SECTION 1
DR. BRYSON L. JAMES
STUDENT COMPETITION

Greg Davis
Section Chairman and Moderator
Allelopathic Influences of Fresh and Composted Yard Waste on Seed Germination

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Nature of Work: Disposal of yard waste is an environmental issue of increasing national concern. Yard waste accounts for up to 25% of the volume of material placed in municipal landfills (Jackson, 1993). In 1986, the Environmental Protection Agency predicted that one-third of existing landfills in the U.S. would be closed by 1992 (Repa and Sheets, 1992), and all current landfills in 14 or more states are predicted to reach full capacity by 1994 (Wilkinson, 1989). Mulch is one way to diminish the problem. The need for landscape mulches has increased dramatically in recent years (Wilkinson, 1989). Thus yard waste, however, could pose problems when used as a landscape mulch, such as changes in soil pH, mulch toxicity from improper composting (Svenson and Witte, 1989), and allelopathic activity (Stein, 1988; Walsh, 1991). Allelopathy refers to a biochemical inhibition of one plant by another and has been reported for many agronomic and horticultural crops (Rice, 1984), with Juglans nigra (black walnut) being perhaps the best known example. Mulches produced from plant material with allelopathic potential can inhibit up to 100% of seed germination and plant growth (Stein, 1988; Walsh, 1991). This report examines the allelopathic potential of yard waste, by germinating seeds on soils exposed to yard waste leachates.

Materials and Methods: Freshly ground yard waste was collected between March and July 1993 from Compost Corporation of America in Knoxville, Tennessee. The 2.3 m³ (three yd³) yard waste samples were collected on each of the following dates: March 2, March 19, April 7, April 22, May 7, May 25, June 9, June 25, July 9, and July 30. The collected material consisted primarily of brush, branches, and leaves. From each sample of yard waste,.09m³ (three ft³) was tested immediately and the remainder was composted for six months for later use. Wooden frames of treated pine were constructed to hold the yard waste from 10 collection dates plus one control with the capacity to hold .03m³ (one ft³) of yard waste for each frame with mulch 8.9cm (3.5") deep. Frames were placed on the experimental field plot, secured to the ground, all vegetation beneath the frames removed by hand, and the yard waste applied in an even layer. After at least 15.2cm (6 inches) of rain had fallen onto the yard waste collections and leached into the ground, the yard waste was removed from the frames. Twenty seeds each of four species were placed into an assigned location within each frame on September 1, 1993 for fresh yard waste and on April 29, 1994 for composted yard waste. Seeds used for the experiment were: Ipomoea purpurea (morning-glory, Convolvulaceae), Tagetes filifolia (marigold, Compositae), Celosia cristata (cockscomb, Amaranthaceae), and Lolium multiflorum (annual ryegrass, Cramineae). These seeds were chosen because they represented four families, and because they usually germinate easily and quickly. After seeding, a 1.3cm (1/2 inch) layer of yard waste was returned to the frame to cover the seeds. This layer was used to continue the treatment effect without inhibiting germination by over-mulching. Germination percentages were recorded 20 days after sowing, by hand pulling and counting. The experimental design
was a Complete Randomized Block with three replications. An analysis was done using a General Linear Model, Duncans Multiple Range Test, and linear regression at alpha = 0.05.

**Results and Discussions:** For the fresh yard waste the first five collection dates gave the lowest percentages of germination and were not significantly different from each other (Table 1.) Collections 3-2, 3-19, 4-7, 4-22, and 5-7 gave complete control of annual ryegrass germination (Figure 1.). Collections 3-2, 3-19, and 5-7 completely inhibited celosia germination. Marigold and morning-glory germination were never completely controlled by any collections, but mean percent germination was reduced by 3-2, 3-19, 4-7, 4-22, and 5-7. The control and 6-25 gave the highest percentages of germination of all collections. Collections 5-25, 6-9, 7-9, and 7-30 were similar, resulting in more than 50% mean germination of all species. Collection 4-22 gave the best control of marigold germination at 13%. Collection 3-19 gave the best control over morning-glory germination at 28%. The control did not always allow the highest germination percentages of the four species of seeds but it did provide the most uniform germination percentages among all species. For composted yard waste the control gave the highest percentages of germination of all collections averaging 91.9% for four species (Table 2. and Figure 2.). Collection 4-22 and 3-2 gave the lowest percentages of germination of the four species.

Inhibition of seed germination has been linked to allelochemicals present in yard waste mulch (Rice, 1984; Stein, 1988; Walsh, 1991). Rice (1984) discusses the testing of leachates from *Juniperus, Pinus, Eucalyptus, Platanus, Celtis,* and other species and their capabilities for inhibiting seed germination. *Acer rubrum* (red maple) leaves, *Tsuga canadensis* (Canadian hemlock) foliage, *Juniperus virginiana* (eastern red cedar) wood chips, and *Juglans nigra* (black walnut) wood shavings have shown the most promising results for inhibiting seed germination when used as a mulch (Stein, 1988). Walsh (1991) found that no single mulch leachate effectively inhibited the germination of all seeds tested. Cocoa bean hulls, red maple and cedar leachates inhibited a wider variety of seed species than other mulches (Walsh, 1991).

In this study the first five collections consisted primarily of red maple, eastern red cedar, Canadian hemlock, and *Pinus virginiana* (Virginia pine). The inhibition of seed germination with mulches of these collection dates was probably related to the allelopathic nature of these species. Collections 5-25, 6-9, 6-25, 7-9, and 7-30 consisted primarily of Virginia pine, *Pinus strobus* (white pine), *Magnolia grandiflora* (southern magnolia), *Liquidambar styraciflua* (American sweetgum), and *Pinus elliottii* (slash pine), species having no known allelopathic effects. After composting collection 3-2, 4-7, and 4-22 gave a slight inhibition of seed germination which probably was related to the allelopathic nature of their content. Collection 3-19, and 5-7 gave a higher percentage of germination after composting compared to fresh mulch which is probably related to the breakdown and leaching out of allelochemicals present. All collection dates had an increase in mean percent germination after composting probably due to the breakdown and leaching out of allelochemicals present in the yard waste during composting or due to the time of year the test was run. Canadian hemlock, eastern red cedar, and red
maple have previously been found to inhibit germination. The testing of fresh and composted yard waste has probably shown that more allelochemicals are present in fresh yard waste than in composted yard waste and that a greater inhibition of seed germination is more likely with fresh yard waste.

Inhibition of seed germination by mulches of known composition has been proven in previous tests, but when yard waste mulch from a mixture of different species is tested for inhibition of seed germination results are sporadic. The sporadic results are probably linked to the constantly changing species comprising the yard waste and uncontrollable field factors. This makes it difficult to predict whether a yard waste has allelopathic potential without identifying each species in the waste.

**Significance to the Industry:** Mulch leachates of species such as red maple, Canadian hemlock, black walnut, and eastern red cedar have shown promising results for inhibiting seed germination. Yard waste that has these species identified in its composition could be predicted to control certain species of weed seed germination when used as a landscape mulch. With further research this tool could be of value to the landscape maintenance industry by providing an alternative to herbicides for weed control.

**Literature Cited**


Table 1. Mean % germination of seeds under 10 collection dates of fresh yard waste, averaged over four species. Mean separation by Duncan’s Multiple Range test, α = 0.05. Same letters indicate no significant difference.

<table>
<thead>
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<th>Collection Dates</th>
<th>Mean % Germination</th>
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<td>7-9</td>
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</tr>
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<td>7-30</td>
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</tr>
<tr>
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<td>26.3 c</td>
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<td>3-19</td>
<td>14.6 c</td>
</tr>
<tr>
<td>5-7</td>
<td>14.6 c</td>
</tr>
</tbody>
</table>

Table 2. Mean % germination of seeds under 10 collection dates of composted yard waste, averaged over four species. Mean separation by Duncan’s Multiple Range test, α = 0.05. Same letters indicate no significant difference.

<table>
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<th>Collection Dates</th>
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<td>63.3ef</td>
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<tr>
<td>4-22</td>
<td>58.0f</td>
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Figure 1. Average germination rate of four species of seed on field soil exposed to 10 fresh yard waste collections. See Table 1 for analysis of variation. Ctl = control (no yard waste).

Figure 2. Average germination rate of four species of seed on field soil exposed to 10 composted yard waste collections. See Table 2 for analysis of variation. Ctl = control (no yard waste).
Field Production of Wildflower Sod

Anne Marie Johnson and Ted Whitwell
South Carolina

Nature of Work: In recent years wildflowers have become a popular choice for providing low maintenance color and diversity in the landscape. However, failure to achieve the desired effect of a wildflower meadow often occurs due to improper seed planting techniques and weed competition (1,2,3). Also, starting a wildflower planting from seed requires at least two to three years for some perennial species to reach peak maturity (4). Having the option of planting a relatively weed free wildflower sod, consisting of established young plants, would eliminate the risks involved in direct seeding and provide the look and color of a mature wildflower meadow in a much shorter time. There are currently wildflower sod products available, but few, if any are field grown and harvested in a manner similar to that of turfgrass sod where seed is sown, plants reach a desired level of maturity, are undercut, and removed from the field.

The first phase of the development of a field grown and harvested wildflower sod began with the selection and evaluation of 29 native and non-native wildflower species. The selection of these species was based on the absence of a large taproot, adaptability to the southeastern climate, flowering period, attractiveness of flowers, and potential for survival after root disturbance. All species were evaluated on their ability to withstand the stresses incurred from the undercutting and transplanting process.

Individual species were direct seeded in respective meter square plots at triple the recommended seeding rate. Each plot was separated by a meter square buffer/transplant area. A complete randomized block design was used with four replications.

Research plot location was the coastal plain area of South Carolina and plantings were made in the Fall of 1993 and the Spring of 1994 in order to compare optimum planting time to survival rates. All plantings received a general application of an all purpose 16-4-8 fertilizer and overhead irrigation was used.

Fall plantings were undercut in early spring (1994), at a depth of two inches with a hand held turf sod cutter. A third of each undercut strip was immediately transplanted to a prepared adjoining area. Two weeks later, half of the remaining, originally cut strip was lifted and moved to a transparent plastic sheeting under overhead irrigation. It was left on the plastic for seven weeks then transplanted back to the field. The same procedure was followed for the Spring planted species in May. Fresh root samples were taken with a four inch auger at a two inch depth. Leaf area measurements were also taken at the time of undercutting for the Fall and Spring planted species. Fresh root samples were also taken from plants that had been transplanted back to the field after being on the plastic for seven weeks.
Results and Discussion: Fall planted species had a higher survival rate after being undercut and moved to the transparent plastic in the early spring of 1994 than spring planted species undercut and moved to plastic sheets in late spring. Perennial species transplanted from the plastic sheeting back to the field improved in vigor and appearance one week after transplanting. Annual species which had already reached peak flowering while on the plastic sheeting eventually died back when transplanted back to the field. Most spring planted species that were undercut and moved to the plastic sheeting in late Spring did not survive probably due to less developed root systems and hotter temperatures.

Species were evaluated according to a visual rating criteria in order to determine survivability. This criteria considered root mat, top growth vigor, appearance of flowers, and seedling establishment. Those species which received the highest rating are the following:

- *Achillea millefolium* (Yarrow)
- *Chrysanthemum leucanthemum* (Oxeye Daisy)
- *Chrysanthemum maximum* (Shasta Daisy)
- *Coreopsis lanceolata* (Lance-leaf Coreopsis)
- *Coreopsis tinctoria* (Plains Coreopsis)
- *Monarda citriodora* (Lemon Mint)
- *Rudbeckia hirta* (Brown-eyed Susan)
- *Verbena tenuisecta* (Moss Verbena)

The following species had a less vigorous top growth and a less densely matted root system. They received a medium survival rating.

- *Bidens aristosa* (Bur Marigold)
- *Gaillardia aristata* (Blanketflower)
- *Gaillardia pulchella* (Indian Blanket)
- *Oenothera speciosa* (Showy Evening Primrose)
- *Silene armeria* (Catchfly)

Those species which declined rapidly after undercutting and moving to the plastic ranked in the lowest category. They are as follows:

- *Centaurea cyanus* (Cornflower)
- *Echinacea purpurea* (Purple Coneflower)
- *Hesperis matronalis* (Dames Rocket)
- *Ipomopsis rubra* (Standing Cypress)
- *Phlox drummondii* (Drummond Phlox)
Several species were eliminated from the study as a result of top growth damage from undercutting machinery and poor seedling establishment.

- *Cosmos bipinnatus* \(\rightarrow\) Cosmos
- *Cosmos sulphureus* \(\rightarrow\) Yellow Cosmos
- *Eschschokia californica* \(\rightarrow\) California Poppy
- *Gypsophila muralis* \(\rightarrow\) Baby’s Breath
- *Lobularia maritima* \(\rightarrow\) Sweet Alyssum
- *Oenothera missouriensis* \(\rightarrow\) Missouri Primrose
- *Papaver rhoeas* \(\rightarrow\) Corn Poppy
- *Ratibida columnaris* \(\rightarrow\) Mexican Hat
- *Rudbeckia amplexicaulis* \(\rightarrow\) Claspingcone Flower
- *Salidago rugosa* \(\rightarrow\) Rough-leaf Goldenrod
- *Salvia coccinea* \(\rightarrow\) Scarlet Sage

**Significance to Industry:** A field grown and harvested wildflower sod would have several advantages in the landscape. Because it would be field grown, plants in the sod would already be adapted to native soils and the southeastern climate which may result in less time adjusting to a transplant site. The wildflower sod could be used for erosion control, creating attractive areas in places more difficult to direct seed, reclamation sites in need of pleasing vegetation, and as a turf substitute. Further research is needed to determine species combinations, seeding rates, and control of top growth to prolong harvesting season.

**Literature Cited**


Seed Germination of Three Provenances of *Rhododendron catawbiense*:
Influence of Light and Temperature

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**Nature of work:** *Rhododendron catawbiense* Michx. (Catawba rhododendron) is a broad-leaf, ericaceous evergreen species indigenous to the mountains of West Virginia and Virginia, extending south to North Carolina, Georgia, and Alabama. It is a prized landscape plant, blooming in late spring with showy flowers ranging from lilac-purple to paler lilac-rose and occasionally white. Traditionally, the principal means of meeting demand in the Southeast has been harvesting of mature, native plants or “cutbacks”, produced when the tops of mature plants are removed (cut back) to within 8 to 10 cm (3 to 4 in) of the soil surface. The latter are then dug and replanted in the field for further growth prior to sale. Both of these practices deplete native stands. Other methods of production, such as sexual propagation, have not been widely utilized in the Southeast due in part to lack of published protocols regarding such practices.

In recent years, popularity and demand for *R. catawbiense* have intensified due to increased interest in native plants. To help satisfy demand, many nurserymen are attempting to utilize sexual propagation. Recently, Blazich et al. (1) reported on the influence of light and temperature on seed germination of a high elevation provenance of *R. catawbiense* located in western North Carolina [35°42'N, 82°22'W, elev. = 1860 m (6100 ft)]. However, in North Carolina and other areas of the southeast, isolated provenances of *R. catawbiense* occur at much lower elevations. These populations may possess desirable horticultural traits (e.g. greater heat tolerance) not found in germplasm originating at the higher elevations. Differences regarding influence of various environmental factors (e.g. light and temperature) on seed germination may also be present. Therefore, the objective of this research was to examine the influence of varying photoperiods and constant versus alternating temperature on seed germination of three provenances of *R. catawbiense* representing diverse geographical and altitudinal distributions.

Mature seed capsules were collected from native stands of open-pollinated plants of *R. catawbiense* growing in Johnston Co., N.C. [35°45'N, 78°12'W, elev. = 67 m (220 ft)], Cherokee Co., Ga. [34°20'N, 84°23'W, elev. = 320 m (1050 ft)], and Yancey Co., N.C. [35°45'N, 82°16'W, elev. = 1954 m (6410 ft)] on October 6, October 12, and November 10, 1992, respectively. Following collection, capsules were dried at 20°C (68°F) for 30 days. Seeds were then removed from the capsules (approximately 160,000 seeds per ounce), and stored in sealed glass bottles at 4°C (39°F). In January 1993, seeds were graded and sown in covered 9 cm (3.5 in) glass petri dishes containing two prewashed germination blotters moistened with tap water. Seeds were placed in the dishes (50 seeds per dish) with half designated for germination at 25°C (77°F) and the other half for germination at an 8/16 hrthermoperiod of 25°C/15°C (77°F/59°F). All dishes were
placed in black sateen cloth bags and were randomized within two growth chambers \(C\)-chambers \(2\}) set at the appropriate temperatures. Within each temperature regime, seeds were subjected daily to the following eight photoperiods: total darkness, \(1/2\), 1, 2, 4, 8, 12, or 24 hr.

Growth chambers were equipped with cool-white fluorescent lamps which provided a photosynthetic photon flux (400-700 nm) of 28 \(\mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}\) (2.2 klx) as measured at dish level. 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. Petri dishes remained continuously unbagged in open chamber conditions for the 24-hr photoperiod treatment. Constant darkness treatment was maintained by keeping petri dishes in the black cloth bags throughout the experiment. For constant darkness, watering and germination counts were performed in a darkroom utilizing a fluorescent lamp equipped with a green acetate filter. All germination blotters were kept moist with tap water throughout the experiment.

Each photoperiod treatment was replicated four times with a replication consisting of a petri dish containing 50 seeds. Germination counts were recorded every 3 days for 30 days. A seed was considered germinated when the emerging radicle was \(\geq 1\) mm (0.04 in). Percent germination was calculated as a mean of four replications per treatment. Within each temperature, for a provenance, data were subjected to analysis of variance and regression analysis.

**Results and Discussion:** Regardless of temperature or provenance, seeds required light for germination and subjecting seeds to daily photoperiods as short as \(1/2\) hr increased total germination to 98% for the Yancey Co. provenance, 85% to 92% for the Johnston Co. provenance, and 87% to 91% for the Cherokee Co. provenance. Seeds from Yancey Co. exposed to photoperiods \(2 1/2\) hr began germinating between days 3 to 6 at 25°C (77°F) compared to days 6 to 9 at 25°/15°C (77°/59°F). However, seeds from Johnston Co. and Cherokee Co. exposed to photoperiods \(2 1/2\) hr began germinating between days 6 to 9 at 25°C (77°F) compared to days 9 to 12 at 25°/15°C (77°/59°F). Regardless of temperature and photoperiod, seeds of the Yancey Co. provenance consistently germinated earlier and had greater cumulative germination.

At 25°C (77°F), photoperiods \(> 8\) hr inhibited germination of seeds from Yancey Co. At 12 days, inhibition was still present for the 24 hr photoperiod, but by day 15 germination for all photoperiod treatments except total darkness was 97%. Inhibition of germination at 25°/15°C (77°/59°F) was more pronounced, since an aHemating temperature can partially substitute for the light requirement for some species (4). Inhibition was first noted at day 9 for photoperiods \(> 2\) hr, but by day 18, cumulative germination for all photoperiods except total darkness ranged from 95% to 99%.

Seeds of the Cherokee Co. provenance also exhibited inhibition of germination at particular photoperiods and this inhibition lasted for a longer period of time. Seeds germinated at 25°C were inhibited by photoperiods \(> 2\) hr; however, by day 18 germination for all photoperiods with the exception of total darkness ranged from 74% to 88%. At 25°/15°C (77°/59°F) inhibition was first noticed at day 12 for photoperiods \(> 2\) hr.
which continued throughout the study. The inhibitory effect of the 24-hr photoperiod was again more pronounced at 25°C/15°C than 25°C. Cumulative germination by day 30 for all photoperiod treatments except total darkness ranged from 70% to 91% with maximum germination of 91% occurring at the 2-hr photoperiod.

Generally, for equivalent photoperiods, inhibition when present, will be more pronounced at 25°C/15°C (77°F/59°F) than at 25°C (77°F) and will dissipate by the end of a 30-day germination period (1). However, inhibition of seed germination of the Cherokee Co., Ga. provenance by photoperiods > 2 hr at 25°C (77°F) and 25°C/15°C (77°F/59°F) was still observed at day 30. This suggests the germination response of the Cherokee Co. provenance to light and temperature might be unique.

Greater seed vigor of the Yancey Co., N.C. provenance also extends to seedling growth. Rowe (3) compared seedling growth of the Yancey and Johnston Co. provenances over a range of day/night temperature regimes. Total seedling dry weights of the Yancey Co. provenance were greater (p < 0.05) at all temperature combinations compared to seedlings of the Johnston Co. provenance. In addition, 2 years after the aforementioned study was conducted, visual observations of containerized plants representing these two provenances confirmed previous results.

Significance to Industry: Generally, light and temperature requirements for seed germination of different provenances of *Rhododendron catawbiense* were similar. Regardless of temperature or provenance, seeds require light for germination, and daily photoperiods as short as 1/2 hr will maximize germination. The major difference in germination response of different provenances was related to vigor. Seeds of a high elevation provenance germinated at a faster rate with greater cumulative germination than seeds of lower elevation provenances. Small seed size plus the requirement of light for germination should caution nurserymen not to cover the seeds during propagation.

**Literature Cited**


Inducing Acclimation of Azaleas by Reducing Water Supply

Tomasz Anisko and Orville Lindstrom

Nature of Work: Early frost, particularly if proceeded by a period of warm and wet weather, can lead to losses in evergreen azaleas (Flint, 1966). The primary cause of such losses is bark split occurring on lower stems. Delayed acclimation in the fall is thought to be responsible for this bark split injury (Flint, 1966; Alexander and Havis, 1980a). Delayed acclimation is especially manifested in azalea's lower stems, which tend to lag behind upper parts of the plant.

High temperatures in a root zone which commonly exists in containerized nursery stock, can further prevent proper acclimation of lower stems (Alexander and Havis, 1980b). In many areas exposure to temperatues critical for acclimation does not occur or occurs too late for evergreen azaleas to harden sufficiently before the first frost.

Low temperatures in a root zone reduces water uptake by roots (Kramer, 1983). Yelenosky (1979) demonstrated that acclimation induced by water stress and low temperature resulted in similar cold hardiness of young citrus trees. Reducing or withholding irrigation is a feasible cultural manipulation in container nurseries. Therefore, the purpose of this study was to examine whether reduced water supply can induce earlier acclimation of three cultivars of evergreen azaleas.

Four-year-old plants of *Rhododendron* L. 'Coral Bell', *R. *'Hinodegiri', and *R. *'Red Ruffle' were grown in 3-gallon containers placed in the open field. Growing medium contained peat and composted pine bark (1:1; v:v). Plants were fertilized (1 oz./container) with Osmocote (18N-2.6P-9.9K) once after planting into containers in May.

Plants were grown under four watering regimes. Volumetric water content of the growing medium was maintained at either 0.3 to 0.4 m$^3$m$^{-3}$ (dry) or 0.5 to 0.6 m$^3$m$^{-3}$ (wet) between June 16 and August 30, 1993. Between August 30 and October 9, the previously imposed watering regime remained unchanged or was switched to the other regime, producing in dry/dry, dry/wet, wet/wet and wet/dry watering regimes.

Cold hardiness of plants was evaluated in the laboratory with freeze tolerance tests on leaves and stems (Lindstrom and Dirr, 1989). Stem sections 2 in. long were sampled from three locations on a plant: lower stems were the mose basal stems up to 2 in. from the roots, upper stems were the current season's leafy stems, and middle stems were leafless stems of the intermediate position. Freezing tolerance tests were performed on August 30 and October 9. To evaluate injury, samples were incubated at room temperature for 7 days. Lethal temperature was determined visually with oxidative browning injured tissues as the criterion.
Results and Discussion: Before the August 30 freeze test, the dry watering regime stimulated acclimation of lower and middle stems of "Hinodegiri" and 'Red Ruffle', as well as upper stems and leaves of 'Coral Bell' compared to wet watering regime (Fig. 1). Continuation of the dry conditions after August 30 further stimulated acclimation in all plant parts of three cultivars except for leaves of 'Coral Bell'. Imposing dry conditions on plants previously grown under wet watering regime also stimulated acclimation of most plant parts except for middle stems of "Hinodegiri' and Coral Bell'. Leaves of all cultivars and upper stems of 'Coral Bell' reached the same level of freeze tolerance by October 9, when grown under dry conditions between August 30 and October 9, regardless of their previous treatment. Lower and middle stems of plants, except for 'Hinodegiri' lower stems, grown under dry watering regime after August 30 acclimated to lower temperature if previously maintained under dry conditions than those maintained previously under wet conditions. Imposing wet conditions between August 30 and October 9 either prevented or delayed acclimation in all plant parts of three cultivars regardless of their previous treatment. In the October 9 freeze test most plant parts reached a similar level of hardiness as a result of wet conditions between August 30 and October 9, regardless of the watering regime prior to August 30. However, in upper stems and leaves of 'Red Ruffle' and in lower stems and leaves of 'Hinodegiri' difference in hardness between plants previously under dry or wet conditions, increased as a result of the wet treatment between August 30 and October 9.

Acclimation of upper plant parts (leaves and upper stems), in most cases, was not stimulated by reducing water supply during early to mid summers. Response of lower plant parts (lower and middle stems) to water stress at that time was cultivar specific. Water stress promoted early acclimation of 'Red Ruffle' and "Hinodegiri', but not of 'Coral Bell'. The preventative effect of high temperatures on hardening of lower plant parts (Alexander and Havis, 1980b) may explain differences in lower and middle stem acclimation between cultivars. Apparently, the same temperatures that prevented early acclimation in "Hinodegiri' and 'Red Ruffle' when well-watered, were permissive for 'Coral Bell' acclimation. In fact, for 'Coral Bell', lower plant parts were even more hardy than upper parts. This observation indicated that delayed acclimation of lower stems as compared to upper stems typical for high temperature conditions did not occur in 'Coral Bell'.

Imposing water stress late in the summer generally increased freeze tolerance of all plant parts regardless of the previous watering regime. In contrast, maintaining high water content of the growing medium during late summers prevented or delayed acclimation, or even caused deacclimation as in the plants stressed prior to August 30.

Significance to Industry: Reducing water supply provides a feasible means of promoting acclimation of evergreen azaleas in late summers. In most cases short term water supply reduction was as efficient in increasing freeze tolerance as was the long term reduction. This allows for better freeze protection without having a detrimental effect on plant growth due to prolonged water supply reduction.
Literature Cited


Fig. 1  Lethal temperature for leaves, lower, middle, and upper stems of 'Coral Bell' (A), 'Hinodegiri' (B), and 'Red Ruffle' (C) azaleas grown under dry/dry, dry/wet, wet/dry, and wet/wet watering regimes on August 30 and October 9.
Styrene-lined and Copper-coated Containered Influence Root-zone temperature and Growth or Red Maple Cultivars

T.J. Brass, G.J. Keever, C.H. Gilliam and D.J. Eakes
Alabama

Nature of Work: Two problems associated with producing plants in containers are root dieback from high media temperatures, and circling roots along the media-container interface leading to poor root development. Numerous approaches for minimizing high temperature have been attempted (1). Strategies for limiting root circling include container modifications to reduce or prevent circling roots and the application of various copper compounds to the containers that result in root systems with more secondary branching and a higher transplant potential (2,3). To address these two problems, the effectiveness of styrene foam, and copper hydroxide (SpinOut) were evaluated. The influence of cultivar on red maple response to foam and copper-coated containers was also determined.

On March 17, 1993, a 2 x 2 x 2 factorial experiment (+/- foam, +/- copper, 2 cultivars) was initiated using 5 ft. bare-root whips of 'October Glory' red maple, a vigorous cultivar in the South, and 'Northwood', a Minnesota selection. These trees were grown in #7 containers in a potting medium consisting of amended pine bark and sand (7:1, v/v).

Before planting, the container were treated as follows: 1) foam lining; 2) sprayed with copper; 3) foam lining sprayed with copper; and 4) untreated. These plants were then placed in full sun 3 feet apart within rows and 4 feet between rows. The experiment was arranged in a completely randomized design with 16 single-plant replicated.

Container medium temperatures with and without foam were monitored during the growing season using thermocouple probes placed at a 1-inch depth directly against or 1-inch from the west container wall. Height and caliper were taken at mid-season and the end of the growing season. A 2-inch wide and 2-inch deep pie-shaped vertical section was removed from each quadrant for root dry weight determination (n=4). Furthermore, the percent root coverage at the container wall-medium interface was recorded, along with a deflection rating of root growth at the medium surface (0 = no restriction of root elongation, 1 = elongation of 1 inch or less, and 2 = no elongation of surface roots).

After the first growing season, 6 replicated from each treatment in which rootball subsamples were not collected were stepped-up into #15 containers to evaluation root regeneration. Six months later, measurements of height and caliper, the percent root coverage, and dry weight of roots that formed outside the original rootball were taken.
Results and Discussion: Medium temperatures from 2 pm until 6 pm were an average of 10° F lower in containers lined with foam than in those without foam. Foam lining or copper had no effect on height or caliper the first year, or 6 months after plants were stepped-up into #15 containers. Both caliper at mid-season and caliper and height taken after the first year's growing season were greater for 'October Glory' than for 'Northwood'. Neither foam or copper had an effect on root dry weight; also root generation of plants grown in copper-treated containers was similar to that of plants grown in non-treated containers. Root dry weight of 'October Glory' (x=9.8 g) were greater than those of 'Northwood' (3.5 g). Percent root coverage of plants grown in pots with copper, was significantly less than that of plants grown in pots not treated with copper; foam-lined pots had greater coverage possibly due to the lower media temperatures recorded in foam-lined pots. Deflection rating for plants grown in pots treated with copper was higher, indicating less root elongation, while deflection rating for 'October Glory' (0.7) was lower than that of 'Northwood' (1.1), indicating copper was less effective in its control. Likewise, root regeneration was significantly higher for 'October Glory' (27.6 g) compared to 'Northwood' (5.7 g).

Significance to Industry: First year results show that red maple grown in foam-lined containers produced a higher percentage of surface root growth, while having no effect on plant height or caliper. The application of copper to the container was highly effective in reducing root circling on the outer rootball and producing a more fibrous root system. Furthermore, greater top growth and a higher root dry weight of 'October Glory' compared to 'Northwood' indicated better adaptability to growing conditions in the South.

Literature Cited


BA-Induced Offset Formation in Hosta

D.A. Findley, G.J. Keever, C.H. Gilliam
Alabama

Nature of Work: Hosta, a herbaceous perennial in the lily family, is popular for partial to-full shade areas in landscapes. Plants are usually clonally propagated in the spring by crown division, a process that produces only a few plants per clump, causing the introduction of new cultivars to take several years. Tissue culture offers potential for rapid clonal multiplication of hosta (4); however, laboratories are expensive to establish, propagation requires skilled labor and sterile techniques, and explants may not be true to type. The application of cytokinins, including BA, has enhanced shoot formation and branching in herbaceous crops, including poinsettia (2), geranium (1), and Dieffenbachia (3). This study was conducted to determine the effects of rates and method of application (foliar or drench) of BA on shoot development (offsets) from dormant axillary and rhizomic buds of blue hosta.

Uniform liners of blue hosta were transplanted from 36-cell flats to 5 in pots containing Metro-Mix 360 on July 14, 1992. On July 28, single foliar sprays of 125, 250, 500, 1000 or 2000 ppm BA applied to the plants to runoff or single drenches of 5, 10, 20, 40 or 80 mg a.i./pot were applied to plants. An untreated control was included for comparison. Buffer-X at 0.2% was added as a surfactant to an spray solutions, and drenches were applied in a volume of 1.7 oz/ container. When treated, plants had 7 to 8 leaves, and only one growing point (no offsets). Growth indices and offset counts were determined 30, 60 and 90 days after treatment (DAT). Plants were transferred to a coldframe on November 21 and allowed to enter dormancy. Growth indices and offset counts were determined on June 3, 300 DAT. On June 21, offsets were cut from the mother plants and placed in open flats of Metro-Mix 360 under intermittent mist. Six weeks later, % rooting and root density were evaluated. Treatments were completely randomized with 7 single-plant replicates.

Results and Discussion: By 7 days after drench application of 80 mg BA/pot, the foliage of blue hosta had extensive phytotoxicity. Symptoms began as a distal bleaching of leaf margins that spread toward the midrib and leaf base. New leaves that developed during 1992 were smaller than those of plants in other treatments and were often twisted or strap-shaped. Foliage that developed in 1993 following a period of dormancy appeared normal. No phytotoxicity occurred on plants receiving the other treatments. Growth indices of plants receiving a single foliar spray were not affected by the BA rate, while growth indices for plants receiving a drench application decreased linearly with increasing rate 30, 60 and 90 DAT (Table 1). Most of the difference in mean growth indices values occurred between control plants and those receiving 40 or 80 mg BA/pot; the decrease for plants treated with 40 or 80 mg a.i. were 8.6 or 15.8%, 6.0 or 14.3%, and 7.2 or 14.4% 30, 60, and 90 DAT, respectively. The large decrease in growth indices of plants drenched with 80 mg BA/pot was primarily due to foliar necrosis and a
concomitant loss of leaf tissue. Following a period of dormancy (300 DAT), growth indices were similar among treatments, regardless of application method or rate.

Within 14 DAT, elongation of rhizomic and axillary buds was evident on plants sprayed with 1000 or 2000 ppm BA or drenched with 20, 40, or 80 mg BA/pot. At an sampling dates, offset counts increased with increasing rates of foliar or drench-applied BA, and were similar for the 2 methods of application. No offsets developed from control plants during the experiment. Offset counts of plants drenched with BA were numerically highest at the 40 mg a.i. treatment 30, 60, and 90 DAT and with the 20 mg a.i. treatment 300 DAT. Within a treatment, offset counts often decreased between 30 and 60 DAT or between 60 and 90 DAT with both foliar and drench application of BA. This decrease reflected the abortion of random offsets and may represent another expression of phytotoxicity. An offsets cut from the mother plant and placed under intermittent mist developed into plants having well-developed root systems within 6 weeks after offset removal (data not shown).

Significance to the Nursery Industry: Most hosta cultivars produce very few offsets per year, which limits the rapid introduction of new cultivars at affordable prices for growers without tissue culture capabilities. The synthetic cytokinin BA, applied as a foliar spray or medium drench, can stimulate offset development from axillary and rhizomic buds, leading to more rapid clonal multiplication. Optimal foliar spray and medium drench rates of BA were 2000 ppm and 20 mg a.i./5 in pot, respectively. Although the higher rates of BA applied caused foliar necrosis shortly after application, following a period of dormancy offsets appeared normal, survived division and developed extensive root systems. These data demonstrate that use of BA can be an effective means for increasing the number of offsets in hosta.

Literature Cited


Table 1. Effects of single foliar sprays or drenches of BA on growth indices and offset counts of blue hosts, experiment 1.

<table>
<thead>
<tr>
<th>Method of application</th>
<th>Rate</th>
<th>Growth Indices</th>
<th>Offset Counts</th>
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<tr>
<td></td>
<td></td>
<td>30 DAT 60 DAT 90 DAT 300 DAT</td>
<td>30 DAT 60 DAT 90 DAT 300 DAT</td>
</tr>
<tr>
<td>Foliar</td>
<td>125</td>
<td>20.6 21.4 21.5 41.2</td>
<td>1.4 1.6 1.3 1.6</td>
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<tr>
<td></td>
<td>250</td>
<td>22.5 24.4 25.0 40.0</td>
<td>0.7 1.0 0.7 1.6</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>22.3 23.6 24.2 37.6</td>
<td>2.9 2.4 2.6 3.0</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>23.4 24.0 23.9 40.8</td>
<td>2.1 2.6 2.4 2.4</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>23.4 24.0 24.3 39.4</td>
<td>3.9 4.0 3.4 3.7</td>
</tr>
<tr>
<td>Drench</td>
<td>5</td>
<td>20.7 22.1 22.3 37.5</td>
<td>1.9 1.7 1.3 2.7</td>
</tr>
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<td></td>
<td>10</td>
<td>22.0 23.7 24.2 40.2</td>
<td>0.4 0.4 0.4 1.7</td>
</tr>
<tr>
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<td>2.9 2.7 2.6 4.1</td>
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<td>80</td>
<td>18.6 19.7 20.2 32.7</td>
<td>2.9 3.4 3.0 3.0</td>
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<tr>
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<td>-</td>
<td>22.1 23.0 23.6 37.4</td>
<td>0.0 0.0 0.0 0.0</td>
</tr>
</tbody>
</table>

*NS, *: Nonsignificant or significant at the 5% level.
*NS,L,Q: Nonsignificant, linear or quadratic response, respectively, at the 5% (*), 1% (**) or 0.1% (***) level; control included in regression analysis.

Growth indices = (height + width at widest point + width 90° to first width) + 3, in cm.
Cultivar and IBA Concentration Influence Rooting of *Buddleia*

Chris Montgomery, Bridget Behe, Joseph Eakes, and Tammy Krentz
Alabama

**Nature of Work:** Butterfly bush is becoming a popular perennial landscape plant because it has heat and drought tolerance and the ability to attract wildlife. Previous research has shown that softwood cuttings treated with 3000 ppm IBA rooted readily (1). The objective of this study was to evaluate the rooting of eleven cultivars of *Buddleia* (2) with three concentrations of synthetic auxin. The eleven cultivars were: *Buddleia davidii* ‘White Profusion’, ‘Empire Blue’, ‘Black Knight’, ‘Royal Red’, ‘Opera’, ‘Charming Summer’ and ‘Pink Delight’; *Buddleia davidii nanhoensis* ‘Nanho Blue’ and ‘Nanho Purple’; *Buddleia fallowiana* ‘Lochinch’; and *Buddleia x weyeriana* ‘Sungold’.

Four-node softwood cuttings were taken from three gallon stock plants in September, 1993, and in May, 1994 and stored overnight in a cooler at 40°F. The following day, four concentrations of K-IBA were mixed in deionized water: 0, 1500, 3000, and 6000 ppm. Five samples of four cuttings per sample per treatment per cultivar were used. IBA was applied to the basal 1.5 inches of the stem after the leaves were removed from the lowest node. Treated cuttings were placed in two-inch containers with medium grade vermiculite. Containers were arranged in a randomized complete block design and placed in a glass-covered propagation house. All cuttings were irrigated by an intermittent spray system for eight seconds every fifteen minutes from 8 a.m. to 5 p.m.. Cuttings were harvested 21 days after treatment. Measures taken at harvest included average length of the three longest roots per cutting, root count, visual root rating, and dry weight. The visual root rating was made on a scale from 0 (no roots) to 5 (very well rooted). Shorter, more numerous roots were considered an indication of good rooting. The data from 1993 and 1994 were analyzed together. Results showed significant effects for treatment, year and cultivar. Thus, data were analyzed by year and by cultivar.

**Results and Discussion:** In 1993, root count increased as IBA concentration increased for ‘Empire Blue’, ‘Nanho Purple’, ‘Opera’, and ‘Royal Red’ (Fig. 1). Root length decreased as IBA concentration increased for ‘Pink Delight’, ‘Nanho Purple’, ‘Nanho Blue’, and ‘Lochinch’ (Fig. 2). The visual root rating increased with higher IBA concentration for ‘Lochinch’. ‘Royal Red’ had the highest visual rating at 1500 ppm IBA. IBA concentration did not affect dry weight for any cultivar. For most cultivars, rooting improved as IBA concentration increased.

In 1994, IBA concentration increased root count for all cultivars tested (Fig. 3), with the exception of ‘Empire Blue’ and ‘Lochinch’. ‘Lochinch’ had the highest root count at 3000 ppm IBA. ‘Empire Blue’ was not significantly affected. Average root length decreased as IBA concentration increased for ‘Nanho Purple’, ‘Lochinch’, ‘White Profusion’, and ‘Nanho Blue’. (Fig. 4). Higher IBA concentrations increased visual root ratings for ‘Nanho Blue’, ‘Pink Delight’ and ‘Sun Gold’. ‘Nanho Purple’ had the highest visual rating at 3000 ppm IBA. Greater dry weights were recorded for roots of ‘Nanho Blue’ and ‘Sun
Gold’ as IBA concentration increased. ‘Lochinch’ had the greatest dry weight at 1500 ppm IBA. Again, rooting of cultivars improved as IBA concentration increased.

Root count on ‘Royal Red’, ‘Nanho Purple’ and ‘Opera’ was higher with increased concentrations of IBA regardless of time of year. However, root count increased on ‘Black Knight’, ‘White Profusion’, ‘Nanho Blue’, ‘Pink Delight’, ‘Sun Gold’ and ‘Charming Summer’ in the 1994 (spring) study but not in the 1993 (fall) study. IBA concentration affected root count of ‘Empire Blue’ in the 1993 (fall) study, but not in 1994 (spring) study. IBA concentration affected root length for ‘Lochinch’, ‘Nanho Purple’ and ‘Nanho Blue’ in both studies. Average root length for ‘Black Knight’ and ‘White Profusion’ increased in the 1994 (spring) study but not in the 1993 (fall) study.

A higher visual root rating was given to ‘Nanho Blue’, ‘Pink Delight’ and ‘Sun Gold’ with higher concentrations of IBA (and ‘Nanho Purple’ at 3000 ppm) in the 1994 (spring) study. ‘Royal Red’ and ‘Lochinch’ were given higher visual ratings in the 1993 (fall) study. ‘Lochinch’, ‘Nanho Blue’, and ‘Sun Gold’ also showed higher dry weights in the 1994 (spring), but not in the 1993 (fall) study.

Significance to Industry: Results showed that rooting of most cultivars of Buddleia were influenced by time of year. Rooting of ‘Opera’, ‘Royal Red’, and ‘Nanho Purple’ were consistent, regardless of time of year. However, ‘Black Knight’, ‘White Profusion’, ‘Lochinch’, ‘Nanho Blue’, ‘Pink Delight’, ‘Sun Gold’ and ‘Charming Summer’ rooted more readily in the spring. ‘Empire Blue’ was the only cultivar that showed a greater root count in the fall. For most cultivars, root length decreased and root number increased as IBA concentration increased. Higher concentrations of IBA were more effective in promoting rooting in the fall than in the spring.

Literature Cited


Influence of Herbicide Rate and Weed Pressure on Prostrate Spurge

Vanessa F. Hepburn, Charles H. Gilliam, Amanda C. Folmar, Gary J. Keever, and D. Joseph Eakes

Alabama

Nature of Work: Prostrate spurge (Euphorbia humistata Engelm. ex Gray) is a major weed problem of container grown nursery stock. Several studies have evaluated preemergence herbicide control of this weed species; however, limited work has evaluated the effects of weed pressure on control with these herbicides.

In this study two herbicides, Ronstar 2G and Snapshot 2.5 TG, were applied at three rates (1/3 X, 2/3 X, and X-recommended rate) with six different weed seed pressures (1, 5, 10, 25, 50, and 100 prostrate spurge seeds per container). Trade gallon containers were filled to within one inch of the top with a 7:1 pinebark sand medium amended with 14 lbs. of Osmocote 17-7-12, 1.5 lbs. of Micromax, and 5 lbs. of dolomitic limestone per cubic yard. Pots were placed in a double polyethylene greenhouse and watered as needed for 2 weeks prior to the beginning of the experiment to germinate any spurge seed present. After 2 weeks, Ronstar 2G and Snapshot 2.5TG were applied with hand-held shakers over the respective treatments. One week after herbicide application, the containers were seeded with either 1, 5, 10, 25, 50, or 100 seeds per container. A completely randomized design with 5 single pot replicates was used. Spurge numbers were counted at 30, 60, and 90 days after treatment (DAT). At 90 DAT, fresh and dry weights were taken.

Results and Discussion: There were no significant herbicide effects when comparing Snapshot 2.5 TG with Ronstar 2G, therefore only the 90 DAT Ronstar data are presented. When weed pressure was 10 seeds per container or less there was no difference in the number of spurge plants per container among the three herbicide rates tested (</container). With 25 spurge seeds per container, the 2/3X rate and the X rate provided similar control. Only when the weed pressure exceeded 25 weed seed per container (50 and 100) did the X rate provide improved weed control compared to the 2/3X rate. Fresh and dry weight data (90 DAT) at low weed pressure (1 and 5 weed seed) were similar with 2/3X and X application rates but higher with the 1/3X rate when 5 seeds per container were sown. The 1/3X rate provided weed control only at one weed per container.

Significance to Industry: These data demonstrate the importance of maintaining a weed free environment in a container nursery. Weed control is enhanced with low weed pressure. Also, potential exists to reduce herbicide application rates if weed free conditions are maintained.
Transplant Size Influences Post-transplant Growth and Development

D.M. Lauderdale, D.J. Eakes, C.H. Gilliam, and G.J. Keever
Alabama

Nature of Work: While an increasing number of trees are being planted in urban areas to modify climate, improve aesthetics, enhance architecture and aid with engineering; their growth rate and life expectancy are severely limited. Kjelgren and Clark (1992) showed that different microclimates cause variation in shoot elongation, crown production, and diameter increase of urban trees. Differences in growth for urban trees has also been reported to be caused by poor root to shoot ratios resulting in transplant shock (Krizek and Dubik, 1987). Berrang et al. (1985) suggest transplanting trees in smaller sizes with higher root to shoot ratios to combat transplant shock.

Limited research has been conducted in the Southeastern United States on tree transplant size and the resulting performance of urban shade trees. Our objective was to evaluate the effects of transplant size and site conditions on growth and development of Acer rubrum ‘October Glory’ (‘October Glory’ red maple) after transplanting.

Two locations, a park and a residential site in Mobile, Ala. (population 476,923) were selected for planting. Eight single plant replicates of 2 tree sizes; 1.5 inch caliper (small) and 3.0 inch caliper (large) were planted at each location. Tree specifications conformed to AAN standards. Trees were planted during May, 1993 by city personnel. Soil pH at the park site ranged from 5.4 to 7.1, while soil pH at the residential site ranged from 5.7 to 6.0.

Mobile Municipal Park consists of playgrounds and picnic areas. This area receives heavy weekend use, up to 20,000 people during peak times. Mobile’s residential area (Park Forest) is an older (~20 yrs.) medium income area with limited vehicle access.

Growth data collected during 1993 included: shoot elongation (based on the average elongation of 3 shoots per plant), height increase, and caliper increase (both height and caliper were measured shortly after transplanting and at the end of the growing season). Gas exchange measurements included: photosynthesis (PN), leaf conductance (CS), and transpiration (TS), which were determined using a LICOR 6200 Portable Photosynthesis System on 2 dates in Aug. Gas exchange measurements were made from 9:00 a.m. until 4:00 p.m. with each tree being evaluated 4 times during each day. Leaf water potential was determined immediately following each gas exchange observation and pre-dawn on single leaves using a pressure chamber. Trends for data collected at each site were similar and therefore pooled.

Results and Discussion: Shoot elongation of small maple transplants was almost twice that of large maple transplants. Small maples had a mean shoot elongation of 11.4 cm, compared to 6.1 cm for large maples (Pr > F = 0.0001). Transplant size had no effect on overall height (Pr > F = 0.7724) or caliper (Pr > F = 0.1584) increase. Mean height and caliper increases for small and large transplants were 7.3 and 6.2 cm.
and 4.1 and 2.7 mm, respectively. These data support Watson’s (1985) findings that 13 years after transplanting, when the original root to shoot ratio of a transplanted 10 inch diameter tree was reached, a 4 inch diameter tree transplanted at the same time had a root and shoot system of similar size.

Small transplants had greater PN, CS, and TS rates than large transplants. Mean PN, CS, and TS rates for small versus large transplants were 9.0 and 5.1 umole•m⁻²•sec⁻¹ (Pr > F = 0.0001), 0.5546 and 0.3024 cm•sec⁻¹ (Pr > F = 0.0001), 0.0042 and 0.0027 mole•m⁻²•sec⁻¹ (Pr > F = 0.0001), respectively. Mean leaf water potentials taken during gas exchange observations were -5.2 and -6.6 MPa for small and large maples, respectively (Pr > F = 0.0001). One of the first and most important plant processes adversely affected by moisture stress is gas exchange (Larcher, 1983). Higher leaf water potentials (less negative) or lower levels of moisture stress for small maples during gas exchange observations appeared to have resulted in the higher gas exchange observations when compared to large maples. Pre-dawn leaf water potentials for small and large maple transplants averaged -2.0 and -3.2 MPa (Pr > F = 0.0118), respectively. These data indicate that small maples rehydrated to a greater extent over night from moisture deficits that occurred during the previous day than large trees.

**Significance to Industry:** Based on gas exchange and water relation data, 1.5 inch caliper transplants of ‘October Glory’ red maple underwent less transplant shock than 3.0 inch caliper transplants. Less restricted metabolic processes allowed more cell elongation to occur, which resulted in enhanced shoot elongation. These data may indicate that nurserymen and landscapers should continue production and installation of smaller sizes in order to reduce transplant shock and possibly increase survival of trees in stressful urban environments.

**Literature Cited**


Weed Control with Herbicide-Coated Fertilizers

Cynthia K. Crossan, Charles H. Gilliam, Gary J. Keever, and D. Joseph Eakes

Alabama

Nature of Work:  Herbicides are typically applied in a container nursery by broadcasting over the containers. Previous research has shown up to 80% of broadcast herbicide falls between containers(1). Nontarget herbicide loss threatens to contaminate local water bodies and the groundwater supply. Herbicide-coated fertilizers applied directly to containers reduce the total amount of herbicide applied. Herbicides are strongly adsorbed to the media in the upper portion of containers(2), virtually eliminating nontargeted herbicide losses.

Experiment 1 evaluated Nursery Special 12-6-6 as a carrier for Ronstar 50WP or Pennant 7.8E or blended with Ronstar 2G or Pennant 5G. Ronstar 50WP was coated on Nursery Special by placing 11.3 kg or 25 pounds of the fertilizer in a Patterson-Kelly (P-K) Twin Shell Blender. Herbicide volumes equivalent to 2, 4 (recommended rate), 8, and 16 pounds of active ingredient per acre (lb ai/A), based on 1/2X, X, 2X, and 4X rates, were mixed with 100 ml of water for the herbicide-coated treatments. Herbicide rates were based on the surface area of the containers fertilized with 11.3 kg of fertilizer at 6.5 g per container. The herbicide solution was poured slowly into the funnel and sprayed out through openings in the horizontal rod which runs across the center of the blender.

Blended granular herbicide with Nursery Special was prepared by layering 11.3 kg of fertilizer with Ronstar 2G in the P-K Twin Shell Blender and mixing for five minutes. This blending process was repeated with Pennant 5G.

Uniform Gardenia jasminoides ‘August Beauty’ liners were potted in trade gallon containers in a 6 pine bark:sand (v:v) medium amended with 1.5 pounds Micromax and 5 pounds dolomitic limestone per cubic yard. Plants were treated by applying 6.5 g of the blended or coated-herbicide fertilizer evenly over the surface of the container, along with an untreated control and broadcast and spray applied controls (4 lb ai/A). Containers for blended herbicide fertilizer treatments received 0.2, 0.4, 0.8, and 1.4 g of Nursery Special based on the rates of 2, 4, 8, and 16 lb ai/A, respectively, to equalize the fertilizer applied to all treatments. All containers were overseeded with prostrate spurge seven days after treatment. The experimental design was a completely randomized design with 10 single plant replicates. Prostrate spurge was counted every 30 days after treatment. At termination (90 DAT), number, fresh, and dry weights of weeds were recorded and growth indices ((height + width1 + width2)/3) of Gardenia were taken.

Experiment 2 evaluated two controlled release fertilizers as herbicide carriers compared to coated Nursery Special 12-6-6. Osmocote 17-7-12 and Polyon 24-4-12 were coated with Ronstar 50WP at rates of 2, 4, 8, or 16 lb ai/A. Trade gallon containers were filled with a similar medium as Experiment 1 on April 14, 1994. Containers were
treated on May 5 with the herbicide-coated fertilizers applied at 6.5 g of Nursery Special, or 20 g of Osmocote or Polyon based on the recommended rate. Containers were overseeded with 10 seeds of prostrate spurge or crabgrass, seven days after the herbicide-coated fertilizer application. There were 17 treatments, in a completely randomized design; each treatment consisted of 10 single container replicates, for each weed species. Prostrate spurge and crabgrass were counted at 30 day intervals.

**Results and Discussion:** In Experiment 1, Ronstar 50WP coated fertilizer provided effective weed control at the 4, 8, and 16 lb ai/A rates (Fig. 1). Treatments of blended Ronstar 2G provided similar weed control to typical broadcast applications. Herbicide formulation, blended or coated, had no effect on weed control.

Ronstar provided superior prostrate spurge control compared to Pennant. Statistically, weed control with both herbicides was linear as herbicide rate increased, weed number decreased. At 90 DAT, weed numbers for the Ronstar 50WP were 2, 1, 0.5, 0.1 per container as rates increased from 2 to 16 lb ai/A, respectively, whereas the sprayed 4 lb ai/A control had 2 weeds per pot. Fresh and dry weights followed this same trend.

Growth indices for Gardenia plants were not affected by herbicide treatment. Even at 16 lb ai/A rate plants did not exhibit any phytotoxic symptoms.

In Experiment 2, herbicide-coated Osmocote at the 2 lb ai/A rate did not provide adequate weed control of either crabgrass or spurge. Herbicide-coated Osmocote at the 2 lb ai/A rate and the untreated control had similar crabgrass and spurge weed numbers. Herbicide-coated Osmocote with Ronstar 50WP did provide effective crabgrass and spurge weed control at the higher rates (4, 8, and 16 lb ai/A). Polyon and Nursery Special provided effective spurge and crabgrass control, both herbicide-coated fertilizers were similar in control.

**Significance to Industry:** Data collected indicate that herbicide-coated or blended fertilizers provide effective weed control in container grown crops; which reduces total herbicide quantity applied and eliminates nontarget herbicide losses.

**Literature Cited**


Figure 1
Spurge Number per Container with Ronstar 50WP

WEED #

10

9

8

7

6

5

4

3

2

1

0

30 DAT

60 DAT

90 DAT

DAYS AFTER TREATMENT

2 lb ai/A

4 lb ai/A

8 lb ai/A

16 lb ai/A

Control (C)

C Spray

30DAT LSD .05 = 3.0 LINEAR
60DAT LSD .05 = 3.5 LINEAR
90DAT LSD .05 = 3.1 LINEAR
Response of Gardenia and Pennisitum to Low Concentrations of Oryzalin in Irrigation Water

Raj Bhandary and Ted Whitwell
South Carolina

Nature of Work: An effective herbicide program reduces the cost of landscape plant production compared to hand weeding (Neal and Senesac, 1991) and hence has become an integral part of nursery management. Preemergent herbicides are normally broadcast applied to control weeds and followed by irrigation. During this process, herbicide granules applied may reside in spaces between containers and then may move in irrigation runoff water. Nursery water recycling systems where irrigation runoff is collected in containment ponds and reused, are beneficial for water conservation but pesticide residues in irrigation water could cause damage to nursery crops and non-target organisms. The possibility of plant damage due to herbicide residues in irrigation water is a major concern to nursery growers.

The herbicide oryzalin is present in commercial formulations of Surflan XL, Rout and Snapshot DF, which are commonly used in nurseries. Movement of oryzalin in nursery runoff water has been documented (Keese et al, 1994). Oryzalin residues were found both in containment pond water and sediments (Camper et al, 1994; Keese et al, 1994) with the highest level of oryzalin in water at 0.15 μg/ml (Keese et al, 1994). The concentrations of oryzalin were high immediately after application and runoff and then declined to below detection by 14 days after treatment. Low levels of oryzalin in containment pond water can, however, be found throughout the year (Camper et al, 1994), which have been attributed to slow release of materials adsorbed to sediment particles as a function of time and to oryzalin application for general weed control around the nursery sites (Camper et al, 1994). Most woody species such as Dwarf Gardenia were found to be tolerant to low concentrations of oryzalin in irrigation water, but plant injury was observed to herbaceous landscape species such as Fountain grass. The objective of this research was to investigate the physiological status of Dwarf Gardenia and Fountain grass in response to low concentrations of oryzalin in irrigation water.

A greenhouse study was initiated at Clemson University in the spring of 1994. Uniform liners of Dwarf Gardenia (Gardenia jasminoides ‘Radicans’) and seedlings of Fountain grass (Pennisetum rupelli) were planted in 3.1 liter containers and 100% fine pine bark was used as the growing media. The plants were irrigated with water fortified with oryzalin at 0 ng/ml, 10 ng/ml, 100 ng/ml and 1000 ng/ml rates. Oryzalin was derived from the commercial formulation of Surflan (DowElanco Products Company, Indianapolis, IN). Due to low water solubility, oryzalin was first mixed in acetone and later in irrigation water. The concentration of acetone in irrigation water was maintained at 1% by volume and silanized glassware were used to...
avoid herbicide binding to glass. Plants were provided with 240 mls (1.1 cm) of irrigation water per each irrigation for 4 weeks and species requirement determined the irrigation frequency.

CO₂ uptake, leaf diffusive resistance, ethylene evolution and fresh weights of shoots and roots were measured for both species. Net CO₂ uptake rate and diffusive resistance of the first fully expanded leaves of Dwarf Gardenia and the third or fourth leaf of Fountain grass were measured using a ADC Model LCA-2 portable infrared gas analyzer (Analytical Development Co., Hoddesdon, England) and a LI-COR steady state porometer model 1600 (LI-COR, Lincoln, NE) respectively. Photosynthesis and diffusive resistance of two leaves per plant were measured between 1100 and 1330 hours on clear days in the third week during treatment application and the fifth week after termination of treatment application. Ethylene evolution was determined by Shimadzu gas chromatograph (Model GC-9A) equipped with a phenyl isocyanate/porasil C column and a flame ionization detector. Plants were acclimatized to a growth chamber before determining ethylene evolution. Whole plant shoots were harvested after light reached maximum intensity and placed in water to avoid desiccation after measuring shoot fresh weights. This system was placed in 1 liter mason jars with a tight lid provided with serum caps for sample collection. Air samples were collected after 2 hours and analyzed for ethylene. Leaf diffusive resistance was measured directly from the porometer as S cm⁻¹ whereas net CO₂ uptake rate was converted into µgCO₂ cm⁻² s⁻¹ for statistical analysis. Ethylene evolution was determined as nl kg⁻¹ h⁻¹.

The experiment followed a randomized complete block design with four replications and was repeated. Data collected were subjected to analysis of variance and treatment means separated using least significant difference (LSD) at P = 0.05.

Results and Discussion: Oryzalin at the highest concentration (1000 ng/ml) reduced Fountain grass shoot and root weight. Net CO₂ uptake or diffusive resistance was not affected by any levels of oryzalin. The fortified irrigation water did not reduce Dwarf Gardenia shoot and root fresh weights. Also oryzalin in irrigation water at rates used in this study did not reduce photosynthesis or stomatal conductance of Dwarf Gardenia. Stress ethylene evolution from treated plants was not affected in both Fountain grass and Dwarf Gardenia. Data from this research indicates tolerance of Dwarf Gardenia to residual oryzalin concentrations but reduction in fresh weights of Fountain grass indicates sensitivity and impact on physiological processes which may be more evident with prolonged exposure. Growth reduction was caused to Fountain grass by 1000 ng/ml oryzalin in irrigation water, which is high compared to oryzalin residues reported in earlier studies. Also, the short persistence period of oryzalin in containment pond water further reduces the risk of plant damage.

Significance to the Industry: Herbicide residues detected in containment ponds of water recycling systems is a major concern to nursery growers. Lack of growth reduction and influence on key physiological processes by oryzalin concentrations comparable to previous reports suggests safety of oryzalin application for weed control with water recycling systems in landscape plant production. The growth of sensitive species such as Fountain grass would be reduced if oryzalin concentrations reached 1 ppm (1000 ng/ml) in irrigation water.
Literature Cited


Figure 1. Fresh shoot and root weights of Fountain grass treated with oryzalin in irrigation water. * Values followed by the same capital and lower case letter are not different according to LSD at $P = 0.05$. Coefficient of variation for shoot and root weights are 14.34% and 23.61% respectively.
Light Environment Influences Gas Exchange of Selected Red Maple Cultivars in the Southeastern United States

Alabama

Nature of Work: Increased emphasis on tree plantings in cities and residential districts has accelerated the selection and introduction of species and cultivars new to the ornamental industry. As a result, trees are often selected for landscape use before adequate information is available on their regional adaptability, resulting in high maintenance or removal costs (1).

A factor of concern unique to the Southeastern United States is different photosynthetically active radiation (PAR) levels when compared with different latitudes. In a study on sugar maple (Acer saccharum L.) progeny of stands less than 0.5 mile apart differed in leaf characteristics, respiration, and net photosynthesis (Pn). Pn was highest in progeny from high-altitude populations, representing the species' ecological margin (2).

In a field study on the performance of red maple (Acer rubrum L.) cultivars in the Southeastern United States, differences in growth and diurnal Pn rates were observed among the cultivars ‘Franksred’ (Red Sunset™), ‘Northwood’, ‘October Glory’, and ‘Schlesingeri’ (3). Rates of Pn were higher for ‘Northwood’ and ‘Schlesingeri’ than for ‘Franksred’ and ‘October Glory’ until midday, at which time Pn rates for ‘Northwood’ and ‘Schlesingeri’ began to decline and Pn rates for ‘Franksred’ and ‘October Glory’ continued to increase. Based on this, the objective of this study was to determine the gas exchange response of these selections grown in containers in full sun to varying PAR.

All trees were obtained from a single nursery source (J. Frank Schmidt and Sons, Inc., Boring, Ore.), on their own root systems in 1993 as 5 to 6 foot bare root whips. They were containerized to 15 gal. containers in a 6:1 (v:v) pinebark, sand mix and grown for 6 months under standard nursery practices. Selections were arranged in a randomized complete block design with 4 blocks of 3 plants per selection per block for a total of 12 trees. Irrigation was supplied to each tree as needed. Shade cloth structures allowing light penetration levels of 25% shade, 50% shade, and 75% shade were used to maintain desired treatment effects.

Trees were acclimated to each light environment for one-half hour prior to gas exchange measurements. Net photosynthesis (Pn), stomatal conductance (Cs), and leaf internal CO₂ (Cl) were determined with a LICOR 6250 Portable Photosynthesis System in a closed mode. Light levels were monitored with a quantum sensor (Model LI-190, LI-COR, Lincoln, Neb.) attached to the plexiglass chamber. Measurements were taken on attached, fully expanded leaves on terminal shoots 4 - 5 nodes from the branch tip in a non-destructive manner. Ambient CO₂ and temperature were 391 ±15
mg \cdot \text{liter}^{-1} \text{ and } 35^\circ \pm 1^\circ, \text{ respectively, under light intensities ranging from 225 to 1950 } \mu \text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1} \text{ PAR. Mesophyllic resistance to CO2 (rm) was calculated using the equation: } rm = \frac{Cl}{Pn}.

**Results and Discussion:** The cultivars ‘Northwood’ and ‘Schlesingeri’ had quadratic relationships for Pn as PAR levels increased. Light saturation points for Pn for the cultivars ‘Schlesingeri’ and ‘Northwood’ were estimated at PAR of 1350 and 1375 \( \mu \text{mol m}^{-2} \cdot \text{s}^{-1} \) respectively (Fig. 1), under the observation conditions utilized in this study. Using data collected on a daily basis by the National Weather Service, the actual differences in total PAR for different latitudes were derived. These results indicate that the cultivars ‘Northwood’ and ‘Schlesingeri’ may be better suited for a more northern latitude than that in which this study was conducted.

In contrast, as PAR increased, there was a linear increase in Pn for the cultivars ‘Franksred’ and ‘October Glory’. No light saturation point was attained for Pn for these cultivars (Fig.1). Mesophyllic resistance to CO2 followed a similar trend as that for Pn, and no relationship was found between PAR and Cs for the four cultivars. These data indicate PAR levels have a greater impact on the internal photosynthetic apparatus than on the role of stomatal control on Pn.

**Significance to the Industry:** These results indicate that the cultivars ‘Northwood’ and ‘Schlesingeri’ may have the ability to perform at their maximum photosynthetic capacity as understory trees in regions with high PAR (Southeastern U.S.). The data indicate that Pn rates for the cultivars ‘Franksred’ and ‘October Glory’ might continue to increase at light levels higher than those found in this region. Also, these cultivars may have the capacity to offset shorter growing seasons found at higher altitudes by utilization of the higher PAR levels typical of higher altitudes. In the future, adaptive ranges of red maple cultivars may be predicted during developmental stages by establishing light curves for net photosynthesis rates. Furthermore, cultivar growth differences noted in previous work (3) may be attributed to different photosynthetic efficiencies.

**Literature Cited**


Fig. 1. Effect of photosynthetically active radiation (PAR) level on net photosynthesis (Pn) of select red maple cultivars. Estimated regression lines followed by r values and significance for the equations are as follows: 'Franksred', $y = 8.86818 + 0.00361 x$, $r=0.65, P = 0.0001$; 'October Glory', $y = 6.71291 + 0.00307 x$, $r=0.48, P = 0.002$; 'Northwood', $y = 4.80619 + 0.01722 x - 0.000006270 x^2$, $r = 0.65, P = 0.0001$; and 'Schlesingeri', $y = 3.52937 + 0.01944 x - 0.000007242 x^2$, $r = 0.67, P = 0.0001$. 
Ground Covers Influence Isoxaben and Trifluralin Content in Simulated Nursery Runoff Water

Chris Wilson, Ted Whitwell, and Melissa Riley
South Carolina

Nature of Work: Off-site movement of herbicides from containerized plant production nurseries is a concern. Camper et al. (1994), Keese et al. (1994), Riley et al. (1994), and Wilson et al. (1994) detected several commonly used herbicides (isoxaben, oryzalin, oxyfluorfen, pendimethalin, and trifluralin) in nursery runoff and irrigation pond water. Factors such as ground cover composition and herbicide release from the formulation may affect the movement of herbicides in runoff water. Keese et al. (1994) showed that oryzalin, pendimethalin, and oxyfluorfen losses from plastic covered nursery plots were greater than from plots covered with woven landscape fabric or gravel. In addition, Keese et al. (1994) also reported differential release patterns for oryzalin, pendimethalin, and oxyfluorfen from the granular herbicides Rout (Grace Sierra) and OH-2 (O.M. Scotts).

The objectives of this study were 1) to determine the influence of ground covers on isoxaben and trifluralin losses in runoff water from miniature nursery plots and 2) to determine the time period over which isoxaben and trifluralin are released from Snapshot 2.5 TG after applications in the field.

Miniature plant nursery sites were constructed and placed on a 5% slope at the South Carolina Botanical Garden, Clemson, South Carolina. Sites were covered with either polypropylene plastic, woven landscape fabric, or uncovered (gravel). Three-liter containerized landscape plants covering a wide range of forms were spaced 25 cm apart on each site. Isoxaben (0.5%) plus trifluralin (2.0%) [Snapshot 2.5 TG, DowElanco] was applied at 100 lb. product/acre using a shaker-can. Overhead sprinkler irrigation was started (1.3 cm) 30 minutes after herbicide application and all runoff water from the plots was collected in stainless steel containers. The plots were then irrigated daily (1.3 cm) for 30 days and all runoff water was collected, measured, and sampled 1, 2, 3, 4, 5, 9, 15, and 30 days after treatment (DAT). Runoff samples were stored at 4 C until extracted.

The release of isoxaben and trifluralin from Snapshot TG was determined by sealing Spectra/Mesh fluorocarbon filters (70 µm mesh opening) in the bottom of 90 mm buchner funnels with silicone. Snapshot 2.5 TG (DowElanco) granules (isoxaben, 12.5 mg; trifluralin 50 mg) were placed on the filters and 85 ml water was poured through the funnels to simulate 1.3 cm of irrigation water daily for 30 days. All leachate samples (water discharged from the funnels) were collected in silanized glassware at the same intervals mentioned earlier. This study was conducted outside at the South Carolina Botanical Garden in order to better simulate actual nursery conditions.

All water samples were pH adjusted to 2.2 to 2.3, filtered through Whatman #5 qualitative filter paper, and extracted using C 18 columns. The herbicides were then eluted
with 2 ml acetone and filtered through 0.2 µ nylon Acrodiscs into amber vials for high pressure liquid chromatographic (HPLC) analysis using a C-18 column, acetonitrile:water gradient, and with detection at 206 nm. The retention times of isoxaben and trifluralin were 7.2 and 21.3 minutes, respectively, and the detection limit for both herbicides was 1 ng/ml. Data on ground cover influences was subjected to regression analysis at \( P = 0.05 \) using a cubic model determined to best fit the data. The herbicide release data was subjected to analysis of variance with means separated using least significant differences at \( P = 0.05 \).

Results and Discussion: Ground cover Effects. The majority of isoxaben and trifluralin detected in runoff water from all ground covers occurred within the first five days following Snapshot TG application (Figures 1 and 2). Cumulative isoxaben and trifluralin losses were greatest from plastic, lowest from gravel, and intermediate from woven fabric. Trifluralin losses from all ground covers were lower than isoxaben even though more (trifluralin) was applied. The lower losses of trifluralin in runoff water may be a reflection of its lower water solubility, higher affinity for carrier particles, and dissipation by photolytic reactions and volatilization. By 30 DAT, 20.9, 28.2, and 24.8% of the applied isoxaben was detected in irrigation runoff water from gravel, plastic, and fabric covered plots, respectively. Only 1.0, 4.4, and 3.7% of the applied trifluralin was detected in irrigation runoff water from the gravel, plastic, and fabric ground covers, respectively, after 30 days. These results indicate that water-permeable ground covers such as gravel are useful in reducing the movement of isoxaben and trifluralin (Snapshot TG) in runoff water.

Release Characterization. The majority of isoxaben and trifluralin was released from Snapshot TG within the first 9 DAT. Cumulative isoxaben and trifluralin detected in leachate from granules exposed to the outside conditions were 16.9 and 6.6%, respectively, 9 days after treatment (Figure 3). Very little additional isoxaben or trifluralin was detected in leachate from samples collected after 9 days. Numerous unidentified compounds appeared in the water samples indicating that degradation of the parent molecules monitored may have occurred. These results indicate that greatest quantities of isoxaben and trifluralin are released from Snapshot TG within the first nine days following application.

Significance to Industry: These results indicate that isoxaben and trifluralin are most susceptible to loss in runoff water within the first nine days following Snapshot TG application. Growers may reduce herbicide losses in runoff water by using water-permeable ground covers such as gravel.
Literature Cited


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**Figure 1.** Points followed by the same letter are not different at $P = 0.05$. Statistical significance of unlabeled points corresponds to the previously labeled point.

**Figure 2.** Points followed by the same letter are not different at $P = 0.05$. Statistical significance of unlabeled points corresponds to the previously labeled point.
Isoxaben and Trifluralin Released from Snapshot TG 9 DAT

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<td>Trifluralin</td>
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Figure 3.
The Effect of Grassed Waterways on the Pesticide Content of Runoff Water

J. A. Briggs, M. B. Riley, and T. Whitwell
South Carolina

Nature of Work: Containerized plant nursery operations routinely utilize ground covers of plastic, gravel, or fabric to optimize product handling and to reduce competition from weeds. Pesticides and fertilizers are used extensively in the industry in order to provide high quality plants in a minimum period of time. The pesticides are applied as granulars or overhead sprays. The runoff water generated by irrigation and rainfall events is relatively free of particulate matter and may contain significant amounts of the applied herbicides, fungicides, insecticides and fertilizers. As much as 80% of a granular herbicide application may fall on the ground cover. Grassed filter and buffer strips have reduced the concentration of herbicides in runoff water from field crops, and aquatic macrophytes have been utilized in the treatment of industrial and municipal waste waters to successfully reduce the concentrations of heavy metals and nutrients.

The objective of this study was to determine the effect of grassed waterways on the herbicide content of runoff water in a model system representing a containerized nursery bed.

Materials and Methods: At the South Carolina Botanical Gardens, three replications of four model waterways were installed. The models were 20 feet in length, 18 inches in width, and on a 3% slope. The treatments were two sheet metal trays, one bare and one lined with Meyer zoysia grass, \((Zoysia japonica 'Meyer')\), and two Cecil clay loam waterways, one bare and one sodded with zoysia grass. Experimental design was a complete randomized block. The grassed models were allowed to establish for a three week period.

Snapshot 80 DF (20% isoxaben, 60% oryzalin) was applied at a rate of 12 ppm (1.137 9 formulated product). The compound was dissolved in 900 ml methanol, and diluted to 20 gallons with tap water. A gasoline powered, pressurized spray unit was employed for application of the solution at a delivery rate of 3.3 gallons per minute. Four samples were collected for each treatment. An initial sample was taken of the tank mixture; samples were collected of the first and last 2.5 gallons of runoff; and a sample was collected from the treatment specific intermediate volume. At 15 and 30 days after the application, 20 gallons of water were applied and a composite sample was collected from the waterways.

Silanized glassware was used throughout the sampling and analytical process. All samples were placed on ice for transport and stored at 4°C until extraction. The pH of the samples was adjusted to 2.2 - 2.3, and 200 ml was passed through Whatman #5 filter paper by vacuum. The herbicides were extracted onto a C\(_{18}\) solid phase column, and eluted with 2 ml of acetone. The filters were visibly coated with particulate matter and herbicides were extracted by shaking for an hour in 15 ml of methanol. Analysis of
the herbicides was by HPLC, UV detector at 206 nm, C\textsubscript{18} reverse phase column. The concentrations of herbicides were computed by adding the area counts of the samples and filters and comparing the results with standards of known concentrations. Amounts recovered were derived from multiplying the concentrations by the amount of runoff water leaving the model. An ANOVA was conducted on the data using Duncan's multiple range test for variables.

Results and Discussion: Runoff volumes were significantly lower for the grassed treatments and the recovered amounts of herbicide was also reduced. Isoxaben concentrations (ug/ml) were less for the first 2.5 gallons of runoff from the grassed treatment, but not for the middle and final samples. Oryzalin concentrations were less for all samples from the grassed treatments with the lowest concentrations found in the first sample. Speculated is that the grass may have a defined capacity for the accumulation of herbicides and once reached, assimilation of additional herbicides cannot occur. At 15 and 30 days after treatment, detected amounts of isoxaben and oryzalin were significantly higher from the grassed metal tray than from the bare tray indicating a release of the parent herbicide over time. Total recovered amounts from initial application and 15 and 30 day samples) were significantly lower for the grassed models.

Significance to Industry: Pesticides in runoff waters from containerized nursery production could contaminate adjoining waters, and could possibly be returned to nursery crops through the practice of recycling irrigation waters. Grass filter strips and waterways are a potential means of reducing the pesticide concentration of runoff water and of lessening amounts lost from production sites.
ISOXABEN CONCENTRATIONS

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ORYZALIN CONCENTRATIONS

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<td>ditch</td>
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<tr>
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</table>
Nature of Work: The neem tree, *Azadirachta indica*, is the source of azadirachtin, a botanical insecticide that is relatively safe for the environment. Azadirachtin, or neem, is known to be an antifeedant and growth regulator for many insect pests (Schmutterer 1990). Because of these properties, there is interest in use of neem-based products as alternative insecticides in urban landscape pest management. Japanese beetles (JB), *Popillia japonica* Newman, feed on more than 300 plant species including flowering crabapples, lindens, roses, Japanese and Norway maples, sassafras, plums, and many other woody and herbaceous ornamentals (Larew 1988, Fleming 1972). Urban landscapes provide a favorable environment for JB development, providing suitable hosts for adult feeding and large areas of turf for egglaying and larval development. Advertising for Margosan-O (W.R. Grace & Co.), a commercial neem-based insecticide, states that the product is “reportedly effective” against JB.

We tested effectiveness of two neem-based products, Margosan-O and Turplex (AgriDyne Technologies, Inc.) as feeding deterrents for Japanese beetles. Marked shoots of linden, rose, purple leaf plum, sassafras, Norway maple, and flowering crabapple trees were sprayed to runoff at labeled rates (8 oz/10 gal for Margosan; 1.6 oz/10 gal for Turplex) on 6 July 1993, or left unsprayed. The following day we collected treated and untreated leaves for use in laboratory preference tests. There was no rain during the interim period. Female JB were placed in individual petri dishes with a pair of leaf disks (23 mm diam) cut from treated and untreated leaves of a particular plant. Each plant species was replicated 10 times with each product. The amount of each disk eaten after 24 h was determined with an electronic area meter. Data were analyzed by Wilcoxon signed rank tests.

Field tests began 18 June 1993 at the start of JB flight. Margosan-O and Turplex were applied at labeled rates to potted hybrid tea rose plants, and to two cultivars of crabapple, Radiant and Royalty, planted in an experimental nursery. Treatments were replicated eight times in a randomized complete block. Foliage was sprayed weekly to runoff for 5 wks until the control plants had become severely defoliated by JB. Sevinmox (carbaryl; Rhone Poulenc Ag. Co.), a carbamate insecticide commonly used for control of JB, was included as a standard (1 lb Al/100 gal rate). Defoliation of each plant was visually estimated to the nearest 10% by four independent observers on 23 July 1993. Data were tested by ANOVA and LSD following arcsine transformation.

Results and Discussion: In the laboratory preference test, Margosan-O was significantly deterrent to Japanese beetles on rose and linden, but not on the other hosts (Fig. 1a). Turplex was more effective, deterring feeding on treated foliage of all six hosts (Fig. 1b). Turplex contains 3% azadirachtin, compared to 0.3% for Margosan-O, so the former product delivers twice the active ingredient at labeled rates.
We observed that neem provided some protection for roses and crabapples early in the flight period while the JB population was low. Neither product was effective once the JB population increased (Fig. 2). Sevinmol provided high levels of protection from defoliation even with the heavy beetle pressure experienced in this trial.

**Significance to Industry** Azadirachtin or neem acts as an antifeedant and growth regulator for many insect pests. It is also relatively non-toxic to humans and environmentally friendly. With today's societal pressures against pesticide applications in urban landscapes, botanical insecticides such as neem may be an acceptable alternative to conventional insecticides. In laboratory trials, we found that Turplex, a commercial neem-based insecticide, deterred feeding by Japanese beetles on six preferred hosts. Another neem product, Margosan-O, was less effective. Unfortunately, neither product provided acceptable levels of protection of preferred host plants under heavy beetle pressure in the field.

**Literature Cited**


Figure 1a. Laboratory preference test, Margosan-O treatment. PLP-Purple leaf plum, Sas-Sassafras, NM-Norway Maple, Lin-Linden, Crab-Crabapple.

Figure 1b. Laboratory preference test, Turplex treatment. PLP-Purple leaf plum, Sas-Sassafras, NM-Norway Maple, Lin-Linden, Crab-Crabapple.
Figure 2. Comparisons of neem and Sevinmol treatments on rose and crabapple cultivars in the field.
Arthropod Diversity and Seasonality Among Different Varieties of the Flowering Dogwood

D. Scott Neitch, Jerome F. Grant and Mark T. Windham
Tennessee

Nature of Work: Dogwood trees are recognized for their aesthetic value as well as for their role in the ecosystem (4). Aside from their beautiful appearance in the wild, they are also a valuable asset to any homeowner’s property (1). Dogwoods are important economically to thousands of nurserymen. In the eastern United States, dogwood sales reach approximately $100 million annually, contributing $35-40 million to the nursery economy in Tennessee (K. Tilt, personal communication).

In the last decade, the flowering dogwood, *Cornus florida*, has become threatened by dogwood anthracnose, a fungal disease caused by *Discula destructiva* Redlin. Many commercial nurserymen and homeowners are concerned about the threat of losing such a beneficial and beautiful asset. The fungal disease is characterized by leaf spots, twig blights, and limb/trunk cankers (3). Since its discovery, dogwood anthracnose has caused extensive mortality in both woodland and ornamental dogwoods (5).

Little information about the transmission of the pathogen is available. Environmental factors, such as extremely damp weather, may predispose a tree to the spores of *Discula* sp. which are often dispersed by wind or rain (2). Mechanical injuries often aid in the entry of the pathogen. Researchers have suggested that insect species may play an important role in epidemiology of dogwood anthracnose. Because of concern about the possible role of insects in dissemination of *Discula* sp. among dogwoods, a two-year research project was initiated to determine insect species associated with different varieties of flowering dogwood.

During 1993, insects were collected bimonthly from May to October from individual dogwood trees at the Plateau Experiment Station, in Crossville, Tennessee. Two trees of three varieties of flowering dogwood were selected based on foliage coloration: Cherokee Princess (green), Purple Glory (red/purple), and First Lady (yellow). On each sampling date, plastic tarps were placed underneath the tree canopy. A selected insecticide, Pyrenone® (a pyrethrin [botanical]), was then applied, in a ratio of 10ml/3.8 liter of water, to the canopy of the tree using a hand-held sprayer. After 2 to 4 hours, fallen insects were removed from the tarps using a modified Dustbuster®, placed in plastic containers, and taken to the laboratory for processing and identification. All insects were identified to species, where possible. Species diversity indices will be calculated, and seasonal incidences of selected species will be evaluated. At the conclusion of this study, insect populations and communities will be compared among the three varieties of flowering dogwoods.

Results and Discussion: Approximately 2,000 insects were collected from dogwoods at the Plateau Experiment Station during 1993. Insect populations and communities were similar for the three varieties of dogwood. The three most common orders
represented were Coleoptera, Diptera, and Homoptera (Table 1). Homopterans made up a lower percentage of the total number collected on Cherokee Princess. Insect densities were greatest on First Lady, where ca. twice as many insects were collected. The predominately yellow foliage of First Lady may have served as an attractant which could account for this higher density. Average insect densities/tree sample were greatest during May and June, peaking in late May to early June. Seasonal fluctuations of insect densities were similar among the three varieties.

**Significance to Industry:** Previous greenhouse and laboratory studies, using the convergent lady beetle, *Hippodamia convergens*, as a model, have demonstrated that insects can disseminate viable conidia to healthy dogwood foliage and that the foliage can develop lesions symptomatic of dogwood anthracnose. This research will provide a better understanding of insect species associated with flowering dogwood and may be useful to growers in the development and implementation of management programs.

**Literature Cited**


### Table 1. Percent composition of taxa collected from three varieties of flowering dogwood, Plateau Experiment Station, Crossville, TN, 1993.

<table>
<thead>
<tr>
<th>Insect Order</th>
<th>Cherokee Princess (549)$^1$</th>
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$^1$Total number of insects collected.
Early Season Drenches of Bonzi and Sumagic for Height Control of Container-Grown Herbaceous Perennials

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South Carolina

Nature of Work: Container-grown herbaceous perennials are becoming an important crop for the nursery industry. One production problem encountered is height control of many perennial species. Crop management and shipping/handling may be improved and greater salability result from height reduction of plants that are normally too tall for efficient marketing.

Rooted liners or plugs are primarily used for nursery production of perennials and growth regulators are routinely used in the propagation cycle (1, 3). However, height/growth control of perennials that were overwintered from the previous year is not straightforward because of the maturity of these plants. These perennials are placed cantight during the winter and plant growth regulator applications at this time would be very efficient.

Early spring applications of plant growth regulators to dormant plants would be advantageous for nursery growers (2). In the spring the nursery stock that has been in winter protection must be moved to allow full and natural growth. Also the spring is when the majority of the year’s sales occur and nursery personnel are dedicated to this task. Any growth regulating treatment, whether it be cultural or chemical, that could be accomplished prior to the spring marketing season would be welcome by the nursery industry.

The objectives of this experiment were to (1) determine effectiveness of Bonzi or Sumagic container drenches on control of the height of selected overwintered herbaceous perennials and (2) determine timing effects of such drenches on height control.

Four species of herbaceous perennials were evaluated for growth response to early season drenches of either paclobutrazol (Bonzi) or uniconazole (Sumagic). These species were Achillea millefolium x ‘Paprika’, Coreopsis verticillata ‘Zagreb’, Chrysanthemum x superbum ‘Snowcap’, and Rudbeckia fulgida ‘Goldstrum’. All plants were grown in 3.8L gallon containers in an 80% pine bark/20%sand soilless media. Each species was overwintered outside in a cantight configuration at Carolina Nurseries, Moncks Corner, SC. Plants were selected for uniformity in size within the species and were topdressed with 16g (1 lb N/yd³) of granular 14-7-7 fertilizer on 1 Mar 94 which corresponded with normal fertilization practices at the nursery.

Container drenches of Bonzi at 20 mg ai/container and Sumagic at 2.5 mg ai/container were applied in 475 ml/container drench volume. Five treatment dates were evaluated beginning with 2 Feb 94 and ending on 30 Mar 94 at two week intervals. An untreated control was included for comparison purposes. All containers were irrigated 2 hr prior to drench applications to assure maximum penetration of the plant growth regulators throughout the root system.
The study was terminated 28 Apr 94 and plant height was measured and floral development determined. Treatments were arranged in a complete randomized block design with four replications of each drench application timing combination. Effects of each plant growth regulator were evaluated separately. All data was analyzed by analysis of variance and mean separation by least significant difference $P=0.05$.

**Results and Discussion:** Rates of Bonzi or Sumagic used were considered high from previous research (1, 4) in order to ensure a treatment date effect. Bonzi drenches had varying effects on plant height according to the plant species evaluated in this study. Bonzi effectively controlled the growth of *Achillea* through the first four drench application dates (Table 1). Plants treated on 30 Mar 94 were taller compared to the previous drench dates. All *Achillea* plants treated were smaller than the controls regardless of drench date. *Chrysanthemum* height was reduced for all drench dates with Bonzi. *Coreopsis* height was reduced for the first three drench dates and increased on the next two dates. Like the *Achillea* and *Chrysanthemum*, all treated *Coreopsis* plants were smaller than the controls. *Rudbeckia* height was not effected by Bonzi drenches at any treatment date.

Sumagic drenches, like the Bonzi drenches, had varying effects. *Achillea* height was reduced compared to the control plants for the first four treatment dates (Table 1) but not for the 30 Mar 94 date. With *Chrysanthemum*, only the 2 Mar 94 and 16 Mar 94 treatments reduced plant height compared to untreated plants. The height of *Coreopsis* was reduced for the first four treatment dates. The only treatment date to reduce *Rudbeckia* was the second drench on 16 Feb 94.

*Achillea* was the only species flowering at the study termination. Bonzi reduced flower production with no flowers formed for the first four treatment dates (Figure 1). Sumagic also delayed flower production but flowers were present on all plants regardless of treatment date and flower formation increased as treatments were delayed.

Drench application of Bonzi or Sumagic in early spring when perennial plants were somewhat dormant was effective in controlling height in some species. The data however suggests that timing of the application is important. All treatment dates resulted in similar height for *Chrysanthemum*, suggesting that active growth of this species did not start until after the last treatment application. The *Achillea* did not start any significant growth until after 2 Mar 94 and the first four drench dates were similar for Bonzi treatments. Sumagic drenches provided similar results for *Achillea*. Drenches applied before active growth reduced flowering (Sumagic) or prevented flower development (Bonzi).

**Significance to Industry:** It is important to maintain marketability during the spring shipping season of container-grown perennials. These plants can be quite vigorous and require much attention to maintain plant size for sale and shipment. Drenches in early spring with Bonzi or Sumagic offer an effective method, though species dependent, of reducing the height of container-grown perennials through the critical spring sales window.

Table 1. Effect of Bonzi or Sumagic container drenches on height (cm) of container-grown perennials.

<table>
<thead>
<tr>
<th>Drench Date</th>
<th>Achillea Bonzi</th>
<th>Sumagic</th>
<th>Rudbeckia Bonzi</th>
<th>Sumagic</th>
<th>Chrysanthemum Bonzi</th>
<th>Sumagic</th>
<th>Coreopsis Bonzi</th>
<th>Sumagic</th>
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<tbody>
<tr>
<td>2 Feb 94</td>
<td>18.4</td>
<td>20.6</td>
<td>17.5</td>
<td>15.6</td>
<td>8.6</td>
<td>13.0</td>
<td>16.8</td>
<td>22.5</td>
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<tr>
<td>16 Feb 94</td>
<td>17.6</td>
<td>23.2</td>
<td>18.3</td>
<td>14.9</td>
<td>9.2</td>
<td>13.3</td>
<td>19.0</td>
<td>21.3</td>
</tr>
<tr>
<td>2 Mar 94</td>
<td>18.4</td>
<td>22.1</td>
<td>20.3</td>
<td>15.9</td>
<td>9.5</td>
<td>11.7</td>
<td>17.5</td>
<td>19.7</td>
</tr>
<tr>
<td>16 Mar 94</td>
<td>14.9</td>
<td>20.9</td>
<td>19.4</td>
<td>17.5</td>
<td>9.8</td>
<td>11.4</td>
<td>22.2</td>
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<tr>
<td>30 Mar 94</td>
<td>26.9</td>
<td>27.9</td>
<td>19.0</td>
<td>17.8</td>
<td>9.2</td>
<td>13.0</td>
<td>26.0</td>
<td>27.3</td>
</tr>
<tr>
<td>Control</td>
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<td>31.1</td>
<td>18.4</td>
<td>18.4</td>
<td>14.6</td>
<td>15.6</td>
<td>30.5</td>
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</tr>
<tr>
<td>LSD (0.05)</td>
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<td>5.9</td>
<td>2.9</td>
<td>3.5</td>
<td>2.0</td>
<td>2.8</td>
<td>3.8</td>
<td>4.9</td>
</tr>
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</table>
Figure 1. Number of flowers formed on 28 Apr 94 of Achillea millefolium x ‘Paprika’ after 5 drench applications of either Bonzi or Sumagic.