacy (0 = no control, 100 = complete control) and phytotoxicity to the crops (0 = no damage, 5 = completely dead). Weed control ratings were taken at 2, 4, and 8 weeks after treatment (WAT), while phytotoxicity ratings were conducted 1, 2, and 4 WAT.

Results and Discussion*: Weed control.* Grass species were effectively controlled (>70% control)(4) at 2, 4, and 8 WAT by metolachlor, metolachlor + simazine, isoxaben + trifluralin, isoxaben, norflurazon, oryzalin, oxadiazon, and isoxaben + oryzalin (Table 2). Dimethazone and prodiamine provided effective control at 2 and 4 WAT, but control declined rapidly between 4 and 8 WAT. Morningglory species were effectively controlled at 2 , 4, and 8 WAT by metolachlor, metolachlor + simazine, isoxaben + trifluralin, oxadiazon, and isoxaben + oryzalin. Isoxaben alone showed variable control. Dimethazone, norflurazon, oryzalin, and prodiamine provided superior morningglory control at 2 WAT and 4 WAT; the eight week percentages for these treatments declined below an acceptable limit of control. Herbicide treatments provided effective control of Carolina horsenettle and yellow nutsedge for the duration of the study.

Crop injury and Phytotoxicity. Marigold displayed the least amount of crop injury throughout the duration of the study. Marigold displayed significant injury only from norflurazon at 1, 2, and 4 WAT (Table 3). Vinca displayed considerable injury from both metolachlor and norflurazon treatments at 1 and 2 WAT. By 4 WAT, vinca no longer displayed many injury symptoms from metolachlor but vinca treated with norflurazon displayed increasing injury over the duration of the study and was seriously injured at 4 WAT. Impatiens and begonia were most sensitive to herbicide treatment. Injury to these sensitive species was evident from 1 WAT through the final rating at 4 WAT with treatments of norflurazon, metolachlor, metolachlor + simazine, isoxaben, and dimethazone. At 4 WAT, results for impatiens and begonia were quite similar, with significant injury (>2.5) occurring in all treatments except dimethazone and oryzalin treatments. In the final rating at 4 WAT, impatiens were most adversely affected, with phytotoxicity ratings ranging from 2.5 - 5.00. Injury symptoms from norflurazon appeared as whitening or chlorosis in affected tissue. Injury symptoms from other herbicides appeared as necrosis and chlorosis tissue.

Significance to Industry: In comparing data on the basis of weed control, many of the treatments provided excellent control. However, no treatment provided excellent control without significant injury to the crop. Herbicides should be chosen based on the weeds known to be present in a particular location and sensitivity of bedding plants to a particular herbicide treatment. It should also be noted that other cultivars of a particular species may respond differently than those evaluated in this study. Dimethazone and oryzalin were least injurious to crops throughout the course of the experiment.

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Table 1. Treatments and manufacturer of products evaluated.

Treatment	Rate (kg/ha)	Common	Manufacturer
Untrt. Check	0.00	---	---
Pennant 7.8 L	3.3	metolachlor	Ciba-Geigy
Derby 5G	3.3	metolachlor + simazine	Ciba-Geigy
Snapshot 2.5G	4.1	Isozaben + trifluralin	DowElanco
Gallery 75 DF	1.1	Isozaben	DowElanco
Dimension 1EC	0.6	dimethazone	Monsanto
Predict 80 WG	3.3	norflurazon	Sandoz Agro, Inc.
Surflan 7.8L	2.2	oryzalin	DowElanco
Ronstar 5G	2.8	oxadiazon	Chipco Ronstar Co..
Barricade 65 WG	.1.	prodiamine	Sandoz Agro, Inc.
Snapshot 80DF	4.1	Isoxaben + oryzalin	DowElanco

Table 1. Weed control ratings.

Treatment	GR	MG	CH	YN	GR	MG	CH	YN	GR	MG	CH	YN
	% Weed Control											
	2 WAT				4 WAT				8 WAT			
Untrt. Check	0.0 d	0.0 e	0.0 c	0.0 c	0.0 d	0.0 e	0.0 c	0.0 c	0.0 c	0.0 f	0.0 c	0.0 c
Metolachlor	100.0 a	93.3 ab	100.0 a	100.0 a	100.0 a	91.7 a	100.0 a	100.0 a	100.0 a	86.7 abc	100.0 a	100.0 a
Metolachlor + simazine	100.0 a	96.7a	100.0 a	100.0 a	100.0 a	93.3 a	100.0 a	100.0 a	98.3 a	90.0 ab	95.0 ab	100.0 a
isoxaben + trifluralin	100.0 a	93.3 ab	100.0 a	93.3 ab	95.0 ab	100.0 a	98.3 a	90.7 a	93.3 a	86.7 abc	96.7 a	76.7 a
isoxaben	86.7 ab	81.7 cd	100.0 a	95.0 ab	83.3 abc	63.3 b	98.3 a	95.0 a	93.3 a	71.7 abc	88.3 ab	88.3 a
dimethazone	91.7 ab	91.7 abc	90.0 b	93.3 ab	76.7 bc	90.0 a	81.7 b	90.0 a	6.7 c	26.7 ef	75.0 b	83.3 a
norflurazon	100.0 a	95.0 ab	100.0 a	100.0 a	83.3 abc	90.7 a	93.3 a	100.0 a	100.0 a	41.7 de	100.0 a	100.0 a
oryzalin	98.3 a	85.7 bcd	93.3 b	90.0 b	95.0 ab	91.7 a	96.7 a	87.3 a	86.7 a	66.7 bcd	88.3 ab	71.7 a
oxadiazon	98.3 a	93.3 ab	100.0 a	98.3 ab	100.0 a	100.0 a	100.0 a	93.3 a	93.3 a	100.0 a	100.0 a	98.3 a
prodiamine	71.7 c	76.7 d	95.0 ab	100.0 a	66.3 c	96.7 a	81.0 b	100.0 a	51.7 b	60.0 cd	87.3 ab	86.7 a
isoxaben + oryzalin	83.3 bc	85.0 bcd	100.0 a	91.7 ab	80.0 abc	86.7 a	100.0 a	90.0 a	99.0 a	95.0 ab	91.7 ab	83.3 a

Gr = grasses, MG = morningglory, CH = Carolina Horsenettle, YN = Yellow Nutsedge

0 = no control, 100 = complete control

Table 2. Crop injury ratings.

Treatment	Marigold	Vinca	Impatiens	Begonia	Marigold	Vinca	Impatiens	Begonia	Marigold	Vinca	Impatiens	Begonia
	Amount of Crop Injury											
	1 WAT				2 WAT				4 WAT			
Untrt. Check	0.00 c	0.00 d	0.00 g	0.00 d	0.00 b	0.00 c	0.00 e	0.00 d	0.00 b	0.00 c	0.00 d	0.00 f
Metolachlor	0.83 b	2.67 c	2.67 ab	2.17 a	0.17 b	2.33 b	3.33 ab	3.83 a	0.00 b	0.33 c	3.92 b	4.00 a
Metolachlor + simazine	0.08 c	0.08 cd	2.17 bcd	0.83 bc	0.00 b	0.00 c	2.00 bcd	2.33 b	0.50 b	0.00 c	2.83 c	3.50 ab
isoxaben + trifluralin	0.17 c	0.17 cd	1.50 def	0.83 bc	0.17 b	0.00 c	1.08 cde	0.17 d	1.67 ab	0.83 bc	2.33 c	2.00 cde
isoxaben	0.00c	0.33 bcd	2.50 abc	1.00 b	0.17 b	0.33 c	0.50 e	0.83 cd	0.67ab	0.33 c	4.17 ab	3.08 abc
dimethazone	0.00 c	0.17 cd	1.67 cde	0.17 cd	0.00 b	0.00 c	0.50 e	0.17 d	0.00 b	0.33 c	0.67 d	0.83 ef
norflurazon	2.00 a	2.83 a	3.17 a	2.00 a	2.67 a	3.17 a	4.15 a	2.25 b	2.17 a	3.50 a	5 a	4.00 a
oryzalin	0.00 c	0.67 bc	0.67 fg	0.00 d	0.00 b	0.00 c	0.50 e	0.00 d	0.33 b	0.67 bc	0.83 d	0.83 ef
oxadiazon	0.00 c	0.83 b	1.33 def	1.17 b	0.00 b	0.00 c	2.33 bc	1.83 bc	0.33 b	0.00 c	4.95 a	3.75 a
prodiamine	0.00 c	0.33 bcd	1.17 ef	0.50 bcd	0.00 b	0.00 c	0.83 de	0.50 d	0.00 b	2.08 ab	2.50 c	1.75 de
isoxaben + oryzalin	0.17 c	0.08 cd	1.33 def	0.50 bcd	0.17 b	0.17 c	2.17 bcd	0.83 cd	1.17 ab	0.83 bc	4.33 ab	2.33 bcd

Phytotoxicity rating: 0=no injury, 10=dead