PR-537

UK AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF KENTUCKY—COLLEGE OF AGRICULTURE

Nursery and Landscape Program

2006 Research Report

Nursery and Landscape Program

Kentucky Agricultural Experiment Station • University of Kentucky • College of Agriculture
Department of Horticulture • Lexington, Kentucky 40546

UK Nursery and Landscape Program

Faculty, Staff, and Student Cooperators

About Our Cover

The cover photo shows the 2000 Theodore Klein Plant Award Winner ***Viburnum nudum*** 'Winterthur' – Winterthur viburnum in Spring Meadow Nursery owner Dale Deppe's home garden near Grand Rapids, Michigan. This plant, described as hardy in USDA zones 5-9, performs equally well in Kentucky gardens, and examples can be seen in gardens across Kentucky, including: the late Theodore Klein's Yew Dell Gardens, Crestwood; Bernheim Arboretum, Clermont; University of Kentucky Research and Education Center Botanic Gardens, Princeton; Christian County Extension Office Gardens, Hopkinsville, and the Boone County Arboretum, Union. <http://www.ca.uky.edu/HLA/Dunwell/VWTRTHR.html>.

Viburnum nudum, Winterthur, - Winterthur viburnum (Smooth Witherod) is known for its dark green, shiny foliage. The late spring flowers are showy white with some fragrance. This selection is from Winterthur Gardens in Delaware. The blue fruit provides an ornamental effect, which is at its best before fall color, ripening and dropping as the exquisite red to purple fall color develops. The combination of all characteristics – habit of growth, flowering, glossy green foliage, blue fruit, and fall color – results in a plant with full-season appeal. The cultivar may be easily propagated by softwood cuttings treated with hormone and placed under mist.

Horticulture

Faculty

Robert Anderson
Sharon Bale
Winston Dunwell
Richard Durham
Bill Fountain
Robert Geneve
Dewayne Ingram
Robert McNiel
Mark Williams

Technical/Professional Staff

Shari Dutton
Amy Fulcher
Dava Hayden
Ross Hunter
June Johnston
Sharon Kester
Kirk Ranta
Hilda Rogers
Joe Ulrich
Dwight Wolfe

Lexington Research Farm Staff

Darrell Slone, Farm Manager
Courtney Hart
Dave Lowry
Janet Pfieffer
Kirk Ranta
Bonka Vaneva

Students

Craig Barbow
Cindy Finneseth
Katie Kittrell
Andrea McMillin
Amy Poston
Stephanie Tittle
Laura Wood

Agricultural Economics

Faculty

Tim Woods

Professional Staff

Jim Mansfield

Biosystems and Agricultural Engineering

Faculty

Richard Gates
Richard Warner

Entomology

Faculty

Kenneth Haynes
Daniel Potter

Students

Rebecca Baumler
Bonnie Miller
Bonny Seagraves

Plant Pathology

Faculty

John Hartman
Lisa Vaillancourt

Technical Staff

Bernadette Amsden
Paul A. Bachi
Julie Beale
Ed Dixon
Patricia deS'a
Ana Maria Holdcroft

Students

Amy Bateman
Hugues Chopy
Pierre-Yves Dymarski
Tobias Fullwood
Sarah Hall
Wiphawee Leesutthiponchai
Jacob Royce

Plant and Soil Sciences

Faculty

Tim Phillips

UK Arboretum

Marcia Farris, Director
Susan Capley
Jim Lempke

Nursery and Landscape Program

This is a progress report and may not reflect exactly the final outcome of ongoing projects. Therefore, please do not reproduce project reports for distribution without permission of the authors.

Mention or display of a trademark, proprietary product, or firm in text or figures does not constitute an endorsement and does not imply approval to the exclusion of other suitable products or firms.

The cost of publishing this research report is shared by the University of Kentucky Department of Horticulture; the Nursery/Landscape Research Fund, a Kentucky Agricultural Development Fund grant through the Kentucky Horticulture Council, Inc.; and the New Crop Opportunities Center.

Contents

UK Nursery and Landscape Program Overview—2006

Dewayne Ingram, Chair, Department of Horticulture

The UK Nursery and Landscape Program is the coordinated efforts of faculty, staff, and students in several departments within the College of Agriculture for the benefit of the Kentucky nursery and landscape industry. Our 2006 report has been organized according to our primary areas of emphasis: production and economics, pest management, and plant evaluation. These areas reflect stated industry needs, expertise available at UK, and the nature of research projects around the world generating information applicable to Kentucky. If you have questions or suggestions about a particular research project, please do not hesitate to contact us.

Although the purpose of this publication is to report research results, we have also highlighted below some of our Extension programs and undergraduate and graduate student activities that are addressing the needs of the nursery and landscape industries.

Extension Highlights

Cooperative Extension is an important source of gardening and landscaping information for consumers. Informed consumers of nursery and landscape products and services are the best customers of professional nurseries, landscapers and garden centers. In an effort to provide electronic access to such information at all times, GardenData.org was developed. Several of the Horticulture Extension faculty, led by Rick Durham, and county Horticulture Extension agents have been involved in the development of this resource.

GardenData.org is an online, interactive database of frequently asked questions. Content of this site is meant to address information needs in the area of consumer or home horticulture. Work on the site began in 2004, and a prototype was launched for use by county Extension agents in February 2005. Gardendata.org was made publicly available in summer 2005 but was not extensively marketed until winter. The site consists of around 700 questions and answers, and users may submit questions to Extension personnel if an answer cannot be found in the database.

In November 2005, Extension agents were provided marketing materials to promote GardenData.org to their counties during the spring 2006 gardening season. With little other external promotion, the GardenData Web site received more than 1,300 hits in December 2005. Use rose steadily and reached a climax of over 6,000 hits in March 2006, with an average of nearly 4,000 hits per month for 2006. Since inception the site has generated over 48,000 hits resulting in over 13,000 answers viewed, and nearly 340 questions submitted online.

Online searchable databases, such as Gardendata.org, provide users with quick, reliable information, and provide an additional conduit through which the public can access Cooperative Extension information. Nurseries and garden centers may wish to promote GardenData.org as an independent and reliable source for gardening information to Kentucky green industry consumers.

Undergraduate Program Highlights

The department offers areas of emphasis in Horticultural Enterprise Management and Horticultural Science within a Horticulture, Plant and Soil Science Bachelor of Science degree. Following are a few highlights of our undergraduate program in 2005-2006:

The Plant and Soil Science degree program has nearly 100 students in the fall semester of 2006, of which almost one-half are Horticulture students and another one-third are turfgrass students. Twelve horticulture students graduated in the 2005-2006 academic year.

We believe that a significant portion of an undergraduate education in horticulture must come outside the classroom. In addition to the local activities of the Horticulture Club and field trips during course laboratories, students have excellent off-campus learning experiences. Here are the highlights of such opportunities in 2006.

- Eleven students participated in an 11-day study tour to Europe led by Robert McNiel.
- Horticulture students competed in the 2006 Professional Landcare Network (PLANET) Career Day competition at Brigham Young University in March (Robert McNiel, faculty advisor).
- Students accompanied faculty to the following regional/national/international meetings, including the American Society for Horticultural Science Annual Conference, Eastern Region—International Plant Propagators' Society, the Kentucky Landscape Industries Conference, Southern Nursery Association Research Conference and Trade Show, and the Mid-States Horticultural Expo.

Graduate Program Highlights

The demand for graduates with master's or doctorate degrees in Horticulture, Entomology, Plant Pathology, and Agricultural Economics is high. Our master's graduates are being employed in the industry, Cooperative Extension Service, secondary and postsecondary education, and governmental agencies. Last year, there were nine graduate students in these degree programs conducting research directly related to the Kentucky nursery and landscape industry. Graduate students are active participants in the UK Nursery and Landscape research program and contribute significantly to our ability to address problems and opportunities important to the Kentucky nursery and landscape industry.

Caliper Gain of Nine Maple Taxa in 15- and 25-Gallon PNP Production Systems

Amy Fulcher, Department of Horticulture

Nature of Work

Maples are important nursery crops in Kentucky and across much of the United States. Maples represent $817,000 in sales, and one-quarter of the deciduous shade trees sold by Kentucky producers according to the 1998 USDA Census of Horticulture [11]. Additionally, with the loss of ash production and sales due to emerald ash borer, the portion of shade tree sales captured by maples may increase.

Acreage of pot-in-pot (PNP) production systems in Kentucky is increasing. Since 2002, more than 25,000 units (one unit = one socket pot, capable of producing one tree per production cycle) of PNP have been installed in Kentucky compared to less than 11,000 units prior to 2002 (unpublished data). PNP production systems have many production benefits over field production and above-ground container production, such as ease of harvest, reduced shipping costs, no designated overwintering structures, reduced water use, and moderated root environment. There are relatively few disadvantages, although initial cost may be high [1, 4]. In addition, plants produced in a PNP system may be harvested at any time of year, which allows nurseries to supply recently finished trees to their markets, even in hot and/or dry weather. Greater biomass accumulation has been reported in herbaceous perennials, shrubs, and trees when grown in PNP versus above-ground container production systems [5,6,7].

Benefits to larger container size relative to liner size have been established for some tree and shrub species in above-ground production systems. Outplanted black spruce seedlings produced the greatest stem volume when they originated from liners that were produced in larger volume containers, 99 cm^3 versus 83 cm^3 [8]. *Ilex* x 'Nellie R. Stevens,' X *Cupressocyparis leylandii* 'Haggerston Grey,' and *Rhododendron* 'Sunglow' all had two times the dry shoot weight when planted into three-gallon containers as compared to one-gallon containers [9]. Fare [3] studied above-ground production of Red Sunset® red maple and found that trunk caliper grew 25 percent more when liners were potted into 15-gallon containers versus seven-gallon containers. While Murray et al. [10], found that a larger PNP container size (20- versus 10- gallon) enhanced root and shoot growth and caliper of honey locust, birch, and green ash, there has been little research to identify the ideal liner/container size for PNP production. There are few published guidelines that address scheduling PNP crops.

Due to the semi-permanent nature of PNP production systems and potential increases in rate of biomass accumulation with this system, growers utilizing PNP production need to determine the optimal container size for the size of tree they wish to produce and the production cycle/schedule that optimizes profits. A smaller container requires less labor, is less expensive to transport, and requires less of each input (container, fertilizer, substrate) than a larger container. However, enhanced biomass production of larger container systems has been established for some species in above-ground and PNP production and may occur on maple taxa in a PNP system. Therefore, the objective of this study was to evaluate the growth of nine maple taxa in 15- and 25-gallon container sizes in a PNP system.

On March 29, 2005, nine maple taxa (*Acer* x *freemanii* Autumn Fantasy™; *Acer rubrum* 'Autumn Flame,' Red Sunset®, 'Somerset,' and 'Sun Valley;' *Acer saccharum* 'Commemoration,' Crescendo™, and 'Legacy;' and *Acer truncatum* Pacific Sunset™ were potted into 15- and 25-trade gallon containers (Nursery Supplies Inc., McMinnville, Oregon) with Barky Beaver Professional Grow Mix (Barky Beaver Mulch and Soil Mix Inc., Moss, Tennessee) and grown on a gravel pad at the University of Kentucky Horticulture Research Farm in Lexington for the 2005 growing season. Trees were irrigated manually with an overhead sprinkler.

In November 2005, the trees were randomly placed into one of the six blocks for both 15- and 25-gallon socket pots in the PNP plot at the Horticulture Research Farm. On April 3, 2006, the trees were uniformly pruned, and on April 7, 2006, the trees were fertilized with 18-2-14 (Harrell's Inc., Sylacauga, Alabama) at the medium rate of 183 grams per 15-gallon container and 357 grams per 25-gallon container.

On June 11, 2006, Snapshot® 2.5 TG (Dow Agrosciences, Indianapolis), at 150 pounds per acre, was applied for weed control. Biobarrier®, (Reemay Inc., Old Hickory, Tennessee) was used for rooting out control at a rate of one sheet (32 nodules) per 15 gallons and two sheets per 25 gallons. On June 16, 2006, the trees were pruned by heading back (removing the tip) the lateral branches. Central leaders were not pruned. Cyclic irrigation was applied at 9 a.m., 12 p.m., and 3 p.m., supplemented by manual irrigation for the duration of the growing season, such that water was not limiting.

On April 15, 2005, baseline caliper measurements were taken to the nearest 0.25 inch on 10 replications of each cultivar. On May 8, July 3, and October 18, 2006, caliper readings were made at the same location on each trunk, denoted by a line made with an indelible black marker, 6 inches above the substrate surface. The experiment was a randomized incomplete block design with a 2-by-9 factorial arrangement. Caliper and caliper gain (from May to July and May to October) data were subjected to statistical analysis using the PROC MIXED procedure in SAS (SAS Institute, Cary, North Carolina) at a p value of 0.05 or less.

Results and Discussion

For each maple taxon except Crescendo™, there was a trend of increasing caliper gain with increasing container size; however, this difference was not statistically significant. The trend in plant growth and container size corresponds to the differences found by other researchers [6,8,9]. The additional growth may be due to the greater available water, as well as greater volume for root system growth with the larger container, such that these were not limiting factors for caliper gain.

The average caliper measurements for the nine maple taxa are reported for 15- and 25-gallon container sizes (Table 1). These data allow growers to gauge the anticipated caliper size after 13, 15, and 19 months in production. The American Standard for Nursery Stock [2] approves 1.5 -inch caliper trees in both 15- and 25-gallon container sizes, therefore, we set a target caliper of 1.5 inches for this project.

On average, Pacific Sunset™ trees grown in 15-gallon containers met the 1.5-inch target caliper within a 15-month production cycle, while all Pacific Sunset™ trees grown in 25-gallon containers met the 1.5-inch target in 15 months. On average, Autumn Fantasy™ and 'Somerset' attained a caliper of 1.5 inch or greater by July, a 15-month production cycle; however, only trees grown in 25-gallon containers did so. Every 'Sun Valley' and Red Sunset® tree grown in 25-gallon containers for 19 months met or exceeded the target caliper.

On average, *Acer rubrum* 'Autumn Flame' and *Acer saccharum* 'Commemoration', Crescendo™, and 'Legacy' didn't reach the target caliper of 1.5 inches during the 19 months in production. July estimates are particularly relevant because summer-finished trees are in demand for new home and commercial construction completed in the hotter months, as these trees are perceived as better able to withstand transplant shock when compared to summer-dug, field-grown trees.

These trees were grown above ground during the 2005 growing season. Therefore, Table 1 may underestimate caliper gain when compared to plants grown continuously in a PNP system with cyclic irrigation and moderate root temperatures.

Table 1. Caliper averages for 15- and 25-gallon container sizes, after 13, 15, and 19 months in production.

	Caliper (inches)			
Maple Taxa	**April 2005**	**May 2006**	**July 2006**	**October 2006**
15-gallon Container *(trade gallon)*				
Acer x *freemanii* Autumn Fantasy™	1	1.16	1.30	1.55
Acer rubrum 'Autumn Flame'	0.5	0.92	1.26	1.35
Acer rubrum Red Sunset®	0.5	1.03	1.30	1.44
Acer rubrum 'Somerset'	0.5	0.97	1.22	1.36
Acer rubrum 'Sun Valley'	0.5	0.87	1.21	1.35
Acer saccharum 'Commemoration'	0.5	0.77	1.02	1.08
Acer saccharum Crescendo™	0.5	0.75	1.01	1.06
Acer saccharum 'Legacy'	0.5	0.79	1.09	1.23
Acer truncatum Pacific Sunset™	0.75	1.18	1.51	1.72
25-gallon Container *(trade gallon)*				
Acer x *freemanii* Autumn Fantasy™	1	1.27	1.50	1.73
Acer rubrum 'Autumn Flame'	0.5	0.97	1.32	1.49
Acer rubrum Red Sunset®	0.5	1.17	1.47	1.72
Acer rubrum 'Somerset'	0.5	1.15	1.51	1.69
Acer rubrum 'Sun Valley'	0.5	1.03	1.44	1.63
Acer saccharum 'Commemoration'	0.5	0.90	1.22	1.34
Acer saccharum Crescendo™	0.5	0.72	0.98	1.01
Acer saccharum 'Legacy'	0.5	0.86	1.25	1.37
Acer truncatum Pacific Sunset™	0.75	1.29	1.58	1.90

Significance to the Industry

Maple tree production is a vital component to Kentucky nurseries. While the conclusions drawn from this study are limited by one season of data, the results indicate that 33 percent of the maple taxa studied reached a 1.5-inch caliper benchmark after 15 months in production and an additional 22 percent reached 1.5-inch caliper after 19 months in production. Trends in caliper growth may be used when determining the costs and benefits of different container sizes. Additionally, PNP nursery producers may use this study as a guide to schedule maple production.

Acknowledgements

The authors acknowledge Tim Geneve, Dava Hayden, Shauna Switzer, Rhonda van Dyke, and Horticulture Research Farm employees for technical assistance; Snow Hill Nursery for liners; and Harrell's Inc. for fertilizer.

Literature Cited

1. Adrian, J., C. Montgomery, B. Behe, and K. Tilt. 1998. Cost comparisons for infield, above-ground container and pot-in-pot production systems. Journal of Environmental Horticulture. 16(2):65-68.
2. American Standard for Nursery Stock. 2004. American Nursery and Landscape Association ANSI Z60.1-2004.
3. Fare, D., 2006. Container size and initial trunk diameter effects growth of *Acer rubrum* L. during production. Journal of Environmental Horticulture. 24(1):18-22.
4. Fulcher, A., M. Ernst, R. McNiel. 2003. Pot-in-pot production budgets, cash flow, and price sensitivity charts, in 2003 Nursery and Landscape Program Research Report.
5. London, J. 1998. Comparing above-ground and in-ground pot-in-pot container systems. Proceedings of the Southern Nursery Association Research Conference. 43:71-75.
6. Cardoso, G., R. Kjelgren, T. Cerny-Koenig and R. Koenig. 2006. Pot-in-pot production of six intermountain west native herbaceous perennial species grown in containers. Journal of Environmental Horticulture. 24(2):77-83.
7. Ruter, J. 1998. Fertilizer rate and pot-in-pot production increases growth of Heritage river birch. Journal of Environmental Horticulture. 16(3):135-138.
8. Paterson, J., 1996. Growing environment and container type influence field performance of black spruce container stock. New Forests. 13:325-335.
9. Tilt, K., T. Bilderback, and W. Fonteno. 1987. Particle size and container size effects on growth of three ornamental species. Journal of the American Society for Horticultural Science. 112:981-984.
10. Murray, C.G.L., C. Chong. 1996. Fertilizer method and container size effects on shade trees grown in in-ground containers. Canadian Journal of Plant Science. 76:507-513.
11. U.S. Department of Agriculture. 1998. 1998 Census of Horticulture. National Agricultural Statistics Service, U.S. Department of Agriculture, Washington, D.C.

Tissue Culture in White Oak *(Quercus alba)*

Stephanie Tittle, Sharon Kester, and Robert Geneve, Department of Horticulture

Nature of Work

White oak (*Quercus alba*) is an important forestry species. Native stands of white oak experienced a major decline with the implementation of forest fire controls in the 20th century (1). Further complicating oak survival is their susceptibility to sudden oak death (*Phytophthora ramorum*). White oak is propagated by seed in the nursery industry but has limited availability because it is difficult to produce as a nursery crop. There is a need for a clonal propagation system for selection of desirable characteristics such as fall color, hardiness pathogen resistance and improved nursery production characteristics.

Somatic embryogenesis could fill the need for a clonal system of propagation and serve as a vehicle for genetic transformation. A system such as this would result in the production of genetically and phenotypically identical trees. However, the development of complete somatic embryogenesis systems have generally been difficult in oaks (5).

In 2005, a single staminate catkin explant produced a somatic embryogenic culture. A low frequency of somatic embryogenesis from male catkins has been previously reported in other oak species (2, 5). This culture has continued to produce secondary somatic embryos for the past year. Therefore, the specific objectives of the current study were to evaluate the impact of stage of catkin development and growth regulator treatment on somatic embryo induction, and to attempt to convert secondary somatic embryos from the 2005 culture into seedlings.

Staminate catkins were collected three times during April 2006 and surface sterilized in 10 percent bleach for 15 minutes followed by a triple rinse in distilled water. The first collection (April 17) resulted in catkins less than 0.7 cm. Samples this small would not allow for the removal of male flowers and the entire staminate catkin was used. The final two collections (April 20 and April 24) resulted in fully expanded catkins prior to anther dehiscence. Male flowers were removed from half of the staminate catkins. At each collection, five explants were placed per Petri dish on MS media (3), containing 1 or 5 μM 2,4-dichlorphenoxyacetic acid (2,4-D) plus 1 μM benzlyadenine (BA) or 5 μM naphthalene acetic acid (NAA) plus 1 μM BA. Explants were cultured in the dark or under cool white fluorescent lamps (PAR 60 $\mu mol \cdot sec^{-1} \cdot m^{-2}$) at 21°C. There were 10 replicate Petri dishes per treatment for the first collection and five replicate dishes per treatment for subsequent collections. The percentage of explants forming callus were evaluated after one month.

The 2005 somatic embryo cultures entered a cycle of repeated secondary embryo formation. In May 2006, individual somatic embryos (globular stage) were moved either to basal MS medium or media containing 5 μM gibberellic acid (GA_3) alone, or 1μM BA plus 1 or 5 μM ABA. There were six explants per Petri dish and four dishes per treatment. Explants were cultured under cool white fluorescent lamps (PAR 60 $\mu mol \cdot sec^{-1} \cdot m^{-2}$) at 21°C. Germination and progression to cotyledon stage embryos without secondary embryo formation was evaluated after one month.

Results and Discussion

The percentage of loss due to fungal contamination was 64 percent or greater (Table 1). Explants treated with 2, 4-D formed a higher percentage of callus than those treated with NAA. Removal of male flowers significantly decreased the percentage of contamination and increased the percentage of callus formation. Light and dark grown cultures responded similarly for callus production. After one month on either 1 or 5 μM 2, 4-D media, explants developed a creamy-yellow callus along the peduncle. The slight appearance of callus growth on the cultures treated with 5 μM NAA occurred at the site of removal from the mother plant and did not spread along the length of the peduncle as observed with 2, 4-D treated explants. At present, no cultures have become embryogenic.

Some development to the cotyledon stage of development was observed on the growth regulator free medium, but the greatest percentage of secondary embryos beginning to germinate was induced on the medium containing GA_3 (Table 2). A similar effect of GA_3 on somatic embryo development was previously observed in Willow oak *(Quercus phellos)* cultures derived from seedling explants (4). These encouraging data suggest that plantlets may be derived via somatic embryogenesis in white oak if an efficient system to induce culture from staminate catkins is developed.

Significance to Industry

White oak may be propagated by seed immediately after collection without any special treatments. This method of propagation, however, does not provide superior cultivars to the nursery industry. A clonal in vitro system for propagation producing superior mature clones could result in increased profits for both liner and field production of white oak. In addition, somatic embryo-

Table 1. The percentage of staminate catkin explants with stamens removed forming callus after treatment were placed on a medium with 1 or 5 mM 2,4-dichlorphenoxyacetic acid (2,4-D) plus 1 μM benzlyadenine (BA) or 5 μM naphthalene acetic acid (NAA) plus 1 μM BA under light or dark conditions.

BA [1mM] media plus	Light	Dark
2,4-D [1mM]	43	100
2,4-D [5mM]	66	83
NAA [1mM]	0	33

Table 2. Somatic embryo development on several conversion media.

	Stage of somatic embryo development			Secondary
Treatment	Globular	Cotyledon	Germinating	embryos
Untreated	33.3a[z]	29.2a	0	37.5c
GA3 [5 mM]	8.3b	16.7b	16.7a	58.3b
BA [1 mM]	0c	4.2c	0	95.8a
BA [1 mM] + ABA [5 mM]	29.2a	4.2c	0	66.7b

[z] means followed by the same letter within a column were not different at $P \leq 0.05$ by Tukey's HSD test.

genesis has proven to be a useful tool for recovering transgenic plants. This could be an important component in a strategy to develop plants resistant to diseases such as sudden oak death.

Literature Cited

1. Abrams, M.D., D.A. Orwig and T.E. Demeo. 1995. Dendroecological analysis of successional dynamics for a presettlement-origin white-pine-mixed-oak forest in the southern Appalachians, USA. J. Ecol. 83:123-133.
2. Gingas, V.M. and R.D. Lineberger. 1989. Asexual embryogenesis and plant regeneration in *Quercus*. Plant Cell, Tissue Organ Culture. 17:191-203.
3. Murashige, T., and F.A. Skoog. 1962. A revised medium for rapid growth and bioassays with tobacco tissue cultures. Physiol. Plant. 15:473-497.
4. Wells, S. K., S. T. Kester, and R. L. Geneve. 2005. Somatic embryo development in willow oak. Combined Proceedings International Plant Propagators' Society 55:133-135.
5. Wilhelm, E. 2000. Somatic embryogenesis in oak (*Quercus spp.*). In vitro Cell. Dev. Biol.- Plant 36: 349-357.

Seed Propagation of Spicebush *(Lindera benzoin)*

Amy Poston and Robert Geneve, Department of Horticulture

Nature of Work

Spicebush (*Lindera benzoin)*, a member of the Lauraceae family, is a shrub native to the Eastern United States from Maine to Florida and west to Kansas (1). As concern grows about nursery production of species designated as exotic invasive plants and the opportunity grows for utilizing native plant alternatives, there is potential for spicebush in the landscape industry as a marketable native shrub.

Spicebush has a dense rounded growth habit in full sun, a more open growth habit in shade and prefers moist well-drained soil. It bears small clusters of yellow flowers in early spring and has smooth light green leaves in the summer which turn bright yellow in the fall. In addition to the aesthetic qualities, there are no serious insect or disease problems (1).

Vegetative propagation of spicebush by cuttings has been difficult (1). Therefore, propagation from seeds is currently the most common production method. The most often referenced suggestion for a dormancy release treatment for spicebush is one month of warm followed by three months of chilling stratification (2, 4). Dirr and Heuser (2) also suggest that spicebush seeds only require three and one-half months of chilling stratification for dormancy release. The objective of the current study was to determine the need for both warm and chilling stratification on dormancy release in a native Kentucky accession, as well as, ease of seedling establishment.

Seeds were collected near Nicholasville, Kentucky in early November 2005. Seeds were removed from the fruits and broken seeds discarded. Seeds were cleaned and stored dry in the cold at 5°C.

Prior to stratification, seeds were surface disinfested by soaking in a 10 percent bleach solution for 10 minutes followed by three rinses of sterile water. Seeds were placed in 15mm plastic Petri dishes with 60 g of autoclaved sand and 15 ml sterile water (20 seeds per plate). Using a factorial experimental design, dormancy release treatments included zero, four, and six weeks of warm stratification at 25°C, followed by zero, six, 12, and 18 weeks of chilling stratification at 5°C, for a total of 12 treatment combinations with 80 seeds (four plates) per treatment. Upon completion of the stratification period, dishes were moved to a growth chamber at 25°C with light. Germination (radicle emergence) was recorded weekly for four weeks.

Upon germination, seedlings were removed from the Petri dishes and transplanted into 7-inch-deep, six-cell packs (5¼ by 3¼ inches wide) using 560 Metro Mix and placed under greenhouse conditions. Seedlings were watered as needed and fertilized with a Peters 20-10-20 solution every seven to 10 days.

Results and Discussion

Approximately 15 percent of spicebush seeds germinated without any stratification treatment. The highest germination percentages occurred after 12 weeks of chilling stratification without a prior warm stratification period (Table 1). Seeds exposed to warm stratification prior to chilling stratification showed significantly lower germination percentages compared to chilling alone, and the warm pretreatment appeared to delay dormancy release during the subsequent chilling period.

Table 1. Seed germination of spicebush exposed to combinations of warm followed by chilling stratification.

Stratification: Weeks at 25°C	Stratification: Weeks at 5°C	Germination percentage[z]
0	0	15.8 c
	6	50.0 b
	12	90.0 a
	18	86.3 a
4	0	15.8 c
	6	18.8 c
	12	37.5 b
	18	53.8 a
6	0	12.5 c
	6	8.8 c
	12	57.5 b
	18	68.8 a

ANOVA	F-value[y]
Main effects	
Warm stratification (W)	45.24**
Chilling stratification (C)	101.78**
Interaction Effects	
W x C	7.54**

[z] means followed by the same letter within a warm stratification treatment were not significantly different at $P < 0.01$ by Tukey's HSD test.

[y] ** indicates significant differences at the 0.01 level.

The spicebush seed lot used in this study displayed an intermediate physiological endogenous type of dormancy (3) that only required chilling stratification. The negative effect of warm stratification appears to be due in part to the induction of secondary dormancy that requires a longer chilling stratification period for dormancy release (Table 1). Additionally, some seed contamination due to exposure to warm temperatures and moist conditions may be reducing overall viability in the warm stratified seeds.

In terms of seedling establishment, a survival rate of 84.7 percent (188 of 222) was achieved for seeds potted immediately following germination. The combination of high germination percentages and seedling establishment indicate the ability of spicebush to be grown commercially for the landscape industry.

A second germination study is currently underway using a Pennsylvania seed lot to further determine the chilling stratification requirement of spicebush, as well as, any geographical differences in dormancy release treatments that may require the combination or warm and chilling stratification.

Significance to Industry

Seed dormancy in spicebush was alleviated after 12 weeks of chilling stratification. Some references suggest the need for a warm stratification treatment prior to chilling stratification. However, warm stratification was not necessary in this Kentucky seed lot and had a negative effect on dormancy release. Seedlings established easily from germinated seeds indicating that spicebush could be propagated by seed with only a chilling stratification treatment

Literature Cited

1. Dirr, M.A. 1998. Manual of Woody Landscape Plants: Their Identification, Ornamental Characteristics, Culture, Propagation and Uses. 5th ed. Stipes Publishing Co., Champaign, Ill.
2. Dirr, M.A. and C.W. Heuser. 1987. The Reference Manual of Woody Plant Propagation: From Seed to Tissue Culture. Varsity Press, Athens, Ga.
3. Hartmann, H.T., D.E. Kester, F.T. Davies Jr., and R.L. Geneve. 2002. Hartmann and Kester's Plant Propagation: Principles and Practices. 7th ed. Prentice Hall, Upper Saddle River, N.J.
4. Young, J.A. and C.G. Young. 1992. Seeds of Woody Plants in North America. Dioscorides Press, Portland, Ore.

Ethylene and Seed Germination in Coneflower *(Echinacea)* Species

Laura Wood, Josh Klein, and Robert Geneve, Department of Horticulture

Nature of Work

Seeds of *Echinacea* vary in their degree of primary dormancy, but most seed lots appear to have some seeds showing endogenous physiological dormancy. Moist chilling stratification will break dormancy in *Echinacea* seeds (5, 6). In some cases, dormancy can be broken without moist chilling by ethylene treatments (4). Ethylene production does not appear to be required for germination, but it is produced in most seeds at the onset of germination (1). It is also clear that for some seeds, the ability to make ethylene is associated with dormancy.

In this study, the relationship between seed dormancy and ethylene was investigated using three *Echinacea* species (*E. angustifolia, E. tennesseensis*, and *E. simulata*). The specific objective was to see if treating seeds with ethylene (via ACC or ethephon) will substitute for chilling stratification to relieve dormancy, and whether this treatment effect will persist in dried seeds. Ethylene exposure could provide an alternative seed treatment to moist chilling for improved germination percentage in *Echinacea* seeds, while allowing them to be handled as dried seeds.

Seeds used in this study were obtained from the University of Kentucky Horticultural Research Farm or purchased from commercial seed companies. Seeds were stored at 5˚ or 10˚C until used. Initial studies determined germination percentages for untreated seeds and seeds stratified for 60 days at 5˚C.

For the loading experiments, 100 seeds for each species were treated in Petri dishes with 6 mL of water, 5mM ACC or 1 mM ethephon for seven days at 5˚C or one day at 25˚C. Following treatment, seeds were briefly washed to remove the surface ACC or ethephon and dried to approximately 8 percent moisture. In addition, untreated seeds were placed directly on water or a solution of 5 mM ACC or 1 mM ethephon for the duration of the experiment.

Seeds for all treatments were germinated in four replicate Petri dishes containing 6 mL water or test solution, two pieces of germination paper, and sealed with parafilm. Dishes were placed in a 25˚C incubator with 16 hours light. Seeds were assayed for germination (radicle protrusion) after 12 days.

Results and Discussion

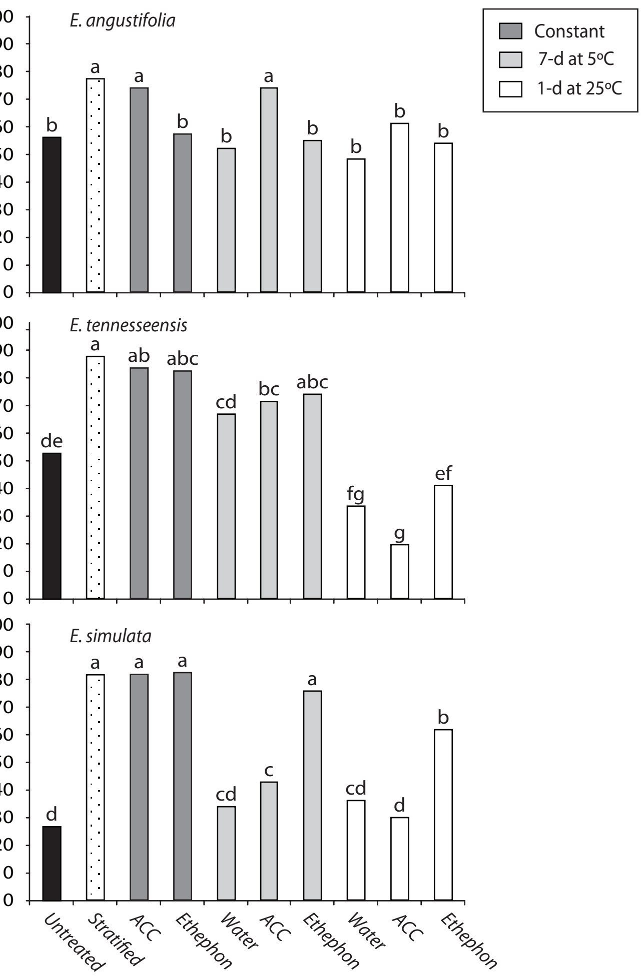
In untreated seeds, germination was between 26 and 56 percent for all three species (Figure 1). Stratification at 5˚C improved germination percentages in all species, with the most dramatic response in *E. simulata*, where germination increased threefold. Chilling stratification has consistently improved germination in *Echinacea* species showing dormancy (2, 3, 6). Constant exposure to ACC or ethephon improved final germination in all species compared to the control, with the exception of ethephon-treated *E. angustifolia* seeds. The efficacy for ethephon to enhance germination in *E. angustifolia* appears to depend on the seed lot being evaluated (3, 4).

The main objective of this study was to see if the promotive effect of ACC or ethephon could be retained following drying in *Echinacea* seeds. Pretreating seeds with ACC or ethephon for seven days at 5˚C was generally more effective than 24 hours at 25˚C for improving germination (Figure 1). For *E. tennesseensis* and *E. simulata* seeds, there was no significant difference between the seven-day ethephon-treated seeds compared to stratified or constant ACC or ethephon seeds. For *E. angustifolia*, there was also no significant difference between the seven-day ACC-treated and the stratified or constant ACC or ethephon seeds. These results demonstrate that dormancy release can be achieved using ACC or ethephon and the effect can be retained in dried seeds. However, additional evaluation of seeds following storage needs to be conducted before this can become a commercially viable pretreatment seed.

Significance to Industry

Seed germination can be erratic in some *Echinacea* species unless they receive chilling stratification to satisfy dormancy. Although stratification is effective, it requires additional grower input, and hydrated seeds can be difficult to sow mechanically. The industry could benefit from a seed pretreatment that would relieve dormancy yet be retained in seeds after subsequent drying. Since dormant *Echinacea* seeds have responded to ethylene releasing compounds for improved germination, it was hypothesized that loading seeds with ethylene precursors might provide a suitable pretreatment. In this study, seeds from three *Echinacea* species (*E. angustifolia, E. tennesseensis,* and *E. simulata*) were pretreated with ethephon or 1-aminocyclopropane-1-carboxylic acid (ACC) for seven days at 5˚C or one day at 25˚C prior to drying seeds back to their original moisture content. Germination was compared to seeds receiving 60 days of moist chilling stratification or seeds germinated in the constant presence of ethephon or ACC. Treating seeds for seven days at 5˚C was more effective than a one-day treatment at 25˚C. With this treatment, germination was improved in all species compared to untreated seeds and reached the level observed in stratified seeds using either ACC or ethephon, depending on the species. These results show that dormancy in *Echinacea* seeds can be satisfied by ethylene treatment and suggests that a commercial pretreatment could be developed to load seeds with an ethylene precursor for improved germination.

Figure 1. Germination in three *Echinacea* species following chilling stratification, constant exposure to ACC or ethephon, and seeds loaded with ACC or ethephon at two different temperatures.



Literature Cited

1. Matilla, A.J. 2000. Ethylene in seed formation and germination. Seed Sci. Res. 10:111- 126.
2. Feghahati, S.M.J. and R.N. Reese. 1994. Ethylene-, light-, and prechill-enhanced germination of *Echinacea angustifolia* seeds. J. Amer. Soc. Hort. Sci. 119 (4): 853-858.
3. Qu, L. W. Wang, E. Hood, and R. Scalzo. 2004. Ethephon promotes germination of *Echinacea angustifolia* and *E. pallida* in darkness. HortScience 39:1101-1103.
4. Sari, A.O., M.R. Morales, and J.E. Simon. 2001. Ethephon can overcome seed dormancy and improve seed germination in purple coneflower species *Echinacea angustifolia* and *E. pallida*. HortTechnology 11(2): 202-205.
5. Thompson, J. C., G. R. Bachman, and W. E. Davis. 2002. Enhancing germination of *Echinacea* species. SNA research conference 47: 361-364.
6. Wartidiningsih, N., R.L. Geneve, S.T. Kester. 1994. Osmotic priming or chilling stratification improves seed germination of purple coneflower. HortScience 29:1445-1448.

Summary of Water and Growing Media Test Results—1996-2005

Joe Ulrich and Robert Anderson, Department of Horticulture

Nature of Work

Many pieces of information are important for growers to have in order to make good decisions in greenhouse production. Water tests and growing media tests help provide important information. This report summarizes water and growing media test results submitted by ornamental and greenhouse growers in Kentucky over a period of 10 years from 1996-2005. The tests are conducted by the Regulatory Services Soil Testing Laboratory, University of Kentucky in Lexington. The water and growing media tests include results for pH, electrical conductivity (EC), nitrate nitrogen, phosphorus, potassium, calcium, and magnesium. The water test also includes the alkalinity of the water. Recently, boron and sodium have been added to both tests, but this is not included in this report. Test results are submitted to the floriculture Extension specialist for interpretation, and recommendations are sent to the county Extension agent and grower.

The water samples were collected from municipal water systems, wells, ponds, creeks, rivers, and cisterns. When 10 years of data is summarized, it is easy to determine that water quality varies in different regions of the state and that the source of the water greatly influences water quality.

The greenhouse media samples originate from commercial potting mixes, amended ground beds and non-amended ground beds as well as from sawdust, bark, worm castings, and animal manure. The growing media test may be used to measure the nutritional status of potting media before planting and used to monitor the nutritional status of potting media while plants are growing. This allows the grower to make changes to correct nutrient deficiencies or toxicities before problem symptoms occur. Most samples summarized here were submitted because of problems and not as a preventative measure, so this summary is a good review of common problems in commercial greenhouses in Kentucky.

The pH and alkalinity are commonly assumed to be similar; however, this is not true. Alkalinity is a measure of the bicarbonates and carbonates in the water while the pH is the measure of the concentration of hydrogen and/or hydroxides in the solution. The pH reading is important for knowing the quantity of specific nutrient uptake by the plants while alkalinity is examined for knowledge of how much effect the pH will have on the growing media or fertilizer solution.

The EC is a measure of the electrical conductivity of the water, measured in millisiemens per centimeter (ms/cm). The EC is a measure of total soluble salts, fertilizer or non-fertilizer, in either a water solution or growing media. Nitrate nitrogen, phosphorus, and potassium levels in water are used primarily as an indication of contamination from other fertilizers or manure. Greenhouse operators and fertilizer companies have vast experience with appropriate nutrient levels for optimum plant production, so the test gives growers appropriate information to compare to published optimum levels. Calcium and magnesium levels are important so growers will know if additional amounts should be added to fertilization programs or if their water supply has sufficient amounts of these nutrients.

A common problem diagnosed by growing media tests is excessive soluble salts. Generally, this occurs when too much fertilizer has been added in relation to the plant's needs. In some cases, the original organic material used to prepare the growing media, such as manure or worm castings, had high salt levels, particularly potassium. High soluble salt levels also occur when root function is impaired by disease or physical damage; this prevents uptake of nutrients and causes accumulation of the salts. The condition of the root system should be observed to see if this is the case.

It is also common for the growing media pH to drift too high or too low. High pH limits the ability of the plant to take up micronutrients, such as iron, boron, manganese, etc. Low pH causes the plant to accumulate micronutrients and cause toxicity problems.

Results and Discussion

Most water samples were collected from wells, ponds, and municipal water sources in the last 10 years (Table 1). The alkalinity showed a wide range of values from cisterns at the low end and wells at the high end. Average alkalinity was acceptable for greenhouse irrigation, but many samples, especially from wells near the Ohio River, had alkalinity levels too high for greenhouse use. The pH was high, above 7.0 in all cases with spring water being the highest. Levels of pH above 7.0 are only a major issue when alkalinity of the same sample is quite high; this occurred in many cases. Electrical conductivity was in the acceptable range for all sources across the state. Calcium concentrations were high enough in most municipal, spring water, well, and river water so growers would typically not need to add calcium to their fertilizer program. Cistern water, creek, and pond water were low in calcium, so growers using these water sources should add calcium to their fertilizer program. Magnesium concentrations were nearly adequate in well water, but most other water sources need to have additional magnesium added to the fertilizer program for optimal plant growth.

Water quality varies in different regions of Kentucky (Table 2). The Jackson Purchase region was low in all categories. The Bluegrass and Western Kentucky had higher EC, alkalinity and calcium than the other regions. In these regions, a grower could expect to have adequate calcium in their water source, but may have trouble with high alkalinity because the pH will increase during crop production. Growers may have to consider the use of acid injection or use of acidic fertilizers regularly to maintain appropriate pH levels. This is especially true if well water is being used in these regions (Figure 1). Magnesium is inadequate in all regions, so additional magnesium needs to be applied. The EC levels are good for all regions, with no problems expected.

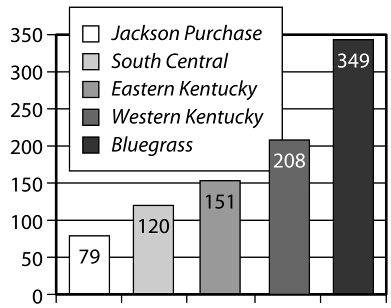
A summary of horticultural greenhouse media tests sent to the University of Kentucky's Regulatory Services from 1996-2005 are outlined in Table 3. These samples may not represent an average situation since samples are generally submitted when a nutritional problem occurs. However, this shows trends of problems that have occurred in the last few years. The parameters for each of the test values in the growing media based on low, acceptable, optimal, high, or very high are outlined in Table 4.

Commercial potting mix samples were the most common sample submitted compared to 25 years ago when homemade potting mixes were the dominate growing media. On average, the commercial mixes had optimum pH and EC values with slightly high nitrate, potassium, calcium and magnesium, and very high phosphorus. This highlights that most growers do a good job with their fertilizer program, but apply too much phosphorus because of use of balanced fertilizers, such as 20-10-20 and 20-20-20. The high phosphorus has been shown to be a main contributor to plant stretch in bedding plants. As a

Table 1. The average water quality of different water sources in Kentucky.

Water Source	Sample Number	Alkalinity (ppm)	pH	EC (ms/cm)	Ca (ppm)	Mg (ppm)
Cistern	3	38	7.4	0.74	9	1
Creek	3	82	7.3	0.32	30	14
Pond	34	109	7.2	0.34	37	12
Municipal	17	136	7.3	0.43	63	19
River	2	151	7.4	0.33	54	11
Spring	4	163	7.9	0.28	67	6
Well	43	205	7.3	0.73	59	22
Unknown	10	148	7.6	0.30	53	8
Total or Average	116	152	7.3	0.50	51	16
Desirable levels		<150	5.5-7.0	<0.75	>60	>25

Figure 1. Average alkalinity of water measured in wells in different regions of Kentucky.



result, fertilizer companies are now formulating more fertilizers with low phosphorus amounts.

Another type of peat-based sample submitted was the homemade mixes that had over 50 percent peat as the main component. These samples were high to very high in all nutrients except for nitrates, with the pH being optimum and the EC being slightly high.

Several samples were submitted from ground beds amended and not amended along with homemade mixes consisting primarily of soil. The modified saturated paste extract greenhouse test is designed for soil-less media, not mineral soil; therefore it is difficult to be confident in the results for these samples. The general trend is high pH, with optimum to high reading for each nutrient.

The rest of the samples involve different materials that can be convenient and cheap, but usually have issues with nutrient levels. These include worm castings, hardwood bark, pine bark, sawdust, manure, etc. Manure and worm castings (worm castings often start with manure) have an extremely high concentration of potassium, which would be a problem for plants unless major modifications are made. The general recommendation is to use a 3:1 ratio of potting mix to worm castings/manure to dilute the high potassium and high salt readings.

Growing media samples were usually submitted for soil tests because the grower was having problems (Table 5). Most problems occurred because fertilizer concentrations were too high or too low. This is revealed by seeing that about 50 percent to 60 percent of samples were either in the low or too high categories for each of the different nutrients as well as for the total dissolvable nutrients (EC). Growing media pH was optimal in about 50 percent of the problem samples.

Growing media test results were summarized based on the crops that were grown (Table 6). The results show that people fertilize correctly or too much for all crops except for the fruit trees samples, which were low in nitrates and magnesium. This becomes

Table 2. Evaluation of water samples submitted based on five geographic regions of Kentucky.

Region	Sample number	Region	pH	EC	Alkalinity	Ca	Mg
Jackson Purchase	4	1	6.4	0.28	79	8	3
Western KY	30	2	7.4	0.52	187	52	18
Bluegrass	49	3	7.3	0.62	162	65	20
South Central KY	24	4	7.4	0.33	109	36	7
Eastern KY	9	5	7.2	0.34	99	26	18
State Average	116	-	7.3	0.50	150	51	16
Desirable levels	-	-	5.5-7.0	<0.75	<150	>60	>25

Table 3. The average analysis of nutrients tested in growing media based on type of media.

Media	Sample number	pH	EC	Nitrate	P	K	Ca	Mg
Commercial potting mix	151	6.0	2.72	268	47	264	332	111
Soil-based homemade potting mix	16	6.9	1.88	211	3	94	296	55
Peat-based homemade potting mix	11	5.5	3.79	29	27	222	537	168
Ground Bed Amended	22	6.7	2.34	134	6	237	298	62
Ground Bed Not Amended	17	6.8	2.26	124	7	117	371	82
Hardwood Bark	5	6.2	0.26	4	3	53	21	7
Pine bark	1	5.2	2.78	39	11	221	113	82
Sawdust	2	3.8	0.31	16	0	7	92	5
Manure/Sawdust mix	5	6.9	5.60	197	24	1720	114	94
Worm Castings	6	5.8	5.46	269	58	1033	646	198

Table 4. The growing media test parameters.

	Low	Acceptable	Optimal	High	Very High
Water pH	0-5.2	5.3-5.6	5.7-6.8	6.9-7.2	>7.2
Soluble Salts	0-1.4	1.5-2.4	2.5-3.4	3.5-4.4	>4.5
Nitrate-N	0-49	50-109	110-174	175-224	>225
Phosphorus	0-3	4-7	8-13	14-19	>20
Potassium	0-69	70-174	175-249	250-324	>325
Calcium	0-59	60-119	120-219	220-299	>300
Magnesium	0-29	30-59	60-99	100-149	>150

Table 5. The number (percentage) of growing media tests from 1996 to 2005 that were in each nutritional status recommendation category.

	Low	Acceptable	Optimal	High	Too High
pH	40 (14%)	42 (14%)	140 (49%)	44 (15%)	21 (7%)
EC	108 (39%)	58 (21%)	26 (9%)	26 (9%)	59 (21%)
Nitrate Nitrogen	87 (31%)	54 (19%)	34 (12%)	17 (6%)	87 (31%)
Phosphorus	61 (22%)	38 (14%)	34 (12%)	36 (13%)	110 (40%)
Potassium	74 (26%)	78 (28%)	36 (13%)	20 (7%)	71 (25%)
Calcium	51 (18%)	55 (20%)	43 (15%)	29 (10%)	101 (36%)
Magnesium	72 (26%)	58 (21%)	55 (20%)	29 (10%)	65 (23%)

Table 6. The average analysis of nutrients tested in growing media based on crops being grown.

Crop	Sample number	pH	EC	Nitrate	P	K	Ca	Mg
Bedding Plants	38	6.3	3.15	214	50	309	348	126
Fruit trees	2	6.1	N/A	28	8	99	73	22
Garden Mums	15	6.6	2.27	348	28	269	277	77
Herbs	80	5.9	2.85	284	41	245	401	122
Ornamental	68	6.2	2.54	154	32	260	286	92
Poinsettia	14	6.1	1.43	106	15	156	87	62
Vegetable	29	6.6	2.51	142	8	133	382	83

more important as fertilizer costs increase. A reduction in fertilizer use will save money and could have other benefits such as improved plant quality and reduced disease and insect problems.

Significance to the Industry

This evaluation of growing media and water tests submitted to the University of Kentucky's Regulatory Services over the last 10 years will help growers see what results are common in the industry. This report helps growers see common growing media problems for different crops. The water test portion shows what water quality to expect from different areas of Kentucky and from different water sources. With this information, growers can better make production management decisions to improve their operations.

Evaluation of Greenhouse Ornamental Production Practices, Fall 2005-Summer 2006

Joe Ulrich, Department of Horticulture

Nature of Work

There are three main crops grown by greenhouse ornamental producers in Kentucky. These are bedding plants in the spring, garden mums in the summer, and poinsettias in the fall. The bedding plant and poinsettia crops are raised in greenhouses, and a majority of garden mums are grown outside on a ground cover fabric. Growers that raise garden mums in greenhouses typically do so in either an evaporative-cooled greenhouse or a naturally ventilated greenhouse. Bedding plants are the most profitable of the three crops. Many small growers only use their greenhouses in the spring for growing bedding plants and hanging baskets. Poinsettia has become a commodity with very little profit margin. The main reasons any growers continue to raise poinsettia is to keep employees year round and to provide cash flow. Garden mums are raised by both greenhouse businesses and farmers who have no greenhouse business. Garden mum growers are looking to raise bigger, better quality mums to help increase profit. The trend for growers is to provide added value to their poinsettia or mum crops by growing in a wider selection of containers.

The purpose of this evaluation is to help growers identify production issues that cause a reduction in sales due to poor quality or death of plants. The key areas that have been addressed are growing media testing, water quality testing, and insect scouting. Plants vary in optimum fertilizer and water needs, especially with the wide variety of bedding plants grown in the spring.

This evaluation provides a summary of the data collected from 29 grower/cooperators from Central Kentucky. They are from the following counties: Barren, Bullitt, Casey, Edmonson, Estill, Fleming, Grant, Green, Hardin, Jefferson, Lewis, Lincoln, Montgomery, Pendleton, Pulaski, Rowan, Scott, Shelby, Spencer, and Taylor. The size of the growers' production spaces ranged from 2,000 square feet up to about two acres. Growers were visited one to five times per growing season, with collection of various data occurring at each visit.

The primary data collected were growing media pH and electrical conductivity (EC) by using pour-thru growing media tests. Secondarily, water quality measurements of pH, EC, and alkalinity were collected. Insect populations were monitored using yellow sticky cards. Greenhouse temperatures were recorded using a sensor that recorded the temperature every 30 minutes during the growing season. The fertigation EC was collected as necessary to determine if the proper amount of fertilizer was being applied to the crop.

Results and Discussion

A big issue every spring is yellowing of new growth in many bedding plants, especially petunia and calibrachoa. Water quality tests and growin
g media tests collected at greenhouse sites were both a factor in diagnosis of this condition. First we looked at water quality. Most growers in Central Kentucky use water with high pH and moderate levels of alkalinity (Table 1).

Alkalinity is a measure of the water's ability to neutralize acids. Alkalinity is measured in parts per million bicarbonate. Perhaps alkalinity can best be understood as liquid lime. The moderate levels of alkalinity caused, in many of these cases, the yellowing of the new growth, which is normally symptomatic of iron deficiency. This happened when the growing media pH was raised partially because of water pH and alkalinity levels being too high. The answer provided to the growers was to use fertilizer as a tool to manage the high water pH and alkalinity. Switching to a more acidic fertilizer such as 21-7-7 (acidity rating of 1700) from a typical 20-10-20 (acidity rating of 422) fertilizer accomplished a release of a much greater amount of acidity into the growing media. The final result was a lowering of the media pH to the 5.4 to 6.0 range that petunia and calibrachoa desire.

Another factor in the yellowing of the new growth is the amount of fertilization. The use of acidic fertilizers such as 20-10-20 or 20-20-20 by many growers causes an increase in the amount of acidity in the growing media. Increased fertilizer concentrations and increased number of fertilizer applications will increase this level of acidity added to growing media and will both reduce the pH and help remove the yellow symptoms

Table 1. Evaluation of water used for irrigation purposes.

Water Source	Number of Growers	pH	EC (mS/cm)	Alkalinity (ppm)
Municipal Water	26	7.6	0.44	114
Pond Water	1	7.7	0.31	155
Spring Water	1	7.2	0.11	35
Well Water	1	8.2	1.68	325

in the newest plant growth (Table 2).

Poinsettia growers started with a lower pH in the growing media and higher EC readings compared to later readings. Once the crop reached a desirable size, the growers reduced fertilization. The EC readings proceeded to decrease and the growing media pH levels increased.

Bedding plant growers had a similar, typical fertilization pattern. The growing media pH started higher with a slightly low EC reading. The grower then began to apply fertilizer once roots were developed, causing growing media pH to drop and EC readings to rise. The fertilization then was reduced once desired plant size is achieved and growing media pH starts to rise as EC readings drop.

Garden mum growers had the opposite result occur, with lower growing media pH values and higher EC values from fertilization at the end of crop production. This was a result of increasing fertilizer rates during July and August. Several growers had high pH problems which resulted in yellowing of the mums. The recommendation was to double the fertilizer rate and apply more frequently. The result was that the growing media pH started to drop as the EC levels starting rising. The mums started growing and returned to a normal green color. Another benefit was the growers were able to get larger mums, which typically bring higher prices.

Insects can be a big problem for growers especially in poinsettia crops. The No. 1 insect found on yellow sticky cards in poinsettia crops were whiteflies (Table 3). The numbers in Table 3 are estimates in some cases because of the high number of insects on the cards.

Whitefly control is very difficult unless proactive measures such as sanitation, scouting, and early treatments are taken. Yellow sticky cards are one tool to use in scouting, but eggs, larvae, pupae, and adults on the plants themselves also should be counted. Once whiteflies get out of control, it is very difficult to regain control and finish a good quality crop of poinsettia plants. One important note is that rotation of chemicals is very important for preventing insect resistance to effective chemical controls. Always rotate between different modes of action classes of chemicals to reduce speed of insect resistance.

Table 2. A summary of soil test results for growing media used to grow poinsettia, bedding plants and garden mums.

Ornamental Crop	Month/Year	Growing media pH	Growing media EC (mS/cm)
Poinsettia	August 2005	6.2	3.82
	September 2005	6.2	3.27
	October 2005	6.4	2.14
	November 2005	6.5	2.64
Bedding plants	February 2006	6.5	2.14
	March 2006	6.1	2.37
	April 2006	6.1	2.04
	May 2006	6.3	1.69
Garden Mum	June 2006	6.8	0.61
	July 2006	6.4	1.83
	August 2006	6.0	3.94

Table 3. Poinsettia sticky card insect count estimates per card (approximate number of insects on one side of sticky card)

Month	Whiteflies	Fungus gnats + Shore flies	Thrips	Winged Aphids
September	4	17	3	5
October	116	28	14	0
November	392	33	6	3

Significance to Industry

The greenhouse business is one being considered by both those with and without farm backgrounds. This information will help identify some of the key issues in production of the three main greenhouse ornamental crops in Kentucky. Monitoring the growing media for pH and EC, checking water quality, and insect scouting are important tools growers can use to be successful. Also by working with growers on an individual basis, these principles and techniques are repeated several times, so growers can apply this information in future crops.

Acknowledgments

The author would like to thank the greenhouse operators involved in this project for their help and information.

Red Maple Production in Three-Container Systems

Ross Hunter, Dava Hayden, Winston Dunwell, and Dwight Wolfe, Department of Horticulture

Nature of Work

Managing optimal fertility levels in container production systems with controlled-release fertilizers requires a thorough understanding of their release characteristics. Fertilizer release rates in container production systems are affected by the method of application, the rate of application, and the application technique (1, 2, 3). Growth and development of container-grown plants are influenced by the design and composition of containers, which correlated to extremes and fluctuations in substrate temperature (1, 2). Substrate temperature fluctuations and extremes are moderated in the pot-in-pot system compared to above-ground containers and the ambient air temperature. This effect appears to be independent of moisture levels (3). The objective of this work is to determine the effect of fertilizer release rates in pot-in-pot, above-ground pot, and Smart Pot® above- ground fabric container systems on the growth and caliper of *Acer rubrum* Sun Valley.

Twenty *Acer rubrum* Sun Valley, averaging 4.5 feet tall with a caliper of 10.34 mm, were transplanted June 1, 2006 into each of three container types: pot-in-pot, above-ground pots, and Smart Pots.® All containers had a 15-gallon capacity. The beginning caliper was not significantly different between treatments. The trees were planted into a substrate consisting of 50 percent pine bark, 30 percent peat, and 20 percent sand by volume. A mark was placed at the top of the root flare to denote a uniform planting depth, and a second mark was placed 6 inches above that to denote where caliper measurements were made on June 1 and November 1. Cotton bags (3 inches by 5 inches) were filled with 20 grams of Harrell's® 17-5-12 slow-release fertilizer. Ten bags were placed in each container totaling 200 grams (amount recommended by Harrell's) per container. Bags were placed evenly around and 1 cm below the surface in each container. Irrigation was through 360-degree emitters controlled by a Smart Clock® controller. Irrigation was set for 15 minutes starting at 6 a.m., and again for 15 minutes beginning at 6 p.m., Monday, Wednesday, and Friday, resulting in a 15 percent leachate. Soil temperature probes were placed at a 15-cm depth in one container per treatment, and data were collected and recorded six times daily, via a Watchdog 800® station. Leachate tests were performed on August 5 and October 15 using the Virginia Tech Extraction method and electrical conductivity (EC) and pH were recorded. At this time, one fertilizer bag was removed from each pot in a treatment and combined with one fertilizer bag from each of the other pots in that treatment. The combined samples (prills) were cleaned and sent to F. Sikora at the UK Soil Testing Laboratory for analysis.

Results and Discussion

EC remained high (mean of 2.69) and uniform throughout the study. There was a significant drop in pH between July (6.20) and August (6.05) but no additional decrease in September. Leachate pH between container types was lower for the pot-in-pot system (6.05) compared to the Smart Pot® (6.19) and above-ground pot (6.05). Leachate pH in the above-ground containers (6.09) was not significantly different from the Smart Pot.®

Final caliper was greater in the pot-in-pot system (22.44 mm) compared to the above-ground containers (20.53 mm) and the mean caliper of plants in the Smart Pot® (20.82 mm) was intermediate to the other systems.

The cotton bags that were used to hold the fertilizer treatments for retrieval did not hold up for the duration of the study. A loose woven synthetic material would probably be more appropriate.

Significance to the Industry

The pot-in-pot system had greater caliper growth than the above-ground containers. Future studies will look at fertilizer application rate and release rate in the different systems and their influence on growth and caliper of *Acer rubrum*.

Acknowledgments

Special thanks to Chuck Wahl and his staff at Wahl's Nursery and Landscaping for their cooperation and assistance; Root Control Inc. for donating the Smart Pots®; and Amy Fulcher for her input and assistance.

Literature Cited

1. Greene, V., Appleton, E.; et.al. (2001). Reducing Root Zone Temperatures of Container-Grown Plants. SNA proceedings vol. 46,108-111.
2. Highland, A., Bilderback, T., (1994). Substrate Temperatures in Above and Below-Ground Containers in a Pot-in-Pot System. SNA proceedings vol. 39, 113-115.
3. Zhu, H., Zondag, R., et.al. Ohio State University, Ornamental Plants Annual Reports and Research Reviews 2004, vol.195, 22.

Biology and Seasonal Phenology of the Maple Shoot Borer, Proteoteras aesculana *(Lepidoptera: Tortricidae)*

Bonny Miller Seagraves, Daniel A. Potter, Kenneth Haynes, Dava Hayden, Amy Fulcher, John Hartman, and Robert McNiel,
Departments of Entomology, Horticulture, and Plant Pathology

Nature of Work

In 2004 we identified a shoot borer that is damaging maples in Kentucky production nurseries as the caterpillar of *Proteoterus aesculana*, a tortricid moth. This pest causes flagging of new shoots and often a double leader. Training a new central leader is time-consuming, and despite those corrective measures, the trunk often incurs a noticeable crook that diminishes tree value. Little is known about the biology and management of this pest.

To determine if the *P. aesculana*, the maple shoot borer (MSB), was ovipositing on or in shoots prior to shipment of liners from West Coast nurseries or alternatively, was infesting the liners soon after they were planted in Kentucky nurseries, four sets of study blocks were established at the University of Kentucky Horticultural Research Farm. Four West Coast nurseries each donated 100 bare root nursery liners. The first three nurseries donated 50 each of *Acer rubrum* 'October Glory' and *A. rubrum* 'Brandywine.' The third nursery donated 50 each of *A. rubrum* 'October Glory' and *A. rubrum* 'Red Sunset.'

For each set of plots, half of the trees from one shipment (25 trees of each cultivar, 50 total trees) were planted by hand in a 3.7-by-3.7-by-2.4 m (12-by-12-by-8-foot) block and covered with a field cage of the same size. The other half of the shipment (50 trees) was planted in an adjacent plot of the same size but was left uncovered.

Trees were planted about 0.5 m apart within plots. One set (two blocks—one covered, one open) of plots was planted for each donating nursery to test the hypothesis that nursery liners are infested during the preceding summer (in Oregon) before they are shipped to Kentucky growers. We expected if that were true, MSB incidence would be similar for both caged and open trees.

Planting occurred as trees arrived; planting dates were March 23, April 6, April 14, and April 19, 2006 for nurseries A, B, C, and D, respectively. Paint markings on the trunks of trees enabled later identification of cultivars. Incidence of flagged shoots was counted and recorded on May 23, 2006 after symptoms became apparent.

The MSB sex pheromone was investigated using gas chromatography-mass spectroscopy (GC-MS) and GC-electroantennogram (GC-EAD) techniques. The female moth's sex pheromone gland was removed and its contents were evaporated and puffed over the male moth's antenna. The neural responses produced by the antenna indicate specific components in the sex pheromone that are stimulatory to the male.

Using the two components that produced responses by the male antenna, sex attractant lures were made with four blends of these components, hung in sticky traps, and traps were placed in blocks of maples at Snow Hill Nursery and monitored weekly for the presence of MSB moths to determine which lure was most attractive.

In the 2006 growing season two concentrations of the most effective lure in 2005, Z8-12:OH, were placed in sticky traps that were hung in four Kentucky nurseries. These were hung in early March and monitored each week, with lures replaced every two weeks. Traps are still in the field, and small numbers of moths are still being captured at the time of this writing (mid-Oct. 2006).

Results and Discussion

No infested shoots were present in the four caged blocks of trees, whereas infested shoots were found on trees planted in all open blocks (Table 1). That indicates that the nursery liners were *not* already infested by MSB before being shipped from Oregon, but rather became infested soon after planting in Kentucky. Earlier planting dates, in general, had fewer infested shoots. Brandywine had a few more infested shoots than did October Glory, but in the one study block that had Red Sunset in place of Brandywine, 18 of the 22 infested shoots were on Red Sunset.

Electrophysiological response of the male antenna to female pheromone gland extracts identified Z8-12:OH and Z8-12:AC as major components of the MSB sex pheromone. Of the several blends of those compounds tested, the most effective for trapping male *P. aesculana* moths in nurseries was pure Z8-12:OH (Table 2). Blends in which Z8-12:OH was the primary component were also attractive (Table 2).

Table 1. Number of shoots on May 23, 2006 infested by *Proteoteras aesculana* in caged and uncaged blocks of red maple cultivars shipped from West Coast nurseries to Lexington, Ky.

	No. of infested shoots	
Nursery	**Caged blocks**	**Uncaged blocks**
Holmlund	0	5
Schmidts	0	9
Femrite	0	22
Robinson	0	13

Table 2. Number of *Proteoteras aesculana* caught in pheromone traps baited with four pheromone blends in 2005 and 2006[a].

Pheromone blend	**No. of *P. aesculana* trapped**
2005 (June 14-28)	
Z8-12:OH 50 µg	5
Z8-12:OH 50 µg + Z8-12:Ac 2 µg	2
Z8-12:OH 50 µg + Z8-12:Ac 10 µg	0
Z8-12:OH 50 µg + Z8-12:Ac 50 µg	0
2006 (April 13-29)	
Z8-12:OH 250µg	5
Z8-12:OH 250µg + Z8-12:Ac 10µg	4
Z8-12:OH 250µg + Z8-12:Ac 50µg	0
Z8-12:OH 250µg + Z8-12:Ac 250µg	0

[a] Based on four traps operated with each blend at Snow Hill Nursery, Shelbyville, Ky., in 2005, and four traps with each blend operated at Snow Hill Nursery and at Hillcrest Nursery, Richmond, Ky., in 2006.

Both concentrations of Z8-12:OH attracted male MSB moths in nurseries throughout the growing season, though typically lure B (the high concentration) traps had more moths than lure A (Figure 1). The first moths were captured on March 9 at Hillcrest Nursery. Flight activity peaked at the end of the first week in April at all four sites, and moths continued to be captured through April. Flight activity declined dramatically or ceased at all trapping sites during May.

A second flight of moths occurred at all study sites from mid-June into July (Figure 1), very likely the emerged adults of the first generation of shoot borers that damages maple trees in the spring. That second pulse of moth flight was not, however, followed by additional shoot damage to the maple liners, suggesting that those moths lay their eggs elsewhere. No pupae or empty pupal "skins" were found inside of damaged shoots in the field, or in flagged shoots that were harvested while the borer was still present and stuck into moist sand for emergence of adult moths in the lab. Many pupae were found in the sand, however, indicating that the borer vacates the flagged shoot before pupating.

The second flight pulse ended in July, and no moths were caught through August or September. At the time of this writing (October 2006), small numbers of MSB moths are again being captured. While three periods of adult activity were apparent in 2006 (Figure 1), only the first (March and April) flight is followed by shoot borers in young growing tips of nursery-grown maples. At this point it is unknown where the offspring of the second and third flights develop. If MSB overwinters as an adult, then moths being captured in October may be the same brood that flies in March/April and lays eggs that become the MSB larvae that damage newly-transplanted maples in the spring. It also is possible that the pest overwinters as a pupa, with adults emerging beginning in March. Our observations on MSB biology, and trap data showing moth flight beginning in March, are not consistent with speculation in the literature (1) that MSB hibernates as a partially-grown larva in buds.

Significance to the Industry

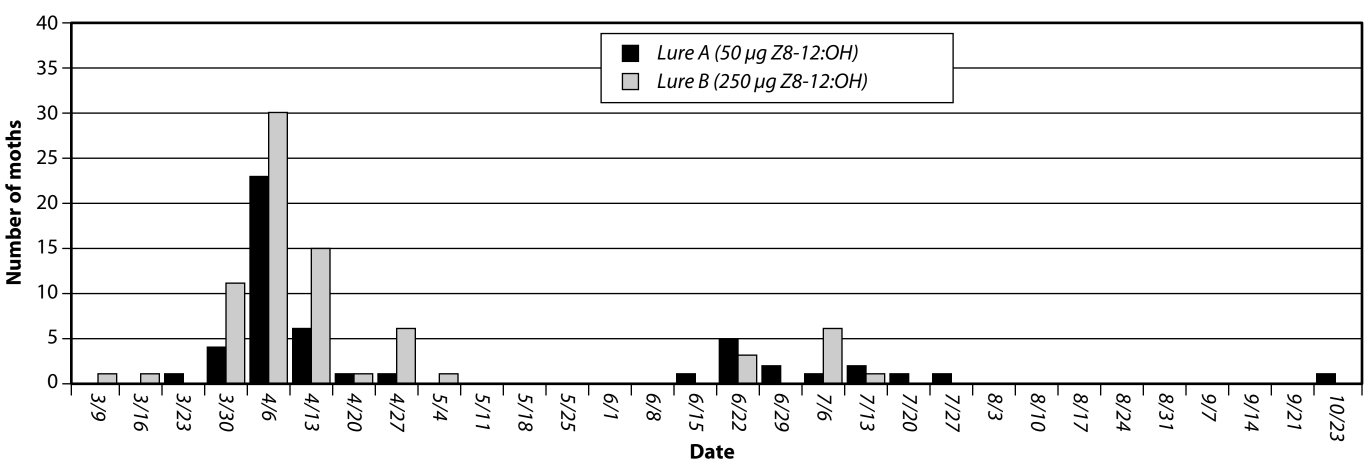
This research showed that maple nursery liners are infested with maple shoot borer soon after they are planted in Kentucky; i.e., the borers are not already in the trees when they are shipped. It indicates that the borers that damage elongating maple shoots in Kentucky in spring originate from eggs laid by moths that emerge and fly in March and April, much earlier in the growing season than was previously recognized. The pest almost certainly is not overwintering as a partially-grown larva in excavated buds, as has been suggested in the literature.

This work suggests that treating trees soon after the moths become active and begin laying eggs will intercept the newly hatched borer larvae before they tunnel into elongating central leaders and other shoots. A sex attractant lure was developed that, when used in cardboard sticky traps, will enable growers to monitor moth activity in the spring for that purpose. Such traps may be hung in blocks of maples in late February and monitored weekly to track activity of the moths. Once the optimum treatment timing is determined, this will enable growers to precisely time preventive treatments. The lure may also have value for detecting and assessing the relative infestation levels of MSB in different blocks of trees. We hope to further test the lure in combination with different treatment timings in 2007. We also will begin discussions with one or more companies that market pheromone lures about getting this blend into commercial production. Targeted preventive control may help growers to reduce the number of sprays that they currently apply for maple shoot borer and get better results from their efforts. It will also reduce time and labor required to correct trees with dead central leaders due to maple shoot borer infestation.

Literature Cited

1. Hale, F.A. and M. Halcomb. 1994. Shootboring caterpillars, *Proteoteras* spp. (Lepidoptera: Tortricidae): major pests of red maple in Tennessee Nurseries. S. Nurs. Assoc. Res. Conf. 39: 178-179.

Figure 1. Pheromone trap catches of *Proteoteras aesculana* at Hillcrest Nursery, Richmond, KY, 2006.



Managing Flatheaded Apple Tree Borer in Nursery-Grown Maples

Daniel A. Potter, Bonny Miller Seagraves, Carl Redmond, Amy Fulcher, Dava Hayden, and Robert McNiel, Departments of Entomology and Horticulture

Nature of Work

The flatheaded apple tree borer (FHATB), *Chrysobothris femorata* Olivier, is the most destructive insect pest of nursery-grown maples in Kentucky and neighboring states. FHATB has one generation per year. The adult beetles emerge in May and June, and mate and lay eggs on the bark of maples, crabapples, hawthorns, and other species, especially stressed or newly-planted trees. The larva feeds and tunnels in the cambium, phloem, and outer sapwood, weakening, disfiguring, and often girdling the tree. Infestation sites are marked by a swollen canker with cracked bark and packed frass, usually < 1 ft above ground and often with a D-shaped hole where the adult beetle has emerged. Infestation by a single borer renders a tree unmarketable. The borer overwinters as a full-sized larva, pupating in spring (1). If not treated, 30 percent or more of the maple nursery liners planted in Kentucky can be destroyed by FHATB during the first growing season (B. Wearren, *per. comm.*).

Previously, FHATB was controlled using pre-oviposition trunk sprays of lindane or chlorpyrifos (Dursban®) which intercepted the newly hatched larvae as they chewed their way into the bark. Now that those products have been cancelled or severely restricted, growers are dependent on pyrethroids such as bifenthrin or permethrin (Onyx, Talstar, Astro; FMC) for borer control. Pyrethroids may not provide the same level or duration of protection as the older products, so effective alternatives are needed. This research evaluated maple species and cultivars for relative resistance to FHATB, as well as alternative insecticidal options for preventive control.

Cultivar Resistance Study. Cultivar resistance maple plots were planted in spring 2005 at three sites: the University of Kentucky Horticultural Research Farm (Lexington), Snow Hill Nursery (Shelbyville), and the University of Kentucky Research and Extension Center (Princeton). The trees were planted on 1.8 m (6 ft) centers and the rows were 3.05 m (10 feet) wide. Aisles were either mowed grass or cultivated, and weeds between trees were controlled using glyphosate (Roundup, Monsanto, St. Louis, Missouri) or with a string trimmer as necessary. There was no supplemental irrigation except one watering by drip irrigation in Lexington in late summer 2005.

Cultivars evaluated in the study are listed in Table 1. Trees were donated by three wholesale nurseries (J. F. Schmidt & Son and John Holmlund Nursery, both of Boring, Oregon; and Robinson Nursery, Amity, Oregon) and were representative of trees purchased by Kentucky growers for production nurseries. Planting dates were March 23 to April 4 for Lexington, April 5 for Princeton, and April 21 for Shelbyville. The trees were planted in a randomized complete block with 10 replicates of 17 cultivars at each site. They were examined for the presence of FHATB infestation (canker in the trunk with cracked bark and packed frass) in summer 2006 after symptoms of attacks initiated in the first growing season were fully expressed. Presence of D-shaped exit holes and height and direction of exit hole (or canker if no exit hole was visible) were also recorded.

Insecticide Trial 1. Imidacloprid (Discus®) and thiamethoxam (Flagship®) were evaluated via soil-applied treatment for systemic control of FHATB in red maples. On March 23, 2005, 96 red maple liners, var. 'October Glory' and 'Red Sunset' (48 trees of each cultivar, about 2 to 2.5 cm diameter) were planted at the UK Horticultural Farm as described above. Blocks of three trees in a row were treated on April 14, 2005 with either Discus®, Flagship®, or left untreated, using a randomized complete block with 16, three-tree replicates per cultivar. The insecticides were applied at the high label rate with 1 liter of water per tree, using a sprinkling can to treat 4.5 sq ft of soil around the base of each tree. To ensure consistent application, a cardboard frame was placed on the ground in the area to be treated. Trees were evaluated in March 2006 for flatheaded apple tree borer symptoms as described earlier.

Insecticide Trial 2. In May 2006, maple tree liners (var. 'October Glory' about 2 to 2.5 cm diameter) were flagged at two central Kentucky nurseries: Waterford Valley Nursery, Taylorsville (198 total trees), and Valley Hill Nursery, Springfield (102 total trees), for a total of 10 blocks of five trees each. Insecticides that were evaluated had been targeted by the USDA-IR4 program as potential alternatives for borer control and were applied according to manufacturers' instructions insofar as rate and mode of application. The six treatments were: 1) clothianidin (Celero® 16WSG) using 20 g per inch dbh applied as a drench; 2) DPX-E2Y45 at 1 qt/100 gal., applied as a trunk spray; 3) bifenthrin (Onyx®) applied at 12.8 oz/100 gal. as a trunk spray; 4) dinotefuron (Safari®) applied at label rate as a drench, 5) NEI25925 applied at 4 ml/in. dbh (with a bark penetrant) as a trunk spray, plus 6) untreated control. There were 50 total trees per treatment. The soil systemic insecticides were applied in 2 liters of water per tree, using a sprinkling can to apply that volume to 4.5 sq ft of soil around the base of each tree. For sprays, the lower trunk was wetted from ground level to 1 m height (about 50 ml per tree). Treatments were applied on May 9, one week before predicted first emergence of FHATB based on degree-day accumulations (742 Fahrenheit DD calculated at base 50° F from January 1 (1). The Celero 16WSG application was delayed until May 17, due to delay in shipping of the product. Trees were evaluated for incidence for flatheaded apple tree borer damage (swollen cankers) on October 20.

Results and Discussion

Cultivar Resistance Study. None of the trees at the Shelbyville site were infested with FHATB so data are presented only for the Lexington and Princeton sites, for which counts were pooled within cultivar (Table 1). Of the red maples, Burgundy Belle had the highest rate of infestation (37.5 percent). Six of the eight red maple cultivars had ≥ 15 percent of the trees infested and Autumn Flame was the only red maple cultivar that had no borers. Borers infested some trees of all species and cultivars except Legacy sugar maple, Autumn Blaze Freeman maple, and *A. campestre*. Overall infestation rates were 24/147, 8/72, 3/60, 2/19, and 0/20 for red, sugar, Freeman, *A. truncatum*, and *A. campestre* maples, respectively. The overall proportion of infested trees was higher for red maples than for Freeman maples or *A. campestre*, but not significantly different between other pairs of species.

Of the 37 infested trees, the numbers having one, two, three, or four exit holes were 29, 5, 2, and 1, respectively. FHATB cankers and exit holes were found facing all cardinal directions, but the fewest were on the north and northeast sides of trees, and the most were on the southwest side. More than 50 percent of infestations were ≤ 10 cm (4 inches) above ground level, and no infestation was found more than 40 cm (16 inches) above ground.

Insecticide Trial 1. The infestation rate in control trees was > 60 percent in 2005 (Table 2). Trees that are stressed are more attractive to FHATB (1) so the hot dry 2005 summer likely contributed to borer attacks in this trial. Although Discus significantly reduced the overall proportion of infested trees, the level of control obtained would not be acceptable in nursery production, nor was it comparable to the > 95 percent control previously obtained with lindane or chlorpyrifos bark sprays (1).

Insecticide Trial 2. Only three of the 300 total trees at the two study sites showed symptoms of FHATB attack, so no conclusions can be drawn regarding efficacy of the treatments. Two of those borers were in untreated trees; the other was in a tree that received DPX-E2Y45. The 2006 growing season was relatively cool and had record rainfall so absence of tree stress, as occurs in more typical Kentucky summers, may have contributed to the low incidence of borers.

Significance to the Industry

Our cultivar evaluations suggest that as a group, red and sugar maples are susceptible to FHATB. Some attacks also occurred on Freeman maples and *A. truncatum*, but hedge maple, *A. compestre*, appears to be resistant. Autumn Flame red maple, Legacy sugar maple, and Autumn Blaze Freeman maple were notable in having no borer attacks and further study is warranted to determine if they are consistently resistant in production nurseries, and across other cropping cycles. It is uncertain to what extent the observed differences in FHATB infestation reflect genetically based variation in resistance characteristics (e.g., secondary chemicals), as opposed to the different cultivars' reactions to transplant stress interacting with opportunistic borers.

Our 2005 insecticide trial failed to support efficacy of the soil-applied systemic insecticides imidacloprid or thamethoxam as substitutes for protective bark sprays. It does reinforce the destructive potential of FHATB, which infested about 50 percent of the trees at our study sites. Our 2006 trial, conducted under less stressful environmental conditions, was inconclusive because of low incidence of borers.

Table 1. Incidence of flatheaded apple tree borer infestation in 17 species and cultivars of maple liners at the Princeton and Lexington study sites during the first (2005) growing season, evaluated in summer 2006.

	Number of			
Specie and cultivar	**Trees[1]**	**Infested trees**	**Exit holes**	**% infested**
Red maples				
Northwood	16	3	2	18.6
Red Sunset	19	3	1	15.8
Burgundy Belle	16	6	8	37.5
Sun Valley	20	3	1	15.0
Brandywine	20	2	0	10.0
Somerset	20	3	3	15.0
October Glory	20	4	4	20.0
Autumn Flame	16	0	0	0.0
Sugar maples				
Crescendo	17	2	1	11.8
Green Mountain	20	4	2	20.0
Commemoration	17	2	5	11.8
Legacy	18	0	0	0.0
Freeman maples				
Autumn Blaze	20	0	0	0.0
Autumn Fantasy	20	2	3	10.0
Sienna Glen	20	1	0	5.0
A. truncatum	19	2	2	10.5
A. campestre	20	0	0	0.0

[1] Out of 20 original trees. Missing trees failed to establish or died from causes other than FHATB.

Table 2. Incidence of flatheaded apple tree borer infestation in two cultivars of red maples planted at the University of Kentucky Horticultural Farm and treated with systemic soil insecticides in 2005.

	No. infested trees per cultivar			
Treatment	**October Glory**	**Red Sunset**	**Total infested**	**% infested**
Discus	9/16	2/16	11/32*	34.3
Flagship	10/16	6/16	16/32	50.0
Untreated	14/16	6/16	20/32	62.5

* Proportion of trees infested is significantly lower for Discus than untreated ($\chi 2 = 5.07$, 1 df, $P = 0.02$) but does not differ between Flagship and untreated ($\chi 2 = 1.02$, 1 df, $P = 0.31$).

Literature Cited

1. Potter, D. A., G. M. Timmons, and F. C. Gordon. 1988. Flatheaded apple tree borer (Coleoptera: Buprestidae) in nursery-grown red maples: Phenology of emergence, treatment timing, and response to stressed trees. J. Environ. Hort. 6: 18-22.

Influence of Tangle-Trap® Applications on Infestation of Flatheaded Apple Tree Borer, *Chrysobothris femorata* Olivier

Amy Fulcher and Shauna Switzer, Department of Horticulture

Nature of Work

Maples are important nursery crops in Kentucky and across much of the United States. Maples represent $817,000 in sales (one quarter) of the deciduous shade trees sold by Kentucky producers according to the 1998 USDA Census of Horticulture [5]. While most maple cultivars have many positive attributes (attractive fall color, fast growth rate, adaptable root systems, relatively free of foliar diseases) that make them popular in retail trade and with nursery growers, they also have several insect pests that can be destructive (3,4). Since 2002, severe losses due to greater than 40 percent infestation of flatheaded apple tree borer, *Chrysobothris femorata* Olivier, (FHAB) have occurred on maples in some Kentucky nurseries (personal observation). A range of flatheaded apple tree borer resistance has been documented among various maple taxa, however, some of the more popular maples cultivars are susceptible (2).

Approximate maple liner cost is between $15 and $25 each, and field preparation and first year maintenance is costly. Therefore, Kentucky nursery growers must have effective products to control FHAB, especially when growing susceptible cultivars. With changing pesticide regulations, the development of an FHAB treatment with minimal environmental impacts would assist growers in controlling this destructive pest. A non-toxic, sticky substance that would physically trap or repel females and thus prevent oviposition would be a sustainable mechanism of controlling FHAB in nurseries. The objective of this study was to conduct a preliminary evaluation of FHAB control with a tacky substance applied to the bark of susceptible trees.

On March 29, 2005, nine maple taxa (*Acer* x *freemanii* Autumn Fantasy™; *Acer rubrum* 'Autumn Flame,' Red Sunset®, 'Somerset,' and 'Sun Valley;' *Acer saccharum* 'Commemoration,' Crescendo™, and 'Legacy;' and *Acer truncatum* Pacific Sunset™ were potted into 15- and 25-trade-gallon containers (Nursery Supplies Inc., McMinnville, Oregon) with Barky Beaver Professional Grow Mix (Barky Beaver Mulch and Soil Mix Inc., Moss, Tennessee) and grown as described previously [1]. On May 8 and 9, 2006 Tangle-Trap® (The Tanglefoot Company, Grand Rapids, Michigan) was applied to the basal six inches of trunk on each tree. Tangle-Trap® is sold as an insect trap coating and is not labeled as a pesticide. Tangle-Trap® may or may not be a sustainable substance; it was chosen as a treatment to address the primary questions of feasibility and efficacy of an adhesive barrier/repellent for control of FHAB.

On May 8, July 3, and October 18, 2006, caliper readings were made at the same location on each trunk, denoted by a line made with an indelible black marker, 6 inches above the substrate surface. The experiment was a randomized incomplete block design with 48 treated trees and 47 control (untreated) trees. Caliper gain data were subjected to statistical analysis using the PROC TTEST procedure in SAS (SAS Institute, Cary, North Carolina) at a p value of 0.05 or less.

Results and Discussion

There were only three FHAB infestations among the 95 trees during the 2006 season. This low infestation percentage is in agreement with other research conducted in Kentucky in 2006 [2]. With such a low FHAB infestation rate, it is impossible to statistically determine the effectiveness of Tangle-Trap®. However, only untreated control trees were infested.

There was no significant difference in caliper gain between treated and untreated trees when analyzed for caliper gain between May and July 2006 or for growth occurring from May to October 2006. Therefore, the Tangle-Trap® treatment didn't inhibit caliper development.

Trees were still coated with Tangle-Trap® on October 18, 2006 when final caliper measurements were taken; however, the product was no longer tacky. The product was visible and, therefore, some consumer education would be necessary. The long term health effects of applying Tangle-Trap® to the trunk was not addressed in this study.

Significance to the Industry

FHAB is a significant pest in nursery production. This preliminary study examined the feasibility of protecting maple trees from FHAB by physical means. By exploring novel methods of controlling FHAB, nursery growers will have environmentally sound control for FHAB and reduce economic losses from this pest.

Acknowledgements

The authors acknowledge Rhonda van Dyke for assistance, Snow Hill Nursery for liners, and Harrell's Inc. for fertilizer.

Literature Cited

1. Fulcher, A. 2006. Caliper gain of nine maple taxa in 15- and 25-gallon pot-in-pot production systems. UK Nursery and Landscape Program 2006 Research Report. In press.
2. Potter, D., B. Miller, C. Redmond, A. Fulcher, D. Hayden, and R. McNiel. 2006. Managing flatheaded apple tree borer in nursery-grown maples. UK Nursery and Landscape Program 2006 Research Report. In press.
3. Potter, D., G. Timmons, and F. Gordon. 1988. Flatheaded apple tree borer (Coleoptera: Bruprestidae) in nursery-grown red maples: Phenology of emergence, timing and treatment. Journal of Environmental Horticulture. 6(1)18-22.
4. Seagraves, B., D. Potter, K. Haynes, D. Hayden, A. Fulcher, J. Hartman, and R. McNiel. 2005. New management approaches for insect pests of nursery grown maples. UK Nursery and Landscape Program 2005 Research Report. Pp. 19-20.
5. U.S. Department of Agriculture. 1998. 1998 Census of Horticulture. National Agricultural Statistics Service, U.S. Department of Agriculture, Washington, D.C.

Evaluation of Root Flare Injection Treatments to Manage Oak Bacterial Leaf Scorch—2006

John Hartman, Ed Dixon, and Tobias Fullwood, Department of Plant Pathology; Shawn Bernick, Rainbow Treecare Scientific Advancements, Minneapolis, Minnesota; Gale Moore, Stone Street Farm; Stacy Borden, Dave Leonard Consulting Arborist; and Larry Hanks, Pampered Properties

Nature of Work

Bacterial leaf scorch, caused by *Xylella fastidiosa*, affects many Kentucky landscape trees including oaks (pin, red, scarlet, shingle, and white), maples (red, silver, and sugar), planes (American sycamore and London), sweet gum, hackberry, elm and mulberry (1-5). Leaves of infected trees typically show marginal necrosis (scorch) late in the summer followed by premature defoliation. Infected trees re-foliate normally in spring and the process of late summer scorch and premature defoliation is repeated. The disease begins on one or a few branches and over several years gradually spreads throughout the tree. After many years, dead twigs, then dead branches and limbs begin to appear in the tree and the condition continues to worsen over the years until the tree needs to be removed. Bacterial leaf scorch is a very serious Kentucky plant disease.

The antibiotic, oxytetracycline, used for management of bacterial diseases in agricultural crops, is active against gram-negative bacteria such as *Xylella*. Cambistat® (paclobutrazol) is a plant growth regulator chemical which inhibits synthesis of the plant hormone gibberellin. Paclobutrazol is said to stimulate root development which could reduce bacterial leaf scorch symptoms. Pentra-Bark® is an adjuvant which promotes penetration of applied chemicals through the bark of treated trees to the vascular system. Phosphite-containing materials such as Agri-Fos® have been shown to have some antibacterial activity. The objective of this research is to determine if root flare-applied antibacterial chemicals or other treatments would have an effect on bacterial leaf scorch disease symptoms in pin oaks.

This research was conducted at Stone Street Farm in Lexington, a horse farm with a history of bacterial leaf scorch disease. Eighty mature pin oak trees with an average diameter of 22 inches (DBH) lining a long driveway and growing along the boundaries of the farm, were selected for this experiment. Treatments (Table 1) were made during June 2006. Antibiotics were injected using one of two methods: a macro-infusion technique and a micro-injection technique.

Macro-infusions were made 5 to 10 inches below the tops of root flares through 15/64- inch holes drilled into the basal flare roots which were exposed by removing soil around the base of the tree with an Air Knife®. Drilled holes, spaced about 6 inches apart on the root flares, were fitted with a series of plastic tees and harnessed to a hand pump to deliver the required suspension evenly all around the tree. Micro-injections were done with an M3 device which is a reusable, pressurize-able applicator capsule. Applications were made through 11/64-inch diameter holes drilled into major root flares at the base of the tree and spaced 6-8 inches apart around the tree. The Cambistat® basal drench was applied to the soil at the base of selected trees at label rates depending on tree size. The eight treatments were replicated 10 times and the experiment was established in a randomized complete block design.

Prior to treatment applications, on October 18, 2005 when symptoms were prominent, trees were evaluated for bacterial leaf scorch symptoms so that trees representing stages of disease from 0 to 100 percent leaf scorch could be distributed equally among the treatments. On August 15, September 6 and 21, and October 3 and 18, 2006, trees were evaluated for percent scorch symptoms.

Results and Discussion

When bacterial leaf scorch evaluations were made on October 18, 2005, the year before any treatments were administered, leaf scorch symptoms from tree to tree on the farm ranged from

Table 1. Root-flare injection, basal drench, and trunk treatments.

Treatment and date	Formulation	Rate	Application method
1 Oxytetracycline June 21, 22	Bacastat OSC	0.6 grams in 150 ml water/inch tree diameter macro-infusion injected	Hand pump with tee and harness system as macro-infusion
2 Oxytetracycline June 26, 27	Bacastat OSC	0.6 grams in 9 ml water/inch tree diameter	M3 injectors for micro-injection
3 Oxytetracycline + paclobutrazol June 21, 22 + June 1, 2	Bacastat OSC + Cambistat	0.6 grams in 150 ml water/inch tree diameter + 4 grams a.i./inch tree diameter (rate F from Cambistat application rate card)	Hand pump with tee and harness system as macro-infusion + basal drench
4 Oxytetracycline + paclobutrazol June 26, 27 + June 1, 2	Bacastat OSC + Cambistat	0.6 grams in 9 ml water/inch tree diameter + 4 grams a.i./inch tree diameter (rate F from Cambistat application rate card) + basal drench	M3 injectors for micro-injection + basal drench
5 Paclobutrazol June 1, 2	Cambistat	4 g a.i./inch DBH (rate F from Cambistat application rate card)	basal drench
6 Surfactant + phosphite June 5	Pentra-Bark + Agri-Fos	2.5 percent solution + 25 percent solution in 1.5 liters	Spray suspension over trunk surface from the ground to 6 to 7 ft.
7 Oxytetracycline June 29	Bacastat OSP	0.6 grams in 9 ml water/inch tree diameter	M3 injectors for micro-injection
8 Untreated control			

Table 2. Effect of treatments on bacterial leaf scorch levels in 2006 expressed as a percentage of leaf scorch levels present the previous year on October 18, 2005.

	2006 Evaluation Date				
Treatment	**August 15**	**September 6**	**September 21**	**October 3**	**October 18**
1 Oxytetracycline (OSC) macro-infusion	1.0	6.7	37.5	78.0	139.5
2 Oxytetracycline (OSC) micro-injection	0.3	5.6	36.8	77.4	83.8
3 Oxytetracycline (OSC) macro-infusion + paclobutrazol	0.9	1.8	18.2	59.4	109.2
4 Oxytetracycline (OSC) micro-injection + paclobutrazol	0.3	4.4	35.0	36.7	74.1
5 Paclobutrazol	0.9	41.5	113.0	138.2	133.3
6 Surfactant + phosphite	9.4	42.5	107.5	126.1	158.3
7 Oxytetracycline (OSP) micro-injection	0.9	13.4	50.3	79.1	110.9
8 Untreated control	27.8	58.6	85.8	134.8	172.5

0 to 100 percent. From these data, trees with varying levels of leaf scorch were equally assigned so that for each treatment group, average leaf scorch the previous year was 30 to 36 percent. Thus no treatment was compromised by use on predominantly heavily diseased trees and compared with another treatment used on predominantly healthy trees. Results are presented in Table 2.

None of the treatments "cured" infected trees or prevented scorch symptoms from appearing by the end of the growing season. However, treatments using antibiotics generally delayed the onset of symptoms by about 3 to 4 weeks. By the end of the 2006 growing season, these same treatments resulted in less disease than was present in the trees the year before. At the same time, untreated trees were more diseased than the previous year, which was expected since bacterial leaf scorch disease worsens progressively each year.

Significance to Industry

Kentucky landscape industry professionals are in need of a remedy for bacterial leaf scorch disease. Although treatments used in this experiment did not cure trees of bacterial leaf scorch, treatments that can delay symptoms by even a few weeks might prolong the useful life of infected trees.

More experiments will be needed so that optimal treatment times and rates can be determined.

Literature Cited

1. Anonymous. 1993. Bacterial leaf scorch of landscape trees. Center for Urban Ecology Information Bulletin. National Park Service. Washington, D.C. 4 pp.
2. Hartman, J.R., Eshenaur, B.C., and Jarlfors, U.E. 1992. Shingle oak, a new host for bacterial leaf scorch caused by *Xylella fastidiosa*. Phytopathology 82:498 (abstr).
3. Hartman, J.R., B.C. Eshenaur, and U.E. Jarlfors. 1995. Bacterial Leaf Scorch Caused By *Xylella fastidiosa*: A Kentucky Survey; A Unique Pathogen; and Bur Oak, A New Host. Journal of Arboriculture 21:77-82.
4. Hartman, J.R., U.E. Jarlfors, W.M. Fountain, and R. Thomas. 1996. First report of Bacterial Leaf Scorch Caused by *Xylella fastidiosa* on Sugar Maple and Sweet gum. Plant Disease 80:1302.
5. Hartman, J.R., Kaiser, C.A., Jarlfors, U.E., Eshenaur, B.C., Bachi, P.A., and Dunwell, W.C. 1991. Occurrence of oak bacterial leaf scorch caused by *Xylella fastidiosa* in Kentucky. Plant Disease 75:862.

Evaluation of Trunk-Applied Treatments to Manage Oak Bacterial Leaf Scorch, 2005-2006

John Hartman, Ed Dixon, and Bernadette Amsden, Department of Plant Pathology; and Shawn Bernick, Rainbow Treecare Scientific Advancements, Minneapolis, Minnesota

Nature of Work

Bacterial leaf scorch, caused by *Xylella fastidiosa*, affects many Kentucky landscape trees including oaks (pin, red, scarlet, shingle, and white), maples (red, silver, and sugar), planes (American sycamore and London), sweet gum, hackberry, elm and mulberry (1-5). Leaves of infected trees typically show marginal necrosis (scorch) late in the summer followed by premature defoliation. Infected trees re-foliate normally in spring and the process of late summer scorch and premature defoliation is repeated. The disease begins on one or a few branches and over several years gradually spreads throughout the tree. After many years, dead twigs, then dead branches and limbs begin to appear in the tree and the condition continues to worsen over the years until the tree needs to be removed. Bacterial leaf scorch is a very serious Kentucky plant disease.

Pentra-Bark® has been recently introduced to the tree care industry as an adjuvant which promotes penetration of applied chemicals through the bark of treated trees to the vascular system. Indeed, Pentra-Bark® plus Agri-Fos® is registered for use in control of sudden oak death, caused by *Phytophthora ramorum*. Phosphite-containing materials such as Agri-Fos® have been shown to have some antibacterial activity. Antibiotics such as Agrimycin® (streptomycin sulfate) and Mycoshield® (oxytetracycline) are active against gram-negative bacteria such as *Xylella*. These antibiotics are already used for management of bacterial diseases of many agricultural crops. Cambistat® (paclobutrazol) is a plant growth regulator chemical which inhibits synthesis of the plant hormone gibberellin. Paclobutrazol is said to stimulate root development which could reduce bacterial leaf scorch symptoms. The objective of this research was to determine if trunk-applied antibacterial chemicals or growth regulators would have an effect on bacterial leaf scorch disease symptoms.

Eighty mature street-side pin oak trees with an average diameter of 30 inches (DBH) growing in a Lexington neighborhood with a history of bacterial leaf scorch disease were selected for this experiment. The purpose of the experiment was to determine whether or not trunk-applied treatments could reduce bacterial leaf scorch in pin oaks. Trunk treatments were made on July 13 and 14, 2005, and where two treatments were required, repeated August 24, 2005. Treatments were applied to all surfaces of individual tree trunks from a few inches above the ground to a height of about 6 ft using a hand-pumped Solo backpack sprayer delivering 25 psi. Each tree trunk received 1.5 liters of suspension. The paclobutrazol basal drench was applied to the soil at the base of selected trees July 19, 2005 at label rates depending on tree size. The eight treatments were replicated 10 times and the experiment was established in a randomized complete block design.

Prior to treatment applications, while foliage was still green, trees were evaluated for symptoms of dieback in early July 2005 so that trees representing stages of disease from 0 to 35 percent dieback could be distributed equally among the treatments. On September 27, 2005 and again October 19, 2006, trees were evaluated for percent scorch symptoms and for percent branch and limb dieback. Treatments are listed in Table 1.

Table 1. Trunk and basal drench treatments.

Treatments	Formulation	Rate	Surfactant (Rate)*
1 Untreated Control	-	-	-
2 Pentrabark + oxytetracycline	Myco-Shield	22.4g/ga.	Pentrabark (2.5%)
3 Pentrabark + oxytetracycline *used twice*	Myco-Shield	22.4g/ga.	Pentrabark (2.5%)
4 Pentrabark + phosphite	Agri-Fos	Agri-Fos (25% solution by volume)	Pentrabark (2.5%)
5 Pentrabark + paclobutrazol	Cambistat	Cambistat (33% solution by volume)	Pentrabark (2.5%)
6 Pentrabark + streptomycin sulfate	Agrimycin 22.7%	22.4g/ga.	Pentrabark (2.5%)
7 Pentrabark + streptomycin sulfate *used twice*	Agrimycin 22.7%	22.4g/ga.	Pentrabark (2.5%)
8 paclobutrazol (basal drench)	Cambistat	4 g a.i./inch DBH (rate F from Cambistat application rate card)	-

* by volume

Table 2. Average percentage twig, branch, and limb dieback present on trees within each treatment in early July 2005, late September 2005, and October 2006, and percentage leaf scorch in September 2005 and October 2006.

	Dieback, mean % (range)				Leaf scorch, mean % (range)		
Treatments	July 2005	Sept. 2005	Oct. 2006	Increase, 2005-06	Sept. 2005	Oct. 2006	Increase, 2005-06
1	12 (2-30)	13 (1-35)	18 (0-100)	31	33 (0-100)	50 (5-100)	51
2	10 (1-25)	14 (0-40)	10 (0-25)	-28	23 (1-75)	65 (10-95)	175
3	10 (2-35)	16 (2-35)	12 (0-30)	-25	30 (0-90)	66 (10-100)	122
4	10 (1-35)	11 (0-40)	20 (0-100)	86	12 (0-95)	37 (5-100)	199
5	11 (2-35)	12 (1-45)	11 (0-50)	-13	25 (1-85)	47 (2-100)	85
6	11 (1-30)	18 (0-100)	20 (0-100)	8	28 (1-100)	67 (15-100)	133
7	11 (2-30)	11 (0-40)	10 (0-40)	-18	26 (0-90)	49 (2-95)	83
8	10 (2-35)	17 (1-50)	18 (0-50)	0	39 (0-90)	53 (2-98)	35

Results and Discussion

Results are presented in Table 2. July 2005 dieback data suggest that trees with varying levels of branch dieback were approximately equally distributed among the experimental treatments. Thus no treatment was compromised by use on predominantly heavily diseased trees and compared with another treatment used on predominantly healthy trees.

Average bacterial leaf scorch ranged from 12 percent to 39 percent in 2005 and from 37 percent to 67 percent in 2006 depending on the treatment. If there had been no treatments, it would be expected that leaf scorch symptoms would increase gradually from one year to the next in any case. In addition, all things being equal, symptoms would be expected to worsen even in the same year from September 27 to October 19. However, the delay in evaluation date was offset by wet weather (which delays symptom expression) in 2006 compared to 2005 which was very dry. None of the treatments significantly reduced scorch levels in 2005 and in 2006. Indeed, it appeared that some treatments were associated with a greater increase in scorch than the untreated trees. To determine if these differences are real will require additional statistical analysis. In any case, only one treatment showed less scorch than the untreated trees and that difference was minimal.

Average twig, branch, and limb percent dieback ranged from 11 percent to 18 percent in 2005 and from 10 to 20 in 2006 depending on the treatment. If there had been no treatments, it would be expected that, like scorch symptoms, dieback symptoms would increase gradually from one year to the next. However, for some treatments, dieback almost doubled and for others, dieback was actually reduced from 2005 to 2006. In cases where dieback increased, at least one tree within the treatment was removed by the tree owner and that tree was scored as 100 percent dieback even though the tree may not have been that badly diseased the year before. This skewed the results. Where dieback was reduced from one season to the next, tree owners had their trees pruned for dead wood removal, and such trees showed less dieback symptoms the next year. In any case, because of high variability, there were no statistically significant treatment effects on dieback.

Significance to Industry

It is important for arborists and landscape professionals to be aware that new approaches for management of bacterial leaf scorch are being tried. In this work, the surfactant Pentra-Bark® was not effective for trunk application of potential treatments for bacterial leaf scorch.

Literature Cited

1. Anonymous. 1993. Bacterial leaf scorch of landscape trees. Center for Urban Ecology Information Bulletin. National Park Service. Washington, D.C. 4 pp.
2. Hartman, J.R., Eshenaur, B.C., and Jarlfors, U.E. 1992. Shingle oak, a new host for bacterial leaf scorch caused by *Xylella fastidiosa*. Phytopathology 82:498 (abstr).
3. Hartman, J.R., B.C. Eshenaur, and U.E. Jarlfors. 1995. Bacterial Leaf Scorch Caused By *Xylella fastidiosa*: A Kentucky Survey; A Unique Pathogen; and Bur Oak, A New Host. Journal of Arboriculture 21:77-82.
4. Hartman, J.R., U.E. Jarlfors, W.M. Fountain, and R. Thomas. 1996. First report of Bacterial Leaf Scorch Caused by *Xylella fastidiosa* on Sugar Maple and Sweet gum. Plant Disease 80:1302.
5. Hartman, J.R., Kaiser, C.A., Jarlfors, U.E., Eshenaur, B.C., Bachi, P.A., and Dunwell, W.C. 1991. Occurrence of oak bacterial leaf scorch caused by *Xylella fastidiosa* in Kentucky. Plant Disease 75:862.

2006 Landscape Plant Disease Observations from the University of Kentucky Plant Disease Diagnostic Laboratory

Julie Beale, Paul Bachi, Sara Long, and John Hartman, Department of Plant Pathology

Nature of Work

Plant disease diagnosis is an ongoing educational and research activity of the UK Department of Plant Pathology. We maintain two branches of the Plant Disease Diagnostic Laboratory, one on the campus in Lexington, and one at the Research and Education Center in Princeton. Of the more than 4,000 plant specimens examined annually, about 40 percent are landscape plant specimens (1).

Making a diagnosis involves a great deal of research into the possible causes of the plant problem. Most visual diagnoses involve microscopy to determine what plant parts are affected and to identify the microbe involved. In addition, many specimens require special tests such as moist chamber incubation, culturing, enzyme-linked immunosorbent assay (ELISA), electron microscopy, nematode extraction, or soil pH and soluble salts tests. The laboratory is also using polymerase-chain-reaction (PCR) testing which, although very expensive, allows more precise and accurate diagnoses. Computer-based laboratory records are maintained to provide information used for conducting plant disease surveys, identifying new disease outbreaks, and formulating educational programs. In addition, information from the laboratory forms the basis for timely news of landscape disease problems through the Kentucky Pest News newsletter, radio and television tapes, and plant health care workshops.

To assist county Extension agents in dealing with plant disease issues, we also operate a Web-based digital consulting system utilizing photographic images. The images may be used to help determine where best to collect samples for submission to the laboratory. The digital consulting system is especially useful in providing advice about landscape tree and shrub diseases and disorders because whole plants are difficult to send to the laboratory. Of more than 1,100 digital consulting cases, 30 percent to 35 percent dealt with landscape and nursery plants.

The 2006 growing season in Kentucky provided mostly warmer than normal temperatures and below normal rainfall until very late in the season; however, these observations varied by location. Average temperatures statewide were warmer than normal in January (+12F) and April (+4). In Eastern Kentucky, temperatures were also well above normal for the entire season whereas in Central and Western Kentucky, temperatures remained near normal. The coldest temperatures occurred on February 19, dropping to 5°F following temperatures in the 60s and 70s in January. Temperatures dropped to 28°F on April 9, well after many woody plants had broken dormancy and may have caused some injury. Rainfall in Central and Western Kentucky was near normal during most months, but was well below normal in Eastern Kentucky with some areas reporting a shortfall of 10 inches of rain until September. In September, record-setting high levels of rain occurred statewide.

With wetness affecting early-season disease development, the percentage of days with rain in Central and Western Kentucky averaged over 40 percent to 50 percent during April and May. Thus, there were ample opportunities for rain-based development of spring plant diseases such as scab, cedar-quince rust, shade tree anthracnose and numerous leaf spot diseases. April and May temperatures were also quite variable alternating from warm to cool. Cool temperatures extended crabapple and flowering pear bloom periods and warm periods promoted bacterial growth so that these ornamentals were more vulnerable to fire blight than usual.

This was a big year for landscape plant disease incidence. The following important or unusual diseases were observed:

Deciduous trees

- Ash, dogwood, maple, oak, sycamore, and walnut anthracnose (Discula, Gnomonia, Kabatiella, and Apiognomonia) and dogwood spot anthracnose (Elsinoe)
- Beech, birch, hawthorn, maple, and London plane leaf spot (Phyllosticta)

- Cherry, honey locust, and maple leaf spot (Cercospora)
- Cherry leaf spot (Phloeosporella) and leaf rust (Tranzchelia)
- Maple tar spot (Rhytisma)
- Crabapple scab (Venturia)
- Dogwood and poplar leaf spot (Septoria)
- Oak Actinopelte leaf spot (Tubakia)
- Oak leaf blister (Taphrina)
- Horse chestnut leaf blotch (Guignardia)
- Dogwood, oak, and walnut powdery mildew (Microsphaera, Phyllactinia)
- Hawthorn, serviceberry, and crabapple cedar rusts (Gymnosporangium juniperi-virginianae, G. clavipes, G. globosum)
- Birch, black gum, cherry, dogwood, maple, oak, redbud, and yellowwood canker (Botryosphaeria)
- Flowering pear and flowering crabapple fire blight (Erwinia)
- Flowering plum and flowering cherry black knot (Apiosporina)
- Magnolia and smoke tree wilt (Verticillium)
- Mimosa wilt (Fusarium)
- Elm Dutch elm disease (Ophiostoma)
- Hackberry, maple, oak, and sycamore bacterial leaf scorch (Xylella)
- Oak and apple root rot (Xylaria)

Needle Evergreens

- Juniper and arborvitae tip blight (Kabatina, Phomopsis) and juniper rusts (Gymnosporangium)
- Pine tip blight (Diplodia), brown spot needle blight (Mycosphaerella), and wilt (Bursaphelenchus)
- Spruce needle cast (Rhizosphaera) and canker (Cytospora)

Shrubs

- Hydrangea leaf spot (Cercospora, Pseudomonas)
- Lilac leaf spot (Cercospora) and bacterial blight (Pseudomonas)
- Rose black spot (Diplocarpon), powdery mildew (Sphaerotheca), and rosette (possible virus, leaf curl mite-transmitted)
- Euonymus powdery mildew (Erysiphe)
- Hydrangea, leucothoe, rhododendron, rose, and viburnum canker (Botryosphaeria)
- Boxwood Volutella canker (Pseudonectria)
- Rhododendron, taxus, hydrangea, and cherry laurel root rot (Phytophthora)
- Holly black root rot (Thielaviopsis)

Herbaceous Annuals and Perennials

- Aster and Amsonia rusts (Coleosporium)
- Dianthus, hosta, and lily anthracnose (Colletotrichum)
- Daylily leaf streak (Aureobasidium)
- Astilbe and goat's beard leaf spot (Cercospora)
- Peony leaf spots and blights (Alternaria, Botrytis, Cercospora, Cladosporium, and Septoria)
- Iris leaf spot (Didymellina) and bacterial soft rot (Erwinia)
- Chrysanthemum leaf spot (Macrophoma), blight (Erwinia), wilt (Fusarium), and root rot (Pythium, Rhizoctonia)
- Pachysandra stem canker and blight (Volutella)
- Anemone, celosia and hosta southern blight (Sclerotium)
- Catharanthus, petunia, and scaevola black root rot (Thielaviopsis)
- Begonia, delphinium, diplodina, English ivy, geranium, hosta, impatiens, lavender, lily, petunia, rudbeckia, sage, and vinca root rots (Pythium, Rhizoctonia)

Significance to Industry

Plant diseases play a significant role in production and maintenance of landscape plants in Kentucky. The first step in appropriate pest management in the landscape and nursery is an accurate diagnosis of the problem. The UK Plant Disease Diagnostic Laboratory assists the landscape industry of Kentucky in this effort. To serve their clients effectively, landscape industry professionals, such as arborists, nursery operators, and landscape installation and maintenance organizations need to be aware of recent plant disease history and the implications for landscape maintenance. This report is a synopsis of useful information about plant disease provided for landscape professionals.

Literature Cited

1. Bachi, P., J. Beale, J. Hartman, D. Hershman, W. Nesmith, and P. Vincelli. 2007. Plant Diseases in Kentucky—Plant Disease Diagnostic Laboratory Summary, 2006. U.K. Department of Plant Pathology (in press).

Evaluation of the Transmissibility of *Diplodia pinea* during the Shearing of Scots Pine Christmas Trees—2006

Amy Bateman, John Hartman, Lisa Vaillancourt, Nathalie Godbert, Celine Moser, and Hugues Chopy, Department of Plant Pathology

Nature of Work

Diplodia pinea (previously *Sphaeropsis sapinea*) is the causal agent of Diplodia tip or shoot blight on more than 30 species of pines as well as cedars, spruces, and firs. In Kentucky, the fungus mainly infects the two-needled pines *Pinus nigra* (Austrian pines), and *Pinus sylvestris* (Scots pines) found in landscape and Christmas tree plantation settings. Infection typically occurs on newly elongating shoots as well as through wounds. Symptoms include needle blight, tip blight, resinous cankers on the main trunk and/or branches, branch dieback, and "shepherd's crooks" of the newly elongating shoots. Symptoms can become visible within days of the infection under ideal conditions and progress rapidly thereafter. Due to the location of infected shoots on diseased trees, the possibility that shearing or pruning a diseased tree could contribute to fungal dispersal is likely, although has yet to be studied. In recent years Diplodia tip blight has been devastating to landscape Austrian pines and to Scots pines grown for Christmas trees in Kentucky (1).

In the spring of 2005, research was begun to test the hypothesis that *D. pinea* can be transmitted via pruning tools and infect uninfected trees and branches through wounds created while pruning or shearing Scots pine Christmas trees. Two farms in Central Kentucky (one in Clark County and one in Fayette County) were used to collect samples during shearing. In the spring/summer of 2006, these same farms were used again to collect more samples. Before samples were collected and shearing had started, disease levels were determined for each tree and these levels were used to categorize the trees as being healthy (0 percent disease), minimally diseased (0.1 to 1.9 percent) and moderately diseased (2 percent or greater). Trees were then placed into groups of six in a row, with the lead tree in each group representing one of the three disease levels followed by healthy or very slightly diseased (or very few symptomatic tips) trees. Samples were collected after the lead tree, and one, three, and five trees down the row after the lead tree. Samples were collected from shearing tools using adhesive tape that was pressed against the blades, which could then be brought back to the lab for further analysis. Fungal colonies were allowed to grow from these tapes and confirmation of *D. pinea* was done through spore identification. In 2006, we attempted to utilize the same groupings, but could not in every case due to the removal of some trees the previous Christmas, and the change of some trees' disease levels from the previous year.

Because tip blight can be such a devastating disease to Christmas tree growers, a means to possibly stop the spread of this disease through disinfestation of shearing tools was also tested. It was hypothesized that disinfestation/cleaning of shearing equipment will decrease transmission from plant to plant. Due to the corrosive effects of bleach on tools and the inconvenience of alcohol washes, common household spray Lysol® was sprayed on tools after shearing the lead tree, since it was the tree that would be likely to have *D. pinea* in each group. Half of all groups from each farm were used in the Lysol® study. Sample collection and processing was done the same as already described and was performed both years.

Upon shearing, resin caps form on the wounds. To test the effectiveness of resin at inhibiting *D. pinea* infection artificial shearing was performed on 4-year-old potted Scots pines in the summer of 2006. Branch tips were removed from four branches of the same whorl of Scots pines. Tips were allowed to produce resin and a 10µL spore suspension at a 1 by 10^6 concentration was added via the addition of a pipette tip to the branch. At zero hour, resin was just beginning to flow. By six hours, a resin cap had started to form, but resin was still soft and liquid. At 24 hours, the resin cap had fully formed, but was still not completely hardened. Spore suspensions were added at zero hour, six hours, and 24 hours after removing the branch tip. A water control also was added at zero hour. Ratings were taken of the disease progress a few weeks after inoculation.

Mock shearing was also performed on young Austrian pines where scalpel blades were used to cut at known diseased tissue and then used to cut off the tips of the pines, simulating shearing that occurs in the field. Disease progression was then recorded.

Results and Discussion

To determine if *D. pinea* could be picked up and possibly transmitted to other trees, colony-forming units (CFUs) were tabulated for each tape sample collected by identifying colonies that grew from these tapes. CFUs could be spores or fungal pieces that adhered to the shearing tools. When all tapes were analyzed, more CFUs were picked up from moderately diseased trees compared to healthy trees with the trend of increasing fungal adhesion to tools as disease level increases (Figure 1). Based on this study, Lysol® application did not successfully disinfest the tools of *D. pinea* (Figure 2). A possible reason for the dramatic increase in the number of CFUs between 2005 and 2006 in the moderate category may be due to the fact that there was more moisture this year, which led to greater pycnidia production on diseased tips prior to shearing so there was more inoculum in general available to be picked up. Also, some shearing sessions were performed while trees were still wet with rain/dew which allowed for spore release from the pycnidia.

Figure 1. Total number of *Diplodia pinea* colony forming units (CFUs) from all tapes from each farm per disease level category for both years of study.

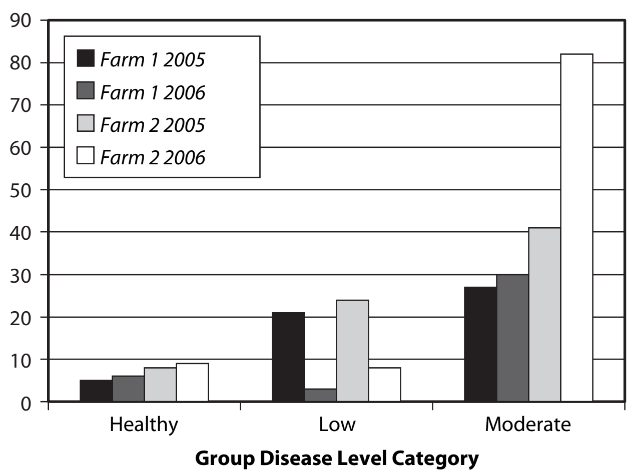
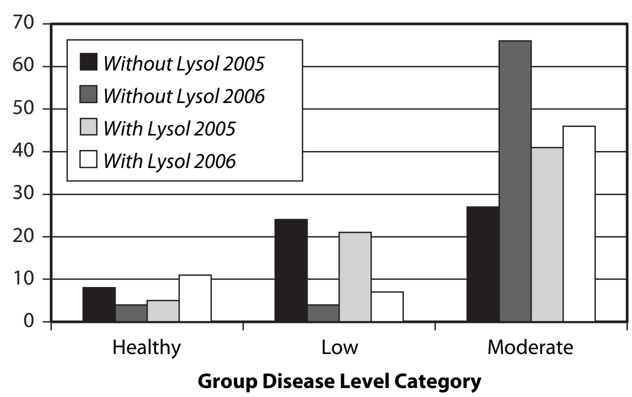
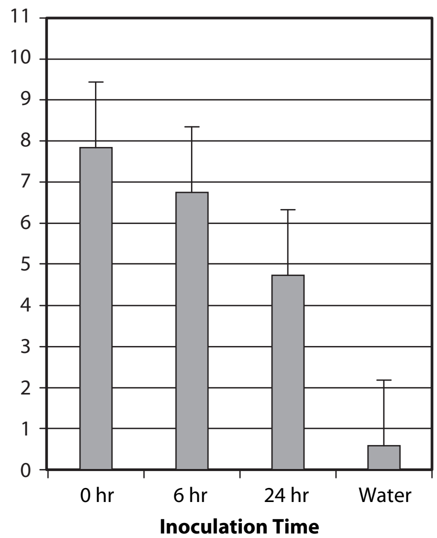


Figure 2. Total number of *Diplodia pinea* colony forming units (CFUs) with or without Lysol® treatment for both farms combined per disease level for both years.



After inoculating Scots pine cut tips following varying amounts of resin formation, there was a noticeable difference in the symptom development between inoculating at zero, six, and 24 hours. This supports the idea that resin and resin cap formation hinders fungal inoculation and disease development (Figure 3).

Figure 3. Average Horsefall-Barratt disease ratings of 4-year-old Scots pines inoculated with *Diplodia pinea* at varying time intervals after shearing.



The mock-shearing on the Austrian pines (done in the summer of 2006) has yet to produce symptoms on the trees. This may be due to the low inoculum amount that was naturally picked up on the blades. This, in combination with the resin capping study, suggests that there is a minimum amount of inoculum needed in order to create symptomatic infections. Because of this, a dilution series test will be performed on sheared Scots pine tips, in conjunction with a second trial of resin capping study, next spring in order to find what the minimum level of inoculum is.

Significance to Industry

Because shearing/pruning is a process that extends beyond the Christmas tree industry, this study is important to show that the acquisition and translocation of fungi can occur during shearing. This notion has been assumed to be true by the scientific community and the general public yet little research has actually been done to prove it. Also, the process of disinfesting tools has been a common recommendation, and this study is helping to demonstrate whether or not recommended disinfestants are useful for management of Diplodia tip blight.

Literature Cited

1. Bachi, P.R., J.W. Beale, J.R. Hartman, D.E. Hershman, W.C. Nesmith, and P.C. Vincelli. 2007. Plant Diseases in Kentucky—Plant Disease Diagnostic Laboratory Summary, 2006. UK Department of Plant Pathology (in press).

National Nursery Survey for *Phytophthora ramorum* in Kentucky, 2006

Patricia B. de Sá, Janet Lensing, Wiphawee Leesutthiphonchai, John Hartman, Pierre-Yves Dymarski, Ana Maria Holdcroft, Joe Collins, and Carl Harper, Departments of Plant Pathology and Entomology

Nature of Work

Phytophthora ramorum was described in 2001 in the Netherlands, and was initially found on ornamental plants in Europe in 1993 and on oak and tanoak trees in California in 1995. It is at present the major *Phytophthora* species of concern for the ornamental nursery industry in the United States. It is the cause of Ramorum blight, a disease affecting many plants and known as sudden oak death when found on oak and tanoak trees. Although this pathogen affects mostly camellias, rhododendrons, viburnums, oaks, and tanoaks, many other plants including woody shrubs and trees, herbaceous plants, and ferns can also become infected and develop Ramorum blight with varying levels of severity. The USDA-APHIS-PPQ publishes on its Web site, a list of plants found to be proven hosts and plants associated with *Phytophthora ramorum* in the United States. The complete list is updated regularly and may be viewed at:

<http://www.aphis.usda.gov/ppq/ispm/pramorum/pdf_files/usdaprlist.pdf>

The long distance spread of *Phytophthora ramorum* is known to occur through the movement of infected plants, plant parts, and soil, and correct identification can only be done by analysis of morphological characteristics or by PCR. There is great concern that *P. ramorum* may spread to native plants in parks and native woodlands in the United States from introduced infected ornamental plants.

The National Nursery Survey in Kentucky in 2006 was performed through collaboration between the Departments of Plant Pathology and Entomology, the Office of State Entomologist at the University of Kentucky, and the USDA-APHIS. Procedures for collecting and testing were according to protocols established by the USDA-APHIS-PPQ. Forty-six nurseries and retail outlets were surveyed for detection of *P. ramorum* in parts of the state that may be at higher risk for establishment of *P. ramorum*. Risk in this case is based on the composition of native plants in the area, climate and weather conditions, and presence of a trace-forward nursery, defined as a nursery that has received plants from another nursery proven to have plants infected with *P. ramorum*.

Research and experience in nurseries have indicated that although many plants are hosts to *P. ramorum* or have been found associated with it, six genera of plants seem to be very susceptible to infection, and plants in these genera are considered high risk plants. The genera are: *Camellia*, *Rhododendron* (excluding azaleas that have small leaves), *Viburnum*, *Pieris*, *Kalmia* (mountain laurel) and *Syringa* (lilac). Collection of plants for the survey was concentrated on these genera, however some other plants showing symptoms of infection by *Phytophthora* were also collected. Leaves, apical shoots and flower buds showing symptoms typical of Ramorum blight were collected, placed in a bag with zip closure and were placed into a second bag closed in the same way. The bags were labeled, placed in a cooler, and taken to the Department of Plant Pathology at the University of Kentucky for analysis.

All the collected samples were tested using a direct Double Antibody Sandwich Enzyme Linked Immunosorbent Assay (DAS ELISA). This assay is based on immunological detection of proteins that are present in organisms in the genus *Phytophthora*. This is a very sensitive assay but not specific enough to differentiate between species, and it may also detect some organisms in the genus *Pythium*. It is a good pre-screening assay and samples that were positive in ELISA were tested further using a more specific and sensitive assay: PCR with nested primers for amplification of *P. ramorum* DNA. For all the samples that tested positive in ELISA, DNA was extracted, and the DNA was sent to the USDA-APHIS for testing by PCR for *P. ramorum*, according to the protocol.

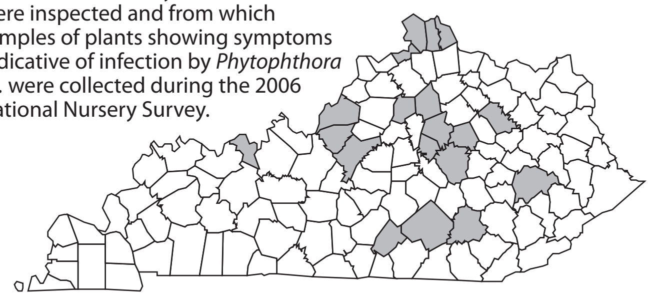


Figure 1. Map showing the 19 counties in Kentucky where nurseries were inspected and from which samples of plants showing symptoms indicative of infection by *Phytophthora sp.* were collected during the 2006 National Nursery Survey.

Results and Discussion

A total number of 14,936 plants were inspected for Ramorum blight in 46 nurseries and retail outlets in 20 counties. Of these, 687 showed symptoms indicative of infection by an organism in the genus *Phytophthora,* and 192 composite samples were collected. Of the 46 nurseries surveyed, 20 nurseries were trace-forward nurseries. Samples were collected from 35 nurseries in 19 counties: Bath (1), Boone (3), Breathitt (1), Bullitt (2), Campbell (1), Clark (1), Fayette (1), Franklin (2), Gallatin (1), Hancock (1), Jefferson (9), Jessamine (1), Kenton (1), Laurel (4), Madison (1), Nelson (2), Pulaski (1), Russell (1) and Scott (2). (Figure 1). No samples were collected from 11 trace-forward nurseries because the plants had already been sold. Forty-two samples tested positive in ELISA for the genus *Phytophthora*; DNA was extracted from these samples and was sent to the USDA-APHIS-PPQ for testing by PCR.

The results of plant sampling are summarized in Table 1.

No samples collected from nurseries in the state of Kentucky were found to be positive for *P. ramorum* in the 2006 nursery survey. Of the 46 rhododendron samples, more than half were positive in ELISA for *Phytophthora sp*, whereas out of 22 azalea samples only two tested positive in ELISA. Although no further testing was performed on rhododendron and azalea samples, it is likely that they were infected by some other species of *Phytophthora*.

The survey results showed that no *Phytophthora ramorum* was found in the surveyed nurseries in Kentucky.

During the National Nursery Survey for *P. ramorum* in 2006, 46 states reported survey results by the end of October, with Alaska, Iowa, Missouri and Puerto Rico not participating in the survey. A total of 95,295 samples were collected from 3,513 nurseries inspected across the country, and 352 samples were confirmed positive for *P. ramorum* in 56 nurseries in 11 states. The number of sites where positive samples were collected by state were: 26 in California; 13 in Oregon; eight in Washington; two in Florida; one in Alabama; one in Connecticut; one in Georgia; one in Indiana; one in Maine; one in Mississippi; and one in Pennsylvania.

Significance to Industry

None of the nurseries surveyed in the state of Kentucky were found to have plants testing positive for *P. ramorum* in 2006, even though some were trace-forward nurseries. Long-distance spread of *Phytophthora ramorum* is believed to occur mostly by movement of infected ornamental plants from nurseries that have the pathogen. There is great concern that if infected plants are introduced into the state, *P. ramorum* may spread within the receiving nursery to landscaped areas, and then to parks and native woodlands, where rhododendrons and azaleas, viburnums, and mountain laurel are native. These native shrubs may become a source of infection for oak trees. Early detection and eradication of diseased plants are important to protect the landscape and nursery industries in Kentucky, and surveys like the national nursery survey and the forest survey are important in the effort to achieve this goal.

Globalization of the nursery trade allows for offshore production of ornamentals that may be commercialized directly to the consumer, and allows for the introduction of new and exotic plants that may be used by growers to develop novelty varieties for increasingly demanding consumers. Plants and plant products are transported long distance across country and state borders to bring these new and interesting plants to the market. However, the long distance movement of plants and plant parts across borders has associated with it the risk of introducing diseases and pests to areas where they were not previously present, and subsequent environmental issues and management problems could result. Further precautions and surveys may be necessary to exclude other pathogens and pests that may be introduced into the state.

Acknowledgements

Thanks to Patricia Dillon and John Obrycki for providing funding for part of this work, and to all the nursery owners for their collaboration.

Table 1. Number and type of plants sampled and results of ELISA and PCR assays for *Phytophthora sp.* and *P. ramorum* during the National Nursery Survey for *P. ramorum* in Kentucky Nurseries in 2006.

Plant Sampled	Number of samples	ELISA Positive for *Phytophthora sp.*	PCR Positive for *P. ramorum*
Rhododendron	46	28	0
Azalea	22	2	0
Viburnum	65	4	0
Camellia	3	0	0
Lilac	30	4	0
Mountain Laurel	3	0	0
Pieris	12	4	0
Photinia fraserii	2	0	0
Leucoth esp	1	0	0
Maple	5	0	0
Beech	2	0	0
Oak	1	0	0
Total	192	42	0

National Nursery Perimeter and Forest Survey for *Phytophthora ramorum* in Kentucky, 2006

Patricia B. de Sá, John Hartman, Wiphawee Leesutthiphonchai, Ana Maria Holdcroft, Pierre-Yves Dymarski, Sarah L. Hall, Jacob P. Royse, and Janet Lensing, Departments of Plant Pathology, Forestry, and Entomology

Nature of Work

Sudden Oak Death was the name given to a disease first reported in the mid-1990s in the United States in coastal areas of central California on tanoak (*Lithocarpus* spp), California black oak (*Quercus kelloggii*) and coast live oak (*Quercus agrifolia*). Six years after the initial report in California, *P. ramorum* was found in Oregon forests.

Affected trees develop bleeding cankers that girdle the tree and lead to death of the entire canopy. Although the name sudden oak death is considered to be a misnomer, it is still used for the disease on oaks and tanoaks. The causal agent was later determined to be *Phytophthora ramorum,* a species of *Phytophthora* that causes blight diseases on more than 100 plants. The name Ramorum blight is used for the disease on plants other than oaks and tanoaks.

Thousands of trees and shrubs on the West Coast have been killed by *P. ramorum* infection, and many more are infected showing sudden oak death symptoms or the typical blight symptoms of leaf necrosis, twig and bud dieback, occasional stem cankers, and in the case of redwood trees, epicormic sprouting.

Trees affected by *P. ramorum* on the West Coast in natural areas include tanoak, coast live oak, California black oak, Shreve's oak (*Q. parvula* var. *shrevei*), and canyon live oak (*Q. chrysolepsis*). Douglas fir and grand fir located in Christmas tree plantations close to heavily infested California bay laurel have exhibited symptoms of Ramorum blight.

P. ramorum has a broad host range and is not immediately lethal to many of the hosts, e.g., plants like the California bay laurel, camellia and rhododendron may become infected and shed symptomatic leaves. Infected plants may serve as a source of spores for stem infections of trees. Leaves on the ground may lead to the development of resistant spores that survive on the ground for a long time and may infect plants put into the infested ground. Movement of infected plants is believed to allow for the spread and introduction of this pathogen into other parts of the country.

An updated APHIS list of regulated hosts and plants associated with *Phytophthora ramorum* may be viewed at:

<http://www.aphis.usda.gov/ppq/ispm/pramorum/pdf_files/usdaprlist.pdf>.

Phytophthora ramorum is considered to be a nursery and forest problem and a major disease threat to forests in the Appalachian region, according to disease risk models generated by the USDA Forest Service that may be viewed at:

<http://www.cnr.berkeley.edu/comtf/html/modeling_phytophthora_ramorum.html>.

The USDA Forest Service and collaborating states have been performing national forest surveys in an effort to detect *P. ramorum* in forest areas and nursery perimeters. Its presence in nursery perimeters could be an indication of its escape from the nursery into the natural landscape or alternatively its introduction into the nursery from the natural environment. In previous years no *P. ramorum* was found in Kentucky in forest areas or in the perimeter of nurseries known to have received plants from nurseries that had infected plants on the West Coast.

The forest and nursery perimeter survey was carried out as collaboration between the USDA-FS, the Kentucky Division of Forestry, and the Departments of Plant Pathology, Forestry, and Entomology of the University of Kentucky. It was performed according to a protocol devised by USDA Forest Service, Forest Health Monitoring. Sampling was performed on 30 locations across the state, on the perimeter of 21 nurseries, and in nine forested or wooded areas that had not been previously surveyed. The areas selected were considered high risk based on having received plants from West Coast states where *P. ramorum* is present, the type of vegetation, proximity to urban areas that may have received infected plants, and areas that may be subject to high tourist traffic.

Four transects were placed on the perimeter of nurseries in such a way as to take advantage of the presence of target host plants. Each transect was 100 meters long and was set using a hip chain. Forest and wooded locations were surveyed by setting four 100 meter transects with the hip chain, one in each of the four cardinal directions from a central point. The width of each transect was determined by how far one could see from the transect line. GPS readings and other host and terrain data were recorded for all areas, and maps were obtained from the TerraServer-USA Web site.

Composite leaf samples and bark samples from individual trees were collected from plants showing symptoms of infection by Phytophthora species in 11 genera: *Acer, Aesculus, Castanea, Fagus Hammamelis, Kalmia, Lonicera, Quercus, Rhododendron, Vaccinium, and Viburnum.* All samples were double bagged, maintained at low temperature and taken to the Department of Plant Pathology at the University of Kentucky. Replicate samples were shipped overnight to a collaborating laboratory for analysis and for confirmation of the results. Leaves and bark were subsampled under containment conditions for DNA extraction and PCR using nested primers for detection of *P. ramorum*. It is not possible to determine if a plant is infected by *P. ramorum* by symptoms alone; the pathogen must be cultured in specific medium for development of differentiating structures, or a method such as PCR must be used.

Results and Discussion

Thirty locations were surveyed in 18 counties. The breakdown of locations in each county is: Bath (1), Boone (3), Breathitt (2), Bullitt (1), Clark (1), Fayette (3), Franklin (1), Gallatin (1), Harrison (1), Jackson (1), Jefferson (4), Jessamine (2), Kenton (2), Laurel (2), Madison (1), Menifee (2), Mercer (1), and Russell (1). (Figure 1).

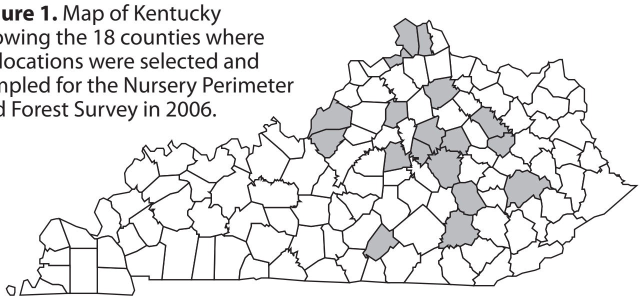


Figure 1. Map of Kentucky showing the 18 counties where 30 locations were selected and sampled for the Nursery Perimeter and Forest Survey in 2006.

Twenty-one transects were on nursery perimeters, and the other nine were in Robinson Forest; Griffiths Woods; Indian Creek in the Red River Gorge; Cave Run Lake within the Daniel Boone National Forest; the woods at Camp Nelson National Heritage Park; Raven Run Nature Sanctuary; McConnell Springs in Fayette County; Middle Creek Park in Boone County; and a privately owned tree farm in Jackson County.

From the 30 locations surveyed, 57 leaf and bark samples from plants showing symptoms indicative of infection by a *Phytophthora* species were collected. DNA was extracted from all samples, and PCR was performed to test for *P. ramorum*. The list of plants sampled and results of PCR reaction is shown in Table 1.

Table 1. Number of samples in each genus and the results of PCR assays for samples collected during the Nursery Perimeter and Forest Survey for *P. ramorum* in Kentucky in 2006. Leaf samples were collected from plants showing foliar symptoms, and bark samples were collected from trees with bleeding cankers.

Genera Collected	Number of Samples	PCR Result
Acer	15	Negative
Aesculus	1	Negative
Castanea	1	Negative
Fagus	1	Negative
Kalmia	1	Negative
Lonicera	27	Negative
Magnolia	1	Negative
Quercus	6	Negative
Rhododendron	1	Negative
Vaccinium	2	Negative
Viburnum	1	Negative
Total	57	Negative

No samples collected from nursery perimeters, forests, and wooded areas in Kentucky were found to be positive for *P. ramorum* in 2006.

Significance to Industry

Thirty locations were surveyed in Kentucky during the 2006 Nursery Perimeter and Forest survey, and no samples were positive for *P. ramorum*. Surveys in nursery perimeters, forests and natural areas have been carried out in Kentucky in 2003, 2004, 2005, and 2006, and to this date *Phytophthora ramorum* has not been found in nursery perimeters and forest areas. This pathogen has a broad host range that includes woody trees and shrubs, herbaceous plants, and ferns, and causes diseases such as Ramorum leaf blight, Ramorum shoot dieback, and on mature oak trees, sudden oak death. Its introduction and establishment into the state could have a major impact on the nursery and forestry industries and cause substantial economic losses. Early detection and eradication of diseased plants are important to protect Kentucky's forest resources and forestry industry as well as the nursery and landscape industry from losses due to *Phytophthora ramorum*.

Acknowledgements

This survey was conducted in cooperation with the Kentucky Division of Forestry (KDF). Thanks to the Kentucky Commerce Cabinet, Department of Parks for providing us with a Scientific Research Permit, and to the USDA-FS for permission to sample in the Daniel Boone National Forest. Thanks to the following organizations for help in identifying suitable areas, giving us permission to sample and accompanying the survey group on the field: KDF; Camp Nelson Heritage Park; Lexington-Fayette Urban County Government, Division of Parks and Recreation; Robinson Forest; Griffiths Woods; and to the private nursery and forest owners who gave us permission to perform the survey and sample on their property.

National Elm Trial—Kentucky Data, 2006

John Hartman, Ed Dixon, Daniel A. Potter, Jenny Edelen, and William Fountain,
Departments of Plant Pathology, Entomology, and Horticulture; and Jerry Hart, Physical Plant Division-Grounds

Nature of Work

The National Elm Trial was established to evaluate landscape-suitable elm cultivars for disease and insect tolerance and for horticultural characteristics at 15 locations nationwide from California to Vermont and south to Kentucky. Locally, 14 elm cultivars were planted April 13-15, 2005 in a grassy area on the University of Kentucky campus in Lexington. An additional three cultivars were planted in April 2006. Plots were located south and east of the sports complex across from the UK Arboretum entrance along Alumni Drive (North 38 deg, 1 min; West 84 deg, 30 min, elev. 990 ft). The site had been graded for construction some years before and consisted of a mixture of topsoil, subsoil, and construction debris. In the planting—a double-allée—each cultivar was replicated five times and arranged in a randomized complete block design. Additional randomized space was left in each block for elm cultivars to be planted in future years. Trees were staked as needed, watered during dry periods, and all trees were mulched over grass that had been killed with an application of Roundup® herbicide.

The 17 elm cultivars planted for this study include:

1. 'JFS Bieberich' Emerald Sunshine—*Ulmus propinqua*
2. 'Emer II' Allee—*U. parvifolia*
3. 'Frontier'—*U. carpinifolia X U. parvifolia*
4. 'Homestead'—*U. glabra* X *U. carpinifolia* X *U. pumila*
5. 'Morton Glossy' Triumph—*U. pumila X U. japonica X U. wilsoniana*
6. 'Morton Plainsman' Vanguard—*U. pumila X U. japonica*
7. 'Morton Red Tip' Danada Charm—*U. japonica X U. wilsoniana*
8. 'Morton Stalwart' Commendation—*U. carpinifolia X U. pumila X U. wilsoniana*
9. 'Morton' Accolade—*U. japonica X U. wilsoniana*
10. 'New Horizon'—*U. pumila X U. japonica*
11. 'Patriot'—(*U. glabra X U. carpinifolia X U. pumila*) *X U. wilsoniana*
12. 'Pioneer'—*U. glabra X U. carpinifolia*
13. 'Prospector'—*U. wilsoniana*
14. 'Valley Forge'—*U. americana*
15. 'Princeton'—*U. americana*
16. 'Jefferson'—*U. americana*
17. 'New Harmony'—*U. americana*

Trees came from the nursery as bare root transplants about 5 to 8 ft tall (except 'Jefferson,' which was much smaller). In the plots, new trees were provided with supplemental water in spring just after planting, but otherwise seasonal rainfall was adequate for the established elms. Tree trunk diameters were measured and tree height and width determined in summer. Japanese beetle damage was assessed on July 28 by estimating the percentage of foliage that was damaged by beetle feeding. Each tree was rated by two independent observers, and their ratings were averaged to provide a single score per tree.

Results and Discussion

Results from the elm plots are presented in Table 1. All of the elm cultivars are increasing in height and trunk diameter. There were significant differences in the average levels of Japanese beetle damage sustained by the different cultivars. Valley Forge, Frontier, New Harmony, Emer II and JFS Bieberich elms appeared to be somewhat less attractive to Japanese beetle feeding, while Patriot, Homestead, Pioneer, and Morton Plainsman appeared to attract more Japanese beetle feeding than most other cultivars.

Significance to Industry

The widespread use of elms in the landscape has been lost largely due to Dutch elm disease. Knowledge of how elms perform in Kentucky in the face of Dutch elm disease, elm yellows, bacterial leaf scorch, Japanese beetles, elm leaf beetles, and other pests and diseases will benefit arborists and the landscape maintenance and nursery industries.

Table 1. Size of elms; effect of elm cultivar on damage from Japanese beetle in 2006.

Cultivar number and name (from list, left)	Average trunk diameter (in. dbh)	Average height (ft)	Average crown width (ft)	Mean (±SE) % defoliation by Japanese beetle feeding*	Range of defoliation
11 Patriot	1.09	11.7	4.4	69.0 ± 7.6 a	40-85
4 Homestead	1.13	11.2	4.8	69.0 ± 8.3 a	45-90
12 Pioneer	1.03	10.2	3.8	63.0 ± 8.7 ab	45-90
6 Morton Plainsman	1.09	10.6	5.1	51.0 ± 8.6 bc	25-75
5 Morton Glossy	0.86	9.3	2.6	46.0 ± 11.6 cd	30-90
15 Princeton	0.96	12.8	1.3	44.0 ± 9.4 cd	25-80
7 Morton Red Tip	1.58	11.2	5.0	43.0 ± 3.0 cd	35-50
9 Morton Accolade	1.08	10.3	3.5	42.0 ± 2.0 cd	35-45
8 Morton Stalwart	1.39	11.9	4.3	41.3 ± 3.8 cde	35-50
10 New Horizon	1.14	9.4	3.1	33.0 ± 4.0 def	20-45
13 Prospector	1.13	10.4	4.3	32.0 ± 5.0 def	15-45
14 Valley Forge	0.79	9.5	3.5	27.0 ± 2.5 ef	20-35
3 Frontier	0.75	10.1	3.9	22.0 ± 4.0 f	10-30
17 New Harmony	0.75	11.0	1.0	21.5 ± 5.0 f	8- 35
1 JFS Bieberich	1.0	11.2	3.4	7.5 ± 1.1 g	5-10
2 Emer II Allee	0.81	7.5	4.4	6.7 ± 1.7 g	5-10
16 Jefferson	0.21	1.8	1.0	not rated	

* Means followed by the same letter are not different at $P < 0.001$ by LSD mean separation.

Hydrangea macrophylla and *serrata* Trials at the University of Kentucky

Robert E. McNiel, Sharon Bale, Terry Jones, and Bonka Vaneva, Department of Horticulture

Nature of Work

During the last decade, *Hydrangea macrophylla* has enjoyed a resurgence as a dominate landscape plant. Selection and hybridization has yielded many new cultivars. During the late 1990s we concluded little was known about the usefulness of the wide range of cultivars for establishment in landscapes in the Ohio River Valley. Starting in 2000, we have established several evaluation plots at three locations across Kentucky as material of landscape size (No. 1 container) became available for use. Cultivars have six replications at each site. Specific cultivars have been established at one, two, or three sites. We have evaluated over 100 cultivars. Data are included here for the cultivars planted at more than one site. Plants have been evaluated for winter hardiness and ability to flower. Quicksand and Lexington sites are on drip irrigation while the Paducah site is hand watered on an as-needed basis. All three sites are in USDA Hardiness Zone 6.

Results and Discussion

Survival data for 75 of the cultivars evaluated are presented in Table 1. The data denotes number of plants which survived as of the spring of 2006 from the original planting of six. Plants without numbers were not located at a particular site.

Table 1. *Hydrangea macrophylla/serrata* cultivar survival rate after 1 to 5 years. Number of plants surviving in spring 2006 from original six plants installed in field plots at the three Kentucky sites.

Cultivar	Paducah	Quicksand	Lexington
All Summer Beauty	4	6	6
Alpenglow		3	4
Altona		6	1
Amy Pasquier		6	5
Arburg	4	5	6
Blau Donau	5	4	6
Blaumiese	6	5	
Blue Billow		5	3
Blue Deckle		5	6
Bodensee		6	4
Böttstein	6	4	6
Brestenburg		4	5
Brugg	6	5	0
Brunegg	2	5	6
Brunette	5		6
Burg Königstein	4	4	3
Burg Rosenburg	4	4	6
Cardinal Red		3	6
Coerula Lace		6	6
David Ramsey	6	2	6
Decatur Blue	5		3
Domotoi	3		6
Dooley		6	6
Dr. Benard Steinberg	3		6
Dunkalk	5	5	5
Endless Summer™/ Bailmer	4	2	6
Freudenstein	5	6	6
Fuji Waterfall	3	2	4
Général Vicomtesse de Vibrayé	4		4
Goffersburg	2		2
Goliath	5		3
Habsburg	5	6	6
Hamburg	4	4	
Harlequin	3	2	
Hildegard	1	5	0
Holstein	3	4	3
Horben	3	6	5
Hörnli		5	5

Table 1. continued

Cultivar	Paducah	Quicksand	Lexington
Kasteln	5	3	6
Koralle	2	3	5
Kuhnert	6	6	6
Kurohime	6	4	5
Kyosume		3	1
Lenzburg	4	6	4
Liebegg	1	2	6
Lilacina		6	1
Madame Emily Mouillére	5	6	3
Madame Fousten Travouillon			6
Masja		5	5
Mathilda Gűtges	2	0	6
Merritt Supreme		6	5
Mereille	1		6
Monte Forte Perle	0	3	2
Nikko Blue		6	6
Oak Hill	6	2	6
Oregon Pride	2	5	6
Parzival		5	3
Penny Mac	6	4	5
Raymond Draps	3	3	6
Red Cap	0	4	2
Red Star	6	6	4
Regula	5	6	6
Rosarita	6	5	6
Rose Supreme	2	5	0
Rotdrössel		3	6
Schenkenburg	3	4	6
Souvenier du President Paul Doumer	4		6
Stafford	1	4	6
Tegerfelden	0	5	3
Teller White		6	6
Ticino	1	4	6
Trotsburg	3	3	1
Wartburg	4	5	4
Wildegg	5	5	6
Wildenstein	4	3	6

2006 Garden Flower Trials Results of Annual Flower Evaluations by Kentucky Master Gardeners

Robert G. Anderson, Department of Horticulture, County Horticulture Agents, and Master Gardeners from McCracken, Marshall, Warren, Allen, Hardin, Pulaski, Fayette, Boone, and Campbell Counties

Annual and perennial garden flowers have been evaluated for many years at the University of Kentucky. Trials have occurred at the University of Kentucky Arboretum since 1993. These trials were expanded at the Horticulture Research Farm in 1999 and 2000 with grants from the Kentucky Department of Agriculture, the Kentuckiana Greenhouse Association, and the USDA New Crop Opportunities Center.

Demonstration gardens have been established at eight locations across the state. We wish to thank the Extension agents and Master Gardeners at these garden locations for planting, maintaining and evaluating the annual flowers in these trials.

- Purchase Area Master Gardener Garden, Paducah
- Marshall Co. Master Gardener Garden, Benton
- Warren Co. Master Gardener Garden, Bowling Green
- Allen Co. Master Gardener Garden, Scottsville
- Hardin Co. Master Gardener Garden, Elizabethtown
- UK Arboretum, Lexington
- Boone Co. Master Gardener Garden, Burlington
- Campbell Co. Master Gardener Garden, Highland Heights
- Pulaski Co. Master Gardener Garden, Somerset

Please plan to visit these trial and demonstration gardens next year.

Selected annual flowers were grown in Lexington and distributed to the demonstration gardens in May. The Master Gardeners and Extension agents planted the flowers in their trial gardens and evaluated them three times during the summer (mid-July, mid-August, and mid-September). All gardens were mulched with wood chip mulch; drip irrigation was used throughout the summer and plants were fertilized during the summer. Plant performance was evaluated on a 1 to 5 scale with 1 = poor and 5 = excellent. The evaluation was based only on the individual gardener's determination of the quality of the plants. Although personal tastes are reflected in individual evaluations, the ratings in each garden reflect the average of 30 to 35 individuals. The demonstration gardens seem to be a good educational activity for the Master Garden educational program. It is the goal of this program to allow Master Gardeners to see new flowers and compare them to the reliable annual flowers seen in Kentucky gardens.

Photos and details about plant performance are continually added to the Kentucky Garden Flowers Web site at <http://www.uky.edu/Ag/Horticulture/gardenflowers>. You may also go to the UK home page <http://www.uky.edu> and search for a plant name; you will be directed to the Kentucky Garden Flowers location.

Common name and cultivar	Scientific name	Average Rating*
Ornamental Pepper—'Black Pearl'	Capsicum annuum	4.9
Petunia—'Tidal Wave Cherry'	Petunia x hybrida	4.7
Angelonia, Summer Snapdragon—'Serena White'	Angelonia angustifolia	4.5
Ornamental Pepper—'Medusa'	Capsicum annuum	4.5
Basil—'Purple Ruffles'	Ocimum basilicum	4.5
Ornamental Millet—'Jester'	Pennisetum glaucum	4.5
Angelonia, Summer Snapdragon—'Serena Lavender'	Angelonia angustifolia	4.4
Basil—'Sweet Dani'	Ocimum basilicum	4.3
Vinca—'Pacifica Red'	Catharanthus roseus	4.1
Dichondra—'Emerald Falls'	Dichondra micrantha	4.0
Begonia—'Prelude Pink'	Begonia x semperflorens-cultorum	3.9
Geranium—'Score Appleblossom'	Pelargonium x hortorum	3.8
Geranium—'Score Violet'	Pelargonium x hortorum	3.5
Nasturtium—'Whirlybird Mix'	Tropaeolum majus	3.5
Geranium—'Score Red'	Pelargonium x hortorum	3.4
Petunia—'Explorer Pink'	Petunia x hybrida	3.4
Petunia—'Daddy Strawberry'	Petunia x hybrida	3.1
Helichrysum—'Silver Mist'	Helichrysum microphyllum	2.9
Geranium—'Ringo Rose Star'	Pelargonium x hortorum	2.9
Blood Leaf—'Purple Lady'	Iresine herbstii	2.4

* Visual rating on a 1 to 5 scale with 1 = poor and 5 = excellent.

Evaluation of Garden Mum Cultivars—2006

Joe Ulrich, Department of Horticulture

Garden mums, also called hardy mums or chrysanthemums, are the No. 1 summer floricultural crop grown in Kentucky. Mums are relatively easy to grow and less capital intensive compared to other floricultural crops because they don't require a greenhouse structure. There are many cultivars of garden mums provided by several companies. Every year more cultivars are introduced to provide a wider array of colors, flower forms, better branching characteristics, and different dates of maturity. An evaluation, using a visual rating, of the performance of many common cultivars is reported here.

These trials were initiated in 2004 at the Horticulture Research Farm in Lexington. Four plants of 50 cultivars were planted in the middle of June. The 2005 cultivar trial was planted on June 16 in the same field. The mums were received as rooted cuttings from growers in central Kentucky. Ninety-six cultivars were planted with four plants representing each cultivar. The ground was mulched and Preen®, a pre-emergent herbicide, was applied at a rate of 1 ounce/10 square feet. Ammonium nitrate was side dressed at a rate of approximately 6 lbs/1,000 square feet soon after planting. A weekly liquid fertilizer application consisting of approximately one pound of 20-10-20 fertilizer per 1000 square feet was applied. Clear water irrigation was applied two to four times per week.

The 2006 trial was conducted by planting 62 garden mum cultivars, four plants per cultivar. The 62 cultivars represented many of the same cultivars from the previous year, but a few different cultivars were added for 2006. Another addition to the trials were 22 cultivars from the University of Minnesota breeding program that were traditionally selected for winter hardiness in their garden mum breeding program.

The 2006 trial was planted the last week of June. The plantings were done in the same soil beds as the 2004 and 2005 plantings. Hardwood mulch was in place on the beds throughout the summer and fall. Calcium nitrate was side dressed at 6 lbs/1,000 square feet and then ammonium nitrate was applied at the same rate about three weeks later. Additionally the plants were fertilized by a liquid feed of 20-10-20 weekly at a rate of about one pound/1,000 square feet. Irrigation and hand weeding were done on an as-needed basis.

The cultivars in this evaluation are separated into three groups. The first group is the plants that were planted in 2006

Table 1. Landscape performance of garden mum cultivars in 2006.

2006 planting	Sept. 8	Sept. 29	Oct. 10	Average Rating*
Alexis	5.0	4.5	4.5	4.7
Cheryl	5.0	4.5	4.5	4.7
Alberta	4.5	4.0	4.5	4.3
Vanessa	4.5	4.5	4.0	4.3
Dark Triumph	4.0	4.5	4.5	4.3
Bold Gretchen	4.0	4.5	4.5	4.3
Delightful Victoria	4.0	4.0	4.5	4.2
Denise	4.0	4.5	4.0	4.2
Glenda	4.0	4.0	4.0	4.0
Spicy Cheryl	4.0	4.0	4.0	4.0
Brigitte	3.5	4.0	4.5	4.0
Pam	3.5	4.0	4.5	4.0
Harmony	4.0	3.5	4.0	3.8
Beth	4.0	3.5	3.5	3.7
Bright Stephanie	3.5	3.5	4.0	3.7
Draga	3.5	3.5	4.0	3.7
Gretchen	3.5	3.5	4.0	3.7
Legend	3.5	4.0	3.5	3.7
Red Remarkable	3.5	4.0	3.5	3.7
Brandi	3.0	4.0	4.0	3.7
Tabitha	4.0	3.0	3.5	3.5
Bold Melissa	3.5	3.5	3.5	3.5
Golden Helga	3.5	3.5	3.5	3.5
Raquel	3.0	3.5	4.0	3.5
Cecilia	4.0	3.0	3.0	3.3
Jenna	3.0	3.5	3.5	3.3
Royal Lynn	3.0	3.5	3.5	3.3
Helen	3.5	3.0	3.0	3.2
Priscilla	3.5	3.5	2.5	3.2
Fiery Barbara	3.0	3.0	3.5	3.2
Flashy Gretchen	3.0	3.5	3.0	3.2
Grace	3.0	3.0	3.5	3.2
Thetis Yellow	4.0	2.5	2.5	3.0
Festive Ursula	3.5	3.0	2.5	3.0
Erica	3.0	2.5	3.0	2.8
Carmella	3.0	3.0	2.5	2.8
Bethany	3.5	2.5	2.0	2.7
Ursula	3.5	2.5	2.0	2.7
Camille	3.0	2.5	2.5	2.7
Julia	3.0	2.5	2.5	2.7
Bravo	2.5	3.0	2.5	2.7
Natalie	2.5	3.0	2.5	2.7
Okra	2.5	2.5	3.0	2.7
Lydia	3.5	2.0	2.0	2.5
Gentle Alberta	3.0	2.0	2.5	2.5
Emily	2.5	2.5	2.5	2.5
Blushing Emily	2.5	2.5	2.5	2.5
Dark Grenadine	2.5	2.5	2.5	2.5
Jessica	2.5	2.5	2.5	2.5
Radiant Lynn	2.0	2.5	3.0	2.5
Debonair	3.0	2.0	2.0	2.3
Barbara	2.5	2.0	2.5	2.3
Glowing Lynn	2.5	2.0	2.5	2.3
Hot Salsa	2.5	2.5	2.0	2.3
Dazzling Stacy	2.5	2.0	2.0	2.2
Lisa	2.5	2.0	2.0	2.2
Zesty Barbara	2.0	2.0	2.5	2.2
Donna	2.0	2.0	2.0	2.0
Nicole	2.0	2.0	2.0	2.0
Bianca	2.0	1.5	2.0	1.8
Golden Marilyn	1.5	1.5	1.5	1.5
Sunny Marilyn	1.0	1.5	1.5	1.3
Minnesota Cultivars				
Purple Pride	3.5	4.0	4.0	3.8
Lemonsota	3.5	4.0	3.5	3.7
Ruby Mound	3.0	4.0	4.0	3.7
Dorothy Degn	3.5	3.5	3.5	3.5
Rose Grenadine	3.0	3.5	4.0	3.5
Starlet	3.0	3.5	3.0	3.2
Happy Face	4.0	2.5	2.5	3.0
Small Wonder	3.0	3.0	3.0	3.0
MinnAutumn	3.0	3.0	3.0	3.0
Cajun Spice	3.0	3.0	2.5	2.8
Grape Glow	2.5	2.5	3.0	2.7
Zonta	2.5	2.5	3.0	2.7
MinnRuby	2.5	2.5	2.5	2.5
Maroon Pride	2.5	2.5	2.5	2.5
Peach Centerpiece	2.5	2.5	2.5	2.5
Betty Lou	3.0	2.0	1.5	2.2
Autumn Sunset	2.5	2.0	2.0	2.2
MinnWhite	2.0	2.0	2.0	2.0
Cameo	2.0	2.0	2.0	2.0
MinnYellow	2.0	2.0	1.5	1.8
Rose Blush	1.5	1.5	1.5	1.5
Sesquicentennial	1.5	1.5	1.5	1.5
2004-2005 Cultivars plantings				
Bold Gretchen	5.0	5.0	5.0	5.0
Cecilia	5.0	4.5	4.5	4.7
Legend	4.0	4.0	4.5	4.2
Helen	4.0	4.0	4.0	4.0
Donna	3.5	4.0	4.0	3.8
Beth	4.0	3.5	3.5	3.7
Bianca	3.5	3.0	3.5	3.3
Festive Ursula	3.0	3.5	3.5	3.3
Zesty Barbara	3.0	3.0	3.5	3.2
Jenna	2.5	3.0	3.5	3.0
Ursula	3.5	2.5	2.5	2.8
Barbara	3.5	2.5	2.5	2.8
Thetis Yellow	3.0	2.5	2.5	2.7
Caesar Bronze	2.0	2.0	2.0	2.0

* Visual rating on a 1 to 5 scale with 1 = poor and 5 = excellent.

that are commercial cultivars commonly raised in Kentucky. The second group is plants that were planted in 2006 that represent the University of Minnesota breeding program. The third group is made up of the plants that had survived from the previous year's plantings.

Cultivars were evaluated for visual performance on September 8, September 29 and October 10 (Table 1). Plant performance was evaluated on a 1-to-5 scale (1= poor and 5= excellent). The ratings were based on branching habits, number of flower buds, aesthetic quality, disease resistance, and flower durability. There was slightly more above-average cultivars than below-average cultivars. This demonstration showed the improvements in the newer cultivars and the wide range of colors and shapes that are available to growers. The significance of this evaluation is to provide garden mum growers the information to select cultivars that will perform well for the consumer.

Do Garden Mums Cultivars have Winter Hardiness in Central Kentucky?

Joe Ulrich, Robert Anderson, and Kirk Ranta, Department of Horticulture

Nature of Work

Garden chrysanthemums, *Dendranthema x grandiflora*, are a major fall flower crop in Kentucky. Many cultivars have been developed over the last 20 years by mum breeding companies. Modern cultivars have been selected to provide different colors, flower shapes, and self pinching plants. However, winter hardiness has not been evaluated by most breeders, with the exception of the University of Minnesota's breeding program. Garden mums were called 'hardy mums' for many years, but because of the inconsistent ability of the mums to survive the winter, suppliers started to use the term 'garden mums' instead of hardy mums.

A garden mum cultivar trial was initiated at the University of Kentucky's Horticulture Research Farm in 2004. Four plants of 50 cultivars were planted in the middle of June. The mums were received as rooted cuttings from growers in central Kentucky. Mums were planted in an open flat field of well-drained Maury silt loam soil; no winter protection was provided. The 2005 cultivar trial was planted during the middle of June in the same field. Ninety-six cultivars were planted with four plants of each cultivar. In 2006, 62 garden mum cultivars were planted in the same beds the last week of June, replacing the mums that didn't survive the previous winter. The 62 cultivars represented many of the same cultivars from the previous year, but a few different cultivars were added for 2006. Additionally, 22 cultivars from the University of Minnesota breeding program were added. These cultivars have been selected for winter hardiness; this addition will help determine whether winter hardiness results are due to genetic or environmental factors.

The cultural management program was based on a combination of traditional in-ground garden mum production and landscape techniques. In 2005, the ground beds were covered with hardwood mulch. Preen®, a pre-emergent trifluralin herbicide, was applied at a rate of 1 oz./10 square feet. Ammonium nitrate was side dressed onto the beds at a rate of approximately 6 lbs/ 1,000 square feet soon after planting. A weekly liquid fertilizer application consisting of approximately one pound of 20-10-20 fertilizer was applied. Clear water irrigation was applied two to four times per week as weather warranted. In 2006, calcium nitrate was side dressed at 6 lbs/1,000 square feet and then ammonium nitrate was applied at the same rate about three weeks later. Additionally the plants were fertilized by a liquid feed of 20-10-20 weekly at a rate of about 1 pound / 1000 square feet. Irrigation and hand weeding were done on an as-needed basis. Lists of the cultivars grown and years planted are shown in Table 1. The plants were evaluated for winter hardiness by May of the following year after plants went through a winter. The dead growth from previous year is not removed until June so that all plants have adequate time for emergence.

Results and Discussion

Garden mums have limited winter hardiness in central Kentucky. Only 1.5 percent of the plants (3 of 200) survived the winter of 2004-2005; two were from the variety 'Beth' and one from 'Golden Helga' (Table 1).

In the spring of 2006, 6.2 percent of the plants (24 of 385) survived the winter of 2005-2006. Plant growth during the summers of 2004 and 2005 was normal; plants were somewhat smaller in 2004 than 2005. Of the three plants that survived the first winter, two plants of 'Beth' survived the winter of 05-06 along with the two new 'Beth' plants started in 2005. Plants of three cultivars, 'Helen,' 'Legend,' and 'Zesty Barbara,' survived the second winter after dying during the first winter. Ten cultivars had plants survive the second winter, but were not part of the first winter trial. All four of 'Beth' and 'Ursula' plants survived the second winter, while three 'Bianca' plants survived.

The winter of 2004-2005 was warmer than normal or normal all months except March (Table 2). The precipitation was above normal, 4.74 inches, the first three months of that winter, but 1.90 inches below normal the last two months of that winter.

The winter of 2005-2006 was also above normal or normal in temperature all months except December. The precipitation was below normal all months except for January when it was also 12°F above normal. Evaluations will continue through the next two winters for the collection of more information on winter hardiness in garden mums.

Table 1. Garden mum cultivars grown in winter hardiness trials in 2004, 2005 and 2006 and the number of plants (in parentheses) surviving the following spring.

	2004	2005	2006
Adonis Purple		X	
Agapi Pink		X	
Alberta		X	X
Alexis			X
Amata Purple	X		
Amor Dark Pink		X	
Amor Spider White	X		
Anna		X	
Argos Orange	X	X	
Armor Pink	X		
Armor White	X		
Autumn Sunset			X
Barbara		X (2)	X
Beth*	X (2)	X (4)	X
Bethany			X
Betty Lou			X
Bianca		X (3)	X
Blushing Emily		X	X
Bobwhite White		X	
Bold Gretchen		X (1)	X
Bold Melissa			X
Brandi	X	X	X
Bravo		X	X
Bright Stephanie		X	X
Brigitte		X	X
Caesar Bronze		X (1)	
Cajun Spice			X
Cameo			X
Camille		X	X
Camina		X	
Carmella			X
Castor Yellow	X	X	
Cecilia		X (1)	X
Cesaro		X	
Cheryl		X	X
Christine		X	
Dark Grenadine		X	X
Dark Triumph	X	X	X
Dazzling Stacy	X	X	X
Debonair	X	X	X
Delightful Victoria		X	X
Denise		X	X
Donna		X (1)	X
Dorothy Degn			X
Draga			X
Emily		X	X
Erica			X
Feniks Bronze		X	
Festive Ursula		X (1)	X
Fiery Barbara		X	X
Firecracker Yellow	X		
Flashy Gretchen			X
Gelati		X	
Gentle Alberta			X
Ginger	X	X	
Glenda		X	X
Glowing Lynn		X	X
Gold Crest Yellow	X	X	
Gold Finch Yellow	X		
Golden Helga	X (1)	X	X
Golden Marilyn		X	X
Golden Spotlight	X		
Gothic Purple	X	X	
Grace		X	X
Grape Glow			X
Gretchen	X	X	X
Happy Face			X
Harmony	X	X	X
Heidi	X		
Helen	X	X (2)	X
Helga	X		
Hermes Purple		X	
Hot Salsa		X	X
Iduna Bronze	X		
Jambo		X	
Janice	X	X	
Jason White	X	X	
Jenna		X (1)	X
Jennifer	X	X	
Jessica	X	X	X
Julia		X	X
Juno Yellow		X	
Legend	X	X (1)	X
Lemonsota			X
Linda	X	X	
Lisa		X	X
Lucera		X	
Lydia			X
Manakin Red		X	
Marilyn		X	
Maroon Pride			X
Mars Orange		X	
Megan	X	X	
Messina		X	
Minerva White	X		
Minn Autumn			X
Minn Ruby			X
Minn White			X
Minn Yellow			X
Mithra Maroon		X	
Natalie	X	X	X
Natasha	X		
Nicole	X	X	X
Okra	X	X	X
Pam		X	X
Patricia	X		
Peach Centerpiece			X
Pluto Red	X	X	
Priscilla			X
Purple Pride			X
Radiant Lynn		X	X
Raquel		X	X
Red Remarkable		X	X
Rhapsody	X		
Rio Dark Pink	X		
Rose Blush			X
Rose Grenadine			X
Rosepink Debonair		X	
Rosy Victoria		X	
Royal Lynn		X	X
Ruby Mound			X
Sesquicentennial			X
Small Wonder			X
Soft Lynn	X		
Spicy Cheryl		X	X
Spotlight	X	X	
Stacy		X	
Starlet			X
Stephanie		X	
Sunduro		X	
Sunny Bianca		X	
Sunny Brigitte		X	
Sunny Denise		X	
Sunny Gretchen	X		
Sunny Marilyn		X	X
Sunny Robin	X		
Sunny Ursula	X		
Sweet Jeanette		X	
Symphony	X		
Tabitha	X	X	X
Thetis Yellow		X (1)	X
Tracy		X	
Ursula		X (4)	X
Vanessa		X	X
Vicki		X	
Warm Megan		X	
Yellow Ginger	X		
Yellow Triumph	X		
Zesty Barbara	X	X (1)	X
Zonta			X

* Two 'Beth' plants survived winter 2004-05, and only two additional plants were added in 2005. All four of the plants then survived winter 2005-06.

Table 2. Weather data for winter 2004-05 and 2005-06 in Lexington.

Year	Month	Average temp. (°F)	Minimum Temp. (°F)	Departure from normal (°F)	Days <=32°F	Total precipitation (inches)	Departure from normal (inches)
2004	November	50	29	+5	5	6.95	+3.56
	December	36	6	0	19	3.69	-0.29
2005	January	37	6	+6	18	4.33	+1.47
	February	40	19	+5	17	2.22	-0.99
	March	41	17	-3	18	3.49	-0.91
	November	48	12	+3	10	1.92	-1.47
	December	32	9	-4	23	2.40	-1.58
2006	January	43	22	+12	12	5.37	+2.51
	February	36	4	0	21	2.13	-1.08
	March	45	19	+1	13	4.17	-0.23

Notes on New Plants at the Arboretum

Sharon Bale, Department of Horticulture

Most people interested in Horticulture have an interest in seeing new, different, or unfamiliar plants. My responsibilities are mostly centered on annual and perennial flowers. In this day and time so many "new" plants are hitting the market it is very difficult, if not impossible, to keep up with them.

There are three main ways "new" flowers make their way to the Arboretum. First, the All-America Selections Trial Garden. Plants that eventually are determined as AAS winners are often observed for their performance for two to three years before they are released to the trade. Second, businesses such as Proven Winners and seed companies such as Jelitto, Benary and Goldsmith will send us products to evaluate. And finally, visiting other gardens and "shopping" also adds the new and different to the collection. The following are some comments regarding plants evaluated in the Arboretum in 2006.

AAS Winners

- *Diascia* 'Diamonte Coral Rose'—Good performance for a Diascia
- *Dianthus* 'Supra Purple—Excellent deep color, some hardiness
- *Nicotiana* 'Perfume Deep Purple'—Performs equal to other Nicotianas, color is unique and attractive
- *Salvia farinacea* 'Evolution'—Good color, good habit, a nice plant
- *Zinnia* 'Zowie!™ Yellow Flame'—Zowie is right, the color combination really attracts attention. The plant has the same disease issues as other *Zinnia elegans*, but the color and cut flower potential make this plant special.

Proven Winners

Proven Winners are trademark plants. The Horticulture Department has no particular preferred endorsement of this company; it simply sends us the product. We would happily accept plant material from other sources. Those that attracted the most attention were:

- *Agastache* 'Color Spires Hot Pink'—A very nice show in the garden. Extended period of bloom and attracted very favorable comments.
- *Chrysocephalum apiculatum* 'Flambe Orange and 'Flambe Yellow'—Commonly called nullabor or golden buttons, it is new to the Arboretum. The small button blooms are produced all season. There are no apparent disease or pest problems and no particular maintenance requirements. Both were quite attractive. I'd like to see these again.
- *Cyperus* 'King Tut' and Cyperus 'Baby Tut'—Both were exceptional additions to the garden for their foliage effect. Although generally thought of as water loving plants, both performed well under general garden conditions. These are a great addition to the garden for texture and cut stem use.
- *Cuphea* 'Flamenco Samba'—A unique bloom, plants performed well, an excellent display.
- *Eupatorium* 'Elegant Feathers'—One day I would be intrigued by this plant, another day I would wonder "when is it going to *do* something?" "Elegant Feathers" is a good description. About 5 feet tall, this plant is very showy late in the season and worth consideration. I just had to cut some. It will hold its own for back-of-the-border texture through most of the season and then puts on a very nice show.
- *Lantana* 'Citrus Blend'—Good habit, nice color blend and very "bright".
- *Oxalis* 'Zinfandel'—Nice color contrast between the burgundy foliage and yellow flowers.
- *Petunia* 'Supertunia® Raspberry Blast' and 'Supertunia® Double Peppermint'—The performance is fine, and the colors of both are outstanding. Both of these would attract a lot of attention in a hanging basket or container.
- *Salvia* 'Golden Delicious'—If you like the trailing lime green color of 'Margarita' sweet potato then this plant is for you for a vertical effect. Big plant, bold color. Frost hit a little early this year and damaged the plant just as it was coming into bloom. I think I can predict that the color combination of red blooms and yellow foliage would have stopped people in their tracks.

There were other Proven Winners in the garden, but those listed above were the showiest. Remember to visit the Arboretum during the season, when something "new or different" to you might just attract your attention.

Update of Industry Support for the University of Kentucky Nursery and Landscape Program

The UK Nursery/Landscape Fund provides an avenue for companies and individuals to invest financial resources to support research and educational activities of the University of Kentucky to benefit the industry. The majority of UK Nursery/Landscape Fund contributions are used for student labor and specialized materials and equipment. These investments have allowed us to initiate new research and to collect more in-depth data than possible before.

All contributors are recognized by listing in the annual report and in a handsome plaque that is updated annually and displayed at the Kentucky Landscape Industry Trade Show and in the UK Agricultural Center North Building. Giving levels are designated as Fellows ($10,000 over 10 years), Associates (>$500 annual contribution), 100 Club members (≥$100 annual contribution), and Donors (<$100 annual contribution). Fifteen individuals and companies have contributed or pledged to at least $10,000 each over a 10-year period. Those contributing at this level are Nursery/Landscape Fund/Endowment Fellows and may designate an individual or couple as University of Kentucky Fellows and members of the Scovell Society in the College of Agriculture.

The Research Challenge Trust Fund was created by the Kentucky General Assembly as part of the "bucks for brains" program to provide state funds to match private contributions toward endowments to support research. Several Kentucky nursery/landscape industry leaders have seized the opportunity and made a significant and long-lasting impact on research to support our industry. Three named endowments and a general endowment have been established. This year, income from this family of endowments provided over $12,000 to support research for our industry. Results from many of the research projects in this report were partially supported by these funds.

Named endowments include:

- James and Cora Sanders Nursery/Landscape Research Endowment, provided by the Sanders Family and friends,
- Don Corum and National Nursery Products Endowment, funded by Bob Corum, and
- Ammon Nursery/Landscape Research Endowment, established by Richard and Greg Ammon.

The General UK Nursery/Landscape Research Endowment was established with donations from several individuals and companies, which were matched with state funds.

The Robert E. McNiel Horticulture Enrichment Fund is being endowed to honor Dr. McNiel and to provide support for faculty and student travel on our study tours and for national student competitions. We must raise the remaining $3,200 by February 2007 to secure the $50,000 match from state funds.

Those individuals and companies contributing to the UK Landscape Fund in 2006 (through November 1) are listed in this report. Your support is appreciated and is an excellent investment in the future of the Kentucky nursery and landscape industries.

Contributions to support the UK Nursery/Landscape Program may be made to the annual gift account for immediate expenditure in the program or may be made to any one of the currently established endowments. Also, the Research Challenge Trust Fund is available to provide the 1:1 match for additional endowments. It is possible for several individuals and companies to pool their commitments to be contributed over five years to reach the $50,000 minimum required for a match. For more information on how to contribute to an endowment or the annual giving program, please contact Dewayne Ingram at 859-257-1758 or the UK College of Agriculture Development Office at 859-257-7200.

UK Nursery and Landscape Fund and Endowment Fellows

Gregory L. Ammon
Ammon Wholesale Nursery

Patrick A. and Janet S. Dwyer
Dwyer Landscaping Inc.

Robert C. and Charlotte R. Korfhage
Korfhage Landscape and Designs

L. John and Vivian L. Korfhage
Korfhage Landscape and Designs

Herman R.* and Mary B.* Wallitsch
Wallitsch Nursery

Daniel S.* and Saundra G. Gardiner
Boone Gardiner Garden Center

Bob and Tee Ray
Bob Ray Company

Stephen and Chris Hillenmeyer
Hillenmeyer Nurseries

Larry and Carolyn Sanders
James Sanders Nursery Inc.

Robert* and Janice Corum
National Nursery Products

Herman, Jr., and Deborah Wallitsch
Wallitsch Nursery

Richard and Shirley Ammon
Ammon Landscape Inc.

**deceased*

2006 Contributors to the UK Nursery/Landscape Fund and Endowments

(through November 1)

Associates ($500 or more)

Winston Dunwell

Pat Dwyer, Dwyer Landscaping Inc.

Dan R. Ezell

Amy Fulcher

Louis Hillenmeyer

Todd Ryan, Valley Hill Nurseries Inc.

Larry and Carolyn Sanders, James Sanders Nursery Inc.

Richard Weber, Springhouse Gardens, L.L.C.

Bob Westerman, Premium Horticultural Supply Co. Inc.

100 Club ($100 or more)

Pamela W. Basconi

Jack Buxton

Bill Henkel, Henkel Denmark Inc.

Sandy Richardson, Spring Hill Nurseries Inc.

Glenn Yost

B.G. and Carole Hubbs, Community Tree Care Inc.

Donor (less than $100)

Dewayne Ingram

Annette and Stan Martin, Windy Ridge Nursery Inc.

Vernon A. Sims

Industry Organizations

Kentucky Landscape Industries Trade Show

Kentucky Nursery and Landscape Association

Western Kentucky Nursery and Landscape Association

Appreciation is expressed to the following companies for the donation of plants, supplies, and other materials or project support funds:

Alex-tronix Controls, Fresno, Calif.
Ammon Wholesale Nursery, Burlington
Ball Seed Company, W. Chicago, Ill.
Bernheim Aboretum and Research Forest, Clermont
Center for Applied Nursery Research, Deering, Ga.
David Leonard, Consulting Arborist, Lexington
DeVroomen Holland, Morrow, Ga.
Femrite Nursery, Aurora, Ore.
Friends of the UKREC, Princeton
Harrell's Fertilizer Inc., Lakeland, Fla.
Hillcrest Nursery, Richmond
Holmlund Nursery, Boring, Ore.
J. Frank Schmidt Nursery, Boring, Ore.
Jelitto Seeds, Louisville
Kit Shaughnessy, Kit Shaughnessy Inc., Louisville
Larry Hanks, Consulting Arborist, Lexington
Oaks Pavers, Cincinnati, Ohio
Oldham County Nursery, Brownsboro
Phytotektor, McMinnville, Tenn.
Rainbow Treecare Scientific Advancements, Minneapolis, Minn.
Red Barn Greenhouses, Nicholasville
Reemay Inc., Old Hickory, Tenn.
Robinson Nursery, Amity, Ore.
Snow Hill Nursery, Shelbyville
Sungro Horticulture, Bellevue, Wash.
Tennessee Valley Nursery, McMinnville, Tenn.
The Scotts Company, Marysville, Ohio
UK Physical Plant Division, Grounds Department
Waterford Valley Nursery, Taylorsville
Wilson's Nursery, Pleasureville

Grants for specific projects have been provided by:

Ground Masters, Hebron
Kentucky Horticulture Council Inc.
Kentucky Agricultural Development Board
Kentucky Nursery and Landscape Association
Rainbow Treecare Scientific Advancements
Urban and Community Forestry Program, Kentucky Division of Forestry
UK Integrated Pest Management Program
UK New Crop Opportunities Center
UK Nursery/Landscape Fund
USDA Animal and Plant Health Inspection Service
USDA Cooperative Agricultural Pest Survey
USDA Forest Service

UK
UNIVERSITY
OF KENTUCKY

The College of Agriculture is an Equal Opportunity Organization
Issued 12-2006