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The editor and the Board of Directors of the Southern Nurserymen's Association wish to express their sincere appreciation to Donald B. Williams, Bonnie Appleton, Kenneth Tilt, Beverly Brewer Sparks, Jerry T. Walker, Robert E. McNeil, Will Witte, Ted Whitwell, James Aitken, and Will Corley for the fine job they did as Section Chairmen and Moderators.

We would like to extend our gratitude to all the researchers and nurserymen who attended our Conference and/or contributed to these Proceedings and continue to make this annual event an industry success.

NOTICE

Mention of a trademark name on a proprietary product does not constitute a guarantee and/or warranty of the product by the researcher(s) or their respective Universities or the Southern Nurserymen's Association and does not imply it's approval to the exclusion of other products that may also be suitable.
USING RESEARCH DATA SAFELY AND EFFECTIVELY

Good Research is conducted under an exact set of controlled conditions, varying only the specific treatments which are to be evaluated. Results from the specific treatments are directly applicable to your operations only if all the conditions in your operation are controlled the same as in the research. Unfortunately, this seldom happens. However, this does not mean that you can not benefit from the research. What it does mean is that you should use the research information on a trial basis first, if your plant species, soil type, watering method, size and age of plant, climatic region, etc. is different than that described by the researcher.

What an alert grower should expect to gain from these research reports is ideas - ideas as to the best control for insects, disease, nematodes and weeds - labor saving ideas such as chemical pruning and using growth regulators to minimize maintenance.

Should you desire additional information on any report, please write to the author. Mailing addresses are listed in the back of this book. We would like to extend an invitation to you to attend all sessions of the Research Conference held in Atlanta each year in conjunction with the SNA Trade Show.
Proceedings of the SNA Research Conference is published annually by the Southern Nurserymen's Association and one copy is provided at no charge to all SNA Members, Horticultural Libraries, and Contributing Authors.

It is the fine men and women in Horticultural Research that we, the Southern Nurserymen's Association, pledge our continued support and gratitude for their tireless efforts in the pursuit of the advancements of our industry.

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The 1990 Porter Henegar Memorial Award was presented to N.C. State's, Frank A. Blazich on Friday, August 3rd. Blazich was honored by his peers with this annual award recognizing those individuals who had made outstanding contributions to ornamental horticultural research and more specifically to the SNA. Blazich (A.A.S., State University of New York at Farmingdale, 1969; B.S., University of Vermont, 1971; M.S., University of Vermont, 1973; Ph.D., The Pennsylvania State University, 1977), a native of Smithtown, NY, joined the staff of the Department of Horticultural Science at North Carolina State University in August, 1978 as an Assistant Professor with responsibilities in teaching and research. Prior to accepting the position at N.C. State, Dr. Blazich was on the staff of the Virginia Truck and Ornamentals Research Station (now the Hampton Roads Agricultural Experiment Station).

Dr. Blazich's present responsibilities at N.C. State include teaching undergraduate and graduate students in plant propagation and also conducting research in this area. He has a very active research program and has served as major professor to a number of M.S. and Ph.D. students. His research in plant propagation is highly regarded, both nationally and internationally, and has resulted in numerous refereed and non-refereed journal articles and various honors and awards. In addition to his own research activities, Dr. Blazich is frequently requested to review research papers of other scientists and is a member of the Editorial Board of the Journal of Environmental Horticulture and an Associate Editor of the American Society for Horticultural Science.

Dr. Blazich has attended and participated in every SNA Research Conference since 1977. He has authored or co-authored many papers which have appeared in the Proceedings of the Conference and has served two 3-year terms as Chairman of the Propagation Section. Currently, Dr. Blazich is serving as a member of the SNA’s Sidney B. Meadows Scholarship Selection Committee.
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SECTION 1
STUDENT COMPETITION

DR. Donald B. Williams
Section Chairman and Moderator
PRUNING EFFECTS ON THE COLD HARDINESS OF TWO WOODY ORNAMENTAL PLANT TAXA

C.L. HAYNES, O.M. LINDSTROM, AND M.A. DIRR
GEORGIA

Nature of Work: Countless woody trees and shrubs are pruned every year by nurserymen and gardeners for a variety of reasons. However, late summer or fall pruning may predispose these plants to winter injury. Many scientists have observed the effects of fall pruning on cold hardiness of fruit crops (Burkholder, 1936; Edgerton and Shaulis, 1953; Wolpert and Howell, 1984). Yet, no studies of pruning effects on cold hardiness have been conducted on woody ornamentals. The purpose of this experiment was to determine how timing of pruning affects the cold hardiness of *X Cupressocyparis leylandii* (A.B. Jacks and Dallim.) Dallim. and A.B. Jacks ‘Haggerston Grey’, (Leyland Cypress) and *Lagerstroemia* L. ‘Natchez’ (Crape Myrtle).

Shoots were collected from one-year-old containerized plants, which were vegetatively propagated and grown under standard nursery practices, in Athens, GA. Plants were randomly assigned dates when they would be pruned. Three-inch (7.5cm) shoots were removed from Leyland cypress and six-inch (15cm) shoots were removed from crape myrtle. Cold hardiness estimations were conducted at various months throughout the winter in such a manner to compare the pruned treatments with the unpruned controls.

Plants were pruned on six different dates from August 1989 to March 1990 and samples were transported to Griffin, GA on ice for testing. Four, 2.5 inch (6.5cm) segments were wrapped in moist cheesecloth and placed in labeled test tubes in a Forma Scientific (Marietta, Ohio; Model 2425) temperature bath. After nucleation and preconditioning (8-12 hours at 28.4F), the temperature was lowered not more than 7F per hour. Temperatures were measured by copper-constantan (Type T) thermocouples placed next to the samples and recorded by a Campbell Scientific (Logan, Utah; Model CR7-X) datalogger. Samples were removed at predetermined temperatures. Controls were prepared and placed at 39.2F for the duration of the test.

After freezing treatment, samples were thawed slowly at 39.2F, placed on moistened filter paper in petri dishes (100% R.H.), and incubated in darkness at room temperature until visual evaluation (Lindstrom and Dirr, 1989; Hummel et al., 1982; Bannister and Fagan, 1989; Fuchigami et al., 1971). Segments showing breakdown of cells and brown discoloration in the cambium and phloem were rated as dead. The number of stems killed at each temperature was determined and reported as the lowest survival temperature (LST) which is the lowest temperature at which little or no injury was observed (Sakai et al., 1986).
Results and Discussion: Pruning treatments decreased the cold hardiness of both taxa compared to the unpruned controls from August to February. August and October pruned samples of Leyland Cypress were less cold hardy than the unpruned controls for 4 to 5 months following pruning treatments. (Table 1.) Leyland cypress pruned in January were 10.8F less cold hardy in February. October and December pruned Leyland cypress decreased in cold hardiness by 7.2F in February.

Crape myrtle samples acclimated much later than Leyland cypress. (Table 2.) August and October samples of crape myrtle exhibited minimal cold hardiness in fall. December pruning of Crape Myrtle reduced the cold hardiness by 7.2F in January.

Both Leyland cypress and crape myrtle are widely used landscape plants in the southeast. Leyland cypress is also popular as a christmas tree with production in the hundreds of thousands (Dirr, 1990). Both nursery and christmas tree production require regular pruning of trees. In general, these data indicate that Leyland cypress plants pruned from October through February were less cold hardy than plants pruned in August.

Since crape myrtle flowers on the new growth of the season, it,too~is frequently pruned. Many people remove old flowers in the summer and fall to encourage new ones. Yet, pruning from mid-August to the first killing frost is discouraged (Wade et al., 1988). Pruning crape myrtle before they are fully dormant may stimulate new growth that is not sufficiently hardened against winter injury. These data suggest that fall and early winter can predispose plants to winter injury. Based on this data, crape myrtle should be pruned in late winter.


(Table 1)

(Table 2)
POSTEMERGENCE CONTROL OF PHYLLANTHUS

Jesse A. Reeder, Charles H. Gilliam, and Glenn Wehtje
Alabama

Nature of Work: Phyllanthus urinaria L. (leafflower) is rapidly becoming a major weed problem in nursery production areas and landscapes. This plant is native to the gulf coast region of the United States, where it ranges from Texas to the Carolinas. Little information is available on its reproductive biology and control. This test was initiated to investigate reproductive biology and postemergence control of Phyllanthus.

The first series of test evaluated the effects of temperature on germination of Phyllanthus seed in growth chambers. Variables were light (light and dark) and temperature, with temperature ranging from 20 to 40 degrees centigrade.

In April 1990, Phyllanthus seedlings were potted into 6-inch pots containing an amended pinebark and sand medium (6:1, v:v) with 14 lb of Osmocote 18-6-12, 5 lb of dolomitic limestone, and 1.5 lb of Micromax per cubic yard. Plants were grown in a double layer polyethylene greenhouse with 47% shade, and watered as needed. Herbicide treatments were assigned to 6 single-pot replicates. Individual treatments were as follows; 2,4-D amine at 0.75 and 1.50 lb/A, Basagran at 1.50 and 3.00 lb/A, Image at 0.25 and 0.50 lb/A, Gramoxone at 0.13 and 0.25 lb/A, Roundup at 0.25 and 0.50 lb/A, MSMA at 2.00 and 4.00 lb/A, Goal at 1.00 and 2.00 lb/A, and a nontreated check. Herbicides were applied on May 17 using a beltsprayer operating at 15 GPA with 30 psi using a 11002 flat nozzle. Postemergence control was visually rated 10, 20, and 30 days after treatment (DAT), using a scale of 0 (no effect) to 100 (death). Dry weights were measured after the final rating.

Results and Discussion: Growth chamber studies show that maximum germination (83, 76, and 77%,) occurred in the light with temperature of 25, 30, and 35 degrees centigrade respectively. At 20 and 40 degrees, little germination occurred in the light. With treatments in the dark, germination was less than 10% for the best treatment.

Roundup and Gramoxone, postemergence-applied herbicides commonly used in the landscape industry, provided excellent control. Superior control was achieved with Gramoxone at 0.25, Roundup at 0.50, and Goal at 1.00 and 2.00 lb/A (Table 1-30 DAT). Lower rates of Gramoxone and Roundup failed to provide adequate control. Previous research has reported that Goal can be safely applied over the top of several woody plants during mid-summer dormancy. Phyllanthus is a summer annual with peak germination occurring around early to mid June in Alabama. This fortunately coincides with the time when woody plants in the Southeast enter summer dormancy. Consequently, a broadcast application of Goal may provide adequate control of Phyllanthus without ornamental injury.
In contrast, herbicides commonly used in turf (i.e. MSMA, 2,4-D amine, and Image) provided poor control. By the 30 DAT rating, control was approximately 30% with these herbicides.

(Table 1)
Cuttage Production of Geranium Stock Plants as Influenced by Plant Growth Regulators

J. T. Foley and G. J. Keever
Alabama

The growing and maintaining of stock plants of desirable cultivars as a propagation source is a common trade practice. To increase branching of stock plants growers may resort to pruning which removes the auxin source and apical dominance of the terminal, allowing axillary growth. By effectively using chemical branching agents to increase the branching of stock plants, labor and space requirements can be reduced when fewer plants are necessary to maintain the number of stock plants needed for propagation. Exogenously applied cytokinins, including Pro-Shear (BA), Promalin (BA + GA 4+7) and Accel (PBA) reduce apical dominance, thereby promoting the growth of lateral buds (1,2,3,5). Florel (ethephon) is labeled for use as a branching compound on geranium stock plants (4). The objective of this study was to determine the effectiveness of several plant growth regulators (PGRs) in inducing lateral branching on ‘Hollywood Star’ geranium stock plants for the purpose of increasing cuttage.

Seeds were sown in 36-cell flats of Pro-Mix BX drenched with Banrot fungicide. Flats were placed in a double polyethylene greenhouse under intermittent mist (10 sec./5 min.) until cotyledons had fully emerged. Seedlings of ‘Hollywood Star’ geranium were transplanted to 6-inch pots on January 6, 1988, and 2 days later the following foliar spray treatments were applied to the plants: Pro-Shear at 75, 150, 300, 600 ppm; Accel at 75, 150, 300, 600 ppm; and Promalin at 150, 300, 600, 1200 ppm.

A second test was initiated to determine appropriate rates and number of applications of the most effective branching compounds from Expt. 1, these PGRs were compared to Florel. On June 27, 1988, plants were treated with foliar sprays of Accel at 37.5 and 75 ppm, Promalin at 75 and 150 ppm and Elorel at 500 ppm. Four weeks after initial treatment, cuttings were taken and a second application was applied to half the plants in each treatment group. Plants were then allowed to produce a second crop of cuttings. Treatments were completely randomized with initial sprays applied to 14 single plant replicates; half of these replicates received a second application.

A third experiment investigated the effect of weekly, biweekly and monthly foliar spray applications of Promalin at 75, 150 and 300 ppm compared to a monthly application of Florel at 500 ppm. Treatments began on May 4, 1989, and were completely randomized with 10 single plant replicates.

Results and Discussion: Experiment 1: Plants treated with Accel tended to produce more branches at the lower rates with a decline at the highest rate
of 600 ppm; this trend was also observed in the growth index (Table 1). Branch length was not affected by Accel treatment. Promalin tended to increase branch length and the growth index as rate increased while the number of branches tended to peak at 300 ppm. As rates of Pro-Shear increased number of branches tended to decrease while branch length increased. The growth index was not affected by Pro-Shear treatment.

Experiment 2: Four weeks after the first treatment, plants treated with Florel produced more terminal cuttings when compared to the control; entire side branches which were divided into single eye and terminal cuttings tended to be shorter in length and smaller in caliper when compared to other treatments (Table 2). Promalin produced competitive numbers of terminal and single eye cuttings and longer side branches of greater caliper but these observations did not differ from the control. Plants were not affected by treatments of Accel. After a second application was applied to the vertical main leader remaining after initial cuttings were taken, plants treated with Promalin produced significantly more single eye cuttings than the control. Plants were not affected by a second application of Accel or Florel.

Experiment 3: (Table 3) As the number of applications increased, the number of single eye and terminal cuttings as well as the side branch length and caliper tended to decrease at 150 and 300 ppm of Promalin. At 75 ppm of Promalin inconsistent results were produced. Florel continued to induce greater numbers of terminal cuttings but Promalin surpassed Florel in single eye cuttings and side branch length and caliper when a monthly application of each rate was applied.

Florel is most effective when terminal cuttings are desired however, if a grower is concerned about the number of single eye cuttings and ultimately the total numbers of plants produced, Promalin should be considered.

LITERATURE CITED


(Table 1) @ 60%

(2) Table 3)@ 60%
CONSUMER PREFERENCES FOR ANNUAL BEDDING PLANT CONTAINERS
Ginger Purvis, Bridget Behe, and Charles Gilliam
ALABAMA

Nature of Work: Packaging of many products, which would include the container, influences consumer purchases. For ornamental horticultural products, this influence has not yet been defined. Some garden center managers reported that customers want larger, more mature plants and are willing to pay the extra costs involved (1). Consumers appear to like larger bedding plants because they provide “instant color” to their home landscapes (2).

The objective of this study was to determine consumer preferences for pansy plants in three types of containers: 6-plant cell packs (grey), 6-inch plastic pots (green), and a plastic grow bag2 (tan). Uniform pansy plants (Viola x wittrockiana) were grown by a commercial producer using standard cultural practices. These plants were then containerized in each type pot or bag and placed in a greenhouse for two or four weeks until used in the study. Two 6-packs were used for the cell packs, 8 plants were used in the bag, and 2 6-inch pots (3 plants each) were used. Price as a variable was not included in the study.

Seventy-four consumers participated in a personal interview and written questionnaire study at two garden center locations on two Saturdays in Montgomery, Alabama, in October and November, 1989. Consumers were evaluated for characteristics of age, education, household size, gender, and income. They were also asked their perceptions of certain plant and container characteristics. Finally, they were asked to select one group of pansy plants they would most prefer if making a purchase that day.

Results and Discussion: Respondents by age group were 25-34 (17%), 35-49 (36%), and 50-79 (47%). Seventy-five percent of the respondents had completed some college or had earned a college degree. Median per capita income was $10,416, while average per capita income was $9,767. Fifty-one percent of the respondents stated that their households contained only two people and the mean number of persons in each household was 2.4. Thirty-seven percent of the respondents were male and 63% were female.

1 The authors thank Wright’s Nursery, Inc., Gold Kist, Inc., and Arthur A. Jones and Associates, Inc. for their generous donations of materials for this research and Southern Homes and Gardens and Harwell’s Green Thumb Nursery in Montgomery for allowing us to utilize their facilities.

2 “Garden on the Spot” grow bag is a product of GoldKist, Inc.
Respondents were asked to rank the importance of several plant and package characteristics. Consumer ratings were evaluated using a 9-point Likert Scale (table 1). Ninety percent of the respondents indicated that the health of the plant was an important attribute. Conversely, the type of container in which the plant was sold was given an important rating by only 18% of the respondents.

Consumers were asked to indicate their attitudes or perceptions about buying plants rated on a 5-point Likert scale. Only 14% of the respondents strongly agreed or agreed with the statement, “I usually grow plants in the container I buy them in.” Eighty-nine percent agreed or strongly agreed that they could tell the difference between a healthy and an unhealthy plant.

Respondents were then asked to choose which pansy on display they would purchase if making a purchase for themselves that day. Of those responding, 51% chose the plants in the bag, 29% chose the plants in the cell packs, and 20% chose the plants in the 6-inch pots.

Conclusions: Price did not appear to be a concern to these consumers, but purchasing a high quality plant was. Health is one measure of plant quality and respondents believed they were able to recognize healthy plants. Plants in the bag may have appeared to grow larger than plants in the cell pack or pots. Consumers may have equated larger sized or more colorful plants with higher quality plants. The plants may have grown larger because the grow bags held more soil, retained more moisture, or provided some nutrition.

Bedding plant growers should consider the results of this study when marketing bedding plants. Larger plants or those with a more colorful display are preferred by consumers. The optimum size container for greenhouse production may not be the optimum size container in which to market plants. Annual plants could be transplanted into larger containers prior to retail sales, which could result in more visual appeal. While many plants would still be purchased in traditional cell pack containers, displaying mature plants in large containers, or a variety of containers, may suggest additional uses and stimulate additional sales.

The container does not appear to play a significant role in the consumer purchase decision directly. However, it may influence the consumers’ perception of quality, most likely by influencing the growth and development of the plant itself. Therefore, the container selection should be given further consideration by producers and retailers of annual bedding plants.
LITERATURE CITED


Characteristics of Alabama’s Nursery Industry: Comparison of Proprietorships and Corporations

Lisa Beckett, Bridget Behe, and Charles Gilliam
Alabama

Nature of work: Agricultural crop production is a major component of Alabama’s economy since the production of ornamental plants in 1988 generated more cash receipts than cotton, peanuts, or other cash crops (1).

There are three major categories of legal business forms: sole proprietorships, partnerships, and corporations. Each business form has distinct advantages and disadvantages which affect the tax liability and daily operation of the firm. Horticultural businesses, especially nursery businesses, are often relatively small and operated by one or two owners (proprietorship or partnerships) who may be the only employees. The proprietor assumes all tax liability under this form of business, yet is not very restricted in the management of the business. Partnerships are similar to proprietorships in personal tax liability and amount of managerial freedom. Corporations are taxed as separate entities from the managers, increasing the tax burden but substantially decreasing the personal liability of the managers.

To learn more about the size and scope of Alabama’s ornamental crop industry, a study was undertaken by the Alabama Agricultural Experiment Station as part of a regional project that included 22 universities. Fifty surveys were mailed to nursery businesses in Alabama. Twenty nine responses were returned for a 58% response rate.

Results and discussion: Of the three major business forms (sole proprietorship, partnership, and corporation), the majority of nursery firms were corporations (72%). The next largest category was sole proprietorships (21%), followed by partnerships (4%) and other business forms (3%). Business management practices of two business forms, proprietorships and corporations, were compared.

A greater percentage of the proprietorships had computerized some business functions when compared to corporations. A higher percentage of proprietorships had computerized word processing (50% versus 38%), accounting (83% versus 38%), inventory (50% versus 33%), financial investments (33% versus 5%), marketing (17% versus 10%), and communications (17% versus 10%) when compared to corporations. Thus, there appears to be a greater willingness on the part of the proprietor, a single individual, to adopt computer technology.

The composition of the product mix for nursery proprietorships and corporations was different (table 1). Proprietorships had a more traditional~ less
broad product mix than did the corporations. More proprietorships sold broad-leaved evergreen plants (67%) than did corporations (43%). More proprietorships also sold deciduous shrubs (24%) than the corporations (6%). More corporations sold evergreen trees (8%), vines and ground covers (24%), roses (3%), herbaceous perennials (5%), tree fruits (7%), and propagation material (18%) than did the proprietorships. The corporations offered a broader product mix than proprietorships perhaps to appeal to a broader consumer market.

The percent of sales by month for proprietorships and corporations was somewhat different. Proprietorships appear to have concentrated less on sales in the spring and increased the sales somewhat in fall. This would indicate less dependence on spring sales, which would reduce the seasonal nature of the business. Conversely, the corporations appear to have a greater proportion of sales in the spring, nearly 25%, and depend less on fall sales. This would make their nursery sales more seasonal. However, they may depend on other products, such as hardgoods or seasonal greenhouse plants, to generate sales at other times of the year.

When establishing a price, management may consider a number of factors. Respondents were asked to select factors they consider important when setting prices for their products. Corporations considered costs of production (57%), grade of plant (33%), market demand (33%), competition’s prices (29%), last year’s price (14%), time of year (5%), and inventory (5%) as important factors when determining a price. Proprietorships considered cost of production (50%), grade of plant (34%), market demand (34%), inventory (34%), and competition’s prices (17%) as the most important factors when determining a price. More proprietors than corporations considered inventory important while more corporations considered last year’s price more important. This would indicate that proprietors are more conservative in their pricing strategy in that they may anticipate a greater amount of product on the market (increased competition), which could drive prices down.

Conclusions: The ornamental industry in Alabama an important to the state’s agriculture. A majority of nursery businesses are corporations, while slightly less than one-quarter are proprietorships. More proprietorships have computerized at least some of their business operations compared with corporations. Corporations offer a broader product mix than proprietorships, perhaps to appeal to a broader consumer market. Proprietorships concentrate less on spring sales and work more to develop fall product sales. In Alabama, many of the nursery businesses have developed beyond the traditional sole proprietor and have become incorporated. This may occur, in part, to reduce liabilities. In many industries, the corporate structure is viewed as a more sophisticated structure than other forms. Having a great proportion of incorporated nursery businesses would indicate the develop-

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ment of Alabama’s nursery industry to a relatively high level of sophistication.

**Literature cited.**


(Table 1)
Nature of Work: In light of recent label changes banning B-Nine SP (daminozide) as a growth regulating substance for height control on vegetable transplants, growers choices for growth regulation have become more limited. There is an increased need for alternatives that are economical, effective and environmentally sound.

Armitage and Kowalski (1) reported that growing plants under low moisture regimes resulted in shorter plants as compared to those grown under high moisture regimes. Several popular articles have suggested the use of moisture stress as an alternative to chemical growth regulators for height control (2,3). Despite articles advocating the use of moisture stress as a viable alternative for height control, little information is available on how it compares to the application of growth regulating substances such as B-Nine.

The objective of this study was to compare moisture stress to B-Nine as a means of height control for three bedding plant species in two commonly used commercial media.

Uniform plugs of two vegetables, \textit{Lycopersicon lycopersicum} ‘Big Boy’ (Tomato) and \textit{Capsicum annuum} ‘California Wonder’ (Pepper), as well as an ornamental, \textit{Tagetes erecta} ‘Janie Gold’ (Marigold) were transplanted into cell packs (48 cells/tray) on 15 May 1990. Cell packs contained one of two commercial media: Fafard #3, a peat:pine bark mix or Pro-Mix BX, a peat:perlite mix. Plants were produced in a polyethylene greenhouse equipped with a fan and pad cooling system. The experimental design was a randomized complete block factorial design with 6 blocks; 6 plants per treatment per block.

Treatments included moisture stress, two rates of B-Nine and a control. Moisture stress plants were allowed to visibly wilt between each irrigation while the remaining treatments received irrigation to maintain a moist media surface. B-Nine treatments were applied at rates of 2500 and 5000 ppm until drip when plants were at the 2 to 4 true leaf stage. The 2500 ppm B-Nine treatment was applied again 3 weeks after the first application. All treatments were initiated on 22 May 1990. On 15 June 1990, plant height and internode number were determined.

Results and Discussion: Moisture stress reduced plant height for tomato (Table 1) and marigold (data not shown, all results similar to tomato) compared to the other height control treatments. Moisture stressed tomatoes
grown in the Fafard medium had a 12% reduction in height compared to the best B-Nine treatment of 2500 ppm applied twice. In comparison, when grown in Pro-Mix, both moisture stress and B-Nine at the 2500 ppm rate reduced plant height by about 15% when compared to B-Nine 5000 ppm and control plants. The number of nodes produced per plant was not affected by any treatment. Consequently, plants in treatments that reduced plant height had a fuller canopy.

With pepper, moisture stress reduced plant height for plants grown in the Fafard medium by 16% but had little influence on plants grown in the Pro-Mix medium when compared to control plants (Table 1). Regardless of media type, 2500 ppm B-Nine applied twice produced the shortest plants. Moisture stressed plants were 6% and 15% taller in the Fafard and Pro-Mix soil mixes, respectively compared to the 2500 ppm B-Nine plants. As with tomatoes and marigolds, the number of nodes per plant were similar among treatments resulting in fuller plants with those treatments that reduced plant height.

Differences caused by media type in how height control treatments influenced plant growth were probably due to the Fafard mix consistently drying out faster than the Pro-Mix medium. Moisture stressed plants grown in the Fafard medium wilted more often than plants grown in Pro-Mix for all three species. Furthermore, pepper plants took longer to wilt during moisture stress treatments than did tomatoes or marigolds, regardless of media type. This fact may explain why the moisture stress treatment was less effective in reducing plant height of pepper compared to the other plant species used in this study.

Results from this study indicate that moisture stress is a viable and legal alternative to the use of B-Nine for height control. However, the effectiveness of moisture stress for height control in bedding plant transplants is media and species dependent. It appears that moisture stress will have a greater influence on controlling plant height for plants which have high water requirements grown in media that have a low water holding capacity. As with any new technique, growers should use caution and become familiar with the wilting process of each plant species and the water holding capacity of their medium to avoid permanent plant damage from moisture stress.
LITERATURE CITED


(Table 1)
**Nature of Work:** Ornamental grasses exist in a great variety of form and color and can therefore be used in landscape plantings as ground covers, in borders, or as lawn features. Annual and perennial grass weeds and encroachment of turf species such as bermuda grass (Cynodon dactylon) are major problems in establishing landscape ornamental grass plantings and in the commercial production of ornamental grasses.

Postemergence grass herbicides are specific herbicides effective in controlling annual and perennial grasses. Differential tolerance of turf species to these herbicides has been reported (Higgins et al., 1987; McCarty et al., 1986, 1989) and, therefore, it is possible that differential tolerance to these herbicides also exists between ornamental grass species. Poast (sethoxydim), Acclaim (fenoxaprop-ethyl) and Fusilade 2000 (fluazifop-P) are postemergence grass herbicides labelled for control of weedy grasses in many ornamental trees, shrubs and herbaceous plants and would therefore be useful for grass control in ornamental grass plantings if tolerance could be determined. However, evaluating the hundreds of ornamental and turf grasses available to these and other postemergence grass herbicides would not be feasible using traditional screening techniques which require several experiments over time to accurately assess herbicide injury. Visual symptoms of chlorosis, arrested growth and meristematic necrosis appear on grasses approximately one week after treatment with postemergence grass herbicides, but it is not for several weeks after application that long term injury can be evaluated. Therefore, rapid screening techniques would be a useful tool in establishing herbicide phytotoxicity information. Postemergence grass herbicide induced leakage of ions and amino acids through cell membranes has been well documented (Crowley and Prendeville, 1979; Hoppe, 1980) and differential susceptibilities were correlated with differences in leaf cell membrane permeability prior to the appearance of visual injury (Crowley and Prendeville, 1979). Therefore, it is possible that measurements of membrane leakage would be a rapid technique for evaluation of grass tolerance to postemergence grass herbicides. The objectives of this study were: to determine the tolerance of 14 ornamental grasses to single applications of postemergence grass herbicides and to evaluate amino acid leakage from leaf discs as a rapid technique for detection of grass tolerance to Acclaim (fenoxaprop-ethyl) and Poast (sethoxydim).

Eleven ornamental grasses were field planted in May, 1989 at the Clemson Botanical Gardens, Clemson, SC. The grasses planted were Calamagrostis arundinacea ‘Karl Foerster’ (Karl Foerster’s feather reed grass), Cortaderia
selloana (Pampas grass), Eragrostis curvula (Weeping love grass), Erianthus ravennae (Ravenna grass), Miscanthus sinensis ‘Gracillimus’ (Maiden grass), M. sinensis ‘Purpurascens’, M. sinensis ‘Variegatus’ (Variegated silver grass), Pennisetum alopecuroides (Fountain grass), P. setaceum ‘Rubrum’ (Purple leaved fountain grass), Sorghastrum avensaeum (Indian grass) and Spartina pectinata ‘Aureomarginata’ (Variegated cord grass). Herbicide treatments were Acclaim (fenoxaprop-ethyl), Fusilade 2000 (fluazifop-P) and Poast (sethoxydim) at 0.36 lb a.i./A (0.4 kg a.i./ha). Acclaim (fenoxaprop-ethyl) and Fusilade 2000 (fluazifop-P) treatments contained 0.5% (v/v) of the surfactant Triton Ag-98 while Poast (sethoxydim) treatments contained 1.25% (v/v) Dash. Treatments were applied 5 weeks after planting using a C°2 backpack sprayer delivering 20 GPA (190 liters/ha). Visual injury ratings (%) and height evaluations were made at weekly intervals and above-ground foliage was harvested 10 weeks after treatment (WAT) and dry weights determined. Visual injury was evaluated on a scale of 0 to 100 with 0 = no injury and 100 = complete kill. Height was measured to the tallest part of the plant at time of measurement. Three Festuca species, Festuca amethystina ‘Bronzeglanz’ (Bronze-color sheep fescue), F. cinerea ‘Harz’ (Olive-green blue fescue) and F. ovina var. glauca (Blue fescue) were planted at Clemson, SC, in November, 1989. Herbicide treatments, adjuvants and application were the same as for the previous study and treatments were applied 10 weeks after planting. Visual injury was recorded at weekly intervals and 14 weeks after treatment height was recorded and dry weights determined.

In the experiments to evaluate amino acid leakage as a rapid screening technique, leaf discs 0.3 in (0.7 cm) in diameter were taken from the most recent fully expanded leaf and three were floated in vials of herbicide solution for 30 minutes. They were then rinsed in deionized, distilled (DDI) water, blotted dry and transferred to vials of DDI water. All vials were shaken in a water bath maintained at 77°F (25°C). Amino acid leakage was estimated spectrophotometrically as absorbance at 280 nm after 2 hours. Solutions containing discs were frozen in liquid nitrogen to rupture cells, thawed and shaken in a water bath at 77°C (25°C) for 2 hours. Percent of total amino acid leakage caused by herbicide treatment was calculated from A_280 readings of original and frozen samples. Calamagrostis, johnsongrass (Sorghum halepense), and centipedegrass (Eremochloa ophiuroides) were used in these studies representing tolerant and sensitive plants. In the first leakage experiment, greenhouse grown Calamagrostis and centipedegrass were used with Poast (sethoxydim) and Acclaim (fenoxaprop-ethyl) concentrations of 0 to 500 ppm. In the second experiment, Calamagrostis and johnsongrass with 0 to 250 ppm Acclaim (fenoxaprop-ethyl) and centipedegrass and johnsongrass with 0 to 100 ppm Poast (sethoxydim) were used.

Results and Discussion: Visual injury evaluations were made weekly for the field study with maximum injury occurring 28 days after treatment (DAT). Calamagrostis showed no injury symptoms following Acclaim (fenoxaprop-ethyl) treatment and did not differ from untreated plants in height or dryness.
weight. These data indicate that Calamagrostis was tolerant to Acclaim (fenoxaprop-ethyl) at 0.36 lb a.i./A (0.4 kg a.i./ha). Other species evaluated in the June field study were either visually injured or growth was reduced by the herbicide treatments. Further greenhouse studies indicated that Calamagrostis was tolerant to rates of up to 2.8 lb a.i./A (3.2 kg a.i./ha) Acclaim (fenoxaprop-ethyl). Based on dry weight measurements *M. sinensis* ‘Purpurascens’, *M. sinensis* ‘Variegatus’ and Sorghastrum recovered from earlier injury, as did Acclaim (fenoxaprop-ethyl) treated *P. alopecuroides* and *Spartina*. Poast (sethoxydim) and Fusilade 2000 (fluazifop-P) treated Calamagrostis also recovered. Festuca species appeared to be tolerant to all herbicides evaluated.

In the first leakage study, similar results were observed with Calamagrostis and centipedegrass in that Acclaim (fenoxaprop-ethyl) did not increase leakage until the concentration exceeded 100 ppm but all levels of Poast (sethoxydim) increased leakage. Poast (sethoxydim) appears to increase membrane leakage at lower concentrations than Acclaim (fenoxaprop-ethyl) for both grasses. In the second leakage study, substantial leakage occurred from johnsongrass at 50 ppm Poast (sethoxydim) but not from centipedegrass indicating that this concentration was effective for determining grass tolerance to Poast (sethoxydim). Acclaim (fenoxaprop-ethyl) increased johnsongrass leakage at concentrations of 100 ppm or higher but Calamagrostis leakage was elevated at 500 ppm. Amino acid leakage measurements therefore have potential for use as rapid screening techniques for detecting grass tolerance to these herbicides. They are quick and require only a small amount of plant material and many species could be screened to postemergence grass herbicides in a relatively short time.

**LITERATURE CITED**


CONSUMER ATTITUDES TOWARD AZALEA LACE BUG DAMAGE TO AZALEAS

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South Carolina

Nature of Work: The azalea lace bug, Stephanitis pyrioides (Tingidae: Hemiptera), is a common pest of azaleas, causing leaf injury and aesthetic damage. Feeding damage is characterized by white spots, or stippling, on the upper surface of the leaves, and black varnishlike spots of excrement disfigure the under surface of the leaves (1). Control of these pests is a concern in both the nursery and landscape. Recently, the concepts of Integrated Pest Management (IPM) have become as important for ornamental plants as to traditional agricultural crops because of pesticide resistance, government regulation of pesticides, environmental concerns, and the increasing cost of chemical controls. IPM is defined as the intelligent selection and use of pest control options in an economically, ecologically, and sociologically compatible manner (2). Control options for IPM programs for the nursery or the landscape must also consider aesthetics as an economic component. Aesthetics are subjective and are measured in terms of what most people regard as tolerable (3).

The objective of this study was to assess these subjective, aesthetic values by measuring consumer attitudes toward azalea lace bug damage to azaleas. ‘Buccaneer’ variety azaleas in 3-gallon containers were used in this study. Each had similar characteristics except damage rating due to damage by azalea lace bugs. Damage ratings were calculated for each plant by first assessing each leaf and placing it in a damage category as follows: 0% damage = 0, 1-25% damage = 1, 26-50% damage = 2, 51-75% damage = 3, 76-100% damage = 4. The percentage of leaves in each category was multiplied by the respective category number, summed, and divided by 100, resulting in the damage rating for each plant. Four plants, designated W, X, Y, and Z, were selected for use in a consumer opinion survey. Damage ratings were assessed.
as 0 for azalea W, 0.30 for X, 0.63 for Y, and 1.18 for Z. Azaleas with these low rating were chosen because previous work had indicated consumers attitudes toward azalea lace bug damage began to become increasingly negative when insect damage ratings were 1.00 or more (4). Customers of Head’s Garden Center in Walhalla, SC. were surveyed on May 30 and 31, and June 4, 6, and 7. Each customer was asked to answer a series of questions while observing one the four azaleas, and their attitudes toward this plant were measured. Fishbien’s multiattribute model was used to measure these consumers overall attitude toward the specimen. Fishbien’s model is expressed as:

\[ A_0 = \sum_{i=1}^{n} b_i e_i \]

where \( A_0 \) = overall attitude toward the azalea, \( b_i \) = strength of belief about the azalea characteristic (rating characteristics as excellent (I) - very poor (S)), \( e_i \) = evaluation of that characteristic (ranking characteristics 1-5, with 1 = most important, 5 = least important), and \( n \) = number of characteristics (plant shape and symmetry; leaf color, condition, and form). Overall attitude score (Ao) is obtained by multiplying the belief score (bi) by the evaluation score (e_i) for each characteristic and summing across all characteristics (5). Mean attitude scores were compared for each azalea. Respondents’ assessment of value of each azalea, likelihood to buy it at a reduced or regular price, and likelihood that it was in need of treatment for disease or insects was also compared for each plant.

Results and Discussion: Mean overall attitude score increased for the four azaleas as damage ratings increased (Table 1). However, there was no significant difference in mean overall attitude scores between the azaleas. It is possible that no significant differences were found because there were only slight differences in the damage ratings for these azaleas. Respondents were asked “How much would you pay for this azalea?” and were given a response scale ranging from $0 to $10 dollars. Responses averaged $3.84 to $4.42 a difference of only $0.58 between azaleas. Average values did not correlate with damage ratings.

To the question, “How likely is it that you would buy this azalea? (at regular price or a reduced price)?”, responses showed that lace bug damage did have an effect on the likelihood of whether or not the respondent would buy the azalea. Most respondents (76 to 68%) said they were likely or very likely to buy the azalea at a regular price (Figure 1). The percentage of respondents that were unlikely or very unlikely to buy the azalea at a regular price increased as damage increased. Most respondents said they were likely or very likely to buy the azalea at a reduced price. Only 6.5 said they were very unlikely to buy azalea X with a rating of 0.63 and 5.6% were for Z with a rating of 1.18 at a
reduced price.

Responses to the question, “How likely is it that this azalea is in need of treatment? (for insects or disease)”, indicated that for plants with a rating less than or equal to 0.63 (W, X, and Y), most respondents felt that it was not likely that it was in need of treatment for insects (Figure 2). For azalea Z, with a rating of 1.18, 26% of the respondents felt that it was likely or very likely in need of treatment for insects. Of all respondents, 32 to 42% were “not sure” whether any of the azaleas were in need of treatment for insects. Most of the respondents (58-53%) felt that it was unlikely or very unlikely that azalea W with a rating of 0 or X with a rating of 0.30 were in need of treatment for disease. Percentages of respondents who felt their azalea was likely to very likely in need of treatment for disease increased as damage rating increased. More than 25% of the respondents were “not sure” whether any of the azaleas were in need of treatment for disease.

In conclusion, azalea lace bug damage does have an effect on consumers’ overall attitude toward these plants, and it affects their decision to buy, the amount they would pay and their decision to treat azaleas. However, most respondents did not recognize this damage as insect damage, and many thought that the damage was from disease rather than insects, or were not sure about the damage.

Table 1. Attitude Scores, Damage Ratings, and Consumer values for azaleas.

<table>
<thead>
<tr>
<th>AZALEA</th>
<th>DAMAGE RATING</th>
<th>ATTITUDE SCORE</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>0</td>
<td>30.4</td>
<td>$4.00</td>
</tr>
<tr>
<td>X</td>
<td>0.30</td>
<td>31.8</td>
<td>$4.42</td>
</tr>
<tr>
<td>Y</td>
<td>0.63</td>
<td>31.1</td>
<td>$4.16</td>
</tr>
<tr>
<td>Z</td>
<td>1.18</td>
<td>36.0</td>
<td>$3.84</td>
</tr>
</tbody>
</table>
LITERATURE CITED


(Figure/Graph #1)
Protecting Patents and Improved Breeding of Roses Using Genetic Markers

Mark Hubbard, John Kelly, Sriyani Rajapakse, Albert Abbott and Robert Ballard
South Carolina

Nature of Work: There are currently a multitude of rose species and cultivars available, and rose breeders continue to introduce new cultivars each year. Breeders patent their cultivars as a means of protecting against illegal propagation, however, positive identification of a particular cultivar is difficult based solely on visual characteristics alone. Also, the new cultivars are increasingly phenotypically similar to existing cultivars, making positive identification of each distinct cultivar difficult. In order to effectively enforce the patent of a rose plant, a rose which has been propagated illegally must be positively determined to be the same as the patented plant. This positive identification can be accomplished by comparing the genetic makeup, or DNA, each plant. DNA can be isolated from plant tissue and examined using techniques of molecular biology (Soller and Beckmann, 1983). Enzyme cutting of DNA results in a specific, repeatable set of DNA fragments which can then be examined. Differences in the primary structure of DNA of different cultivars results in the creation or alteration of enzyme cutting sites, and thus change DNA fragment lengths. These differences in fragment
length, restriction fragment length polymorphisms (RFLPs), can be detected by Southern hybridization (Southern, 1975). This technique provides positive identification by providing a “fingerprint” of each cultivar. The fingerprint patterns of two roses can be compared to determine if the plants are the same.

RFLPs can also be used to develop a genetic linkage map of the rose. RFLPs conform to Mendelian inheritance and can be studied through backcrosses to determine their linkage. Linkages between RFLPs and quantitative traits can then be investigated and the location of desirable traits determined. This will allow breeders to determine the presence of a given trait as soon as DNA can be obtained instead of waiting months or years for the plant to express that trait (Soller and Beckmann, 1983).

The purpose of this study is to create a DNA library of the rose genome, study the genome for RFLPs to develop DNA fingerprints of rose cultivars, and to construct a genetic linkage map for rose breeding.

DNA was extracted from leaves of the rose cultivar ‘Confection’ using a standard extraction procedure (Bemard and Tanksley, 1986). The DNA was cut into fragments with the restriction endonuclease HindIII, the DNA fragments joined with bacterial plasmids, and the plasmids transferred into bacterial cells. The rose DNA fragments were maintained in the plasmids of bacterial cells and the cells stored in the freezer. This library of rose DNA fragments is the source of DNA probes used in developing fingerprints.

To develop cultivar fingerprints, DNA is extracted from the leaves of a number of cultivars and the DNA separated by 0.8% agarose gel electrophoresis, and then transferred to a nylon membrane (Southern 1975). A radioactively-labeled probe is then added to the nylon membrane and allowed to bind to the DNA for 16 hours. The membrane is then rinsed of excess radioactive probe and exposed to X-ray film to visualize the DNA hybridization, or binding, pattern of each cultivar. The hybridization pattern can then be used for cultivar fingerprinting and/or genetic map construction.

Results and Discussion: Approximately 1000 rose DNA fragments are present in DNA library and additional fragments are added as our research progresses. The majority of radioactive probes used have yielded RFLPs. However, only one probe thus far examined has been able to distinguish all cultivars. The more distantly related cultivars and species are more readily distinguishable by most probes. Closer related cultivars, in particular one cultivar and one of its sports, have not been distinguished by most probes. In developing DNA fingerprints, it is essential that genetically similar cultivars be distinguishable. Soller and Beckman (1983) have suggested that 15-20 fingerprint probes are sufficient to differentiate cultivars. Probes are continually being studied for
developing fingerprints, and rose cultivars are being obtained for fingerprinting. Also, RFLPs are being studied to determine their usefulness in genetic linkage map construction, and the initial results are promising.

The rose genome has shown a great deal of variability from study using RFLPs as genetic markers. As the techniques improve, and the time consuming process of screening probes continues, RFLPs will undoubtedly be revealed which can fingerprint every cultivar, and establish a genetic linkage map of the rose.

LITERATURE CITED


Morning and Afternoon Transpiration of Plant Growth Regulator-Treated Photinia x fraseri

Allen D. Owings and Steven E. Newman
Mississippi

Nature of Work: Plant growth regulators (PGRs) have been used for many years in floricultural crop production. When used according to recommendations, PGRs can enhance the growth habit of treated plants to create a more visually appealing product. Some of the newer, highly active PGRs could potentially be used by woody ornamental growers to achieve desirable characteristics previously seen only in floricultural crops. While research has shown the result of PGR applications on vegetative and reproductive growth of some nursery crops (2, 3, 4), the influence of PGRs on transpiration has not been extensively studied. Conflicting results exist in literature as to how PGRs influence plant water relations (1, 5). With an increasing concern about irrigation requirements and subsequent water runoff, it would be desirable to continue studying how transpiration is influenced by PGR applications. Therefore, the objective of this research was to determine the morning (1000
CDT) and afternoon (1400 CDT) transpiration rates of *Photinia x fraseri* at 6 and 12 weeks after PGR application.

*Photinia x fraseri* liners were planted (2/pot) in 3-gallon nursery containers on March 28, 1989. The media consisted of pine bark with incorporated amendments of Micromax at 1.5 lbs./yd^3^ and granular dolomite at 4 lbs./yd^3^.

Osmocote 18-6-12 (18N-2.6P-IOK) was topdressed at 3.8 oz./pot immediately after planting. Plants were grown on a concrete slab in full sun and were hand watered daily, when necessary, to 10% leaching.

On May 16, 1989 the following PGR treatments were foliar applied: Bonzi (paclobutrazol) at 60, 100, 140, and 180 ppm, Sumagic (uniconazole) at 30, 60, 90, and 120 ppm, Atrinal (dikegulac-sodium) at 150C, 3000, 4500, and 6000 ppm, A-Rest (ancymidol) at 33, 66, 99, and 132 ppm, Promalin (6-BA + GA_47 ) at 250, 500, 750, and 1000 ppm, and Pro-Shear (6-BA) at 250, 500, 750, and 1000 ppm. A hand pruned treatment and a control were also included. Foliar spray treatments were applied between 1100 CDT and 1300 CDT with a CO_2_ pressure sprayer (30 psi) at the rate of 2 qts./100 ft^2_. Air temperature before and after application was 72.4°F and 78.5°F, respectively. Each treatment in the completely randomized design was replicated three times.

Stomatal transpiration measurements were randomly taken with a LI-1600 steady state porometer (Li-Cor, Inc., Lincoln, NE) on each treatment replication on June 27, 1989, which was 6 weeks after treatment (WAT), and August 9, 1989, 12 WAT. Plants were watered to 10% leaching at 1800 CDT on the day before transpiration was taken. Transpiration was taken on the abaxial side of recently matured upper leaves beginning at 1000 CDT and 1400 CDT.

**Results and Discussion:** At 6 WAT, transpiration rates of *Photinia x fraseri* were higher at 1400 CDT than at 1000 CDT for some PGR treatments, however the hand pruned treatment and control were not affected by time of day (Table 1). Differences were also noticed in regard to transpiration due to PGR application rates. Some photinia, especially those treated with A-Rest, Pro-Shear, or Atrinal, had higher transpiration values as application rates increased, but plants treated with Pro-Shear had lower transpiration rates as application rates increased.

Afternoon (1400 CDT) transpiration measurements at 12 WAT found that hand pruned photiniias had higher transpiration rates than some of the PGR-treated photinia. At 1000 CDT, photinia transpiration increased with increases in application rates of Pro-Shear. By 1400 CDT this response was not found, however photinia treated with Bonzi, Sumagic, or Promalin showed increased transpiration as application rates increased. Pruned and control plants had similar transpiration rates regardless of WAT or time of day.
Transpiration data presented herein indicate that for an initial period after application of some PGRs, *Photinia x fraseri* lose water at a higher rate per unit of leaf area than hand pruned plants, especially during early afternoon. After several months, these PGR-treated plants began losing water at rates similar to control plants and usually lower than hand pruned plants. Causes for this change could include differences in overall leaf area between control, pruned, and PGR-treated plants or modifications to leaf morphology and/or physiological processes due to the PGR applications.

**Acknowledgments**

The authors express appreciation to Foliage Farms of Mississippi, formerly of Columbus, for donation of plant material and to the following companies for donation of plant growth regulators: Valent USA Corporation, Abbott Laboratories, and Sandoz Crop Protection.

**Literature Cited**


HOW COMPOSTING PERIOD AND MINERAL AMENDMENTS AFFECT PHYSICAL PROPERTIES OF A HARDWOOD:PINE BARK BLEND

John Watkins and W.T. Witte
Tennessee

Nature of Work: In recent years, the need for less expensive media components for container grown plants has become increasingly important. Milled pine and hardwood barks have become widely accepted in the nursery industry (1,2,4,6). Superior growth of a wide variety of plants has been obtained in a blend of composted hardwood:pine bark (50:50 by volume) which took approximately 13 weeks of composting to stabilize to a temperature of 40°C (104°F) (8). Partially favorable results with noncomposted blends indicated that a semi-stabilized bark compost may yield a suitable container medium. A faster composting period would have greater appeal to nurserymen as it would reduce the time required to prepare the media as well as reducing shrinkage.

Chemical analysis of media in previous experiments showed high levels of potassium (7). One factor of this experiment was elimination of potassium nitrate. Magnesium levels were lower than desired, so additional magnesium sulfate was included. The pH of the finished 50:50 blend of compost was 5.6. A higher pH would be more favorable to plant growth, therefore sulfur was eliminated. This experiment was also designed to contrast two composting periods to determine whether a semi-stabilized bark compost would have suitable physical properties for a container medium. Sixteen treatment combinations in a factorial arrangement for the initial composting ‘recipe’ were outlined.

Two yd³ (1.55 m³) each of pine and hardwood bark were measured and placed in each of eight bins arranged in a windrow fashion. The material was mixed thoroughly with various starter amendments (Table 1). The material was then wetted to a moisture content of 70%. Piles were turned on a weekly basis. Targeted endpoints for the composting procedures were 50°C (122°F) and 40°C (104°F). Endpoints were achieved when a pile which had previously been hotter than the target endpoint was turned and then failed to exceed the target temperature after 3 or 4 days. Sufficient media for measurement of physical properties was removed at each endpoint. Particle size distribution (PSD) was determined by screening a 250 ml (8.5 oz.) oven-dry sample through U.S. Standard Sieves. Bulk density, percentage water holding capacity (WHC), percentage air capacity (AC), and percentage total pore space (TPS) were determined by a volume loss method adapted from Gessart (5) and Whitcomb (9). Plastic bags were placed in 2.5 liter (0.66 gal) containers. Containers were then filled and packed with 2.25 l (0.6 gal) of each medium.
BD was calculated by dividing weight of the medium by its volume. A known volume of water containing 0.02% Triton AG98 surfactant was poured into each container. When the media appeared fully saturated the bags were sealed and media allowed to soak for 24 hrs. An additional volume of water was then added to again bring the media to saturation. The total volume of water added was divided by 1% of the initial volume of the medium to obtain TPS as a percent by volume. Drain holes were cleared and the medium allowed to drain for two hours. The volume of water collected was divided by 1% of the initial volume of the medium to obtain percent AC as a percent by volume. Percent WHC was then calculated by subtracting percent AC from percent TPS.

Results and Discussion: The 50°C (122°F) endpoint was reached in 6 weeks. An additional 3 weeks were required to reach the 40°C (104°F) endpoint. Media composted to 50°C (122°F) and 40°C (104°F) lost an average of 17% and 35% of volume, respectively, due to shrinkage. Initial reports on PSD show no significant differences due to endpoint temperature or mineral amendments. Endpoint temperatures had significant effects on all physical parameters of the media (Table 2). The 50°C (122°F) endpoint had a higher BD and %AC while the 40°C (104°F) endpoint had a higher %TPS and %WHC. The elimination of potassium nitrate and the addition of magnesium sulfate had no significant effect on physical parameters of the media. However, the elimination of sulfur resulted in a higher %WHC.

Our data show that the physical parameters of a 50: 50 hardwood:pine bark blend of media are significantly influenced by the length of composting. The elimination of sulfur results in a higher %WHC while other mineral amendments tested show no effect. Although differences between composting lengths are observed, physical parameters of the media still fall within acceptable levels for suitable plant growth (3). Therefore, a shorter composting period to a 50°C (122°F) endpoint and elimination of sulfur, potassium nitrate, and magnesium sulfate added at the beginning of composting will yield a suitable container growing medium. Nurseryman will thus be able to reduce the amount of time required to prepare the media as well as eliminating additional costs of adding mineral amendments prior to composting.

Literature Cited


(Table #1)

(Table #2)
ROOTING PERFORMANCE OF ‘NELLIE R. STEVENS’ HOLLY CUTTINGS FROM HERBICIDE-TREATED STOCK PLANTS

C. J. Catanzaro and W. A. Skroch
North Carolina

Nature of Work: Nurserymen express concern about the potential of preemergence herbicides to decrease rooting of cuttings taken from stock plants exposed to repeated herbicide applications (1,2,3). This long-term study is being conducted to determine whether the weed management program employed affects rooting of cuttings taken from field-grown stock plants.

Field bed preparation of a Cecil clay soil at North Carolina State University Research Unit 4, Raleigh, NC, included incorporation of 7.5 cm (3 in) of pine bark and adjustment of pH and fertility to within recommended ranges for field-grown woody ornamentals (4). Liners of ‘Nellie R. Stevens’ holly (Ilex X ‘Nellie R. Stevens’) in 1 gal. containers were planted in autumn 1987. The experimental design was a randomized complete block design with 6 blocks.

The preemergence herbicide treatments included Devrinol SG, Pennant 5G, Ronstar 2G, Surflan 4SC, and Treflan IOG, each at 4.5 kg ai/ha (4 lb ai/A), and OH2 (oxyfluorfen+ pendimethalin) 2+lG, Rout (oxyfluorfen+oryzalin) 2+lG, Southern Weedgrass Control 2.45G, and XL (benefin+oryzalin) 1+lG, each at 3.4 kg ai/ha (3 lb ai/A). Gramoxone 1.5SC at 0.6 kg ai/ha (0.5 lb ai/A) + 0.25% nonionic surfactant was included as a chemical check treatment, and a cultivated check was also included. Granular herbicides were applied on a weight/plot basis and dispersed using a hand-held whirlbird spreader. Liquid treatments were applied using a CO2 backpack with 8003 XR flat fan nozzles delivering 411 L/ha (44 gpa). Treatments were applied during March and Aug., 1988, and May and Aug., 1989.

Six 4-inch terminal cuttings were taken in January 1989 and Feb. 1990 from each of the 66 plants (11 treatments x 6 blocks). Immediately prior to sticking cuttings, leaves were stripped from the basal 3.8 cm (1.5 in) and two heavy wounds made on the basal 2.5 cm (1.0 in) of each cutting, with the wounded portion dipped for 5 sec in a 5,000 ppm solution of IBA (acid formulation) in 50% ethanol. Cuttings were placed in a randomized complete block design under intermittent mist in a greenhouse propagation bed filled with medium (4 perlite:1 peat, v/v). Root number and rootball visual rating were recorded on a per cutting basis 7.5 weeks after cuttings were stuck. By this time the rootballs of the most extensively rooted cuttings had reached a commercially acceptable size. A visual rootball rating was also performed using a scale of 1 to 6 with 1=no rooting and 6=greatest root number and length. Rooting percentages were calculated. Data means were subjected to the analysis of variance procedure and the Student-Newman-Keuls multiple range test at
Results and Discussion: A combined analysis of 1989 and 1990 data revealed no significant differences among the eleven treatments for the rooting variables examined. After four herbicide applications at maximum use rates it is reasonable to conclude that the preemergence herbicides tested do not adversely affect rooting of cuttings from ‘Nellie R. Stevens’ holly stock plants.

LITERATURE CITED


The Effect of Media Sterilization on Weed Populations in Container-Grown Nursery Stock

Gene B. Cross and Walter A. Skroch
North Carolina

Nature of work: The production of nursery Stock in North Carolina for both local and interstate shipments is an expanding industry. North Carolina farmers searching for alternatives to traditional row crops have turned to greenhouse or nursery areas as acceptable economic substitutes. Nationally, the state currently ranks 8th in cash receipts for greenhouse and nursery crops with 1988 receipts of $215 million. The container industry in North Carolina continues to increase and currently accounts for over 1900 certified production acres.

In the production scheme, weeds have been coupled with the steady growth of the nursery industry. Container weeding represents a labor-intensive task in the nursery and results in direct added costs. In one study, Elmore (2)
indicated that the weeding costs without herbicides in a single container nursery for six months was $2,418 per acre. A combination of two herbicide applications, along with hand weeding, results in the reduction of weeding costs to $468 per acre. In order to develop a more integrated approach to weed control, it is imperative that weed scientists explore the ecological relationships among crops, weeds, and production practices (1). Ecological studies may provide basic information related to the numbers of weed seed in the seed bank and the potential for using seed levels in the soil to predict future problems with weeds. Wilson (4) observed that with a knowledge of the seed bank and environmental considerations, individuals should be able to predict seedling density.

Research in the area of weed seed introduction in nurseries is sparse. Williams and Sanders (3) conducted research designed to quantify the relative importance of weed seed introducton in nurseries. Parameters examined in this study were splashing, lateral dispersal, wind dispersal, and dispersal by irrigation water in container grown nursery stock. Research exploring the introduction of weed seed through media components is deficient.

The objectives of this research were to determine if weed infestations in nursery containers are introduced through bark or sand media components, and to study the occurrence of specific weeds in container stock.

Weed seedling development was assessed in container expenments conducted at seven commercial nursery sites during the period of October 1988 through September 1989. Bark and sand components from each of the nurseries were collected and sterilized using live steam in a Lindig cart for 30-45 minutes at 82-88°C. Four bark and sand (3:1, v/v) nursery mixes were prepared as follows; sterile bark and nonsterile sand, bark and sterile sand, sterile bark and sterile sand, and bark and sand. Individual nursery media mixes were placed in color coded pots for ease of identification. The unplanted treatment pots were alternately placed in expenmental container areas at each of seven nursery locations consisting of one gallon juniper or azalea plants and were allowed to remain in piace for a full year. Four treatments consisting of 40 pots of each mix were placed in a completely randomized design using location as replications. The expenmental areas receiving standard nursery practices with the exception of herbicide applications. All containers in the plots were hand-weeded on approximately 30 day intervals. The number and identification of germinating seedlings per pot were recorded at this time. Any unidentifled weed seedlings were allowed to mature and were identified during subsequent visits.

Results and discussion: A summary of the data indicated that 14 families of weeds were observed during the study, representing a total of 24 weed genera. Hairy bittercrest, prostrate spurge, yellow woodsorrell, and groundsel were
the most frequently observed weed species. Their frequencies of occurrence across all treatments were 22, 22, 38, and 27 respectively.

After one year, no differences were detected between the numbers of weed seedlings in the four nursery media treatments. Results indicated that weed seed introductions through media components represented only a minor part of the overall seed influx. These results reinforced the work of Aldrich (1) who concluded that the majority of weed introductions at sites was related to the immediate environment.

Data from this study suggests that sterilization of media components as a technique to eliminate weed seed introductions would not be a recommended action. Prudent judgement should be used in the selection of bark and sand sources and any acquisition of media components from weedy storage sites should be avoided. The presence of a few major weeds noted in the study confirms the importance of the immediate environment in the continuation of weed problems.

**Literature Cited**


Section 2
CONTAINER-GROWN PLANT PRODUCTION

Dr. Bonnie Appleton
Section Chairman and Moderator
EFFECTS OF METHOD OF APPLICATION AND RATE OF THREE SLOW RELEASE FERTILIZERS

Alabama

Nature of work: Slow-release fertilizers are an integral part of the fertilization programs of many container-grown nurseries. Plant growth and nutrient release characteristics vary depending on the method of fertilizer application, slow-release fertilizer product used, fertilizer rate and plant species (1, 2, 4). The objective of this study was to compare methods of application of slow-release fertilizer products at 3 rates on the growth of 2 woody plant species.

Uniform liners of Juniperus conferta 'Blue Pacific' (juniper) and Rhododendron x 'Coral Bells' (azalea) were potted May 16, 1989, in a 3:1 pine bark:peat moss medium in trade gallon containers. The medium was amended with 6 lb. of dolomitic limestone, 2 lb of gypsum, and 1.5 lb of Micro-max/yd³. Fertilizer treatments were Osmocote 18-6-12, Nutricote 16-10-10 (Type 270) and High-N 24-4-8 (all 8-9 month formulations) applied either preplant incorporated, dibbled or topdressed at 1.5, 2.0 and 2.5 lb N/yd³. There were 5 replications of 2 plants each arranged in a randomized complete block design.

Medium leachates were collected 30, 60, 90, 120, 150 and 180 days after fertilizer placement using the pour through technique to determine medium solution electrical conductivity (EC) (3). In November, juniper and azalea shoot dry weights and relative root densities were determined. Root densities were rated on a scale of 1 to 5, where 1 = no visible roots on the rootball medium surface, 3 = 50% of the rootball medium surface covered with roots, and 5 = entire rootball surface covered with roots.

Results and Discussion: Shoot dry weights and root ratings were greatly reduced as N rate increased for 'Blue Pacific' junipers receiving dibble-applied fertilizer regardless of the fertilizer product being used. Dibble placement of fertilizer at the rate of 1.5 lb. N/yd³ produced plants that had 57 and 38% more shoot dry weight than those receiving 2.0 and 2.5 lb N/yd³, respectively. In contrast, when fertilizer was incorporated into the medium or topdressed shoot dry weights and root ratings generally increased as N rate increased for 'Blue Pacific' juniper. Shoot dry weights and root ratings were not influence fertilizer product used.

'Coral Bells' azaleas that were topdressed and dibbled had 31% and 27% greater shoot dry weights than those receiving medium incorporation of fertilizer, respectively. Both Osmocote18-6-12 and Nutricote 16-10-10 resulted in greater 'Coral Bells' azaleas shoot dry weights than plants receiving
the High-N 24-4-8 fertilizer. Shoot dry weight for 'Coral Bells' azaleas generally increased as N rate increased for all fertilizer products and methods of application.

Root ratings were 3.9 and 3.8 for dibbled and medium-incorporated fertilizer placement 'Coral Bells' azaleas, respectively. In comparison, plants receiving topdressed fertilizer placement had a mean root rating of only 3.5. Root ratings increased for 'Coral Bells' azaleas as fertilizer rate increased, while fertilizer product had no effect.

Osmocote 18-6-12 consistently had the highest EC levels from day 60 through day 120 following fertilizer application, with a mean EC of 0.21 dS/m over the 3 sampling dates. In comparison, Nutricote 16-10-10 and High-N 24-4-8 had mean ECs for the 3 observation dates of 0.13 and 0.16 dS/m, respectively. As fertilizer rate increased, EC increased on observation days 30 through 120. During the first 90 days after fertilizer placement, medium-incorporated treatments had higher EC levels when compared to dibbled and topdressed fertilizer placement. Regardless of fertilizer product, method of application or rate, EC levels began to decline 120 days after application. Mean EC across the 27 treatments was 0.08 dS/m by day 150 following fertilizer application.

In summary, the fertilizer products used in this study had little influence on the growth of 'Blue Pacific' juniper. Shoot dry weights and root density ratings for 'Blue Pacific' juniper were greatest when fertilizer was medium incorporated at 2.5 lb N/yd$^3$. Dibble fertilizer placement at rates greater than 1.5 lb N/yd$^3$ may injure the roots, reducing growth of 'Blue Pacific' juniper. The greatest shoot dibble application of Osmocote 18-6-12 and Nutricote 16-10-10 at the rate of 2.5 lb N/yd$^3$.

**Literature Cited**


Irrigation Monitoring At Container Nurseries

Donna C. Fare, Charles H. Gilliam, and Gary J. Keever
Alabama

Nature of Work: Water quality in container nurseries has become a great concern to nurserymen in the Southeastern United States. Developing better water management practices, including controlled output and distribution, may be the first strategy in improving water quality. Irrigation output and distribution are dependent upon many variables: design of the system (pipe sizing, head spacing, and operating pressure), nozzle size and type, plant size and spacing, and wind. A well designed and managed system can eliminate or reduce many of these variables. Little information is known about existing systems in nursery productions. The first step in improving water management practices is to understand current irrigation practices and conditions of the nursery industry. A survey was initiated to determine irrigation practices at container nurseries.

Seven commercial nurseries in Alabama were monitored to determine the amount and distribution of irrigation applied. Nurseries 1 through 5 are located in central and south Alabama and have similar production practices, while nurseries 6 and 7 are located in north Alabama. Rain gauges were placed in nursery containers at random locations within a block of nursery stock in each nursery to collect irrigation over a 60-minute period. The same blocks of plants were monitored for irrigation output monthly from March until November.

Total volume of water applied during an irrigation cycle was not determined. Results and Discussion: The amount of irrigation applied varied with nursery and time of the year. Only 2 of the 7 nurseries (nurseries 4 and 5) had consistent irrigation output from March through November (Table 1). An average of the irrigation collected over the 9-month period shows the amount applied at nursery 4 was less than one-half inch (0.8 cm), while nursery 5 applied about three-fourths of an inch (1.7 cm). Nursery 2 was similar to nursery 4 in irrigation output, averaging less than a half-inch per irrigation per hour.

Nurseries 1 and 3 had major differences in irrigation applied compared to nurseries 4 and 5. Nursery 1 applied an average of 1.4 in (0.6 cm) in March and 0.6 in (1.5 cm) in November. Nursery 3 irrigation output varied from 0.9 in (2.2 cm) in March to 0.4 in (0.9 cm) in August and September.

Plants in nursery 6 and 7 are grown in plastic-covered overwintering greenhouses during the colder months. Plastic is removed from these greenhouses when the danger of frost is over and plants that were pot to pot during the winter are spaced in the greenhouses and adjoining beds in the spring.
Irrigation nozzles that were used in the greenhouses were large enough to accommodate the irrigation demand in the expanded area.

Both nurseries had extreme differences in the amount of water applied each sampling date, as shown in Table 1. Nursery 6 ranged from 1.6 in (4.2 cm) in March in the greenhouse to 0.4 in (0.9 cm) in September in the expanded growing area. Nursery 7 applied 1.9 in (4.9 cm) in March in the covered area but as low as 0.6 in (1.5 cm, October) in the expanded growing area.

Wide variations in irrigation output occurred within a given nursery block. For example, in July and September nursery 5 had irrigation outputs ranging from 0.4 to 1.3 in and 0.3 to 2.5 in (0.9 to 3.3 cm and 0.8 to 6.4 cm), respectively, within the same block of plants. Average values presented in Table 1 of the irrigation collected in the gauges does not reflect this variance. During the same 2 months, nursery 4 had irrigation output ranging from 0.1 to 0.4 in (0.2 to 1.0 cm) during July and 0.2 to 0.4 in (0.4 to 1.1 cm) in September in the same block of containers.

These irrigation data reflect the management strategies of current production practices. Currently, irrigation uniformity in container nurseries ranges from good (nurseries 4 and 5) to poor (nurseries 6 and 7). With increasing concerns about the environment and water utilization in container nursery production, proper design and uniform application of irrigation are critical. ‘Best management’ strategies in the future may dictate irrigation designs with more uniform output and distribution within the container blocks.

(Table #1)
Growth Response of Formosa Azalea, Korean and Common Boxwoods to Container Medium and Capillary Irrigation Bed Surface

Thomas J. Banko and Marcia Stefani
Virginia

Nature of Work: Capillary irrigation is a method of supplying water to container-grown plants through the bottom of the pots from a moist supporting surface. At the last SNA Research Conference we described the construction of a capillary system in use at the Hampton Roads Agricultural Expt. Station (2). The same system was employed in this study. Other studies of capillary irrigation have suggested a need for the addition of sphagnum peat to the container medium to increase water absorption. Recommendations for the amount of peat to use have varied (1,3,4). Therefore, one of our objectives in this study was to determine how increasing proportions of peat in a pine bark medium affect plant growth on a capillary irrigation system. In our previous report (2) we evaluated 3 different landscape fabrics or films for effectiveness in controlling weeds on the irrigation surface, and for controlling root growth from the bottoms of the pots. As a current second objective, the most effective of these materials, Visqueen 4-mil ground cover film (Ethyl Corp.), was further evaluated for possible effects on plant growth and capillary uptake.

In mid-April, rooted liners of Rhododendron indicum ‘Formosa’ (Formosa azalea), Buxus sempervirens (common boxwood), and B. microphylla koreana (Korean boxwood) were planted in 3 qt containers with 5 media treatments consisting of pine bark:peat:sand percentages (by vol) of 90:0:10, 80:10:10, 70:20:10, 60:30:10, and 50:40:10. Dolomitic limestone was incorporated into the boxwood media at 4 lbs/yd³. The plants were grown in a greenhouse for the first 6 weeks and fertilized with soluble Peter’s 20-20-20 (400 ppm) 3 times during this period. The plants were also fertilized with Osmocote Plus tablets (16-8-12 plus trace elements), one tablet (approx. 7 g) per container.

The plants were moved onto the capillary beds on 30 May. Water was supplied through drip lines (Drip-In Corp.), m e water pressure was 10 psi, which provided 140 gal/day to 600 ft² of bed surface. The bed surfaces were either plain sand, sand surface treated with Surflan A.S. (3 lbs ai/A), or sand covered with the porous Visqueen ground cover. There were 3 containers of each of the 5 media treatments for each plant species on each of the 3 bed surface treatments, for a 3 x 5 split plot design replicated 4 times.
On 19 Oct. plant height and width were measured. The plant tops were dried and weighed. The data for the 3 plant species were analyzed separately. Plant size corresponded closely with the dry weights; therefore, only dry weight results are presented in this report.

Plants in containers with the same media treatments described previously were replicated 4 times on an adjacent gravel pad with overhead irrigation to provide some comparison with the capillary system. The overhead sprinklers provided 233 gal/day for an area comparable to that of the capillary beds. Data for this area were collected and presented as for the capillary system; however, because the overhead irrigation bed itself was not replicated and randomized with the 3 capillary bed treatments, statistical comparisons for the overhead system were not made.

**Results and Discussion:** On the sand and Surflan-treated-sand surfaces, growth increased as the proportion of peat increased up to 40% (Fig. 1). Growth of azaleas on the Visqueen increased less than on the sand surfaces as peat content increased. At a peat content of 40%, the azaleas from the Visqueen surface had a significantly lower dry weight than those from the sand surfaces, suggesting that the Visqueen was interfering with capillary flow even with high levels of peat in the container medium.

The growth of Korean boxwood increased on all capillary surfaces as peat increased to 40% (Fig. 2). Although growth on the Visqueen was not significantly less than on the other two surfaces at each peat level, it consistently had the lowest value numerically, suggesting inhibition of capillary water flow.

Common boxwood growth also reached a maximum on the capillary system at a peat content of 40%, with the plant weights for the sand and the Surflan-treated- sand surfaces being almost identical (Fig. 3). The growth of common boxwood was significantly greater on the sand surface than on the Visqueen at media peat contents of 30 and 40%. Growth also exceeded that obtained with the overhead irrigation when peat content of the medium was 30 or 40%.

Capillary irrigation is an alternative to overhead sprinklers for irrigation of container-grown woody plants; however, in the pine bark:peat:sand medium that we used, 30 to 40% peat was usually needed to obtain growth comparable to that obtained with the overhead irrigation system. The added expense of the additional peat may be justified by the fact that 40% less water was used. Although the Visqueen was effective in controlling weeds and root growth into the sand beds, it had an inhibitory effect on plant growth.


(Figure #1)
Fig. 1-3 Dry weight of Formosa azalea, Korean and Common Boxwood as affected by percentage of peat in the container medium, capillary bed surface and irrigation method. Within each level of peat, means with the same letter are not significantly different (p=0.05, DMRT). Statistical comparisons with the overhead irrigation system were not made (see text).
Fertilization of Trees Grown in Low Profile Containers

Dan Milbocker
Virginia

Nature of Work: Conventional containers are approximately as tall as they are wide. Past research has established that plants grow best in media depths between 8 and 12 inches (1,3). Most containers with volumes greater than 5 gallons are taller than 12 inches. Containers that maintain their 8 to 12 inch heights but have greater volumes because of their greater width are termed low profile containers. They are easily made by placing an 8 to 12 inch tall wood or plastic ring on 6 mil plastic sheeting. Trees grown in these containers are characterized as having fibrous instead of circling roots and are easy to transplant (2).

Fertilization rates for large containers are based upon small container rates and increased in proportion to the increase in container size. High rates of fertilization for conventional containers determined by this method have proven to be too high for some plants but similar testing of rates has not been done for low profile containers. Increased upper surface area of low profile containers as compared to conventional containers requires different irrigation frequencies, has different evaporation rates, heat absorption, nutrient release rates, leaching of nutrients, capillary action and water retention. All of these factors have an effect on the availability of nutrients for the plant. The purpose of this research was to determine how the rate of fertilization affects trees grown in low profile containers.

River birch, Betula nigra; redbud, Cercis canadensis and apricot, Prunus armeniaca year old field grown seedlings were grown in 25 gallon low profile containers. The birch and redbud were grown two years and the apricots, one year. Apricots were fertilized at rates of 0, 2, 4, 6, 8 and 10 grams of 18-6-12 Osmocote per gallon of growing medium. Birch and redbud were fertilized at rates of 10, 15, 20, 25 and 30 grams 18-6-12 Osmocote per gallon of growing medium per year. Three birch seedlings were planted per container, the others were single. Birch and redbud trunk diameters were measured and apricot tops were weighed as measures of growth and fertilizer performance.

Results and discussion: By the end of the second year, birch and redbud trees were seven to ten feet tall and healthy. Fibrous roots completely filled the containers, birch with three trees more completely filled the container than redbud. Redbud is a dryland tree and does not respond well to forced growth. Limb growth was very long causing some breakage and excess moisture caused root damage on some trees. The amount of growth in terms of trunk cross-sectional area was highest for birch because it was totaled for three trees. The only treatment variation was a reduction when fertilized with 10 grams per gallon of medium. Redbud trees did not show a similar reduction,
possibly because available nutrients were satisfactory for individual trees. These results show that high rates of fertilization (above 10 9 per gal) produced no additional tree growth and when trees were grown individually, 15 grams of fertilizer per gallon produced optimum growth (Fig. 1).

When apricot trees were grown at lower rates (0 to 10 grams per gallon) growth increased rapidly over the entire range with 10 grams per gallon producing the heaviest plants (Fig. 2).

Results, on three tree species, show that 10 to 15 grams of 18-6-12 Osmocote per gallon of medium produced the most growth in low profile containers. Neither positive nor negative growth responses indicate that nutrient concentrations were near the optimum for growth and easy leaching of shallow media prevented excessive concentrations from building up.

**Literature Cited**


(Figure #1)
MICRONUTRIENT SUPPLY FROM SULFATE SOURCES IN A PINE BARK MEDIUM

Alex X. Niemiera
Virginia

Nature of Work: There are reports which show plant growth responses (8, 9,10) and no growth responses (3, 6) when micronutrients are added to container media. Reasons for these apparently contradictory claims are most likely related to difference in species, media, interactions with other fertilizers such as P and lime, and other production practices. Milled pine bark, the predominate medium used in southeastern U.S. nurseries, contains significant amounts of micronutrients. Ogden et al. (7) report the total micronutrient analysis of pine bark to be: B 9 ppm, Cu 77 ppm, Fe 790 ppm, Mn 119 ppm, Zn 119 ppm. However, there are no standards for testing container media for micronutrient levels due to the many extractants used. Using water as an extractant, solution concentrations in a pine bark medium average: B 0.47 ppm, Cu 0.21 ppm, Fe 0.85 ppm, Mn 0.74 ppm, Zn 0.24 ppm (7). Broschat and Donselman (2), testing several micronutrient fertilizers, showed relatively constant micronutrient supplies in irrigated containers. However, they used ammonium acetate as an extractant which has been shown to be a poor indicator of micronutrient status in media (4). In contrast, use of DTPA (diethylenetriaminepentaacetic acid) has been shown to be a relatively reliable indicator of media micronutrient status (4). Furthermore, use of DPTA has resulted in relatively good correlations ($r^2 = 0.80-0.86$) between plant growth and medium micronutrient concentrations and pH (4). The
purpose of this research was to determine the micronutrient supply (using DTPA) from two commercial sulfate micronutrient fertilizers, Micromax and Ironite, as influenced by irrigation. Micromax is commonly used in the container nursery trade and Ironite, recycled mine spoils, is primarily used in the western U.S. to supply micronutrients to mineral soils. Analysis of these sources are shown in Table 1.

Pine bark (*Pinus taeda*), amended with 6.6 lb/yd³ (kg/m³) dolomitic lime, was treated with 2.2 lb/yd³ (kg/m³) Micromax (Grace-Sierra, Milpitas, CA), 2.2 lb/yd³ (kg/m³) or 4.4 lb/yd³ (2 kg/m³) Ironite (Ironite Products Co., Scottsdale, AZ). Bark (50 g), including an untreated treatment (control) was put into 1.5" x 6" PVC tubes with one end of tube covered in cheesecloth to allow for drainage. Tubes were then drip irrigated (distilled water) with 0.06 gal (0.24 l), 0.12 gal (0.48 l), 0.18 gal (0.72 l), or 0.24 gal (0.96 l) which was intended to simulate 30, 60, 90, and 120 applications of 0.25 " (0.63 cm) of water, respectively. There were five tubes per treatment per irrigation. Following irrigation, a modified saturated media extract was performed (1) by adding 40 ml of 0.001 M DTPA (4) to the wet bark. After 45 min the bark solution was vacuum removed and tested for Cu, Fe, Mn, and Zn using an atomic absorption spectrophotometer.

Results and Discussion: Irrigation had no or very little effect on micronutrient concentrations from saturated medium extracts (data not shown). Broschat and Donselman (2) and Handreck (4) showed a similar trend for several micronutrient fertilizers in a soilless media. Handreck (4) suggested that this strong retention of Fe by bark is via phenolic hydroxyls and acidic carboxyls.

There were no substantive differences in Fe and Zn concentrations supplied by any of the sources or control (Table 2). The similar Fe and Zn concentrations in the control treatment as in treatments with micronutrient additions explains why there is often no growth response to micronutrient additions (3, 6). Apparently, pine bark supplies sufficient amounts of indigenous micronutrients to satisfy plants need for such elements. An instance where there are responses to micronutrient additions may be explained by decreased availability or uptake caused by interactions with other fertilizers such as P (2, 4) and lime (5).

The lack of micronutrient differences between the 1 and 2 g/l Ironite treatments was unexpected since Handreck (4), using DPTA as an extractant, showed increases in Fe extractability with increases in Fe amendment rates. The reason for this is not known.

Micromax supplied more extractable Cu and Mn than Ironite treatments (Table 2). Although not proportional, this finding reflected the relative difference in the Cu and Mn content between Micromax and Ironite (Table
1). The extractable micronutrient levels of Ironite were not substantially different than in unamended bark (control) suggesting that, under the conditions of this experiment, the Ironite release from bark or Ironite solubility was relatively low. Associatively, Fe and Zn levels from Micromax were only 6.0% and 23% greater than control levels, respectively.

This work shows that significant amounts of micronutrients could be extracted with DTPA from unamended bark. This is noteworthy since Handreck (4) has shown that DTPA extractable micronutrient levels, in conjunction with media pH, are correlated with plant growth response. Handreck (4) lists minimum Fe extract concentrations to produce high quality plants for a few species, mostly Australian, but more work is needed to determine minimum concentrations for the more common species grown in the U.S.

**LITERATURE CITED**


A MULTIPLE CHEMICAL DELIVERY SYSTEM FOR CONTAINER-GROWN NURSERY STOCK

Bonnie Appleton and Jeffrey Derr
Virginia

Nature of Work: Production of nursery stock in containers is very labor intensive, with labor often accounting for 75% or more of production costs. Many different chemicals, including fertilizers, herbicides, fungicides, insecticides, etc., need to be applied each growing season, frequently more than once. While some of these materials can be applied by an overall application method (via the irrigation system, or with broadcast or aerial spray equipment), many of the chemicals are applied by hand to individual containers-

Quality nursery stock cannot be produced without the use of a certain amount of these various chemicals. A means of applying as many chemicals as possible all at one time, and only once during each growing season, would greatly reduce labor costs and help to alleviate the problem of a labor pool that is rapidly disappearing.
In addition, with many of the “overall” application methods currently used, far more chemical is applied than is needed because the chemicals are applied not only to the target plants, but also to the spaces on the container beds between the plants, to the roadways, etc. This not only wastes material but also contributes to the pollution of runoff and ground water. In addition, many calculation errors are made each year, resulting in application rates that are either excessive and damage both the target plants and the environment, or that are at rates too low to be effective.

Fertilizers with various slow release mechanisms in part address the need to reduce excessive fertilizer runoff, and attempt to give season long release of nutrients, but nothing of a similar nature currently exists for most of the commonly used nursery pesticides. Other container-grown nursery stock weed control methods have and are being studied, including physical barriers (1, 2, 5, 7), herbicide-treated mulches (6) and slow release tablets (3, 4), but as yet no alternative is commercially available.

From previous work looking at disks of various materials (plastic, paper, geotextiles) simply as physical barriers for container weed control (1), it became obvious that an herbicide was still needed for three main reasons: 1. container volume and design within each container size vary considerably, meaning one size disk would not adequately “fit all”; 2. containers are not consistently filled with medium to the same height, meaning the exposed medium surface area varies on the disk outer edge; and 3. in order to fit a disk around a liner there must be a central hole and slit, again exposing medium where weeds can grow.

In 1989, disks were made of a combination geotextile- herbicide product (Biobarrier - Typar spunbonded polypropylene with Treflan herbicide) marketed for other commercial applications. These were compared to disks of the fabric alone, to the herbicide OH2, and to no herbicide checks. In addition, a slow release fertilizer was either topdressed with the disks, or glued to the disks to create a multiple chemical disk.

For 1990 the single layer disk was changed to a two layered “collar”, with OH2 and a slow release fertilizer contained between the layers. In addition, the collars were made from different “carrier” materials including geotextiles of varying permeability, biodegradable peat/paper, and photodegradable plastic.

**Results and Discussion:** In 1989, test plants surrounded by the Biobarrier disks with attached fertilizer grew as well as or better than any other treatment. The major problem was uneven fertilizer release due to excess glue (though water soluble) used to attach the fertilizer (confirmed by Virginia Tech’s pour- through sampling procedure). For that reason, and so that employees placing the disks would not be directly contacting the
chemicals, the two layer collar was developed. Ongoing research will continue to refine the collar looking for the best carrier materials, for the best handling design, and for inclusion of as many chemicals within the collar as possible.

LITERATURE CITED


The Affect of Container Media Physical Properties on the Quality of Nursery Grown Mountain Laurel

Richard E. Bir and T. E. Bilderback
North Carolina

Nature of Work: Mountain Laurel, *Kalmia latifolia* L., a native evergreen flowering shrub that has long been admired by gardener, has been available only in limited supply from nurserymen. Until the 1980’s and the evolution of tissue culture, propagation difficulties were cited as the primary reason for the limited supply of excellent plants. However, by 1988 an adequate supply of high quality tissue culture propagated liners was available, but a consistent supply of excellent mountain laurel did not exist.

Research by Hummel and Johnson (3) indicated that mountain laurel could be grown equally well in media of 1:1 or 4:1 pine bark:peat in Georgia, or 1:1 or 4:1 fir bark:peat in Washington. Particle size analysis of the bark used in both locations showed the fir bark contained significantly more fine particles which could result in less air space and greater water holding capacity. The cultivars ‘Elf’ and ‘Freckles’ produced good plants in both locations while ‘Goodrich’ did not produce good plants in either location.

In 1989 we conducted a survey of cultural practices of nurseries growing mountain laurel in thirteen states. Plant handling, pruning, pest management, fertilization, cultivar performance and winter protection were compared (2). Growing media was analyzed for nine of these nurseries located in CT, MA, NC and TN. The anonymity of individual nursery production practices was guaranteed.

All nurseries involved in this study produced consistently good quality mountain laurel. A subjective evaluation system was used to determine differences. It included growth rate, branching, foliage color and pests. This rating system was weighted for uniform excellence in overall plant quality.

Media components used by these nurseries included hardwood bark, pine bark, composted hardwood leaves, composted brewery sludge, composted municipal sludge, sand, granite tailings, loamy soil, peat (at least 3 grades), perlite, styrofoam, and vermiculite. Growing media obtained from all nine nurseries was analyzed by the Horticultural Substrates Laboratory at N. C. State University following the procedures of Bilderback and Fonteno (1). Physical properties of media were compared to determine factors potentially influencing quality of plants produced in these nurseries.

Results and Discussion: Particle size distribution is shown in Table 1., other physical properties are shown in Table 2.
Particle Size - When comparing particle size distribution for the two nurseries producing the poorest and the two nurseries producing the best quality mountain laurels, differences were minimal. Fine particles, sieve size less than 0.5 mm, averaged 23.1% for the poorest and 22% for the best. Therefore, characteristics other than particle size need to be investigated.

Bulk Density - Three media were statistically (Duncan’s New Multiple Range test, Rp .05) heavier than all others, ranging from 0.72 to 0.79 g/cc. They also produced the poorest of these good quality mountain laurel. Therefore, unless a grower is producing plants large enough to need heavier particles such as sand and soil to anchor containers in the wind, media components with higher bulk density do not appear to contribute to producing higher quality plants.

Total Porosity and Air Space - Total porosity is comprised of air space, available and unavailable water. The three nurseries producing the most consistently excellent plants averaged 76.8% total porosity while the three producing the poorest plants averaged 63.5% total porosity. This would seem to indicate that mountain laurels grow better in a relatively “open” mix. However, these same nurseries had air space (% volume) of 13.8% for the best plants and 7.9% for the worst. Therefore, differences in total porosity were not due entirely to air space in the media. Ideally, air space of over 10% is suggested with best growth for many plants between 15 and 20% air space. Mountain laurel seems to grow best with less air space than other plants.

Available and Unavailable water - The volume of water available to a plant affects the frequency and quantity of irrigation necessary to sustain plant growth. The three nurseries producing the best plants averaged 43.2% available water while the nurseries producing the poorest plants had 39.1%, or 4.1% less available water. This difference should affect nursery water management practices more than plant growth.

Conclusions: Since all nurseries participating in the study were producing good mountain laurel in containers, media management by nurserymen can be considered the greatest variable in producing consistently excellent plants. These results indicate that the best mountain laurel were produced in relatively lightweight mixes with greater total porosity, air space and available water. Since our quality evaluation was heavily weighted for consistency, it should be noted that the poorest two nurseries in terms of mountain laurel quality were also those with the least consistent media (nonlinear regressions used for predicting container models for these two has r^2 0.857 while all others were 0.9 or greater).


(Table 1)
Growth Response of Mountain Laurel as Influenced by Temperature and Photoperiod

Asiah A. Malek, Frank A. Blazich, Stuart L. Warren and James E. Shelton

North Carolina

Nature of Work: An experiment was conducted in the North Carolina State University Phytotron to study the effects of photoperiod and selected day/night temperatures on growth of mountain laurel (Kalmia latifolia L.). Uniform seedlings in 1 liter containers were placed in controlled—environment A-chambers (4 seedlings/chamber) maintained at 9 hr day/15 hr night temperatures of 22°/18° (72°/64°), 26°/22° (79°/72°) and 30°/26°C (86°/79°F) under both short day and long day conditions (1). Long days were obtained by interruption of the 15 hr dark period from 11 p.m. to 2 a.m. with light from incandescent lamps. Plants were watered once daily and fertilized twice weekly with the standard Phytotron nutrient solution (1). After 12 weeks, the experiment was terminated and top dry weight determined.

Results and Discussion: For each temperature, top dry weight of plants under long day conditions was significantly greater than that of short days. These data suggest that commercial production of plants under long days may be advantageous to accelerate growth.

Literature Cited

USE OF COMPOSTED SAWDUST, FLY ASH AND PINE BARK AS A POTTING MEDIUM

T.E. Bilderback, Everette F. Hartzog and Rob Means
North Carolina

Nature of Work: Recycling and determining alternative uses for materials that historically have been sent to landfills is rapidly becoming a required avenue in the disposal of many agricultural and industrial by-products. In this study, composted mixtures of wood sludge, wood ash and wood fines were used as components in potting medium to grow 3 ornamental crops. The sludge was derived from a waste water process at a hardboard manufacturing plant. The fly ash was produced by burning mixed bark and sawdust as a fuel source, the wood fines were used as an additional carbon source and bulking agent for composting to produce a stabilized product. A standard nursery potting medium of 5 pine bark:1 coarse sand (by volume) was selected as a control medium. The standard mix (control medium) was amended to include 1 part (by volume) of 1 of 3 composted products, resulting in 5:1:1 (by volume) test media. The composted products were as follows: 1/2 inch screen compost containing fly ash, unscreened compost containing fly ash, and screened compost without fly ash. On April 15, 1988 twelve each of Rhododendron ‘PJM’, Rhododendron sp. ‘Gumpo’ azalea, Prunus laurocerasus ‘Zabeliana’ cherry laurel and Pieris japonica ‘Christmas Cheer’ were potted into 3 qt (2.781) containers with one of the 4 media. Each media was incorporated with 8 lb dolomitic limestone, 6 lb superphosphate (0-20-0), and 1.5 lb C-Trel minor element supplement (Coor Farm Supply, Smithfield, N.C.) / cu.yd. Each species was arranged in a completely randomized block containing 48 plants and a total of 192 plants were included in the study. After 2 weeks, each container was topdressed with 1 teaspoon 14-26-6 sulfur coated slow release Coor Farm fertilizer. Container leachates were collected by VTEM extraction procedures on 5 sampling dates (Data from 2 sampling dates shown) from ‘Gumpo’ azalea containers and analyzed for pH, electrical conductivity (EC) Ammonium N, Nitrate N, P, K, Ca, and Mg (1). The study was terminated after 30 weeks. A plant quality rating from 1 to 5 and growth index were conducted on all species except ‘Gumpo’ azalea. A flower bud count was conducted for ‘PJM’ rhododendron.

Physical properties including total porosity, air space, water holding capacity and bulk density were determined for each of the media. Cation ion exchange capacity (CEC) was determined by the North Carolina Department of Agriculture Soils Testing Laboratory by an additive cation procedure. All data was statistically analyzed by general linear models procedure.

Results and Discussion: Incorporation of fly ash into the pine bark sand medium increased CEC, the screened fly ash medium was higher in CEC than
the unscreened fly ash (Table 1). Incorporation of the composted component with or without fly ash decreased total porosity, and increased bulk density. Incorporation of the compost without fly ash increased air space compared to the control but decreased water holding capacity. The screened medium without fly ash maintained a lower pH than other media during the first 8 weeks of the study (Table 3&4). However, leachate samples analyzed after 14, 18 and 20 weeks indicated that the media containing compost increased in pH while the standard mix decreased to 5.8 (Data not shown). The screened without fly ash media rose from 5.5 to 6.3, while media 1 &2 containing fly ash rose from 6.2 and 6.4 to 6.7 and 6.9 respectively (Data not shown). Soluble salts, NO₃-N, P, Ca and Mg decreased with each sample time but concentration levels were not different among media for any sample time. Potassium levels were only different among media for sample time 1, in which the standard mix had lower K levels than amended media. Nitrate-N levels were highest at sample time 2 (Table 3&4) while ammonium-N levels were highest at sample time 1.

Plant growth responses tended to be similar for all media, except for Rhododendron ‘PJM’ (Table 4). The growth index, visual rating and bud count tended to be higher for media containing fly ash for Rhododendron ‘PJM’. ‘PJM’ in the screened fly ash medium did produce more flower buds than the other media. This may have been the result of higher P levels late in the growing season in this medium. Although P levels were not significantly higher in the screened fly ash medium at any sample time, at sample time 5 (October 6, 1988) the screened fly ash had 14.9 ppm P while other media ranged from 9.0 to 4.5 ppm. Visual ratings for ‘Zabeliana’ cherrylaurel indicated that fly ash containing media yielded better plants; however growth index data did not show that the difference was significant. The container media treatments appeared to have no distinguishable affect on plant growth responses for Pieris japonica ‘Christmas Cheer’.

LITERATURE CITED

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COMPARISON OF CONTAINER LEACHATE LEVELS AND PLANT RESPONSE TO SLOW RELEASE FERTILIZERS

E. LEWIS PHILLIPS AND T. E. BILDERBACK
NORTH CAROLINA

Nature of Work: Monitoring electrical conductivity (soluble salts) levels in containers is one of the few ways that a nurseryman can assess the status of his container cultural practices. Irrigation practices, the container medium, fertilizer and application rates and environmental factors such as rainfall and temperature all have effects upon the electrical conductivity (EC) levels in the container.

Since 1985, many nurserymen and extension agents working with nurserymen have employed the VTEM pour through extraction procedure as reported by Wright (3). Previous reports indicate that large variations exist between the suggested liquid feed guidelines for EC and nutrient levels observed when testing containers in slow release fertilizer programs (1,4). Slow release fertilizers do not maintain uniform EC and nutrient levels throughout their release periods and some are more affected by temperature than others. Phillips and Bilderback reported that EC and nutrient levels often did not reach the minimal levels suggested by Wright for liquid feed. Nevertheless, monitoring slow release EC and nutrient levels was concluded to be very helpful if employed routinely over the growing season by growers.

The intent of this study was to compare container leachate levels and plant response to several slow release fertilizers. Uniform rooted cuttings of Rhododendron ‘Hinodegeri’ were potted into trade 2 gallon containers (6 qt.) on May 2, 1989. The growing medium was an aged pine bark screened to 1/2 inch and builders grade washed sand (4:1 by volume) a minor element supplement (Micromax, Sierra Chemical Co.) at 1.5 lbs./cu. yd. and 6 lbs/cu. yd. dolomitic limestone were added if not contained in the test product. Containers were placed on black plastic ground cover in 15 blocks. Irrigation applied at 1 inch every other day was provided by overhead impact sprinklers. Fertilizer treatments were assigned using a randomized complete block design and a surface application made to containers with one of six commercial slow release fertilizers (Table 1). Four of the 15 blocks were randomly selected for leachate sampling. Leachate samples were collected following VTEM procedure. Leachate conductivity and pH were measured using an AG-6 Agri-Meter (Myron L Co. Carlsbad, Calif.) every three weeks throughout the growing season resulting in 7 sampling dates. Leachate nutrient levels were determined 3 times during the study (4,12, and 25 weeks after application) when leachate samples were placed in bottles, refrigerated and stored for elemental analysis. Samples were analyzed for NO₃-N, NH₄-N, and P by colorimetric procedures. The study was terminated 25 weeks after initiation.
In October 1989, the medium was washed from the roots and plants were placed in a drying oven for 5 days at at 140° F. Dry weight of each plant was then recorded and new fully expanded leaves collected for foliar analysis.

**Results and Discussion:** The highest EC levels were generally maintained by Escote 20-4-11 and Sierra 18-6-13 (Figure 1). However, the Sierra 18-6-13 maintained the highest N03-N and NH4-N levels of fertilizers studied throughout the growing season (Table 2). Combined N03-N and NH4-N were well below VTEM guidelines for nitrogen solution levels. Escote 18-8-9 and Escote 20-4-11 had P levels above 10 ppm after 4 weeks (Data not shown). All other phosphate leachate levels were below the 10 ppm VTEM guidelines.

Top and root dry weights for ‘Hinodegri’ azalea were greatest for Sierra 18-6-13, Escote 20-4-11 and Prokote 20-3-10 (Table 3). These were also the treatments which maintained highest EC levels (Figure 1). Sierra 16-6-10 and High N were lowest in foliar N levels at 1.5% dry weight, although this is within acceptable guidelines for azalea (2) (Table 3). Sierra 18-6-13 provided the highest foliar P and Sierra 16-6-10 had the 2nd highest foliar levels which corresponded with the 12 and 25 week leachate data (Data not shown). Escote 20-4-11 had the lowest foliar K content. All other elements were not significant except for Fe which was significantly greater in the Sierra 18-6-13 treatment (Data not shown).

**LITERATURE CITED**


(Table 1)

(Table 2)
ARCILLITE: EFFECT ON GROWTH OF CONTAINER-GROWN NURSERY CROPS

Stuart L. Warren and Ted E. Bilderback
North Carolina

Nature of Work: Container production of landscape plants has expanded rapidly and now represents over one-half of all landscape plants sold in the United States. Production of container-grown plants with traditional production methods uses large quantities of water. Many nurserymen have successfully reduced water usage by converting to drip or trickle irrigation. However, not all nurseries lend themselves to alternative irrigation practices. Researchers have attempted to reduce irrigation frequency by amending potting mixes with moisture extending agents with limited success (Bowman et al., 1990; Keever et al., 1989; Ingram and Yeager, 1987;). If the grower could reduce irrigation frequency this would drastically reduce water usage. However, reducing irrigation frequency usually results in decrease plant growth and quality (Stewart, et al., 1981). The importance of an adequate water supply for the growth of nursery crops is well documented by Zahner (1968).

Arcillite has been reported to improve the growth of container-grown plants when mixed with a loam soil or peat compared to loam soil or peat alone (Wildon and O’Rourke, 1965). However, no work has been reported using a pine bark medium. This study was designed to determine the effect of arcillite, a calcined montmorillonitic clay, on container-grown nursery crops.

The experiment, a 2 X 5 X 3 factorial in a randomized complete block design with six replications, was conducted at North Carolina State University, Horticultural Research Unit 4, Raleigh. The three main factors were as follows: 2 arcillite materials (2 particle sizes); 5 arcillite rates [0, 45, 85, 118 and 158 lbs/yd³]; and 3 irrigation frequencies (1, 2 or 4 days). The major component of the container medium was milled pine bark.

Uniform rooted cuttings of ‘Skogholm’ cotoneaster (Cotoneaster dammeri ‘Skogholm’) was potted into 4 quart containers on May 8, 1989. All media were amended with 6 lbs/yd³ dolomitic limestone and 3 lbs/yd³ Perk. All plants received 34 oz of water daily via spot spitters (Roberts Irrigation Products) until May 26, 1989, thereafter plants received 34 oz per specified irrigation frequency. One-half ounce of Escote 20-4-11 was applied to the medium surface of each container on May 26, 1989. On November 11, 1989, the shoots (aerial tissue) were removed and dried at 160° F for 96 hours. Data was subjected to analysis of variance and regression analysis (SAS Institute, Cary, NC).
Results and Discussion: ‘Skogholm’ cotoneaster shoot dry weight was not significantly affected by the arcillite materials. However, shoot dry weight was significantly effected by arcillite rate and irrigation frequency. In addition, the interaction of arcillite rate and irrigation frequency was significant. Shoot dry weight increased linearly with increasing arcillite rate at irrigation frequencies of 2 and 4 day (Figure 1). Shoot dry weight increased curvilinearly with increasing arcillite rate when irrigated daily, with maximum shoot weight occurring at 118 lbs. This suggests that there is an upper limit to the addition of arcillite. The addition of arcillite increased shoot growth 59, 65, and 51%, for irrigation frequencies of 1, 2 and 4 days, respectively, compared to plants grown without arcillite. For cotoneaster, the addition of arcillite to the growing medium could allow the grower to reduce the irrigation frequency. For example, by adding 45 lbs of arcillite to a pine bark medium and irrigating every 2 days, a grower could produce a plant equivalent in size to those grown in pine bark alone which was irrigated daily.

ACKNOWLEDGEMENT

Technical assistance of William Reece and Mary Lorscheider is gratefully acknowledged. This research was supported, in part, by grants from Aimcor, Inc. and the Horticultural Research Institute. The arcillite used in this study is a commercial material distributed under the trade name “Turface” by Aimcor, Inc.

LITERATURE CITED


AZALEA GROWTH RESPONSE TO CALCIUM AND MAGNESIUM DEPENDENT UPON WATER QUALITY

E. W. BUSH, D. L. FULLER AND M. L. ROBBINS
LOUISIANA

Nature of Work: Dolomitic lime is used as a calcium (Ca) and magnesium (Mg) source, as well as a pH neutralizing material for the production of woody ornamentals. Unfortunately, when acid-loving plants are irrigated with alkaline water, media pH may exceed optimum levels. Alkaline well water sources in north Louisiana frequently contain high levels of sodium. Research has shown that uptake of calcium and magnesium is reduced in the presence of high sodium levels in the media matrix (1,2). The objective of this experiment was to determine effects of Ca/Mg sources and water quality on the growth and production of container-grown azaleas.

Four inch Azalea indica ‘Formosa’ liners were planted on January 29, 1990, into 1 gallon containers filled with an amended 4:1 (v,v) pine bark to sand medium (pH=4.2, Na=62 ppm). The medium was amended through the incorporation of Sierra Blend 17-7-10 + Fe (13 lbs/yd³) and Micromax (1.5 lbs/yd³). Dolomitic lime (CaCO₃, CaO, MgCO₃, MgO) or a combination of gypsum (CaSO₄) + epsom salt (MgSO₄) was incorporated individually into the planting medium to supply Ca + Mg treatments [0 lbs + 0 lbs/yd³, 1.0 lbs + 0.5 lbs/yd (1X)], [2.0 lbs + 1.0 lbs/yd³ (2X)] and [3.0 lbs + 1.5 lbs/yd (3X)].
respectively. The experimental design was a randomized complete block with 12 replications. Irrigation water (600 ml) was supplied daily as either deep well water (pH 8.6, Na 250 ppm) or filtered (Reverse Osmosis) well water (pH 5.8, Na 25 ppm) to the medium surface through spray stakes. Visual ratings (1=poor - 5=excellent) were taken after 90 and 157 days. Medium samples were taken at 90 days and analyzed by the LSU Soil Testing Lab.

**Results and Discussion:** Calcium and magnesium levels of the medium were comparable across water sources (Table 1). All treatments irrigated with filtered well water maintained vigorous growth regardless of Ca/Mg source or rate after 157 days (Table 2). However, plants irrigated with deep well water resulted in significant growth differences. Na and pH levels of the medium significantly increased with deep well water irrigation (Table 1). These medium changes resulted in observable limiting of plant growth and some foliar chlorosis after 90 days. Plants grown in medium amended with Gypsum + Epsom salt maintained significantly better quality than plants in dolomitic lime treatments (Table 2). Plants in the control treatment maintained acceptable quality despite the absence of calcium or magnesium applications. Low levels of calcium and magnesium can be supplied through irrigation water (3), however decreasing plant quality ratings of those plants irrigated with deep well water suggests inadequate availability. ‘Formosa’ azalea growth response to Ca/Mg sources in this experiment was dependent upon water quality.

**Literature Cited**


Donald L. Fuller
Louisiana

Nature of work: Coron (Coron Co., Souderton, PA, 18964) a liquid—controlled release nitrogen (CRN) product derives its CRN from a number of complex water-soluble ureaforms (polymethylene ureas). As with solid ureaform products the complex polymethylene urea chains are slowly mineralized to more available forms of nitrogen (urea-N; NH₄ -N; and NO₃ -N). The mineralization rate of liquid forms is of limited value if the product is quickly leached from the media. The purpose of this research was to determine the leaching losses of liquid polymethylene urea products and urea in three different medias. In this study Coron-HU (High Urea) 28-0-0, Coron-LU (Low Urea) 22.5-0-0 and urea 46-0-0 were top applied at the rate of 0.02 oz (600 mg) N to PVC 3'' X 10'' columns (7.6cm x 25.4cm) containing 34oz (1000 ml)of either pine bark, peat or sand. Media pH were adjusted to 6.5 with CaCO₃. De-ionized water was used to bring the media to its maximum water holding capacity (pine bark-40%; peat-60%; and sand -20%) prior to adding fertilizers. PVC columns were incubated at 27°C (81°F) in a constant temperature incubater and columns were covered with perforated plastic lids to minimize evaporation and facilitate aeration. Three replicates of each fertilizer and media were successively leached on days 3, 5, 7, 14, 21, 28 and 35. A total of 0.02oz (600 ml)of de-ionized water was applied weekly. Volume of water leached was recovered after each application and aliquots were analyzed for total N utilizing the Kjeldahl method.

Results and Discussion: In sand media Coron fertilizers leached at the same rate as urea. (Table 1). 87% or greater of the total N recovered from sand media treatments was leached in the first week. In pine bark and peat media Coron fertilizers leached at a rate of 2 to 3 times faster than that of urea. Leaching rates for Coron LU and Coron HU did not differ for any of the media tested.

All fertilizer materials leached at a much slower rate in pine bark and peat media than in sand. Recovery of N from urea treated peat and pine bark was no greater than 13% of that recovered from urea—treated sand. Recovery of N from Coron treated peat and pine bark was no greater than 38% of that recovered from Coron treated sand.

As indicated from this research the liquid polymethylene fertilizers leached very rapidly in sand and at a rate of 2 to 3 times faster than that of urea in pine bark and peat. Under growing conditions commonly encountered in nurser-
ies and greenhouses where considerable leaching can occur it is questionable whether the slow mineralization rate of the polymethylene ureas would be of benefit.

Table 1. Total N leached (mg) as affected by fertilizer source and time. ¹

(Table 1 here)

¹ 0.02oz (600 mg) N applied per pvc column

NS,*,**, Nonsignificant or significant at P <.05 or .01, respectively.
Nitrogen Release Characteristics of Reactive Layers Coated Urea Fertilizers During a 39 Week Incubation in sand.

Donald L. Fuller
Louisiana

Nature of Work: An experimental fertilizer called reactive layers coated urea (RLCU) has been developed by coating urea with a mixture of diisocyanate and polyol in the presence of a catalyst. As with other resin coated products the rate of release can be manipulated by altering coating thickness. This new slow release fertilizer is in the preliminary development stages for use on container nursery stock and initial evaluations are needed to determine N-release rate as affected by coating. Urea and three granular RLCU fertilizers with coating weights of 4, 7 and 14% were incorporated at a rate of 0.02oz (600 mg) N to 3" X 10" PVC columns (7.6cm x 25.4cm) containing 34oz (1000ml) of sand medium. De-ionized water was added to bring the medium to maximum water holding capacity (20% moisture). PVC columns were incubated at 27°C (81° F) in a constant temperature incubator and columns were covered with perforated plastic lids to minimize evaporation but facilitate aeration. Seven ounces (200 ml) of de-ionized water was applied and leachate collected on days 3, 5 and 7 and weeks 2, 3, 4, 5, 7, 9, 11, 14, 17, 20, 23, 27, 31, 35 and 39. Volume of water leached was recorded and aliquots were analyzed for total N using a Technicon Autoanalyzer. The experiment was conducted in triplicate.

Results and Discussion: The rate of release of RLCU materials varied greatly depending on coating thickness. 100% of all leached nitrogen from uncoated urea was recovered in the first week of the 33 week incubation period (Table 1). RLCU materials released 80% N compared with uncoated urea in 2, 11 and 31 weeks for coating weights of 4%, 7%, and 14%, respectively. Both the 4% and 7% RLCU materials began to show a reduction in N release rate after the first week, with the latter declining at a much slower rate (Table 1). The rate of diffusion decreased as the urea concentration within the capsule was reduced. The 14% coating weight had a linear rate of release for the first 14 weeks followed by a slower reduced rate.

The RLCU materials appear to give a consistently metered release of nitrogen which can be manipulated by varying the coating thickness. The 14% RLCU material would give a theoretically steady release of N for the first 14 weeks at a temp of 27°C (81° F). Longevities twice this length would be needed for production of most nursery crops in the south. This could be accomplished by increasing the coating thickness or improving the coating reaction process during manufacturing. Manufacturing improvements have recently been
made resulting in coating thicknesses of one-third that used in this test but
having similar rates of N release during water soak tests. Future long term
evaluations will continue with the newer generation of RLC materials.

(Table 1 here)

1 0.02 oz (600mg) N of urea applied per PVC column
2 Means within rows seperated by Duncan's multiple range test at P=0.05.
Nature of Work: Slow release fertilizers are widely used in the production of container nursery stock. One of the most frequently used slow release fertilizers by the nursery industry during the last two decades has been Osmocote 18-6-12 (Sierra Chemical Co., Milpitas, CA). Osmocote has a resinous membrane coating which is a copolymer of dicyclopentadiene and glycerol ester of soybean oil. Nutrient release rate is dependent on the coating thickness. Advances in coating technology have helped produce a new generation of resin coated slow release fertilizers. Polyolefin resin coated fertilizers are included in formulations of Nutricote (Plantco, Inc. Bramalea Ontario, Canada), ProKote (O.M. Scotts & Sons, Co., Marysville, OH) and Woodace (Vigoro Industries, Inc., Winterhaven, FL). Parker Fertilizer (Sylacauga, AL) has introduced a new experimental coated polymer of diisocyanate and polyol called reactive-layers coated (RLC). The effect on plant growth and duration of nutrient release of these new products in southern Louisiana growing area is not known. For this reason a study was undertaken to evaluate the influence of six slow release fertilizers (Table 1), 3 application methods (Incorporated; Top Dressed; and Dibbled), and two rates (2 lb N; and 3 lb N/cu. yd.).

Fertilizers were incorporated, top dressed and dibbled at 2 and 3 lb N per cu. yd. in a pine bark media amended with 1.5 and 6.0 lbs per cu. yd. of Micromax and dolomite, respectively. Liners (3" Juniperus conferta ‘Shore’) were transplanted on May 11, 1989, into #1 (3.8 l) containers and placed on a limestone bed in full sun with overhead irrigation (0.5 in/day). All treatments were replicated five times. Fresh shoot weight of plant foliage and plant quality ratings (1=dead; 10=superior) were performed after a full growing season on March 22, 1990. Leachate extractions were performed on the 3 lb N per cu. yd. rate of all fertilizers and placements. This was done by pouring 10.5oz (300 ml) de-ionized water on #1 (3.8 l) unplanted containers for weeks 1, 3, 5, 8, 11, 15, 20, 25, 30, 35, 40 and 45. The leachate experiment was replicated four times. Total N was determined with a Technicon Autoanalyzer.

Results and Discussion: Length of nutrient release (weeks) calculated for each of the following fertilizers and placements (last week leachate N levels were above 10ppm):
Dibble placement increased the longevities of all materials. Top dressing of Nutricote, Woodace, and ProKote lengthened the release duration compared with incorporated placement. Osmocote fertilizers had shortest durations when top dressed. Shortest durations for all placements were recorded for Osmocote (I) and RD452.

Osmocote 18-6-12 and Nutricote 20-7-10 released the lowest levels of N on week 3 (Table 2). Highest leachate N levels for all placements were recorded for Nutricote during the last 15 weeks. N release rate dramatically increased during the first 11 weeks for incorporated and dibbled-applied Osmocote 18-6-12. Osmocote (I) 18-6-13 had more release of N upfront and increases in release rate were not as climatic compared with Osmocote 18-6-12.

As indicated from leachate data, Osmocote (I) and RD452 were the most short lived materials and Shore’ juniper fresh shoot weight and quality were generally the lowest for these materials regardless of placement or rate (Table 3). The RLC coating technology of the RD452 product has been improved since the conclusion of this experiment and materials with increased longevities will be included in future trials. Dibble-applied Osmocote 18-6-12 and Nutricote resulted in higher fresh shoot weights and quality when compared with other dibble-applied materials (Table 3). Lowest release rates for both Osmocote 18-6-12 and Nutricote were recorded at week 3 (Table 2) and this would be advantageous since higher concentrations of salts could be harmful to newly emerging roots.

At the low rate (2 lb N/cu. yd.) of incorporation Nutricote produced significantly greater fresh shoot weights and quality ratings when compared with other fertilizers (Table 3). At the high rate (3 lb N/cu. yd.) of incorporation Nutricote, Woodace, ProKote and Osmocote 18-6-12 produced similar fresh shoot weights and quality ratings of 8.0 or greater. Highest fresh shoot weight and quality for top dressed materials were recorded for Nutricote, Woodace, and ProKote, regardless of fertilizer rate. Generally, an increase in fertilizer rate resulted in an increase in fresh shoot weight or quality for most fertilizers and placements.
Nutricote was the most consistent fertilizer at all rates and placements with regard to Shore’ juniper fresh shoot weight and quality (Table 3). Evaluations were done after a 45 week production period which extended well past the longevities of most of the fertilizers. Nutricote had the longest release duration of the materials tested and was at a distinct advantage during the longer production period. Shorter production periods and earlier evaluations could result in a much different picture.

This research demonstrates how difficult it is to make meaningful comparisons between controlled release fertilizer materials. Manufacturers that are claiming certain longevities of nutrient release should perform standardized incubation trials to determine nutrient release profiles for various placements and temperatures. This standardized information if made available would give the researcher and grower a better idea of how the materials would perform under similar conditions. Informed researchers and growers could then make more meaningful comparisons of controlled-release fertilizers.

(Table 1 Here)
(Table 2 here)
Influence of Hydrophilic Gels on the Water Holding Capacity of Pine Bark Media

South Carolina

Nature of Work: The maintenance of adequate moisture levels in container grown ornamentals becomes difficult during times of high temperature and low humidities. The excessive amounts of water used during these periods are expensive and tend to leach nutrients from the container.

The use of water-absorbants such as polyacrylamide gels have been shown to reduce water consumption (2) and irrigation frequency (2,3,4,5). Increased root development has also been noted with the use of these gels (1,3,4).

Plant material selected for this study was azalea, Rhodondendron obtusum. Treatments of 0, 1, 2, 3, 4 and 5 lbs gel/ cu yd of media, pine bark:sand (80:20), were made by adding the gel as dry powder and hydrating the mix overnight before potting into 3 gallon plastic pots. The plants were allowed to grow for six weeks before data collection started. The pots were watered thoroughly and allowed to drain for 12 hours before the initial weights were taken. Pots were weighed 3 times a week until wilting was observed in the morning, then the pots were watered again to determine the rewetting characteristics of the gel. The sequence of data collection was done 3 times with 4 weeks between collection periods.
Results and Discussion: The initial amount of water retained by the bark:sand media varied significantly with increase in the amount of gel added to the media (Table 1). The higher rates retained the greatest amount of water as would be expected. The first sampling period gave the greatest variation of water retention. Subsequent sampling periods showed less variation between treatments possibly indicating that the gel was becoming inactivated by salts etc with each dry and rewetting cycle.

The most important parameter in this study is the actual amount of water that would be available to the plant from the amended media. This was measured as the amount of weight lost by the pots after initial weighing and plant wilting. During the first sampling period, the 4lb rate was significantly greater than the 0lb rate (Table 2). All other rates were not different statistically. The second sampling period gave varied results with the 2lb rate losing the greatest amount of water and by third sampling, no differences existed between treatments.

Equally important as the actual amount of water lost is the percentage of the initial weight that was lost. No significant differences existed between treatments during any of the sampling periods except in the first period where the 5lb rate lost the least amount of water.

An important consideration in the use of gels for water retention is the rate at which the gels will re-hydrate or rewet after drying. After each sampling period, the pots were again watered thoroughly several times during a 24-hour period, allowed to drain and reweighed. The percentage rewet was quite variable between sampling periods as shown in Table 3. The measurement of the rewetting capabilities of the gel was difficult to conduct with any consistancy. In general, the gel treatments returned to greater than 75% of their initial weight.

A general conclusion to make from this study is that the gels tend to slightly reduce their effectiveness after several wetting and drying cycles. The duration of their usefullness needs to be determined with long term studies.

LITERATURE CITED


(Table 1

Table 2)
INFLUENCE OF TEMPERATURE ON ROOT RESPIRATION IN ‘ROTUNDIFOLIA’ HOLLY

JOHN M. RUTER AND DEWAYNE L. INGRAM
GEORGIA AND FLORIDA

Nature of Work: Supraoptimal root-zone temperatures have been shown to influence growth, assimilate partitioning and respiratory characteristics of Ilex crenata ‘Rotundifolia’ (2,5). Decreased root dry weight (1,4) has been reported when woody plants were exposed to root-zone temperatures above 104°F. Increased respiration rates can affect the long-term growth and vigor of container nursery stock when exposed to supraoptimal root-zone temperatures. Therefore, this study was conducted to determine the effect of temperature on the respiratory rates of Ilex crenata ‘Rotundifolia’ grown at supraoptimal or ambient root-zone temperatures.

Rooted stem-tip cuttings of Ilex crenata ‘Rotundifolia’ were grown in Metro-Mix 300 (W.R. Grace and Co., Cambridge, MA) for 12 weeks in a greenhouse under natural daylength conditions before being transferred to a high light growth room three weeks before the initiation of the experiment. The experiment was conducted in a 9.6 ft by 25 ft. walk-in growth room with irradiance supplied by 18 1000-W phosphor coated metal-arc HID lamps (GTE Sylvania Corp., Manchester, NH). The photoperiod was 13 hours daily with the dark period being interrupted for three hours with incandescent light.
Air temperature and relative humidity were maintained at 85±1.5°F and 40% during the light period and 70±1.5°F and 90% during the dark period. Plants were fertilized twice weekly with a 300 ppm N solution of Peters 20-20-20 (W.R. Grace and Co., Cambridge, MA).

Plants were grown at root-zone temperatures of 85, 93, 100 and 108°F for six hours daily for 21 days before respiration of excised roots was measured in buffer solution at a temperature corresponding to the growth temperature or at 77°F. Plants were also grown at a root-zone temperature of 85°F and respiration measurements were made in buffer solution at temperatures ranging from 77 to 115°F. Root-zone temperature treatments were replicated 5 times using a completely randomized design. Root-zone temperatures were maintained within ±1.8°F using an electronically controlled root-heating system (3).

Respiration measurements were made with a Clark-type oxygen electrode (Hansatech, Kings Lynn, England). Oxygen electrode temperature was maintained by circulating water from a temperature bath through the water jacket of the reaction vessel. The buffer solution consisted of 0.3 M mannitol and 25 Mm Tes buffer adjusted to pH 7.1 with potassium hydroxide. Fibrous white roots (100 mg samples) cut to approximately 1 cm in length were used. Respiration rates were determined 8 to 10 minutes after steady state oxygen uptake was achieved and expressed on a root fresh weight basis.

**Results and Discussion:** Respiration rates in solution at 77°F decreased linearly (R²=0.98) with increased root-zone temperatures ranging from 85 to 108°F. Root-zone growth temperatures did not affect respiration rates when the buffer solution temperature was equal to the root-zone growth temperature.

When roots grown at 85°F were exposed for 10 minutes to buffer solution temperatures ranging from 77 to 115°F, there was a quadratic response for respiration (R²=0.94). The maximum respiration rate occurred at 93°F while respiration decreased by approximately 50% at 115°F in relation to the respiration rate of the control (77°F).

Increased respiration rates at high temperatures have generally been attributed to increased maintenance respiration costs and/or changes in enzyme activation energy. Maintenance respiration generally increases with increasing temperature to produce the energy required to maintain cellular integrity in response to changing environments. Differences in respiration rates at different buffer solution temperatures (100 and 108°F in solution at those temperatures compared to 100 and 108°F at 77°F) may be due to increased maintenance respiration costs upon exposure to the higher buffer solution temperatures. The maximum temperature used in this study (115°F) was below the critical threshold temperature (118°F) for direct membrane injury in ‘Rotundifolia’ holly roots (5).
Lack of differences in respiration rates when respiration was measured at the same temperature as the growth temperature is in agreement with previous research (5). However, prolonged exposure of roots to temperatures above 100° F can lead to membrane damage and loss of photoassimilates. This research indicates that increased root-zone growth temperatures and short-term exposure to high temperatures can be detrimental to root respiratory processes necessary for tissue maintenance and growth. Nurserymen should use cultural practices such as container spacing to reduce the incidence of direct solar radiation on container walls in an attempt to prevent supraoptimal container medium temperatures.

**Literature Cited**


EFFECTS OF CONTAINER VOLUME AND SHIFTING STRATEGIES ON GROWTH OF SOUTHERN MAGNOLIA

Chris A. Martin and Dewayne L. Ingram
Florida

**Nature of Work:** Young plant liners are typically transplanted into small containers and spaced can-to-can in nursery production beds. This protocol increases plant density per unit land area. Growing trees in this manner can reduce trunk caliper growth and cause the development of a weak branch structure and poor form after canopies converge and overlap (1). Enhancement of tree quality, structure, and form may require spacing individual containers at greater distances. However, container walls spaced at greater distances intercept more solar radiation and this may affect tree growth by increasing container medium temperatures. Reducing high growth medium temperatures may be accomplished by increasing the container volume and/or modifying the sequencing of container shifting regimes. The objective of this study was to determine the effect of 3 container volumes and 6 shifting treatments on growth of southern magnolia spaced apart to enhance top growth.

On 1 March 1988, rooted cuttings of Magnolia grandiflora ‘St. Mary’ averaging 12 inches in height were transplanted individually into containers having volumes of 3, 7, or 15 gallons filled with a 3 pine bark: 1 sand (v/v/v) growth medium amended with 10 lb/yd³ Osmocote 18N - 2.6P - 9.9K (Grace-Sierra Inc., Miltpas, Cal.), 5 lb/yd³ dolomitic limestone, and 1.5 lb/yd³ Micromax (Grace-Sierra Inc., Miltpas, Cal.). Additional applications of Osmocote fertilizer at the rates of 0.5, 1.0, and 1.5 oz per 3-, 7-, and 15-gallon containers, respectively, were top-dressed on 1 July 1988 and 1989. Containers were placed on black polypropylene fabric and spaced 48 inches on center. A drip tube irrigation system was installed with 1, 2, or 3 drip tubes per 3-, 7-, or 15-gallon container, respectively. Trees were irrigated every other day for 45 min from March to November, 1988 and March to October, 1989. Water replacement was applied at an average rate of 0.7 gallons per hour per gallon of container volume.

On 1 March 1989, trees were transplanted according to 6 shifting regimens of 1) 3- to 3-gallon, 2) 3- to 7-gallon, 3) 3- to 15-gallon, 4) 7- to 7-gallon, 5) 7-to 15-gallon, or 6) 15- to 15-gallon containers. Monthly measurements of tree height and caliper were made from 1 March to 1 November, 1988 and from 1 March to 1 October, 1989. Height was determined from the growth medium surface to the base of the highest apical bud. Trunk caliper was measured one inch above the container medium surface. Copper-constantan thermocouples were positioned in the growth medium half-way down the container profile at the center location and on the east and west coordinates, 0.75 inch inside the container wall. Temperature data in 4 replicate contain-
ers were recorded at 5-minute intervals and averaged over each 15-minute period for one 24-hour period monthly during the growing seasons of both years.

The experiment was arranged in a completely randomized design with 15 replications. Height and caliper data were analyzed by container volume and shifting treatments for the first and second years, respectively. Differences in tree growth due to treatment were tested by repeated measures analysis (4).

Results and Discussion: On 24 August 1989, a typical sunny summer day, the mean maximum temperature at the center location of the 15-gallon containers was 97.8±3.6°F (1930 HR) and was 7.6° and 10.8°F lower than the 7-gallon (105.4°F at 1730 HR) and 3-gallon (108.1°F at 1845 HR) containers, respectively. The highest mean growth medium temperature occurred at the western exposure for all container sizes and was 118.6°F (1745 HR), 113.7°F (1715 HR), and 113.5°F (1630 HR) for the 3-, 7-, and 15-gallon containers, respectively.

Height and caliper of magnolias increased linearly over time during the first year; however, the rate of increase for trees grown in 7- and 15-gallon containers was greater than for trees in 3-gallon containers. At the end of the first year, height of trees grown in 3-gallon containers was 46% and 54% less than 7- and 15-gallon containers, respectively. Height differences as a function of container volume became visually apparent during midsummer. At the end of the first year, caliper growth of trees in 15-gallon containers was 1.5 times greater than for trees in 3 gallon containers. A similar response was found on ‘Bradford’ Callery pear (2).

For the second year, growth was yellowerly greater for trees shifted to larger containers. Data analysis of second-year growth trends demonstrated that 1) regardless of shifting treatment, height and caliper increases of trees grown in 7- or 15-gallon containers during the first year were linearly greater than for trees grown in 3 gallon containers the first year, 2) height increases of trees transplanted from 7 gallon into 15-gallon containers or grown both years in 15 gallon containers were linearly greater than for trees grown both years in 7-gallon containers, and 3) caliper increases of trees transplanted from 3 gallon into 7- or 15 gallon containers were lineally greater than for trees grown both years in 3 gallon containers.

High root-zone temperatures may have intensified differences in tree growth attributed to different container volumes or shifting regimens. Container walls, unshaded by tree canopies, were exposed to daily rhythms of solar radiation which created microcosms inside the container medium volume where temperatures were high enough to kill root tissue (3). These microcosms occurred principally in the east, south, and west exposures of the growth medium. Temperature-induced lethal microcosms in growth media
restrict the viable volume available for root growth and may reduce overall root and shoot growth. Reductions of the viable rooting volume in 3-gallon containers were probably intensified in 3-gallon containers by small tree canopies in 7- and 15-gallon containers. Magnolia grown in 3-gallon containers had a greater percentage of the total root system located in the north and bottom layers of the container profile compared to 7- and 15-gallon containers.

In conclusion, the mean maximum temperature at the center location was 7.6° and 10.6°F lower in the 15-gallon compared to the 7- and 3-gallon containers, respectively. The time required for magnolias to attain marketable size when containers are spaced apart may be shorten by shifting trees earlier in the production cycle to larger container volumes or starting trees in the container volume in which they will be marketed.

**Literature Cited**


WATER USE OF CONTAINER-GROWN LANDSCAPE PLANTS

Gary W. Knox
Florida

Nature of Work: Scheduling irrigation is extremely complex because of the large numbers of different plant species, the various sizes of containers and plants, and different stages of growth that can be found in the nursery. Irrigation water can be used more efficiently when plants with similar water requirements are grouped to permit irrigation scheduling based on plant needs. Nursery irrigation requirements are largely determined by plant species, time of year, and geographic location (4). Environmental factors such as rainfall, light intensity, temperature, relative humidity and wind speed also influence irrigation demand. These environmental factors vary with time of year and geographic location. Finally, plant size, growth rate, and stage of growth also affect water use.

The objective of this project was to determine water use by plants grown under optimum nursery conditions. Liners of Juniperus horizontalis `Wiltonii´ (blue rug juniper), Ilex crenata `Rotundifolia´ (`Rotundifolia´ holly), Rhododendron x `Hershey’s Red´ (`Hershey’s Red´ azalea), Pyracantha x `Teton´ (`Teton´ pyracantha), and Photinia x fraseri (redtip) were grown in 1-gallon containers with a pine bark, sphagnum peat, sand medium (2:1:1). A slow-release fertilizer (Osmocote 18-6-12, Sierra Chemical Co., Milpitas, CA) was incorporated in the medium at the rate of 10 lbs/yd³ and supplemented by surface applications of 9g (0.3 oz) per container every three months. Plants were grown under a clear vinyl-covered structure to exclude rainfall but allow ambient temperature, wind, relative humidity, and about 70 percent of full sunlight.

Plants were irrigated on an as-needed basis to avoid stress. A micro irrigation system was used to irrigate each container with one half inch of water every one to five days as needed. Containers were placed on tables to facilitate collection of leachate from each container. By subtracting the volume of leachate from the known volume of irrigation water, it was possible to calculate the actual water use of each plant (the volume lost by evapotranspiration). Results and Discussion: Water use data were collected for almost a one year period: from June 24, 1986 through June 19, 1987. Problems with the irrigation system prevented collection of data for two weeks in October 1986 and after June 19, 1987. Throughout the 51-week period, evaporation was recorded from a National Weather Service Class A evaporation pan. Plant heights and widths were measured every four to six weeks.
Pyracantha and photinia plants rapidly grew to a salable size during the first few months of the experiment. Groups of photinia and pyracantha liners replaced the full-grown plants in September and October, thus producing two crops during the experiment.

The cool, north Florida winter caused a quiescent/dormant period that ranged from 11 weeks for photinia to almost 24 weeks for azalea. Azalea plant growth stopped in early October, and pyracantha and photinia in mid-November. Azalea, holly, juniper and photinia resumed growth in mid-February, while pyracantha dormancy continued until mid-March.

During active growth, weekly water use was greatest for azalea (5.3 oz) followed by pyracantha (5.0 oz), holly (4.8 oz) and juniper (4.6 oz), with photinia consuming the least water (3.6 oz). Although this study cannot be directly compared to previous research, the values of water use/week during active growth are within ranges reported for summer water consumption of sub-tropical landscape plants in south Florida (1, 2).

During the 5l-week period, the largest total amounts of water were consumed by pyracantha (13.3 gal) and azalea (12.7 gal), followed by holly (11.4 gal) and juniper (11.0 gal). Photinia plants consumed the least water (9.9 gal). However, since two crops of pyracantha and photinia were produced during this period, these two species are more efficient users of water.

Because plants in this study were watered on an as-needed basis, this water use information represented the maximum amount of water that these plants would utilize under the specific environmental conditions of that 5l-week period. Other factors also could modify water use of container-grown plants. In a nursery situation, rainfall would provide some of the plants’ water needs. Also, additional irrigation is usually necessary to account for the low efficiencies of most sprinkler irrigation systems, for leaching excess soluble salts, and for water losses due to drift, evaporation, and deflection by foliage.

Close relationships were found between pan evaporation and plant species and size (3). These results suggest that it may be possible to develop equations to determine irrigation needs of nursery crops based on the plant species, size, and pan evaporation (or other environmental measurements). References


EFFECTS OF COMPOSTING PERIOD AND MINERAL AMENDMENTS ON PRODUCING A GROWING MEDIUM FOR AZALEA

John A. Watkins and W.T. Witte
Tennessee

Nature of Work: In recent years, the search for adequate replacements for more expensive media components for container grown plants has become increasingly important. The use of milled pine and hardwood bark has been widely noted (1,2,3,4,5). Svenson and Witte (7) showed that superior growth of a wide variety of plants occurred in a 50:50 blend of composted hardwood:pine bark that took approximately 13 weeks of composting to stabilize to a temperature of 40°C (104°F). Favorable results with noncomposted blends of hardwood bark and pine bark indicate that a semi-stabilized bark compost may be a suitable container media. A faster composting time, or using a partially composted media, would have greater appeal to nurserymen as it would reduce the time required to prepare the media as well as reducing shrinkage.

Chemical analysis of media and plants in previous experiments (6) showed high levels of potassium. Thus one factor of this experiment was the elimination of potassium nitrate. Conversely, magnesium levels were lower than desired, so a second factor of this experiment was the addition magnesium sulfate. The pH of the finished 50:50 blend of compost was 5.6. A pH of about 6.2 would be more favorable, thus elimination of sulfur was a third factor. This experiment was also designed to contrast the effects of composting period to determine if a semi-stabilized bark compost would be suitable as container media. This yielded sixteen treatment combinations in a 2 x 2 x 2 x 2 factorial arrangement for the initial composting ‘recipe’. 
Precisely 1.55 m$^3$ (2yd$^3$) each of pine bark and hardwood bark were measured and placed in each of eight bins arranged in a windrow fashion. The material was mixed thoroughly by turning with a front end loader. The differing starter amendments (Table 1) were added and the piles again mixed thoroughly and wetted to achieve a moisture content of 70%. Piles were turned on a weekly basis. Targeted endpoints for the composting procedures were 50°C (122°F) and 40°C (104°F). Endpoints were achieved when a pile which had previously been hotter than the target endpoint was turned and then failed to exceed the target temperature after 3 or 4 days. Sufficient media for the plant production phase of the experiment was removed as each endpoint was achieved. Liners of Rhododendron var. ‘Red Ruffles’ were planted in 2 gal. containers in each media and observed for one growing season. Ten replications were arranged in a randomized complete block design. A single application of Osmocote 18-6-12 was applied at the rate of 20 grams/pot two weeks after planting. Uniform watering was accomplished by the use of a drip irrigation system.

In evaluating the subsequent growth of the azaleas, a growth index (GI) was developed. Plant height in cm. was taken from medium level to tip of tallest stem, plant width in cm. was taken at plant’s widest dimension (width A) and again perpendicular to this (width B). The growth index was then calculated using the following formula:

$$GI = \frac{cm \text{ width A} + cm \text{ width B}}{2}$$

**Results and Discussion:** The 50°C (122°F) endpoint was reached in approximately 6 weeks. An additional 3 weeks were required to reach the 40°C (104°F) endpoint. Analysis of variance showed significant differences between the two endpoints for both GI and fresh weight of the azaleas. No significant differences in growth were found due to the main factors of mineral amendments, though some complex interactions occurred. Plants grown in media composted to the 40°C (104°F) endpoint consistently had higher GI and fresh weight compared to counterpart media composted to the 50°C (122°F) endpoint (Table 2). The highest GI and fresh weight was obtained by media containing nitrogen only composted to the 40°C (104°F) endpoint. The lowest GI was found in media containing nitrogen only composted to the 50°C (122°F) endpoint while the lowest fresh weight was found in media containing all three amendments composted to the 50°C (122°F) endpoint.

These data show that the growth of ‘Red Ruffles’ azaleas in a 50:50 hardwood:pine bark blend of media is significantly influenced by the length of composting. Best growth occurs in a medium that is allowed to complete the composting process to a stabilization temperature of 40°C (104°F). No significant differences in growth were found to be due to mineral amend-
ments when the media was allowed to stabilize to a temperature of 40°C (104°F). Therefore eliminating sulfur, potassium nitrate, and magnesium sulfate added at the beginning of composting will enable nurserymen to produce a good container growing medium for azaleas while cutting costs on mineral amendments added prior to composting.

LITERATURE CITED


(Table 1)
SLOW RELEASE FERTILIZERS WITH MINOR ELEMENTS
TOPDRESS VS. INCORPORATION ON 100% BARK MEDIUM

Ken Tilt, Willard T. Witte, Mark Halcomb, and John Watkins
Alabama and Tennessee

Nature of Work: Demonstration/research plots were established at two locations: Mountain Creek Nursery near McMinnville and the OHLD Research Nursery at UT-Knoxville. The objectives were to 1. determine whether topdressing or incorporation of slow release fertilizer with minor elements increased plant growth, and 2. monitor longevity of these products via leachate soluble salts.

On April 12, 1989, Berberis thunbergi ‘Aurea’ was planted at Mountain Creek Nursery near McMinnville in #l nursery containers in pine bark medium with no other amendments. Fertilizer products were either topdressed or incorporated at the intermediate rate recommended on the product label as follows:

A. Sierra 17-6-12 plus minors 3-4 month release @ 9 grams/container or 6 lbs/yd³;

B. Sierra 17-6-10 plus minors 8-9 month release @ 15 grams/container or 10 lbs/yd³;

C. Sierra 16-6-10 plus minors 12-14 month release Q 12 lbs/yd³; These are trademarked by Sierra Chemical Co., Milpitas, CA.

Due to lack of material, fertilizer C was used on only 7 samples per replication and the top dress treatment eliminated. All other fertilizers at this location
were used in both topdressed and incorporated treatments. A randomized incomplete block design was used with 4 replications and 15 samples (containers) of each treatment per replication.

Plants were measured for height and two widths on Dec 11, 1989. A growth index was calculated by using the mean of the two widths, adding the height and dividing by two. Analysis of variance was performed on the data and main effect means separated with Duncan’s Multiple Range Test at the 5% level.

The second trial was planted at the UT-Knoxville research nursery April 20, 1989. Uniform quart liners of *Photinia fraseri, Ilex x attenuata ‘Foster #2’, Juniperus conferta ‘Blue Pacific’, Rhododendron x obtusum ‘Red Ruffles’, and Cupressocyparis x leylandii ‘Silver Dust’* were potted using unamended pinebark medium in #2 containers. We applied 45 grams fertilizer per container, either top dressed or incorporated, except azaleas received 25 grams per container. Ten replications of each species except azalea which had five replications were arranged in a randomized complete block, with a single container per treatment per replication. Data was recorded in early December 1989. Azaleas were measured like the barberry, and a growth index calculated the same way. Height and caliper was recorded for photinia, Foster holly, and leyland cypress. Average length of the three longest runners and average width was recorded for shore juniper. Analysis of variance was performed on the data and means separated at the 5% level with a Waller/Duncan Multiple Range Test, where appropriate.

Soluble salt levels were monitored about every two weeks beginning July 18 and ending November 10, using the VTEM method (1). Micromhos/cm of leachate from each container in replication 1-5 of juniper was measured with a Hach multirange conductivity meter. Mean values were plotted for each fertilizer/method combination.

**Results and Discussion:** Table 1 shows Sierra 16-6-10 plus minors resulted in larger golden barberry plants than the other two fertilizers in the McMinnville trial. Nitrogen rates were not equivalent due to use of label rates for each fertilizer. Fertilizer incorporation resulted in statistically larger plants than simple topdressing, with a growth index of 34.6 vs 33.7. The statistical analysis was able to pick up this small difference because of the uniformity and large numbers of plants in the experiment. Growers will have to decide whether the 3% advantage in growth obtained is sufficient to offset the labor and cost of incorporation or whether it is more efficient to topdress.

In the Knoxville trials, few differences occurred. Nitrogen rates per container were nearly equivalent (Tables 2, 3, 4). No differences in growth index attributable to type of fertilizer or method of application were obtained for azalea.
No main factor effects were significant for height or caliper in leyland cypress, though Table 2 shows an interaction occurred with fertilizer C, Sierra 16-6-10 plus minors, 12-14 month release, where the incorporated treatment resulted in shorter plants.

No main factor effects were significant for height in photinia, with all plants about 120 cm (4 ft) tall. Table 3 shows an interaction in caliper (mm) measured 4 inches above the surface of the media, with less growth in the incorporated treatment of the 3-4 month release product.

Shore juniper was unaffected by fertilizer type, but produced wider plants with longer runners when fertilizer was incorporated (33 vs 38.7 cm average width). This translates into 17% advantage in growth.

No main factors were significant for height or caliper of Foster holly, but Table 4 shows the interaction for caliper where fertilizer A, the 3-4 month release product, had smaller caliper in the topdressed treatment than fertilizer B, the 8-9 month release product.

Figure 1 shows the downward trend of leachate conductivity (soluble salts) during summer and fall in the UT-Knoxville trial. Fertilizer A, having the quickest release rate, was consistently below the other two in leachate conductivity. Since monitoring began two months after initiation of the experiment, we may have missed any higher earlier release. Soluble salt levels were lower than the 750-1500 micromho level suggested by Wright(1) but growth was satisfactory. We also monitored leachate pH at UT-Knoxville (Figure 2). The low initial pH values on July 18 were due to overhead irrigation followed by rainfall during the previous day. Thereafter all plants were on drip irrigation and there was little rain. There was no statistical difference between fertilizer treatments, and pH declined from a high of about 7 on Aug 2 to about 6 on Nov 10. Our irrigation water averaged about 7.7 during that time.

Results of the McMinnville trial showed the Sierra 16-6-10 plus minors 12-14 month release product increased growth by 10-15% over the other two treatments at labelled rates. The Knoxville trials, where nitrogen rates were nearly equivalent, did not show any consistent advantage due to fertilizer type. The McMinnville trial showed incorporation produced slightly larger plants. The Knoxville trials showed this only for shore juniper. Several interactions occurred in the Knoxville trials that make it difficult to give a clear recommendation for type of fertilizer or method of application. Observations at both locations showed the best treatments produced plants as large as those obtained from standard nursery practice (data not presented). As a practical matter, it appeared that good quality salable plants could be produced in straight pine bark with the simple method of topdressing with the slow release fertilizer plus minors products. This could prove to be
very attractive to smaller growers without adequate machinery or facilities to do a good job of mixing amendments into their growing medium.

LITERATURE CITED


(Table 1)

(Table 2)
(Table 3)

(Table 4)
(Figure 1)

(Figure 2)
Composted Rice Hulls and a Light Weight Clay Aggregate as Components of Container-Plant Growth Media

Adolph J. Laiche, Jr. and V. E. Nash
Mississippi

NATURE OF WORK: Organic materials such as pine bark or peat moss and inorganic materials such as builders’ sand, calcined clay, perlite and vermiculite are used to formulate growth media for production of woody ornamental landscape plants in containers (1, 3). Two to three million acres of land are planted in rice in the U. S. each year. The major production areas are in Mississippi, Louisiana, Texas, Arkansas, and Missouri. Large quantities of rice hulls are readily available as a by-product from the milling process. Fresh rice hulls are composted for use as a growth medium by first storing them in pits where anaerobic decomposition occurs. The hulls are then removed from the pits and piled in windrows for aerobic decomposition. The temperature of decomposing hulls may reach 55 to 66°C (130 to 150°F) (2). Arkalite (Arkansas Lightweight Aggregate Corp., West Memphis, Ark) is a light weight clay aggregate used to manufacture light weight concrete masonry units and is also marketed as a ground covering material for use by the landscape industry.

The objective of these studies was to compare composted rice hulls and Arkalite to pine bark and sand media components for plants grown in containers. Factorial experiments utilizing randomized complete block designs were conducted in 1982, 1984, and 1985. Treatments in 1982 were 4 volumes of fresh milled pine bark or composted rice hulls mixed with 1 volume of builders’ sand or Arkalite of 3 particle sizes (screened, crushed or blended) and each treatment amended or not amended with 4.7 kg/m³ (8 lb/yd³) dolomitic limestone. All media blends were amended with slow-release 18N-2.6P-IOK (18-6-12) (Sierra Chemical Co., Milpitas, CA), at 4.5 kg/m (7.5 lb/yd³). Treatments were replicated 6, 6 and 5 times for Rhododendron indicum ‘Formosa’, Ilex crenata ‘Compacta’ and Juniperus horizontalis ‘Plumosa’, respectively. Liners of ‘Formosa’, ‘Compacta’ and ‘Plumosa’ were planted in 6 liter (#2), 3 liter (#1) and 3 liter (#1) containers, respectively on April 15, 1982. Additional slow-release fertilizer was surface applied at 6.7 g (2.4 oz)/container on July 23 to ‘Compacta’ and ‘Plumosa’ and on August 2, 1982 to ‘Formosa’. The study was terminated on October 29, 1982.

Two experiments with Rhododendron indicum ‘Formosa’ in 6 liter (#2) containers were conducted under 45% shade in 1984. Experiment I consisted of three media treatments of pine bark : composted rice hulls : sand [4:0:1, 2:2:1, and 0:4:1, respectively (v/v/v)]; three of pine bark : composted rice hulls : crushed Arkalite [4:0:1, 2:2:1 and 0:4:1, respectively (v/v/v)]. Two rates of 17N-3P-IOK (17-7-12) fertilizer, (Sierra Chemical Co., Milpitas, Ca.)
5.3 and 8.9 kg/m³ (9 and 15 lb/yd³), were added to the 6 media blends. All media treatments were amended with 1.2 kg/m³ (2 lb/yd³) of dolomitic limestone. Experiment II consisted of pine bark or composted rice hulls mixed with sand in a 4:1 ratio (v/v), two rates of dolomitic limestone, 0 and 1.2 kg/m³ (0 and 2 lb/yd³) and two rates of 17N-3P-10K (17-7-12) fertilizer, 5.3 and 8.9 kg/m³ (9 and 15 lb/yd³). Media treatments in both experiments were replicated 7 times. Both experiments were begun on April 17, 1984 and terminated on October 15, 1984.

Growth media treatments in 1985 consisted of pine bark : composted rice hulls : sand in ratios of 4:0:1, 2:2:1, and 0:4:1, respectively; dolomitic limestone rates of 0, 1.2 and 4.7 kg/m³ (0, 2, and 8 lb/yd³); and 17-7-12 rates of 25 and 42 g (0.9 and 1.5 oz) /container. Liners of Juniperus conferta ‘Emerald Sea’, Rhododendron x ‘Herbert’ and Raphiolepis indica ‘Elizabeth’ were planted on April 10, 1985 in the media for each treatment and replicated 4 times in 3 liter (#1) containers. The study was terminated on October 10, 1985.

All experiments were amended with 0N-8.6P-0K (0-20-0) and fritted trace elements (FTE 550) at 0.59 kg/m³ (1 lb/yd³) and 74 g/m³ (2 oz/yd³), respectively. Plant growth data were taken at the end of each experiment. Samples of the media were taken at the initiation and at the termination of the study conducted in 1982 with container plants of Ilex crenata ‘Compacta’.

RESULTS AND DISCUSSION: Analysis of growth media samples indicated that calcium and magnesium were contained in rice hulls and Arkalite and were released during the experiment. Pine bark contained magnesium but not calcium. Plant growth with the inorganic materials of sand and Arkalite was generally similar. Growth data obtained in these studies indicated that composted rice hulls were a good substitute for pine bark as an organic component of container plant growth media. The growth of container plants when the organic component was 100% composted rice hulls or 50% composted rice hulls and 50% pine bark compared favorably with the growth obtained with 100% pine bark. The addition of dolomitic limestone at 4.7 kg/m³ was detrimental to the shoot growth of Rhododendron ‘Formosa’, Juniperus ‘Plumosa’ and Ilex ‘Compacta’ in 1982 and Rhododendron x ‘Herbert’, Raphiolepis indica ‘Elizabeth’ and Juniperus ‘Emerald Sea’ in 1985 indicating that this rate of dolomitic limestone should not be added to growth media with the organic component of 50 or 100% composted rice hulls. Best growth was obtained using 0 or 1.2 kg/m³ of dolomitic limestone with composted rice hulls. Results with 4.7 kg/m³ of dolomitic limestone with pine bark were variable. This rate decreased shoot fresh weight of 2 of 3 test plants in 1982 and increased shoot fresh weight of 2 of 3 test plants in 1985. Poorer root
systems were obtained with 4.7 kg/m³ of dolomitic limestone regardless of the growth medium. Excellent growth, comparable to the growth obtained with pine bark, was obtained with composted rice hulls when zero or very small amounts of dolomitic limestone were added to composted rice hulls.

LITERATURE CITED


Effects of Media Blends of Pine Bark With Peat Moss, Fresh Pine Wood Shavings, Composted Rice Hulls or Sand on the Growth of Azaleas

Adolph J. Laiche, Jr.
Mississippi

NATURE OF WORK: Pine bark has become a major organic component of container-plant growth media and has been used successfully mixed with peat, soil, sand, vermiculite and perlite (1, 2, 4, 7, 10). Pine wood shavings, another by product of the forestry industry, is a readily available material that has been used as a peat substitute in growth media containing top soil to produce azaleas (8). It has been suggested that pine shavings constitute no more than one-fourth of the growth medium by volume (2) when used as a component of container-plant growth media. Composted rice hulls have been found to be a practical soil substitute in container-plant growth media (3). Growth of plants grown in a medium of composted rice hulls, in a 1:1 (v/v) mixture with pine bark and as a single component growth medium, compared satisfactorily with pine bark mixed with sand in a 4:1 (v/v) ratio and as a single component growth medium (5, 6).

Many growers use pine bark as the only organic component of their growth media for woody landscape plants with the exception of azaleas. Pine bark -
peat moss blends are preferred to produce azaleas (9). The objective of this study was to compare the growth of three azalea cultivars produced in growth media blends of pine bark with peat moss to blends of pine bark with fresh pine wood shavings, composted rice hulls or sand.

Liners of Rhododendrons (azaleas) ‘Carroll’, ‘Adelaide Pope’ and ‘Hinodegiri’ were planted in 1 gallon containers on April 14, 1987. All growth media blends were amended with 2 lbs of dolomitic limestone, 1 lb of 0-18-0, 1 1/2 lb of Micromax TM and 4 lb of 17-7-12 slow release fertilizer (Osmocote TM) per cu yd. Sta-green, 20-5-10, 5 grams (1 teaspoon) and slow release 17-7-12, 13.2 grams (6 lb/cu yd) were surface applied on May 27, 1987. All plants were grown in full sun and irrigated with an overhead system.

Treatments were growth media blends of pine bark with peat moss, wood shavings, composted rice hulls or sand in volume ratios of 1:1, 2:1 and 4:1, Table 1. Separate experiments were conducted with each cultivar. The 12 treatment combinations were arranged in a randomized complete block design with 7 replications per cultivar with 1 container plant as an experimental unit. The study was terminated on October 20, 1987.

RESULTS and DISCUSSION: A significant interaction was observed between component and ratio with fresh weight of azalea ‘Hinodegiri’. Only with pine shavings was the fresh weight of ‘Hinodegiri’ less at a 1:1 ratio when compared to ratios of 2:1 and 4:1, Table 1. Differences due to growth medium ratio were not obtained with one exception. With azalea ‘Carroll’ a significantly higher growth index was obtained with a 1:1 ratio, 11.1 inch, compared to ratios of 2:1, 10.6 inch, and 4:1, 10.7 inch.

The incorporation of peat moss with pine bark consistently resulted in excellent growth with the three cultivars used in this test, Table 2. Acceptable growth was also obtained with amendments of composted rice hulls or sand. Generally, growth was slightly better with composted rice hulls compared to sand and poorest growth was obtained with pine shavings, Table 2.

When using peat it is important to note, due to its high cost, that the growth medium need not consist of a high percentage of peat. In this study, beneficial effects were obtained by amending pine bark growth media with as little as 20% peat moss. Azalea growers using media without peat and not meeting production schedules because of unacceptable quality may find the added expense of using peat as a component of their growth media justified.


(Table 1)
(Table 2) verticle
Effects of Container Size and Slow Release Fertilizer Rate on the Growth of Two Woody Landscape Plants

Adolph J. Laiche, Jr. and Steven E. Newman
Mississippi

NATURE OF WORK: Slow release fertilizers are applied to container plants by incorporation during blending of growth medium components, or top dressed, or applied in a dibble hole directly beneath the transplanted liner at rates determined on a volume (cubic yard) basis (1, 5, 6, and 8). Methods of incorporation during blending or by dibble application can only be used at planting. Subsequent slow release fertilization is accomplished by surface application. Regardless of the method of application, fertilization on a volume basis results in greater amounts of fertilizer per plant as container size increases. However, greater per plant amounts of fertilizer may not be justified with increasingly larger containers, especially with container capacities exceeding 5 gal.

Laiche (4) found no difference in plant size or foliage color of azalea ‘Formosa’ grown with 7.0, 9.5 or 12 lb of slow release 18-6-12/cu yd in 3 versus 5 gal containers. In contrast, Goodale and Whitcomb (2) found that growth varied among the species tested, when using 4 different container sizes (diameter from 5 inch to 8 inch) and 18-6-12 fertilizer rates of 0.4 to 1.1 oz/container-plant. Elaeagnus increased in size as fertilizer rate increased, but not as container size increased. Juniper and pyracantha increased in size as fertilizer rate and container size increased. No or only slight differences were obtained with Dwarf Burford holly and aucuba. Barberry did not grow well in the larger containers. Tilt et al. (7) obtained a 2-fold increase in top dry weight of three test plants as container volume increased from 1 to 3 gal. Amendments added to the growth medium during the blending procedure included 6.3 lb/cu yd of 18-6-12. Hanson et al. (3) found that container size and shape influenced oak seedling growth. Increased shoot and root dry weight was obtained in 6 x 14 inch containers than in smaller containers, however growth was not increased in 6 x 43 inch containers. Fertilization was in proportion to container sizes so all received the same amount of fertilizer per unit volume of potting medium.

The objective of this study was to determine the effects of four container sizes and six fertilizer rates of 17-7-12 slow release fertilizer on the growth of Rhododendron ‘Formosa’ and Ilex aquifolium x cornuta ‘Nellie R. Stevens’. The experimental design for each cultivar was a split plot with 6 replications. Main plots were 4 container sizes (1.5, 3, 6 and 12 gal). Subplots were 6 fertilizer rates. Experimental units were one container plant with the exception of the 1.5 gal container size which consisted of 2 container plants. Liners in 0.34 qt containers (3 inch square pots) of ‘Formosa’ and ‘Nellie R. Stevens’ were transplanted into 1.5, 3, 6 and 12 gal containers on April 29 and
May 18, 1987, respectively. The growth medium was 100% pine bark. One day after planting, an amendment mixture and complete fertilizers 20-5-10 and 17-7-12 were surface applied and the growth medium cultivated 2-3 inch deep. The amendment mixture consisted of 2 lb of dolomitic limestone, 1 lb of Micromax (Sierra Chemical Company, Milpitas, CA 95035) and 1 lb of simple super phosphate (0-20-0) applied at the rate of 3 lb/cu yd. This amendment mixture was reapplied without media cultivation on August 19, 1987, and April 5 and July 6, 1988. Complete fertilizer, 20-5-10 (Parker Fertilizer Company, Sylacauga, AL 35150), was applied one time in a circular band 5 to 6 inch from the liner ball at 0.2 oz per container plant.

Treatments using 17-7-12 slow release fertilizer (Sierra Chemical Company, Milpitas, CA 95035) were applied at rates of 1, 2, 4, 8, 12 and 16 lb/cu yd. In 1988, the same treatments with the 17-7-12 fertilizer were reapplied without medium cultivation at the rates used in the spring of 1987 on April 5 and at one third this spring rate on July 6. Therefore, total amounts of 17-7-12 fertilizer applied per treatment in 1988 were 1.3, 2.6, 5.3, 10.6, 15.9 and 21.2 lb/cu yd. Plants were grown in full sun and irrigated as required with overhead sprinklers. Nineteen months after planting (November 1988) plants were severed at the growth medium surface to obtain shoot fresh weight.

RESULTS AND DISCUSSION: Fertilizer rates used in this study were on a volume basis. Therefore, the amount of fertilizer applied per container plant increased as container size increased. Compared to plants in 1.5 gal containers, fertilizer applied per plant in the 3, 6 and 12 gal containers was 2, 4 and 8 fold higher, respectively. In addition to comparisons of fertilizer rates on a volume basis, comparisons of container sizes were made between plants with identical fertilizer rates per unit plant.

Comparisons - Fertilizer Rates Per Unit Volume - Fresh weight of ‘Formosa’ increased either linearly (1.5 gal containers) or quadratically by increased fertilizer rate, Table 1. A linear increase was obtained with container size. Fresh weight of ‘Nellie R. Stevens’ increased quadratically by fertilizer rate in all container sizes, Table 1, and linearly by container size 19 months after transplanting.

Comparisons - Fertilizer Rates Per Unit Plant - At fertilizer rates of 0.3 to 1.2 oz/plant of 17-7-12 there were no differences in fresh weight due to container size for either cultivar, Tables 2 and 3. At higher rates, plant growth was restricted by smaller container sizes with both species, Tables 2 and 3. At 2.5 oz/plant less growth was obtained in 1.5 gal and 3 gal containers compared to 6 gal and 12 gal containers with both cultivars, although the growth obtained with ‘Formosa’ in 3 gal containers was not different than growth obtained in 12 gal containers. At 5 oz/plant less growth was obtained in 3 gal containers compared to 6 gal and 12 gal containers with ‘Formosa’. At 5 oz/plant growth of ‘Nellie R. Stevens’ was reduced by container sizes of 3 gal
compared to 6 gal and in 6 gal compared to 12 gal. At 10 oz/plant less growth was obtained with both cultivars in 6 gal containers compared to 12 gal containers, Tables 2 and 3.

Results on a per plant basis with both cultivars indicated that optimum growth was obtained in larger containers only in the presence of sufficient quantities of fertilizer. At low fertilizer rates per plant growth in large containers was not increased. At high fertilizer rates per plant small container size restricted growth.

Fertilizer rates applied per plant, at which reduced growth occurred, shared common lb/cu yd fertilizer rates. For example, growth of ‘Formosa’ in 3 gal containers and ‘Nellie R. Stevens’ in 6 gal containers was reduced at 2.5 and 5 oz/plant, respectively, rates equivalent to 10.6 lb/cu yd. Similarly, reduced growth was obtained with both cultivars in 1.5, 3 and 6 gal containers at 2.5, 5 and 10 oz/plant, respectively, rates being equivalent to 21.2 lb/cu yd. The results of this study conducted for two growing seasons with two cultivars indicate that growth was restricted by container size in 1.5, 3 and 6 gal containers when 17-7-12 fertilizer rates were increased to 10.6 lb/cu yd and beyond.

**Literature Cited**


(Table 1)
(Table 2)

(Table 3)
Growth and Quality of Two Bedding Plant Species in Peat Moss and/or Expanded Shale Potting Media

Mark A. Nash, Tim P. Brubaker, and Billy W. Hipp

Texas

Nature of Work: The availability and economics of currently-used potting media components is unpredictable over the long-term. Therefore, potting media formulated from alternative materials have been investigated (1,3,4,5). Most of these research efforts have centered on organic materials; less emphasis has been placed on inorganic materials as potting media constituents.

Expanded shale (Texas Industries, Dallas, TX) is used for manufacturing foundation blocks in the building industry. Preliminary observations showed that expanded shale absorbs water and possibly plant nutrients similarly to vermiculite. However, moist vermiculite can be irreversibly compressed (2) during potting operations which reduces air space and possibly available water content of media formulated with it, whereas expanded shale is resistant to compression forces. Expanded shale has a similar configuration to that of perlite, but is less fragile. Thus, initial physical properties of potting media with expanded shale as a component should remain more constant with time than media composed of less stable components. This study was conducted to evaluate potential of expanded shale as a potting medium constituent for container-grown bedding plants.

A greenhouse study was conducted to investigate 2 grades of expanded shale (coarse and fine) alone or in various combinations with peat moss (PM) as substrates for growing two species of bedding plants. Five PM and/or shale media ranging from 100% shale to 100% PM, in 25% increments of PM, were prepared for both coarse shale (CS) and fine shale (FS). Uniform liners of Petunia hybrida ‘Rose Flush’ and Impatiens F₁ ‘Accent Red’ were potted in 500 ml of each medium on January 12 and 22, 1990, respectively. All plants received 0.7 ml dolomitic lime to supply Ca and Mg. All other plant nutrients were supplied with weekly 100 ml applications of Miller Greenhouse Special 20-20-20¹ which contains micronutrients as well as most macronutrients. The fertilizer rate was 150 ppm N. Plants were watered daily or every 2 days depending on environmental conditions.

Air space and container capacity of each peat moss-shale mixture was determined. Beginning January 19 and February 2 for Impatiens and Petunia, respectively, weekly growth indices were measured and calculated as the average of height measured from the medium surface to the tip of tallest stem and 2 width measurements taken perpendicular to each other. Weekly visual
quality ratings were taken beginning February 2 and 16 for Impatiens and Petunia, respectively. Ratings ranged from 0 to 9 where 0 indicates a dead plant and 9 indicates exceptional quality in terms of color, compactness of growth, and overall marketability. Values of 5 or above were considered marketable. At the termination of the study, shoot dry weights were measured.

The experiment was conducted as a completely randomized design with 5 replications of each of the 9 medium treatments. Each plant species was treated as a separate experiment. Statistical analyses consisted of analysis of variance and mean separation by the Student-Newman-Keuls test (P = 0.05). Effects of peat moss/shale ratio were evaluated by regression analysis.

**Results and Discussion:** In both plant species, the growth index and quality increased quadratically with increasing PM in PM-CS media and linearly with increasing PM in PM-FS media. Highest growth and quality of Impatiens and Petunia occurred in PM-CS media with at least 50% PM and in PM-FS media with at least 75% PM on most sample dates. In PM-CS, highest growth occurred in media with an air space (AS) ranging from 17.3% (75 PM/25 CS) to 21.2% (100 PM) and a container capacity (CC) of 35.8% (75 PM/25 CS) to 46.8% (100 PM). However, in PM-FS, highest growth occurred in media with an AS ranging from 7.8% (75 PM/25 FS) to 21.2% (100 PM) and a CC of 46.8% (100 PM) to 62.9% (75 PM/25 FS). Thus, no relationship was found between plant growth and CC or between plant growth and AS. Shoot dry weights of both plants increased quadratically with increasing PM in PM-CS mixtures. Dry weights of impatiens increased quadratically with increasing PM in PM-FS, but petunia responded linearly with increasing PM in these PM-FS mixtures.

Observations of the root system of both plants at the termination of the study showed that roots of both plant species occupied the entire container profile in 100% PM media or PM-CS media whereas the root systems in PM-FS media were restricted to the upper half of the profile. This suggests poor air/water relations in the lower profile of PM-FS mixtures. Differences in total volume of the media profile with acceptable air/water properties may account for differences in optimal AS and CC between PM-FS and PM-CS mixtures.

This study showed that expanded shale has potential as a growing medium component for bedding plants when mixed with PM. The proportion of shale which may be used in a potting medium appears to depend on the grade of shale and plant requirements. Air space and CC are often measured by growers to evaluate potting mixture air/water relations since the procedure requires no specialized equipment. This study, however, demonstrates that AS and CC is not enough information on air/water relations for selecting the PM/shale ratio needed for growing bedding plants.
**WATER RELATIONS AND CONSUMPTIVE WATER USAGE OF SELECTED CONTAINER GROWN LANDSCAPE PLANTS**

Fred T. Davies, Jr., Jayne M. Zajicek and Sharon A. Duray
Texas

**Nature of Work:** The nursery and landscape maintenance industries need to have identified landscape plants which are water-use efficient. Furthermore, the minimum amount of water needs to be determined for producing and maintaining commercially desirable landscape plants without reducing quality. There are increasing demands for low maintenance, drought resistant, native landscape plants to benefit the consumer. To date, little research has been conducted on water usage and water relations of low-maintenance, drought resistant landscape plants. Questions to be answered are how does water usage and drought resistance of native plants compare with nonnative species? The objective of this research was to determine water relations and
consumptive water usage of selected container grown landscape plants under optimal irrigation conditions. Establishment of non-water stressed baselines of selected woody plant species is a key to measuring and interpreting plant water stress. Our goal is to develop a list of recommended water-use efficient landscape species for nursery producers, retailers and ultimately the consumer.

Materials and Methods: Seven species of woody ornamental plants (Salvia gregii, Anisacanthus wrightii, Myrica cerifera, Ilex vomitoria, Euonymous kiautschovica, ‘Manhattan’, Viburnum suspensum, and Magnolia grandiflora) were planted in 3.8 liter containers containing 4 composted pine bark:sand (v/v) amended with 3.7 kg/m$^{-3}$ (6.3 #/yd$^3$) 18N-6P-12K, 3 kg/m$^{-3}$ (5.1 #/yd$^3$) gypsum and dolomitic limestone and 74.2 g/m$^{-3}$ (20z/yd$^3$) fritted trace elements. Plants were established for 10 weeks prior to the start of the experiment. The study was initiated on November 16, 1987 in a glasshouse with a maximum PPFD of 1260 µmol m$^{-2}$s$^{-1}$ at plant height, night temperatures of 18°C (65°F), and day temperatures of 30°C (85°F). The study consisted of two 2-day cycles beginning the evening of November 16, when plants were hydrated and then rehydrated 2 days later on November 18. Following each hydration, containers were covered with polyethylene bags which were secured around the plant crown to prevent moisture loss from the container medium surface. A completely randomized design was used with the main effect consisting of the 7 species. Analysis of variance procedures were performed on all data, and means separations were determined by Duncan’s Multiple Range test.

Leaf water potential (L) was measured with a Scholander-type pressure chamber at 0600 hr on the 1st morning of the 1st and 2nd cycles and at 1400 hr of the following days. To reduce transpiration losses and possible error during afternoon readings, leaves were enclosed in polyethylene bags and removed from the plant for leaf water potential determination. Measurements were taken on 4 plants/species with 2 subsamples/plant (n=12). Leaf transpiration (T) and stomatal resistance (r) were determined with a LiCor 1600 Steady State Porometer. Measurements were taken each morning and afternoon of the study using 4 plants/species with 3 subsamples/plant (n=12). Whole plant transpiration (E) was determined through gravimetric means using ten plants/species weighed daily at 0800 hr and 1600 hr. From these data and leaf areas measured at harvest, transpirational water flux (E) on a whole plant basis was determined.

The study was terminated after 4 days on November 20, 1987. Upon completion of the study, plants were harvested and leaf area, leaf number, shoot dry weight, root dry weight, and root to shoot ratios were determined.

Results and Discussion: Whole Plant Transpiration and Total Water Transpired - Whole plant transpiration (E) was calculated using the equation: (mg
H₂O lost) (m² s⁻¹). Under nondrought conditions, Salvia and Myrica had the highest E, while Viburnum, Magnolia and Euonymous had low E. The total amount of water transpired per plant was greatest with Viburnum and Salvia and lowest with Myrica and Ilex; Anisacanthus, Euonymous and Magnolia had intermediate levels of transpirational loses.

**Leaf Water Potentials:** Ilex and Magnolia maintained high (least negative) L throughout the experiment. Although Viburnum initially had a high predawn L at the beginning of each cycle, it had the lowest (most negative) L at the end of each cycle.

**Leaf Transpiration and Diffusive Resistance:** Myrica and Anisacanthus generally had the highest leaf transpiration (T) rates and the lowest diffusive resistance (r) values. Salvia had low r, but intermediate T values. Magnolia and Viburnum had high r and low T by the end of each cycle. Due to leaf size, Ilex was not studied for T and r.

**Plant Growth and Development** - Viburnum had a significantly higher leaf area and total shoot and root dry weight than the other species in the study. Salvia had the second highest leaf area, while Anisacanthus, Euonymous and Magnolia had intermediate leaf areas as well as total dry weights, while Ilex and Myrica had the lowest leaf areas and total dry weights. Although Myrica and Ilex had the lowest leaf areas and dry weight values, they along with Magnolia had significantly higher root:shoot ratios than the other species. Salvia had the lowest root:shoot ratio which would make it more susceptible to drought; it also had the highest leaf area ratio, which represents the rate of photosynthesizing to respiring material within a plant.

**Summary:** establishment of non-water stressed baselines of selected woody plant species is a key to measuring and interpreting plant water stress. By analyzing the components of growth under non-limiting conditions, it may be possible to predict which species would be most sensitive to water deficit under reduced irrigation. In conclusion, under non-drought conditions, Salvia had the highest wholeplant transpiration (E) (per leaf surface area), while greatest transpiration water losses (total water loss) occurred with Viburnum. Viburnum had the largest evaporative surface, which accounts for the greater transpiration losses. With the high E, low root/shoot ratio and high LAR, one would suspect that the native ornamental Salvia would be the least drought resistant of the species tested. E was lowest in Viburnum which would suggest that under landscape conditions it would have relatively high drought resistance; however, under containerized conditions with restricted soil water availability and due to it's large evaporative surface, containerized Viburnum would more likely experience drought than Magnolia or Anisacanthus. Containerized Ilex, Euonymous and Magnolia were among the more potentially drought resistant of the species tested based on water relations and growth data.
SECTION 3
FIELD PRODUCTION

Kenneth Tilt
Section Chairman and Moderator
Row Management of Field-Grown Crapemyrtles and Redbuds

Leila P. Baldridge and Steven E. Newman
Mississippi

Nature of Work: Row management is an important aspect of field nursery production. The method of cultivation used to protect the soil, conserve water and reduce weeds within rows is critical. Clean cultivation increases soil erosion and requires a large expenditure in chemical and mechanical weed control. Studies on nursery stock interplanted with grasses showed that grasses have a detrimental effect on the vigor and growth of trees and is attributed to competition for water and/or nutrients. Bould and Jarrett demonstrated that trees grown under Timothy grass and ryegrass showed a decrease in growth and yield when compared to those grown under clover and natural sward. There is a need for southern-based research to determine which method of row management best controls weeds and erosion without compromising plant vigor.

The objective of this study was to compare the effects of row cover management and irrigation on growth of field-grown woody ornamental plants. To accomplish this objective, two sub-objectives were established:

1) Determine if a leguminous cover crop, lespedeza clover, can enhance plant growth of field-grown crapemyrtles and redbuds compared to clean cultivated rows or rows mulched with pine bark; and
2) Determine how trickle irrigation rates (low or non-irrigated (when soil tension reached -80 centibars) and high (when soil tension reached -40 centibars)) influence plant growth responses of crapemyrtles and redbuds grown under the three row cover treatments (clover, clean cultivated, and pine bark mulch).

Plant materials for this study were 3-year old container-grown (1 gal.) Cercis canadensis, Eastern redbud seedlings and Lagerstroemia indica 'Muskogee', crapemyrtle cuttings. These were planted in 4. 100 ft rows on 39 inch centers at the Mississippi Agricultural and Forestry Experiment Station Plant Science Research Center in August, 1988 and irrigated with drip system. Ammonium nitrate at 5lb/1000 ft² was broadcast in late May 1989.

The 3 treatments included, 1) clean cultivation (chemical and mechanical), 2) cover of Lespedeza striata, Kobe leapedeza (planted April 29, 1989), and 3) pine bark mulch applied 4 inches deep. Each row was randomly assigned one of two irrigation treatments. Rows in treatment one were irrigated for 48 hours whenever the soil tension measured -40 centibars or less. Rows in treatment two were only irrigated if the soil tension measured less than -80 centibars. Plant growth data was measured October, 1989 by determining plant height and caliper of redbuds and crapemyrtles and number of branches for crapemyrtles.
Results and Discussion: No differences were found in height of irrigated crapemyrtles regardless of row management treatments (Table 1). Crapemyrtles that were not irrigated had the greatest height when clean cultivate compared to crapemyrtles planted to clover (Table 1). Mulched plants were similar in height to those clean cultivated or with clover. Crapemyrtles with a cover of clover had the least increase in caliper whether irrigated or not (Table 1). Caliper of plants with no cover or mulched was not different (Table 1).

There was no difference in the number of branches for any ground cover for irrigated crapemyrtles (Table 2). However, non-irrigated crapemyrtles in stands of clover had fewer branches than crapemyrtles that were clean cultivated or mulched (Table 2). There were no differences between irrigated and non-irrigated crapemyrtles for height or caliper (data not shown).

Both irrigated and non-irrigated redbuds had the least increase in height and caliper when planted to clover (Table 1) There were no differences in height or caliper between the mulched and clean cultivated redbuds at either irrigation level (Table 1). Irrigation did not appear to affect plant growth of redbuds (data not shown).

The following conclusions can be reached from this study. Crapemyrtles with no cover appeared to utilize water more efficiently than those with a cover of mulch or clover when sufficient water ia available from either rainfall or irrigation. Mulching increased the efficiency of water utilization during periods of water stress such as occurred in August of 1989, while clover decreased it. Clover interplantings decreased the height and number of branches in crapemyrtles without supplemental irrigation. Non-irrigated crape myrtles with a cover of clover had smaller gains in height and had fewer branches than those with mulch or no cover. No differences were found in height and branching on irrigated crapemyrtles. Use of supplemental irrigation appeared to be a more important factor in the growth of crapemyrtles than cultivation.

Growth data of redbuds indicated that use of clover as a cover decreased the height and caliper regardless of whether supplemental irrigation was used. Therefore, summer clover interplantings should not be used for field production of redbuds.
Literature Cited


(Table 1)
EFFECTS OF MICRO-IRRIGATION PATTERN ON ROOT DISTRIBUTION OF TREE IN FIELD-GROW CONTAINERS

Gary W. Knox, Edward F. Giknan, Uday Yadav, and Catherine A. Neal
Florida

Nature of Work: The development of fabric containers (or bags) for field production has required growers to adapt production practices to the new technology. Use of fabric containers in sandy soils makes irrigation particularly challenging. Sandy soils allow little lateral movement of water, and irrigation of 50% to 60% of the root zone is recommended for crop production on sandy soils (5). Although fabric containers may contain a large portion of the root system (3), growers have been concerned about placement of irrigation water for maximulll tree growth and for establishment after transplanting. Lagerstroemia x ‘Natchez’ (‘Natchez’ crapemyrtle) height and width increased as irrigation frequency and irrigated area increased, although Quercus laurifolia (laurel oak) was unaffected (4). This study was designed to determine the effects of microirrigation pattern on root mass and distribution of ‘Natchez’ crapemyrtle and laurel oak produced in Field-Grow containers.

This study was conducted at Cherry Lake Tree Farm near Orlando, Florida, in an Astatula sand soil. Trees were transplanted from three-gallon (oak) or one-gallon (crape myrtle) containers into 18-inch Field-Grow Containers (Root Control, Inc., Oklahoma City, OK) on April 5, 1988. Trees were spaced 6 feet apart within the row and 10 feet between rows. Each plant was fertilized with 3 oz. of Osmocote 17-6-10 Plus Minors (Sierra Chemical Co., Milpitas, CA) top-dressed within the bag at planting and with 1.5 oz. of the same fertilizer banded within and around the bag the following August and May.

All plants were irrigated at a rate of 1 inch every other day for the first 4 weeks after planting before irrigation treatments began. Treatments consisted of unirrigated controls, 0.5 inches of irrigation applied primarily within the bag, and 0.5 inches of irrigation applied within the bag plus an area extending 10 inches beyond the bag. Irrigation pattern was achieved with one 0.072 gallon per minute (gpm) or two 0.064 gpm mini sprayers (Spot-Spitters, Roberts Irrigation Products, Inc., San Marcos, CA), respectively. Cumulative rainfall at the nursery from April 1988 through September 1989 was 59.6 inches, 26.6 inches below normal for the Orlando area.

Treatments were arranged in a randomized complete block with 1 replication per treatment in each of 6 blocks for both species. Root systems from 3 trees of both species in each treatment (total 18 trees) were harvested September 26 and 27, 1989. In addition to harvesting roots within the bag, all
roots were harvested outside the bag from 90° wedges on the north and south sides of each bag (total 2 wedges). Maximum root extension from the trunk was recorded within each harvested wedge. Root systems were separated into 4 root-diameter classes, dried, and weighed. Diameter classes were: less than 2 mm (0.08 inches), 2 to <5 mm (0.08 to 0.2 inches), 5 to < 10 mm (0.2 to 0.4 inches), and over 10 mm (0.4 inches).

Results and Discussion: Root tips of unirrigated crape myrtle extended an average of 38.5 inches from the trunk, significantly shorter than for plants irrigated inside the bag (45.5 inches) or irrigated inside and outside the bag (49.5 inches). For laurel oak, maximum root extension was not affected by irrigation (distances of 29.0, 27.5, and 27.7 inches for unirrigated, irrigated inside the bag, and irrigated inside and outside the bag, respectively).

Irrigation did not affect the percentage of total root system weight harvested within the bag. About 69% of crapemyrtle and 92% of the total weight of laurel oak root systems were harvested within the bag. The percentage for laurel oak may be high since the trees required another 6 months of growth before they would have been considered salable.

For crapemyrtle, total dry weight of the root system within the bag was greatest for irrigated trees. When examined by diameter class, irrigated trees had significantly greater weight of roots smaller than 2 mm (0.08 inches) and larger than 10 mm (0.4 inches). For roots found outside the bag, irrigated trees had greater total root weight, partitioned to roots with diameters less than 5 mm (0.2 inches). Thus, irrigation increased crapemyrtle root weight, but size of the irrigated area did not affect root weight or distribution among diameter classes.

Total dry weights of laurel oak roots found within and outside the bag were not significantly affected by irrigation treatments. However, when irrigation was confined to the area within the bag, there was greater weight of roots less than 2 mm (0.08 inches) in diameter than trees either unirrigated or irrigated inside and outside the bag.

Differences in distribution of roots among diameter classes may be crucial for transplant success (2). Root systems characterized by fibrous roots improved plant survival after transplanting (1). Any treatment that increases numbers of small diameter roots might improve water and nutrient absorption, thereby reducing transplant shock and increasing survival and rate of establishment.

Crapemyrtle height and width were greatest with irrigation of 0.5 inches per day applied over an area encompassing the bag plus an area 10 inches beyond the bag (4). Irrigation of crapemyrtle increased caliper and overall root weight as compared to unirrigated plants. For laurel oak, irrigation placed only within the bag increased the weight of small-diameter roots harvested in
the bag. Irrigation increased oak width and caliper, but pattern or frequency had no effect. Although these results indicate species-specificity in response to irrigation pattern and frequency, they also suggest that water use and shoot and root growth might be optimized by irrigating only within the bag.

ACKNOWLEDGEMENT

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LITERATURE CITED


Residual Control of Yellow Nutsedge in Field Grown Ornamentals

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Alabama

Nature of Work: Yellow nutsedge infestations occur frequently in nursery production. Yellow nutsedge is difficult to control and is easily spread from field to field by equipment. Currently, Pennant 7.8E (Dual) is the only preemergence-applied herbicide registered for use in woody ornamentals that has activity on yellow nutsedge. In 1986, a test was initiated evaluating several new herbicides for activity on yellow nutsedge and injury to ornamentals. Herbicides evaluated included Classic, Reflex, Scepter, Zorial, and Dual (pennant). The latter three herbicides provided excellent control of yellow nutsedge; however, the Scepter killed most of the ornamentals during a two-year test. In the test these herbicides were applied twice annually at the following rates: Scepter 0.5 and 1.0 lb/A, Zorial 1.5 and 3.0 lb/A, and Dual 4.0 lb/A. Applications were made in April and July of both 1986 and 1987. The four ornamental species planted in 1986 were removed from the test in the fall of 1987. In the spring of 1988, liners of four ornamental species were replanted in the herbicide plots to evaluate residual yellow nutsedge control and injury from Scepter herbicide to the four ornamentals. The ornamentals were Andorra juniper, Foster holly, Greenluster japanese holly and Korean boxwood. No additional treatments were applied, except surflan plus princep (3+1 lb./A) was applied across all plots in April and July of 1987 and 1988. Plots were rated for nutsedge control and plant growth.

Results and Discussion: During 1988, excellent residual control of yellow nutsedge was achieved with application of Scepter 1.0 lb/A, Zorial 3.0 lb/A, and Dual 4.0 lb/A. At the rating made in July of 1989, both the Scepter and Dual treatments had declined in control by about 20% compared to the previous rating made in the fall of 1988. Residual control from Zorial (3.0 lb./A) continued through the last rating made in June 1990, almost two years from the time of the last Zorial application. Scepter stunted the growth of the four ornamental species even though they were planted 9 months after the last application (data not shown). There was no injury from either the Zorial or Dual treatments.

These data indicate that Pennant is an excellent choice for preemergence control of yellow nutsedge when applied at the recommended rate (4.0 lb/A) twice annually for the duration of the crop. Residual control may be expected for one to one and one-half years after the the final application. Zorial, a herbicide registered for fruit and pecan trees, shows excellent promise. No injury occurred to the four ornamental species grown at the time of application or the replanted species. Residual control continues two years after the last application. While Scepter has excellent activity against yellow
nutsedge, it should not be used where ornamental crops will be planted within the next year.

(Table 1)

Effect of N Fertilization on Growth of Field Grown Nursery Trees in the Mid-South

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Tennessee

Nature of Work: Nitrogen is the most limiting plant nutrient in nursery production of shade and fruit trees. However, limited definitive work has been accomplished with shade tree fertilization due to the large number of variables and the time commitment before growth differences are manifested (Dirr, 1975). Van De Werken (1970) reported that no response of field grown nursery stock was observed until the third year following planting of Acer saccharum (Sugar maple), Quercus palustris (Pin oak), and Liriodendron tulipifera (Tulip poplar). Hensley and Aldrige (1990) reported that when ammonium nitrate was band applied to newly planted Pinus sylvestris (Scotch pine) application of 50 lb N/acre increased survival and growth compared to 0, 100, and 200 lb N/acre rates.

The recommended N fertilization rate for field grown nursery stock in Tennessee is 150-200 lb N/acre/year split into a early spring and summer application, however, much research is needed with different types of crops, timing of application, rates, and analyses of N fertilizers (Tilt). Therefore a study was conducted in production nurseries to determine the optimum N fertilization rate and timing of application for several field grown ornamental trees in 1989, a year when favorable plant growth was observed throughout the Middle Tennessee region.
Ammonium Nitrate was band applied in the spring (March 25) at rates ranging from 0 to 100 lb N/acre and in the summer (June 24) at rates ranging from 0 to 200 lb N/acre to second year to Malus sp. ‘Indian Magic (Indian Magic crabapple) and Malus sp. ‘candied apple’ (Weeping crabapple) liners, 3 year old irrigated Prunus x Yedonesis (Yoshino cherry) trees, and 2 year old irrigated Thuja occidentalis (Pyra-midal arbovitae) trees. All four experiments utilized a split-plot design with summer N rates in the whole plots, spring N rates in the subplots, and three replications.

The study with crabapples was conducted on a silt loam upland soil located in Dekalb county Tennessee. The crabapples were planted in 5 ft. rows; subplot size was 10 ft. of row which contained approximately 20 trees. Plant caliper 1 in. above the budding location was measured in November. The resulting data, presented in Table 1, indicates that little significant response to N fertilization was observed with either crabapple variety. However, the summer application of 50 lb N/acre resulted in the greatest diameters of both varieties regardless of the spring fertilization rate.

The Yoshino cherry tree experiment was conducted on a fine sandy loam bottomland soil located in Warren county Tennessee. The Yoshino cherry trees were planted in rows 6 ft. apart; subplot size was 30 ft. of row which contained approximately 10 trees. Plant caliper 1 in. above the ground was measured prior to the spring fertilizer application and in November. The trees initially had an average plant caliper 1 in. above the ground of 0.84 in. and height of 6 ft. The resulting data, presented in Table 2, indicates a significant caliper growth increase due to application of 50 lb N/acre. Greater application of rates did not result in significantly greater caliper growth than the 50 lb N/acre rate. The average growth when N was supplied was 0.92 in compared to 0.62 in when no N was supplied, a 48% increase in growth.

The Pyramidal arbovitae tree experiment was conducted on a cherty silty clay loam upland soil located in Warren county Tennessee, The arbovitae trees were planted in rows 6 ft. apart; subplot size was 20 ft. of row which contained approximately 10 trees. Plant height was measured prior to spring fertilization, prior to summer fertilization, and in November. The average initial plant height was 12.2 in. The resulting data, presented in Table 3, indicates a significant spring growth (from spring to summer fertilization) response to spring application of N. Application of N fertilization at the summer date reduced plant height growth from an average of 10.1 in. if no N was applied to 7.6 if 100 lb N/acre was applied.

**Results and Discussion:** In summary it was observed that established small trees intended to be used as liners require very little if any N fertilizer. Larger trees intended to be balled and burlapped should be fertilized at a rate of 50
lb N/acre in late June. Arbovitae and probably all small evergreen bushes intended to be balled and burlapped should be fertilized in the early spring at a rate of 25 lb N/acre. The results reported here represent only one year of data, further studies are needed to confirm these results.

**Literature Cited**


(Table 1)

(Table 2)
(Table 3)
VARIATION IN HORTICULTURAL CHARACTERISTICS, DISEASE RESISTANCE, AND BORER INFESTATIONS IN TEN FLOWERING DOGWOOD CULTIVARS

M. Windham
Tennessee

Nature of Work: The flowering dogwood, *Cornus florida* L., is a popular ornamental tree in the eastern United States. Dogwoods are prized for its spring bloom and its red foliage and berries in the fall. Over 20 named cultivars of dogwoods are cultivated. Little is known how cultivars vary in resistance to plant diseases, frost damage, time of blooming, length of bloom period, etc. The objective of this study was to compare 10 dogwood cultivars for resistance to dogwood diseases and various horticultural characteristics.


Trees were rated for disease severity and dogwood borer infestations. Dogwood canker incidence was determined by examining the bark of each tree for cankers using symptomatic criteria described by Lambe and Jones (3).
Spot anthracnose disease severity was estimated in 1989 with the following scale:

O= healthy, l= <5 lesions /bract, 2= 5-10 lesions /bract, 3= 5-10 lesions /bract and lesions with necrotic centers, 4= >10 lesions with necrotic centers /bract and 5=bracts destroyed. Dogwood borer infestations were determined by examining each tree for borer frass or potential entry sites. Infestations were confirmed by peeling back the bark to reveal the larvae.

Horticultural data were obtained for susceptibility to freeze damage, number of blooms /tree, and bract length. Freeze damage susceptibility was rated with the following scale: O= none, l= scorch at bract edges, 2= some bracts with scorch extending from edges into middle of bracts, 3=all bracts with damage beyond bract edges, 5= bracts destroyed. Number of blooms /tree was determined by counting the number of blooms on each tree. Bract lengths were estimated by measuring randomly selected bracts of five blooms on each tree.

All data were analyzed with the ANOVA procedure of the Statistical Analysis System. Significant differences between means were determined with the Student-Newman-Keul Test.

**Results and Discussion:** Dogwood canker was higher in ‘Purple Glory’ than in the other nine cultivars (Table 1). Spot anthracnose damage was most severe in ‘Barton’ and ‘Cloud 9’. Dogwood borer infestations were most severe in ‘Purple Glory’ and in the cultivar with doubled blooms, ‘Plena’. This data is in agreement with research by Pless and Stanley who observed a cultivar with doubled white flowers that was heavily infested with borers ( ).

Cultivars were variable for various horticultural characteristics. As bracts were expanding, a period of cold weather (28 F) was recorded on May 8, 1989. Heavy frost was noted. Bracts of ‘Barton’, ‘Cloud 9’, and ‘Welch’s Jr. Miss’ were damaged more by freeze damage than the other cultivars (Table 1). Because this damage, these cultivars may not be appropriate in areas where heavy frosts occur after dogwoods start to bloom.

Plena had significantly more blooms than did any other cultivars. ‘Cherokee Princess’, ‘Fragrant Cloud’, and ‘Springtime’ had larger bracts than the other seven cultivars, but bract length of the latter two cultivars were not significantly different than bract length of ‘Rubra’. Some cultivars with the largest bracts were also heavy bloomers including the cultivars ‘Cherokee Princess’, ‘Rubra’, and ‘Springtime’. The small number of blooms on trees of ‘First Lady’, ‘Purple Glory’, and ‘Welch’s Jr. Miss’ may have been due to observed lack of vigor. Lack of vigor in ‘Purple Glory’ may have been due to high canker and borer incidence. ‘First Lady’ a variegated cultivar, was less vigorous than the other cultivars.
REFERENCES


(Table 1)
SECTION 4
ENTOMOLOGY

Dr. Beverly Sparks
Section Chairman and Moderator
SEASONAL EMERGENCE OF DOGWOOD BORERS, AND INFESTATION LEVELS AND ENTRY SITES ON DOGWOOD IN COMMERCIAL NURSERIES

M. Windham, J. Grant, and L. Rogers
Tennessee

Nature of Work: Dogwood borer, *Synanthedon scitula* (Harris), is a serious pest of flowering dogwood, *Cornus florida* L., in the eastern United States (Pless and Stanley 1967, Williams et al 1985). Larvae feed in the phloem and cambium of the tree and can partially or completely girdle trunks or limbs (Potter and Timmons 1983). Little information is available concerning the emergence of this pest or the infestation levels of dogwoods in Tennessee nurseries. A study was conducted to accomplish the following objectives: 1. to monitor seasonal incidence of dogwood borer in eastern and middle Tennessee, to assess borer infestation levels in commercial nurseries, and to determine the site of larval entry on trees in a nursery environment.

Seasonal incidence. Dogwood borer flight activity was monitored from April 1987 to September 1988 using 22 pheromone traps placed in commercial nursery, urban, and forest habitats at nine locations in eastern and middle Tennessee. Each trap consisted of a Pherocon IC sticky trap baited with a rubber septa impregnated with 250 ug of a synthetic pheromone, (Z,Z)-3,13 octadecadien-l-ol acetate (Z,Z-ODDA). Traps were sampled weekly from April through mid-October and monthly from mid-October to early April.

Infestation levels. Dogwood borer infestation levels were determined in 13 nursery blocks (range=275 to 7625 trees/block) in middle Tennessee. Borer incidence was determined on each tree in each block by examining trees for the presence of larval frass or potential borer entry sites. Infestation was confirmed by removing a layer of bark to reveal the larva.

Entry sites. Three hundred one-year-old dogwood trees were transplanted into a field at the Plateau Experiment Station. Trees were examined for borer infestations, dogwood canker incidence, and presence of mechanical wounds prior to transplanting. All trees were rated as healthy. Trees were examined twice yearly for three years for presence and location of mechanical wounds, pruning wounds, and cankers. After three years (May 1990), borer incidence and infestation locations on each tree were recorded.

Results and Discussion: Seasonal incidence. Dogwood borers were active from May through September in 1987 and 1988 in eastern and middle Tennessee. Adult dogwood borers were not detected in the forest habitat. In commercial and urban habitats, borers exhibited a bimodal period of emergence with the first peak in mid-May and the second peak in early August (Fig. 1). These data agree with research by Potter and Timmons (1983) in
Kentucky. The existence of two peaks of adult borer activity has important control implications and supports the use of two properly timed chemical application for control of dogwood borers. Borers are vulnerable to insecticides only before they penetrate the bark.

Infestation levels. The average percent infestation level in nursery blocks was $6.56\pm2.31\%$/block. Percent infestation of dogwood trees in this habitat varied widely and ranged from 0.14 to 24.89% per block. Variability in infestation levels in the nursery blocks may be the result of pest management practices and the number of years that the dogwood trees have been in the field.

Entry sites. Dogwood borers were found to use man-made and natural wounds and cankers for entry into trees (Table 1). Entry via wounds was in agreement with research by Potter and Timmons (1981). The most common entry site was dogwood canker. The predisposition of dogwoods to borer infestations by dogwood borers may partially explain why trees with dogwood canker rapidly decline in vigor.

LITERATURE CITED


(Table 1)
(Figure 1)
Evaluation of Stirrup M as a Tank-Mix Addition to Miticides

James C. Stephenson
Alabama

Nature of Work: Mites continue to be a concern for many nurserymen in Alabama. The ineffectiveness of some compounds coupled with problems of spray coverage in dense plant canopies, close plant spacing, and environmental conditions complicate control measures. Several mites are economic pests in Alabama nurseries. The twospotted spider mite, *Tetranychus urticae* Koch, continues to be one of the most serious and widespread. Damaging populations can build rapidly and under favorable conditions take as little as 5 days to develop from egg to adult.

One recent approach to offset some spray coverage problems is to bring the pest into contact with a toxicant by the addition of a pheromone. A pheromone is a substance produced by one individual that induces a specific reaction by others of the same species. It is a way of communication. In this case, Stirrup M, a sex pheromone has been reported to result in mites moving around in the plant canopy out of their sheltered locations. This improves the chance and length of time a mite contacts the miticide. This new approach has been reported to be successful in the western U.S. on fruit trees(1) and the dessert Southwest on cotton(2). This study was initiated to evaluate Stirrup M as a tank-mix addition to miticides for use on ornamentals.

Mite infested miniature roses growing in a glass greenhouse were selected for treatment. Good spray coverage on this plant is difficult due to the spray droplets beading up and not spreading out on leaf surfaces. Sprays were applied to run-off using a hand-pumped compressed air sprayer to upper leaf surfaces. No spray adjuvant was included in the first trial. Chevron X-77 at the rate of 8 fl. oz/100 gal water was added in the second trial.

Results and Discussion: In the first trial, the lack of control with all treatments was surprising. There was a high degree of variability within treatments also. This prompted us to add a spray adjuvant to insure better coverage on the leaf surfaces in the second trial.

In the second trial (7 days after treatment), good control was observed with most miticide treatments compared to the untreated check. There was no advantage by adding Stirrup M to the spray tank. Twenty-one days after treatment, our final evaluation, the same conclusion concerning Stirrup M was reached.

In summary, these two trials indicate that no clear advantage is gained by adding Stirrup M to the spray tank for control of the twospotted spider mite. However, there are other factors affecting pheromone use that must be
addressed before a definite conclusion can be reached. No compatibility or phytotoxicity problems were observed.

**LITERATURE CITED**


(Trial 2)
Nature of Work: Discovery of an insect on an ornamental plant need not always be cause for alarm. A problem can arise when the grower is unable to distinguish between harmful, beneficial, or incidental insects. The purpose of this paper is to acquaint the grower with the habits and life stages of some of the common beneficial insects that they may encounter.

Neuroptera

The order Neuroptera (also called the lacewings) are voracious predators of aphids, mealybugs, and scale insects. The Chrysopidae, Hemerobiidae, and Coniopterygidae in particular are relevant to the grower. Some species of green lacewings or aphid-lions (Chrysopidae) are predatory as adults while others are nectar feeders (Fig. la). The larvae are all predatory. The larvae have long, sickle-shaped mandibles (Fig. lc) that they utilize to grasp and puncture the bodies of soft-bodied insects or their eggs. Larvae have been recorded as consuming over 200 aphids during their development. The larvae of some species of chrysopids have developed the interesting habit of attaching the bodies of their prey or debris on their backs for camouflage. These have commonly been called walking trash piles. Once the larva is fully fed, it seeks a secluded area in the duff or under a leaf where it spends a small two-stage silken cocoon. The larva pupates within this cocoon and, depending upon weather conditions, can either overwinter or emerge as an adult. The eggs of the green lacewings are distinctive in that they are laid singly on a long stalk (Fig. lb).

The brown lacewings or aphid wolves (Hemerobiidae) resemble the green lacewings but there are some important differences. All adult brown lacewings (Fig. ld) are predatory and are often found in the same habitat as the larvae. Brown lacewing larvae have shorter, more compact mandibles (Fig. lf) when compared to green lacewing larvae. An excellent way to distinguish the larvae of green and brown lacewings in the field is to observe them walking. If the head capsule remains in one place while walking, the larva is a green lacewing. If the head capsule moves quickly back and forth while walking, the larva is a brown lacewing. Brown lacewing larvae are not trash carriers although this misconception often finds its way into the literature. Morphologically, brown lacewing larvae are incapable of carrying debris. Brown lacewing larvae can consume an average of approximately 25 aphids per day. Brown lacewing larvae also spin small cocoons prior to pupation and adult emergence. Adults can live for nearly three months and females can lay an average of nearly 1,000 eggs in their lifetime. Brown lacewing eggs are not stalked and are laid on the substrate surface (Fig. le).
The dustywings (Coniopterygidae) are the smallest (2-4 mm) of the Neuroptera and the adults resemble adult whiteflies in size and appearance (Fig. 1g). They get their name from the grey-white wax found on their wings and body. Dustywing larvae (Fig. li) feed on whiteflies, scales, and mites and may be one of the most common groups of Neuroptera but their biology has not been well studied. Because they are so small, they are often overlooked, but a single larva can consume 29-83 mite eggs, larvae, or nymphs per day. Adults will generally feed on the same prey as the immatures. Eggs are laid singly on the substrate (Fig. 1h).

**Coleoptera**

The beetles (Coleoptera) are a large order that contains both beneficial and destructive species. One family of beetles that contains many beneficial species is the Coccinellidae or lady beetles. Lady beetles are also voracious predators of many of the soft-bodied insect pests of ornamentals. Some of the best success stories involving biological control have been through the use of various species of coccinelids. Adult lady beetles can be found in a broad range of color and pattern variation (Figs. 2a-d). They are commonly from 2-5 mm long and about 2/3 as broad. Lady beetles can be distinguished from other destructive leaf beetles by looking closely at the number of tarsal segments. Lady beetles will have what appears to be only three segmented tarsi (Figs. 2e). The immatures could be confused with the larvae of Neuroptera but are covered with minute tubercles or spines and are often spotted or banded with bright colors (Fig 2g). The larvae of some species of lady beetles are covered with a fluffy wax which often confuses them with mealybugs. Lady beetles do not pupate in cocoons but are exposed on the leaf where they are attached by the tip of the abdomen (Fig. 2f). Eggs of lady beetles (Fig. 2h) are often orange to yellow and are frequently deposited close to potential prey.

**Diptera**

Another important predator of aphids are the syrphid flies (Syrphidae). Also known as flower flies or sweat flies, these flies are predaceous only in the larval stage. The adults (Fig. 3b) feed on nectar and pollen and superficially resemble bees or wasps. Syrphid flies can be distinguished from bees and wasps by having only a single pair of wings and by their hovering flight habits. The larvae are small slug-like maggots (Fig. 3c). Larvae feed on aphids by grasping their prey with small mouth hooks and sucking out the body contents. A syrphid fly larva can destroy aphids at the rate of one per minute. Once the larva is fully fed, it drops from the plant to form a puparium (Fig. 3d) in the duff or soil. Syrphid eggs (Fig. 3a) are elongate, white and are laid close to their potential prey.
Control: As more and more regulations are imposed upon pesticides and their application, both growers and researchers need to take a closer look at alternative methods for controlling arthropod pests. Beneficial insects offer a good potential for a pest maintenance program especially in a closed environment such as a greenhouse. Although control of pests may not be immediate, ‘there is virtually no chance for pest species to develop resistance to a predator. The grower must be able to recognize all developmental stages of beneficials in order to determine predator from pest species of insects. When pesticides are to be applied, consideration should be given to those compounds which cause lower mortality to beneficial insects.

ADDITIONAL REFERENCES


Fig. 1. Neuroptera. A, Adult green lacewing; B, Eggs of green lacewing; C, Green lacewing larva; D, Adult brown lacewing; E, Eggs of brown lacewing; F, Brown lacewing larva; G, Adult dustywing; H, Egg of dustywing; I, Dustywing larva.

Fig. 2. Coleoptera. A, Convergent lady beetle; B, Twice-stabbed lady beetle; C, Two-spotted lady beetle; D, Delphastus pusillus; E, Three segmented tarsi; F, Eggs of convergent lady beetle; G, Larva of convergent lady beetle; H, Pupa of convergent lady beetle.

Fig. 3. Diptera. A, Eggs of flower fly; B, Flower fly adult; C, Flower fly larva feeding on aphid; D, Puparium of flower fly.
Nature of Work: The red imported fire ant, *Solenopsis invicta* (Buren) and the black imported fire ant *S. richteri* Forel (Hymenoptera: Formicidae), have become two of the most important insect pests in the southeastern United States. The painful bites and stings of these species as well as their mounds have made imported fire ants a target for insecticide based control strategies. Imported fire ants may become established in container grown horticultural crops and sod where they can damage seedlings and where they must be controlled prior to shipment out of the fire ant quarantine areas. Fire ants also build mounds against vertical objects such as trees, utility poles, fence posts, and in irrigation control and telephone equipment. Disruption of this equipment and routine maintenance often necessitates entering and working in infested equipment. Rapid knock down and kill of fire ants would allow safe shipment of seedlings and access to equipment.

The purpose of this study was to evaluate the performance of two rapid fire ant mound control strategies. One method incorporated the use of pressurized wasp and hornet spray and an injector rod. The wasp and hornet spray tested was Whitmire Wasp Stopper CF (0.10% d-trans Allethrin) (Rainbow Waspkiller II) because it had shown excellent knockdown performance against bees and because this formulation did not damage a variety of plastics that are used in horticultural and electrical equipment (1,2). Different techniques of spray application were evaluated. A fire ant infested Christmas tree farm located approximately 10 km from the Auburn University campus in Lee County, Alabama was selected as the field site. Thirty mounds, 40 to 90 cm in diameter, were selected for treatment September 28, 1988. These were large, mature late season mounds; most mounds are smaller than those used in this study. The following application methods were employed (3): topical application alone (approximately 1, 14 oz can), application of 1 can using an injector rod only (no topical application), approximately 8 insertions of 2 sec spraying/insertion, topical and rod application [25% of 1 can topical, 75% rod (approximately 6 insertions of 2 sec spraying/insertion)], circle mound with a barrier spray followed by topical and rod application (approximately 6 insertions of 2 sec spraying/insertion), and circle mound with a barrier spray, break up mound followed by topical and rod application (approximately 6 insertions of 2 sec spraying/insertion). Each treatment was replicated 6 times. Performance was evaluated 3 min after application, 1, 7, and 30 days after treatment. Evaluations consisted of tapping and probing mounds to determine the presence of live ants. Repellency of the spray was evaluated by noting the presence of new mounds within a 1 m radius of the treated mound. These mounds were considered relocations. Six untreated control mounds were also selected and evaluated as above.
The second mound control strategy utilized the drench technique with a natural insecticide: d-limonene. A fire ant infested pasture located in Auburn, Lee County, Alabama was selected as the field site. Sixteen mounds, approximately 30 cm (12 inches) in diameter, were selected for treatment May 31, 1990. These were mature average size mounds. A solution composed of 29.6 ml (1 oz) of d-limonene per 3.785-l (1 gallon) was used for the treatments. Exactly 7.57-l (2 gallons) of solution was applied to each mound. Performance was evaluated 35 minutes after treatment. Mounds were rated on a 0-3 scale where 0 was no living ants, 1 was 1-100 living ants, 2 was 101-1000 living ants, and 3 was >1000 living ants. Evaluations consisted of tapping, probing, and digging open mounds to determine the presence of live ants. Ten untreated control mounds were also selected and evaluated as above.

Results and Discussion: There was no mound mortality or relocation with the untreated control mounds. Topical and rod treatments alone did not give 100% kill 3 min after treatment (Table 1). All combined treatments of topical and rod application (n = 18), however, gave 100% kill within 3 min. Topical treatments resulted in only 17% mound kill at 7 and 30 days after treatment. There was 100% kill with the rod application at 7 and 30 days, but 0% kill at 1 day. All combined applications (topical and rodding) gave 100% mound kill after 3 min and at 1, 7, and 30 days after treatment. Therefore combined applications were more efficacious more quickly than single method applications.

A maximum of 33% of the treated mounds relocated (Table 1). More relocations occurred in topical and rodding methods alone and the combined topical and rodding method than with treatments including an initial perimeter spray. This may indicate that initial relocations occur very quickly during treatment and that the perimeter spray repels the relocating ants. In all cases, however, the relocated mounds were not abutted to the treated mounds. This aerosol formulation when applied as a perimeter spray followed by breaking up the mound, topically spraying on the ants, and then rodding the spray into the mound gives 100% kill within 3 min and limits mound relocations to < 17%. This application technique also results in 100% mound kill over at least a 30 day period.

There was no mound mortality (mean performance rating of 3 ± 0) of the untreated control mounds. Mounds treated with d-limonene had significantly fewer ants than did the control mounds as indicated by a mean performance rating of 1.06 ± 0.11. The majority of mounds (13 of 16) had a performance rating of 1 indicating the presence of only 1-100 living ants. Two mounds had a rating of 2 and one mound had complete mortality or a rating of 0. The mound drench treatment was relatively easy to apply. The scent of the d-limonene was quite pleasant, especially when compared with that of Orthene, another mound drench formulation. D-limonene applied as a 1 oz
per gallon solution rapidly and significantly reduced populations of the red imported fire ant.

Excellent control of fire ants can be obtained using either the spray injector or the d-limonene mound drench method. If immediate (within 3 min) kill is required, then the spray injector method is recommended.

**LITERATURE CITED**


(Table 1)
EVALUATION OF BAGWORM CONTROL STRATEGIES, 1989

P. B. Schultz and M. A. Coffelt
Virginia

Nature of Work: The bagworm, *Thridopteryx ephemeraeformis* (Haworth), is a polyphagous defoliator that prefers evergreen species as hosts. Arborvitaee, Leyland cypress and juniper are highly susceptible; however, many species of deciduous and evergreen ornamentals are damaged. Bagworms occur throughout the eastern U. S., and are found as far west as Texas and as far north as New York. Severe defoliation often results, which may cause death of the host.

Larvae hatch beginning in late May to early June (depending on spring temperatures) from the bags in which females had lived and oviposited the previous year. The larvae usually remain on the host, but can be carried for short distances by the wind on silk threads. The larvae begin constructing bags composed of silken threads and bits of foliage shortly after hatching, and the bags increase in size as the larvae grow, reaching 2 inches in length at maturity. The male moth leaves the bag and mates with the female in the bag. The bagworm has only one generation a year, overwintering as eggs in the bag.

When practical, light infestations of bagworm can be controlled by hand-picking between August and the following May. Chemical control of bagworm is effective in early summer when the larvae are small, but declines in effectiveness as the larvae become large. Nine insecticide treatments and an untreated check were evaluated for control of the bagworm on June 30, 1989. Insecticides were applied to field-grown Leyland Cypress, *Cupressocyparis leylandii*, approximately 6 meters high located at the Hampton Roads Agricultural Experiment Station in Virginia Beach, Va. Infested areas of trees were sprayed to runoff with a CO2 sprayer at 30 psi. Triton X-100 at a rate of 0.5% was added to each treatment. Three days after application, 15 bagworm larvae collected from each of three replicates per treatment. Bagworms were subjected to high temperature (>100°F) in the laboratory. Survival was determined by counting the number of live larvae 7 days post-treatment that became active within 30 minutes after initiation of temperature stress. Temperature at time of treatment was 75°F and plants were irrigated twice daily for 20 minutes using an overhead sprinkler system.

Results and Discussion: The results indicated that Karate and all formulations of Talstar treatments provided significantly better control than the remaining treatments and untreated check. Sevin SL provided good control. CGA 184699 is an insect growth regulator, and control after such a short interval was not expected. A later evaluation on October 11, 1989 comparing
bagworm survival between CGA 184699 treatments and untreated checks indicated that survival to adulthood was greatly reduced by this treatment (12% survival in treated versus 67% in untreated). No phytotoxicity was observed.

(Table 1)
Severe defoliation of urban oak trees in Norfolk, Virginia has occurred since 1981. City officials have sprayed for oakworm on a calendar basis without regard to oakworm lifestage and abundance. Oakworms can be controlled with insecticides (2), but other methods can be used in the urban landscape. In 1988, an integrated pest management (IPM) program was implemented to control oakworm infestations. A. senatoria populations were monitored on 10% of the oak trees and defoliation estimates made. An aesthetic injury level (AIL) was used to determine when trees were sprayed. The AIL was determined from a citizen survey and analysis of root starch content in defoliated trees. The survey asked citizens the level of damage they were willing to accept (0, 15, 25, 50, 75, or 100%). Trees which received 0% (n=7), 25% (n=3), and 100% (n=7) defoliation in August were sampled in December of 1988 and percent root starch (dry weight) determined by enzymatic hydrolysis (3). Percent starch and transformed values (arcsine) were subjected to analysis of variance, and means separated by the Waller-Duncan k-ratio procedure.

Results and Discussion: Table 1 indicated 70% of the citizen were willing to tolerate some damage. Twenty-eight percent felt 25% defoliation was aesthetically acceptable. If 25% defoliation was allowed to occur in the IPM program, the impact on the trees had to be established. Percent starch is an indicator of tree vigor and data showed 25% defoliation did not affect tree health. Trees that were 100% defoliated had a significantly lower mean starch content (2.93%) than non-defoliated trees (6.66%) (P<0.05), but trees that were 25% defoliated did not differ significantly in mean starch content (4.86%) from non-defoliated trees (P>0.05).

Table 3 showed pesticide volume sprayed for oakworm control peaked in 1986 at 14,575 gallons. Monitoring and only spraying trees with greater than 25% damage (AIL) in 1988 resulted in an 80.3% decrease in pesticide use compared with 1987. Control of oakworm populations was improved and pesticide volume decreased by implementing an IPM program.

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Potential Host Plant Resistance to Azalea Lace Bug

P. B. Schultz
Virginia

Nature of Work: Opportunities for identification and propagation of insect resistant ornamental plants are limitless. Resistant ornamentals can be derived from initial observation followed by laboratory and field screening from among the vast resources of currently available plant material. Azaleas offer excellent diversity of size, form, and color with over 6000 cultivars (1).

The azalea lace bug, Stephanitis pyrioides (Scott), is a major pest of azaleas wherever they are grown. Adults are about 1/8 inch long, flat, and oval with netted wings. The azalea lace bug overwinters as eggs which are typically laid in the leaf tissue along the midrib. Nymphs hatch in early spring and the first generation develops in about 40 days. In Virginia, we have observed up to 4 generations per year. Nymphs and adults live on the leaf undersurface, and feed by withdrawing plant sap from the leaf. Leaf undersurfaces become rust-colored and covered with black spots of tar-like excrement. Nymphal caste skins are often also observed. The upper leaf surface of damaged leaves has a stippled appearance that with continued feeding becomes blanched. Besides the aesthetic injury associated with lace bug feeding, plant vigor is greatly reduced.

Studies over the last four years have lead us to conclude that azalea lace bug exhibits cultivar preference. Certain plants in landscapes are attacked more heavily year after year, while others are avoided or only attacked late in the season. Possible factors that may affect resistance include bloom color and period, leaf pubescence, nutritional status, and plant location in the landscape. Our studies are currently looking at the first two factors and their effect on oviposition of azalea lace bug.

A study designed to determine azalea resistance to azalea lace bug was conducted in 1989. Ten replicates of 20 azalea cultivars were purchased in early April, 1989, from a commercial Virginia nursery, re-potted, fertilized, and placed on a gravel bed at the Hampton Roads Agricultural Experiment Station, Virginia Beach, VA. From May to September, cuttings were removed from each plant, and individual cuttings were placed in a water-filled vase. Lace bugs were collected from foundation plantings of mixed cultivars from several locations in Norfolk and Virginia Beach, Virginia. Azalea cuttings were covered with a plastic cylinder covered with nylon organdy, and a single azalea lace bug female was introduced for one week. After the insect was removed, the amount of leaf area injury was measured with a Skye leaf area meter, and the number of eggs laid was counted. This study was repeated monthly.
Leaf pubescence is commonly suspected as a leading morphological factor in insect resistance. Many papers including several by the author have dealt with this area. In studies using Cotoneaster and the hawthorn lace bug, we found significant reduction in insect oviposition and retarded development on species with densely pubescent foliage (2). Anecdotal evidence suggested the densely pubescent cv. ‘Seigai’ was rarely infested with lace bug. Lace bug oviposition was compared using methods similar to the previously described study, utilizing cvs. ‘Seigai’ and ‘Delaware Valley White’, the latter having glabrous foliage.

Results and Discussion: Our results in 1989 indicated that azalea lace bug oviposition levels differed significantly between cultivars. Our data indicate ‘Macrantha’ as having the lowest oviposition rate, significantly lower than 17 of the 19 remaining cultivars in this study (Table 1). Bloom color is often reported by homeowners as a significant factor in insect resistance. However, our data indicate no correlation between colors. Each color group examined (red, white, pink, and purple) had cultivars that were highly preferred and cultivars showing evidence of resistance. With blooming period, there was a trend of reduced adult feeding in late blooming cultivars.

Leaf pubescence did affect oviposition behavior of azalea lace bug. Fewer eggs were laid on cv. ‘Seigai’, and the eggs were laid throughout the leaf, and not on the midvein as observed with ‘Delaware Valley White’ and is commonly observed on other cultivars.

Our results indicate that cultivars resistant or at least tolerant of azalea lace bug do currently exist. Additional study should identify cultivars with appropriate form, color, and size that could be recommended for production and sale.

References


(Table 1)
Establishment of a Korean Lady Beetle in Virginia for Control of Euonymus Scale

P.B. Schultz
Virginia

Nature of Work: Lady beetles (Family: Coccinellidae) are important insect predators of scale insects. Williams and Kosztarab (4) included 6 genera of coccinellids (Adalia, Brachyacantha, Chilocorus, Coccinella, Hyperaspis, and Scymnus) in their index to beneficial insects associated with Coccidae (soft scales) in Virginia. Chilocorus kuwanae (Silvestri) was introduced from the Republic of Korea into the U.S. by the Agricultural Research Service (USDA) in 1984 as a potential biological control agent for euonymus scale, a serious pest of ornamental shrubs throughout much of the United States. Initial releases were made in the U.S. National Arboretum in fall 1984 on Euonymus europaeus L. (1). Subsequent releases have been made in 25 states. The beetle is similar to native species, 1/8 inch long, shiny black with 2 reddish spots on the wing covers. Adults are voracious feeders of all stages of the scale (2). Eggs are laid on the plant, either under empty scales or plant crevices. Larvae feed on scales during their development. They pupate on the foliage. There are 3 generations per year out of doors and continual reproduction in the greenhouse. Adults overwinter in protected areas near host plants. Recovery of the C. kuwanae has been reported from NJ, PA, DE, DC, and MA (3).

In Virginia, 40 C. kuwanae were released in March, 1988, 35 at one residential location in Virginia Beach with scale-infested euonymus, and 5 at the Hampton Roads Agricultural Experiment Station (HRAES) in Virginia Beach, VA.

Results and Discussion: In July 1988, 20 adult beetles were recovered from the initial release site and transported to 2 additional residential sites for release. In May 1989, the initial site was free of scale, and no C. kuwanae were observed. The second residential release site had substantial beetles, while the euonymus died at the remaining site. Beetles at HRAES also overwintered and increased in numbers. C. kuwanae overwintered at both established sites in 1989-1990, and have increased in numbers. Beginning in 1990, HRAES is serving as the source for additional releases in Virginia in cooperation with the Cooperative Extension Service.

REFERENCES

Beneficial Insects and Pesticides: Discussion of General Issues

R. F. Mizell, III
Florida

Nature of Work: Relativevly few pesticides are labeled for use on woody ornamentals. Those currently available should be managed judiciously to retain their efficacy against the target pests while preserving the environment and worker safety. One detrimental effect of chemical pesticides that often is not considered is the mortality caused to beneficials. Beneficials here are arthropod predators and parasites that kill pests and are considered helpful to the grower. This paper provides a brief discussion of the problems with conserving beneficials when pesticides are used.

Discussion: Many species of beneficial insects and mites occur naturally on woody ornamental plants where they find food, moisture, shelter and mates. Lady beetle larvae and adults (Coccinellidae) are well known predators of aphids and miscellaneous insects and mites, but many species specialize on scales. Lacewings, primarily the larvae, (green, Chrysopidae; brown, Hemerobiidae) also feed on aphids and mites as well as other miscellaneous arthropods they contact. Less commonly seen but important predators are the carabids, nabids, mirids, anthocorids, syrphids, thrips, reduviids, and non-webbing spiders. A large number of species of predatory mites also prey on the phytophagous mites associated with ornamental plants. Parasites are represented by many families and species of Hymenoptera (wasp) and Diptera (tachinid flies) that are often very specialized as to the host species they attack. Most species of insects including beneficials are attacked by some species of parasitic Hymenoptera. Populations of Lepidoptera (moths and butterflies), aphids, and scales are often regulated by parasites. Diseases also infect arthropods and are important sources of mortality to pests. Bacillus thuringiensis (BT) is a well known bacterial disease of Lepidoptera with EPA registration. insect diseases will not be discussed further but they are often
suppressed by fungicides and bactericides targeted to plant diseases. However, microbial pesticides like BT are usually not harmful to beneficials.

Theiling and Croft (1988) developed a computer database and reviewed the literature concerning response by beneficials to pesticides. The following comments were extracted from that work. Generally insecticides are the most toxic to beneficials, followed by herbicides, acaricides, and fungicides. There is a trend of increasing toxicity to beneficials from older inorganics to the synthetic pyrethroids. Predators are usually less susceptible to pesticides than are parasites but their response is more variable. Life stages of beneficials differ in their response to pesticides. The more protected egg and pupal stage of predators usually are less susceptible. For parasites the larval and pupal stages are usually less susceptible.

Direct mortality to beneficials is not the only detrimental effect imposed by pesticides. Sublethal effects such as decreased longevity and fecundity, interference with sensory modalities which influence the ability to locate and attack prey, and decreased mobility may also occur. Indirect mortality from starvation by the beneficial can occur when pesticides destroy nearly 100% of the prey. A dramatic decrease in prey populations may cause surviving beneficials to disperse from the crop in search of new prey.

Management choices concerning pesticides that affect beneficials and are under grower control include the rate, method (type of sprayer, size of area treated), and frequency of application; population level of pest or damage level to plant when treated; and selection of chemicals to apply (formulation, chemical class, activity spectrum, relation to previously used chemicals).

Application rate and thus the residual concentration of the pesticide on the plant may be reduced when using some chemicals to the benefit of beneficials. This is directly related to the concentration or dose of the pesticide necessary to be toxic to the pest and beneficials. The toxic dose of a specific pesticide is almost never the same for beneficials and pests. The degradation or breakdown rate of pesticides is related to their chemistry, climate and weather and to plant chemistry. Pesticides with acute toxicity but short residual times may have less total mortality on beneficials than those with less toxicity but long residuals. Dursban (chlorpyrifos) has a long residual on most organic substrates, Malathion does not. Use of reduced rates may also help conserve beneficials by allowing the survival of low levels of prey. Continuous availability of food is necessary to stop dispersal by surviving beneficials after pesticide treatments.

Spot treatment of pests is recommended to minimize the area in which beneficials may contact toxic pesticides. And use of an airblast sprayer may not deliver pesticides into the plant interiors allowing untreated refugia for beneficials. Less frequent applications and the acceptance of higher pest
populations or damage levels also will decrease the amount of time when pesticides are present to affect beneficials.

Granular systemics are usually less harmful to beneficials than foliar sprays. Unfortunately, few systemic chemicals are available. Some species of predators are almost completely tolerant of certain classes of pesticides as for example green lacewings and pyrethroids. This concept is termed selectivity. Pesticides which are less broad spectrum against pests will generally be less toxic (more selective) to some predators. To delay the onset of the development of resistance to pesticides by pests it is suggested that the available pesticides be used in a rotation, rather than repeated use of one or a few (this issue is needs further discussion elsewhere).

Table 1 presents a list of insecticides and acaricides registered for use on woody ornamentals or field-grown trees with an accompanying assessment of their potential toxicity to beneficials, bees and birds. These data were gleaned from pesticide labels, published literature and my own research. It is very difficult to make a general assessment for specific species of beneficials and individual pesticides without testing. Therefore, these data should be used as a guide only. Growers should be able to recognize the life stages of beneficial species as well as pest species. When in doubt about a pesticide’s impact on the beneficials present, test the pesticide first in small plots before spraying large blocks. Read the pesticide label! THE LABEL IS THE LAW! Pesticide labels and literature will contain at least some information concerning the toxicity of the pesticide to nontarget organisms.

**Literature Cited**

Table 1)
EFFECT OF HYDROPHILIC GELS ON THE ACTIVITY OF
SYSTEMIC INSECTICIDES FOR CONTROL OF LACE
BUGS ON CONTAINER-GROWN AZALEAS

David R. Alverson, Kevin M. Hoffman, and James B. Aitken
South Carolina

Nature of Work: Hydrophilic gels are water-absorbent polymers which are useful as media amendments in certain horticultural practices (1). Because of their absorbent nature, these gels are potential carriers of water-soluble compounds which can be extracted by the plants. As one component of a larger study of their potential enhancement of agri chemical efficacy, we examined the expressed effect of hydrophilic polymers as capture and delivery agents for systemic insecticides in containerized azaleas.

Azaleas (‘Hino Crimson’ cvr.) were used in insecticide and fungicide studies because they are common host to both an economically and aesthetically important insect pest, the azalea lace bug, *Stephanitis pyrioides* (Scott), and a persistent fungal pathogen, *Phytophthora cinnamomi*. Lace bugs cause injury resulting in plasmolysis, discoloration, and premature loss of leaves. They are controlled with foliar insecticides or systemic insecticide drenches. Polymer-fungicide interactions are discussed elsewhere (2).

Treatments were established on 22 April 1, 1989, in a 4 X 5 (gel X insecticide) factorial arrangement of a randomized complete block design with eight replications. An azalea growing medium (85:15 bark:sand) was amended with Water Grabber™ hydrophilic polymer by either the addition of dry polymer (dry pre-mix) as a 0.1% (by weight) pre-mix or as a hydrated gel pre-mix using equivalent weights of polymer hydrated with water (135 ml water/g polymer) 30 minutes prior to mixing with the soil. Azaleas were repotted from one-gallon containers into 10-liter (3-gallon) trade containers containing these two amendments. Another group of repotted azaleas was injected with the same amount of hydrated gel (hydrated-injected) using a specially manufactured 1-liter syringe, producing a single mass of gel in the root zone of the plants rather than a homogenous mix. A fourth group served as an unamended controls.

To each of the containers containing these four gel treatments, the systemic insecticides Metasystox-R™ (MSR) or Cygon™ dimethoate were applied as 300 ml (per pot) drenches. MSR was applied at rates of 1.1% and 0.55% active ingredient (A. I.), and Cygon was applied at rates of 0.8% and 0.2% A. I. One group of pots was treated with water only for experimental control.

Plants were held on wire benches in a shadehouse with screened partitions between each replicate and watered by electrically timed drip irrigation with the equivalent of one-half inch rainfall each day. Live adult azalea lace bugs
were collected by aspirator from local azaleas, released on caged azaleas overnight, and transferred on newly infested leaves to each plant on the following schedule: 23 April and 4 May - 10/plant (total 1600 lace bugs each date); 18 May - 4/plant; 31 May - 3/plant; 14 June - 5/plant; 24 July - 4/plant; 29 August - 5/plant. Counts of adults, nymphs and damage ratings were made weekly through November, 1989.

**Results and Discussion:** Efficacy against lace bugs was maintained until late August (Julian date 230-240) in all insecticide treatments, with no apparent enhancement or decrease in efficacy attributable to gel treatments (Fig. 1). Expression of efficacy was long-lived, especially considering the relatively high watering rates used in this study. Though differences were evident between insecticidal treatments, there is no indication that any of the gel amendments affected the lace bug efficacy for any one chemical treatment. Cygon at 0.8% gave good season-long control with minimal damage under high pest pressure.

In laboratory experiments, we determined that Water Grabber polymers would not absorb the insecticides tested, regardless of the degree of prehydration or dilution of pesticide. The porous absorbancy is apparently selective for water and dissolved minerals or salts. Also, plant uptake of these systemic insecticides occurs quickly (unpublished current study), and they are retained by the plants for relatively long periods of time. It is uncertain but doubtful that hydrophilic gels have any value as retention agents of these chemicals under high watering regimes. We are currently investigating the length of efficacy expression under minimal watering conditions where the plants are more dependent on gel-retained water.

**LITERATURE CITED**


**FIGURES**

Fig. 1. Mean numbers of adult lacebugs per azalea plant in the 1989 season under each of the gel amendment-insecticidal drench regimes.
CONSUMER ATTITUDES TOWARD AZALEA LACE BUG DAMAGE TO AZALEAS

Debra D. Oliver and David R. Alverson
South Carolina

Nature of Work: The azalea lace bug, Stephanitis pyrioides (Tingidae: Hemiptera), is a common pest of azaleas, causing leaf injury and aesthetic damage. Feeding damage is characterized by white spots, or stippling, on the upper surface of the leaves, and black varnishlike spots of excrement disfigure the under surface of the leaves (1). Control of these pests is a concern in both the nursery and landscape. Recently, the concepts of Integrated Pest Management (IPM) have become as important for ornamental plants as to traditional agricultural crops because of pesticide resistance, government regulation of pesticides, environmental concerns, and the increasing cost of chemical controls. IPM is defined as the intelligent selection and use of pest control options in an economically, ecologically, and sociologically compatible manner (2). Control options for IPM programs for the nursery or the landscape must also consider aesthetics as an economic component. Aesthetics are subjective and are measured in terms of what most people regard as tolerable (3).

The objective of this study was to assess these subjective, aesthetic values by measuring consumer attitudes toward azalea lace bug damage to azaleas. ‘Buccaneer’ variety azaleas in 3-gallon containers were used in this study.
Each had similar characteristics except damage rating due to damage by azalea lace bugs. Damage ratings were calculated for each plant by first assessing each leaf and placing it in a damage category as follows: 0% damage = 0, 1-25% damage = 1, 26-50% damage = 2, 51-75% damage = 3, 76-100% damage = 4. The percentage of leaves in each category was multiplied by the respective category number, summed, and divided by 100, resulting in the damage rating for each plant. Four plants, designated W, X, Y, and Z, were selected for use in a consumer opinion survey. Damage ratings were assessed as 0 for azalea W, 0.30 for X, 0.63 for Y, and 1.18 for Z. Azaleas with these low rating were chosen because previous work had indicated consumers attitudes toward azalea lace bug damage began to become increasingly negative when insect damage ratings were 1.00 or more (4). Customers of Head’s Garden Center in Walhalla, SC. were surveyed on May 30 and 31, and June 4, 6, and 7. Each customer was asked to answer a series of questions while observing one the four azaleas, and their attitudes toward this plant were measured. Fishbien’s multiattribute model was used to measure these consumers overall attitude toward the specimen. Fishbien’s model is expressed as:

\[ A_0 = \sum_{i-1}^{n} b_i e_i \]

where \( A_0 \) = overall attitude toward the azalea, \( b_i \) = strength of belief about the azalea characteristic (rating characteristics as excellent (1) - very poor (5)), \( e_i \) = evaluation of that characteristic (ranking characteristics 1-5, with 1 = most important, 5 = least important), and \( n \) = number of characteristics (plant shape and symmetry; leaf color, condition, and form). Overall attitude score \( (A_0) \) is obtained by multiplying the belief score \( (b_i) \) by the evaluation score \( (e_i) \) for each characteristic and summing across all characteristics (5). Mean attitude scores were compared for each azalea. Respondents’ assessment of value of each azalea, likelihood to buy it at a reduced or regular price, and likelihood that it was in need of treatment for disease or insects was also compared for each plant.

**Results and Discussion:** Mean overall attitude score increased for the four azaleas as damage ratings increased (Table 1). However, there was no significant difference in mean overall attitude scores between the azaleas. It is possible that no significant differences were found because there were only slight differences in the damage ratings for these azaleas. Respondents were asked “How much would you pay for this azalea?” and were given a response scale ranging from $0 to $10 dollars. Responses averaged $3.84 to $4.42 a difference of only $0.58 between azaleas. Average values did not correlate with damage ratings.

To the question, “How likely is it that you would buy this azalea? (at regular price or a reduced price)”, responses showed that lace bug damage did have an effect on the likelihood of whether or not the respondent would buy the
azalea. Most respondents (76 to 68%) said they were likely or very likely to buy the azalea at a regular price (Figure 1). The percentage of respondents that were unlikely or very unlikely to buy the azalea at a regular price increased as damage increased. Most respondents said they were likely or very likely to buy the azalea at a reduced price. Only 6.5 said they were very unlikely to buy azalea X with a rating of 0.63 and 5.6% were for Z with a rating of 1.18 at a reduced price.

(Table 1)

Responses to the question, “How likely is it that this azalea is in need of treatment? (for insects or disease)”, indicated that for plants with a rating less than or equal to 0.63 (W, X, and Y), most respondents felt that it was not likely that it was in need of treatment for insects (Figure 2). For azalea Z, with a rating of 1.18, 26% of the respondents felt that it was likely or very likely in need of treatment for insects. Of all respondents, 32 to 42% were “not sure” whether any of the azaleas were in need of treatment for insects. Most of the respondents (58-53%) felt that it was unlikely or very unlikely that azalea W with a rating of 0 or X with a rating of 0.30 were in need of treatment for disease. Percentages of respondents who felt their azalea was likely to very likely in need of treatment for disease increased as damage rating increased. More than 25% of the respondents were “not sure” whether any of the azaleas were in need of treatment for disease.

In conclusion, azalea lace bug damage does have an effect on consumers’ overall attitude toward these plants, and it affects their decision to buy, the amount they would pay and their decision to treat azaleas. However, most respondents did not recognize this damage as insect damage, and many thought that the damage was from disease rather than insects, or were not sure about the damage.

LITERATURE CITED


(Figure 2)
SECTION 5
PATHOLOGY & NEMATOLOGY

Dr. Jerry T. Walker
Section Chairman and Moderator
A Bacterial Leaf Spot of Florist Azalea

John W. Olive
Alabama

Nature of Work: In the fall of 1989, a grower of florist azaleas (Rhododendron sp.) reported a leaf spot on the cultivar ‘Prize’. Symptoms included small water-soaked areas visible on the lower leaf surface, progressing into necrotic lesions often delimited by veins. During periods of high humidity, water-soaked tissue was evident surrounding lesions. When leaf spots were plated on potato-dextrose agar, no fungus was detected after 10 days. However, when tissue was macerated in sterile distilled water (SDW) and streaked on nutrient agar and yeast extract-dextrose-calcium carbonate (YDC) agar, almost pure cultures of a yellow bacterium were consistently isolated. Gram reaction (KOH) (2), flagella stain and oxygen requirement (I) was determined.

Four azalea cultivars: Rhododendron x ‘Prize’, B. x ‘Gloria’, B. x ‘Road Runner’ and B. x ‘Hershey’s Red’ growing in 1 qt. pots for forcing were obtained from a commercial grower. Four plants of each cultivar were atomized with a suspension of bacteria in SDW resulting in a concentration of 4 x 10^5 colony forming units/ml. Two plants of each variety were sprayed with SDW alone. Plants were enclosed in polyethylene bags for 3 days and maintained under intermittent mist. Plants were then unbagged and held in a propagation house where relative humidity remained higher than 90%. Plants were evaluated for disease symptoms 4 and 10 days after inoculation. Koch’s postulates were completed by isolation from symptomatic tissue. Inoculations were repeated using a different isolate of the suspected pathogen.

Results and Discussion: The suspected pathogen was an aerobic, gram negative bacterium with a single polar flagellum. It formed yellow mucoid colonies on YDC medium.

When plants were observed 4 days after inoculation, water-soaked areas were evident on the leaves of all inoculated plants. At 10 days after inoculation all cultivars exhibited necrotic leaf spots often surrounded by water-soaked tissue. Plants sprayed with SDW alone never developed symptoms. Similar results were obtained when the test were repeated. The suspected pathogen was easily isolated from symptomatic tissue of the inoculated plants.

Bacterial diseases are not common on azaleas. The disease in the nursery however, was preceded by a week of unseasonably cool temperatures (Avg. 63°F), a prolonged period of high humidity (7 days), and cloudy weather. These are ideal environmental conditions for a bacterial disease to develop and any grower of florist azaleas should be alert to the possibility of this
problem. This particular bacterium produced a serious leaf spot on Rhododendron X ‘Prize’, and has potential to infect several other cultivars. The grower can avoid costly and ineffective fungicide applications if he can identify this disease as bacterial.

Unfortunately, there are no effective chemical controls for bacterial leaf spots under these conditions. Cultural practices that improve air circulation and limit leaf surface moisture continue to be the only methods of disease control.

LITERATURE CITED


Influence of Hydrophilic Polymers in Potting Media on Development of Phytophthora Root Rot of Azaleas

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Nature of Work:  Hydrophilic gels are water absorbent polymers which have been used to improve the water status of plants during production (3). Some polymers can absorb 500 times their original weight in water and release up to 96% of the water to plants on an as-needed basis. It has been postulated that hydrogel technology may help reduce water and chemical application rates. However, the concern exists that the presence of more constant moisture in the potting media may provide a more conducive environment for development of soilborne diseases such as Phytophthora root rot.

Phytophthora root rot is serious, widespread, and difficult to control disease in nurseries and landscapes (1). High soil moisture and warm soil temperatures favor growth of the fungus. Effective control of Phytophthora root rot can be achieved by applying fungicides on a regular basis (2). These applications can be quite expensive due to the actual use of the fungicide, labor costs, and potential problems associated with pesticide runoff. Development of an enhanced delivery system of the fungicides would be advantageous for nurserymen, landscape management professionals and homeowners.

This project was initiated to evaluate the hydrophilic gel Water Grabber™ (FP Products Inc., Atlanta, GA) as a retentive aid for metalaxyl (Subdue) and fosetyl-Al (Aliette). Another objective was to determine if the presence of the gel would favor development of Phytophthora root rot of azaleas grown under typical nursery conditions.

Two sources of azaleas were used for the study. “Hino Crimson” naturally infested with P. cinnamomi and “Hinodegiri” which were grown free of the fungus were obtained. One hundred twenty 2-inch liners from each source were transplanted into one gallon pots which contained a 3:1 ratio pine bark/sand mixture. One third of the pine bark/sand mix had been amended with 0.2% Water Grabber by weight prior to planting. Another third contained 0.8% and the final third contained no Water Grabber. The potted plants were placed on raised screen benches and a drip irrigation tube was placed in each pot. Sierra-blend 17-6-12 slow release fertilizer was applied at the rate of 5 g per pot on June 29. All plants received the equivalent of approximately 1/2 inch of rain each day. With the onset of cooler temperatures, the irrigation rate was reduced to 0.25 inches/pot every other day on October 10.
Inoculum of *P. cinnamoni* was prepared by growing the fungus on sterile oat grains for 30 days (1). Three weeks after the plants were transplanted, approximately 30 infested oat grains were placed around the perimeter of designated root balls at a depth of 1 to 2 inches. The initial fungicide applications were made on the inoculation date. *Subdue 2E* was applied at a rate of 1 oz/100 gal. water and .76 pts. were applied as a drench per plant. *Aliette* was applied at the rate of 12.8 oz/100 gal. water and .76 pts. were applied per plant as a drench. *Aliette* was also applied as a foliar spray at the rate of 5 lb./100 gal. water. Plants were sprayed to runoff. Fungicide applications were repeated on August 30. A randomized complete block with 5 replicates per treatment was used.

On November 10, plants were removed from the pots and root ratings were assigned as follows: 1 = healthy roots; 2 = fine roots necrotic; 3 = coarse roots necrotic; 4 = crown rot; and 5 = dead plant.

**Results and Discussion**: The addition of the hydrophilic gel to the potting media did not enhance development of *Phytophthora* root rot either with or without the application of fungicides (Tables 1,2). “Hino Crimson” plants grown in potting media amended with .8% *Water Grabber* received significantly lower root rot ratings than plants grown in the absence of *Water Grabber*. This was not observed with the “Hinodegiri” plants. The application of 1/2 inch of rain per pot per day provided a relatively constant moist environment even without the addition of *Water Grabber*. Future studies should include treatments with lower irrigation rates whereby non-amended media becomes somewhat dry as compared to the hydrophilic gel amended media which would retain more constant moisture.

Fungicide applications resulted in lower root rot disease ratings in most treatments (Tables 1,2). There was no indication in these experiments that the hydrophilic gel helped retain higher concentrations of fungicides. Perhaps the fungicides could be incorporated into the gels in order to provide a slow release mechanism.

**References Cited**


(Table 2)
Nature of Work: Dogwood anthracnose was first found in the North Carolina and Georgia in October, 1987 (Anderson, personal communication). Since that time, the disease has been detected in seven southeastern states. Disease incidence and severity were higher at the upper elevation range of flowering dogwood, 1500 -3000 ft, (3) but increasing disease pressure has been noted at lower elevations in both forest and urban habitats in 1990 (Windham, unpublished).

Chemical and cultural control strategies for this disease have been reported in the Northeast (1). The objective of this study was to determine if fungicidal sprays and pruning would be as effective for controlling dogwood anthracnose in Tennessee as they were in New York.

Three Tennessee locations were selected for this study: Chilhowee Mountain, Ozone, TN, and Roaring Fork Creek in Great Smoky Mountain National Park. Fungicide treatments and rates were: control (water spray), Benlate 50 WP - .16 oz/gal, Bravo 750 - .18 oz/gal, Dithane M45 - .24 oz/gal, Lynx - .5 tp/gal, and Zyban - .24/gal. One drop of Triton B-1956 (spreader/sticker) was used with most treatments. Each fungicide treatment was sprayed to runoff on 20 potted dogwood trees that were located underneath trees infected with dogwood anthracnose. Trees were sprayed on a 10 day schedule throughout the summer of 1989. Once a month, half of the trees in each fungicide treatment were pruned to remove symptomatic leaves and twigs. Trees were rated for symptom severity using the Mielke-Langdon scale (2).

In another study, 23 pairs of native trees were selected for similar size, trees within pairs being within 20 ft of each other and similar levels of anthracnose disease severity. Diseased foliage was pruned from one member of each pair monthly from June - August, 1989. Trees were evaluated monthly for disease severity using the Mielke-Langdon scale.

Results and Discussion: Disease severity ratings for trees that had been pruned were not different from ratings for unpruned trees in both the fungicide and pruning experiment. Since all trees were located in areas with severe dogwood anthracnose epidemics, the trees in the test plots may have been so overwhelmed with inoculum that pruning was not effective. These data differ from reports of Daughtery et al (1) who recommended pruning for disease control.
Fungicidal sprays were effective in controlling dogwood anthracnose at all locations. Although fungicide sprays were stopped at the end of August, disease incidence was lower in October for fungicide treated trees than for control trees. Leaves of the control trees were dead and were hanging onto the trees in October.

An unusual response was noted in trees sprayed with Benlate and Zyban. The leaves in the Benlate and Zyban treatments remained green and soft until the first killing frost in November whereas leaves in other fungicide treatments had turned red and fell off the trees. The trees with green foliage did not “harden-off” and were severely damaged by extremely cold weather in December.

REFERENCES


(Table 1)
CHEMICAL CONTROL OF POWDERY MILDEW ON LILAC AND SERVICEBERRY

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Tennessee

Nature of Work: Powdery mildew occurs on many woody ornamentals grown in Tennessee nurseries (2). Woody ornamentals such as crape myrtle (Lagerstroemia indica), common lilac (Syringa vulgaris), Persian lilac (Syringa x persica), euonymus (Euonymus spp.), rose (Rosa spp.) and serviceberry (Amelanchier sp.) may be seriously damaged by powdery mildew. Young shoots and leaves may be twisted and distorted by the fungus. Damage to flower buds often causes misshapen flowers that are of low quality.

The objective of this study was to evaluate new fungicides for efficacy on powdery mildew on woody ornamentals. Common lilac and serviceberry were chosen as test plants as they are highly susceptible to Microspillaera pencillata and Erysiphe polygoni, respectively. The fungicide trials were conducted on lilac in 1989 and on serviceberry in 1990.

Field nurseries at two Tennessee locations were selected for this study: Harrison Ferry Mountain, Warren county (lilac) and Altamont, Grundy county (serviceberry). Fungicides included in the two trials were: Anvil (hexaconazole; ICI Americas), Banner (propiconazole; Ciba-Giegy), Bayleton (triadimefon; Mobay), Benlate (benomyl; Dupont), Lynx (foficur; Mobay), Rubigan (fenarimol; Dow Elanco), Sentinel (cyproconazole; Sandoz) and Systhane (myclobutanil; Rohm and Haas). Triton B-1956 (Rohm and Haas) was used as a spreader-sticker at a rate of 1 oz/100 gal of spray solution. Each fungicide treatment was applied to runoff with a back pack sprayer. Lilac were sprayed on June 26 and July 17, 1989 and evaluated for disease severity on August 8, 1989. Serviceberry were sprayed on May 24, June 8 and June 23, 1990 and evaluated for disease severity on July 11, 1990. Plants were evaluated for percent foliage infected with powdery mildew using the Horsfall-Barratt Scale (2).

A randomized complete block design consisting of four blocks was used at both test sites. Experimental units consisted of 10 plants with a total of 40 plants used per treatment.

Results and Discussion: All fungicides effectively controlled powdery mildew on serviceberry and lilac (Table 1). Disease pressure was high and uniform across blocks in both trials. Nontreated lilac was severely infected with mildew as leaves were covered with mycelium. Nontreated serviceberry was also severely infected as new growth was stunted and distorted. No phytotoxicity or plant growth regulator activity was noted for any of the treatments during either test.
LITERATURE CITED


(Table 1)
Mycoflora of Roots of Texas Palm (Sabal mexicana Mart.) in Louisiana

Clayton A. Hollier and Severn C. Doughty
Louisiana

Nature of Work: Root rot has been reported as a problem of palms worldwide (2,4,5,6). Various fungi have been associated with serious damage to the root system expressed above ground as decline, dieback or death of the entire plant (2,5,6).

Several dozen Texas palms in New Orleans, Louisiana display symptoms of decline or dieback and root rots have been associated with these symptoms since the early 1980’s. Attention was drawn to these palms because they either were leaning at angles or had completely fallen over. Damage caused by root rots are difficult to assess in the field.

Our objectives were to determine 1) the frequency of fungal invasion of roots of Texas palm and 2) the extent to which invaded tissues show disease symptoms.

Below ground parts of four asymptomatic and five symptomatic Texas palms were assayed for internally borne fungi. Roots were excavated with a shovel and washed to remove loose soil. The roots were kept on ice en route to the laboratory, where they were cleaned by agitation in a mild detergent solution and rinsed under running tap water. Root sections were cut into 1-cm pieces, and pieces were randomly selected for assay. Tissues assayed from each plant included 20 pieces of root replicated five 23 times for a total of 100 pieces per root system.

After tissue pieces were examined for discoloration or necrosis, they were surface-sterilized in an aqueous solution of 0.5% NaOCl (Chlorox) and 5% ethanol for 2 min, rinsed with distilled water, blotted dry on sterile tissue paper and placed on potato dextrose agar (PDA) amended with 30 mg/L each of chlortetracycline-HCl and streptomycin sulfate. Plates were incubated at 26 C for four days. Fungi were then counted directly or subcultured on PDA for identification.

Data pertaining to fungi isolated from symptomatic and asymptomatic plants were used to calculate relative frequency (RF) of invasion. RF was defined as the number of root pieces invaded per 20-piece sample.

Results and Discussion: Roots of both symptomatic and asymptomatic plants rarely showed disease symptoms. From symptomatic plants 11% of the root pieces assayed were discolored while those from asymptomatic plants numbered less than 3% although one or more fungi were isolated from over 75% of the root pieces regardless of source.
Rhizoctonia solani and Fusarium spp. were isolated most often from symptomatic plants with means of 19.4 and 4.6, respectively (Table 1). Curvularia spp., Trichoderma spp. and Phoma spp. were isolated less often with RF values of 2.1, 1.5 and 0.4, respectively.

From asymptomatic plants Trichoderma spp. and R. solani were isolated most often with RF values of 9.5 and 8.5, respectively. Fusarium spp., Curvularia spp. and Phoma spp. were found less frequently (Table 1).

When RF values of symptomatic versus asymptomatic plants were compared, symptomatic R. solani - infected root values were significantly greater than its presence on asymptomatic plants. The same was true for Fusarium spp., but the opposite was true for Trichoderma spp. (Table 1). The other fungi isolated did not differ in frequency regardless of source.

The fungi isolated from the root systems of symptomatic and asymptomatic Texas palms were the same regardless of source. Root discoloration percentage varied slightly but the percent of root pieces from which one or more fungi were isolated was very high.

In symptomatic plants the RF of Rhizoctonia solani was significantly greater than for any other isolated fungus. It was found more than four times that of any other fungus. R. solani is a known root rotting organism of numerous plant species (1). Its presence in such quantity may explain the slight increase in the observed root discoloration of the symptomatic plants and the presence of above ground symptoms. Currently pathogenicity studies are underway to determine the role of R. solani in this syndrome.

Trichoderma spp. was more prevalent from the roots of asymptomatic plants than from symptomatic plants. It was evident that as Trichoderma spp. increased, the RF of R. solani decreased. Trichoderma spp is a known antagonist to several fungi (1,3) and probably explains the decrease in the presence of R. solani. The reduction in the presence of R. solani from the roots of asymptomatic plants further supports the theory that R. solani plays an important role in the deterioration of Texas palm root systems and subsequently leads to symptom expression.

Some fungi commonly isolated from palm roots, for example species of Monacrosporium, Cylindrocarpon, Pythium and Penicillium, were noticeably missing in our study. These fungi might have been present but were not detected because of competition from other microorganisms, incompatibility with Texas palm or unsuitability of the culture medium used for isolation.

Even though we observed relatively little root discoloration or necrosis indicative of disease, fungi, including reported root pathogens, were frequently found. Perhaps the presence of fungi in symptomless Texas palm
root tissue is a more common phenomenon than previously believed. For symptomless but invaded roots to become diseased may require one or more stress factors or the natural weakening of senescence to trigger pathogenic activity by these fungi.

LITERATURE CITED


(Table 1)
Soybean Cyst Nematode Testing Program for Kentucky Nurseries

Win Dunwell, Don Hershman, John Hartman, and Rudy Scheibner
Kentucky

Nature of Work: In 1989 a Kentucky nurseryman discovered that in order to ship balled and burlaped shade trees to Canada the soil balls had to be certified free from Soybean Cyst Nematode (Heterodera glycines). The need for this certification created a serious problem. The bioassay to confirm the existence of soybean cyst nematode (SCN) takes a minimum of 30 days. If shipping and the initial test for the presence of any nematodes are added, it could take six weeks to get accurate results back on a SCN test. A proactive program of soil testing that encouraged periodic monitoring of existing nursery fields would allow nurseries to avoid delays in getting field grown stock certified free of SCN and thus, increase sales. Also, sampling fields for SCN, prior to planting, would allow nurseries to avoid planting in SCN infested soils.

The first step in this program was to check with other states and see what their regulations were concerning SCN. Several states have regulations specifically forbidding the importation of soils and seed contaminated with SCN. Other states will not allow importation of soils from counties designated as SCN infested. All states have regulations requiring any imported plant material be "free from all pests" and assume this includes SCN.

Following discussions with state regulatory personnel in other states it was apparent that they would accept field-grown balled and burlaped material from fields certified free of SCN. Soil testing for the presence SCN would be necessary in order for the Kentucky State Entomologist to certify balled and burlapped plants free of SCN.

The Department of Plant Pathology Nematology Laboratory at the University of Kentucky Research and Education Center in Princeton would test the samples submitted by nurserymen and forward the results to the Kentucky State Deputy Entomologist. The Deputy State Entomologist would then supply the documentation for shipments to states that require certification that plant materials and related soils are free of SCN. The Nematology lab would also maintain records on SCN tests so that nurseries could have test results on file and available when needed. A specific form for submitting samples for testing has been developed so the nurserymen will receive results appropriate for the nursery industry.

Results and Discussion: The program is voluntary and not regulatory in nature. To date the nursery industry in Kentucky has not made use of the testing program specifically for the SCN certification program. Samples have
been submitted and tested for the presence of SCN, but these were from nurseries wanting to know the status of their fields prior to planting. Testing fields for the presence of parasitic nematodes has been recommended by the University of Kentucky Cooperative Extension Service for many years. The program will be continued in spite of the lack of immediate interest by the industry. This will ensure availability of SCN free certification for those needing it in the future. It is anticipated that more stringent regulations and increased enforcement of existing regulations by neighboring states should result in greater use of this program by the Kentucky nursery industry.

Effect of Banrot on Germinating Seeds, Rooting of Transplants and Propagation of Cuttings

Dan Milbocker
Virginia

Nature of Work: Banrot is one of several broad spectrum fungicides used on bedding, foliage, herbaceous and woody plants. It is effective for controlling Pythium, Phytophthora, Rhizoctonia, Fusarium and Thielaviopsis root rots. Banrot is a combination of two fungicides with activity in the soil as well as being systemic in the plant. Systemic activity requires absorption by the plant. The effect of Banrot absorption on the plant is the subject of this research. Grace Sierra Horticultural Products Company funded this research in their continuing pursuit of a greater understanding of their products.

Fungicide sensitive plants have not been found to belong solely to one genus or species but instead were cultivars among commonly grown greenhouse and nursery crops. When crop losses have been experienced, sensitive cultivars were damaged most severely but losses were not always limited only to sensitive cultivars. Therefore, determining why damage occurs is more important than screening for sensitive cultivars.

The search to find causes for injury was done by inducing damage. Seeds, seedlings and cuttings were exposed to concentrations of Banrot higher than, and for durations longer than encountered when using Banrot according to label recommendations. For this research, 12 ounces of Banrot per 100 gallons of water was used (3X recommended rate). Exposure to Banrot was assured by soaking for as long as 32 hours rather than drenching. This
practice is not recommended for growers and was used in this research only to induce injury and determine plant sensitivity.

Results and Discussion: Seed germination. Tolerant seeds germinated after soaking in Banrot solution for 32 hours. Sensitive seed germination was significantly reduced by only 8 hours of soaking. Germination was delayed 2 to 4 days as a first response. Longer delays became permanent reductions in germination. Ungerminated seeds generally remained resistant to decay beyond the germination period for untreated seeds.

Seedling transplanting: Tolerant seedlings were not damaged by 12 hours of exposure to Banrot. Roots were damaged on sensitive seedlings by as few as 4 hours of exposure. Damaged roots were sorted from undamaged roots 4 to 6 days after transplanting. Roots of undamaged plants continued to grow from their ends. Plants with damaged roots initiated new roots from their crown. Since root initiation required a few extra days, damaged plants were more sensitive to stress after transplanting.

Cuttings for propagation. Cuttings from tolerant plants were not damaged by 12 hours of soaking. Sensitive cuttings were damaged by 4 hours. This type of lengthy exposure to fungicides is not a recommended practice during propagation. Herbaceous cutting damage was a watersoaked appearance to the stem. Watersoaking was not easily seen on woody cuttings. Treated cuttings that had not rooted after 40 days, as compared to rooted untreated cuttings, were considered damaged. Root initiation occurred just above the water soaked portion of herbaceous cuttings which resulted in smaller plants. Damaged woody cuttings eventually rooted or died after the delay.

Unless extensively damaged, Banrot damaged seeds, transplants or cuttings will recover with only a delay in germination, transplant recovery or root initiation. These results show the importance of following recommended rates and practices for fungicide application. Application above recommended rates and poorly followed directions can result in damage to sensitive plants. Particular care should be taken in regard to Banrot to drench with water after application as recommended. In this research, higher than recommended rates and longer exposure times were necessary to induce damage indicating the safety of recommended application rates.
(Table 1)
SECTION 6
ENGINEERING, ECONOMICS,
STRUCTURES AND INNOVATIONS

Dr. Robert E. McNeil
Section Chairman and Moderator
MULTI-MEDIA INFORMATION DELIVERY FOR LANDSCAPE PLANTS

R. A. Baumgardner and David M. Price
South Carolina

Nature of Work: A videodisc has the capacity of recording thousands of still images. Each image is referenced by a frame number between one and 54000. The capacity and durability of the disc and the ability of a laser videodisc player to rapidly and accurately access still frames or motion provide for an exciting new information delivery technology.

A videodisc titled *Encyclopedia of Landscape Plants Volume 1, Woody Landscape Plants of The Temperate United States* was produced by Videodiscovery, Seattle, WA in 1987. This disc contains 8,000 images that show about 900 species and cultivars of woody ornamental plants in a wide range of identification and use modes. For example, the set of images for flowering dogwood provides 12 separate views showing this plant in a range of situations including bloom, fall color, etc. Collectively, these images serve to clearly identify and differentiate the flowering dogwood from others and also indicate some possible landscape uses. Slides illustrating approximately 100 insect, disease, and environmental disorders are also included on this disc.

A written index giving an alphabetical listing of the plants by botanical and common names and associated frame numbers is provided with the disc. The slides are also Indexed by chapter; i.e., the genus Vaccinium is located in chapter 23. Using the index and a remote control device to operate a laser disc player, images of interest can be quickly located and viewed.

Results and Discussion/MACRAPID: We have developed a computer program linking the computer with the *Encyclopedia of Landscape Plants* videodisc. MACRAPID© CU, *Macintosh Rapid Access Plant Image Display*, provides a more user friendly and flexible access to this woody ornamental slide database.

This Hypercard stack provides for the selection of plants from a rolodex type file according to either botanical or common name. The program also links to MACCAPS© Terisan, Astoria, OR; *Macintosh Computer Augmented Plant Selector*. With this linkage, a user can quickly select and view plants that meet very specific selection criteria.

HERBACEOUS DISC: After working with the woody ornamental disc, it quickly became apparent that a videodisc of herbaceous landscape plants was needed. Consequently, we have produced Clemson University Video Encyclopedia of Herbaceous Ornamentals. This disc is composed of 1237 color
images of approximately 450 species, including annuals and perennials. The Manual of Herbaceous Ornamental Plants by Dr. Steven Still served as the principal reference for the disc.

In most cases two images of each plant are available; a close-up and a more distant view of the plant. The close-up perspective enables viewers to study individual plant characteristics, while the distant view can illustrate potential landscape uses. Some plants have additional slides showing varietal differences such as size and flower characteristics. Each different plant is preceded by a title slide, giving the botanical and common name.

**FINDING IMAGES:** The index provided with this disc contains an alphabetical listing of the plants giving the frame number, botanical name and common name. The disc also contains chapter stops at each alphabetical change. Thus, one can readily access an image by using a remote control device to operate a laser videodisc player. For greater ease and flexibility of image selection, a Hypercard© stack will be available which will link MacCAPS© Perennials and the disc. Further information about the Hypercard © stack and MacCAPS© Perennials by Terisan® can be obtained from the following:

Attn:  Herbaceous Disc  
Clemson University Horticulture Department  
Room E142 Poole Agriculture Center  
Clemson, SC 29634-0375  
Phone: (803) 656-3403
Field Digging With Pallets

Jake Tinga
Georgia

Nature of Work: Landscaping shade trees are usually moved in a container that is 2 feet deep and 2 feet wide. During recent droughts, it was observed that many transplanted trees died. The object of this research was to propose a new type container which was half as deep and twice as wide to get more viable roots moved to the new site. At first, this was done with a plastic sheet placed 20 cm below the surface, as a root depth barrier. Then a wooden pallet was planted under the trees and the whole pallet and root ball was moved to the new site. Results: more roots, less weight, less labor, more equipment. Trees of Myrica, Magnolia, and Quercies have been moved in this new way.

Procedure: with a road blade, clear a space in the topsoil 8 inches deep and 5 feet wide. Place wooden pallets of 4X4 feet in this bed oriented so they can be lifted from the side. Make the row 12 feet wide and the trees in row 6 feet apart. Cover pallets with burlap or sisal paper. Use road blade to replace topsoil on pallet. Plant trees on pallet. Use drip watering. Grow in the usual way: weed control, water, fertilizer. For harvesting, dig out one side, insert a fork lift, and take all soil and roots that will hang on. Wrap ball with a plastic sheet. Move directly to the truck.

Planting procedure: Scrape out a hole 8 inches deep and 5 feet across. With a front end loader, move tree into this shallow hole. Cover the root ball with soil. Apply 3 inches of bark mulch. Supply multiple head drip waterer.

This is ideal for local landscaper moving trees from his holding bed to the final landscape site.

We have moved 10 Oaks, 10 Magnolia, and 10 Myrica on 3 or 4 foot pallets. All have lived. All compare well to balled and burlapped trees. Less labor, more roots, not easy to ship.

Roots weighted from the wide ball vs. the conventional ball have up to 100% increase in dry weight. We think this will result in more livability.

When you change one factor in a system, all other factors are changed. In the old days, all trees were bare root. Then the Vermeer Digger and wire basket were developed. The pallet ball is a suggestion for another development.
Computer Use in the Georgia Nursery Industry

Steven C. Turner
Georgia

**Nature of Work:** Computer technology is used primarily to support and supplement decision making and transaction processing activities. Decision support activities include budgeting analysis, irrigation scheduling, and market analysis. Transaction processing activities include payroll and inventory control. Accounting and database management applications are combinations of the two above activities (Putler and Zilberman).

An increasing number of software programs are being supplied to nursery growers. Thomas and Midcap developed Risk-Rated Enterprise Budgets to be used in azalea, holly, and juniper production. Johnson and Tilt also developed computerized spreadsheets to analyze costs and returns for various field grown nursery stock. Thus, computer use in the nursery industry is being encouraged and actively supported. But little analysis of computer use in agriculture and the nursery industry, in particular, has been performed. Putler and Zilberman examined computer ownership and application patterns in California agriculture. Of the 449 respondents, 19 (4%) indicated they produced nursery products. Of these 19 producers, 8 (42%) reported computer ownership. The nursery computer ownership percentage was the highest of the eight farm product categories investigated.

Identification of the factors that influence nursery computer ownership will be helpful to software developers and other groups interested in developing, utilizing, and expanding computer technology in the nursery industry. Thus, the objective of this study is to identify the business characteristics of landscape plant producers in Georgia that influence computer ownership.

**Data:** A mail survey of licensed Georgia nurseries of three acres or more who grew landscape plants was conducted in February 1989. Of the 329 questionnaires mailed, 156 (47%) were returned. Of those 156 respondents, 116 (35%) provided enough information to be included in this study. The questionnaire included questions about computer use, firm characteristics, and perceived limitations to growth. Various factors were hypothesized to influence computer use. They included age of the firm, organizational arrangement, size (as measured by gross sales), degree of diversification (as measured by number of plant categories grown), innovativeness (as proxied by use of field grow bags), management attitudes (as measured by management or hiring of management as seen as a limit to growth), marketing involvement (as measured by activity in different marketing levels (retail, wholesale, etc.), price decision making (as measured by the use of inventory or cost information in making price decisions), and export activity outside Georgia.
Results and Discussion: The significant influence of the above factors on computer ownership was identified by estimating probability models for computer use. Since the probability of computer adoption is bounded by zero and one, a limited dependent variable estimation technique (probit) was utilized.

In the probit model, the probability of computerization ($P_i$) by the $i^{th}$ nursery is given by

$$ P_i = F(X_i'B), \quad (1) $$

where $X_i'B$ is the deterministic portion of the model and represented by

$$ X_i'B = B_0 + B_1AGE + B_2CORP $$

$$ + B_3GSALES + B_4DIVERS + B_5INNOV $$

$$ + B_6MGLIM + B_7MKTACT + B_8PRICEDT $$

$$ + B_9EXPORT $$

The $B_0$-$B_9$ are parameter estimates associated with the explanatory variables as described in table 1. Results appear in table 2.

A 0.10 level was used to identify significant influential factors in the computerization decision. Age of the firm was hypothesized to affect adoption in a linear manner, but the model indicates that AGE was not a significant factor. The organizational arrangement of the firm was the most significant factor in the model. Holding all the other explanatory variables constant at their mean, an incorporated firm was 32% more likely to be computerized than a non-incorporated firm. The size of the firm as measured by gross sales was also a significant explanatory variable. The relationship was positive in that as gross sales increased so then did the probability of computer adoption. In fact, each additional $100,000 in gross sales had the effect of increasing the probability of computerization by 1.3%, ceteris paribus. An explanation of this relationship would relate to the transaction processing needs of the firm. This result is consistent with the results of Putler and Zilberman.

To put the effect of gross sales on computerization into some perspective, the average firm of the sample was examined with respect to probability of being computerized at different gross sales level. This average firm was also incorporated, not using field grow bags, did not view management as a limit to growth, used cost and inventory information to determine prices, and exported some production out of Georgia. At gross sales of $100,000, the probability of this firm being computerized was 17.54%, while at $500,000,
the probability was 21.60%, and at $1,000,000, the probability was 27.38%. The real increase in the probability of computerization occurred when this average firm went from $1,000,000 to $3,000,000 in gross sales as the probability increased to 55.38%. The probability of computerization increased to 80.84% when this average firm had $5,000,000 in gross sales.

The diversity of the nursery as measured by the number of plant categories produced had a significant inverse effect on computerization. That is, the more specialized firms were more likely to be computerized. In fact, each additional category produced had the effect of decreasing the probability of computerization by 3%.

An innovative attitude as proxied by the use of field grow bags was not a significant explanatory variable, but the parameter estimate was positive as hypothesized. Since only about 7% of the included sample used field grow bags, the insignificance of the estimate might change with a larger sample.

Firms who viewed management as a limiting factor to growth were 17% more likely to be computerized than firms who did not. This was a significant explanatory factor and implies that nurseries do, in fact, use computers to support the management process. The parameter estimates for MKTACT, PRICEDT, and EXPORT were not significant.

Overall, the model correctly predicted a nursery’s computer status about 75% of the time. Correct predictions of noncomputerized firms was 88% while for computerized firms the rate was 48%. The reason for this large difference in correct predictions relates to the number of noncomputerized (75) and computerized firms (41) in the sample. The model tends to overpredict noncomputerization since the expected risk is lower for that forecast. This characteristic was also exhibited in the Putler and Zilberman study.

This study indicates that computerization of a nursery firm can be explained by organizational arrangement, size, degree of specialization, and management attitudes. Identification of these factors may assist various groups interested in the computerization of the nursery industry.

**Literature Cited**


Characteristics of Alabama’s Nursery Industry:  
Comparison by Age of Business  

Bridget Behe and Charles Gilliam  
Alabama  

Nature of Work: Agricultural crop production is a major component of Alabama’s economy and ornamental plant are the leading crop grown in the state. Ornamental plant production generated more cash receipts than cotton, peanuts, or other plant crops grown in Alabama in 1988 (1). In addition to production, ornamental crops form a foundation for several other successful industries in the state including landscape contracting and design, retail sales of ornamental plants and related consumer products, and maintenance of recreational industries.

To determine more about the size and scope of Alabama’s nursery industry, a study was undertaken by the Alabama Agricultural Experiment Station as part of a regional project that involved 22 universities. Fifty surveys were
mailed to nursery businesses in Alabama. Twenty nine responses were returned for a 58% response rate.

**Results and Discussion:** One third of the nursery businesses were established prior to 1950, 3% in the 1950’s, 3% in the 1960’s, 45% in the 1970’s, and 17% in the 1980’s. This means that over half of the nursery firms in Alabama are less than 20 years old, while 35% have 30 or more years in operation. Many small businesses fail within the first five years in operation (2), yet some farm related businesses extend beyond the founder where second and third generations continue the family business. A large proportion of nursery businesses included in this survey were started after 1970. Thus, it would appear that many nursery firms remained viable over the years.

Businesses were categorized by the length of time they had been in business in order to compare similarities and differences. Firms in operation less than 10 years were labeled “newer” businesses; firms operating for 10 to 29 years were labeled as “established” firms; and businesses in operation for more than 30 years were labeled as “older” businesses.

Nearly all the businesses participating in this study used a computer to aid in the performance of some business functions. More newer firms had business functions computerized than established or older firms, particularly word processing (70% versus 14% or 40%), inventory (60% versus 21% or 20%)—accounting (50% versus 43% or 40%), and marketing (20% versus 7% or 0%). These results may indicate a resistance of older and established firms to utilize the computer’s capability whereas newer firms appeared to be more willing to invest in computer technology and made it a financial priority.

The product mix for each business age category was relatively broad, but appeared to narrow with age. Older firms had a narrower product mix than established and newer firms. Older firms tended to rely on more traditional products, such as deciduous shade and flowering trees (54%), broad leaved evergreen shrubs (30%) and deciduous shrubs (28%). Older firms included in this study did not sell any propagation material, fruit bearing plants, herbaceous perennials, roses, or vines and ground covers. In contrast, the established and newer firms had a smaller percentage of their business in deciduous shade and flowering trees (16% and 15%), deciduous shrubs (11% and 17%), and evergreen trees (6% and 3%) than did older firms.

All three age categories had a similar percentage of sales by month of the year (figure 1). Newer firms had a higher peak sales in spring when compared with the more established and older firms. Older firms had a higher peak in fall than did the newer or more established firms. This would indicate that the younger firms have a more seasonal nature to their sales, whereas the older firms have worked to increase the fall sales, thus reducing the seasonal nature of their businesses. Established firms had the lowest fall sales when compared to the other firms.
The percentage of sales allocated to advertising varied by the age of the business. Newer firms allocated 1.6% of sales to advertising, while established firms allocated 1.7%; older firms allocated 3.0%. More older firms (20%) used newspaper advertising when compared with established firms (14%) and newer firms (0%). Older firms were more likely to also use yellow pages, billboards, and newsletters than established or newer firms. Older firms likely have developed a reputation after 30 years in business, thus advertising would likely be used for purposes other than customer awareness or building a clientele. They may have acquired some experience with advertising and their resources may be directed toward developing sales in fall.

**Conclusions:** The ornamental crop production industry in Alabama has developed into an important component of Alabama agriculture. One third of the nursery businesses have been in operation more than 30 years, indicating solid management over the long term. Newer firms, those in business less than 10 years, are more likely to have adopted computer technology, offer consumers a broader mix of products, and have a higher proportion of sales in the spring. Older firms use computers less, offer consumers a more narrow product mix, and have sales with a less seasonal nature. As businesses mature, efforts are focused toward a more specialized segment of the market in order for them to remain profitable and competitive in the long term.

**Literature Cited**


Nature of Work: This paper presents the outline of a “Lotus” computer spreadsheet program which can be used to estimate the cost of container-grown nursery stock. The spreadsheet contains a model container nursery as an example and guide. Users can estimate their own cost of production by adjusting the example to reflect size, cost or other resource differences between the example and their own operation. The program provides detailed fixed and variable cost information along with numerous efficiency factors as they relate to space utilization and associated cost. In addition, the program allows users to perform “what-if” types of operations which are useful for planning purposes.

The program uses a similar format as the spreadsheet program Cost of Greenhouse Plants by Larry A. Johnson at the University of Tennessee. The Tennessee program is a revised and expanded version of the original program A Greenhouse Cost Analysis written by Kelly, Rathwell and Luke from Clemson University. Size of operation, production practices and cost of materials for the example were obtained from the Mississippi Experiment Station Research Report Cost of Producing Woody Ornamental Plants by Crafton, Phillips and Blessington.
Results and Discussion: The program includes a series of tables where users can adjust the example for the fixed cost of facilities, general overhead, operating information and variable cost for up to four different types of nursery stock. The program analyses Azaleas, Burford Holly, Photinia and Pfitzer Juniper in the example. Separate columns highlighted in green are listed for users to include specific information about their own operation. The following list is a summary of the tables. (1) Tables to be adjusted by users: (A) General Production and Asset Inputs, (B) Asset Years of Life, (D) Annual Overhead Cost Estimates, and (E) Container-Grown Plant Fixed and Variable Cost Computation. (2) Tables Calculated by the Computer: (C) Output Information: Investment and Fixed cost Estimates, and (F) Monthly Allocation of Building, Equipment, and Overhead Cost.

The computer program is quite complex, especially in the manner by which it handles overhead costs. Basically, overhead costs are assigned depending upon when the different plants are in the facility and the relative amount of space required by each. Variable costs are determined in units of one-thousand which allows the user to adjust the number of plants of each type produced and costs will automatically be determined.

The following is a partial list of tables included in the computer program. The example information is for example only! A more complete study of current cost in a bona fide research survey is needed before the example is technically correct. The program will be available for public distribution in the near future.

References


(Table A & B)

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SECTION 7
GROWTH REGULATORS

Dr. Will Witte
Section Chairman and Moderator
Nature of Work: Herbaceous perennials are attractive to consumers because they do not have to be replanted in the landscape yearly and they provide an array of textures, forms, and colors not found in annuals. Retailers have observed that sales of herbaceous perennials are greatest when plants are flowering. However, the regulation of flowering of few herbaceous perennials has been investigated. Growers need good cultural information to efficiently produce high quality, flowering plants.

*Phlox subulata* (moss pink, creeping phlox) is frequently used as a groundcover because of its fine-textured, evergreen foliage and attractive flowers. Softwood stem cuttings can be rooted in late spring or fall (1, 2). Plants can also be propagated by division after flowering or in fall. Rooted cuttings or divisions are typically exposed to cool temperatures during winter to stimulate late winter and spring flowering. However, time and amount of flowering can be uncertain. Gibberellic acid (GA$_3$) is a plant hormone that promotes earlier and more uniform flowering in many plants. The objective of this research was to determine how GA$_3$ influences flowering of *P. subulata*.

*P. subulata* were potted into 6-inch containers using amended 7 pine bark:1 sand. Plants were treated on March 5, 1990, with 0, 75, 150, 225, 300, or 375 ppm Pro-Gibb (GA$_3$) as a foliar spray. Ten single-plant replicates were arranged in a completely randomized design in a greenhouse. Night-break incandescent lighting from 10:00 p.m. to 2:00 a.m. provided long-day photo-periods. Plants were fertilized weekly with 300 ppm N from 20N-10P$_2$O$_5$-20K$_2$O. Growth indices were taken 6 weeks after treatment.

**Results and Discussion:** The mean number of days from GA$_3$ treatment, regardless of rate, to flowering was about 3 weeks (Table 1). All treated plants flowered within 33 days after treatment. Only 30% of nontreated plants flowered within 12 weeks after treatment; these plants required an average of 16 additional days to flower as compared to the GA$_3$ treated plants.

GA$_3$ treated plants were up to 33% larger than nontreated plants (Table 1), primarily due to increased internode elongation. However, this increase in shoot length was judged to not detract from the appearance of the plants.

Application of GA$_3$ to *P. subulata* may enable growers to stimulate flowering on a predictable schedule without adversely affecting plant quality.
LITERATURE CITED


(Table 1)
EFFECT OF FLURPRIMIDOL (CUTLESS™) SPRAYS ON PANSY, VIOLA x WITTROCKIANA CV. IMPERIAL BLUE

Candace Williamson-Murdock and Kenneth C. Sanderson
Alabama

Nature of Work: Growth retardants have been used successfully on a wide range of bedding plants to reduce height and improve quality (2), however not all bedding plants are affected by growth retardants. Pansy, Viola x wittrockiana is one bedding plant species that does not respond well to growth retardants. Cathey (4) and Heins et al. (5) found that ancymidol or A-Rest (x-cyclopropyl- x-(4-methoxyphenyl)-5-pyrimidinethanol) sprays are ineffective on Viola. A chemical analog of ancymidol called flurprimidol [x-(1-methylethyl)-x-[4-(trifluoromethoxy) phenyl] - 5 - primidinemethanol] has recently been introduced for turf growth control (1). Research has shown that flurprimidol can be an effective growth retardant on geranium, chrysanthemum, and poinsettia (3). The objective of this study was to evaluate flurprimidol sprays as a growth retardant on pansy, Viola x wittrockiana cv. Imperial Blue.

Seedlings of Viola x wittrockiana cv. Imperial Blue were transplanted into 1 sphagnum peat moss:1 horticultural perlite medium amended per m³ (1.3 yd³) with 1.5 kg (48 oz) dolomitic limestone, 300 g (11 oz) superphosphate, 300 g (11 oz) KN03 and 35 g (1.2 oz) fritted trace elements. Plants were grown in a glasshouse during Feb.-Mar. at a minimum night temperature of 16°C (61°F) and daily maximum irradiance of 881 µmols s⁻¹ m⁻² PAR (approximately 7,200 ft-c). A weekly fertilizer program of 2.4 g/liter (2 lb per 100 gal) of water soluble 20.0N-8.7P-16.6K (20-20-20) was used. Treatments were applied in a randomized complete block design with 5 replications. A single plant in a 7.5 cm (3 in.) pot served as an experimental unit. Treatments were applied two weeks after transplanting using a high volume, low pressure spray at 0, 50, 100, 150 ppm flurprimidol until runoff. Data on height were taken 4 weeks after treatment.

Results and Discussion: Flurprimidol sprays were highly effective in controlling plant height (Table 1). As spray concentration increased a corresponding reduction in height was obtained. No phytotoxicity was observed at any of the spray concentrations used. High concentrations should be investigated to determine if prolonged retardation results or sales are affected. Generally, 4-6 weeks retardation was observed with treatments of 50 to 150 ppm, however, environment and culture could affect the length of time the growth retardant is effective. It would seem that the lowest concentration of 50 ppm would suffice to retard Viola x wittrockiana height in most situations.
Literature Cited


(Table 1)
HEIGHT CONTROL OF SELECTED ANNUALS WITH PACLOBUTRAZOL (BONZI™) DRENCHES

Candace Williamson-Murdock and Kenneth C. Sanderson
Alabama

Nature of Work: Growth retardants are commonly used on bedding plants to reduce height and improve marketability (1). The choice of retardant and method of application are often varied depending on the bedding plant species involved. Daminozide or B-Nine [butanedioic acid mono (2,2-dimethylhydrazide)] is only effective as a spray but is widely used because of its ease and safety of application, low cost, spectrum of species control, and low phytotoxicity (3,5). Ancymidol or A-Rest [x-cyclopropyl-x-(4-methoxyphenyl)-S-primidinemethanol] is effective as a spray, drench or granular, application however it is not effective on all species (4) and is much more expensive than daminozide. Paclobutrazol or Bonzin™ [B-(4-chlorophenyl)methyl]-x-(1,1-dimethyl)-1H-1,2,4 triazole-1-ethanol, a recently introduced growth retardant, is also effective as a spray or drench but it is not as readily absorbed by the foliage (2). Our purpose in this research was to study the effect of various rates of paclobutrazol drenches on selected annuals grown as bedding plants.

Seedlings of Begonia semperflorens cultorum Link & Otto cvs. BX 603, 851, 1159, and 1168; Pelargonium x hortorum L. H. Bailey cv. Ringo Scarlet; Petunia x hybrida Hort. cv. Blue Hagic; Salvia splendens F. Sellow ex Roem & Schult. cv. Bonfire; Tagetes erecta L. cv. First Lady; and Zinnia elegans Jacq. cv. Dahlia Flowered Mixture were transplanted in February into 7.5 cm (3 in.) pots and grown in a 1 sphagnum peat moss:1 vermiculite medium amended per cu. m³ (1.3 yd³) with 1.5 kg (48 oz) dolomitic limestone, 300 g (11 oz) superphosphate, 300 g (11 oz) KNO₃ and 35 g (1.2 oz) fritted trace elements. A glasshouse with 16-C (61°F) minimum night temperature and daily maximum irradiance of 881 u mols s⁻¹ m⁻² PAR (7,200 ft-c) was used for plant culture. Plants were hand watered as needed and fertilized weekly with a water soluble 20.0N-8.7P-16.6K (20-20-20) fertilizer at the rate of 2.4 g per liter (2 lb per 100 gal). Each species was a separate, randomized block designed experiment with treatments replicated 5 times. Treatments, applied two weeks after transplanting, were paclobutrazol drenches of 0, 0.7, 1.4, 2.8, 5.5 mg per sq. ft. Data on height were collected at flowering 4-6 weeks after treatment.

Results and Discussion: Paclobutrazol drenches caused significant height retardation on Begonia, Pelargonium and Petunia (Tables 1 and 2). Salvia, Tagetes and Pelargonium plants were not retarded by paclobutrazol drenches. With the exception of Begonia cv. BX603, the height retardation response to paclobutrazol drenches increased with increasing concentrations, i.e. it was
linear (Table 1). Cultivar BX603 showed a quadratic response to the paclobutrazol treatments. Generally, rates of 0.28 mg or more were necessary to produce significant height differences in Begonia; however, Begonia cultivars differed significantly in their response to paclobutrazol. Both Pelargonium and Petunia displayed increased height retardation as rate increased, i.e. linear effect (Table 2). Quadratic and cubic treatment effects were noted for Pelargonium treatments. Rates of paclobutrazol produced a cubic response with Pelargonium height; however, the 2.8 and 5.5 mg rates were similar and caused the greatest height retardation. It would seem that rates above 2.8 mg per sq. ft. are unnecessary for adequate height retardation. Rates of paclobutrazol greater than 0.7 g caused similar retardation on Petunia. A rate of 1.4 mg per sq. ft. should provide adequate Petunia retardation and higher rates would not seem to be necessary, practical or economical.

This work shows that Begonia, Pelargonium and Petunia height can be retarded with paclobutrazol drenches. Paclobutrazol trenches were ineffective in controlling the height of Salvia, Tagetes and Zinnia plants, and other growth retardants should be tried to retard the growth of these plants.

**Literature Cited**


(Table 1)

(Table 2)
GROWTH RESPONSE OF ACANTHACEAE TO ANCYMIDOL (A-REST™) DRENCHES AND SPRAYS

Kenneth C. Sanderson
Alabama

Nature of Work: The colorful foliage and unusual flowers of plants in the Acanthaceae make them valuable tropical landscape plants. Their rapid growth rate, large plant size and absence of free branching habits limits the use of such Acanthaceae as polka dot plant (Hypoestes Phyllostacha Bok), shrimp plant (Justicia brandegena Wassh & L.B. Sim), purple false eranthemum (Pseuderanthemum attro purpureum L.H. Bailey), sanchezia (Sanchezia speciosa Leonard), goldilocks (Pachystachys lutea Wees) and persian shield (Sanchezia speciosa Leonard). Tjia and Johnson (6) have used dikegulac sodium or Atrinal™ (sodium salt of 2,3:3,4S-bis-O-(1-methylethylidene-1-xylo-2-hexulofuranosonic acid) to retard Pachystachys height but reported that piproctanyl bromide or Stemtrol™ (1-3.7 dimethyloctyl)-1-(2-propenyl) piperidinium bromide) and ethephon or Florel™ (2-chloroethyl phosphonic acid) caused branching. Both Tjia and Johnson (6) and Joiner et al. (4) observed erratic height control on Pachystachys with ancymidol or A-Rest (x-cyclopropyl-x-(4-methoxyphenyl)-5-pyrimidinemethanol) drenches. Morphactins, cytokinins, ethylene generators and growth retardants have been used as pre-propagation dips (total immersion) to retard growth; however effectiveness varied with species and chemical (5). Morphactins were the most effective growth inhibitors but caused severe growth abnormalities. Pseuderanthemum height was reduced by prepropagation dips. Other unpublished work by the author confirms the erratic response of Acanthaceae to growth regulators. In addition to the species-chemical response observed by other workers, there may be a response depending on mode of application. Cathey (2) found that generally media-applied retardants are more effective than sprays on most plants, but are more time consuming to apply. The effectiveness of ancymidol drenches has recently been reported to be reduced in pine bark media because the chemical enters the non-capillary pore spaces created by the pine bark particles in the media and is easily removed from the rhizophere by leaching (1). The purpose of the present research was to investigate various forms or methods of ancymidol application on five Acanthaceae species.

Three rooted cuttings of Hypoestes, Justicia, Pseuderanthemum, Sanchezia, and Strobilanthes were established in 15 cm (6-inch) pots containing a 1 sand:1 sphagnum peat moss: 1 pine bark medium amended with 6.0 lb dolomitic limestone, 1.4 lb Perk minor elements, 1.4 lb calcium nitrate, 1.4 lb granular Aqua-gro wetting agent and 1.0 lb uramite 31-0-0 per yd³. Cuttings were transplanted on January 26, pinched on March 9. Ancymidol treatments were applied on April 9, and data on height and plant area (top of plant)
measured in two directions on June 6. Plants were grown in a glasshouse at a minimum night temperature of 62°F (17°C) and an average irradiance of 1296 to 1584 umols s\(^{-1}\) m\(^{-2}\) PAR or 6,500-8,000 ft-c. Every two weeks the plants were fertilized with water soluble 20.ON-8.8P-16.6K (20-20-20) at the rate of 2 lb per 100 gal (2.3 g per liter). Treatments consisted of a check (no treatment) ancymidol drenches of 2 and 4 ppm, and a 150 ppm ancymidol spray. Rates were derived from Heins et al. (3) and preliminary experimentation. A single pot of 3 plants served as an experimental unit in a randomized complete block design with 5 replications of each treatment. Each species was a separate experiment.

**Results and Discussion:** Ancyroidol treatments did not significantly retard the growth of Hypoestes, Sanchezia and Strobilanthes plants and it is assumed that these plants do not respond to ancymidol at the concentrations tested (data not shown). Jolner et al. (4) have used ancymidol drenches at 10 times the rates used in this work and obtained very little retardation on Pachystachys. Growth retardation was obtained on Justicia (Table 1) and Pseuderanthemum (Table 2) plants with ancymidol treatments. With Justicia the results can only be described as erratic. Justicia height was retarded the most by the 2 ppm drench, followed by the 150 ppm spray, check and 4 ppm drench. A quadratic response to treatment was observed. Pseuderanthemum height and plant area were influenced by ancymidol treatment. All ancymidol treatments produced taller Pseuderanthemum plants than the untreated plants. A quadratic response to treatment was significant with height. Pseuderanthemum plant area was also affected quadratically with ancymidol treatments. The 150 ppm sprays produced plants with the least area, however the response was again erratic because a 2 ppm drench produced plants with the greatest area. The erratic response to ancymidol treatments agrees with other worker results with ancymidol drenches on Pachystachys plant (4,6). Unpublished work at Auburn indicates little and erratic retardation on Pachystachys, Strobilanthes, Sanchezia, Justicia, and Pseuderanthemum plants with paclobutrazol or Bonzi\(^\text{TM}\) (B-[(4-chlorophenyl)methyl] - x - (1,1 - dimethyl) 1-H-1,2,4, triazole-l-ethanol) drenches and flurprimidol or Cutless\(^\text{TM}\) ( (1-methylethyl)- x -methylethyl) - (4-(trifluoromethoxy) phenyl) -5- primidinemethol) sprays. Piproctanyl bromide or Stemtrol has been an effective retardant on Acanthaceae in some instances (6) but this retardant is no longer being marketed. Dikegulac-sodium was found a successful retardant on Pachystachys by Tjia and Johnson (6), and these workers have suggested combining the inhibitor dikegulac-sodium with piproctanyl bromide for growth retardation and branching. It can be concluded from this study and the work of other researchers that there still exists a need for a growth retardant or method of application that will satisfactorily retard Acanthaceae plants and produce a compact, well branched plant.
Literature Cited


(Table 1)

(Table 2)
Growth and Flowering of Mandevilla ‘Alice du Pont’ in Response to Sumagic

G. J. Keever and C. F. Deneke
Alabama

Nature of Work: The genus Mandevilla consists of more than 100 species of nonhardy, woody, twining vines and shrubs planted outdoors in tropical and subtropical areas (1). ‘Alice du Pont’, the most widely available cultivar of Mandevilla, is grown for greenhouse use or as a horticultural annual in temperate areas. The cultivar blooms over a long season and is useful for arbors, trellises or other supports about which the stems can twine.

The vigorousness of ‘Alice du Pont’ creates production problems for the grower since consumers are interested in manageable plants in flower. To produce flowering plants, growers frequently contend with excess vegetative growth that twines around other plants and structures. The objectives of this research were to determine how rate and application number of Sumagic, a new triazole growth retardant, influenced vegetative growth and flowering of ‘Alice du Pont’ mandevilla.

In 3 experiments conducted in 1989, rooted cuttings of ‘Alice du Pont’ were potted into #1 containers of amended 7 pine bark: 1 sand. Plants were pruned to 2 nodes before applying Sumagic. Plants were fertilized weekly with 300 ppm N from 20N-10P₂O₅-20K₂O. Heights were taken weekly until plants were in full flower. At that time, flower diameter and days to flower were determined.

In the first experiment, a single application of 0, 30, 60, 90, or 120 ppm Sumagic was applied. In the second experiment, one or two applications of 0, 5, 10, 15, or 20 ppm Sumagic were applied. The second application was applied to all treatments (rates) when plants treated with 10 or 15 ppm began to regrow normally. In the third experiment, applications of Sumagic from 0 to 20 ppm in 2.5-ppm increments were repeated as necessary when plants within a treatment (rate) resumed a normal growth pattern. There were 5, 8, and 10 single-plant replicates in the first, second, and third experiments, respectively, in a completely randomized design.

Results and Discussion: In the first experiment, all rates of Sumagic suppressed growth excessively for at least 6 weeks, after which plants began to exhibit normal growth (Fig. 1). All rates of Sumagic induced leaf cupping, delayed flowering and reduced bloom size.

In the second experiment, single applications of 5, 10, 15, or 20 ppm Sumagic did not provide acceptable control of internode elongation (Fig. 2). With two applications of Sumagic, 5 ppm was inadequate, 10 and 15 ppm were
acceptable, and 20 ppm was excessive in controlling shoot elongation. In the third experiment, multiple applications of Sumagic effectively suppressed elongation (Fig. 3). As the concentration of Sumagic increased, the interval between applications increased from 28.5 days with 2.5 ppm to 39.5 days with 20 ppm.

**Literature Cited**

Foliar Phytotoxicity of Plant Growth Regulators to Photinia x fraseri

Allen D. Owings and Steven E. Newman
Mississippi

Nature of Work: Foliar applications of plant growth regulators (PGRs) show potential to control height and initiate lateral branching in Photinia x fraseri. Researchers have reported foliar phytotoxicity resulting from PGR use on several nursery crops, even when the PGRs are applied at or below the recommended rate (1, 2, 3, 4). Phytotoxicity is commonly characterized by chlorosis, leaf curling, and/or necrosis of foliage. The objective of this research was to examine Photinia x fraseri for foliar phytotoxicity symptoms resulting from various application rates of seven PGRs.

Photinia x fraseri liners were planted (2/pot) in 3-gallon nursery containers on March 28, 1989. The media consisted of pine bark with incorporated amendments of Micromax at 1.5 lbs/yard³ and granular dolomite at 4 lbs/yard³. Osmocote 18-6-12 (18N-2.6P-10K) was topdressed at 3.8 oz/pot immediately after planting. Plants were grown on a concrete slab in full sun.
The following PGR treatments were applied between 1100 CDT and 1300 CDT on May 16, 1989: Bonzi (paclobutrazol) at 60, 100, 140, and 180 ppm, Sumagic (uniconazole) at 30, 60, 90, and 120 ppm, Atrinal (dikegulac-sodium) at 1500, 3000, 4500, and 6000 ppm, A-Rest (ancymidol) at 33, 66, 99, and 132 ppm, Promalin (6- BA + GA4+7) at 250, 500, 750, and 1000 ppm, Provide (GA4+7) at 250, 500, 750, and 1000 ppm, and Pro-Shear (6-BA) at 250, 500, 750, and 1000 ppm. Foliar spray treatments were applied with a CO₂ pressure sprayer (30 psi) at the rate of 2 qts./100 ft². Air temperature before and after application was 72.4°F and 78.5°F, respectively. Each treatment in the completely randomized design was replicated six times.

Observations of foliar phytotoxicity were taken on May 24, 1989, which was 8 days after treatment (DAT), June 1, 1989, 16 DAT, and June 9, 1989, 24 DAT. Foliar phytotoxicity ratings were based on a scale from 1 to 5 where 1=total necrosis, 2=partial leaf necrosis, 3=marginal necrosis, 4=leaf curling, chlorosis, and 5=no damage.

Results and Discussion: Foliar phytotoxicity was seen on Photinia x fraseri in all treatments at 8 DAT and in all treatments except some of the Bonzi and Sumagic-treated plants at 16 DAT (Table 1). Even though Sumagic and Bonzi are considered highly active PGRs, photinias treated with these products had less foliar damage than those treated with other PGRs. Slight leaf curling and chlorosis occurred in Bonzi and Sumagic-treated photinia at 8 DAT, however this damage was not as prevalent at 16 DAT.

The greatest foliar damage was on photinias treated with high rates of Atrinal, A-Rest, Promalin, Provide, and Pro-Shear (Table 1). There was a noticeable increase in damage with increasing application rates of A-Rest and Pro-Shear. The phytotoxicity found in these treatments persisted to 16 DAT. Foliar damage was no longer visually present in any treatment by 24 DAT (data not shown).

Based on these findings, it appears that some spray applications of PGRs can damage foliage of Photinia x fraseri. This damage frequently lasts for as long as 2-3 weeks following application. While growers should not be greatly concerned about permanent damage when using these PGRs at recommended rates, it should be considered that some foliar damage may occur when PGRs are included in production practices.

Acknowledgments

The authors express appreciation to Foliage Farms of Mississippi, formerly of Columbus, for donation of plant material and to the following companies for providing plant growth regulators: Valent USA Corporation, Sandoz Crop Protection, and Abbott Laboratories.


(Table 1)
BONZI REDUCES INSECTICIDE PHYTOTOXICITY ON SALVIA

Joyce G. Latimer and Ronald D. Oetting

Georgia

Nature of Work: Insecticide phytotoxicity is a major problem in using chemicals on ornamentals because of the great variety of plants and the lack of specific phytotoxicity tests for many of these plants. Phytotoxicity is also influenced by environmental (Crocker & Brewer, 1987) and cultural practices (Oetting et al., 1988) in plant production. A-Rest (ancymidol) increased insecticide phytotoxicity on woody ornamentals (McConnell et al., 1985). Since plant growth regulators are commonly used during production of bedding plants, this work was undertaken to evaluate the effect of Bonzi (paclobutrazol) on the phytotoxicity of three insecticides on salvia.

In each of two experiments, salvia (Salvia splendens ‘Red Pillar’) seedlings were treated with 0 or 50 ppm Bonzi, 1.0 ml/plant, about one week after transplanting to cell-packs filled with Pro-Gro 200 seedling medium. Five hours after treatment with Bonzi, the seedlings were treated with insecticides. In a March experiment, treatments included three insecticides at five rates: 0, 1, 2, 4, and 8X the label recommendation. Label rates were 0.5 lb a.i./100 gal for Orthene 75S (acephate, an organophosphate), 1% (65 oz a.i./100 gal) Safer’s Insecticidal Soap (potassium salts of fatty acids), and 0.5 lb a.i./100 gal Dycarb 76W (bendiocarb, a carbamate). In a May experiment, only Dycarb was applied, at the same rates as listed above. The treatments were arranged in a randomized complete block with four plants per treatment in each of four replications. Plants were evaluated for height and phytotoxicity damage at 7, 14, and 21 days after treatment using a damage scale which after transformation corresponded to 0 = no injury to 90 = severe injury. Final growth was measured on the plants in the May experiment 26 days after treatment.

Results and Discussion: In the March experiment, there was very little phytotoxicity damage on salvia treated with Orthene or Safer’s Insecticidal Soap but Dycarb caused a very high average damage rating (Table 1). All three chemicals caused the same types of phytotoxicity, leaf twisting or cupping, tipburn and marginal burn. However, Dycarb caused more severe marginal burn while the damage from the other chemicals was primarily limited to tipburn. Application of Bonzi reduced the maximum damage caused by the insecticides as measured 14 days after treatment and improved the recovery of plants from the phytotoxicity damage as measured 21 days after treatment.

Examination of the phytotoxicity of Dycarb at individual insecticide rates indicates that Bonzi provided significant protection from damage at the IX
label rate at each measurement time in both experiments (Fig. 1). In contrast with the average damage rating in Table 1, Dycarb at the 4X rate caused about the same degree of maximum damage in Bonzi-treated plants, but recovery from damage was again improved.

Bonzi and Dycarb each decreased plant height in the May experiment (Table 2). Dycarb caused additional reduction in height of plants treated with Bonzi only at the 7-day measurement. In a similar manner, plants not protected by Bonzi had less leaf area and dry weight at all rates of Dycarb than those not treated with Dycarb (data not shown). However, Bonzi did not provide enough protection to prevent further reductions in leaf dry weight gain at the 4X and 8X Dycarb rates.

Very little damage was observed on salvia treated with Orthene or Safer's Insecticidal Soap. Bonzia provides protection from phytotoxicity at the lower rates of Dycarb and improves plant recovery from damage at higher insecticide rates. The mechanism of this protection is unknown. Research to determine the effect of the relative time of application of the plant growth regulator and the insecticide in ongoing.

**Literature Cited**


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(Contents of Table 2)
SECTION 8
PROPAGATION

Dr. Ted Whitwell
Section Chairman and Moderator
SECTION 8
PROPAGATION

Dr. Ted Whitwell
Section Chairman and Moderator
Micropropagation of Eastern Redbud

R.L. Geneve, S. Yusnita and S.T. Kester
Kentucky

**Nature of Work:** Eastern redbud (*Cercis canadensis* L.) is a small flowering tree producing attractive lavender or white, pea-like flowers before the foliage emerges in the spring. Eastern redbud is usually propagated from seed or with variable success from T-budding. The nursery industry would benefit from an efficient method for asexually propagating selected cultivars of redbud.

A white flowering form of Eastern redbud (*Cercis canadensis* var. *alba*) (4) and Mexican redbud, (*Cercis canadensis* var. *mexicana*) (1) have been successfully propagated from tissue culture. However, two major obstacles remain before the efficient commercial micropropagation of Eastern redbud becomes economically possible. These problems include the difficult-to-root nature of microshoots and persistent shoot tip necrosis in extended redbud cultures.

**Results and Discussion:** Microshoots of Eastern redbud have been difficult-to-root and untreated microcuttings from a mature white flowering form of Eastern redbud did not root under *in* or *ex* *vitro* conditions (4). However, pulse treatments of microcuttings with 300 µM (60.9 ppm) indolebutyric acid (IBA) or 300 µM (55.9 ppm) β-naphthaleneacetic acid (NAA) resulted in greater than 70% rooting (Table 1). Microcuttings treated for 15 days *in vitro* on a half strength woody plants’ medium (WPM) (2) and transferred to WPM without growth regulators or transferred directly into peat-perlite (1:1) soilless rooting medium in plug trays covered with polyethylene film were rooted at high percentages (Table 1). The high rooting success was probably related to the number of subcultures (>8 subcultures) prior to the rooting experiments (4).

Shoot tip necrosis became evident in redbud cultures after successive subculturing (2,4). Shoot tip necrosis has been reported as a problem for other species, including apple, rhododendron and birch. Sha et al. (3) were able to eliminate shoot tip necrosis in potato microshoots by including additional calcium in the multiplication medium. Eastern redbud cultures were treated with 10 µM (2.3 ppm) benzylaminopurine (BAP) and a combination of WPM media including bactoagar (0.7%), gelrite (0.2%), supplemental calcium at 5 x calcium in WPM (480 mg I⁻¹CaCl₂ 2H₂O), activated charcoal (0.3%), and soluble polyvinylpyrrolidone (PVP, 0.7%) to test their combined effects on shoot-tip necrosis and phenolic exudation (Table 2). There was no treatment combination that successfully eliminated shoot-tip necrosis from Eastern redbud cultures with chronic shoot tip necrosis. The best treatment combination to reduce both shoot tip necrosis and phenolic exudation was BAP.
plus gelrite (Table 2). However, there was no apparent relationship between shoot tip necrosis and phenolic exudation, so cultures with BAP plus bactoagar performed equally as well as BAP plus gelrite in regards to shoot tip necrosis. Supplemental calcium had no effect on shoot tip necrosis, but did result in better leaf color in microshoots. Activated charcoal and PVP had no beneficial effect on Eastern redbud cultures.

The available research data suggests the following protocol for the successful, sustained micropropagation of mature forms of Eastern redbud:

**Establishment of Multiplication Stages:**

(1) Collect 0.5 m stems from selected redbud cultivars in early spring as the flower buds begin to swell in prelude to opening. Place the stems in the greenhouse in a florists’ flower preservative solution (18 gm l⁻¹).

(2) Collect newly emerged growth and disinfect the leafless shoots in successive solutions of 70% ETOH (10 sec.), 1500 ppm benomyl (10 min.) and 10% bleach plus .01% detergent (15 min) before rinsing 3 times in autoclaved, deionized water.

(3) Two-node explants are placed on WPM medium with supplemental calcium (480 mg l⁻¹ CaCl₂ 2H₂O) containing 10 or 15 µM (2.3, 3.4 ppm) BAP. Subculture every 7-8 weeks.

(4) Cultures are maintained at 24° C (75 F) with a 16 hr photoperiod provided by fluorescent lamps at a fluence of ~ 30 μMol sec⁻¹ m⁻².

**Rooting stage:**

(1) Microcuttings (3-5 cm) are placed on half-strength WPM with 300 µM (60.9 ppm) IBA for 15 days, then stuck directly into a peat:perlite (1:1), soilless medium in plug trays covered with polyethylene film or other suitable high humidity environment.

(2) Microcuttings are rooted after 21 days and can be acclimated to greenhouse conditions by gradually reducing the humidity.

**Re-establishment stage:**

(1) After successive subcultures, shoot tip necrosis becomes a chronic problem making inefficient cultures with poor quality microcuttings. New cultures can be re-established from stock plants in the greenhouse from previously rooted microcuttings of selected cultivars. Shoots from the stock plants can be disinfected and established as previously de-
scribed. Eastern redbud will continue to grow in the greenhouse without a dormant period if maintained under long-day conditions with supplemental lights during the winter.

**Literature Cited**


(Table 1)
Nature of Work: Ornamental grasses are desirable landscape plants because of their low-maintenance, drought-tolerance and adaptability to poor soils. Some species or cultivars are not widely available, however, due to propagation problems. *Cortaderia selloana*, pampas grass, is propagated through seeds or division. However, progeny from seeds are variable for sex, plume size and color. Through division, only about a 4-fold increase is obtained each year. Some of the cultivars of *Miscanthus sinensis* are also slow-to-propagate. These cultivars are sterile and must be propagated through division. Tissue culture could provide a rapid method of clonally propagating these plants. The following study was undertaken to determine whether these plants could be rapidly propagated through tissue culture, and whether the regenerants would be true-to-type.

Plants selected for study were *Cortaderia selloana* ‘Pumila’ (dwarf pampas with large white plumes), *Miscanthus sinensis* ‘Gracillimus’ (maidengrass, green blade with a white midrib), and *M. sinensis* ‘Zebrinus’ (zebra grass, green and white horizontal striping). The cultured plant material was obtained from large field-grown plants. Plant parts tested were immature inflorescences, mature leaves, immature leaves, nodal segments, internodal segments, meristematic regions and ovules. The tissues were disinfested by soaking in 95% ethanol for 30 to 60 seconds, then 20% Clorox for 20 minutes, followed by 3 rinses in sterile distilled water. Culture medium consisted of MS (Murashige and Skoog, 1962) salts and vitamins plus 2% sucrose, gelled with 0.2% gelrite. Several levels of auxins, cytokinins, and auxin-cytokinin combinations were tested for ability to stimulate callus and/or plant formation. Regenerated plants were rooted, hardened to greenhouse conditions and field-tested.

Results and Discussion: Pampas: Of all tissues tested, only immature inflorescences (approximately 2-4 weeks prior to flowering) were capable of forming plants. Florets derived from the basal half of the inflorescences yielded the greatest number of plants. At this stage, each inflorescence measured 6 to 12 inches, and could yield at least 50 to 100 pieces of tissue (each about 0.75 inches in length) for culturing. Growth regulator levels of 0.1 to 1.0 ppm 2,4-Dichlorophenoxyacetic acid (2,4-D) combined with 1.0 to 2.0 ppm 6-Benzylaminopurine (BA) induced plant formation in 80 to 90 % of the cultures. Plants formed directly from swollen floret tissue within 4 weeks of culture initiation; subculture to the same medium resulted in further plant development. When transferred to MS with 2 ppm Indole-3- butyric acid (IBA), each plant tillered to produce an average of 3 plants, though some cultures yielded as many as 40 plants. Rooting occurred spontaneously.
Rooted plants were transferred to potting medium and hardened under intermittent mist. Nearly 100% of the plants acclimated successfully to the greenhouse.

Field testing revealed no apparent changes from the parent plant. **Miscanthus**; Plants were formed only from immature inflorescences. In maidengrass and zebragrass, inflorescences harvested 3 to 4 weeks prior to flowering (6 inches or less in length) gave best results. Callus was initiated from 90% of the tissues cultured on MS medium with 2 ppm 2,4-D. Approximately 20% of these cultures formed plants, with about 20-30 plants per culture. When the plants were separated and re-cultured onto MS medium with no growth regulators, roots formed and the plants tillered. On average, each shoot produced 1-3 tillers every 6-8 weeks. Tillering continued as long as the cultures were maintained (1 year). Rooted plants were transferred to potting soil and placed under intermittent mist in a greenhouse for hardening. About 80% of the plants survived acclimatization. These were transferred to the field. Maidengrass and zebragrass retained the variegation patterns characteristic of the parent plants.

Tables 1 and 2 provide conservative estimates for the number of plants that can be obtained through tissue culture of these cultivars of pampas and Miscanthus. Data given is per inflorescence. Since each plant actually has many inflorescences, the possible multiplication rate per plant is quite high. As shown in Table 1, each inflorescence of pampas will yield approximately 1350 hardened plants in a period of 6 months. As compared to pampas, Miscanthus plants tiller readily in vitro. The data given in Table 2 show that in 7 months, approximately 128 plants can be obtained from each inflorescence. An additional culture time of 2 months could have increased these numbers to about 250 plants. Tillering is an effective method of rapidly increasing plant production in vitro.

**Literature Cited**

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</table>
Nature of Work: Research was conducted to examine the influence of varying photoperiods and a constant versus an alternating temperature on seed germination of Rhododendron catawbiense Michx. (catawba rhododendron) and Rhododendron maximum L. (rosebay rhododendron) (1).

On November 13, 1986 mature seed capsules were collected from native populations of open-pollinated plants of R. catawbiense and R. maximum growing in western North Carolina. Plants of R. catawbiense were located in Buncombe County at an elevation of 1860 m (6100 ft) and the site for R. maximum was in Avery County at an elevation of 950 m (3100 ft). Capsules were stored in paper bags at 20°C (68°F) for 30 days. Seeds were then removed from the capsules and stored in sealed bottles at 4°C (39°F). At storage, the moisture content of seeds of R. catawbiense and R. maximum was 4% and 6%, respectively. Moisture content was determined by calculating the mean moisture content of six 100 and six 200-seed samples for R. catawbiense and R. maximum, respectively, following drying at 105°C (221°F) for 24 hr.

In March 1989, seeds of each species were removed from storage and graded by manual removal of abnormal, damaged and undersized seeds. Graded seeds were sown in covered 9-cm (3.5 in) glass Petri dishes containing two pre-washed germination blotters moistened with tap water. Following placement of seeds in the dishes, half were designated for germination at 25°C (77°F) and the other half for germination at an 8/16 hr thermoperiod of 25°C/15°C (77°C/59°F). All dishes were placed in black sateen cloth bags and the seeds allowed to imbibe overnight at 21°C (70°F). The next day, bags were randomized within two growth chambers [C-chambers (2)] set at the appropriate temperatures. Chamber temperatures varied within ± 0.5°C (0.9°F) of the set point.

Within each temperature regime, seeds were subjected daily to the following nine photoperiods: total darkness, 1/2, two 1/2 hr photoperiods separated by 7 1/2 hr of darkness, 1, 2, 4, 8, 12, or 24 hr. Regardless of temperature, photoperiod treatments were administered the same time each day and for the alternating temperature of 25°C/15°C (77°C/59°F), all photoperiod treatments with the exception of total darkness and 24 hr began with the transition to the high temperature portion of the cycle. Growth chambers were equipped with cool-white fluorescent lamps which provided a photosynthetic
photon flux (400-700 nm) of 40 µmol m⁻²s⁻¹ (3.0 klx) as measured at dish level with a cosine corrected LI-COR LI-185 quantum/radiometer/photometer. All photoperiod treatments, except total darkness found the 24 hr irradiation, were regulated by removal and placement of the Petri dishes in black satin cloth bags. For the 24 hr photoperiod treatment, the Petri dishes remained continuously unbagged in open chamber conditions. Regardless of the photoperiod, temperatures within the Petri dishes as measured with a thermocouple, never exceeded ambient by more than 1°C (2°F). Petri dishes representing the total darkness treatment were kept in the black cloth bags throughout the experiment and all watering and germination counts were performed under a green safelight. Germination blotters were kept moist with tap water throughout the experiment. Seeds showing signs of decay were immediately removed from the dishes. Each photoperiod treatment was replicated four times within each temperature regime, with a replication consisting of a Petri dish containing 100 seeds. Germination counts were recorded every 3 days for 30 days. A seed was considered germinated when the emerging radicle was > 1 mm (0.04 in).

Percent germination was calculated as a mean of four replications per treatment. Within each temperature, data were subjected to analysis of variance procedures and regression analysis (3).

**Results and Discussion:** After 30 days at 25°C (77°F), germination of *R. catawbiense* in darkness was 5% but increased to 64% at 25/15°C (77/59°F). At both temperatures, germination >95% was attained by day 15 for photoperiods of 1/2 to 12 hr. Regardless of temperature, seeds of *R. maximum* required light for germination. At 25°C (77°F), increasing photoperiods increased germination with 79 and 81% germination occurring by day 21 for the 12- and 24-hr photoperiods, respectively. The alternating temperature of 25/15°C (77/59°F) enhanced germination when light was limiting. At this temperature, germination of 92 to 97% was reached by day 21 for photoperiods > 4 hr.

**Literature Cited**


SECTION 9
WEED CONTROL

Dr. James Aitken
Section Chairman and Moderator
Clopyralid: A New Herbicide for Weed Control in Conifers

Walter A. Skroch
North Carolina

Nature of Work: An extensive study to assess the tolerance of newly planted Canadian hemlock (3-1), Eastern white pine (2-0), Fraser fir (3-2), and blue spruce (3-1) to Clopyralid (Stinger) was conducted. Herbicides were applied with two 8003LP flat fan nozzles applying 25 gpa at 20 psi. All treatments received .25% (v/v) AG-98 non-ionic surfactant. Three application dates were chosen to correspond with budbreak, 1 to 2 inches of new growth, or terminal bud dormancy (Table 1). Vigor ratings were made on a basis of a 0 to 100 rating for each plant. The mean of six plants per species is presented. These plants were to be evaluated the following spring, but were severely damaged by a 19°F freeze after the new growth had started.

Results and Discussion: White pine and hemlock vigor was variable on this site thus the reduced vigor ratings for the checks. This site has a pH around 5.0 with an organic content of 5.0 at 3000 ft. elevation. The data in Table 2 shows that the fir and spruce were in good condition and that the white pine and hemlock were no different statistically than the check in all cases.

In another study, phytotoxicity to redcedar, Virginia pine, longleaf pine, or bald cypress was not detected at the .25 lb/A rate.

Several difficult to control weeds are susceptible to clopyralid at rates of .25 lb/A. Efficacy data has been collected on the following species:

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>dandelion</td>
<td>Taraxacum officinale</td>
<td>TAROF</td>
<td></td>
</tr>
<tr>
<td>annual fleabane</td>
<td>Erigeron annus</td>
<td>ERIAN</td>
<td></td>
</tr>
<tr>
<td>cornflower</td>
<td>Centaurea cyanus</td>
<td>CENCY</td>
<td></td>
</tr>
<tr>
<td>red-stem filaree</td>
<td>Erodium cicutarium</td>
<td>EROCI</td>
<td></td>
</tr>
<tr>
<td>broadleaf dock</td>
<td>Rumex obtusifolius</td>
<td>RUMOB</td>
<td></td>
</tr>
<tr>
<td>hairy vetch</td>
<td>Viola villosa</td>
<td>VICVI</td>
<td></td>
</tr>
<tr>
<td>prickly lettuce</td>
<td>Lactuca serriola</td>
<td>LACSE</td>
<td></td>
</tr>
<tr>
<td>musk thistle</td>
<td>Carduus nutans</td>
<td>CRUNU</td>
<td></td>
</tr>
<tr>
<td>dogfennel</td>
<td>Eupatorium capillifolium</td>
<td>EUPCP</td>
<td></td>
</tr>
<tr>
<td>horseweed</td>
<td>Conyza canadensis</td>
<td>ERICA</td>
<td></td>
</tr>
</tbody>
</table>

Clopyralid (Stinger) was used at .25 and .5 lb ai in this series of experiments. Control of dandelion was variable (Table 3). Control was excellent at location 2, whereas only suppression or partial control was obtained at location 1. The lack of control at location 1 might have been accentuated by a 45°F temperature at the time of application. Horseweed and fleabane, closely related plants, were controlled very well when treated at 4 to 6 inches tall. Cornflower was 6 to 8 inches tall at the time of treatment. Control was 85%
or better with both rates. Control of filaree was not acceptable with clopyralid alone, but the addition of oxyfluorfen .4 lb ai/A gave nearly complete control. Dock control at .25 lb/A over-the-top (OTT) was marginal. This could be because trees were 3 to 4 foot tall, thus band width was wider, causing application rate to be reduced. All other treatments gave excellent control. Vetch treated at 4 to 12 inches tall was eliminated. Some crown and narrow-leaf vetch was also observed to be extremely sensitive to clopyralid. Prickly lettuce treated in the rosette stage was controlled very well. Musk thistle control was excellent. Some reduction in control with the OTT treatment was recorded. This again could be the result of a wider spray band due to tree height.

Dogfennel treated at 4 to 12 inches tall was controlled with .5 lb/A clopyralid (Stinger) after 38 and 54 days at two locations.

With the tolerance of conifers and the weed spectrum that clopyralid (Stinger) controls, it should make an excellent contribution to weed management programs.

(Table 1)
(Table 2)
(Table 3)
Weed Management in Wildflowers

L. B. Gallitano and W. A. Skroch
North Carolina

Nature of Work: The use of wildflowers in naturalized plantings along highways has been increasing in popularity since first brought to the attention of the public in the late 1960’s and early 1970’s by Lady Bird Johnson (1). This interest was further stimulated by Federal legislation that was adopted in September 1987 requiring that 25 cents of every $100 in Federal highway landscaping funds be used to plant wildflowers (2). The North Carolina Department of Transportation (DOT) has begun to use wildflowers extensively over the past few years and at present has over 1200 acres planted along the highways with an additional 350 acres scheduled for planting this year.

Wildflower beds have been planted and maintained with an annual mowing. However, after a period of 2-3 years, weed encroachment has become a problem. In the past, the solution has been to plow, fumigate and replant the bed. This practice is costly and defeats the goal of establishing permanent wildflower beds. The current literature that deals with wildflowers (4, 5) discusses weed control treatments at the time of planting however there are no recommendations for long-term weed management for extensive plantings. The only other weed control method discussed in the literature is burning (4) which is not feasible for large scale highway use.

The DOT objective in using wildflowers is twofold. First, to beautify the highways and second, to reduce mowing and maintenance costs. In addition to highway usage, landscape architects and golf course managers are designing open spaces with wildflower plantings for the same reasons (5).

The objective of this project is to develop weed management strategies for large scale wildflower plantings that will arrest the natural succession of the planting in order to maintain an acceptable flowering phase over an extended period of time. Without proper management, disturbed planting sites will eventually return to their natural climax vegetation which in the southeast is generally pine and later hardwood forests. Early successional vegetation includes herbaceous perennials such as horseweed, asters and broomsedge with pine seedlings emerging in several years (6). Arresting and managing the natural succession of the site will extend the acceptable life of the wildflower planting thereby reducing maintenance and replacement costs.

One approach that is being evaluated for wildflower management is the use of selective herbicides on existing highway wildflower plots. A highway site in eastern North Carolina planted with Chrysanthemum leucanthemum (ox-eye daisy) which had a weed encroachment problem was selected for
evaluation of 14 herbicides. The study used a randomized complete block design and herbicide spray treatments were applied in October, 1989. Injury ratings were taken one month later in November for the ox-eye daisy and four weed species. Weed control ratings and flower counts were taken in March and April, 1990 respectively.

**Results and Discussion:** Of the 14 treatments applied, five were unacceptable due to reduced flowering of the ox-eye daisy. Five treatments were no different from the check plot from a flowering standpoint. Four treatments significantly increased the flowering of the ox-eye daisy over the check plot. Sinbar (terbacil) applied at 1 lb ai/A was best overall for weed control and flowering, nearly doubling the number of flowers over the check plot. It also provided excellent control of plantain, vetch, sow thistle and lespedeza. Sinbar at .5 lb ai/A in combination with Surflan (oryzalin) at 4 lb ai/A also significantly increased flowering and provided excellent control of the four weed species. Devrinol (napropamide) at 4 lb al/A and Surflan at 4 lb ai/A each showed significant flowering increases although Devrinol did not control plantain and Surflan did not control plantain, sow thistle or lespedeza.

In addition to flowering for the current season, reseeding potential is of concern for future seasonal bloom and must be evaluated. An initial review of the plots for reseeding has shown that areas of bare ground have significant seedlings yet no data has been collected on this aspect of the study. This study will be continued in order to determine the long term effect of the treatments on weed control, flowering and reseeding potential.

**References Cited**


MUSK THISTLE BIOLOGY AND MANAGEMENT IN SOUTHERN NURSERIES

D. W. Monks, K. E. Kalmowitz, M. A. Halcomb, W. A. Skroch
North Carolina and Tennessee

Nature of Work: Musk thistle, *Carduus nutans* L., sometimes referred to as nodding thistle, is an erect biennial or annual, herbaceous weed that has naturalized across the southern United States from the Midwest (1). The thistle is native to Western Europe where it was once reported to be grown as an ornamental. The name, nodding thistle describes the large flowers which bend over and appear to nod or droop. Musk thistle is frequently found in overgrazed pastures and areas of poor fertility such as roadsides and waste areas. On these sites, research indicates the optimum time for musk thistle control is while the plant is in the rosette stage before thistles produce a flower stalk (3). Post applications with 2,4-D, dicamba, or combinations of these two herbicides can give excellent control of musk thistle. However, these herbicides are not normally applied in many horticultural crops such as ornamentals or vegetables because of the great potential for injury.

One of the best strategies for control of musk thistle is to learn to identify the weed shortly after emergence and to be familiar with its life cycle. Although environmental conditions may be suited for development of winter annual or biennial types the thistle usually requires 1 year to complete its life cycle (2). Seed germination generally occurs in the fall throughout the southeast, and the seedling forms a rosette which is suitable for overwintering. The rosette can measure approximately 18 inches or more across at full development. Stem elongation begins in early March and the first flowers appear in May and June. Musk thistle is known to spread rapidly because it produces many seeds and distributes seeds by wind (7). A large, mature plant can have as many as 10,000 seeds per head. Within the past five years thistles have migrated from the roadsides and have become a major weed species in nursery production fields.

A musk thistle survey was mailed to 981 nursery growers in middle Tennessee and field studies were conducted with preemergence and postemergence herbicides on grower locations in Tennessee and western North Carolina (5, 6). A phone survey of weed specialists in Alabama, Florida, Georgia, Kentucky, South Carolina, and Virginia was made to determine the extent of musk thistle (and other thistles) in ornamental production sites.

Results and Discussion: The results of the survey to growers in the six county nursery producing region of middle Tennessee indicated approximately 5400 acres or 30% of the nursery acreage is currently infested with musk thistle. Musk thistle was the second most commonly listed weed when growers were asked to list their five worst weeds. Musk thistle can be found in nursery
production areas in western North Carolina and northeastern-southwestern Virginia as well as Tennessee. Effective control of musk thistle in these areas is limited by the high rate of germination, continuous reseeding from uncontrolled thistles, diversity of ornamental plants and lack of plant tolerance to herbicides, and lack of cultivation or mowing in hilly or sloped fields.

Presently, Georgia and Kentucky report musk thistle as the most prevalent weed in pastures and roadsides, a problem of increasing significance because of recent dry years. In northern Alabama, South Carolina, and Florida the weed appears in isolated areas and is beginning to be seen along the roadside. From the phone survey, other thistle species reported to be of concern in container or field nursery production are bull (Carduus vulgare), yellow (C. spinosissimus), Canadian (C. arvensis), plumeless (C. acanthoides), and sow thistle, (Sonchus oleraceus).

In middle Tennessee nurseries, Roundup 4L (glyphosate) and Surflan 4L (oryzalin) were the two most commonly applied herbicides for musk thistle control. In North Carolina conifer production, Princep Caliber 90 (simazine) and AAtrex Nine-0 (atrazine) are used because of greater tolerance to these herbicides across species. All states reporting this weed problem indicated the majority (70%) of herbicides are applied between March and June, with few herbicides applied during August through December, the optimum time of musk thistle emergence. The extensive Tennessee survey indicates musk thistle is a common weed in Tennessee nurseries and is spreading because preemergence herbicides are not applied just prior to musk thistle emergence.

Field studies conducted in Tennessee were on sites naturally infested with musk thistle (5). Following applications with preemergence and postemergence herbicides, control of musk thistle was visually estimated over time. Control of musk thistle with preemergence applications varied from poor to excellent, and was herbicide-rate dependent as time increased. Of herbicides presently labeled in nursery production AAtrex Nine-O at 2.0 lb/ac, Princep Caliber 90 at 1.5 lb/ac, and Snapshot DF (Surflan + Gallery) at 3.0 lb/ac gave 93% or greater control of musk thistle. Surflan at 2.0 lb/ac or Pennant 5G at 4.0 lb/ac gave 80% or less control. Pennant (4.0 lb/ac) in combination with Princep (1.0 lb/ac), marketed as Pennant Plus gave 88% control but at lower rates (2.0 + 0.5 lb/ac, respectively) gave less than 80% control. Devrinol 50WP (napropamide) did not have any activity on musk thistle. Not only was control not acceptable with some treatments but many plants survived these treatments and produced seed.

The postemergence application of Roundup at the rates of 1.5 or 2.0 lb/ac gave 89% control or greater, and the lower rate of 1.0 lb/ac gave unacceptable control (63%), at 8 weeks after application. In North Carolina 1990 field studies indicate two new postemergence herbicides with registrations in
Christmas tree plantations, Stinger 3L (clopyralid) and Redeem 3L (triclopyr), have excellent activity on a number of thistles, including musk thistle (6). Effective control of 18 in. tall thistles can be obtained with the use rate of 2-4 oz/ac for both herbicides.

The phone survey also revealed that Kentucky, Georgia, North Carolina and Virginia are presently using the thistle-head weevil, Rhinocyllus conicus, a proven biological control agent to reduce musk, bull, and plumeless thistle infestations occurring in roadsides and pastures (4). No states reported a release of this biological agent in ornamental nurseries. The use of the biological agent is predicated on an area of 1000 thistle plants to maintain the weevil population.

Musk thistle has been identified as one of the worst weeds in Tennessee nurseries and may be increasing in nurseries throughout the southeast as it spreads from heavily infested roadsides and pastures. These studies have shown preemergence herbicides currently labeled that when applied just prior to plant emergence will give excellent preemergence control of musk thistle. Also, some effective postemergence herbicide options are available for controlling musk thistle in ornamental production. It appears from the information available that an integrated control scheme may best control this persistent weed.

LITERATURE CITED


SPLIT APPLICATION OF HERBICIDES FOR WEED CONTROL IN WOODY NURSERY PLANTS

Robert E. McNiel and Leslie A. Weston
Kentucky

Nature of Work: Research was conducted over a two year period (1989-1990) to evaluate the efficacy of standard and newly released herbicides for preemergence weed control in nursery crops. The evaluation will be conducted for a total of three years with herbicide applications performed annually in May and November. Newly released herbicides for evaluation include Pennant and Pennant Plus (Ciba Geigy Inc.), Snapshot and Gallery (Dow-ELANCO Inc.), Goal (Rohm and Haas, Inc.) and Stakeout (Monsanto, Inc.). In addition to these materials, other treatments included the industry standards Surflan, Princep and Kerb.

During April 1989, plots measuring 1800 sq. ft. were planted with ten tree and shrub species, using three plants of each species per plot. Each treatment was replicated three times. In 1989, herbicide application occurred on May 2 and 4, and November 26. In 1990, herbicide application occurred on May 25. Method of application was with a rotary granular spreader or a backpack sprayer calibrated to 26 gallons per acre using 8004 nozzles at 28 Ibs psi at the boom. Weed control ratings were performed at four week interval in spring and summer 1989 and 1990. All treatments included: Taxas cuspidata, ‘Densa’, Euonymus alata ‘Compacta’, Viburnum lantana ‘Mohican’, Juniperus chinensis ‘Pfitzeriana’, Thuja occidentalis ‘Techny’, and Picea abies. In addition treatments (Table 1 ) 1-6 included: Pyrus calleryana ‘Aristocrat’, Fraxinus americana ‘Autumn Purple’, Acer saccharum and Tilia cordata. Treatments 7-9 included: Syringa vulgaris, Quercus rubra, Crataegus viridis ‘Winter King’ and Gleditsia triacanthos ‘Shademaster’. Treatments 10-14 included Syringa vulgaris, Quercus rubra, Acer rubrum and Gleditsia triacanthos ‘Skyline’.

Results and Discussion: Visual weed control ratings, conducted upon a percentage basis from 0 to 100 were obtained 5 months after fall 1989 application in April 1990. Ratings were also collected four and eight weeks after spring application in June and July of 1990. Results from 1990 are presented in Tables 1 and 2.

Weed pressure was significantly reduced in early spring and summer months in 1990 due to wet cool spring weather conditions. Significant weed pressure was observed after July 15, 1990. Plots were infested with a wide range of monocots and dicots. Monocots included yellow nutsedge, large crabgrass, giant foxtail and barnyardgrass. Broadleaf species included ivyleaf morningglory, field bindweed, smartweed, red sorrel, common ragweed, honeyvine milkweed and redroot pigweed. The predominant uncontrolled
weed species for each treatment are listed in Table 2.

Excellent broadleaf weed control was provided by both formulations of Snapshot, the higher rates of Goal and Stakeout as well as Gallery. Surflan alone, Kerb and the low rate of Pennant provided poorest broadleaf weed control. Yellow nutsedge was poorly controlled by Princep plus Surflan, Surflan and the low rates of Stakeout and Goal. Excellent grass control was provided by both formulations of Snapshot, the high rates of Stakeout and Goal as well as Princep plus Surflan. Kerb and the low rate of Pennant Plus provided inadequate control of crabgrass, barnyardgrass and giant foxtail. Overall, both formulations of Snapshot as well as the high rates of Goal, Stakeout, Pennant and Pennant Plus appeared promising for control of yellow nutsedge, broadleaves and grasses.

Shrub and tree phytotoxicity were noted in certain herbicide treatments in 1989. Goal, Gallery, Pennant Plus, Stakeout and Kerb. In 1990, very little phytotoxicity was observed except for Pennant Plus, which appeared to stunt the growth of Thuja occidentalis.

Table 1. Herbicide Treatments and Weed Control Ratings, July, 1990.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Broadleaf</th>
<th>Grasses</th>
<th>Nutsedge</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Princep (4L) + Surflan (75 W) 2.5 pts/A + 4 lbs/A</td>
<td>89.3 a</td>
<td>94.3 a</td>
<td>46.7 bc</td>
</tr>
<tr>
<td>2. Pennant (7.8 L) 3 pts/A</td>
<td>79.3 ab</td>
<td>81.0 ab</td>
<td>96.7 a</td>
</tr>
<tr>
<td>3. Pennant (7.8 L) 6 pts/A</td>
<td>88.3 a</td>
<td>88.3 a</td>
<td>100.0 a</td>
</tr>
<tr>
<td>4. Surflan (75 W) 4 lbs/A</td>
<td>84.0 ab</td>
<td>88.3 a</td>
<td>23.3 cd</td>
</tr>
<tr>
<td>5. Pennant Plus (5 G) 40 lbs/A</td>
<td>61.7 bc</td>
<td>61.7 bc</td>
<td>96.7 a</td>
</tr>
<tr>
<td>6. Pennant Plus (5G) 80 lbs/A</td>
<td>88.7 a</td>
<td>88.7 a</td>
<td>100.0 a</td>
</tr>
<tr>
<td>7. Snapshot (80 DF) 3.75 lbs/A</td>
<td>97.3 a</td>
<td>97.3 a</td>
<td>98.3 a</td>
</tr>
<tr>
<td>8. Snapshot (2.5 G) 150 lbs/A</td>
<td>97.3 a</td>
<td>97.3 a</td>
<td>86.7 a</td>
</tr>
<tr>
<td>9. Gallery (75 DF) 1 lb/A</td>
<td>93.3 a</td>
<td>93.3 a</td>
<td>100.0 a</td>
</tr>
<tr>
<td>10. Stakeout (1 G) 100 lbs/A</td>
<td>91.7 a</td>
<td>92.3 a</td>
<td>36.7 c</td>
</tr>
<tr>
<td>11. Stakeout (1 G) 200 lbs/A</td>
<td>96.0 a</td>
<td>96.0 a</td>
<td>86.7 a</td>
</tr>
<tr>
<td>12. Kerb (50 WP) 4 lbs/A</td>
<td>50.0 c</td>
<td>40.0 c</td>
<td>73.3 ab</td>
</tr>
<tr>
<td>13. Goal (1.6 E) 5 pts/A</td>
<td>88.3 a</td>
<td>88.3 a</td>
<td>40.0 c</td>
</tr>
<tr>
<td>14. Goal (1.6 E) 10 pts/A</td>
<td>96.0 a</td>
<td>96.0 a</td>
<td>88.3 a</td>
</tr>
<tr>
<td>15. Unweeded check</td>
<td>0.0 d</td>
<td>0.0 d</td>
<td>0.0 d</td>
</tr>
<tr>
<td>Treatment</td>
<td>Weeds</td>
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<td></td>
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<tr>
<td>-----------</td>
<td>-------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Princep (4 L) + Surflan (75 W) 2.5 pts/A + 4 lbs/A</td>
<td>Prickly sida, yellow nutsedge, honey vine milkweed, bindweed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Pennant (7.8 L) 3 pts/A</td>
<td>Ragweed, prickly sida, ivyleaf morning glory, bindweed, red sorrel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Pennant (7.8 L) 6 pts/A</td>
<td>Prickly sida, ivyleaf morning glory, red sorrel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Surflan (75 W) 4 lbs/A</td>
<td>Honey vine milkweed, prickly sida, ragweed, yellow nutsedge, jimson weed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Pennant Plus (5 G) 40 lbs/A</td>
<td>Prickly sida, foxtail, crabgrass, ivyleaf morning glory, smartweed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Pennant Plus (5 G) 80 lbs/A</td>
<td>Prickly sida, ivyleaf morning glory, bindweed, jimson weed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Snapshot (80 DF) 3.75 lbs/A</td>
<td>Prickly sida, red sorrel, bindweed, nutsedge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Snapshot (2.5 G) 150 lbs/A</td>
<td>Nutsedge, barnyardgrass, prickly sida</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Gallery (75 DF) 1 Ib/A</td>
<td>Foxtail, prickly sida, velvetleaf, crabgrass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Stakeout (1 G) 100 lbs/A</td>
<td>Honey vine milkweed, prickly sida, redroot pigweed, yellow nutsedge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Stakeout (1 G) 200 lbs/A</td>
<td>Ivyleaf morning glory, ragweed, smartweed, yellow nutsedge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Kerb (50 WP) 4 lbs/A</td>
<td>Ragweed, velvetleaf, foxtail, yellow nutsedge, ivyleaf morning glory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Goal (1.6 E) 5 pts/A</td>
<td>Bindweed, yellow nutsedge, ivyleaf morning glory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Goal (1.6 E) 10 pts/A</td>
<td>Yellow nutsedge</td>
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OXIDIAZON COMBINATIONS FOR IMPROVED CONTAINER WEED CONTROL

Jeffrey F. Derr
Virginia

Nature of Work: Oxadiazon (Ronstar) has been used effectively for container weed control due to its safety on a wide range of woody nursery crops. Although oxadiazon controls a wide range of annual weeds, there are several species that are less susceptible to this herbicide. Common chickweed (Stellaria media), prostrate spurge (Euphorbia supina), eclipta (Eclipta alba), and common groundsel (Senecio vulgaris) are not effectively controlled by oxadiazon, especially at lower application rates.

Experiments were conducted in 1988 and 1989 to evaluate combinations of oxadiazon with other preemergence herbicides for improved control of the four broadleaf weeds listed above. Oxadiazon was combined with napropamide (Devrinol), pendimethalin (Southern Weedgrass Control), diflufenican (DFF), chloramben (Amiben) and simazine (Princep) in the 1988 study. For comparison, Ornamental Herbicide 2 (OH2), Rout, Devrinol and two formulations of Ronstar were applied alone. Green Beauty boxwood (Buxus microphylla), Andorra juniper (Juniperus horizontalis Plumosa), 'Hershey Red' azalea (Rhododendron obtusum), and Bennetts compacta ' holly (Ilex crenata) were planted in one gallon containers containing pine bark:sand, 4:1 v/v. Weed seed was planted prior to treatment. Pots were weeded, reseeded and retreated two months after the first treatment.

In the 1989 study, oxadiazon was combined with napropamide, oryzalin (Surflan), oxyfluorfen (Goal), metolachlor (Pennant), prodiamine and acifluorfen. 'Pleasant White' azalea (R. kaempferi) and Rotundifolia holly (I. crenata) were planted in one gallon containers and weed seed was planted in separate containers. Pots were weeded, reseeded and retreated two months after the first application.

Results and Discussion: All rates of Ronstar gave poor control of common chickweed and eclipta (Table 1). Ronstar wettable powder applied at 1.5 and 2.0 lb ai/A gave fair control of common groundsel and prostrate spurge. Combining Ronstar with Southern Weedgrass Control or DFF resulted in fair to excellent control of all four weed species. Combining Ronstar with Princep, Amiben or Devrinol improved weed control, but unacceptable control was observed with at least one of the four weed species. Ornamental Herbicide 2 (OH2), Rout, Ronstar plus DFF, Ronstar plus Amiben, and Ronstar wettable powder injured azalea. No other crop injury was seen.
Ronstar applied alone in the 1989 study did not adequately control eclipta, common groundsel or common chickweed. Combining Ronstar with Surflan resulted in good to excellent control of all four weeds (Table 2). Addition of the highest rate of Devrinol with the highest rate of Ronstar gave good to excellent control of all four weeds, although lower application rates resulted in unacceptable control of common chickweed. Combinations of Ronstar with the other preemergence herbicides resulted in unacceptable control of at least one of the four weed species. Ronstar plus Goal and Ronstar wettable powder injured azalea. No other crop injury was observed.

Combinations of Ronstar with dinitroaniline herbicides, especially Surflan, improved broadleaf weed control over that observed for Ronstar applied alone. Other preemergence herbicides improved broadleaf weed control when combined with Ronstar, but the other combinations evaluated did not adequately control all four weed species.
(Table 1)
(Table 2)
SPOTTED SPURGE CONTROL IN CONTAINER-GROWN ORNAMENTALS

Jeffrey G. Norcini and Gary W. Knox
Florida

Nature of Work: Spotted spurge (Chamaesyce [formerly Euphorbia] maculata) is a major weed problem due to lack of postemergence control with existing herbicides without injury to container-grown ornamentals. The purpose of this study was to evaluate the effectiveness of existing preemergence herbicides and herbicide combinations for controlling spotted spurge as compared to newly released and experimental herbicides. Daylily, known to be easily damaged by commonly used herbicides, was used for phytotoxicity measurements.

Sixteen herbicide or herbicide combinations (see Table 1) were applied to 1-gallon pots containing pine bark:sphagnum peat:sand (5:1:1) on 23 June 1989. The pots were irrigated with about one-half inch of water immediately after application. There were 16 replications per treatment in a randomized complete block design. Weeds were counted 2, 3, 6, and 10 weeks after treatment, and then harvested at 10 weeks. Phytotoxicity was evaluated on similarly treated 1-gallon ‘Aztec Gold’ daylily (Hemerocallis x ‘Aztec Gold’) at 2.5, 6, and 10 weeks. Plants were rated on a 0 to 5 basis, with 0=dead and 5=no injury. A rating of 4 was considered economically acceptable.

Results and Discussion: Short-term spotted spurge control (6 weeks), with little or no daylily injury (bleached spots that become necrotic), was achieved with GALLERY 75DF, both SNAPSHOT formulations, and DIMENSION 1G at 1.5 or 2 lb ai/A (Table 1 and 2). After 10 weeks, the only treatments that provided good spotted spurge control and caused little or no injury were SNAPSHOT 80DF and DIMENSION 1G (2.0 lb ai/A). Although no other weed species were present in sufficient numbers to determine treatment effects on individual species, these two treatments provided good overall weed control.

RONSTAR G + PRODIAMINE 65WDG provided excellent control of all weeds; however, this treatment also caused unacceptable phytotoxicity the first several weeks after application. This herbicide combination warrants further consideration since it may be less phytotoxic to other ornamentals.
(Table 1)
(Table 2)
Phytotoxicity Evaluations of Preemergent Herbicides on Selected Ornamental Nursery Crops

Donald L. Fuller
Louisiana

Nature of Work: There are several excellent preemergence-applied herbicides labeled for use on container-grown nursery ornamentals. Three of the more widely used herbicides with extensive registration for use on container-grown nursery stock are Ronstar 2G (oxadiazon), OH-2 3G (oxyfluorfen and pendimethalin) and ROUT 3G (oxyfluorfen and oryzalin). Several new herbicides which include Gallery 75DF (Isoxaben), Snapshot 80DF (isoxaben and oryzalin), Snapshot 2.5TG (Isoxaben and trifluralin), XL 2G (Oryzalin and Benefin), and Dimenson O.5G (Dithiopyr) have potential for controlling weeds but tolerances for use on several container-grown ornamental species have not been well established. The objective of this research was to determine foliage and root phytotoxicity of several ornamentals to multiple applications of the newer herbicide formulations.

Three inch liners of the following species were transplanted on May 8, 1989 in #1 (3.8 l) containers using a media of recently milled pine bark:

- **Acuba japonica** 'Picturata'
- **Buxus microphylla** Wintergreen'
- **Cleyera japonica**
- **Eleagnus pungens** 'Fruitlandi'
- **Euonymous japonica** 'Golden'
- **Gardenia jasminoides** 'Radicans'
- **Ilex vomitoria** 'Schillings Nana'
- **Juniperus conferta** 'Shore'
- **Langerstroemia indica** x Faurier 'Natchez White'
- **Ligustrum japonicum**
- **Magnolia grandiflora**
- **Mahonia bealei**
- **Nandina domestica** 'Purpurea Nana'
- **Rhododendron indicum** 'Judge Solomon'
- **Trachelospermum asiaticum**

Sequential applications of preemergent herbicides were made at manufacturers recommended rate on May 9, July 18 and October 10, 1989. Sprayable formulated compounds were applied over-the-top with a single 8003E nozzle delivering 43 gallons per acre, and granular formulated compounds were shaken from small paper bags. All treatments included 3 single plant replicates. Final evaluations of foliage and root injury were made on November 15, 1989.
Results and Discussion: Formulations with isoxaben (Gallery 75 DF; Snapshot 80 DF; and Snapshot 2.5 TG) resulted in a considerable amount of phytotoxicity to a large number of the species tested (Table 1). The sprayable Snapshot formulation was the worst and eleven of the species tested suffered unacceptable levels of injury to their roots and foliage. Materials that did not result in comprehensive injury to the species tested include the granular formulations of XL, Dimension, ROUT, OH-2 and Ronstar (Table 1). ROUT and OH-2 did however severely injure both the roots and foliage of Azalea and Nandina, respectively. For those plants where little or no injury has been demonstrated the use of a particular preemergent herbicide would be dictated by the spectrum of weed species controlled and economics.

See Table 1 - Following Page
(Table 1)
SECTION 10
LANDSCAPE

Mr. Will Corley
Section Chairman and Moderator
LANDSCAPE FERTILIZER EFFECTS ON GROWTH OF DWARF BURIFORDI HOLLY

W. L. Corley and W. L. Hargrove
Georgia

Nature of Work: The advent of environmental concerns for resource conservation and ground water pollution has focused increased attention on slow release fertilizers for growing ornamental plants in the nursery production phase and subsequently in landscape installation/grounds maintenance situations. In 1986 we initiated a test to compare the efficacy of low, medium and high rates of 18-6-12 fertilizer in both liquid and slow release formulations on the growth and quality of *Ilex cornuta* ‘Dwarf Burfordi’ plants. Quality, uniform liners were obtained from a commercial propagator and potted into trade gallon containers in early spring using a medium of pinebark, peat, and sand (3/1/1:v/v/v) which was amended with five pounds of dolomite per cubic yard. Water soluble minor elements were applied at recommended rates. Three slow release fertilizer treatments were surface applications of 18-6-12 at 9, 14 and 19 grams per container. Lab formulated liquid fertilizer equivalents applied with a siphon proportioner at weekly intervals comprised the remaining three treatments. Plants were grown for six months and then half of the 24 replicates were measured, weighed and analyzed for nutrient content. An equivalent number of plants were transplanted during late fall to a field site typical of urban soils. Soil nutrient status was low for major and secondary elements except for adequate Ca and Mg levels. The new transplants received five landscape fertilizers: granular 16-4-8 @ 6 pounds N/K square feet, liquid 12-4-4 @ 6 pounds N/K square feet, and 17-7-12 Osmocote @ 3, 6 and 12 pounds N/K square feet. Plants were mulched with aged woodchips, drip irrigated as needed, and weeded with a shield banded biannual application of Roundup and Surflan. Plant measurements and leaf samples for nutrient analyses were taken in early winter for three growing seasons. Plants were decapitated and weighed after three years.

Results and Discussion: Table 1 shows that fertilizer treatments did not significantly affect growth indices or dry weight of the production phase plants. Visual quality of the plants were similar. Nitrogen leaf content was highest in high liquid and medium to high Osmocote treatments. Phosphorus levels were highest in medium and high Osmocote applications. Potassium levels were highest in the three Osmocote and high liquid treatments. Calcium levels were highest in the low liquid and all three Osmocote levels, while Mg levels were highest in the low Osmocote plants. Few visual differences were detected in plant quality and growth for the factorized landscape fertilizer treatments as expressed by the data in Table 2. Production fertilizer had no significant effect on performance of plants growing in the landscape fertilizer treatments. After the second growing season, low and medium Osmocote rates gave highest growing index ratings. Plant fresh
weight was significantly higher for the medium Osmocote and liquid fertilizer treatments. Few significant differences were noted for primary and secondary elemental content of leaves. Potassium content was generally higher in high Osmocote and liquid treatments. The data generated by growth response indicate that Dwarf Burfordi holly nutrition requirements are fairly low. Their nutrient needs are partially met by decomposing bark mulch. Fertilizer choices by landscape managers are influenced by both economic and environmental concerns.

**Literature Cited**


(Table 2)
WILDFLOWER RESPONSES TO FERTILIZER RATES AND FORMULATIONS

W. L. Corley
Georgia

Nature of Work: Interest in wildflowers for cost-efficient beautification of public and private landscapes continues to increase at a phenomenal rate. Research has been aimed previously toward adapted species and establishment practices. No research in the southeastern U.S. has been reported for wildflower culture and management. During 1988, research was initiated in Georgia since soil testing laboratories routinely quote wildflower fertilization recommendations synonymously with annual and perennial fertilizer recommendations. These recommendations appeared too high for optimum wildflower culture.

Two infertile testing sites were chosen: a loamy sand in extreme southwest Georgia and a Cecil clay heterogeneous subsoil in north-central Georgia. Plots were seeded in fall 1987 with a southeastern wildflower mix, mulched with clean wheat straw, and irrigated during extreme drought stress periods. The following fertilizer treatments were applied in early spring and midsummer of 1988 and 1989: (1) none, (2) 500 lb./acre granular 16-4-8 (1 lb./100 ft.²), (3) 1,000 lb./acre granular 16-4-8 (2 lb./100 ft.²), (4) 500 lb./acre 18-6-12 Osmocote, and (5) 1,000 lb./acre 18-6-12 Osmocote. Soil samples were taken 60 days after fertilizer applications. Visual quality ratings of wildflowers were made at monthly intervals during the bloom season and average plant heights were recorded concurrently. Floriferousness (quality) was rated on a scale where 1 = poor, 3 = acceptable, and 5 = excellent.

Results and Discussion: Table 1 summarizes the data collected over the duration of the fertilizer test. Since wildflower mixes are more commonly used by landscapers, rather than individual or single species, plant quality data was averaged for the various species in the mix. Soil nutrient data shows that levels of P, K, Ca, and Mg were low except for a few instances where P accumulated to medium levels during the second year. Acidity levels increased slightly during the second year as expected. Plant height was increased slightly by all fertilizer treatments, especially by higher fertilizer rates in clay soil. Bloom quality was enhanced by all fertilizer treatments. Slow release (Osmocote) fertilizer applications were especially effective in improving bloom quality in clay soils. The inverse relationship between higher nutrient levels and lower bloom quality in loamy sand soil requires further study. Economics, site accessibility, and ground water contamination should influence choices in fertilizer formulations and rates for the landscape contractor and backyard gardener. Research continues.


(Table 1)
An Economic Profile of the Commercial Landscape Industry in Georgia

Gary L. Wade and E. Eugene Hubbard
Georgia

Nature of Work: Unlike the greenhouse and nursery industries that are characterized by periodic census reports and licensing requirements of the Department of Agriculture, the commercial landscape industry in Georgia has no such data.

In 1988, a survey to determine the physical size, distribution, economic value, employment generated, and perceived future growth of the commercial landscape industry was conducted. The survey resulted from the cooperative efforts of the Agricultural Economics and Extension Horticulture Departments of The University of Georgia. Funding for an enumerator was provided under Hatch Project 1356, and postage for the questionnaire mailings was provided by the Georgia Association of Landscape Professionals.

From an identified population of 400 commercial landscape firms statewide, a sample size of 140 firms was selected from cities and towns throughout the state. A one-page confidential questionnaire was then mailed to each of the sampled firms along with a cover letter signed by the President of the Georgia Association of Landscape Professionals and an Extension Specialist. Usable data was collected from 137 (98 percent) of the firms sampled and 34% of the estimated population. Forty-nine percent of the respondents were in an 18-county Metropolitan Atlanta area and 51% were in the remainder of the state.

Results and Discussion: The commercial landscape industry in Georgia is a young industry. Sixty-seven percent of the firms surveyed had been in business less than ten years, and 93% less than twenty years (Fig. 1). Yet more than one-fifth (21%) of the respondents reported annual gross sales in excess of $1 million.

Commercial clients (i.e. office parks, shopping centers, or restaurants) accounted for 68% of the gross revenue in the Atlanta area, 48% in other areas of the state, and 64% statewide. As gross revenue increases, the trend is for commercial clients to account for a greater share of the revenue generated than residential clients (Fig.2). A wide variety of services are offered; over 70% of the firms reported doing exterior design, exterior installation, exterior maintenance as well as seasonal color installation.

From the total gross revenue reported by the sampled firms, revenue generated by the entire population was mathematically estimated. Statewide gross revenue was estimated at $212 million, with Metro Atlanta accounting for 73% of the total (Fig.3). It should be noted, however, that these figures
do not include the revenue generated by landscape architects and so-called property development companies that have their landscape service staff in-house.

From the survey it was also estimated that the industry employs over 4,000 full-time employees and more than 3,000 part-time employees statewide.

Landscape operators are optimistic about their future (Fig.4). Ninety-four percent of the firms in Metro Atlanta and 88% of the firms statewide expect a moderate or major increase in their gross sales in the years ahead.

A complete summary of the findings of this survey have been published in Research Report 573 of The Georgia Agricultural Experiment Station, December, 1989.

References


(Figure 1)
(figure 2)

(Figure 3)

(Figure 4)
Evaluating Potential Irrigation Savings by Implementing Xeriscape Concepts

E. Neal Weatherly, Jr.
Georgia

Nature of Work: The droughts of 1986 and 1988 fostered a great deal of interest in outdoor water conservation, especially in the northern half of Georgia. An outgrowth of this interest is an on-going, joint educational effort between Water-Wise Georgia and the Georgia Cooperative Extension Service. One aspect of this educational effort is a demonstration garden which features xeriscape principles. The site selected, Southface Energy Institute on Moreland Avenue, is in Atlanta, Georgia. Southface already had interior demonstrations and exhibits as well as existing educational programs in energy and interior water conservation. The Extension Service provided the new design and members of Metropolitan Atlanta Landscape and Turf installed this xeriscape demonstration.

The objectives of this effort were four-fold:

1. To introduce xeriscape concepts to the southeast
2. To show that this landscape concept would not necessitate the introduction of designs or plants that are not typical of this region.
3. To show that the utilization of xeriscape principles could improve water efficiency and still be attractive, and
4. To create a landscape that compliments Southface’s office, a Victorian style former residence, offer color in the landscape at most seasons and be a low maintenance garden in its upkeep requirements.

The demand level for water in ornamental plantings is determined in the site design and planting design process. The type and quantity of plants selected determines the amount of water necessary for adequate maintenance. One of the designer’s most effective tools for water conservation is the selection/placement of plants that reduces water demand.

Results and Discussion: To estimate water-efficiency in various landscape plantings, a model is needed that portrays a wide range of landscape types. There is appreciable data regarding irrigation needs of the various turf grasses in the southeast but very little data regarding a wide range of trees, shrubs and ground covers (Table 1). (1, 2)

The main concern at Southface was whether a lawn would be provided in the front yard or should a more water-efficient ground cover be installed. In the
initial plan, centipede grass was specified. After much discussion, Variegated Loriope was substituted (figure 1 and 2). All factors except k (monthly plant type coefficient) are constants in the comparison, so the designers only compared monthly factors for the two plant types (Table 2).

In summary, the four previously mentioned objectives were realized in that a landscape plan incorporating xeriscpae concepts was established at Southface Energy Institute and a self-guided tour brochure was developed. The design is very conventional in layout (for this region) except that ground cover is substituted for turf in the front yard and the plant material, which has been proven very drought-tolerant by observation, is commonly used throughout the region. Finally, the landscape compliments the building in form and color.

It should be also noted that a reduction in k of .1 equals a reduction under maximum conditions of .89 inches of irrigation water for the metropolitan Atlanta area. So the shift from turf to ground cover is estimated to result in a savings of 1.4 inches of irrigation water for the planting area.

REFERENCES


(Table 1) verticle
(Table 2 & 3)
(Figure 1 & 2)
COLD HARDINESS OF MAGNOLIA GRANDIFLORA L. CULTIVARS

Orville M. Lindstrom and Michael A. Dirr
Georgia

Nature of Work: Southern magnolia, *Magnolia grandiflora* L., is a commercially important landscape plant in hardiness zones 7 to 9 (1). Low temperatures, however, limit its use in the northern U.S. and severe winters may injure plantings throughout its range. The cold tolerance of well established cultivars of *Magnolia grandiflora* has been approximated through field observations, but little or nothing is known about newer selections. Laboratory methods are available to assess the cold hardiness of existing cultivars and new selections (4).

The cold hardiness of landscape plants varies with time of the year (3). For that reason, the cold hardiness of eight selections of southern magnolia, ‘Bracken’s Brown Beauty’, ‘Little Gem’, ‘Phyllis Barrow’, ‘Select #3’, ‘Edith Bogue’, ‘Spring Grove #16’, ‘Spring Grove #19’, and ‘Spring Grove #43’ was determined in December 1989 and January and February of 1990.

Stem and leaf samples of ‘Bracken’s Brown Beauty’, ‘Little Gem’, ‘Phyllis Barrow’ and ‘Select #3’ were collected from trees grown in the Athens, GA area while samples of ‘Edith Bogue’ were sent from the Morris Arboretum in Philadelphia, PA and samples of the Spring Grove selections were sent from Spring Grove Arboretum, Cincinnati, OH. Samples from Philadelphia and Cincinnati were collected and sent to our lab via overnight mail express service.

Shoots of current season’s growth were removed from each plant, wrapped in wet paper towels, placed in plastic bags and transported on ice to Griffin, Georgia. Within 4 hrs of arrival, the plant samples were prepared for the freezing test. The leaves were removed and the terminal 7 cm (2.75 in) of each stem severed, wrapped in moist cheesecloth and placed into test tubes. Whole leaves were treated like the stems. The tubes were then submerged in ethylene glycol in a Forma Scientific Model 2425 temperature bath preset to \(-2.0 + 0.5^\circ\text{C}(28 + 1\text{F})\). Stem temperatures were measured by thermocouples placed next to the stem or leaf and recorded by a Model CR7-X Campbell Scientific datalogger. The cheesecloth was nucleated with ice crystals and the temperature held constant at \(-2.0 + 0.5^\circ\text{C}(28 + 1\text{F})\) for overnight (about 14 h), then the temperature was lowered at a rate of \(4^\circ\text{C}(7^\circ\text{F})\) per hour. Samples were removed from the bath at \(3^\circ\text{C}(5^\circ\text{F})\) intervals. Controls were prepared and kept on ice for the duration of the freezing test. Each tube contained 4 stem and leaf segments from each taxon sampled, thus each taxon was replicated 4 times at each temperature.
After thawing at 0°C(32°F), the samples were removed from the tubes and incubated at room temperature and 100% relative humidity for 10 to 14 days. At this time stems and leaves were visually evaluated for injury (2,6,7). Tissues showing brown discoloration and breakdown of cells in the cambium and phloem were rated as dead. The number of leaves and stems killed at each temperature was recorded and from these data the lowest survival temperature (LST) was determined. The LST (5) is the lowest temperature at which little or no injury is observed. The low temperature limit of the temperature bath was -30°C(-22°F), therefore, several taxa in midwinter were not killed and are reported as having a LST of -30°C(-22°F).

Results and Discussion: Tremendous differences exist among the Magnolia grandiflora selections with ‘Edith Bogue’, ‘Bracken’s Brown Beauty’ and ‘Spring Grove #19’ the most cold hardy and ‘Little Gem’ the least cold hardy (Table 1). ‘Spring Grove #19’, ‘Phyllis Barrow’ and ‘Select #3’ also exhibited fairly high levels of cold hardiness. ‘Spring Grove #43’ was only evaluated on the January and February dates and was not as cold hardy as the others. However, prior to laboratory evaluation the Spring Grove selections were exposed to -30°C(-22°F) outdoor temperature and were injured, thus, the samples of Spring Grove #43 that we received for freezing tests were already injured, making accurate cold hardiness determinations of this cultivar difficult.

Our laboratory cold hardiness determinations closely agree with the observed field survival. ‘Edith Bogue’ and ‘Bracken’s Brown Beauty’ are cold hardy and are grown in Philadelphia, New York and Washington, D.C. areas. The Spring Grove selections have survived, on more than one occasion, temperatures as low as -32°C(-25°F). In December 1989, for example, they were exposed to outdoor temperatures of -30°C(-22°F). Field evaluation, in June 1990 by the authors, found that they all survived and ‘Select #16’ had little stem and leaf damage while ‘Select #19’ exhibited more damage and ‘Select #43’ experienced the most damage. This is in agreement with our laboratory cold hardiness determinations (Table 1).

Based on these data, the laboratory cold hardiness determinations correspond with a plant’s observed field performance. Even though the absolute low temperature tolerance may vary from year to year depending on preconditioning factors, there are some selections of southern magnolia identified that do have potential for growth in colder regions of the country.


(Table 1)
Growth of Southern Magnolia After Root-zone Temperature Treatments

Chris A. Martin and Dewayne L. Ingram
Florida

Nature of Work: Transplanting containerized trees in the landscape may position roots into more favorable microenvironments compared to that of a container (2,5). The potential for growth and subsequent establishment of trees in the landscape may be directly related to previous exposure of trees to sub- or supraoptimal environmental factors, such as temperature, during the container production phase. The objective of this study was to quantify growth of southern magnolia following exposure to selected root-zone temperature (RZT) treatments.

Ten-month old rooted cuttings of *Magnolia grandiflora* ‘St. Mary’ averaging 12 inches in length, were potted, one per pot, into 10- by 3-inch polyethylene sleeves containing Metro-Mix 500 (Grace-Sierra, Inc., Cambridge, Mass.) and grown in a glass-covered, temperature-controlled greenhouse. Light intensity at canopy height inside the greenhouse was 7250 foot-candles at 1100 HR on 15 Sept. 1989. Natural daylength was supplemented with 3 hours of incandescent lighting during the night. Air temperature was 82 to 86°F / day gradually changing to 68 to 72°F / night. Relative humidity was approximately 40% day /80% night. Trees were fertigated daily with a 0.1 3-gallon solution consisting of soluble 20N - 8.8P - 16.6K fertilizer (Peters 20-20-20, Grace-Sierra, Inc., Cambridge, Mass.) at 50 ppm N. Root-zone temperatures of 86, 94, 100, and 107+1.4°F were sustained 6 hours per day, 1000 to 1600 HR, for 8 weeks during August through October of 1989, using an electronically controlled root-heating system (3).

Following the root-heating period, trees were transplanted into 5-gallon containers (12 inch height by 12 inch mean diameter) with Metro-Mix 500 medium and grown for 16 weeks in the greenhouse. Root-zone temperatures after transplanting were recorded half-way down the container profile in the center location and ranged from 80°F / day to 68°F / night. Following transplanting, each tree was top-dressed with 2 tsp of Osmocote 14N - 6.2P - 11.6K (14-14-14, Grace-Sierra, Inc., Miltpas, Cal.). Trees were watered to container capacity approximately every 4 days. At transplanting and 16 weeks after transplanting, 6 trees per RZT were harvested for growth analyses. Root systems were severed at the soil line and thoroughly washed. Total root length was measured with a Delta-T area meter (Decagon Devices, Pullman, Wash.) and Ikegami model ITC-510 camera (Ikegami Electronics, Inc., Tampa, Fla.) (1). Roots and shoots were then oven dried to constant weight and dry weights were determined. The experiment was arranged in a completely randomized block design with single tree replicates in 18 blocks. Regression analysis was used to test linear and quadratic responses of total root length and root and shoot dry weight to increasing temperature treatments.
**Results and Discussion:** Total root length was negatively correlated with RZT. After the RZT treatment period, root length decreased quadratically with increased RZT. Mean cumulative root length of trees exposed to the 94°F RZT treatment totaled 48.4 feet, which was 1.9 times greater than the 107°F RZT treatment. Root systems exposed to 107°F RZT were partially water-soaked in appearance developing into necrosis (personal observation) which indicates direct injury to root tissue (4). After the 16-week, post-transplant growth period, total root length decreased linearly with increased RZT. Mean cumulative root length of trees previously exposed to the 86°F RZT treatment totaled 259.8 feet and was 2.3 times greater than for trees at 107°F RZT.

At the time of transplanting to the larger containers, shoot and root dry weights of magnolias exposed to the 4 different RZT treatments were similar. However, after the 16-week, post-transplant growth period, shoot and root dry weights were negatively correlated with RZT in a quadratic pattern. Mean shoot dry weight at week 16 of trees previously heat-treated at 107°F was 25.0 grams, which was 34% and 45% less than the 100° and 94°F RZT treatment, respectively. Mean root dry weight at week 16 of trees previously heat-treated at 107°F was 11.9 grams and was 43% and 47% less than for the 100° and 94°F RZT treatments, respectively. Since there was similar reductions in shoot and root dry weights with increased RZT, there was no change in shoot to root ratios as a function of increased RZT.

**In Conclusion:** The growth response of southern magnolia as a function of RZT suggests that post-transplant suppression of growth by the 107°F RZT treatment was still evident at week 16 due to earlier injury of root tissue. Prior exposure of southern magnolia roots to supraoptimal root-zone temperatures higher than 100°F suppressed post-transplant growth and could lengthen the establishment period of trees in landscapes.

**Literature Cited**


Effect of Root Pruning at Different Shoot Growth Stages on Growth and Transplantability of Southern Magnolia

Edward F. Gilman and Michael E. Kane
Florida

Nature of Work: Root pruning of trees in fruit, forest and landscape nurseries is an old and varied practice (Hawley and Smith, 1954). It has been used as a horticultural tool to produce a sturdier tree, force development of a more compact, fibrous root system, retard shoot growth and increase transplant survival and post-transplant growth (Mullin, 1966). The timing, frequency, severity and location of root pruning are governed more by practical experience and tradition than by scientific studies. Only recently have the effects of root pruning on pre- and post-transplant tree growth been studied.

Nursery operators growing trees in the field for the landscape trade have relied on guidelines generated for 1 to 3-year-old seedling-sized trees. The objectives of the two experiments in this study were to measure the effects of root pruning landscape-sized southern magnolia on 1) tree root and top morphology at transplanting and, 2) post-transplant survival and growth.

Southern magnolia trees from #3 containers were planted in rows on 6' x 12' spacing in the fall 1984 on a fine sand near Gainesville, Florida. Irrigation (1 gallon/tree) was applied through microspray stakes generally daily except during rainy periods and winter. Ammonium nitrate at 10 lb N/1000 ft2/year was divided into 5 equal applications and applied to a 9 ft2 circular area around each tree. Glyphosate was periodically applied to control weeds in a 3 ft-wide strip centered on the tree line down each row.

Two hundred and twenty-four trees (32 trees/treatment) were root pruned in 1987 at the following times: 1) mid-dormant season - February, 2) just following the first shoot growth flush, after a terminal bud formed - June, 3)
following the second growth flush - October, 4) mid-dormancy and following first flush - February and June, 5) mid-dormancy and following second growth flush - February and October, 6) following the first and second growth flush - June and October, and 7) non root-pruned control. Trunk caliper and tree height were recorded immediately prior to initiating treatments, in Feb. 1987 and in Jan.1988. Root pruning cuts were made with a sharpened hand-spade inserted to a 12-inch depth at 60° from the horizontal in a circle 15 inches in diameter centered around the trunk. Irrigation (2 gallons/tree) was applied to all plants in the study for 7 days following a root pruning treatment.

Five trees from each of the 7 treatments were dug on 20 Jan 1988 with a 20-inch diameter rootball according to American Association of Nurserymen standards. Soil was washed immediately from the rootball with a stream of water. Roots were separated into 3 diameter classes: 1) fine (0-2 mm), 2) medium (> 2-5 mm) and 3) coarse (> 5-10 mm), and dried. Leaf area, dry weight and leaf number were measured for each plant.

Results and Discussion: Root pruning at all stages of growth reduced leaf number, tree height and trunk caliper in Jan, 1988, just prior to transplanting. Leaf size was unaffected by root pruning; however total-tree leaf area and total leaf weight for all root pruning times, except October, were less than for the unpruned controls. A single root pruning during dormancy (February) and following the first growth flush (June) reduced overall root dry weight within the rootball compared to the unpruned control. However, root dry weight of trees root pruned in October or any trees root pruned twice was not different from the unpruned trees. Fine root (0-2mm diameter) weight was not affected by root pruning. Root pruning following the second growth flush (October) increased the ratio of fine roots to coarse roots. This ratio ranged from 1.31 to 1.99 for root pruned plants compared with 0.99 for unpruned plants. Root pruning had no effect on leaf:root (roots within rootball) dry weight ratios.

Sixteen trees from the unpruned, and pruned in February, June, and October treatments (total 64 trees) were transplanted on 17 Feb 1988 with a 20-inch diameter root ball using a 2-blade mechanical tree spade. Irrigation (1 gallon/ tree) was applied daily, except when it rained, during 1988 to assure adequate water supply to the transplants. Tree height and stem caliper were measured at transplanting and at the end of the first post-transplant growing season, Dec 1988.

All 64 transplanted trees survived and grew following transplanting. Root pruned trees were shorter and had less caliper at transplanting than the unpruned controls. Height and trunk caliper increased more for root pruned than unpruned trees in the 10 months following transplanting (Table 1). However, there was no significant difference in height or trunk caliper among pruned and unpruned transplanted trees one growing season following transplanting (Dec 1988).
Fine root to coarse root dry weight ratio was positively correlated with post-transplant height and trunk caliper growth. This indicates that post-transplant tree growth may be related to the distribution of roots among diameter classes within the rootball and that trees may benefit from treatments encouraging a high fine root: coarse root ratio at transplanting.

During production, shoot growth of plants root pruned twice was similar to that in the single pruned treatments. In general, there was no difference in the shoot:root ratios when root pruned once or twice. This agrees with a similar study by Hobbs (1987) in which double root pruned seedlings grew similarly to single pruned plants. In one study, increasing the number of root prunings enhanced post-transplant growth (Bacon and Bachelard, 1978), while in another, growth up to 5 years after transplanting was reduced by multiple pre-transplant root prunings (Benson and Shepherd, 1977). Therefore, there does not appear to be a clear advantage to multiple root prunings on these small caliper trees.

Root pruning 4, 8 or 12 months prior to transplanting corresponded to more post-transplant growth than trees not root pruned, but did not result in larger trees 10 months after transplanting. Given two similarly-sized trees, one pruned and the other not, one would do best by purchasing the pruned plant. However, root pruned trees should command a higher price since they will grow slower in the nursery than a tree which has not been root pruned. On a fixed budget, a landscaper meeting specifications with a tree which has not been root pruned will be able to install a larger tree than one planting a root pruned plant. However, under well-watered conditions, the root pruned tree will grow faster in the first year after transplanting.

Roots grow up to 4'/year in the first years following root pruning, so many regenerated roots probably grew beyond the harvested rootball by the time the magnolia trees were transplanted. Root pruning trees 1 to 3 months before transplanting may be more beneficial than pruning many months before transplanting since more of the regenerated roots would be collected in the harvested rootball. The response of trees to root pruning may also be species and tree-size dependant, so the results of this research may not be applicable to other plants.

Acknowledgement

We acknowledge the support of Big Trees Nursery, Newberry, FL for donating their time and resources to this project.


(Table 1)
Tissue Elemental Status of Landscape Laurel and Shumard Oaks

Thomas H. Yeager, Karen A. Kainer and Raymond N. Gallaher
Florida

Nature of Work: Tissue elemental levels can be used as a diagnostic aid or for monitoring the nutritional status of a plant, provided optimal or baseline levels are known. Most reported levels are for landscape trees that received various fertilization treatments (2,3,5,6). However, it is not uncommon for established landscape trees to grow well and appear healthy for several years without fertilization. It would be helpful to establish baseline tissue levels for landscape trees grown without fertilization.

The objective of this study was to determine the tissue elemental levels of two oak species grown in a landscape without fertilization. These data will provide a baseline or reference for diagnostic testing.

The Quercus hemisphaerica and Q. shumardii trees used in this study were planted about ten years ago on the University of Florida campus in the sandy, siliceous, hyperthermic Grossarenic Paleudult, part of the Arredondo-Urban land complex (1) and it is unlikely the trees have been fertilized except for a possible application at planting. The three trees for each species were planted as a group with each tree about 15 to 18 feet apart in a triangular arrangement. Both species groups were located near Fifield Hall. The trees were not mulched and are currently 30 to 40 feet tall with desirable form.

Uppermost mature leaves or leaves from the most recent flush were removed on September 14, 1988. Leaves from three or four stems from each of three trees per species were sampled, dried in a forced-air oven and ground with a Wiley mill. Six cores of soil were collected with a soil probe from around the base of each tree and combined to comprise one soil sample for each tree. Elemental analyses for leaf and soil samples were performed according to standard procedures.

Results and Discussion: Tissue levels for both tree species were generally similar to each other (Table 1), but lower than most levels reported by Goodroad and Corley (5) for maple, pistache and sycamore, Canon et al. (2) for honey locust and Gilliam et al. (3) for ‘Bradford’ pear receiving various fertilization regimes. However, tissue levels for both species except for K, Mg and Fe were similar or higher than those of shumard oak in the fertilization study of Ingram and Joiner (6) and micronutrient levels were similar to many of the tree species sampled by Lumis (7). This indicates that baseline levels vary with species and possibly some plants accumulate nutrients to an optimal tissue range regardless of fertilization. Gilliam and Wright (4) determined that ‘Helleri’ holly accumulated N to about 2% before shoot elongation began. Accumulation and hence elongation was delayed at low fertility levels.
The tissue levels and elements extracted from the soil (Table 2) did not exhibit the direct relationship or correlation that Lumis (7) found with P and K. The high soil Ca levels in our study were probably due to high levels in the irrigation water.

Tissue levels from this study provide general guidelines or baseline data that may be used in making diagnostic or fertilization decisions. Optimal tissue levels may vary with species and fertilization practices and thus must be interpreted accordingly.

**Literature Cited**


Time of Transplanting *Magnolia Grandiflora* L. ‘Little Gem’ Grown in Fourteen Gallon Containers

Adolph J. Laiche, Jr.
Mississippi

**Nature of Work:** The best time for transplanting most plants in the South is considered to be in the fall, from November 1 to January 1. Broadleaf evergreens are best transplanted in the spring. Transplanting in the North has been done successfully in both fall and spring (2).

*Magnolia grandiflora* is considered difficult to transplant from the wild or field, especially in large sizes, and transplants best as balled and burlapped or container-grown trees in early spring (3, 5 and 6). The objective of this study was to determine the effects of transplanting in the fall, winter and spring on the growth of *Magnolia grandiflora* ‘Little Gem’ grown in 14 gal containers.

*Magnolia grandiflora* ‘Little Gem’ grown in 14 gallon containers with an average height of 6.4 ft, width of 3.4 ft and trunk diameter of 1.25 inch were transplanted into a Ruston fine sandy loam soil in rows 30 ft apart and 25 ft apart within the row. Treatments were transplanting dates on November 5, 1987 and January 4, March 7 and May 5, 1988. A Randomized Complete Block Design was utilized with treatments replicated eight times. An experimental unit consisted of one tree per plot.

Planting holes were 30 inch in diameter and 16 inch deep. One half pound each of dolomitic limestone and slow release fertilizer 17-7-12 were incorporated 6 inch deep in the soil in the bottom of the planting hole. One and one half pounds of dolomitic limestone and 2 oz of a 20-5-10 fertilizer were mixed with the back-fill soil when planting. After planting a levee, 4 1/2 ft square was constructed around each tree and the area inside the levee was mulched with pine bark 2 - 3 inch deep.

Trees planted on November 5, January 4, and March 7 were fertilized with a broadcast application (inside the levee) of 4 oz of 20-5-10 on March 7, 1988. Trees still in containers for planting on May 5, were fertilized with a broadcast application of 2 oz of 20-5-10 on March 7, 1988. Subsequent fertilizer application with 20-5-10 fertilizer was broadcast inside the levee at the rate of 4 oz/tree on May 5, July 5 and September 5, 1988. In 1989, the 20-5-10 fertilizer was broadcast at the rate of 4 oz per tree on March 5, May 5, July 5 and September 5.

The trees were irrigated with 65 gallons of water/tree on 5/10/88, 6/2/88 and 6/27/88. The trees were not irrigated in 1989, an extremely wet year.
Data were taken for analysis after the 1988 and 1989 growing seasons when the trees were dormant. A small nail was driven into the trunk of each tree 6 inch above the container rim before transplanting to obtain a point of reference to measure tree height and trunk diameter. Tree canopy width is an average of two measurements taken perpendicular to each other. Limb growth per tree is an average of the annual growth of 10 limbs, two on each of four sides and two on top, randomly tagged immediately after transplanting.

Results and Discussion: All plants survived transplanting and after the first growing season there were no significant differences in tree height and width, trunk diameter or limb growth, Table 1. Tree width was slightly less with May planted trees after two growing seasons. Limb growth with trees planted in May was slightly less in the second growing season. However, no differences in total limb growth after two growing seasons due to planting date were observed, Table 1.

Overall, growth of all trees over a two year period was excellent. In this study, conducted in the deep south, difficulty to successfully establish Magnolia grandiflora ‘Little Gem’ using large trees and transplanting in the fall or winter months was not encountered compared to spring transplanting.

Research in areas of the country where colder soil temperatures occur, indicates that poor root regeneration occurs in soils below 39°F, which may result in only marginal success of transplanting. Also, transplanting should be accomplished four weeks before soil temperatures drop to 45°F (1). In this study, average monthly minimum soil temperatures were 45°F or higher, Table 2, (4) and successful transplanting was obtained in the fall, winter and spring. The higher winter soil temperatures prevalent in this area may have contributed to the successful transplanting of Magnolia grandiflora ‘Little Gem’ in early November and January.

Regardless of other factors such as the time of year and geographical location, proper maintenance practices such as mulching and irrigation to avoid stress are essential for subsequent survival and growth after transplanting.

LITERATURE CITED


(Table 1)

(Table 2)
Nature of Work: A portion of a larger research study of the allelopathic effects of several commonly available mulches on the germination of weeds is reported in this paper. Uneven percolation of 1" of rain through 1, 2 and 3" of mulch noted in preliminary tests indicated that the greenhouse mist system could be used to quantitatively study percolation through mulch by misting for one hour. Leachates were collected in 36 containers placed underneath the mulch. Uneven percolation distribution occurred. Some containers became full whereas others nearby or adjacent remained empty. Extreme differences in leachate color also were observed. Since these differences could be a source of error in the main study, duckweed (Lemna sp.) was used as a bioassay to test the toxic properties of four leachate designated as follows: partial (less than 100 ml), full (over 300 ml), light (lightest leachate) and dark (darkest leachate). Three equal size duckweed plantlets were placed in 15 ml of leachate contained in four wells of a six-well petri dish. Water from the mist system was used as a control in the fifth well. The petri dish wells were covered and placed under shade cloth in the greenhouse in a randomized complete block design and replicated four times. The number of duckweed plantlets were recorded after a minimum of seven days.

Results and Discussion: The percentage of the mean value of living plants in controls for leachate types for each of the mulches are shown in Figure 1. White pine (Pinus strobus) and bald cypress (Taxodium distichum) were tested as two depths only, because of similar leachate colors. Leachates from black walnut (Juglans nigra) and white oak (Quercus alba) uniformly suppressed growth of plantlets. Cocoa bean mulch (Theobroma cacao) consistently suppressed growth to 20% of control whereas there was less than 10% difference in eastern red cedar (Juniperus virginiana), bald cypress and oats (Avena sativa) among the leachate types. Red maple (Acer rubrum), white pine and redwood (Sequoia sempervirens) each showed less than a 20% difference among types. Yellow poplar (Liriodendron tulipifera) showed the most extreme variation with the dark leachate being the most inhibitory. Black walnut and white oak were the most effective in suppressing plantlet increase whereas red maple, yellow poplar, redwood and cocoa bean suppressed growth under 40% of the control treatment. Leachates from the two conifers, eastern red cedar and bald cypress, were less than 25% effective in suppressing growth.

The effects of the leachate type are shown as a percentage of the control for the mulch levels in Figure 2. Because of difficulty in obtaining sufficient leachate through the mulches, black walnut was tested at the 2” level and cocoa bean was tested at the 1” and 3” levels.
White oak uniformly suppressed duckweed growth at all mulch levels. Red maple,
eastern red cedar and white pine were uniform to within 10% among levels. Bald
cypress and redwood were effective to within 20% among the three levels. Yellow
poplar, oats and cocoa bean showed 30 - 45% differences among the three levels.
No level was consistently more effective in stimulating or inhibiting growth than
any other. Black walnut and white oak were most effective in controlling plantlet
increase whereas oats and white pine were somewhat stimulatory. In comparing
variations associated with mulch depth to those associated with leachate type, black
walnut and white oak uniformly suppressed growth independent of either leachate
type or mulch depth. The slight stimulatory affect of oats and white pine does not
appear to be a function of mulch depth or leachate type. With yellow poplar,
redwood and cocoa bean mulches, duckweed plantlets were alive at time of
counting; however, they were not healthy and probably were in the process of dying.
If further investigation supports this observation, than these three mulches would
have more allelopathic effect in suppressing growth of duckweed than present data
show.

The mean pH levels of leachates ranged from 4.1 for white oak to 7.8 for white
pine and soluble salts ranged from 218 micromhos/cm for white pine to 1941
micromhos/cm for cocoa bean. No correlation has been made between this
information and detrimental effects on duckweed.

In summary, current observations indicate that mulch depths and leachate
types may be a source of variation in the main allelopathic study.
NCSU ARBORETUM EVALUATION OF KOREAN PLANTS FOR COMMERCIAL NURSERY/LANDSCAPE USE.

J. C. RAULSTON
NORTH CAROLINA

Nature of Work: During the fall of 1985, a three-month plant collecting expedition in the southwest section of the Republic of South Korea was conducted by the U. S. National Arboretum under the auspices of the Friends of the National Arboretum. Funding was provided by the University of British Columbia, North Carolina State University (through N. C. nurserymen, landscape contractor, and landscape architect donations), R. J. Reynolds Industries, Tom Dodd Nursery, the Holly Society of America, and many private individuals. The trip participants were Dr. Ted Dudley and Barry Yinger of the U. S. National Arboretum, Peter Wharton of the University of British Columbia, and Dr. J. C. Raulston of North Carolina State University.

Extensive collections of seed were made as well as limited vegetative accessions from Korean nurseries and wild plants of unique individuals which were unlikely to be obtained from seed. All accessions were backed by voucher herbarium specimens which were deposited with each sponsoring institution as well as the University of Seoul. Detailed collection site data are available in the 1985 Korea Expedition Collections Field Data Report (7). Seed and
plants from the expedition were divided and distributed to participants for growth performance and adaptation evaluation.

Ca. 5,000 plants of 45 taxa were grown for evaluation trials at The NCSU Arboretum with excess plants being distributed to public gardens and nurserymen across the U. S. Work with Korean Ilex has been reported extensively elsewhere and will not be duplicated here (1-6). The climate of southwest Korea is very similar to that of the southeast U. S. and most species from that area are well adapted for potential landscape use in the southeast. The native Korean flora is rich in both herbaceous and woody plants of great potential ornamental value and many of these are already common in commercial use - e. g. Aucuba japonica, Cornus kousa, Euonymus alata, Ilex cornuta, Liriope and Ophiopogon, etc. Some plants have less immediate commercial potential with lack of seed availability or other propagation problems- e.g. Abies, Actinodaphne, Cellis, etc. This paper presents 20 species or cultivars of plants from the 1985 Korean expedition which: (A) have performed well in Raleigh, NC, (B) are not at present commonly available in the nursery trade, and (C) that do have commercial possibilities.

**Results and Discussion:** The following table presents plants of promise with brief notes on characteristics and propagation technique.

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Characteristics and Performance Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspidistra elatior ‘Akebono’</td>
<td>A cultivar of common “Cast-Iron Plant” with white tips more attractive than the striped variegated form now available. Evergreen herbaceous perennial. Division of clumps.</td>
</tr>
<tr>
<td>Campsis grandiflora</td>
<td>Asian equivalent to southeast trumpet vine with larger flowers of apricot-orange. Very showy and long flowering. Woody vine. Seed, root or softwood cuttings.</td>
</tr>
<tr>
<td>Carpinus coreana</td>
<td>Asian equivalent to southeast “Ironwood”. Handsome deciduous shade tree. Seed or softwood cuttings.</td>
</tr>
<tr>
<td>Cephalotaxus coreana</td>
<td>Perhaps more vigorous growing and larger than most “Plum-Yews” presently grown. Evergreen conifer. Hardwood cuttings.</td>
</tr>
<tr>
<td>Cornus controversa</td>
<td>Largest species of dogwood reaching 70’ with rapid vigorous growth. Not drought tolerant. Flowering (shrub panicle-type flowers rather than bracts) shade tree. Seed or softwood cuttings.</td>
</tr>
<tr>
<td>Plant Name</td>
<td>Characteristics and Performance Notes</td>
</tr>
<tr>
<td>----------------------------------</td>
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</tr>
<tr>
<td>Cornus walterii</td>
<td>Similar to C. controversa in character - large and fast but seems more stress tolerant. Seed or softwood cuttings.</td>
</tr>
<tr>
<td>Daphniphyllum macropodum</td>
<td>Evergreen tree to 25' with large, dramatic foliage. Red flowers in spring with purplish fruit in autumn on separate male/female trees. Seed.</td>
</tr>
<tr>
<td>Dianthus superbus var. Longicalycinus</td>
<td>Herbaceous summer-flowering perennial with lavender flowers; very heat tolerant. Seed or softwood cuttings.</td>
</tr>
<tr>
<td>Euscaphis japonica</td>
<td>Deciduous tree with dark green, glossy foliage; spectacular red fruit in autumn which split to reveal shiny black seeds; and beautiful purple winter bark with white veining. Seed (Possibly cuttings but has not been attempted).</td>
</tr>
<tr>
<td>Ficus nipponica</td>
<td>Perhaps the hardiest Ficus - larger foliage than F. pumila (repens) - vining, climbing plant suitable for groundcover or use on trellis or growth on wood or masonry surfaces. Softwood cuttings.</td>
</tr>
<tr>
<td>Hosta yingerii</td>
<td>New species discovered on this expedition. Distinctive rounded glossy foliage, lilac flowers. Seed or clump division.</td>
</tr>
<tr>
<td>Ophiopogon jaburan ‘Variegata’</td>
<td>Showy, creamy-white variegated evergreen groundcover. Slow rate of development for division will limit quick commercial use.</td>
</tr>
<tr>
<td>Rhamnella franguloides</td>
<td>Small deciduous tree with handsome glossy foliage and showy fruit in summer with color change of yellow to orange to blackish. Seed (Cuttings have not been successful).</td>
</tr>
<tr>
<td>Rhaphiolepis umbellata</td>
<td>Best of the evergreen shrub “Indian Hawthorns” in our trials - rapid growing, disease resistant foliage, dark green color. White flowers. Cuttings any time of year.</td>
</tr>
<tr>
<td>Rhus chinensis</td>
<td>Deciduous flowering tree to 25' with large panicles of white flowers in September. Root cuttings.</td>
</tr>
<tr>
<td>Plant Name</td>
<td>Characteristics and Performance Notes</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Rhododendron schlippenbachii</td>
<td>A beautiful species of deciduous azalea which has not previously been adapted to use in the south. This collection at sea level in near subtropical summer heat and humidity is growing well in Raleigh and should expand the range of use of this species. Seed.</td>
</tr>
<tr>
<td>Scilla scilloides</td>
<td>Herbaceous bulb with 10-18” spikes of lavender flowers in August. One of the few species in this genera which do not flower in spring. Seed or division.</td>
</tr>
<tr>
<td>Styrax japonica ‘Sohuksan’</td>
<td>A large-leaved and flowered seedling variant of this popular species of small flowering tree found on Sohuksan Island and preserved through vegetative propagation. Seedlings of the tree did not come true to this form. Probably a polyploid with the unusual characteristic of producing flowers which have 3, 4, 5, and 6 petals on different flowers in the same inflorescence. Softwood cuttings; Side-Veneer Grafts; Tissue Culture.</td>
</tr>
<tr>
<td>Viburnum awabuki ‘Chindo’</td>
<td>Broadleaved evergreen large shrub/small tree with white flowers in spring and bright red fruit in summer and fall. A vegetatively propagated selection with large, dense inflorescences with more fruit than normal for the species. Original plant in a schoolyard on Chindo Island was 15’ tall and much more highly ornamental in fruit than other seedlings of the planting. Cuttings any time of year.</td>
</tr>
<tr>
<td>Vitex rotundifolia</td>
<td>Deciduous shrub of great sun/salt tolerance for beach plantings. Blue summer flowers, blue-grey round foliage on vine-like runners which root into sand and provide erosion control. Potentially useful from Maryland to Texas. Less useful inland where it is leggy out of the wind and less attractive. Softwood cuttings. Already in production and use in N. C.</td>
</tr>
</tbody>
</table>

Note: The NCSU Arboretum provides material to commercial nurserymen for trial upon request as available.
References


EVALUATION AND SELECTION OF DROUGHT RESISTANT SPECIES OF BIRCH

T.G. Ranney, R.E. Bir, and W.A. Skroch
North Carolina

Nature of Work: Many species of birch (Betula) are desirable and widely utilized landscape plants. Unfortunately, however, many of these species such as European white birch (B. pendula Roth.) and paper birch (B. papyrifera Marsh.), are native to cool, moist climates and perform poorly on dry sites. However, the genus Betula is quite large with approximately 40 species - many of which have desirable ornamental features. The size and diversity of this genus may provide for considerable genetic variation and afford substantial opportunities for selecting species of birch with superior stress tolerance.

One component of drought resistance is the maintenance of physiological processes during stress. The capacity to maintain turgor pressure while under water stress can contribute to this aspect of drought resistance. Turgor is a prerequisite for cell expansion and stomatal opening and is often positively correlated with photosynthesis and plant growth under water stress. The capacity for maintaining turgor pressure as leaves lose water is primarily a function of tissue osmotic potential (solute concentration). Tissues with lower osmotic potentials (greater solute concentrations) will have a greater capacity to maintain turgor during water stress. The objective of this experiment was to evaluate and compare water relations and leaf gas exchange among six species of birch in response to water stress.

Bare-root seedlings of monarch Birch (Betula maximowicziana Reg.)[see Santamour Jr. and Meyer (I) for proper identification], river birch (B. nigra L.), paper birch, European white birch, ‘Whitespire’ Japanese birch (B. platyphylla var. japonica Hara. ‘Whitespire’), and gray birch (B. populifolia Marsh.), ranging from 2.0 to 3.5 ft. in height, were planted in 3 gallon black plastic containers between 20 March 1989 and 4 April 1989. Growing medium consisted of 14 milled pine hark: 5 sand: 5 sphagnum peat moss (by volume). Plants were initially grown outdoors and received daily irrigation at the Mountain Horticultural Crops Research Station, Fletcher, N.C. On 20 July 1989 plants were moved into a polyethylene-covered (double layer clear) house. One tree of each species was then transplanted into each of six plywood boxes (3.2 ft. x 7.2 ft x 1.2 ft.) filled to a depth of 1 ft. with 0.86 yds$^3$ of the same growing medium. Plants were well-irrigated for 57 days at which time (15 September 1989) irrigation was withheld. At this time, plants were similar in size and were approximately 4.0 ft in height. The experimental design was a randomized complete block with six replications.
Leaf water potential was determined using a pressure chamber. Tissue osmotic potentials and the capacity of leaves for maintaining turgor were estimated using pressure-volume methodology (3) and analyzed as described by Schulte and Hinckley (2). Leaf samples were collected for pressure-volume measurements periodically throughout the stress period. Net photosynthesis and stomatal conductance were measured using a portable gas exchange system (LI-COR model LI-6200, Lincoln, Neb.). Following measurement of gas exchange rates, leaves were immediately excised and water potentials were measured.

Results and Discussion: Prior to initiation of water stress, there was nearly a two-fold variation in stomatal conductance and net photosynthesis among the six species studied (Fig. 1). River and 'Whitespire' Japanese birch maintained two of the highest rates of net photosynthesis while paper and monarch birch had two of the lowest. Rankings of net photosynthesis were typically similar to those of stomatal conductance. After irrigation was withheld, stomatal conductance and net photosynthesis gradually decreased for most species (Fig. 1). River birch appeared to be the most sensitive species to mild water stress as indicated by early reduction of both conductance and photosynthesis. After 28 days without irrigation, stomatal conductance and net photosynthesis of river birch had dropped to two of the lowest levels. ‘Whitespire’ Japanese birch appeared to be the least sensitive to the imposed water stress, maintaining higher levels of stomatal conductance and net photosynthesis throughout the stress period as compared to most other species. After 28 days without irrigation, 'Whitespire' Japanese birch maintained significantly higher stomatal conductance and net photosynthesis than any of the other species. There was no evidence of solute accumulation by any of these species in response to the applied stress. However, there was substantial variation in the capacity for maintaining turgor under increasing levels of water stress (i.e. decreasing leaf water potentials)(Fig. 2). The water potential at which turgor was lost varied from a high of -1.34 MPa for river birch to a low of -1.78 MPa for 'Whitespire' Japanese birch. Rates of net photosynthesis and stomatal conductance under mild water stress (average pre-dawn leaf water potential of -0.61 MPa) were significantly correlated with leaf osmotic potential. Thus, the greater net photosynthesis of ‘Whitespire’ Japanese birch under water stress appears to have resulted from a superior capacity for maintaining turgor at low leaf water potentials that in turn provided for greater stomatal conductance and CO₂ uptake. Results further indicate that 'Whitespire' Japanese birch is better adapted to dry sites than the other species.
LITERATURE CITED


3. Tyree, M.T. and H.T. Hammel. 1972. The measurement of the turgor pressure and the water relations of plants by the pressure-homh tech-

Figure 1. Stomatal conductance and net photosynthesis for six species of birch (Betula) in response to water stress. Vertical bars represent LSD$_{0.05}$ values.

Figure 2. Bulk turgor pressure as a function of leaf water potential. Curves were generated from pressure-volume measurements on individual leaves.

(Figure 1)
Nature of Work: The ornamentals and turf industry grew dramatically in the 80’s. Never before have we witnessed an increase in both the number of businesses and services offered in a total industry. The farm gate valve of nursery crops alone increased from 27 million (1980 county agent estimate) to over 100 million (1989 estimate). According to a 1987 turf survey, the value of turf in North Carolina is over 700 million dollars, made up of over 2 million acres of grass. The ornamentals and landscape industry has gotten much more “professional” than ever before. There are several state registration and certification programs to separate the “pro” from the novice. Pesticide licenses in the ornamentals and turf out number all other categories (80%). Currently there are 3100 registered pesticide applicators in this area.

North Carolina State University is committed to address the needs of this growing industry in all three areas: Extension, Research and Teaching. There are currently 12 faculty members (10.5 FTE’s) involved in ornamentals program from the Horticulture Department.

Results and Discussion: The 1990 Landscape and Turfgrass Field Day was the 10th and most successful field day to date. This program is an exhibition of research and extension plots presented by the faculty from several departments. The following is an example of a typical field day program:

Landscape Stops

1. Handling and Planting Barefoot Nursery Stock
2. Evaluation & Selection of Stress Tolerant Birch Trees
3. Weed Management in Landscape Beds
4. Measuring Soil Compaction on Landscape Sites
5. Environmental Concerns and New Innovations for Insect Control in Turf and Ornamenals
6. The NCSU Aboretum’s “Best of Show”
7. Disease Control in Azalea and Rhododendron Beds

Turf Stops

1. Disease Problems and High Sand Content Bentgrass Golf Greens
2. Potassium Sources on Bentgrass Greens
3. Plant Growth Regulators and Tall Fescue Morphogenesis
4. Winter Survival, Carbohydrate Reserves and PGR’s
5. Summer Annual Weedy Grass Control: New Horizons
6. Root Development and Preemergence Herbicides
7. Turf Selection and Current Cultivar Options
8. Turfgrass Tolerance to Aquatic Herbicides
The Field Day is co-sponsored by the commodity associations: North Carolina Landscape Contractors Association and Turfgrass Council of North Carolina.

A budget is developed by a field day committee made up of North Carolina State University faculty and association board members. The 1989 budget for expenses was $6,238.00. The actual income was $10,095.00 - a profit of $3,956.70. The profit was divided between North Carolina Landscape Contractors Association and Turfgrass Council of North Carolina, who in turn designated this money back to the University for Extension and Research projects. Total paid attendance was 1167.

Along with the regular Field Day program is a Product and Equipment Show, a scholarship fund raising auction (1990 was $3000.00), a special “hands-on” construction workshop, a turf field center open house, and numerous arboretum tours.

AN UPDATE ON THE USE OF GEOTEXTILES FOR LANDSCAPE WEED CONTROL

Marc Teffeau, Bonnie Appleton and Jeffrey Derr
Maryland and Virginia

Nature of Work: The benefits of controlling vegetation around the base of newly transplanted trees has been well established. In recent years, a new suppression method - the application of porous geotextile barriers - has been added to handweeding, mulching (with and without black plastic) and applying herbicides as an additional weed control measure. The ability of these geotextiles to suppress weeds varies considerably, depending upon the weed or grass species investigated, the type of geotextile used, and the type and depth of mulch placed atop the geotextile (2, 3, 4, 5).

Two additional evaluations have been needed: 1. - to distinguish between suppression of weeds that develop from beneath the geotextiles as contrasted to those that develop in the overlying mulch layer or invade from atop the geotextiles, and 2. - to insure that environmental conditions created by the geotextiles are conducive to landscape plant growth. Higher soil nitrogen content has been reported where mulches were underlaid with a geotextile as compared to mulch alone (2).
To address #1., one gallon containers were filled with a pine bark/sand medium (4:1, v:v), and for the barrier treatments, overlaid with a piece of polypropylene fabric or polyethylene film. One inch of shredded pine bark mulch was placed on top of the fabrics and films. One control consisted of medium with no fabric or film, and no mulch, while a second control consisted of medium with mulch alone. The treatments, with six single-pot replications in a randomized complete block design by weed species, were: Weed-X (polyolefin/polypropylene), Miracle Mulch (perforated polyethylene with very small holes), Weed Barrier (polypropylene), Typar (polypropylene), WeedBlock (embossed polyethylene with small holes), Duon (polypropylene), Magic Mat (polypropylene), Weed Stop (polypropylene)’ solid brown polyethylene film (2.5 mil), mulch alone, and bare medium.

All treatments were either seeded with approximately 1 tsp. of large crabgrass seed or sprigged with three 3-4 inch pieces of bermudagrass stolons plus shoots per pot. The containers were placed on a conventional nursery container bed and overhead irrigated with 0.5 inch water per day. The study was repeated a second time with similar results.

To address #2., a large field study was established (see reference 3 for materials and methods), with one gypsum block to record soil moisture, and one thermocouple to record soil temperature, installed at a 6 inch soil depth per plot. Soil moisture and temperature readings were taken biweekly for one year.

Results and Discussion: In the container study, bermudagrass and large crabgrass were not completely controlled by any soil covering. Weed-X reduced bermudagrass shoot fresh weight significantly more than all other materials except Miracle Mulch and Magic Mat, and large crabgrass shoot fresh weight more than all other materials except Miracle Mulch and brown polyethylene.

 Bermudagrass roots were able to penetrate all fabric and film treatments, while large crabgrass roots were able to penetrate all except the brown polyethylene film. Roots of both species penetrated Weed-X and Miracle Mulch significantly less often than all other fabrics or films except the brown polyethylene film. Root fresh weights confirmed the root penetration ratings.

If weed roots penetrate a fabric or film, rapid weed growth develops due to the favorable environment for root growth which occurs under landscape fabrics and films (3). Though brown polyethylene stopped most root penetration because it is nonporous, like black polyethylene (plastic) it creates a barrier to oxygen and water exchange, two factors important for the root growth of desired plants in landscapes. One reason landscape fabrics and films differ as to the extent of root penetration may be the difference in the ratio of open to closed areas for the various materials. Fabrics such as Weed-
X, which limit root penetration, should provide superior weed control over fabrics and films that permit greater root penetration.

In the field study, a significant interaction occurred between soil coverings and the presence or absence of mulch. When plots were mulched, there were essentially no differences in morning or afternoon soil temperatures, or soil moisture, among the weed control treatments (bare ground, herbicide, black plastic, and geotextiles) across all four seasons. Soil moisture and temperature conditions under geotextiles covered with organic mulches appear to be essentially the same as for organic mulches alone. Whether or not a geotextile should be used should therefore be based on other considerations such as weed suppression, cost, and any other problems that may arise from their use. Two potential problems noted in the field study were an increase in vole runs under the geotextiles, and tree root penetration of, and growth into, certain of the geotextiles (1).

**LITERATURE CITED**


Nature of Work: Three-quarters of the vast area west of the Mississippi River was once covered with native grasses. At least 6 separate grassland communities are recognized there. In West Texas the region identified as the shortgrass prairie extends from the Texas Panhandle and South Plains northward to Canada, touching or spreading across 7 states. Despite their abundance and availability, few of the many species of grasses native to this prairieland have found their way into landscapes, although native plant societies and agronomists have long called for their consideration (1,2,3,4,5,6,7,8,9). Buffalograss, *Buchloe dactyloides* (Nutt.) Engelm., is an outstanding exception. One of the dominant grasses in the shortgrass prairie, buffalograss is a drought-hardy, low-growing species which is used successfully in Southwestern landscapes as a turfgrass. Many other native grasses should be considered for both turf and ornamental use.

Several species of grasses are being collected from native stands in the Texas South Plains and increased at the Texas Tech University Horticultural Greenhouses and Nursery. Species selected are those that appear to exhibit ornamental qualities of color, vigor, compactness, and uniformity of growth habit over a 3- to 5-year period of study. Those that appear to have these qualities include: *Schizachyrium scoparium* var. *frequens* (C. E. Hubbard) Gould, little bluestem; *Agropyron smithii* Rybd., western wheatgrass; *Tridens flavus* (L.) Hitchc., purpletop; *Eragrostis trichodes* (Nutt.) Wood, sand lovegrass; *Sorghastrum nutans* (L.) Nash, yellow indiangrass; *Poa arachnifera* Torr., Texas bluegrass; *Rhynchosporium repens* (Willd) C. E. Hubbard, natalgrass; *Muhlenbergia lindheimeri* Hitchc., Lindheimer’s muhly grass; *Aristida purpurea* Nutt., purple threeawn; and *Bouteloua curtipendula* (Michx.) Torr. var. *curtipendula* sideoats grama.

These grasses are being compared in growth habit to several introduced grass species which have become established in High Plains landscapes: *Panicum virgatum* L. ’Rehbraun’, red switchgrass; *Pennisetum setaceum* (Forsk.) Chiov. ’Rubrum’, crimson fountaingrass; *Pennisetum alopecuroides* (L.) Spreng. fountaingrass; *Oplesmenus hirtellus* (L.) Beauv., basketgrass; *Arundo donax* L., giant reed; *Cortaderia selloana* (Schult.) Asch. & Graebn., Pampas grass; and *Elymus glaucus* Buckl., blue wild rye.

Results and Discussion: Results after two years of observations indicate the following:

Purple threeawn is shallow-rooted and easily dug. It does not appear to increase well, yet when established is a lovely grass, reaching only 6-8 inches
in height, and when grown in a bed produces a reddish tint. It survives
mowing well. It is non-palatable to livestock and apparently to rabbits, so may
be useful in the landscape.

Texas’ state grass, sideoats grama, established well the first year of the study
and reseeded rapidly. It will survive here and apparently increase readily in
a landscape setting.

Unlike many of the other Southwestern natives, western wheatgrass responds
vigorously to application of water, and due to its low growing habit may
perform well as a ground cover. However, in a droughty setting, it becomes
rank and loses its natural deep green color. It also spreads readily.

Natalgrass and Lindheimer’s muhly grass have not survived South Plains
winters this far north of their native or naturalized range in USDA Hardiness
Zone 8b. These grasses likely should be considered for locations from San
Antonio south.

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