

SECTION 1

STUDENT COMPETITION

Dr. Fred T. Davies, Jr.
Section Chairman and Moderator

**Seed Germination of Pieris floribunda:
Influence of Light and Temperature**

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Nature of Work: Nurserymen have often commented to the authors that seed germination of Pieris floribunda (Pursh ex Sims) Benth. and Hook. (mountain andromeda) is slow and generally poor. Lack of knowledge regarding the influence of various environmental factors on germination prompted this study which examined the influence of varying photoperiods and a constant versus an alternating temperature on seed germination of P. floribunda.

On October 25, 1986 mature seed capsules were collected from a native population of open-pollinated plants of P. floribunda growing in Haywood County, North Carolina at an elevation of 1768 m (5800 ft.). Capsules were stored in a paper bag at 20°C (68°F) for 21 days. Seeds were then removed from the capsules and stored at a moisture content of 6% in a sealed glass bottle at 4°C (39°F). Moisture content was determined by calculating the mean moisture content of six, 100-seed samples following drying at 105°C (221°F) for 24 hr.

In March 1990, seeds were removed from storage and initially graded with the use of an air column (General Seed Blower-Model ER, Seedburo Intl. Equip. Co., Chicago, Ill.). This device is commonly used to separate seeds of different grass species based on a variable air flow. To remove chaff and empty seeds, the seed separator was set at 25 with all ports closed, utilizing pan screen #2 (60x60 mesh), for a duration of three min. Seeds retained on the pan screen were then subjected to further grading under a dissecting scope. Abnormal, damaged, discolored or undersized seeds and other large debris, not eliminated by the air column, were manually removed. Graded seeds selected for the germination study were firm and possessed a golden yellow color.

Graded seeds were then sown in covered, 9-cm glass petri dishes, each containing two pre-washed (rinsed) germination blotters (Filtration Sciences Corp., Mt. Holly Springs, Pa.) moistened with tap water. Following placement of the seeds in the dishes, half were designated for germination at 25°C (77°F) and the other half for germination at an 8/16 hr thermoperiod of 25°/15°C (77°/59°F). All dishes were placed in double-layer, black, sateen cloth bags and the seeds allowed to imbibe overnight at 21°C (70°F). The next day, bags were randomized within two growth chambers [C-chambers (1)], set at the appropriate temperatures. Chamber temperatures varied within $\pm 0.5^\circ\text{C}$ (0.9°F) of the set point.

Within each temperature regime, seeds were subjected daily to the following photoperiods: total darkness, 1/2, two 1/2 hr photoperiods separated by 7 1/2 hr of darkness, 1, 2, 4, 8, 12 or 24 hr. Regardless of temperature, photoperiod treatments were administered the same time each day. All photoperiod treatments

for the alternating temperature of 25°/15°C (77°/59°F), with the exception of total darkness and 24 hr, began with the transition to the high temperature portion of the cycle.

Growth chambers were equipped with cool-white fluorescent lamps which provided a photosynthetic photon flux (400-700 nm) of 69 $\mu\text{mol m}^{-2} \text{s}^{-1}$ (5.3 klx) as measured at dish level with a cosine corrected LI-COR LI-185 quantum/radiometer/photometer (LI-COR, Lincoln, Neb.). All photoperiod treatments, except total darkness and the 24 hr irradiation, were regulated by removal and placement of the petri dishes in black sateen cloth bags. For the 24-hr photoperiod treatment, the petri dishes remained continuously unbagged in open chamber conditions. Regardless of the photoperiod, temperatures within the petri dishes, as measured by a thermocouple, never exceeded ambient temperature by more than 1° C (2° F). The constant darkness treatment was maintained by keeping the petri dishes in the black cloth bags throughout the experiment and all watering and germination counts were performed in a darkroom utilizing a fluorescent lamp equipped with a green acetate filter (Rosco Laboratories, Port Chester, N.Y.). Germination blotters were kept moist with tap water throughout the experiment. Seeds showing signs of decay were immediately removed from the dishes. Each photoperiod treatment was replicated four times within each temperature regime, with a replication consisting of a petri dish containing 100 seeds. Germination counts were recorded every 3 days for 30 days. A seed was considered germinated when the emerging radicle was ≥ 1 mm (0.04 in.).

Percent germination was calculated as a mean of four replications per treatment. Within each temperature, data was subjected to analysis of variance and regression analysis (2).

Results and Discussion: In seeds exposed to light, germination at 25° C (77° F) began between 3 and 6 days compared to 6 to 9 days at 25°/15° C (77°/59° F), but the delay did not influence cumulative germination. With the exception of seeds not exposed to light, 30-day germination for equivalent photoperiods at both temperatures was similar. Without light, 30-day germination at 25° C (77° F) and 25°/15° C (77°/59° F) was 38% and 52%, respectively. Daily photoperiods as short as 1/2 hr increased cumulative germination to 90% at 25° C (77° F) and 25/15° C (77°/59° F). The remaining light treatments yielded 88 to 95% germination. High germination percentages were due in part to rigorous seed grading prior to initiation of the study.

Significance to Industry: Seed germination of *P. floribunda* is relatively easy to accomplish at temperatures of 25° C (77° F) or 25°/15° C (77°/59° F) provided seeds are subjected to rigorous grading prior to sowing. Regardless of temperature, seeds do not require light for germination but daily photoperiods $\geq 1/2$ hr will maximize germination.

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**Effects of Light Intensity and Leaf Temperature on
Lesion Growth Rates in Dogwood Anthracnose Disease**

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Nature of Work: Dogwood anthracnose was first reported in the Northeastern United States in the late 1970's. This disease has caused shoot dieback and mortality in Cornus florida L. in the Eastern United States as well as in C. nuttallii Aub. in the Western United States (2). A fungus, Discula spp. has been consistently associated with this disease. Discula forms asexual fruiting structures known as acervuli from which spores arise on dogwood tissue. Disease symptoms include blighted leaves and petioles with both necrotic and purple-rimmed lesions, leaf chlorosis, lower limb dieback, trunk cankers, and tree death.

Dogwood anthracnose was first identified in the Southeast in 1988 (3). Within two years, dogwood anthracnose was found in Alabama, Georgia, Kentucky, North Carolina, South Carolina, and Tennessee. Epidemics have been most severe at higher elevations in the Appalachian forests (3).

The purpose of this study was to evaluate effects of leaf temperature and light intensity on dogwood anthracnose lesion growth rates in full sun and densely shaded areas.

Materials and Methods: Field studies were conducted in Knoxville and Lookout Mountain, Tennessee between July 19 and August 25, 1990. Trees used in this study were located in densely wooded areas as well as direct sunlight in both areas. C. florida trees were selected and tagged at each plot. Four trees used in both sunny and shady areas at Lookout Mountain, and two trees in similar areas were selected at Fountain city in northern Knoxville. Anthracnose lesions were mapped on five leaves of each tree. Lesion size was measured in millimeters once a week. For each of the five leaves, leaf temperature was measured with a portable automatic porometer approximately every two hours from 8:00 AM to 3:00 PM. In addition, light intensity, at the canopy of every tree, was taken periodically throughout the

day. Air temperature was also recorded. After five weeks of field observations, the leaves were harvested, returned to the laboratory, and placed in moist chambers to induce sporulation. Acervuli which developed on the lesions were counted, and Discula was isolated from these areas on the leaf.

Results and Discussion: Radiant energy from direct sunlight caused leaf surfaces on trees in the sun to be warmer than leaf surfaces on trees in densely shaded areas. Leaf temperature did not rise as much on overcast days as it did on days of full sun. However, leaf temperature did rise in both sunny and shaded plots regardless of the amount of sunlight on any particular day.

Mean lesion diameters increased in both sunny and shaded plots in both Knoxville and Lookout Mountain. Lesion size continued to increase during the experiment at similar rates in both plots.

Trees in direct sunlight sustained a much higher mean light intensity than trees in the shaded areas.

Acervuli formed on totally necrotic lesions more often than on lesions with a purple-rimmed halo surrounded by chlorosis. Totally necrotic lesions were located more abundantly on leaves in shaded plots than on leaves in sunny plots. Likewise, purple-rimmed lesions tended to form on leaves in the sunlight. This suggests that acervuli form more easily on leaves in the shade than on those in direct sunlight. The reduction of sporulation on leaves in full sun may explain Daughtrey's observation that full sun exposure deterred symptom development in dogwoods on Long Island in 1986 (1). Conversely, the increased sporulation observed on leaves from shaded areas may explain why epidemics have been observed in urban areas near shade.

Significance to Industry: This research correlates greater dogwood anthracnose disease incidence, more severe symptoms, and increased fungal sporulation to densely shaded areas. Dogwoods located in direct sun or partial sun had a higher leaf temperature and light intensity than trees located in the shade. These differences may cause the fungus to advance at a slower rate in a tree in the sun. Thus, homeowners or nurserymen may wish to plant trees in sunny locations.

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Ornamental Herbicide Detection in Nursery Irrigation and Containment Water

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Nature of Work: Herbicides are used in container nursery production to control problem weeds. Granular formulations are applied by broadcast rotary spreaders which deliver the herbicide to both the containers and surrounding surfaces of gravel or plastic. The dinitroaniline herbicides (pendimethalin and oryzalin) and diphenyl ether herbicide (oxyfluorfen) are formulated on clay granules and marketed as OH-2 by Scotts and Rout by Grace-Sierra Chemical Co. These are the most common preemergence herbicides used from March to November. Herbicide residues in runoff and irrigation ponds may be a potential problem because of the effects on other nursery plants and non-target organisms.

Herbicide concentrations in runoff water depends on the chemical properties and formulation of the herbicide, soil properties and condition, and the timing of application in relation to rainfall [1,5]. Soils treated with oryzalin contained nine degradation products, which accounted for only 4% of the initial treatment [3] Oxyfluorfen is strongly absorbed to soil and not readily desorbed or leached [2]. Soil persistence of oxyfluorfen is relatively short with a half life of 30-40 days; however, it is potentially toxic to aquatic organisms [4].

Objective: Determination of the amounts of pendimethalin, oryzalin and oxyfluorfen herbicides moving from container applications into irrigation and containment ponds.

Materials and Methods: Two SC container nurseries (located in upper Piedmont and Coastal Plains) were used for sample collection. Both nurseries contain their runoff water on the premises and reuse it for irrigation. Water and sediment samples were collected from irrigation and catch ponds every four weeks beginning in late February. Glassware for collecting and analysis was silanized to prevent herbicide adherence to surfaces. The pH of the water samples was recorded and it was adjusted to pH 2.2-2.3 and then filtered to remove debris. Herbicides were extracted from the water by passing through a C18 solid phase extraction column. Herbicides were then eluted with 2 ml acetone. Sediments were dried for 3-4 hours at 105C then ground to a powder in a mortar and pestle. Samples (5 g) were weighed and placed in a 50 ml flask with 10 ml methanol and agitated at 225 rpm for two hours on a shaker and were filtered. All samples were then filtered (0.2 u acrodisc) and stored in a freezer prior to analysis. Duplicate samples were injected into a Varian HPLC equipped with a C₁₈ column for herbicide quantification. Running conditions consisted of a gradient of 60:40 acetonitrile:water to 100% acetonitrile, and W detection at 206 nm. Herbicide standards were detected as follows: oryza-

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lin 4.8 min., oxyfluorfen 9.9 min, and pendimethalin 10.9 min. retention times. Herbicide detection limits were approximately 1 ppb (1 ng/ml) for water samples and 1 ppm (1 ug/g) for sediment.

Results and Discussion: The February and March samplings, prior to and at the beginning of applications, revealed no herbicides detectable in the water or sediments at either site. April samplings at the Piedmont site detected only pendimethalin (9.74 ppm) in sediment of the large containment pond (Table 1). The Coastal site contained pendimethalin and oryzalin in irrigation water (6.5 and 1.3 ppb, respectively) and sediment (2.8 and 0.29 ppm, respectively). All three herbicides were detected pond sediment samples at 2-3.5 ppm.

May collections at the Piedmont site showed 3.16 ppm pendimethalin in irrigation pond sediment and 0.5 ppm oryzalin in sediment from the large containment pond. The Coastal site irrigation pond water contained 0.72 ppb pendimethalin and 1.02-12.3 ppm oryzalin in sediment, and 1.5-2.57 ppm pendimethalin in sediment, depending on location. The containment pond water samples contained 5.29 ppb pendimethalin and both oryzalin and pendimethalin in sediment samples.

Table 1: Summary of herbicide detection in containment and irrigation water at Piedmont and Coastal sites. No herbicides detected in February and March, and multiple locations were sampled per pond. ORY=oryzalin, PEN=pendimethalin, OXY=oxyfluorfen, W=water samples, S=sediment samples, - =none detected.

| | <u>Piedmont Site</u> | | | | | |
|-------------|----------------------|-----|-----|-----|-----|-----|
| | April | | | May | | |
| | ORY | PEN | OXY | ORY | PEN | OXY |
| Irrigation | - | - | - | - | S | - |
| Containment | - | S | - | - | W,S | - |
| | <u>Coastal Site</u> | | | | | |
| | April | | | May | | |
| | ORY | PEN | OXY | ORY | PEN | OXY |
| Irrigation | W,S | W,S | - | S | W,S | - |
| Containment | S | S | S | S | W,S | - |

Multiple sites per pond were sampled, with herbicides detectable in some locations but not others. The water collection areas near the container beds generally

contained higher levels of herbicide. These three herbicides were not detectable at the beginning of the growing season. After initiating herbicide applications the levels of herbicides became detectable. The proximity of sample collection to time of application and high versus low water levels also play a role in detection. Further work will evaluate accumulation over the growing season, consider whether residues are detectable immediately following application, and the binding abilities of mulch (plastic, fabric or gravel) on herbicide movement.

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Impact of Late Season Insect Defoliation on Tree Growth

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Nature of Work: The orangestriped oakworm, *Anisota senatoria* (J. E. Smith) (Lepidoptera: Saturniidae) is a native insect and pest of both forest and urban plantings throughout the northeastern and southern United States (2). Severe defoliation in August has occurred on the same urban oaks over consecutive years in Norfolk, VA and on nursery grown oaks (1). Tree care practitioners, nurserymen, and researchers alike have suggested that *A. senatoria* defoliation is of little consequence because it occurs so late in the summer (3). Our objectives were to evaluate this late season defoliation on trees grown in a nursery environment and trees in the urban landscape.

Nursery conditions were simulated by planting pin oaks, *Quercus palustris*, northern red oaks, *Q. rubra*, and willow oaks, *Q. phellos*, in grow bags (Root Control Inc., Oklahoma City, OK) on March 25, 1987 in a randomized complete block design (5 blocks). Trees in grow bags received 2 oz. of 18-6-12 Osmocote in April 1987-88 and were placed on daily drip irrigation. Treatments (0, 1, 2, 3, and 4 years of defoliation) consisted of placing *A. senatoria* larvae on trees in August of each year (1987-1990) in numbers sufficient to cause 100% defoliation. Tree height and

caliper were measured on June 13, 1988-90. Trees were removed in October, 1990 and roots contained in grow bags plus escape roots were dried and weighed. Pin oaks in the urban landscape were sampled four times a year (December, March, May, and September). Two primary roots per tree were collected and analyzed for percent starch content. Treatments were 0, 24, and 100% defoliation.

Results and Discussion: Pin oaks grown in grow bags that received 3 and 4 consecutive defoliations had significantly less top growth than trees that received 0 or 1 defoliation (Table 1). Willow oaks that received 3 and 4 defoliations had significantly less top growth than trees that received no defoliation, and northern red oaks showed no significant differences in top growth (Table 2). Pin oaks that received 2, 3, and 4 defoliations were the only trees that showed a significant reduction in caliper. Furthermore, pin oaks that received 4 defoliations were the only trees that had a significantly lower below ground dry weight (grow bag plus escape roots) (0.4+0.06 lbs) than trees that received no defoliation (4.2+1.5 lbs). Landscape pin oaks that received 3, 4, and 5 defoliations had significantly lower mean root starch content than trees that received no defoliation over all sample dates (Table 2). Starch has been shown to be an accurate indicator of tree vigor, and reduced starch often suggests unhealthy, stressed trees (4).

Significance to Industry: Late season defoliation can adversely affect oak tree vigor, especially of pin oak; therefore, infestations of A. senatoria should be controlled both in the nursery and in landscapes.

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Table 1. Mean top and caliper growth of three oak species defoliated by A. senatoria, 1987-1990.

| No. yrs. 100% defol. | Pin Oak top growth | NY | Mean \pm SEM | | Willow Oak | |
|----------------------------|------------------------------|----|-----------------------------|----|-------------------|----|
| | | | N. Red Oak top growth | N | top growth | N |
| 0 | 36.8 \pm 4.6a ^z | 20 | 14.0 \pm 3.1 a | 15 | 45.4 \pm 3/6a | 17 |
| 1 | 37.2 \pm 4.0a | 10 | 15.0 \pm 3.4a | 9 | 39.2 \pm 5.7ab | 10 |
| 2 | 27.9 \pm 2.8ab | 15 | 16.2 \pm 4.4a | 11 | 36.8 \pm 4.2abc | 15 |
| 3 | 24.8 \pm 5.3b | 10 | 8.9 \pm 2.4a | 8 | 32.5 \pm 2.8bc | 10 |
| 4 | 14.3 \pm 3.2b | 5 | 5.9 \pm 1.6a | 3 | 25.6 \pm 4.0c | 5 |
| | caliper growth | | caliper growth | | caliper growth | |
| 0 | 0.6 \pm 0.04a | 20 | 0.1 \pm 0.04a | 15 | 0.6 \pm 0.04a | 17 |
| 1 | 0.5 \pm 0.04a | 10 | 0.1 \pm 0.04a | 9 | 0.6 \pm 0.04a | 10 |
| 2 | 0.3 \pm 0.04b | 15 | 0.1 \pm 0.04a | 11 | 0.4 \pm 0.04a | 15 |
| 3 | 0.2 \pm 0.04b | 10 | 0.1 \pm 0.04a | 8 | 0.5 \pm 0.04a | 10 |
| 4 | 0.2 \pm 0.04b | 5 | 0.1 \pm 0.04a | 3 | 0.5 \pm 0.04a | 5 |

^y N= number of replications. Growth in inches.

^z = Means within columns followed by the same letter are not significantly different (P>0.05: Student-Newman-Keuls test).

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Table 2. Mean percent root starch content in pin oak trees defoliated by A. senatoria, 1988-1990.

| Sample dates | Mean \pm SEM percent starch (dry weight) | | | | |
|--------------|--|------------------|----------------|----------------|----------------|
| | Check | Mean of 24% def. | No. of 3 | No. of 4 | No. of 5 |
| Dec. 1988 | 6.6 \pm 0.8a ^z | 4.8 \pm 1.0ab | 2.9 \pm 0.8b | | |
| Mar. 1989 | 5.0 \pm 0.8a | 1.9 \pm 0.5b | 1.7 \pm 0.3b | | |
| May 1989 | 3.9 \pm 0.5a | 3.5 \pm 0.3a | 2.5 \pm 0.2b | | |
| Sep. 1989 | 9.4 \pm 1.8a | 6.5 \pm 1.3a | | 1.9 \pm 0.8b | |
| Dec. 1989 | 1.6 \pm 0.2a | 1.6 \pm 0.2a | | 0.9 \pm 0.1b | |
| Mar. 1990 | 2.6 \pm 0.5a | 1.8 \pm 0.3ab | | 1.2 \pm 0.2b | |
| May 1990 | 3.6 \pm 0.9a | 1.2 \pm 0.3b | | 1.1 \pm 0.2b | |
| Sep. 1990 | 13.7 \pm 1.9a | 13.0 \pm 1.4a | | | 7.0 \pm 1.3b |
| Dec. 1990 | 17.0 \pm 1.5a | 12.9 \pm 2.2a | | | 3.5 \pm 1.3b |

Number of replications = 7 trees (check and 24%); 9 trees (100%).

^z = Means within rows followed by the same letter are not significantly different (P>0.05; Waller-Duncan k-ratio) after arcsine transformation.

Evaluation of Photoelectric Sensors for Robotic Transplanting

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Nature of Work: In commercial greenhouses, one of the largest costs is labor and few operations require more hours of labor than manually transplanting bedding plant seedlings (4). Many growers are considering an investment in automated equipment to help reduce the cost of labor.

A robot equipped with a specialized gripper and photoelectric sensors (See figure 1) is being used to transplant bedding plant seedlings without any missed cells in the grow flats. The transplanting system consists of several modifications to an IBM 7535 Selective Compliance Assembly Robot Arm or SCARA (3). The first modification was the addition of a pair of finger extensions to the robot's gripper. The fingers allowed the robot to grasp the seedling plugs and remove them from the plug tray. Another addition was a pneumatic cylinder mounted on the robot arm. The cylinder rod, when extended, acted as a stop to give the robot an intermediate z-axis wrist location. Two photoelectric sensors were then added to give the robot the ability to detect seedlings. The sensors provided the robot controller with the information required to intelligently transplant seedlings. Finally, a sprayer was also mounted on the gripper after initial testing to aid in transplanting the seedlings. The water jet from the sprayer helped settle the soil around the plant after it was transplanted.

The robot went through the following steps during transplanting. First, the robot end effector would approach the plug cell location and attempt to retrieve a seedling. It would then check the sensors and determine if a seedling was present in the gripper fingers. If the sensors did not detect anything, the robot would move to a drop point and attempt to discard any debris that might have been retrieved from the plug cell. The robot would then return to the plug flat and attempt to retrieve another seedling from the next location. If a seedling was detected in the gripper fingers, the robot would move to the appropriate cell pack location and transplant the seedling. The sensors were checked again after the seedling had been transplanted to insure that the robot had been successful in releasing the seedling in the cell pack location. Next, it would return to the plug flat and repeat the process. When either the grow flat was filled or the plug flat was empty, the robot would return to the home position after transplanting the last seedling and wait for the operator to press a button as a signal that a new grow flat or plug flat had been placed and that transplanting could resume.

Results and Discussion: Initial tests were conducted without checking the sensors after a seedling had been transplanted. The results of these tests showed that the system was capable of detecting seedlings but that there was one major problem.

This problem was that the seedlings sometimes would adhere to the fingers of the robot and cause skips in the cell packs of the grow flat. Whether or not a seedling was transplanted was highly dependent on the moisture content of the grow flat media. If the soil media moisture content was less than 54%, the water from the spray nozzle would only increase the adhesion of the soil around the dibble hole to the seedling plug and fingers. The cohesion of the media then would not be great enough to hold the seedling in place as the gripper was retracted. Only 31% of the grow flats initially tested were completely filled.

Although the soil media moisture content was found to be a factor in causing the seedling to stick to the gripper fingers, the fingers would sometimes spear the root ball in the plug to cause the seedling to not be transplanted. To determine if the seedling had been successfully transplanted, another step was added to the robot's program to check the sensors after transplanting. This would insure that all of the locations in the grow flat were filled. With this second sensor check in place, 99.8% of the seedling locations in the grow flats were filled.

To determine the flexibility of the robot, tests were conducted with three types of plug flats, six types of grow flats and nine species of plants. 390, 392 and 512 cell plug flats were used in combinations with 32, 36, 48, 50, 54 and 72 cell grow flats. These combinations were used with vinca (*Catharanthus roseus* 'Little Bright Eye', *C. roseus* 'Little Pinkie', *C. roseus* 'Peppermint Cooler'), geranium (*Pelargonium x hortorum* 'Ringo Deep Scarlet'), impatiens (*Impatiens wallerana* 'Superelfin salmon Blush', *I. wallerana* 'Superelfin Red Velvet'), tomato (*Lycopersicon esculentum* 'Better Boy', *L. esculentum* 'Beefmaster'), begonia (*Begonia sempefflorens* 'Whiskey'), marigold (*Tagetes patula* 'Golden Boy'), dahlia (*Dahlia pinnata* 'Figaro Mix'), dusty miller (*Senecio maritima* 'Silver Dust') and petunia (*Petunia x hybrida* 'Flash Mix') (1,2).

After transplanting, the seedlings were moved to a greenhouse. Approximately three weeks later, the seedlings were taken to a local grower that had supplied the plugs. There, they were visually compared with plugs of the same age that had been manually transplanted for any sign of impaired development. The seedlings transplanted by the robot showed no deficiency in either plant growth or root development. Best success was achieved with species that had stem lengths from 1 to 2.5 inches and a relatively large amount of foliage on top of the seedling, such as vinca and marigold. With vinca, between 89% and 96% of the seedlings retrieved were detected and many of the discarded seedlings were ones that had adhered to the gripper fingers. The seedlings were discarded to ease test observations but an attempt could be made to again transplant these seedlings. With marigolds and geraniums, the sensors also detected a high percentage of seedlings, but the plug flats were overfilled with soil media so that the roots were allowed to overgrow the plug cell walls. The intertwined roots tended to either pull a seedling out of the fingers or rotate it out of the sensors detection range. Small plant species, such as impatiens and petunia, turned out to be the most difficult species to detect with the photoelectric sensors because the seedlings were so short, and therefore far away from the sensors. The tests showed that 20% of the retrieved seedlings were dis-

carded. This was due mainly to the second check of the sensors after transplanting. If the sensitivity of the sensors was set high enough to detect all of the seedlings, during the second check, the sensor would give a false positive reading. When the sensitivity was adjusted so that the false readings were eliminated, the seedlings' foliage could not reflect enough light to relay a positive reading for a seedling back to the controller.

Significance to Industry: Transplanting tests proved that the photoelectric sensors could detect bedding plant seedlings. Seedlings that had stem lengths from 1 to 2.5 inches and relatively large amounts of foliage were more often detected with both of the sensors on the same side of the gripper.

The IBM 7535 robot proved capable of performing the transplanting. A SCARA robot is well suited for transplanting since it was designed to accomplish pick and place operations. The IBM 7535, however, has a rather small workcell. This limited the arrangements available for locating the grow flat and plug flat. The arrangement used was the optimum for the 7535 but it yielded transplanting times that need to be decreased to be competitive with manual transplanting rates. This modified robot could be a part of an automated transplanting system to reduce seasonal labor costs significantly.

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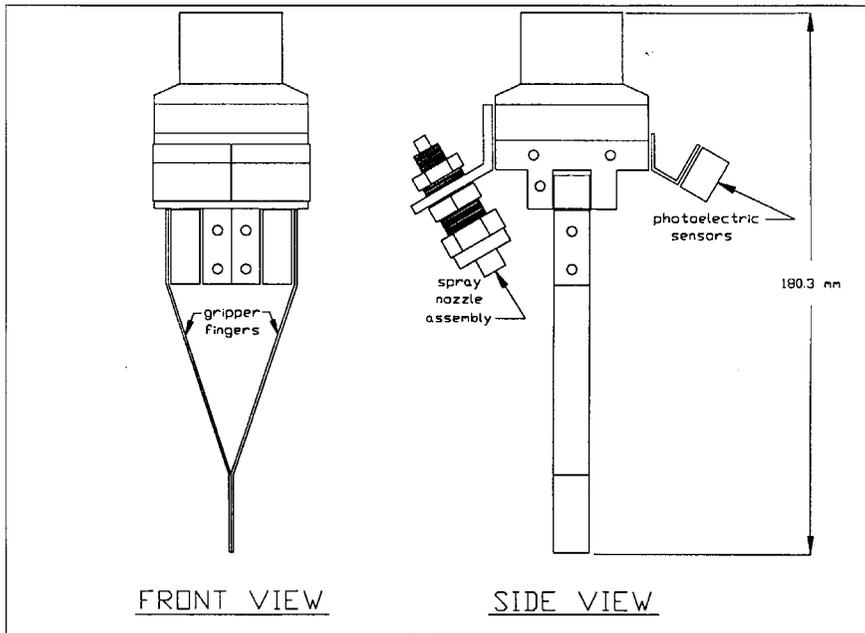


Figure 1. Robot end effector with photoelectric sensors and spray nozzle

An Integrated Pest Management Extension Program for Nursery Producers in South Carolina

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Nature of Work: The growth of the horticultural industry in South Carolina over the past decade has been quite significant. In 1986 the ornamentals and turf industry had gross sales of \$178.5 million. The industry is related to other sectors of the economy. This relationship means that the total industry value to the economy in South Carolina exceeds this figure, equating to a total value of approximately \$238.6 million annually(3). Therefore the nursery and turf industries are an important part of the state's well being.

The typical nursery producer employs a scheduled spray program of broad spectrum pesticides. These applications add to production costs. Costs for a typical sixteen acre nursery have been estimated at \$5365 or \$335/ acre for Japanese Holly to \$218 or \$14 /acre for Kurume Azalea, not including labor or machinery(2).

More significantly, these figures do not include hidden costs, such as damage to the environment and health risks to workers from long term exposure to pesticides. These long term costs must be absorbed by society at some later time, therefore the growers' costs are greater than they may appear to be.

In order to decrease this environmental risk, proliferation of resistant pests, and costs to the public, a new method of pest management at the nursery must be developed. Integrated Pest Management (IPM) represents such an alternative. Rather than chemical reliance, IPM utilizes a combination of cultural, biological, and chemical management measures based on regular monitoring of the nursery. The fundamentals of IPM are 1) observation of the problem, 2) identification of the problem, 3) deciding on the best management option for the particular identified problem, and 4) implementation. Integrated Pest Management is not a program of pest eradication, but pest management in which some tolerance of pests is allowed. Integrated Pest Management programs for nurseries have been developed in other states including Maryland, New York, and Massachusetts (1).

Due to increasing public intolerance of chemical usage, and to provide growers with alternatives to chemical reliance, an Extension nursery IPM program was initiated in South Carolina. In order to succeed, this program needed to accomplish several objectives. First, the program introduced the concept of IPM to nursery operators. Secondly, efficacy of IPM in the nursery industry had to be determined. Thirdly, nursery operators had to develop pest management skills to make sound decisions. Finally the program needed to create an awareness among growers towards responsible pest management practices and environmental concerns.

Presently, this project is in the second of three phases. In the first phase, 1990, a mail survey was conducted of the ornamental nursery industry. From this pool of responses, sixteen nurseries were selected as possible cooperators in this IPM program. On-site surveys were then conducted, and the results were compiled to identify ten nurseries for participation in this program. Consideration for selection was based on factors such as location (a broad geographic distribution was desired), ornamental species grown (major crops should be similar among nurseries monitored), the willingness of the operator to open records to the project, and the type of pesticide program presently used. In the summer of, 1990, these ten nurseries were monitored in an effort to ascertain the types of pest problems and management techniques used by the operators. Pest/plant relationships were noted, but this data is preliminary because pests populations fluctuate from year to year due to changing environmental conditions.

Objectives of the second phase were to implement IPM strategies. Fewer nurseries were involved in this phase of the project in order to allow for more intense monitoring. These three nurseries agreed to allow scouting a portion of the nursery and implement IPM strategies. At the end of this growing season the costs and efficacy of IPM will be assessed and compared to the standard pest program for each nursery.

In the third phase, 1992, the program will continue the implementation of IPM in selected nurseries and illustrate efficacy of IPM through demonstration days. This will allow growers from across the state to examine a working IPM system and learn new techniques that can be employed in their pest management programs.

Results and Discussion: Results of the survey conducted in 1990 are shown in Table 1. Most nurseries operators rely on chemicals for control of pests with little or no consideration of other management options. They also treat all of the plants in nursery or in block when spraying, rather than treating only those plants that are affected by the problem. The survey also revealed the nursery operators define spot treatment as treatment of all plants that are the same or in some cases plants, which are located in the proximity of the problem plants, regardless of the fact that the problem may not affect the other species. It is evident that these nursery operators need help in the identification of the insects, pathogens, and weeds which can be considered problems. It is significant that the growers reliance on chemical spray programs for pest eradication is making them dependent on chemicals for all pest problems encountered.

Results derived from the survey indicate what each nursery operators considered to be their biggest insect problem are listed in Table 2. On-site monitoring allowed for comparison of observed pests and those that were perceived to a problem by the growers. On-site monitoring also allowed for observation of some plant pest relationships. These relationships are important because they indicate potential pest problems and the plants that are attacked, as well as the approximate time of appearance.

Significance to the Industry: Due to increasing public pressure and government regulation, it is becoming increasingly difficult to attain and apply the current arsenal chemicals used to control pests in the nursery situation. It is therefore vital for the survival of the nursery operator to learn alternative measures to management of pest problems. One way of doing so is by learning about the lifecycle of the pest, proper identification, and knowledge of the threshold at which the pest population represents a real problem. This Extension IPM program is attempting to address the nursery situation and determine how alternative measures can be implemented to manage pest problems and still produce a viable and saleable plant, with minimum risk to the environment and human health.

Table I

| Questions | % of Respondents |
|---|-------------------------|
| How do you determine when to spray; | |
| A. My workers inform me of pest infestations | 27 |
| B. I make that decision based on my own observations | 20 |
| C. My pest manager makes the decision | 13 |
| D. Combination of workers, management, pest manager | 40 |
| When spraying for pest control do you | |
| A. spot treat the affected area only | 44 |
| B. treat the whole area | 25 |
| C. treat all of that particular plant no matter how many acre | 31 |
| Do you have a particular threshold you look for before spraying such as the number of plants affected or the amount of damage observed? | |
| yes | 19 |
| no | 81 |
| Do you spray regularly, as in a preventative program? | |
| yes | 63 |
| no | 25 |
| both | 12 |
| If yes, how frequently, on the average do you spray? | |
| A. weekly | 30 |
| B. bi-weekly | 30 |
| C. monthly | 40 |
| Would you say the use of chemicals for pest control at your nursery is | |
| A. routine as in preventative | 46 |
| B. only when needed to spot treat | 47 |
| C. irregular but heavy | 7 |
| D. last resort | 0 |

Table 2

| Major Insect Problems: | |
|-------------------------------|-------------------------------|
| Insects | # of Nursery Responses |
| Aphids | 10 |
| Whitefly | 6 |
| Spider Mite | 7 |
| Lace Bug | 4 |
| Scale | 4 |
| Beetles | 2 |

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Preemergence Herbicide Use in Seed-Propagated Chestnut Oaks

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Nature of Work: Container production of seedling trees is becoming increasingly popular; however, weed control is a limiting production practice because of limited information on herbicide susceptibility. Graunke (3) evaluated several herbicides in seed beds with mixed results for northern red oak, black walnut, loblolly pine, dogwood, and tulip poplar. Devrinol and Modown applied in combination reduced population and growth of dogwood and tulip poplar and Ronstar reduced population and growth in tulip poplar. In another seed bed test, Geyer (2) reported Lasso, Lorox, Surflan, and Dacthal were harmful to Kentucky coffee tree, while only Lasso, Dacthal, or the combination was safe on black locust and honey locust. In a similar test (4) EPTC and Ronstar caused reduction in survival of Kentucky coffee tree and reduced the survival and growth rate of honey locust. Black locust survival and growth rate were reduced by Lasso, Enid, Devrinol, and Surflan. Little information is available on herbicide use with container grown trees where a soil-less potting medium is used. Chestnut oak has become increasingly popular in the southeastern United States. The acorns are sweet and highly prized for wildlife food, while the bark is rich in tannin (1). The objective of this study was to evaluate several herbicides for their effects on germination and subsequent growth of Chestnut oak (Quercus prinus) in tree containers.

Chestnut oak acorns were gathered on October 24, 1990, placed in plastic bags, and maintained at 38°F. On December 12, acorns were sown in 3 5/8"x 6" band tree pots 1/2 - 1" deep in a pinebark-sand potting medium (6:1,v:v), amended with 5 lbs of dolomitic lime and 1.5 lbs of Micromax per yd³.

Plants were treated on December 17, 1990 with 8 herbicides at their recommended rates: Southern Weed Grass Control 2.68G, Ronstar 2G, Rout 3G, Devrinol 5G, Devrinol 50WP, Snapshot 2.5G, Monsanto 1G, and Treflan 5G. Granular herbicides were applied with a hand-held shaker and all others were applied with a CO₂ backpack sprayer at a rate of 20 GPA.

The experimental design was a randomized complete block with 5 replications of 5 plants each. Trees were grown in a double polyethylene greenhouse, watered, and fertilized with 150 ppm using Peters 20-20-20 as needed.

Trees were evaluated at 30, 60, and 90 days after treatment (DAT) for phytotoxicity and height. Tree phytotoxicity was rated on a scale of 1=healthy to 5=dead. At 30 DAT percent germination was determined. Root fresh weights were taken at 60 and 90 DAT; roots were separated into two groups: primary and secondary roots and weighed.

Results and Discussion: Devrinol 50 WP suppressed percent germination when applied before oak germination. Average germination of the control treatment was 80%, while the pots treated with Devrinol 50 WP had about 50% germination. In contrast the granular formulation of Devrinol did not cause any suppression of chestnut oak germination.

Several herbicides affected the growth rate of the germinating seedlings. Dimension 1G, a new herbicide from Monsanto, caused the greatest suppression of height growth during the first 30 days following treatment. Pots treated with Dimension 1G had about 1/3 the growth of most other treatments. Devrinol and Snapshot 2.5 TG caused slight suppression compared to the control; however, at 60 DAT, these 2 treatments were among the treatments with the greatest growth. At 90 DAT, the plants initial growth flush had slowed and no differences occurred among treatments.

The greatest foliar injury among the treatments occurred with Dimension 1G and Snapshot 2.5 TG. At 30 DAT injury symptoms were characterized by leaf distortion and shoot dieback. Symptoms were evident throughout the study. Ronstar caused slight leaf distortion throughout the study; however, plant size was not affected.

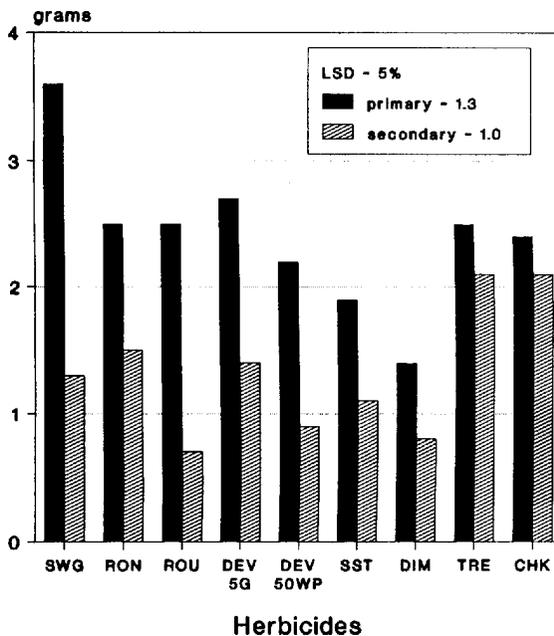
Dimension 1G herbicide suppressed both plant height and root growth (Fig. 1). Separating the root system (tap root vs. secondary roots) showed that 3 herbicides suppressed secondary root development at 60 DAT: Rout 3G, Devrinol 50 WP, and Dimension 1G. At 90 DAT root fresh weights were similar.

Significance to Industry: Results of this study show that Dimension 1G, Snapshot 2.5 TG, and Devrinol 50 WP caused severe injury to germinating chestnut oak seedlings. To a lesser extent, Rout and Ronstar caused minor injury which the plants quickly grew past. Other herbicides used in this test, Southern Weed Grass, Ronstar, and Treflan proved to be safe preemergence herbicides for container seed-propagation of chestnut oak.

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Fig. 1 Root Fresh Weights (60 DAT)



SWG - Southern Weed Grass
Ron - Ronstar
Rou - Rout
Gal - Gallery
Dev 5G - Devrinol 5G
Dev 50WP - Devrinol 50WP
SST - Snapshot
Dim - Dimension
Tre - Treflan
Chk - Check

Relationship of Bronze Speckle of Marigold To Iron DTPA in Peat-Based Media

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Nature of Work: Marigolds are an important crop for the bedding plant industry. In commercial production some of the improved African cultivars (*Tagetes erecta*) develop a specific physiological disorder of the leaves characterized by a mottled pattern of interveinal chlorosis and/or bronze speckling and downward curling of leaves, called Bronze Speckle (authors' nomenclature). Analysis of commercially grown plants exhibiting the disorder were shown to be high in Iron (Fe) and Manganese (Mn). Preliminary research by the authors indicated that the disorder was inducible with high concentrations (5-20 ppm) of iron diethylenetriaminepentaacetic acid (DTPA) applied to peat-based media. Objectives of this experiment were to determine the effects of increasing concentrations of Fe DTPA on occurrence and characteristics of the disorder.

Two African marigold cultivars, 'Voyager' and 'First Lady' were chosen because of their reported susceptibility to the disorder. The experiment was designed as a complete factorial with 2 cultivars, 4 treatments, and 6 replicates per cultivar/treatment combination. Six plants grown in a single 6 cell pack constituted a replicate. Treatments were arranged in a completely randomized design within a controlled environment chamber. A modified Hoagland's solution (Hoagland and Amon, 1938) with a nitrate to ammonium ratio of 3:1 was used as the base nutrient formulation which included all minor elements. Manganese was supplied as Mn ethylenediaminetetraacetic acid (EDTA) at 0.5 ppm. Fe DTPA concentrations of 1, 5, 15, and 20 ppm corresponded to treatments 1 through 4, respectively, which were incorporated into the liquid fertilizer. Plants were grown in a peat-based commercial media (Metro-mix 360, Grace/Sierra, Fogelsville, PA). The experiment was conducted in a growth chamber programmed to deliver 10 hours of light, 18 - 20 °C in a ramped mode over a 24 hr period with maximum temperature corresponding to peak light hours and minimum temperature during the dark cycle. PPFD at peak irradiation was 779 $\mu\text{moles m}^{-2} \text{s}^{-1}$ at 6 inches above plant canopy. Plants received a beginning and end of the day far red treatment to simulate commercial greenhouse environmental conditions. Treatments were initiated with the appearance of the first true leaflet pair and were re-applied at regular intervals to maintain constant moisture and fertility throughout the experiment. Liquid fertilizer applications were made at a rate of 250 ml per 6 cell pack. Leachate samples of the media were collected weekly beginning a week after treatments were first applied, and were analyzed for pH, total soluble salts, Fe and Mn. Plants were harvested when at least one flower was open on all plants. Leaves were separated by visual inspection into symptom and non-symptom tissue. Tissue was dried at 70 °C for 24 hours, weighed, and analyzed for Fe and Mn.

Results and Discussion: Plants receiving treatments of Fe DTPA of 15 or 20 ppm all developed symptoms in the characteristic pattern associated with the disorder, progressing from interveinal chlorosis on recently matured leaves to necrotic speckling and downward curling leaves. Within 3 days, necrotic speckling appeared on both cultivars of the 20 ppm Fe DTPA treatment group; within 7 days, necrotic speckling appeared on both cultivars of the 15 ppm Fe DTPA treatment group; and within 14 days, necrotic speckling appeared on 'Voyager' of the 5 ppm Fe DTPA treatment group; relative to the first day of treatments. Among plants exhibiting the disorder, symptoms increased in severity with increasing treatment levels. By harvest, symptoms had developed in both cultivars receiving 15 or 20 ppm Fe DTPA and in 'Voyager' treated with 5 ppm Fe DTPA. No symptoms developed in plants of either cultivar treated with 1 ppm Fe DTPA, or 'First Lady' treated with 5 ppm Fe DTPA. Total plant dry weight for both cultivars was not affected by treatment, but dry weight of symptom and non-symptom leaf tissue increased and decreased, respectively, with increasing treatment level (Table 1).

Iron concentrations of symptomatic leaves were affected by Fe DTPA treatments and response varied with cultivar. Iron concentration in symptom tissue increased with increasing treatment levels for both cultivars. Iron concentrations were consistently higher in symptom tissue than non-symptom tissue for both cultivars at all treatment levels (Table 2). No clear relationship was found between Mn concentrations in tissue and treatments (Table 3). Media leachate pH ranged from 6.2 at first leachate sampling to 4.2 at harvest. Iron concentrations in media leachates increased over time for both cultivars and all treatments. At the highest treatment level, Fe concentrations in the media exceeded the actual treatment level by over 15 ppm by week 5. Others studies have shown that soil less organic media yielded Fe and Mn in leachates, even when supplied with neither. This may indicate that the media itself may be an extraneous source of Fe and Mn (Broschat and Donselman, 1985).

Significance to the Industry: Results of this study indicate that the symptoms characteristic of Bronze Speckle are inducible with Fe DTPA concentrations of 5 to 20 ppm applied to the media. The symptoms induced with increasing levels of Fe DTPA are consistent with those reported in the commercial industry. There appears to be a relationship between tissue iron levels and symptom occurrence, whereas for Mn, there is no clear relationship identified. This leads us to believe that the disorder, Bronze Speckle of Marigold, may be a micronutrient toxicity. However, other factors which may be important to the occurrence of the disorder must be investigated. Therefore, current and future work will focus on how forms of Fe chelates, media pH and composition, and environmental growing conditions affect the occurrence of Bronze Speckle of Marigold.

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Table 1. Tissue weight, symptom and non-symptom for both cultivars.

| Treatments | 'First Lady' | | | | 'Voyager' | | | |
|-------------|--------------|------|------|------|-----------|------|------|------|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Symptom | - | - | 1.67 | 2.13 | - | 0.53 | 1.82 | 2.59 |
| Non-Symptom | 2.54 | 2.99 | 0.77 | 0.44 | 3.12 | 2.60 | 0.75 | 0.38 |

Table 2. Tissue Fe concentrations, symptom and non-symptom for both cultivars.

| | | | | | | | | |
|-------------|-----|-----|------|------|-----|-----|------|------|
| Symptom | - | - | 1030 | 1647 | - | 511 | 1194 | 1171 |
| Non-Symptom | 561 | 640 | 754 | 1144 | 483 | 573 | 679 | 808 |

Table 3. Tissue Mn concentrations, symptom and non-symptom for both cultivars.

| | | | | | | | | |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Symptom | - | - | 327 | 315 | - | 197 | 342 | 364 |
| Non-Symptom | 336 | 299 | 347 | 341 | 353 | 341 | 412 | 348 |

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Reactive Layer Coated Slow Release Fertilizers

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Nature of Work: Slow release fertilizers have, since their introduction, become a standard means of fertilization in container nurseries. Over the past twenty years, one of the most widely used products has been Osmocote 18-6-12 (Sierra Chemical Co., Milpitas, CA). In the past few years, advances have been made in the coating of slow release fertilizer products. Pursell Industries (Sylacauga, AL) has developed a slow release fertilizer coated with a polymer of diisocyanate and polyol called polyon or reactive layer coated products (RLC). The objective of these experiments was to evaluate the influence of slow release coating methods on nutrient release over time, plant growth and nutrient uptake for 'Blue Pacific' shore juniper.

In experiment 1, uniform liners of *Juniperus conferta* 'Blue Pacific' were potted into trade gallon containers on June 6, 1990. Media was a 6:1 pine bark:sand mixture amended with 1.5 lb of Micromax and 5 lb of dolomitic limestone/yd³. Fertilizer treatments were applied, June 12, 1990, as a topdress at a rate of 2 lb N/yd³. Fertilizers evaluated were a RLC complete 18-6-12 (N-P-K in single prill), RLC blend 18-6-12 (N-P-K in separate prills), and Osmocote 18-6-12. There were 4 replications of 2 plants/treatment/replication in a completely randomized block design.

In experiment 2, the above medium was placed in trade gallon containers without plants. The fertilizer treatments were the same as for experiment 1. There were 14 replications of 2 plants/treatment/replication in a completely randomized block design.

Medium leachates were collected from containers with and without plants 7, 14, 28, 56, 112, and 168 days after application (DAA) using the pour through technique to determine medium solution electrical conductivity (EC) (1). On the same days that medium leachates were taken, fertilizer prills were removed from containers without plants by hand and analyzed to determine total N remaining in the individual pots. Growth indices were taken on days 63 and 175. Plants were harvested on day 175 to determine tissue N content.

Results and Discussion: Fourteen DAA, the RLC complete fertilizer had released over 40% of total N applied, in contrast the Osmocote and RLC blend treatments had released about 21% and 5% of total N applied, respectively (Figure 1). N release from the 3 fertilizers corresponded to medium solution EC. Mean medium solution EC levels for the RLC complete, Osmocote, and RLC blend fertilizers were 0.86 dS/m, 0.21 dS/m, and 0.20 dS/m, respectively.

By day 28, there had been a sharp increase in the % N released from the RLC blend treatment increasing from 5.1% to 29.4% of N applied. RLC complete had released 52.5%, and Osmocote had released 25.3% of the total N applied. As on day 14, medium solution EC was correlated to N release rates. Mean EC levels for the RLC complete, Osmocote, and RLC blend were 0.48 dS/m, 0.18 dS/m, and 0.21 dS/m, respectively.

Percent N released for the RLC complete and RLC blend were similar for 56 and 112 DAA. By day 168, the RLC complete and RLC blend had lost 89% and 91% of total N applied, respectively. In contrast, Osmocote had lost just over 83% of total N applied. RLC complete and RLC blend medium solution EC levels decreased for observation days 56 through 112. The medium solution EC level for Osmocote increased on day 112 compared to day 56. Mean EC levels on day 112 were 0.14 dS/m, 0.18 dS/m, and 0.32 dS/m, for RLC complete, RLC blend, and Osmocote, respectively. By day 168, medium solution EC had declined for RLC complete, RLC blend, and Osmocote treatments. Mean EC levels were 0.10 dS/m, 0.14 dS/m, and 0.16 dS/m, respectively. For all dates and fertilizers, medium solution EC levels for containers with and without plants were similar.

Both 63 and 175 D M, RLC complete plants had the greatest growth indices followed by Osmocote and RLC blend plants (Table 1). Although RLC complete plants showed the greatest growth indices for both observation dates, growth index increases for Osmocote plants from day 63 to 175 were 31 and 59% greater than for RLC complete and RLC blend plants, respectively.

Tissue N content was highest in plants fertilized with Osmocote and lowest for RLC complete plants. The higher tissue N content for Osmocote may be related to the percent N released by Osmocote during the period of 56 through 168 DAA. Mean tissue percent N levels were 1.13, 1.36, and 1.71 for RLC complete, RLC blend, and Osmocote, respectively.

Significance to Industry: The 3 fertilizers evaluated in these experiments each showed differences in both amount of N released and the time period over which the release took place. Although the RLC complete and RLC blend both had much quicker release rates than the Osmocote, the RLC complete fertilizer produced a plant at harvest that was comparable to the Osmocote fertilizer which had a slower release rate. These results suggest that the RLC technology may produce quality slow release fertilizers for use in the container nursery industry.

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Table 1. Blue Pacific shore juniper growth indices (height + width + width/3).

| Treatment: Fertilizer | Days after fertilizer application* | |
|--|---------------------------------------|--------|
| | 63 | 175 |
| Reactive Layer Coated Complete 18-6-12 | 75.7a** | 87.4a |
| Osmocote 18-6-12 | 66.9ab | 83.9ab |
| Reactive Layer Coated Blend 18-6-12 | 61.4b | 68.3b |

* Data collected 8-1S-90 and 12-14-90

** Mean separation within columns by Duncan's Multiple Range Test, P-0.05.

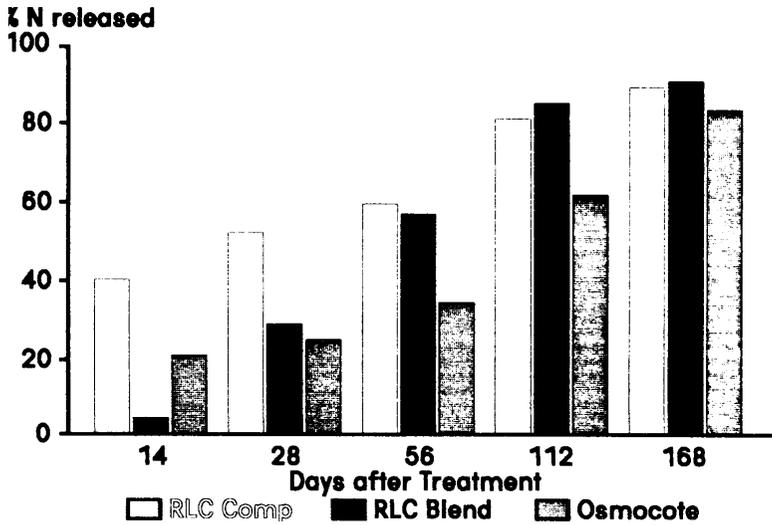


Figure 1. Percent total nitrogen released over time.

Exploring Episodic Growth and its Benefit to The Grower

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Nature of Work: Episodic growth is a term used to define alternate episodes of rapid shoot growth and shoot inactivity. The stages of an episode of growth begin with shoot elongation, unfolding and expansion of leaves, the terminal bud entering into inactivity, followed by completion of leaf expansion and greening. Woody ornamentals such as Japanese holly, *Pittosporum Tobira*, *Ligustrum japonicum*, *Euonymus japonica*, and Rhododendron undergo multiple shoot growth flushes during their natural growing season. Hershey and Paul (1983) found that nitrate-nitrogen ($\text{NO}_3\text{-N}$) uptake was highest during periods of shoot inactivity of *E. japonica*. Episodes of shoot growth alternating with episodes of root growth and shoot inactivity have been found to occur in Japanese holly, pine and oak. Neimiera and Wright (1982) found that the concentration of $\text{NO}_3\text{-N}$ affected the duration and dry weight gains of alternating shoot and root growth that occurred.

Research exploring actual changes in weight gain during episodes of growth in woody ornamentals is limited. Therefore, the focus of this study was to develop a better understanding of the growth and nutrient uptake patterns of *Ligustrum japonicum*, an episodic species, using nondestructive measurements of fresh weight and measurement of solution depletion.

Terminal rooted cuttings of six *Ligustrum* plants each having an 8 cm stem and 4 leaves were grown in an aerated, modified Hoagland's solution (Hoagland and Arnon, 1938) containing 3.74 mM $\text{NO}_3\text{-N}$. Plants were grown in 2 liter containers in a growth chamber with a ramped temperature of 27° C maximum (day), and 21° C minimum (night) and a 16 hr ramped photoperiod with a maximum irradiance of 400 $\mu\text{moles m}^{-2} \text{s}^{-2}$. Length of shoot elongation, root and shoot fresh weight, NO_3 depletion, and pH were measured every three days at which time the nutrient solution was renewed. Nondestructive root and shoot fresh weights were measured by a technique developed by Young and Wemer (1984) using Archimedes' principle of buoyancy. We selected one plant as a representative of the six plants and present data for this plant in Figures 1-3.

Results and Discussion: Shoot elongation occurred in three distinct phases. However shoot and root fresh weight gradually increased throughout the experiment, with root fresh weight following approximately the same pattern as shoot fresh weight (Fig. 1). Although this provides no evidence of alternating phases of root and shoot growth, fresh weight increase was fairly continuous throughout the experiment.

Changes in fresh weight gain are revealed by root to shoot ratios (Fig. 2). Fresh weight gain of the roots in respect to shoots increased during periods of shoot elongation and decreased during the cessation of shoot elongation. This contradicts

the work of Mertens and Wright (1978) who used length as the measurement of growth. They found that root growth ceases during shoot growth and is initiated again when shoot growth ceases. This experiment indicates that in *Ligustnum*, alternate phases of root and shoot elongation do occur while actual increase in fresh weight gain seemed to be greatest for the roots during shoot elongation and greatest for the shoot during root elongation.

Nitrate uptake was greater during periods of shoot elongation. Solution pH increased to about 7.0 and remained constant after day 98 (Fig. 3). This contradicts the results of Hershey and Paul (1983) who found that NO_3^- uptake was greater when shoot elongation had ceased and uptake was lowest when shoot elongation began, with pH following this same pattern. In *Ligustrum*, it would appear that root growth (fresh weight gain) is highest during shoot elongation and that an increase in NO_3^- uptake may be necessary for continued shoot growth after elongation has occurred.

Significance to Industry: A better understanding of growth cycles and nutrient uptake patterns of episodic plants could lead to improved timing of fertilizer application and better control of plant growth. The ability to control flush cycles of episodic plants would not only enable the grower to produce a better quality plant over a determined period of time, but could also lead to better plants for propagation purposes .

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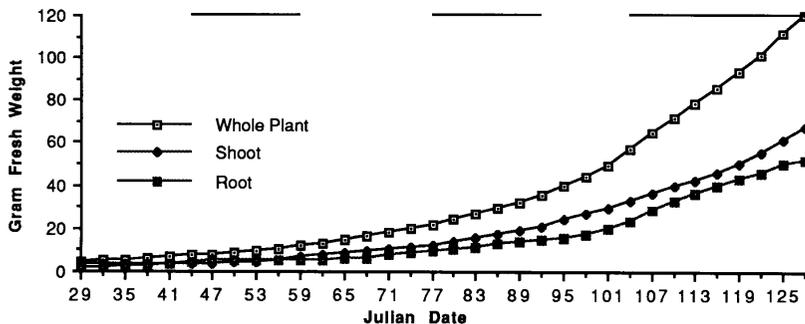


Figure 1. Gram fresh weight of whole plant, shoot, and root of Ligustrum. Horizontal bars indicate periods of shoot elongation.

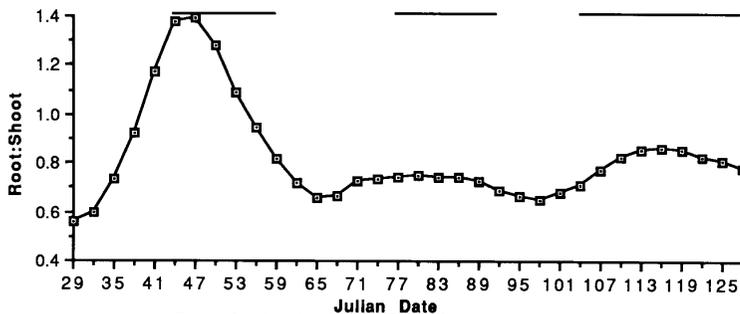


Figure 2. Root to shoot ratio of Ligustrum. Horizontal bars indicate periods of shoot elongation.

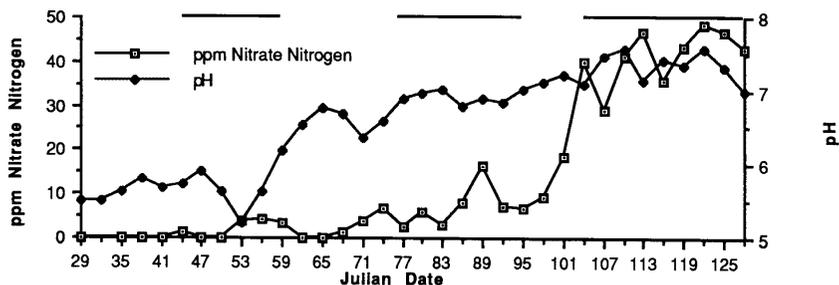


Figure 3. Uptake rate of nitrate and pH of nutrient solution. Horizontal bars indicate periods of shoot elongation.

**Effects of Chemical Root Pruning
on Root Regeneration and Cellular Structure
of Viburnum Root Tips**

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Nature of Work: Forestry researchers used copper carbonate, CuCO_3 , concentrations from 25 to 500 g/l of exterior latex paint (LP) to chemically root prune conifer seedlings (1, 3, 9). Effectiveness of root pruning varied due to species, container size, growing media and copper concentration (6, 8). Copper has the ability to displace most other ions from root exchange sites and become strongly bound in root surface tissues yielding higher copper levels within roots of plants (5). The earliest plant response to high copper levels is inhibition of root growth (7). Rapid root regeneration after removal from copper painted containers was observed (2), followed by development of a root system comparable to naturally established conifer seedlings. However, copper carbonate is relatively expensive and not readily available through normal supply channels.

Copper hydroxide, $\text{Cu}(\text{OH})_2$, (CH) is a low cost readily available fungicide. This experiment was designed to study CH in a LP carrier as a root pruning agent on container grown Viburnum tomentosum plicatum 'Mariesii' and subsequent effects on root regeneration and root cellular structure. The experiment design was a randomized complete block with 6 treatments, 5 replications, and 2 plants per replication/treatment.

Plants were grown in ground pine bark for 5 months in 3 liter containers painted with CH/LP on interior walls, with CH concentrations from 0 to 260 grams per liter (4). One plant per replication/treatment was transplanted to a 12 liter container to observe root regeneration after 32 days. The other plants were destructively harvested for elemental analysis and histology samples. Root tips (RT) in contact with container walls were removed as serial sections and 5 replications pooled for elemental analysis. RT designates the apical 5 mm root tip, and S2 the next 5 mm. A third section (S3) of the root system was composed of the first 2.5 cm (1 inch) below the soil surface. Foliage (F) from the top third of the plant was also removed. Tissue samples were dried and ground prior to analysis by MMI, Inc. of Athens, GA.

Root tips 3 mm long were fixed in CrAF III, degassed in a vacuum chamber, dehydrated in a graded 2-propanol series and embedded in Polyfin™. Longitudinal sections (10 μ) were cut on a rotary microtome, expanded on a water pool on a glass slide and dried on a warming tray. Sections were deparaffinized in Micro-Clear™ and stained in 0.01% toluidine blue (borax buffer, pH 9.0) for 30 minutes. Stained sections were cleared with Micro-Clear~ and cover glasses affixed with EUKITT® mounting reagent.

Results and Discussion: Mengel and Kirby (7) stated the normal range of Cu in dry plant matter is 2 - 20 ppm. Figure 1 shows Cu levels were highest in RT and S2 and rapidly decreased to acceptable levels in S3 and F tissue samples. Root tips in contact with the 260 CH treatment failed to resume growth. However, regeneration did occur as a result of secondary branching immediately behind those root tips.

Root tips from untreated containers (Figure 2) showed normal growth and development with cellular structures clearly defined. In the 90 CH treatment (Figure 3) the cortex and vascular cylinder were more mature, and ergastic substances were more prevalent in the cortex. In the 260 CH treatment (Figure 4) roots became thicker and club-like, and root tip structure appeared callus-like with no visible cellular definition within the root cap or root tip area. As little as 90 g/l CH was sufficient for chemical root pruning of viburnum. No visual signs of Cu toxicity were observed at levels up to 90 g/l. At higher levels, root tips were visibly darker and thicker.

Significance to Industry: Increased secondary root growth was observed in viburnum plants due to chemical root pruning with copper hydroxide in latex paint applied to inner container surfaces. Root systems with more secondary branching, thus more root tips, should provide a larger root surface area for absorption of water and minerals, and should respond well when set in the landscape.

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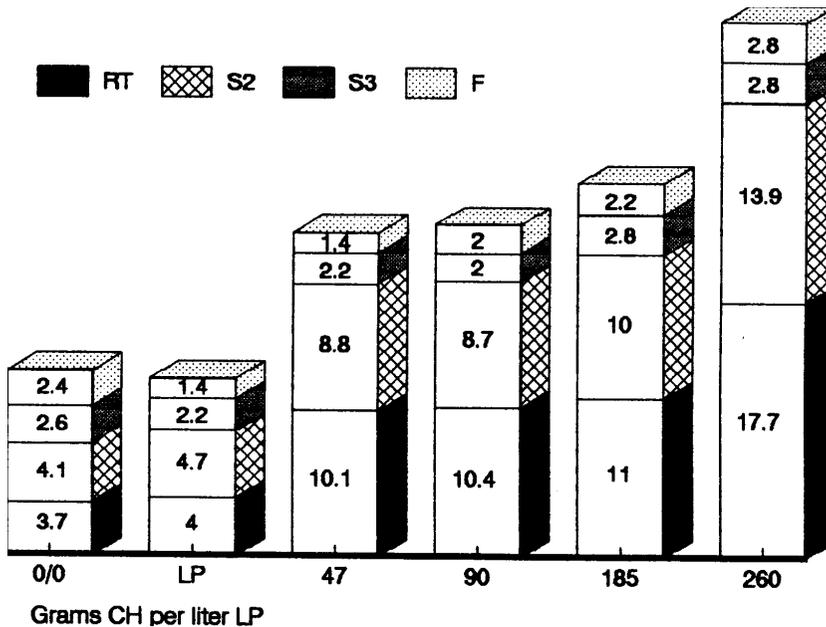


Figure 1. Cu concentrations root (RT, S2, S3) and foliage (F) tissues of viburnum grown in copper hydroxide (CH)/latex paint (U) treated containers for 5 months. Values are expressed as $\sqrt{\text{ppm}}$.



Figure 2. Medial, longitudinal section of a normal viburnum root tip grown in untreated 3 l. plastic containers. RC, root cap; E, epi-dermis; C, developing cortex; VC, immature vascular cylinder. Bar = 100 μ m.



Figure 3. Medial, longitudinal section of a viburnum root tip grown 5 months in 3 l. containers painted with 90 g/l cupric hydroxide in latex paint on the interior walls. RC, root cap; E, epidermis; C, cortex; EG, ergastic substances; VC, maturing vascular cylinder. Bar = 100 μ m.



Figure 4. Medial, longitudinal section of a viburnum root tip grown 5 months in 3 l. containers painted with 260 g/l cupric hydroxide in latex paint on the interior walls. CL, callus-like mass replacing root cap; E, epidermis; C, cortex; VC, mature vascular cylinder. Bar = 300 μ m.

Application of Callus Culture For The Study Of Blackspot Disease Resistance in Roses

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Nature of Work: Blackspot, caused by *Marssonina rosae*, is the most serious disease of roses. Some species roses have natural resistance to blackspot, but the resistance mechanism is unknown. Biochemical control, possibly pathogenesis-related (PR) proteins, may explain this resistance. However, PR proteins have not been reported in roses.

The usual method of studying blackspot resistance employs a detached leaf system. The technique has disadvantages (leaf senescence and protein degradation) for investigating protein mediated defense. Tissue culture systems using pathogens co-cultured with host tissue offer the advantage of host-pathogen interaction studies. Rose calli usage should eliminate the problem of protein degradation that occurs during senescence of leaflets. This study was conducted to determine if tissue culture could replace the detached leaf method for determining protein mediated blackspot resistance.

Rosa x 'Pascali' and 'Tropicana', hybrid teas susceptible to blackspot, and *Rosa setigera 'Prairie'* and *Rosa roxburghii 'Chestnut'*, species roses resistant to blackspot were studied. Plant calli were established on 2 media, containing 0.44% Murashige and Skoog (MS) salts, M7150 MS vitamins, 3% sucrose, and 0.8% agar.

Growth regulators used for the hybrid teas were 2 ppm 2,4-dichloro-phenoxyacetic acid, 1 ppm 1-naphthaleneacetic acid, and 0.2 ppm benzyladenine. Growth regulators were reduced by half for the species rose medium since they require lower levels (2). Calli were cultured at 77°F with no light except for 'Prairie', which required 16 hours of light (4.1 klux).

All calli were inoculated with a *M. rosae* conidial suspension. After inoculation, calli were cultured in darkness at 77°F. Cultures were weighed and rated according to necrotic reaction 28 days after inoculation. Comparisons with controls were to determine if resistance was expressed *in vitro*.

Protein patterns of *M. rosae* inoculated and uninoculated leaflets and calli were compared, using 1-dimensional sodium dodecyl sulfate polyacrylamide gel electrophoresis according to Laemmli (3) 1, 7, 14, and 21 days after inoculation.

Results and Discussion: Inoculated calli showed more necrosis than controls. Based upon percent difference between ratings of inoculated and control calli, 'Pascali' callus reacted most severely. No differences occurred in ratings among the other cultivars (Table 1).

Inoculated calli decreased in percent weight change compared to uninoculated calli. Based upon the percent difference between the percent fresh weight change of inoculated and control calli, 'Prairie' callus was the least affected by inoculation. The other calli were not different from each other (Table 2).

Callus derived from resistant and susceptible roses did not express resistance *in vitro*. Blackspot resistance may only be expressed in differentiated tissue.

Comparisons of the protein profiles of all detached leaflets showed no constitutive proteins present in the blackspot resistant 'Chestnut' and 'Prairie' leaflets accounting for resistance. Inoculation resulted in two new 24 and 34 kD proteins in 'Pascali' leaflets by day 14 and by day 21 for 'Tropicana'. Inoculation did not result in any new proteins in any calli as the 24 and 34 kD proteins were constitutively present. The proteins may represent PR proteins known to be constitutively present in callus (1). The 24 and 34 kD proteins, however, did not appear in inoculated leaflets of 'Chestnut' and 'Prairie' and are not responsible for resistance expressed by these cultivars.

Significance to the Industry: Use of calli for studying blackspot resistance does not yield comparable results to those obtained with the detached leaf method. The tissue culture system was useful, however, when employed in conjunction with the detached leaf method, especially for protein comparisons.

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Table 1. Necrotic reaction ratings of rose calli at 28 days inoculated with *Marssonina rosae* conidia.

| Cultivar | Necrotic Reaction Rating ^z | | Control | Percent Difference |
|-------------|---------------------------------------|----------------|---------|---------------------|
| | Inoculated | | | |
| 'Chestnut' | 1.56 | b ^y | 3.82 a | 59.0 b ^x |
| 'Pascali' | 1.07 | b | 3.70 a | 70.6 a |
| 'Prairie' | 1.55 | b | 3.54 a | 55.7 b |
| 'Tropicana' | 1.30 | b | 2.41 a | 60.8 b |

^z Necrotic reaction rating of 1 to 4 where 4=no necrosis, 3=less than 25% necrosis, 2= between 25 and 50% necrosis, and 1=greater than 50% necrosis.

^y Ratings within rows followed by the same letter do not differ (P=0.05), according to the Least Significant Difference Test.

^x Values within columns followed by the same letter do not differ (P=0.05), according to the Least Significant Difference Test.

Table 2. Percent change in fresh weight of rose calli 28 days after inoculation with *Marssonina rosae* conidia.

| Cultivar | Change in Fresh Weight (%) | | Percent Difference | |
|-------------|----------------------------|----------------|--------------------|---------------------|
| | Inoculated | Control | | |
| 'Chestnut' | 88.7 | b ^z | 214.4 a | 57.1 a ^y |
| 'Pascali' | 42.4 | b | 107.1 a | 60.4 a |
| 'Prairie' | 207.6 | b | 282.6 a | 24.1 b |
| 'Tropicana' | 94.7 | b | 385.6 a | 69.3 a |

^z Values within rows followed by the same letter do not differ (P=0.05), according to the Least Significant Difference Test.

^x Values within columns followed by the same letter do not differ (P=0.05), according to the Least Significant Difference Test.

Influence of Iron DTPA Chelate Concentrations on the Occurrence of a Specific Physiological Disorder in Geranium

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Nature of Work: For the past several years geranium growers have experienced a physiological disorder affecting their crop as it reaches maturity(4). During this time period, an increasing number of growers began using soil-less peat-based media concurrently with peat-lite fertilizers (the term peat-lite used generically). The symptoms of this disorder begin with an interveinal chlorosis, or speckling, which progresses to, marginal chlorosis, and in extreme cases, leaf necrosis. A bronzing of the lower leaves may also occur in some cases. As is typical of a micronutrient toxicity, symptoms usually appear on the oldest, most mature leaves and progress to the younger leaves. In previous research with seedling geraniums, high concentrations of iron (500 ppm) have been observed in symptomatic tissue usually in association with elevated levels of manganese (300 ppm)(1).

Media pH below 5.8 and soluble salts above 2000 micromhos have been reported to enhance the occurrence of the disorder (2,3) and possibly there are other factors involved. Due to a similarity of symptoms, this disorder may be confused with magnesium deficiency. Magnesium deficiency is expressed as interveinal chlorosis, or speckling, which may progress towards the leaf margins. Leaf tissue may also redden or bronze. The key difference between magnesium deficiency and this disorder is the magnesium deficient leaves curl up, while leaves affected by this disorder typically curl down. Research is needed to aid the commercial grower in correct identification and treatment of this disorder.

Objectives of this experiment were to induce symptoms of the disorder using different levels of iron chelate in the liquid fertilizer program. Experimental design was a complete factorial with two cultivars, four treatments, and ten repetitions. A single plant constituted a replicate. Two cultivars, 'Aurora' and 'Grace', that have been reported to be susceptible to the disorder were used. Rooted cuttings were grown in a peat-based media. Iron was supplied in the form of iron DTPA (Diethylenetriaminepentaacetic acid) in the regular liquid feed program, which consisted of 250 ppm N (Peter's 20-10-20 Peat-Lite). Treatment levels of iron DTPA included 1 (control), 5, 15, and 20 ppm, treatments 1, 2, 3, and 4, respectively. Treatments were assigned in a completely randomized design within a greenhouse. During the final two weeks of the experiment N concentration was reduced to 125 ppm to simulate the grower practice of "hardening-off" the plants before shipment.

Using a pour through leachate method, pH and soluble salts were monitored on a weekly basis. This method involved bringing the plant containers to field capacity the evening before, then just enough water was added to collect 100 ml samples the following morning. Leachates and tissue were analyzed for iron and manganese

using atomic absorption spectrophotometry. Plants were harvested nine weeks after treatments began. Leaves were collected and divided into symptom and non-symptom tissue for dry weights.

Results and Discussion: 'Aurora' was more susceptible than 'Grace'. Symptoms were observed in all 'Aurora' plants at every treatment level. All cases began with slight interveinal chlorosis, progressing to marginal chlorosis and necrosis. Plants of treatment 1 had higher symptom dry weights than treatments 2, 3, and 4. This may have been due to the latter three treatments having many leaves in which determination of symptom or nonsymptom tissue could not be made (Figure 1.). 'Grace' showed few symptoms as treatment level increased.

Tissue iron and manganese concentrations were higher in symptom tissue in both cultivars. Tissue iron concentrations increased with increasing treatment level in symptom and non-symptom tissue in both cultivars (Figure 2). Manganese tissue concentrations stayed constant with increasing treatment level in symptom and non-symptom tissue in both cultivars (Figure 3). The concentration of iron in the leachates accumulated in treatments 3 and 4 to levels exceeding the actual treatment level by over 100% after four weeks with both cultivars.

Significance to Industry: Symptoms characteristic of this disorder as described by the commercial industry were induced with iron DTPA treatments. Though a relationship between the occurrence of this disorder and the level of iron DTPA treatment could not be established in this study, tissue with symptoms had consistently higher concentrations of iron and manganese than tissue without symptoms. Symptoms occurred in plants receiving 1 ppm iron DTPA, which is the same concentration and formulation as in peat-lite fertilizers used in geranium production. Results of this study suggest that this disorder may be a micronutrient toxicity, particularly of iron and manganese. However, this data is preliminary and other factors which may be important to the occurrence of the disorder have yet to be elucidated. The role of cultural factors including media pH, growing temperatures, nitrogen concentrations, and growth regulators, in the onset of this disorder will be explored in future research.

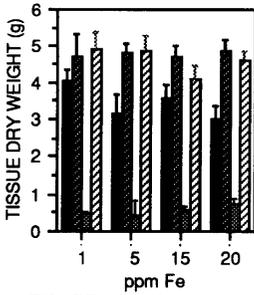


FIGURE 1. Leaf tissue dry weight of 'Aurora' and 'Grace' with increasing iron treatment level.

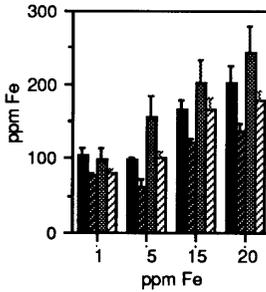


FIGURE 2. Leaf tissue iron concentration of 'Aurora' and 'Grace' with increasing iron treatment level.

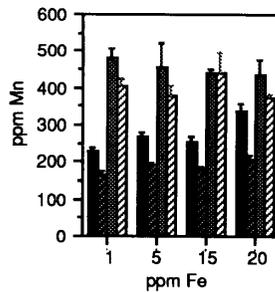
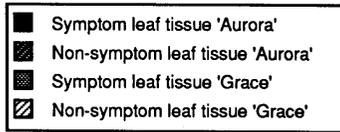


FIGURE 3. Leaf tissue manganese concentration of 'Aurora' and 'Grace' with increasing iron treatment level.



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