PR-520

UK AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF KENTUCKY—COLLEGE OF AGRICULTURE

Nursery and Landscape Program

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

About Our Cover

The cover photo shows the 2005 Theodore Klein Plant Award Winner *Hakonechloa macra* 'Aureola' Golden Japanese Forest Grass, in Dan Hinkley's Heronswood Nursery and Garden in Kingston, Washington <http://www.ca.uky.edu/HLA/Dunwell/HakmacAureola.html>

Hakonechloa macra 'Aureola' Golden Japanese Forest Grass is a proven winner for Kentucky landscapes. It can be seen across the United States in private and public gardens. The foliage of 'Aureola' has strips of green running the length of the yellow-gold foliage. The bright contrast of the foliage against green plants shows like a beacon in the garden, attracting one's line of sight. The USDA hardiness zones for *Hakonechloa macra* 'Aureola' are 5 to 9, and it favors zone 7. The cultivar 'Aureola' does well in Kentucky's zone 6 when grown in a light shade with moist soil environment. It loses some of its yellow-gold foliage color in dense shade. The plant is propagated by division and is slow growing. The foliage does have a pinkish red fall color and is bronze in winter. It becomes twice as wide as tall and is frequently found at about one foot tall by three feet wide.

UK Nursery and Landscape Program

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Nursery and Landscape Program

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The cost of publishing this research report is shared by the UK Department of Horticulture, the Kentucky Agricultural Experiment Station, the Kentucky Cooperative Extension Service, the Nursery/Landscape Research Fund and a Kentucky Agricultural Development Fund grant from the Kentucky Horticulture Council Inc.

Contents

UK Nursery and Landscape Program Overview—2005

Dewayne Ingram, Chair, Department of Horticulture

The UK Nursery and Landscape Program is the coordinated effort of faculty, staff, and students in several departments in the College of Agriculture for the benefit of the Kentucky nursery and landscape industry. Our 2005 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 degree programs that are addressing the needs of the nursery and landscape industries.

Extension Highlights

During 2005, a Nursery Crops Scouting Program was initiated by the UK Nursery Crops team for Kentucky nursery producers. This program was funded by the Kentucky Horticulture Council through a grant from the Agriculture Development Board and by a grant from Kentucky Integrated Pest Management. The program was developed, in part, to increase knowledge of nursery pests, adapt scouting techniques to nursery crop production, and empower nursery crops growers to achieve a higher level of pest management. The program combines earlier efforts of compiling documented thresholds for specific nursery pests and current control options in the IPM for Deciduous Tree Production Calendar, with detailed information of when and how to scout each pest. With both the calendar and the scouting guide, growers have comprehensive information on integrated pest management for the most common pests of deciduous trees.

The Nursery Crops Scouting Program began with selecting nurseries to participate in the program. Nurseries were identified and selected based on their ability to provide a range of deciduous trees at a two-year stage, appropriate pesticide record keeping, and ability to fit into one of three spray frequency categories. Nurseries were selected such that high, medium, and low spray frequencies were represented. Weekly scouting sessions were implemented beginning the first week of April and continuing through July. The scout visited each nursery three weeks out of every four-week period. For more detailed information on scouting methodology, please see the "Pilot Nursery Crops Integrated Pest Management Scouting Program" article in this report. Each scouting session ended with a report to each participating nursery, which included pest population levels for the relevant pests, trap counts, new pest sightings, and any cultural observations deemed useful.

The program will be continued in 2006, and our expanded goals include increasing the distribution of information gathered at scouting sessions. For more information on how your nursery can benefit from this program, please call Amy Fulcher, Extension Associate for Nursery Crops, 859-257-1273.

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 2004-2005. The Horticulture Plant and Soil Science degree program has more than 100 students in the fall semester of 2005, of which almost one-half are Horticulture students and another one-third are turfgrass students. Sixteen Horticulture students graduated in the 2004-2005 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 2005:

- A 17-day study tour in Pacific Northwest states was led by Drs. McNiel, Dunwell, and Geneve involving 14 students.
- Horticulture and Landscape Architecture students competed in the 2005 Professional Landcare Network (PLANET) Career Day competition at the University of Maryland in March (Drs. Robert McNiel and Robert Geneve, faculty advisors).
- Students accompanied faculty to regional/national/international meetings, including the American Society for Horticultural Science Annual Conference and the Kentucky Landscape Industries Conference and Trade Show.

Graduate Program Highlights

The demand for graduates with M.S. or Ph.D. degrees in Horticulture, Entomology, Plant Pathology, Agricultural Economics, and Agricultural Engineering is high. Our M.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.

Somatic Embryo Development in Willow Oak

Sara Wells, Sharon Kester, and Robert Geneve, Department of Horticulture

Nature of Work

Willow oak (*Quercus phellos*) is an important landscape plant and forestry tree generally propagated by seed for commercial production. Willow oak can be propagated from cuttings taken from juvenile stock plants; however, this does not allow for selection of mature characteristics such as autumn color, tree shape, winter hardiness, or ease of production.

Somatic embryogenesis is the creation of an embryo from vegetative rather than sexual reproduction. It would allow for the mature mother plant to be rejuvenated into a juvenile form for cutting propagation while still having the clonal characteristics desired (3). Somatic embryogenesis has been reported in a number of oak species with the majority of the work being performed in English (*Q. robur*) and cork oak (*Q. suber*). In these species, the frequency of somatic embryo induction is between 80 and 100% from immature zygotic embryo explants but less than 15% using seedling leaf tissue (8). However, regardless of the initial source, somatic embryo maturation, conversion, and germination have been difficult. Often the somatic embryo forms shoots or roots only, and complete recovery of plants is at a low frequency (8).

Typical treatments used to enhance normal somatic embryo formation and encourage conversion include abscisic acid (ABA) and altering the osmotic potential of the medium using sucrose, mannitol, and sorbitol. Treatments used to stimulate germination in oaks are cytokinins and gibberellic acid (8). The objective of this research was to investigate the effects of ABA, cytokinin, gibberellic acid, and sucrose concentration on development of somatic embryos derived from immature cotyledons of willow oak.

Acorns were collected in August and surface sterilized in 10% bleach for 15 minutes, followed by a dip in 70% ethanol and rinsed three times with sterile water. Cotyledon halves from the zygotic embryo were placed on MS (6) basal media in Petri plates containing 1µM benzyladenine (BA) and 0, 1, 5, or 10 µM naphthaleneacetic acid (NAA). These plates were then placed under cool white fluorescent lights (16 hr lighted photoperiod, PAR 60 $\mu mol \cdot sec^{-1} \cdot m^{-2}$) at 21°C. Explants were transferred to MS media containing no growth regulators every three weeks until somatic embryos formed.

Somatic embryos that reached the cotyledon stage were moved to media containing ABA (0, 1, or 5 µM), GA_3 (0, 10, or 50 µM), or BA (0, 1, or 10 µM) in combination with 30 or 60 grams per liter of sucrose. Shoot and root development was evaluated after two months.

Results and Discussion

Somatic embryos formed at all concentrations of BA and NAA evaluated, with the greatest percentage being produced at 5 µM NAA (45%). Those at 10 µM NAA produced somatic embryos at 11%, and there was no difference between 1 µM NAA and the control (4%).

The use of ABA or GA_3 only slightly increased the number of somatic embryos producing a root or a shoot (Table 1). On average, there was no difference between the two concentrations of sucrose. However, the highest frequency was seen using 50 µM GA_3 and 6% sucrose. Including BA in the media had no effect on shoot or root production (data not shown).

Table 1. Percentage of somatic embryos forming a root or shoot after two months on MS media containing combinations of sucrose with abscisic acid or gibberellic acid.

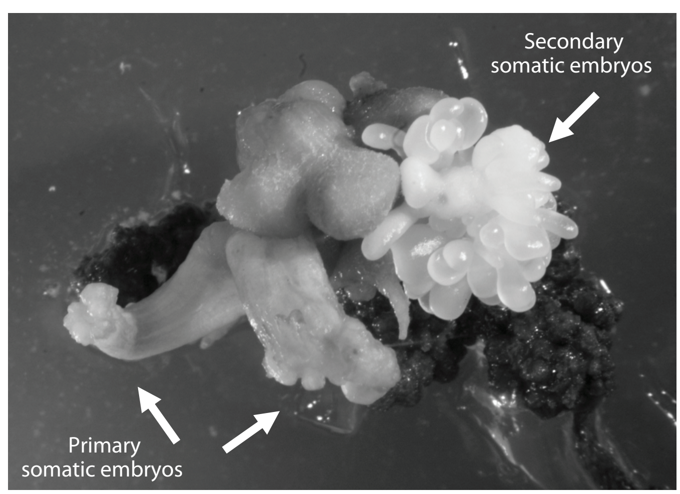
Growth Regulator (µM)		Sucrose Concentration (%) 3	6
ABA	0	15%	6%
	1	4%	18%
	5	7%	0%
GA_3	10	6%	16%
	50	20%	24%

Somatic embryos producing either a root or shoot were more frequent than the development of a seedling producing both. Seedlings having both a radicle and a shoot were transferred into a perlite and peat potting mix under high humidity, but none of the seedlings developed into plantlets.

NAA was effective at inducing somatic embryos in willow oak. NAA is often more effective than 2, 4-D at inducing somatic embryogenesis in various oak species (8). An auxin source was important in inducing primary somatic embryogenesis in willow oak, but secondary somatic embryos formed readily and repeatedly on basal medium without growth regulators (Figure 1).

ABA is often used during somatic embryogenesis to promote more normal embryo development, but ABA usually

Figure 1. Secondary somatic embryo formation in oak after three months.



inhibits embryo germination. Therefore, it was unexpected that ABA would promote shoot and root growth (Table 1). In cork oak, ABA reduced the development of new secondary embryos (1). It is possible that by suppressing secondary somatic embryo formation, ABA allowed the continued development of the primary embryo that allowed it to germinate.

GA_3 can be used to promote germination in slowly developing somatic embryos. Previous work with other oak species showed that GA_3 had a minimal effect at promoting somatic embryo germination (4, 5, 7). More often, BA has been shown to stimulate shoot and root growth in oak (8). However, in willow oak BA was ineffective at promoting germination, while GA_3 was as effective as ABA (Table 1).

Doubling the sucrose concentration did not consistently impact somatic embryo development or germination, but there was a trend toward a higher frequency of embryos with roots or shoots when grown at 6% sucrose (Table 1). Sucrose plays the dual role of providing a carbohydrate source for growth and acting as an osmoticum. It is possible that the sucrose concentration used in this work was not high enough to impact embryo development. Using cork oak, Garcia-Martin et al. (2) found that 150 g/L of sucrose allowed 75% of the somatic embryos to convert to seedlings. This conversion rate is comparable to the improvement in conversion of English oak to 83% found by slowly drying somatic embryos for three weeks prior to germination (8).

To date, no plantlets have been recovered from willow oak via somatic embryos. Future research will focus on adjusting the water potential of the somatic embryo by drying or exposure to high osmotic concentrations to promote more normal seedling development.

Significance to the Industry

Oaks are important nursery and forestry species. Most oaks are propagated by seeds because they are difficult to root from cuttings, and many oaks experience delayed graft incompatibility. This severely limits availability of superior cultivars for the nursery trade. The ability to propagate superior mature clones of oak would result in increased selection and therefore profitability for oak liner and shade tree production. Recently, growers have begun to propagate some oak species (including willow oak) using cuttings from juvenile stock plants. The ability to regenerate mature oaks via somatic embryogenesis would produce juvenile stock plants from superior trees, which in turn could be used as a source for cutting propagation. The current research addresses some of the limiting steps toward achieving the goal of obtaining plants through somatic embryogenesis in North American oaks.

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Pilot Nursery Crops Integrated Pest Management Scouting Program

Amy Fulcher, Winston Dunwell, Dava Hayden, Robert McNiel, and Derrick Hammons, Department of Horticulture

Nature of Work

In 2005, a Nursery Crops Scouting Program was initiated through the support of Kentucky IPM and a Kentucky Horticulture Council grant from the Kentucky Agricultural Development Board. The Nursery Crops Scouting Program is in phase one of a four-year plan, with the following goals:

1. Provide Kentucky-specific IPM techniques, strategies, and thresholds for nursery crops.
2. Empower growers and their employees to increase their level of pest management by using IPM techniques such as scouting and pest identification, nutrient monitoring, economic thresholds, and reduced toxicity as well as biological control methods.
3. Examine the relationship between pest population levels and resulting plant damage. Compare pest control and the related plant quality at production settings with high, moderate, and low pesticide application frequency.
4. Safeguard human and environmental health by increasing awareness and knowledge of pesticide toxicity, avoiding human exposure to pesticides, leaching potential, volatilization, and solubility.

The long-range goal of the Nursery Crops Scouting Program is to use the information mentioned above to create a decision-making tool based on the relationship between pest population levels and plant aesthetics. This tool would assist new growers is making difficult pest management decisions and would assist all nurseries in training employees and in initiating a more precision-oriented and knowledge-based pest management strategy.

The first step in creating the decision-making tool was to create and compile nursery scouting methodology for the program's scout to use at partner nurseries in order to efficiently assess the weekly pest status. The Nursery Scouting Guide includes a weekly "to do" list for the months of February through September. The companion to this is the Nursery Pest Scouting Reference, which lists detailed instructions for each pest regarding which plants to scout, where on the plant to look, what symptoms and signs to assess, pheromone lures to use, etc. Links to the Nursery Crops Scouting Guide and Nursery Pest Scouting Reference as well as scouting forms can be found at http://www.ca.uky.edu/HLA/Dunwell/KHC/NurseryUpdate.html.

Results and Discussion

While additional seasons of data collection and assessment are necessary to meet the goals of the Nursery Crops Scouting Program, the following observations were made in 2005 and may be of assistance to growers:

- Maple spider mites hatch and move to the small leaves that are closest to the trunk early in the season, progressing toward the tip of the branch as the season progresses. These small interior leaves are the best place to select leaves when scouting early in the season.
- Maple spider mite, honeylocust spider mite, and Eastern tent caterpillar presence varied widely among nurseries in the program.
- Trap counts reinforce finds from previous work (1), which demonstrate that peachtree borer and lesser peachtree borer have long periods and can be a threat to nurseries over a significant portion of the growing season. Growers experiencing borer damage may need to trap to determine if controls are in place the entirety of the flight period.
- Potato leafhopper populations developed on red and Freeman maples sufficient to cause foliar hooding and deformation very quickly and at thresholds lower than previously established action thresholds suggest (2).
- Honeylocust spider mites increased from zero to approximately 40 spider mites (using the bang-board test) in two weeks, likely influenced by weather.
- Surrounding property appeared to influence insect pest populations. Nurseries adjoining farmland versus forest rarely experienced Eastern tent caterpillars.
- Opportunities to utilize host plant resistance in nursery pest management can be more fully exploited. Many instances of host plant resistance and susceptibility were noted among taxa with comparable market demand. For example:
  - Eastern tent caterpillar was noted heavily infesting *Prunus* x cistena plum, while crabapple cultivars nearby endured lighter infestations;
  - enormous seedling variation regarding hemlock rust mite resistance was observed;
  - cercospora leaf spot defoliated 'Sunburst' honeylocust, while a neighboring cultivar was only lightly infected; and
  - Autumn Blaze® Freeman maple had nearly twice as many maple mites as October Glory® or Red Sunset® by the end of the season.
- Armed with a very targeted list of pests to scout based on the week of the year, as well as precise scouting methods, scouts can assess approximately 100 acres of trees in 60 to 90 minutes.

It must be stressed that these are observations made over a limited time period and at limited locations and may not be observed in every nursery setting.

The 2006 scouting program will continue the work that began in 2005, but will include nurseries representing different geographic locations in Kentucky. The positional effect (N.S.E.W.) of leaves sampled will be examined for variation in pest population development. A mechanism will be explored by which the current pest status, as derived from weekly scouting sessions, can be disseminated across the state.

Significance to the Industry

The Nursery Crops Scouting Program provided the industry with real-time pest status information, i.e., first flight, hatch, emergence, etc., for serious and moderate nursery pests as determined from weekly nursery visits; early assessments of the efficacy of pesticide applications; an opportunity for owners, managers, and employees to receive training on specific scouting and trapping skills; and an early warning on emerging pests in Kentucky, such as Asian ambrosia beetle and calico scale.

Regular observation of the same fields revealed subtle changes during the season, allowing the nursery crops team to be better informed and better able to relate to the changing needs in the nursery. This and the weekly acquisition of pest population status information enhanced assistance by the Nursery Crops team and the team's interaction with nursery crop producers across the state. The creation of the Nursery Crops Scouting Guide and Nursery Pest Scouting Reference provides specific scouting information developed under nursery conditions in Kentucky that should assist nursery producers to efficiently and effectively monitor trees in production.

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A Preliminary Look at Pruning Techniques to Enhance Branch Formation and Canopy Development of Sourwood, *Oxydendrum arboreum*

Amy Fulcher, Winston Dunwell, Dava Hayden, June Johnston, and Hilda Rogers, Department of Horticulture

Nature of Work

Sourwood, *Oxydendrum arboreum*, occupies a niche in nursery crops sales. Sourwood's many ornamental attributes deem it a desirable plant in the landscape. These assets include bright yellow, red, and purple fall color; fragrant white flowers that hang in racemes, lasting three to four weeks; and attractive, shiny, green leaves (1). In addition, sourwood is a native plant, found through the East and Southeast.

One barrier to widespread use is that sourwood is purported to recover poorly from the transplanting process, and thus successful nursery production often incorporates root pruning and/or transplanting during production in order to develop a root system that will better support the plant during its transition to a new location (2). Additionally, plants grow slowly, making production an extensive, long-term venture compared to faster growing ornamental trees.

Propagation by cuttings has been unsuccessful. Seeds germinate readily, and successful tissue culture methods have been developed. Plants propagated from seeds exhibit seedling variability, visible as a large variation in phenotype (for example, variation precociousness, number of flowers, fall color, and susceptibility to leaf spot) and presumably less detectable seedling variation in physiological responses to environmental conditions.

In a study of retail customer preferences of a similar plant, *Cornus florida*, consumers identified branch structure, fullness, and symmetry as important attributes (5). Beginning with the earliest stages of production, liner characteristics will influence the attributes of the finished tree. Growth characteristics of the liner are variable in part due to the influence of varying light levels during production, which impacts the red:far red phytochrome ratio (7). Sourwood is an understory/mid-canopy tree and thus is able to grow in shade conditions; however, it exhibits a shade avoidance response to low light conditions, i.e., under high light levels sourwoods are shorter and more branched with many buds breaking, and under low light levels they are taller and more sparsely branched (7). This light response is documented in other species (6).

Sourwood liners are available in both "trained" and "untrained" forms. The untrained liners consist of seedling-grown plants that are often relatively short and well branched, indicating production in a high light setting. Recently, trained liners have become available. These liners are staked and grown on close spacing, much like production of rootstocks, which lowers the light level and produces a tree with a straight central leader and relatively minimal branching. Large liners and straight central leaders are often desirable; however, this method of liner production does reduce branch development and may leave unanswered questions by the nursery grower regarding how to develop a canopy that is acceptable to the consumer on this defiant species.

The number of branches is partially controlled by apical dominance. Apical dominance is the tendency of a plant to have a strong central leader and suppressed growth of lateral branches in relationship to the central leader. In other words, apical dominance refers to the fact that the apical meristem controls the development of lateral buds. Auxin, specifically indole-3-acetic acid (IAA), is a plant-produced hormone. IAA is produced by actively growing tissue, in particular, the shoot apex. IAA moves through the plant, apparently in the parenchyma tissue associated with the phloem, although not specifically in the phloem, as research has shown that IAA movement is slower than phloem movement.

The heading back cut is a common orchard and nursery pruning technique, which involves removing the tip portion of a central leader or lateral branch. This cut has been demonstrated to induce branching on many woody species by releasing apical dominance on the lateral buds. From the resultant new branches, the grower can select and train those branches that contribute optimally to the canopy, as determined by market preferences. Heading back cuts are frequently used to reduce the size of an excessively tall central leader that is devoid of branching and develop a denser canopy. Heading back cuts are more commonly made in the dormant season, with some exceptions in nursery crops (for example, red maple and hybrids of red and silver maple).

A similar logic is used in notching. Notching is a procedure used infrequently in orchard crops and rarely on nursery crops. It is reported as being laborious and the response often being inconsistent (4). Notching blocks auxin flow from the terminal bud and allows the lateral buds along the central leader to break. The procedure involves using a knife to cut through the bark above an individual bud. Phloem and associated tissue, but not xylem, is severed, disrupting auxin flow from the apex of the leader. Notching is used to develop individual branches along bare sections of the central leader and is typically performed on very young trees.

Spacing, or lateral positioning, is used frequently in orchards (but rarely in deciduous nursery crops) to correctly shape the canopy, to induce lateral branching, and for earlier fruit production (3). Auxin transport decreases in branches that have been spaced or bent into a more horizontal position (4). Once the branch has been positioned into a horizontal orientation, apical dominance continues to be a factor. Auxin produced by the buds on the upper side on the branch inhibits bud growth on the underside of the branch. Spacing involves positioning lateral branches horizontally with spacers or weights and is often utilized on many branches per tree, especially those fruit trees that tend to grow upright, such as ‘Delicious’.

This pilot study was conducted in order to: 1) identify and examine pruning methods that can be utilized to control branch development on *Oxydendrum arboreum* and 2) develop a protocol for future pruning research.

Study No. 1

On April 5, 2004, seedling liners were planted at the University of Kentucky Research and Education Center. Liners were 5 to 6 feet tall, in No. 2 containers, and ranged in caliper from 0.295 to 0.591 inches. Most of the central leaders had been headed back and had a new leader taped the previous growing season. A small number of branches developed near this heading back cut on most liners. Five plants were potted into No. 6900 containers (Nursery Supplies Inc., McMinnville, OR) with Morton’s Nursery Mix (Morton Horticultural Products Inc., McMinnville, TN) and placed in a pot-in-pot production system. The remaining five plants were lined out in the field nursery. On April 6, 2004, 100 grams of Harrell’s 18-5-10, five- to six-month controlled-release fertilizer were applied. On April 7, 2004, Snapshot® was applied to both field and container trees at a rate of 150 pounds per acre. Prior to the pruning treatments, an average of 9.8 buds had broken dormancy, mainly from the top 12 to 24 inches of the central leader. The following training/pruning treatments were made on May 6, 2004: heading back, notching, bending leaders into a lateral position, and heading back and bending leaders into a horizontal position.

Study No. 2

During early July 2004, plants grown in the field site were subjected to hoeing, which is hypothesized to have severed the root systems of the sourwood trees during a period of infrequent rain. Shortly after pruning, all of the leaves on two of the five field-grown trees dried up and clung to the tree, which would support a root injury event and related plant water deficit. The result was buds breaking along the entire length of the stem. Study No. 2 was initiated to examine this phenomenon. On April 15, 2005, the trees in the pot-in-pot system were fertilized with 323 grams of Harrell’s 14-4-10 and were kept weed free during the season by hand weeding.

On June 20, 2005, these plants were subjected to “whipping” in an effort to duplicate the defoliation event of the previous summer. Whipping is an industry term used to describe the removal of all branches and foliage from the central leader. It is most commonly performed when the liner is of poor branch structure or when an environmental event, such as a late frost, causes large-scale branch death. Whipping is chosen as the pruning method when developing an entirely new canopy is necessary to produce a high-quality tree. It often increases production time by one season, increasing costs. Whipping is a pruning technique that is used sparingly, depending on the proclivity of the individual nursery grower, but is found sporadically across the nation.

Results and Discussion

This preliminary pruning project trialed several techniques to induce branching on sourwood, *Oxydendrum arboreum*. With few replications and one season of data per treatment, it is not possible to show that the pruning treatments are responsible for the variation in branch number. However, the following observations were made:

- Seedling variation likely plays a role in branch development. The number of branches varied from four to 18 new branches in the top 24 inches of the leader before pruning treatments were conducted. The opportunity for plant selection based on canopy development (among other factors) exists.
- High light levels provided by appropriate plant spacing appears to be sufficient stimulus for moderate branch development. There was an average of 10.7 branches in the top 24 inches of the central leader prior to imposing the pruning treatments. These branches were not always evenly spaced along the 24-inch section of trunk.
- Pruning treatments to induce branching may be unnecessary and increase production costs.
  - Heading back the leader did not noticeably induce branching as compared to control plants.

- Spacing/lateral positioning appears to be very effective at inducing bud break and branch development. However, it is laborious and requires study to improve branching on the lower side of the leader (the side oriented toward the ground when the leader is in a lateral position); determine the optimum time to straighten the leader so that branch number is optimized and a straight central leader is recovered; and minimize broken leaders.
- Notching was ineffective at inducing buds to break. It is possible that the notches were made improperly and caused damage to the buds or were not made sufficiently deep to stop auxin flow.
- On average, plants that were whipped had less than half of the branches of the control (not whipped). However, imposing the whipping during the second summer of production was a severe treatment and removed large caliper branches.

• Due to the response of sourwood to high light levels, production may be optimized by purchasing trained liners for their tall, straight leaders and providing a high light spacing with minimal pruning for initial canopy development.

• To more fully assess these pruning techniques, it is necessary to apply the techniques at different stages of growth over multiple seasons and utilize several replications.

Acknowledgments

Appreciation is expressed to Harrell's Inc. for fertilizer.

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Water Use Efficiency in Container Nursery Crop Production

Dava Hayden and Winston Dunwell, UK Department of Horticulture, and Kenneth Bowman, Murray State University, College of Agriculture

Nature of Work

Efficient irrigation practices are essential for optimum plant growth and environmental protection. Inadequate water applications cause plant stress and reduced plant growth. The results are easily observed, and therefore most nurseries err on the side of over-watering. Over-watering creates poor aeration of the substrate, root diseases, overall reduced plant quality, and leached nutrients including nitrogen (1). Research indicates substantial volumes of water, nitrogen, and phosphorus are lost from a container when irrigating with excessive amounts of water (3). Cyclic or intermittent irrigation is more efficient than conventional overhead irrigation by reducing water and nutrient leaching through containers (2). Though many container growers utilize cyclic irrigation, applying the appropriate amount of water to the crop continues to be a problem, especially in pot-in-pot (PIP) systems. The design of a PIP system does not easily allow the grower to observe the amount of water leached through the bottom of the pot, increasing the potential of over-watering. One of the difficulties involves identifying the optimum water input and the amount of water utilized by the plant. Another problem that exists is the lack of irrigation management during times of changing watering needs such as in early spring or fall or rainy, cloudy, or windy days, which influences evapotranspiration rates.

This study was conducted at the University of Kentucky Research and Education Center in Princeton to identify the water use efficiency of two water enhancement products: Regulator® substrate moisture additive and Smart Clock irrigation controller. Regulator®, in powder form, was incorporated into the potting mix to determine if the amount of water required to maintain an adequate moisture level by a containerize plant was reduced. The Smart Clock controller was installed to irrigate rows one and two of the study. The Smart Clock Controller, by Alex-Tronix Controls, is designed to provide user-friendly and affordable "smart water technology" with temperature budgeting and built-in rain gauge to simulate evapotranspiration.

A non-randomized arrangement was used to determine if a significant difference exists in water savings when Regulator® and/or a Smart Clock were used. The plot consisted of four rows of 10 plants each. Forty *Chamaecyparis* 'Boulevard', of similar size, were used to measure plant response of the water applications. Each plant was potted into three-gallon containers, with the same amount of substrate per pot, and top-dressed with Osmocote Plus. To compare the effectiveness of the Smart Clock rows one and two were controlled by the Smart Clock and rows three and four by the Superior controller, a common irrigation controller. In Row 1, the plants were irrigated by the Smart Clock, and the substrate was incorporated with the manufacturer's suggested rate of Regulator®. In Row 2, the plants were irrigated by the Smart Clock, but no Regulator® was applied to the substrate. In Row 3, the plants were irrigated by the Superior controller, and no Regulator® was applied to the substrate. In Row 4, the plants were irrigated by the Superior controller, and Regulator® was incorporated into the substrate at the same rate as row 1, 10 ounces per cubic yard of aged pine fines.

The temperature budgeting feature on the Smart Clock was programmed with the appropriate longitude and maximum temperature for August, 99°F. The water gauge was set to ¼ inch of water for rain budgeting. A water meter was installed at the beginning of each row to measure water applied per row. Each plant was placed inside a five-gallon bucket and rested on a 4-inch PVC spacer. Each controller was programmed to apply 300 milliliters of water four times daily from August 5, 2005, until September 8, 2005. The controllers were manually placed on rain delay on August 26 through August 31, when 8.845 inches of rain were received; data were omitted during this time due to overflow. On September 9, both controllers were reduced to deliver 300 milliliters of water twice a day**.** Water meter readings of the four rows and the amount of water leached from each of the 40 plants was measured and recorded weekly during August and September.

Results and Discussion

The data were statistically analyzed by using the multiple regression method with Regulator® and the Smart Clock being the indicator variables. The results indicate that if Regulator® is used, water consumption declined by 0.56 ounces per watering on average for each container. If a Smart Clock is used, water consumption declined by 10.8 ounces per watering on average. Assumptions of data collected from this experiment show 13,147 gallons of water can potentially be saved per acre each year when Regulator® is used. When the Smart Clock is used, an estimated 253,553 gallons of water can potentially be saved per acre each year. If the Smart Clock and Regulator are used together, 266,701 gallons of water can be saved each year per acre.

Visual observations revealed Rows 1 and 2, under Smart Clock irrigation, produced a larger root system and canopy (see Figure 1). Roots of plants irrigated by the Smart Clock controller appeared to hold the substrate together when removed from the container unlike the plants irrigated by the Superior controller that easily fell apart.

Preliminary results show, plants that receive optimum water applications produce a larger canopy and root system in shorter time than over-watered plants. Financial savings must include the reduced production duration, the cost of water, and the expense of wasted solution fertilizer if it is used. Additional research is in progress to determine the amount of nutrients lost from controlled-release fertilizers due to over-watering. If the data show a significant difference in the loss of nutrients when over-watered, controlled-release fertilizer will also become a variable to consider for calculating savings.

Significance to the Industry

Although a leaching fraction of less than 20% is recommended, there must be a certain amount of leachate through the pot to eliminate salt buildup (3). Based on the results of this study, "Smart" technologies can safely reduce the amount of water used to produce a crop with water saving of up to 25%. Providing this information to nursery growers can stress the importance of water management and provide an understanding of "Smart" technologies now available to large and small nurseries.

Acknowledgments

A special thanks to Mark Lurey with M. L. Irrigation Systems Inc. and Sarah Baker for all their assistance with this project.

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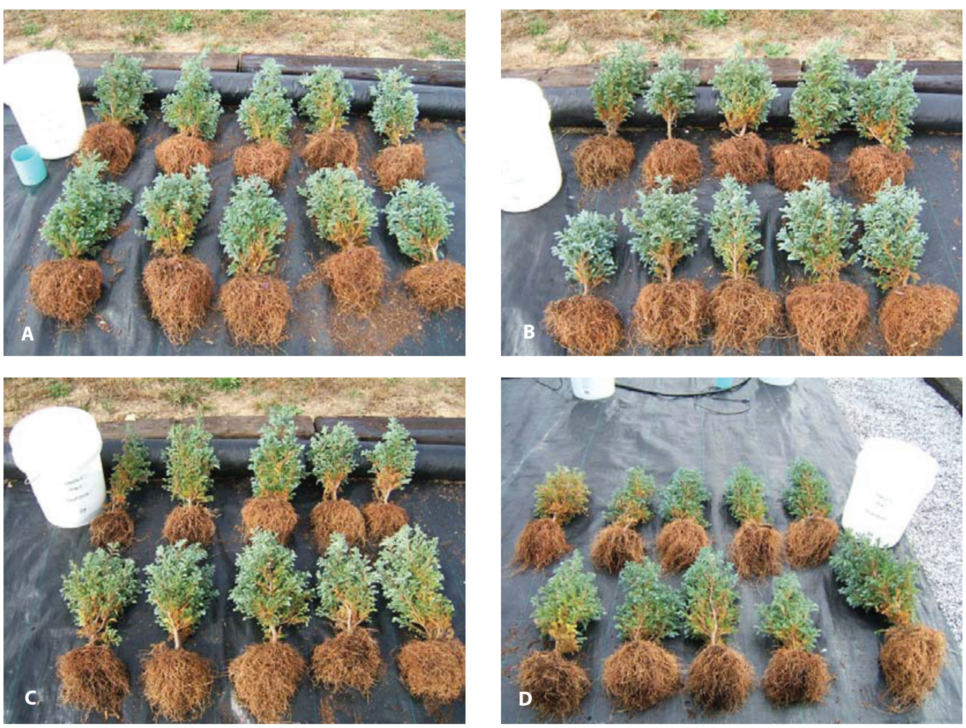
Figure 1. Shoot and root mass of *Chamaecyparis* 'Boulevard' as affected by: A. Smart Clock with Regulator®; B. Smart Clock only; C. Superior only; D. Superior with Regulator®.



On-Farm Nursery Crop Demonstrations in Western Kentucky

Dava Hayden and Winston Dunwell, Department of Horticulture

Nature of Work

Two on-farm nursery crop demonstrations were conducted in western Kentucky to evaluate production methods while providing technical support to the cooperators. Each cooperator agreed to host an evening field day event to share their experiences with other nursery managers. The two cooperatives were located in McCracken and Calloway counties. One demonstration observed the utilization of an aboveground Smart Pot™ growing system, while the other observed the use of supplemental liquid fertigation in a pot-in-pot production system. Each grower was seeking information to enhance his or her current production system.

Results and Discussion

General Summary

At the pot-in-pot nursery cooperator (nursery A), we wanted to determine if the quality plants can be produced in less time by introducing supplemental fertigation while increasing the number of saleable plants per acre of land. The life of a pot-in-pot system was assumed to be 15 to 20 years if properly maintained. If a significant increase of growth per season was observed but production duration remained the same, then would the plant become more valuable to the consumer? Due to the nature of this demonstration, specific production costs were obtained from the cooperator, but only general figures will be documented in this report.

The second cooperator (nursery B) had previously grown shade trees in traditional aboveground container production. As an alternative, fabric bag production was considered. Fabric bag production is not widely used in Kentucky nursery crop production, but the advantages described by Root Control Inc., the maker of the Smart Pot™, seemed worthy of investigation. The Smart Pot™ is designed to be used aboveground, allowing small roots to penetrate into the earth's surface and resist blow-over while creating a fibrous root system favorable for accelerated growth and successful landscape establishment.

Each nursery provided land, trees, labor, and irrigation. A Kentucky Horticulture Council grant from the Kentucky Agriculture Development Board provided a portion of the supplies necessary to carry out the demonstrations.

Nursery A installed an H.E. Anderson J+ Dual Injector for the purpose of the demonstration. Harrell's custom blend polyon fertilizer, formulation 17-8-12 with 6.91% NO_3^-, 5.61% NH_4^+, 4.49% urea and minors package, was top-dressed at manufacturer's recommended high rate (269 grams/#15). Pro•Sol™ water soluble fertilizer, formulation 20-10-20 with 8% NH_4^+, 12% NO_3^-, and minor nutrients, was used as the supplemental solution fertilizer. Solution fertilizer was injected at 150 ppm every third day from April 9 to July 30. A leachate sample was analyzed every other week from each block to monitor soluble salt and pH levels. Leachate was obtained by the Virginia Tech Extraction Method (3). The recommended soluble salt levels for combined use of controlled-release and solution fertilizer on container nursery crops are 0.5 to 1.0 mmhos (1). If soluble salt levels were higher than 1.5 mmhos, the amount of solution-free irrigation water was increased. A suggested leaching fraction less than 20% was maintained (2). Growth and pruning demands were observed on first-year *Taxodium, Cercis, Gleditsia,* and *Betula* species, and second-year *Acer, Prunus, Betula, Malus*, and *Cercis* species. The demonstration began on April 8, 2005, and concluded following the on-farm demonstration presentation on September 27, 2005.

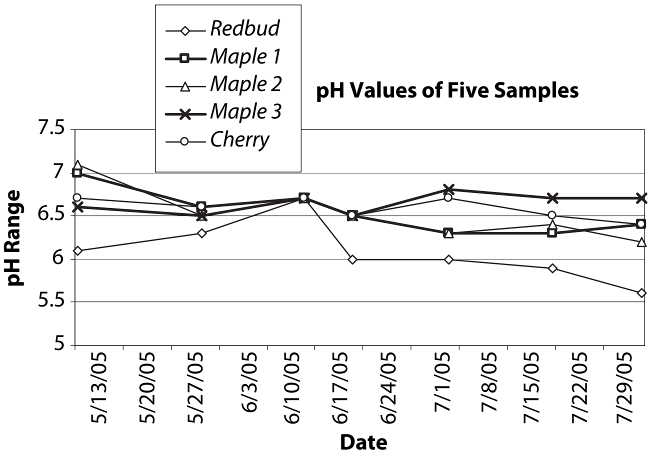
Nursery B potted potted 15- and 25-gallon Smart Pot™ fabric bags for observation purposes. Cultural observations were conducted on the following species: *Prunus, Pyrus, Liquidamber, Populus*, and *Acer*. Root Control Inc. promoted the use of topsoil in substrate mixes to prevent rapid substrate dryness and to help add weight to the base of the plant to reduce blow-over. Kentucky's native clay base soils, however, have not previously been recommended for container production because of their high water-holding capacity, low pore space, lack of consistency, potential of soil-borne contaminants and complications created by increased weight during planting, harvesting, and shipping. Therefore, cultural observations included production use of a soilless substrate (75% pine fines, 15% peat, and 10% sand) and a topsoil mixture substrate (40% Loring Silt Loam local soil, 40% pine fines, and 20% sand) and monitoring substrate temperature, substrate moisture, and plant growth of each mix. Trees received cyclic low-pressure irrigation. Substrate moisture levels and substrate temperatures were recorded from one representative sample of each group. The data were recorded by a WatchDog™ data logger model 400 every hour and analyzed monthly. A soil moisture probe and a temperature probe were inserted 5 inches below the soil level of each represented group. The project began on March 16, 2005, and is still ongoing through the winter months to monitor winter substrate temperature and plant response. An evening field day on September 19, 2005, focused on observations made to date.

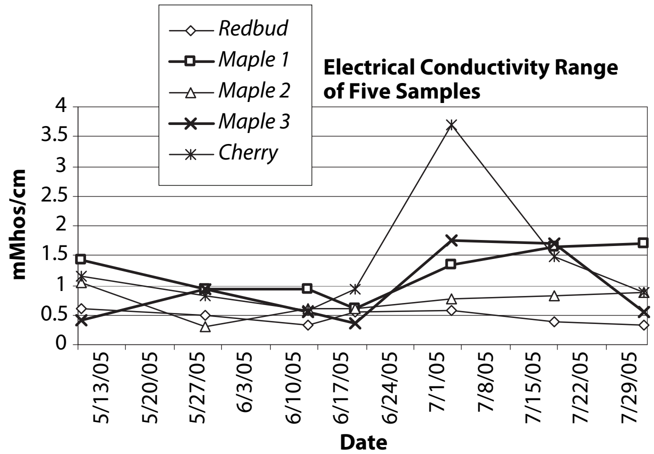
Nursery A Observations

Soluble salt and pH levels were recorded every two weeks, mid-April through July. The leachate was then tested with a hand-held pH and electrical conductivity meter, Hannah 8611. Targeted range: pH 5.5 to 6.1, E.C. 0.5 to 1.5 mmhos/cm from pour-through leachate. Targeted E.C. range of fertigation from emitter at 150 ppm: 1.00 mmhos/cm. Actual leachate recordings are represented in Figure 1.

High E.C. readings were recorded on *Prunus* in July. Solution-free water was increased for one week to reduce soluble salt buildup. *Prunus* generally require less water and are more salt sensitive than most species. Once E.C. levels returned to

Figure 1. pH and E.C. values of representative samples from each block in pot-in-pot.





our desirable range, the amount of water supplied to the *Prunus* block was reduced to accommodate cultural needs. All blocks received 150 ppm solution fertilizer every third day they were irrigated. Although the *Prunus* received less water and thus less solution fertilizer than other blocks, elevated soluble salts levels remained a concern. Since the fertigation system is not capable of delivering variable solution rates on salt-sensitive species, a lower rate of slow-release fertilizer will likely be applied in the future while a 150 ppm solution rate is maintained on all species. E.C. readings were observed to be higher on second-year crops, but were attributed to higher water demands of the plants. Irrigation duration was increased on second-year crops to accommodate their water needs. Second-year maples began to show nutrient deficiency symptoms in late July. Plant and soil analysis reported high levels outside the acceptable range for phosphorous, potassium, zinc, and manganese in the substrate and phosphorus and manganese in the foliage. No nutrient alterations were made since the problem appeared to be associated with substrate characteristics. Instead, the plants are to be up-potted into larger containers this fall with a more reliable substrate.

Nursery B Observations

Daily substrate moisture levels and substrate temperatures were recorded with the data logger. A representative sample from each block (soilless mix and with soil mix) remained consistent throughout the study. Growth and leachate were observed at the beginning, middle, and end of the trial. Based on the data retrieved from the data logger, there appeared to be no significant difference in the substrate temperature. There was, however, a noticeable difference in the moisture saturation in bags potted with soil versus those without soil. It appeared the water from the irrigation emitter created channels in bags potted with soil, while the soilless mix allowed water to disperse more evenly throughout the bag. As an attempt to correct this problem, all of the original irrigation emitters were replaced with new emitters that would provide even surface-area coverage. The data logger reported substrate moisture levels remained higher than desired by most plants, but the design of the Smart Pot™ appeared to allow the excess water to pass freely through the sides of the bag. This likely contributed to the fact that none of the trees observed in this trial experienced reduced root growth from excessive moisture. We observed good subsurface root anchoring through the bottom of the bag in both substrate mixes in plants potted in late winter and early spring. Plants potted late in the spring did blow over, whereas trees potted earlier did not.

Results and Discussion

Results are based on observations and nursery cooperator reporting experiences.

Nursery A

Birch liners of comparable size, approximately 0.5-inch caliper whips, were potted in 2004 and 2005. The birch liners potted in 2004 had a reported caliper size of 1 inch on average at the end of that year's growing season, a 0.5-inch average caliper increase. Birch liners potted in the spring of 2005 were reported having 1.25-inch caliper trunks as of August 2005, a 0.75-inch average caliper increase. Six-foot, one-year branched Autumn Blaze® maple liners, approximately 0.875-inch caliper, were potted in February 2004. At the end of the 2004 growing season, the caliper was reported as 1.125 inches, a 0.25-inch average caliper increase. The same maples after two growing seasons had a reported caliper size of 2 inches, a 0.875-inch caliper increase. Trees appeared to have fuller and denser canopies; foliage was darker and wider than those without supplemental fertilizer and seemed to have less noticeable leaf disturbances from insects and mites.

Each tree was topped-dressed with Harrell's fertilizer at the recommended medium to high rate 17-8-12 (five- to six-month release) at a cost of $0.61 per tree. Pro•Sol 20-10-20 water-soluble fertilizer was used at a cost of approximately $0.08 per tree, not including the cost of the injector. Total cost of fertilizer per plant is estimated to be $0.69.

Although results are preliminary, the data collected during this on-farm evaluation indicate a significant growth increase with the use of supplemental fertigation on birch and Autumn Blaze® maple trees with minimal increases of pruning requirements and fertilizer. The accelerated growth provided the cooperator with marketing options: produce a quality tree in less time or sell a larger plant at a higher cost to the consumer. As a result, catalog prices were adjusted 12.25% for larger caliper; grade A, No. 15 deciduous shade trees, while prices remained the same for traditional plant size. Calculations made from data provided by the cooperator's cash flow report indicated that a 2 to 10% increase of profits to the business could be obtained. Likewise, trees originally scheduled for an 18-month production cycle could potentially be reduced to a 12-month cycle. A shorter production cycle of 12 months versus 18 months could potentially result in one-third more trees produced on one acre of land that is allocated to pot-in-pot production, assuming the system is functional for 15 years. In conclusion, this cooperator could potentially gain $65,220 in sales over 15 years on one acre of pot-in-pot with an 18-month production cycle if a +12.25% value-added price adjustment for increased caliper size was adopted. If the cooperator chooses to reduce the production cycle to 12 months and maintain the value of the crop at the smaller size, then the cooperator could potentially see an $201,095 increase of sales over 15 years on one acre of pot-in-pot.

Nursery B

Deciduous shade trees potted with soil showed no significant differences in trunk or canopy growth than those potted without soil, but root structure development differed. Trees potted with soil created channels of water movement unlike the soilless mix with evenly distributed and dense root mass. Additional root structure and growth trends were examined by comparing Zelkovas produced in Smart Pot™ bags at the cooperators' nursery with pot-in-pot grown Zelkovas from the University of Kentucky Research and Education Center in Princeton. Through visual observations, it was obvious that Zelkovas grown in the Smart Pot™ bags had larger trunk calipers, canopies, and root masses than the pot-in-pot produced Zelkovas. The root structure of the Zelkovas grown in a Smart Pot™ was much more dense and evenly branched when compared to the pot-in-pot grown Zelkova that showed long unbranched roots with girdling tendencies.

The use of the Smart Pot™ was observed to be more cost efficient for this nursery than the previous method of plastic container production. Trees grown in the Smart Pot™ resisted blow-over by allowing small roots to pass through the bottom of the bag into the upper soil surface. No additional support system was required to prevent blow-over when potted in late winter or early fall. Handling the trees at planting and at harvest showed no difference when soilless mix was used in comparing traditional container and bag production. Trees potted with soil required one additional laborer to maneuver the added weight of soil during planting and at harvest. Consumer demand showed no resistance of the fabric bag when marketed to buyers seeking an alternative to root-bound or girdling roots associated with traditional container production. Consumer demand continues to be based on tree quality, size, price, and service.

Significance to the Industry

Continuing to make production systems more efficient should be a goal for all businesses. Our industry is competitive and constantly changing. Those who embrace change and anticipate shifting trends while closely monitoring costs of production will sustain a vital role in Kentucky wholesale nursery crop production. Sharing valuable education experiences with nursery managers across Kentucky will continue to strengthen networking relationships and help reach our goal to make Kentucky widely known as a producer of quality nursery crops.

Acknowledgments

A special thanks to Valerie Neale with Kentucky West Nursery and Brick and Craig Green of Green's Silo House Nursery for this successful cooperative experience and to Steve Mullican with John Deere Landscapes–Nursery and Agricultural Irrigation, Tommy Mathis with Harrell's Fertilizer, and Kurt Reiger with Root Control Inc. for all their services and products.

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Evaluation of Greenhouse Ornamental Production Practices, Fall 2004-Summer 2005

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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 the greenhouse, and a majority of garden mums are grown outside on groundcover. Those who do raise garden mums in greenhouses 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 a little 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 purpose of this evaluation is to help growers identify production issues that cause a reduction in sales due to poor quality or death of plant. The key areas that have been addressed are growing media testing, water quality testing, and temperature management. Plants vary in optimum temperature, 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 31 grower/cooperators from central Kentucky. They are from the following counties: Anderson, Bourbon, Bracken, Campbell, Fleming, Franklin, Garrard, Grant, Harrison, Jefferson, Lincoln, Mason, Mercer, Nelson, Rowan, Scott, Spencer, and Washington. The size of the growers' operation ranged from 2000 square feet up to about 10 acres of production space. 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 EC (electrical conductivity) by using pour-through growing media tests. Secondarily, water quality measurements of pH, EC, and alkalinity were collected. These two measurements were done on every visit. 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

Temperature management has become an important topic for growers as energy costs rise. The first choice of some growers is to lower the thermostat to reduce energy costs. However, two major things have to be considered. Do the plants like warm or cool conditions, and will their development be slowed down too much? Pansy prefers cool weather with flowering being delayed about 1.5 days for every 1 degree Fahrenheit (F) drop in average daily temperature (ADT) over the range of 54° to75°F (1). Compare this with petunia which also likes cool weather, but flowering is delayed about three days for every 1 degree F drop in ADT over the same 54° to 75°F range. Poinsettia likes warm temperatures, but flowering is delayed if night temperatures are above 72°F. Greenhouse operators may have trouble with poinsettia in keeping temperatures down in August and September (Table 1). High temperatures can lead to poor root development which causes stunting and delay of flower initiation. Greenhouse design affects proper ventilation to keep temperatures at desirable levels. Growers with taller greenhouses, bigger fans and louvers, or taller side curtains had better control of maximum temperatures. Bedding plant growers heated more early on; then as temperatures outside increased, they reduced heating in April and May as development was finished or nearly complete.

Table 1. The monthly average temperature data collected from poinsettia and bedding plant growers in central Kentucky during the fall of 2004 and spring of 2005.

Month	ADT[1]	DIF	HI	LO	Range
Aug 2004	76.7°F	28.7°F	94.3°F	65.6°F	109-56°F
Sep 2004	73.5	25.2	89.3	64.1	109-48
Oct 2004	69.5	17.4	80.6	63.5	94-47
Nov 2004	67.7	12.0	75.3	63.3	101-55
Feb 2005	65.7	13.8	74.9	61.1	82-55
Mar 2005	67.9	17.9	78.5	61.2	99-46
Apr 2005	67.2	23.2	81.2	57.9	98-40
May 2005	66.8	29.3	84.9	54.5	100-39

[1] ADT = average daily temperature; DIF = difference between high day temperature and low night temperature; HI = average daily maximum; LO = average daily minimum; Range = the highest and lowest recorded temperature during the month.

One observation was the high temperatures in August and September in the poinsettia greenhouses. This caused stressed plants and in some cases delay of flowering. Also the poinsettia crop production requires a higher night temperature in October and November for proper scheduling of flowering and preventing diseases such as Botrytis gray mold.

The bedding plant growers lower their thermostats in April and May at night to 55° to 58°F to save energy and slow plant growth. This works fine for the cool weather bedding plants if size is adequate, but the warm weather bedding plants can suffer especially with delay in flowering and diseases such as Botrytis and root rots.

A big issue in the spring was yellowing of new growth in petunia and calibrachoa. Water quality tests and growing media tests collected at greenhouse sites were both a factor in this condition. First we looked at water quality. Most growers in central Kentucky use water with high pH and moderate levels of alkalinity (Table 2).

Table 2. Evaluation of water used for irrigation purposes.

Water Source	Number of Growers	pH	EC (ms/cm)	Alkalinity (ppm)
Municipal water	24	7.4	0.42	117
Pond water	5	7.7	0.29	147
Spring water	2	6.8	0.40	160

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.

The other factor dealing with yellowing of the new growth is the amount of fertilization. The use of 20-10-20 or 20-20-20 by many growers causes an increase in acidity in the growing media. Higher fertilizer concentrations and increased number of fertilizer applications will reduce the high pH and remove the yellow symptoms (Table 3).

Table 3. 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	Aug 2004	6.2	1.81
	Sep 2004	6.0	2.04
	Oct 2004	6.3	2.75
	Nov 2004	6.4	1.69
	Dec 2004	6.6	1.03
Bedding plants	Mar 2005	6.1	2.11
	Apr 2005	6.2	1.67
	May 2005	6.3	1.69
Garden mums	June 2005	6.7	1.94
	July 2005	6.3	2.23
	Aug 2005	5.9	2.99

Poinsettia and bedding plant 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. Garden mum growers had the opposite happen with lower growing media pH values and higher EC values at the end of crop production. This was a result of increasing fertilizer rates during July and August. The majority of growers had high pH problems causing yellowing of 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 mum color. Another benefit was the growers were able to get larger mums, which typically bring higher prices.

Significance to the 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 monitoring temperatures are very important for growers 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.

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Acknowledgments

The author would like to thank Robert Anderson, Extension floriculture specialist, and Kirk Ranta as well as all of the greenhouse operators in this evaluation for their help and information.

New Management Approaches for Insect Pests of Nursery-Grown Maples

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Nature of Work

This project is evaluating tree cultivar resistance and other reduced-risk tactics for managing insect pests of nursery-grown maples. Resistance to certain diseases (e.g., sudden oak death) also is being rated. Maples are among the top nursery crops in Kentucky and likely will remain so given emerging problems afflicting other tree species (e.g., sudden oak death/decline, emerald ash borer). Maples, however, have their own pest problems. Flatheaded apple tree borer (FHATB) and potato leafhopper (PLH) are especially damaging to red maples (2, 3), and growers presently apply multiple cover sprays for each species. FHATB control is complicated by recent cancellation of traditional borer insecticides (e.g., lindane, chlorpyrifos). Growers also report increased problems with calico scale, maple spider mites, Japanese beetles, and shoot borers that destroy terminal buds, affecting tree symmetry. Little is known about biology or management of the latter four pests in production nurseries. Several large growers asked that we investigate these problems.

Host plant resistance ideally is the first line of defense against insects and pathogens both in nurseries and landscapes. Choosing species and cultivars that are less pest-prone reduces production costs and need for chemical inputs. This project is evaluating relative resistance of newer maple cultivars and popular standards to multiple insect pests. Species and cultivars being evaluated include:

Acer rubrum: Autumn Flame, Burgundy Belle, October Glory, Red Sunset, Somerset, Sun Valley, Brandywine, Northwood
Acer sacharum: Crescendo, Green Mountain, Commemoration, Legacy
Acer freemanii: Autumn Fantasy, Autumn Blaze, Sienna Glen
Acer × *truncatum*: Pacific Sunset
Acer compestre: Hedge Maple

Trees were planted in replicated field plots at Snow Hill Nursery (Shelbyville), the University of Kentucky South Farm (Lexington), and at the UK research facility at Princeton. They were evaluated three times during the 2005 growing season for density of pests and/or severity of pest symptoms. South Farm trees were inoculated with calico scale to ensure adequate infestations. Severity of calico scale will be determined when females swell and become obvious in May 2006.

Susceptibility to sudden oak death disease (*Phytophthora ramorum*) was evaluated by shipping detached leaves to cooperators in Oregon who challenged them with two different strains of the pathogen.

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 forked 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 clarify its seasonal development, 20 infested shoots from various cultivars were collected weekly beginning May 10 over the subsequent five weeks. Each shoot was dissected, and the number of larvae per 20 shoots was recorded and the larvae preserved in 75% ETOH. Head capsule measurements were then taken on the larvae to learn more about the number of instars for this species.

We also did studies to identify the shoot borer sex pheromone because having such a lure would allow growers and Extension agents to hang sticky traps to detect infestations and monitor emergence for purposes of spray timing. We reared virgin female moths from infested shoots, extracted their pheromone glands, and analyzed the extract by gas chromatography/mass spectroscopy. We also measured physiological response of male antennae to components of the female extract to pinpoint the stimulatory compounds.

We also are studying two systemic soil insecticides, Discus (Imidacloprid) and Flagship (thiamethoxam), for season-long preventative control of major maple pests (especially FHATB and PLH) from a single early-spring soil treatment. Effectiveness against borers will be evaluated by quantifying incidence of cankers and emergence holes in spring 2006.

Results and Discussion

Our 2005 field evaluations revealed significant differences between maple species and cultivars within species with regard to each pest (Tables 1, 2). Red, sugar, and Freeman maples are all susceptible to shoot borers. Red and sugar maples are susceptible to maple spider mites and potato leafhopper, whereas Freeman maples were relatively resistant to those pests. Sugar maples, especially 'Crescendo', are the only maples to sustain significant damage from Japanese beetles. *Acer* × *truncatum* and *A. compestre* showed resistance to all four pests.

Preliminary results indicate a very broad range of susceptibility to *P. ramorum*, varying from three varieties showing lesions covering almost 100% of the leaf area, to six varieties showing < 5% affected leaf area. The remaining varieties had lesions covering from between 40 to 60% of the leaf area. That evaluation will be repeated in 2006.

Shoot borer larvae were found in shoots as early as May 10, when the damage (flagged terminals) first became obvious (Table 3). They doubtless were present earlier, before the damage appeared. The borer reached full size by late May (note head capsule widths) and by mid-June, most of the damaged shoots were vacated as the larvae pupated. When infested shoots were "stuck" into moist sand for rearing out the moths in the

Table 1. Comparative data on susceptibility of maple cultivars to important insect pests, 2005.

Species Cultivar	Shoot Borer (no. per tree)[a]	Maple Mite Rating[b]	Potato Leafhopper Rating[c]	Japanese Beetle (% defoliation)[d]
A. rubrum				
Brandywine	3.4 a	0.8 b	0.9 ab	4.5 a
Burgundy Belle	2.4 ab	0.3 c	1.3 ab	3.6 abc
October Glory	2.3 ab	0.8 b	0.8 bc	2.5 bc
Northwood	1.9 ab	1.5 a	0.3 c	4.4 ab
Autumn Flame	1.0 b	0.7 bc	1.6 ab	1.1 cd
Sun Valley	1.0 b	0.3 c	1.7 a	2.5 bc
Somerset	1.0 b	0.6 bc	0.9 abc	0.5 d
Red Sunset	0.8 b	0.6 bc	1.4 ab	2.0 cd
A. saccharum				
Legacy	3.6 a	0.2 a	0.0 a	11 c
Crescendo	1.3 a	0.3 a	0.1 a	39 a
Green Mountain	1.3 a	0.3 a	0.1 a	24 b
Commemoration	1.0 a	0.3 a	0.0 a	20 bc
A. freemanii				
Sienna Glen	2.5 a	0.5 a	1.1 a	5.0 a
Autumn Fantasy	1.7 a	0.4 a	0.0 a	1.0 b
Autumn Blaze	1.2 a	0.6 a	0.1 a	0.5 b
A. × truncatum				
Pacific Sunset	0.2	0.0	0.0	3.3
A. compestre				
Hedge Maple	0.2	0.0	0.0	1.0

* Within maple species, means followed by the same letter do not statistically differ (two-way ANOVA, LSD, P > 0.05).
[a] Mean number infested shoots per tree, Princeton site, 1 June 2005.
[b] Mite damage rating scale: 0 = no mites, 1 = 1-10 mites, 2 = 10-20 mites, 3 = 20-50 mites, 4 = 50-100 mites, 5 = 100+ mites, Shelbyville site, 15 July 2005.
[c] Potato leafhopper damage rating scale: 0 = no damage, 1 = slight damage, 2 = moderate damage, 3 = heavy damage, 4 = severe damage, Princeton site, 7 July 2005.
[d] Mean percentage defoliation based on visual estimate, Princeton site.

Table 2. Comparative susceptibility of nursery-grown maples to selected insect pests, averaged across cultivars within species.

Species[a]	Maple Shoot Borer (no. per tree)	Maple Mites Rating	Potato Leafhopper Rating	Japanese Beetle (% defoliation)
Red maples	1.7 a	0.5 b	0.4 b	2.6 b
Sugar maples	1.8 a	0.7 a	1.1 a	23.6 a
Freeman maples	1.8 a	0.0 d	0.0 c	2.2 b
A. × truncatum	0.2 b	0.2 c	0.1 c	3.3 b
A. compestre	0.2 b	0.0 d	0.0 c	1.0 b

[a] Ratings and data presentation as in Table 1.

Table 3. Seasonal development of maple shoot borer population in Shelbyville, Ky., 2005.

Date	No. Larvae per 20 Infested Shoots	Average Head Capsule Width (mm)
10 May	20	0.78
17 May	16	0.95
24 May	13	1.01
31 May	7	1.09
7 June	1	1.1

laboratory, cocoons with pupae were found mainly in sand, often attached to the rearing container or stem below the substrate. Moths emerged mainly in June. We now can better predict when shoot borer larvae become active in the spring and begin determining its overwintering site and stage. Our findings of moth emergence in June, apparent lack of moth flight in early spring, and presence of medium-sized larvae in early May support the hypothesis that maple liners are already infested when they arrive from suppliers. If correct, that means that management by suppliers during the summer *before* shipment could eliminate the shoot borer problem faced by Kentucky nursery producers in newly planted maples.

In the pheromone work, two major components of maple shoot borer sex pheromone were identified, and various blends of these were made and field tested. Because it took about a month to do the analytical work, we were unable to field-test the candidate pheromone lures until late June near the end of what we presume was the seasonal flight period. Nevertheless, moths were captured with pure Z8-12:OH and the blend in which it was the primary component (Table 4). Using these data, we can begin monitoring seasonal maple shoot borer activity next spring, providing additional insight into the biology of this important pest.

Table 4. Pheromone blends evaluated and shoot borer captures in field trial conducted in late 2005 shoot borer flight period (28 June to 19 July 2005).

Pheromone Blend	Number of Shoot Borers Trapped
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 50 μg	0
Z8-12:OH 50 μg Z8-12:AC 10 μg	0

Significance to the Industry

This project is evaluating relative resistance to insects and diseases of numerous maple cultivars being grown by Kentucky nursery producers. This information will help growers and consumers to choose the best-adapted varieties, helping to reduce production costs and need for chemical inputs. Our research on maple shoot borers will support more focused control, provide growers with a monitoring tool, and likely will prove that nursery liners are already infested when they are shipped to Kentucky. Managing the pest during the summer before shipment may eliminate the flagging and loss of terminal leaders experienced by our growers. Our work on systemic insecticides may help nursery growers to multiple-target several key pests with a single application.

Residual and Antifeedant Activity of Landscape Insecticides Against Adult Japanese Beetles

Rebecca Baumler and Daniel A. Potter, Department of Entomology

Nature of Work

The Japanese beetle (*Popilla japonica*) is the most widespread and destructive insect pest of turf, landscape, and nursery crops in the eastern United States (2). The adults feed on leaves, flowers, and fruit of more than 300 plant species (1), often severely defoliating lindens, Norway maples, sassafras, grapes, crabapples, certain *Prunus* species (e.g., purple-leaved plums), and other preferred hosts. They wreak havoc with blooms of roses, hibiscus, and other flowering plants and also are pests of grapes, berries, and other fruits. Japanese beetles are of major regulatory concern in Kentucky nurseries because quarantines restrict shipment of potentially grub-infested nursery crops with soil to states where the pest is not yet established.

Carbaryl (Sevin®), a broad-spectrum carbamate, has been both the industry and home landscape standard for controlling *P. japonica* for many years. Because carbaryl is highly toxic to bees and beneficial insects (predators and parasitoids) and generally provides only about one week residual, there is need for longer-lasting and reduced-risk alternatives. The purpose of this study was to examine residual and antifeedant activity of newer landscape insecticides including pyrethroids, botanicals, and reputed repellents using foliage of linden, a preferred plant, as a representative system.

Beetles were collected from the field from late June to early August using standard yellow funnel traps with floral lures. The females were then separated, held in bins with moist soil, and starved overnight prior to each assay. Males were discarded. All treatments were applied at labeled rates to separate intact, undamaged shoots of large littleleaf linden (*Tilia cordata*) trees, a preferred food plant for Japanese beetles. Foliage was thoroughly sprayed on both sides to ensure full residue coverage. Shoots were tagged according to treatment and left on the trees to weather until harvest.

Conventional Insecticides

Eight insecticides were chosen based on their active ingredients to evaluate and compare their relative effectiveness to one another and to untreated controls (Table 1). The sprays were applied at four separate timings: 19, 14, 7, and 2 d before shoot harvest. On day zero (July 15), the shoots were excised and brought into the lab. The sprayed shoots were exposed to varying amounts of rainfall while they weathered in the field: 19 and 14-d residues experienced 2.7 inches, 7-d residues experienced 0.3 inches, and 2-d residues experienced 0.24 total inches of rain. Maximum and minimum daily temperatures during the weathering period (June 26 to July 15, 2004) averaged 84º and 66ºF, respectively.

No-choice assays were used to compare the feeding damage between treatments of a given residue age as well as feeding on different residue ages within a treatment. Assays were done in 16 oz. clear plastic drink cups with lids. Each cup received a treated or control leaf and 10 beetles. Each combination of treatment and residue age was replicated five times. Beetles were exposed to the leaves for 6 h. All leaves were then replaced with untreated leaves overnight to evaluate the same beetles' capacity to feed after exposure to the residues.

Table 1. Insecticides and reputed repellent products that were evaluated.

Active Ingredient	Trade Name	Source
Conventional Insecticides		
Bifenthrin	TalstarOne	FMC
Bifenthrin	Onyx*	FMC
Carbaryl	Sevin SL**	Bayer
Cyfluthrin	Tempo SC Ultra	Bayer
cyfluthrin/imidacloprid	Bayer Advanced***	Bayer
Deltamethrin	Deltagard T&O 5 SC	Bayer
lambda-cyhalothrin	Scimitar GC	Syngenta
Permethrin	Astro	FMC
Homeowner Products		
Azadirachtin	Neem-Away	Gardens Alive!
Capsaicin	Hot Pepper Wax	Hot Pepper Wax
d-limonene	Orange Guard	Orange Guard
garlic juice and oil	Garlic Guard	Super-Natural Gardener
Kaolin	Surround WP	Engelhard
pyrethrins, canola oil	Pyola	Gardens Alive!
rotenone, pyrethrins	Liquid Rotenone-Pyrethrins	Bonide

* Onyx is formulated in a non-xylene solvent designed to penetrate leaves.
** Sevin SL was also used in the assays with homeowner products.
*** Bayer Advanced Rose & Flower Insect Killer Concentrate.

Homeowner Products

Six organic products reputed to be effective in deterring feeding by *P. japonica* were evaluated against carbaryl and an untreated control (Table 1). We included Surround WP, a kaolin-based particle film along with several botanical derivatives. Leaves were treated and left to thoroughly dry in the field for 4 h. No-choice assays were conducted as before. We also tested for repellence from the residues by placing five beetles in containers and providing them one treated and one untreated leaf, with six replicates per treatment. Leaves were removed for evaluation after 24 h. Three more choice assays were conducted in this manner. In the first, we treated the leaves as before, and after 4 h, we simulated rain on the residues with a watering can. For the remaining choice assays, we allowed the residues to weather naturally for 3 and 7 d.

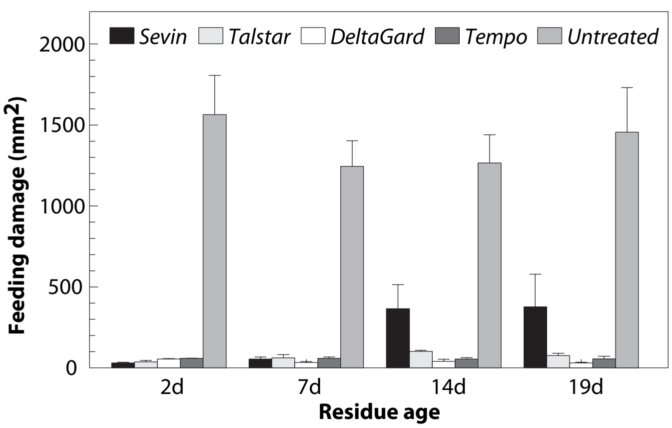
To measure feeding damage, leaves were secured between two clear acrylic sheets and photocopied. The copies were then electronically scanned, and the eaten areas of the leaves were measured digitally using Adobe Photoshop 7.0. The areas were then recorded and converted from pixels to square millimeters.

Results and Discussion

Conventional Insecticides

- Weathered residues of TalstarOne, Onyx (data not shown), Tempo, Deltagard, and Scimitar provided 94 to100% protection of linden foliage for at least 19 days (Figure 1). Nearly all of the beetles were killed outright so there was little or no feeding damage when they were provided a second, untreated leaf.
- Sevin SL and Astro also provided significant protection (74 and 85% reduction in initial feeding, respectively, on 19-d-old residues). However, beetles exposed to older residues of those products generally recovered and fed when provided a second, untreated leaf.
- The Bayer Advanced product (cyfluthrin and imidacloprid) also reduced initial feeding by 73 to 84% for as long as 19 days, but most of the exposed beetles recovered and fed as much as the control group when provided a second, untreated leaf.

Figure 1. Japanese beetle feeding damage (mean ± SE) on linden leaves with different-aged residues of foliar insecticides (professional products). Shoots were pre-sprayed and residues were allowed to weather in the field. Treated leaves were then harvested and challenged with 10 female beetles for 6 h.



Homeowner Products

- In the no-choice test, 4-h-old, dry residues of Sevin, Pyola, and Neem-Away significantly reduced feeding (99, 97, and 68%, respectively) relative to untreated controls (Figure 2). Pepper wax and Surround did not reduce feeding.
- Sevin was the only homeowner product that killed the beetles, although they were noticeably intoxicated by Pyola. These treatments reduced subsequent feeding by 100 and 77%, respectively.
- Neem-Away provided short-term deterrence, but its effectiveness was reduced by simulated rain (Figures 3, 4).
- Garlic Guard and Orange Guard caused severe phytotoxicity.
- Pyola significantly deterred feeding for at least three days, but was no longer active after seven days. Simulated rain did not reduce its short-term effectiveness (Figures 3, 4).
- None of the other homeowner products (i.e., Hot Pepper Wax, Orange Guard, Garlic Guard, Surround, or Rotenone/pyrethins) protected linden leaves in choice tests.

Figure 2. Japanese beetle feeding damage (mean ± SE) on linden leaves with 4-h-old dry residues of selected homeowner products. Treated leaves were challenged with 10 female beetles for 6 h.

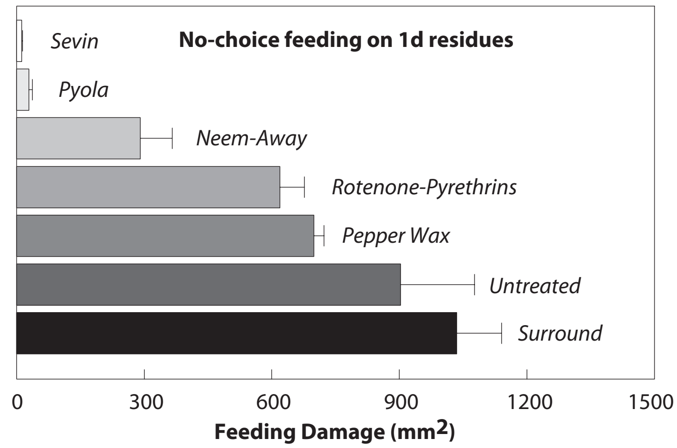


Figure 3. Feeding deterrence of different-aged residues of Pyola (pyrethrins and canola oil) and Neem-Away (azadirachtin) versus Japanese beetles in paired choice tests. To test for rainfastness, leaves with dry residues were drenched (2.54 cm of water) with a sprinkling can, then allowed to dry before the challenge.

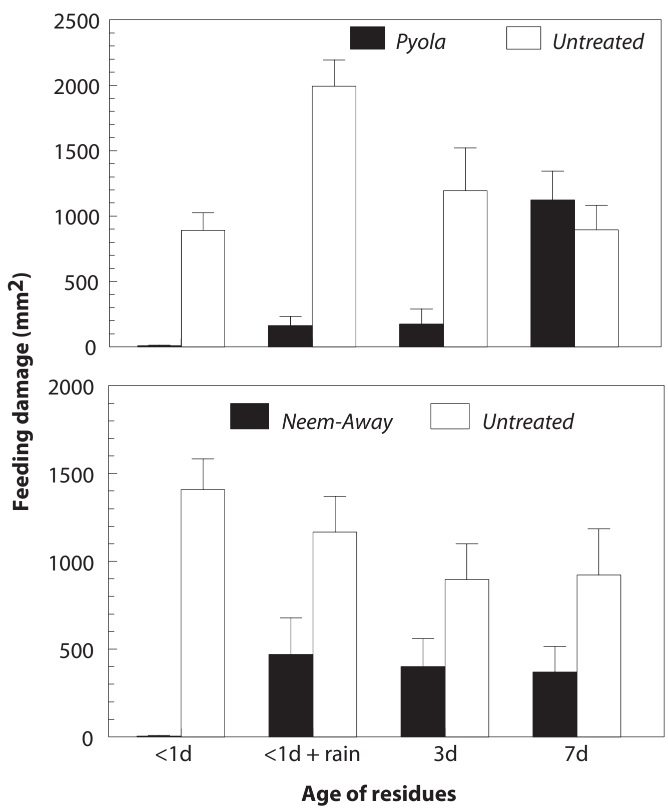


Figure 4. Typical silhouettes Neem-Away- or Pyola-treated linden leaves (left) versus untreated leaves (right) in choice tests. Residues of those products deterred Japanese beetles for several days (see also Figure 3).

Significance to the Industry

Field-weathered residues of Deltagard, TalstarOne (Talstar), Onyx, Scimitar, and Tempo provided 94 to 100% protection of linden foliage from Japanese beetles for at least 19 days (Figure 2). Those newer pyrethroids outperformed Sevin, which had been the industry standard for Japanese beetle control for many years. With the pyrethroids, beetles were knocked down quickly so there was little or no feeding damage before they were killed. The extended residual was obtained despite frequent and heavy rainfall on the sprayed shoots. Pyrethroids should allow arborists, landscape managers, nursery managers, and other professionals to manage Japanese beetle adult with fewer sprays and much less active ingredient than in the past. Homeowner formulations containing pyrethroids (i.e., products whose active ingredient ends in "-thrin") should also be effective.

Among the reputed repellents and "soft" pesticides marketed to home gardeners for Japanese beetle control, kaolin clay (Surround), capsaicin (Hot Pepper Wax), d-limonene (Orange Guard), garlic extract (Garlic Guard), and a rotenone/pyrethins combination were ineffective. Orange Guard and Garlic Guard caused severe phytotoxicity (drying out and burning) of linden leaves. Azadiractin or neem oil (Neem-Away) and a pyrethrins/canola oil mix (Pyola), both purchased online from Gardens Alive!, deterred Japanese beetles for about three days. Pyola resulted in knockdown and paralysis of beetles, as well as deterrence, whereas neem acts mainly as a feeding deterrent. Those products provide an option for homeowners seeking alternatives to chemical insecticides.

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Acknowledgments

This project was supported in part by a grant from the UK Nursery/Landscape Endowment Fund. The authors also thank Reid Maier, Bonny Miller, and Callie Prater for helping to sort and sex the thousands of Japanese beetles needed for the trials.

2005 Landscape Plant Disease Observations from the University of Kentucky Plant Disease Diagnostic Laboratory

Julie Beale, Paul Bachi, and John Hartman, Plant Pathology Department

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% 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. When the system is used to provide a diagnostic assist, the images can 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 almost 700 digital consulting cases, 30 to 35% dealt with landscape and nursery plants.

The 2005 growing season in Kentucky provided mostly warmer-than-normal temperatures and below-normal rainfall; however, these observations varied by location. The coldest temperatures occurred in late December 2004 and ranged from -11°F in parts of western Kentucky to +9°F in the central and east regions. Cold temperatures occurred before some plants were completely hardened off. A late spring frost occurred the last week of May in some locations. For most of Kentucky, prevailing temperatures were above normal for all months except March and May. Rainfall in most Kentucky locations was below normal every month except January and August (Hurricanes Dennis and Katrina). Indeed, central Kentucky suffered moderate to severe drought for most of the summer, and eastern Kentucky was in a state of severe drought by summer's end.

When winter cold temperatures occurred in December 2004, many plants were not yet fully hardened off. Cold temperature injuries of the trunk and major limbs were seen during the growing season on many hosts including holly, juniper, flowering prunus, and spruce. Despite dry weather, there was enough rainfall in spring to promote development of anthracnose and fire blight diseases. April and May temperatures were quite variable alternating from unseasonably warm to unseasonably cold. Cold 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. Hot dry summer conditions caused stress for all landscape plants that were not irrigated.

This year the following important or unusual diseases were observed:

Deciduous Trees

- Ash, dogwood, elm, maple, oak, redbud, and sycamore anthracnose (*Discula, Kabatiella,* and *Apiognomonia*)
- Ash, dogwood, maple, redbud, and willow canker (*Botryosphaeria*)
- Dogwood powdery mildew (*Microsphaera, Phyllactinia*), spot anthracnose (*Elsinoe*)
- Dutch elm disease (*Ophiostoma*)
- Flowering pear and flowering crabapple fire blight (*Erwinia)*
- Flowering plum and flowering cherry black knot (*Apiosporina*)
- Hawthorn, serviceberry, and crabapple cedar rusts (*Gymnosporangium juniperi-virginianae, G. clavipes, G. globosum*)
- Maple and redbud wilt (*Verticillium*)
- Maple leaf spot (*Phyllosticta*)
- Oak and maple canker (*Hypoxylon*)
- Oak bacterial leaf scorch (*Xylella*) and Actinopelte leaf spot (*Tubakia*)

Needle Evergreens

- Juniper and arbor vitae tip blight (*Kabatina*) and juniper rusts (*Gymnosporangium*)
- Pine and spruce tip blight (*Diplodia*) and pine needle casts (*Mycosphaerella, Plioderma*)
- Spruce needle cast (*Rhizosphaera*) and canker (*Cytospora*)
- White pine decline (abiotic) and ozone injury (abiotic)

Shrubs

- Azalea leaf and flower gall (*Exobasidium*)
- Boxwood Volutella canker (*Pseudonectria*)
- Holly and boxwood black root rot (*Thielaviopsis*)
- Hydrangea leaf spot (*Cercospora*)
- Rose black spot (*Diplocarpon*) and rosette (possible virus, leaf curl mite-transmitted)

Herbaceous Annuals and Perennials

- Begonia powdery mildew (*Erisyphe*)
- Celosia, chrysanthemum, foxglove, geranium, impatiens, pansy, petunia, salvia, vinca, and zinnia root rots (*Pythium, Rhizoctonia*)
- Chrysanthemum web blight (*Rhizoctonia*)
- Chrysanthemum leaf spot (*Septoria*)
- Daylily rust (*Puccinia*)
- Impatiens leaf spot (*Alternaria*)
- Iris leaf spot (*Didymellina*) and bacterial soft rot (*Erwinia*)
- Hosta southern blight (*Sclerotium*)
- Pansy, petunia, and vinca black root rot (*Thielaviopsis*)
- Anemone foliar nematode (*Aphelenchoides*)
- Anemone tobacco rattle virus
- Peony unidentified nepovirus

Significance to the 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 the useful information about plant disease provided for landscape professionals.

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Evaluation of Cambistat Treatments for Woody Plant Diseases

John Hartman, Ed Dixon, Amy Bateman, Natalie Godbert, and Céline Moser, Plant Pathology Department

Nature of the Work

Landscape tree bacterial leaf scorch (*Xylella fastidiosa*), pine tip blight (*Sphaeropsis sapinea*), and dogwood powdery mildew (*Microsphaera pulchra* and *Phyllactinia guttata*) are serious diseases of woody landscape plants in Kentucky (1). Cambistat (paclobutrazol) is a plant growth regulator chemical that inhibits synthesis of the plant hormone gibberellin. Some effects of paclobutrazol are reduction in shoot growth and stimulation of root development. The chemical is also a weak fungicide. Preliminary evidence suggests that application of Cambistat may improve tree health and reduce the effects of plant disease. Cambistat is applied as a soil drench around the base of the tree and is taken up into the tree systemically. Cambistat effects may not appear until the year after the treatments, but its beneficial effects are thought to last for three years. The objectives of these experiments were to test the efficacy of Cambistat treatments against bacterial leaf scorch, pine tip blight, and dogwood powdery mildew.

Oak treatments. Cambistat was applied at labeled rates to the base of mature, disease-susceptible pin oaks (*Quercus palustris*) (20 trees) and red oaks (*Quercus rubra*) (five trees) in Lexington, Kentucky. Each tree was paired with a tree of similar age, placement, and condition which was treated only with water. The experiment utilized both street trees in scattered locations around Lexington, treated August-October 2003, and oaks growing on the Idle Hour Country Club golf course, treated July 2003.

Pine treatments. Cambistat treatments were made in July 2003 at labeled rates to 20 mature Austrian pines (*Pinus nigra*) growing in a screen planting on the UK campus. Pines were infected with varying levels of tip blight disease, and matching experimental controls were treated with water.

Dogwood treatments. Sixteen flowering dogwoods (*Cornus florida*) growing at the University of Kentucky Horticultural Research Farm in Lexington were treated in July 2003 with labeled rates of Cambistat in replicated trials with an equal number of water-treated controls.

Results and Discussion

Oaks and bacterial leaf scorch. Oaks were evaluated in October 2003, 2004, and 2005. Symptoms of dieback and leaf scorch were observed, and a percentage was assigned for each. Photographs were also taken so that tree health progress could be noted over the years. In both the golf course and street tree groups, tree scorch symptoms were highly variable from tree to tree. Some trees are 100% scorched, while others are showing no scorch. Although the results are not statistically significant, some trends may be occurring. For the pin oaks in the golf course environment, bacterial leaf scorch and dieback symptoms generally decreased in 2005 from the 2003 and 2004 average. However, along the city streets, pin oaks showed more severe scorch and dieback symptoms. The difference may be that during the regional drought of 2005, the golf course trees received water from nearby turf irrigation, while street trees did not.

Cambistat-treated golf course pin oaks fared a little better than their water-treated counterparts. On street tree pin oaks showing high levels of scorch, treatment effects are not apparent. However, dieback remained basically unchanged, which suggests that tree decline was not accelerating. In any case, because of the high degree of variability between tree observations, these results are not statistically significant. For the red oaks in the experiment, there were too few trees from which to draw meaningful conclusions. Data showing the range of scorch and dieback symptoms observed in 2005 and the increase or decrease in symptoms for 2005 compared to 2003 and 2004 averages are presented in Table 1.

Table 1. Effect of Cambistat treatments on bacterial leaf scorch of pin oaks and red oaks growing as open-field golf course specimens and as street trees.

Species and Number of Trees	Treatment	Range of Symptoms Observed in 2005		Average Third-Year Symptom Change*	
		Scorch	Dieback	Scorch	Dieback
Oaks Growing in a Golf Course Environment					
Pin oak - 10	Cambistat	0 - 60%	0 - 10%	- 5.4%	- 3.6%
Pin oak - 11	Water	0 - 100%	0 - 15%	- 1%	- 3.5%
Red oak - 4	Cambistat	0 - 95%	1 - 15%	6%	1%
Red oak - 4	Water	0 - 80%	0 - 15%	4%	- 2.8%
Oaks Growing as Street Trees					
Pin oak - 10	Cambistat	20 - 100%	5 - 55%	25%	1%
Pin oak - 10	Water	0 - 90%	5 - 45%	15%	1%
Red oak - 1	Cambistat	0%	0%	-18%	0%
Red oak - 1	Water	0%	10%	-15%	2%

* Results are not significantly different due to high variability of symptom changes.

Based on data from the second year of the three-year study, significant treatment effects on scorch disease are not being noticed. Cambistat does appear to decrease oak growth. On the golf course, annual increase in trunk diameter of water-treated trees was 0.16 inches compared to 0.05 inches for Cambistat-treated trees. From a distance, shoot growth also appeared to be reduced with Cambistat treatments.

Pines and tip blight. Pines were evaluated in July 2005 for levels of tip blight disease and for detection of the causal fungus in healthy tissues (latent infections) using PCR assays. Many of the pines continued to deteriorate since 2003, whether treated with Cambistat or not, and several have had to be removed. Data on disease incidence, latent infection detection, and pine tree growth are presented in Table 2.

Table 2. Effect of Cambistat treatment on Austrian pine tip blight disease, presence of latent Diplodia, and tree growth in 2005.

Treatment	% Tip Blight in 2005	% Decrease in Latent Infections Detected	1-Year Trunk Diameter Increase (in.)	1-Year Shoot Terminal Growth (in.)	1-Year Lateral Branch Growth (in.)
Cambistat	22.1 a*	8.9 a	0.27 a	5.0 a	4.1 a
Water	33.7 a	27.7 a	0.41 a	6.3 b	4.5 a

* In a column, means bearing the same letter are not significantly different (Waller-Duncan K-ratio test P = 0.05).

It appears that Diplodia tip blight disease may be slowing down in Cambistat-treated pines, and that latent infections in Cambistat-treated trees did not appear to decrease as fast as in water-treated trees. If these trends were significant, one could surmise that latent infections are converting to active infections at different rates, thus accounting for the differences. Cambistat-treated Austrian pines are growing more slowly than water-treated pines, which would be expected for this growth regulator chemical. At this point, it appears that Cambistat treatments will not quickly cure pines of tip blight disease, if at all.

Dogwoods and powdery mildew. Dogwoods were evaluated in spring and throughout the summer for effects of treatments on the trees and for powdery mildew. All Cambistat-treated dogwoods showed noticeable phytotoxicity. Flowering was delayed and bracts did not fully expand in spring. Leaves never fully expanded, but they remained green and presumably functional throughout the season. Water-treated trees did not show any growth abnormalities. Powdery mildew appeared in early summer and reached high levels by midsummer. Cambistat-treated trees showed significantly less powdery mildew in August (Table 3). At the rates used, Cambistat was too phytotoxic to dogwoods for practical landscape use.

Significance to the Industry

Cambistat treatments are being used for landscape tree disease management by some arborists in Kentucky. There are few data to suggest that the chemical will make an impact on disease. The results of this study will be useful to the Kentucky landscape industry.

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Table 3. Effect of Cambistat treatment on dogwood growth and powdery mildew.

Treatment	Annual Trunk Diam. Increase (in.)	Leaf Size (in.)	Percent Bloom		Flower Bract Size (in.)	Percent Powdery Mildew		
			11 Apr.	12 May		26 July	26 Aug.	19 Sep.
Cambistat	0.16 a*	1.9 b	27 b	62 b	1.5 b	14 a	19 a	28 a
Water	0.34 a	4.4 a	76 a	16 a	2.9 a	20 a	27 b	37 a

* In a column, means bearing the same letter are not significantly different (Waller-Duncan K-ratio test P = 0.05).

Phylogenetic Analysis of Kentucky Strains of *Xylella fastidiosa*

Nicki Mundell, Chris Schardl, and John Hartman, Plant Pathology Department

Nature of Work

The phytopathogenic bacterium, *Xylella fastidiosa*, causes several economically important plant diseases, including bacterial leaf scorch of landscape trees and Pierce's disease of grapes. In Kentucky, bacterial leaf scorch affects many oak and maple species in addition to sycamore, hackberry, elm, sweetgum, and mulberry. Over the past 30 or more years, bacterial leaf scorch has caused tree mortality and tremendous losses, especially in oaks, along streets and in landscapes of many Kentucky cities. Pierce's disease of grape appeared only recently in a western Kentucky vineyard in 2001. *X. fastidiosa* has recently been detected in several symptomless grasses, vines, shrubs, and weeds in the landscape. Diseases caused by *X. fastidiosa* are vectored by xylem-feeding leafhoppers.

It was the goal of this research to identify hosts of *X. fastidiosa* around Kentucky and use phylogenetic analysis (which determines how closely different organisms are related to one another) to compare DNA sequences of specific genes between *X. fastidiosa* in different samples. The DNA of two genes was examined: the 16S rDNA (gene coding for bacterial ribosome structure and function; ribosomes are needed for bacteria to make proteins) and the gyrase B gene (*gyrB*, which codes for a bacterial DNA maintenance protein). Landscape plant samples were collected in urban areas of Kentucky between 2002 and 2004 and tested for the presence of *X. fastidiosa* by enzyme-linked immunosorbant assay (ELISA) and poymerase-chain reaction (PCR). The ELISA test detects proteins only found in *X. fastidiosa,* and the PCR test detects only *X. fastidiosa* DNA. Primer sets developed for *X. fastidiosa* were used to amplify part of the 16S rDNA and the *gyrB* gene from DNA extracted from plant tissue. Sequence data from these PCR products were assembled using computer programs that sort out complex DNA sequence data. Phylogenetic analysis was then done with another computer program to show how closely the bacterial DNA in the samples were related to one another. Comparisons with strains outside of Kentucky were also done using *X. fastidiosa* sequence data obtained from the National Center for Biotechnology Information.

This research tests the hypothesis that DNA base sequence comparison can determine if all cases of bacterial leaf scorch in Kentucky are caused by the same strain of *X. fastidiosa*. In addition, can DNA analysis identify asymptomatic hosts and vectors that serve as a source of inoculum for pathogenic strains of *X. fastidiosa?*

Results and Discussion

Results indicate that the Kentucky Pierce's disease strain of *X. fastidiosa* is most likely a true Pierce's disease strain and not a bacterial leaf scorch strain transmitted from oaks or other hosts to infect grapevine because it fits into the same grouping with the other strains isolated from grape elsewhere (1).

With few exceptions, *X. fastidiosa* sequences from oak samples fit into a group associated with bacterial leaf scorch of shade trees. According to the *gyrB* gene analysis, host of origin has a greater effect on the relationship between sequences than geography. For example, one group consists of strains from grape originating in California, Florida, Georgia, and Kentucky. Also, the sequences from oak samples group together despite the fact that they were collected in different parts of Kentucky and even different states. Results of phylogenetic analysis suggest that use of the *gyrB* gene is superior to the 16S rDNA for studying the relatedness of *X. fastidiosa* strains.

This research addressed the hypothesis that sequence comparison can be used to identify potential asymptomatic hosts and vectors for pathogenic strains of *X. fastidiosa*. The results of the collection and detection part of this study underscore the problems associating *X. fastidiosa* with a given host, particularly those that are asymptomatic. Isolation proved to be difficult, if not impossible for *X. fastidiosa*, and ELISA is known to cross-react with plant sap of some hosts. PCR detection methods can bypass these problems to some extent, if the primer set used is specific for *X. fastidiosa* and if the method of DNA extraction effectively eliminates PCR inhibitory compounds.

The ultimate conclusion from this study is that the detection and comparison of strains of *X. fastidiosa* is dependent on reliable molecular methods. This requires the use of DNA extraction techniques that successfully access the DNA of *X. fastidiosa* in the xylem while minimizing the effect of PCR inhibitory compounds. It also requires the use of primers developed to specifically amplify *X. fastidiosa* DNA, and particularly to amplify meaningful genes or genomic regions that can be used in phylogenetic analysis.

Significance to the Industry

Effective management of bacterial leaf scorch of landscape trees will depend on knowledge of sources and transmission of *X. fastidiosa*, which requires complex molecular studies. It is now known that the appearance of Pierce's disease in Kentucky grapes does not represent a threat to landscape trees nearby because the *X. fastidiosa* strain that attacks grapes is not found in landscape trees. The landscape industry ultimately benefits from basic studies of host-pathogen interactions.

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Cytology of *Diplodia pinea* in Diseased and Latently Infected *Pinus nigra* Shoots

Jennifer Flowers, Lisa Vaillancourt, and John Hartman, Plant Pathology Department

Nature of Work

Diplodia tip blight, also known as pine tip blight or Sphaeropsis tip blight, is a serious disease of conifers worldwide. The causal pathogen, *Diplodia pinea* (syn. *Sphaeropsis sapinea*), causes tip blight on more than 30 different pine species. Symptoms are particularly severe on nonnative, two-needled *Pinus* species and typically include stunted, necrotic needles and shoots of the current year's growth, resinous cankers, and a general decline of the tree. During the past 15 years, Diplodia tip blight has emerged as a serious problem in Kentucky landscapes and Christmas tree farms. Our surveys of diseased and symptomless Austrian pines revealed that latent infections of symptomless shoots by *D. pinea* were common (3). Latent infections also occur in symptomless terminal buds. Latent infections may account for rapid decline of mildly diseased pines in the landscape.

To investigate the colonization habits of *D. pinea* within its host, naturally infected, diseased and asymptomatic Austrian pine tissues were examined. A polymerase chain reaction (PCR) assay of *D. pinea* DNA extracted from pine tissues was used to determine if asymptomatic samples were healthy or latently infected (2). Pine tissue samples were embedded in a plastic resin, sliced very thinly with a diamond knife microtome, placed on glass slides, and treated with toludine blue O stain. Microscopy and traditional histological methods were used to define the location of latent infections in current-year's shoots and terminal buds. The location of fungal colonization was compared in healthy, diseased, and latently infected *P. nigra* tissues at three different times of the year (January, May, and August).

Results and Discussion

Healthy shoots (asymtomatic, PCR negative) displayed normal anatomy which changed with each season as shoots matured. Healthy shoots showed very sparse epiphytic and subcuticular fungal growth; however, no fungal tissues were present within the shoots.

Diseased shoots (symptomatic, PCR positive), even with only very early symptoms of tip blight, were completely colonized by the pathogen. An extensive network of fungal hyphae was observed in the pith, xylem, phloem, cortex, and epidermal tissues. Most of the pine tissues were so degraded and collapsed that their structure could no longer be discerned even though the shoot was mildly infected with only a few dead needles. Some xylem tracheids appeared intact and very likely functioned to support the still-healthy needles of the diseased shoots. Even resin ducts, thought to be important in host defense against disease, contained fungal hyphae.

In latently infected shoots (asymtomatic, PCR positive), crevices created between the needle fascicles and the outer epidermal layers of the needle base were filled with fungal hyphae and spores, and hyphae were observed colonizing the needle fascicle sheaths. Hyphae were also observed breaching the shoot epidermal layer in these crevices and colonizing the underlying periderm. Unlike the observation of extensive *D. pinea* colonization in all tissues of diseased shoots even early in symptom development, fungal hyphae in latently infected shoots were localized. Localized pockets of tissue disintegration were observed in the periderm and adjacent cortical cells located around areas of needle attachment in these asymptomatic, latently infected shoots. Necrophylactic periderms were observed forming a barrier around degraded cortical cells colonized with hyphae, and eventually a lignified layer was formed. This appears to be a host response to colonization by the fungus. The mechanism that operates to prevent expansion of these infected pockets in the latently infected shoots is still unclear. Although not as common, our findings also show that dormant terminal buds can become infected in ways similar to elongating shoots.

Our observations suggest that infection of pines can occur in the crevices created between the bark and the needle bases rather than through needle stomata as was previously thought. The fungus penetrates directly through the relatively thin, unprotected epidermal layers at the base of the needle into the adjacent periderm and cortex. If the host tree is unable to restrict the fungus to the periderm and adjacent cortical cells, colonization would progress into the vascular tissues, resulting in symptom development. Vascular colonization may occur more readily if the host is stressed, but the exact mechanism by which stress indexes susceptibility is not known. This is the first report of visual observations of latent infections of conifer tissues (1).

Significance to the Industry

Our findings emphasize the importance of integrating various control measures to reduce tip blight disease severity on *P. nigra* in the landscape. Cultural controls such as reducing tree stress and practicing sanitation are very important for maintaining healthy landscape trees. Drought stress and excess fertilizer have been shown to increase Diplodia tip blight incidence and severity and should be avoided. Inoculum levels can be reduced by removal of diseased host material. Chemical controls applied just before bud break and continuing through shoot elongation have been relatively ineffective in controlling this disease in Kentucky landscapes. This study suggests that topically applied fungicides may not reach the real infection sites deep in the crevices at the needle bases or that fungicides are applied after dormant terminal buds are already infected. Arborists, landscape managers, and nursery workers will benefit from the basic biological information obtained from this study.

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Preliminary Evaluation of the Transmissibility of *Diplodia pinea* During the Shearing of Scots Pine Christmas Trees

Amy Bateman, John Hartman, Lisa Vaillancourt, Nathalie Godbert, and Céline Moser, 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, this 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 it 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. At the start, disease levels were determined for each tree, and these levels were used to categorize the trees as being healthy (0% disease), minimally diseased (0.1 to 1.9%), or moderately diseased (2% or greater). Trees were then placed in 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 (one or two 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.

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.

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, significantly more CFUs were picked up from moderately diseased trees compared to healthy trees ($p < 0.001$ and $p = 0.008$ for farms 1 and 2, respectively) with the trend of increasing fungal adhesion to tools as disease level increases (Figure 1). Based on this preliminary study, Lysol application did not successfully disinfest the tools of *D. pinea* (Figure 2).

Symptom evaluation will be done in 2006 to determine if transmission of the fungus occurred from diseased to healthy trees and created new infections. The entire study will be repeated as well in 2006.

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

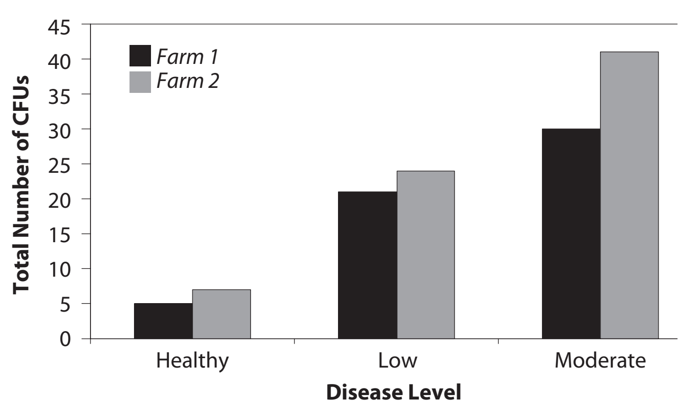
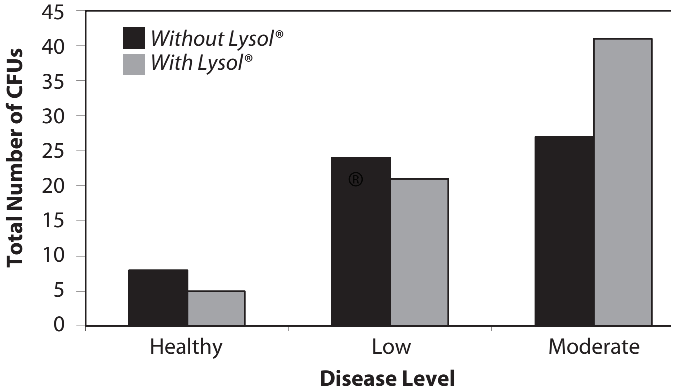


Figure 2. Total number of *Diplodia pinea* colony-forming units (CFUs) with or without Lysol® treatment[1] for both farms combined per disease level.



[1] Lysol® treatments applied to shearing tools after only lead tree shearing.

Significance to the 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.

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National Nursery, Forest, and Nursery Perimeter Survey for *Phytophthora ramorum* in Kentucky, 2005

Patricia B. de Sá, John Hartman, Joe Collins, Carl Harper, Bernadette Amsden, David Begley, Nathan Jennings, and Céline Gouwie, Departments of Plant Pathology and Entomology

Nature of Work

Phytophthora ramorum, found in North America and Europe, is a fungus-like organism that can infect woody trees and shrubs, herbaceous plants, and ferns in natural woodlands, parks, and nurseries. Disease symptoms vary depending on the kind of plant that is infected and the weather conditions and may be seen on leaves, twigs, and shoots and on branches and main stems or tree trunks. On plants other than oak trees, symptoms are seen mostly on the shoots, leaves, and twigs and sometimes as cankers on the stem and branches. Diseases caused by *P. ramorum* generally fall into three groups: a) sudden oak death, b) Ramorum leaf blight, and c) Ramorum shoot dieback. Sudden oak death results from formation of bleeding cankers on trunks and limbs of oaks and tanoaks. Ramorum leaf blight symptoms are brown necrotic rounded leaf spots or triangular blotches along the mid-rib of the leaf. Necrosis can develop on the leaf tip or along the edge of the leaves where water accumulates. Ramorum shoot dieback symptoms are limp shoots that turn brown and necrotic. Ramorum leaf blight and Ramorum shoot dieback develop on plants like camellia, rhododendron, viburnum, pieris, and mountain laurel and also on leaves of trees such as maple and buckeye. Douglas fir and grand fir can develop symptoms in Christmas tree plantations located close to heavily infected California bay laurel with symptoms of Ramorum tip dieback and Ramorum leaf blight. Infected redwood trees develop shoot dieback symptoms on epicormic sprouts, and leaf blight and small cankers on branches.

P. ramorum has been found in plants in native woodlands and parks in California and Oregon in the United States and in Europe with similar symptoms. Many plants have mild symptoms and shed the infected leaves, so the disease is not immediately lethal to them. However, a large number of spores are produced on these leaves, and the spores can be transported to oak trees by rain splash and infect them, causing trunk and branch cankers, sudden oak death, a serious and lethal disease of oak. In Europe, an association between infected rhododendrons and infected oak trees has been observed, and in California infected California bay laurel plants are believed to be the source of infection for oak and tanoak trees. This disease has killed thousands of trees. On mature trees, cankers varying in color from red and brown to black develop on the main stem, and dark or reddish sap oozes from the bleeding cankers. In time the canker girdles the tree, and soon the tree foliage fades to pale yellow and then to brown. Infected trees fail to refoliate later in the season or the next spring, and the tree is killed.

There are several *Phytophthora* species and other fungi in forest and nursery environments that cause identical or similar symptoms on leaves and shoots and even bleeding cankers on tree stems. But these organisms are not exotic species and not as destructive as *P. ramorum* and are part of the natural ecosystem. Not every bleeding canker or leaf blight is caused by *P. ramorum*, and it is not possible to diagnose it correctly based on symptoms only. Presently two approaches are used for correct identification of this pathogen: 1) isolating it in a pure culture on a selective medium and having the spores identified under a microscope by a trained specialist; 2) extracting DNA from infected leaves or from a pure culture and performing PCR assays if necessary.

An increasing number of plants are found to be host to *P. ramorum* or associated with it, and an updated list of host and associated plants is available on the USDA-APHIS-PPQ Web site. This list is updated regularly as new susceptible plants are found in nature or as a result of inoculation tests. The September 14, 2005, update added eight plants to the list, bringing the total number of plants listed to 85. Proven hosts are those for which Koch's postulates have been completed, and 40 plants are listed as such; the other 45 plants are considered to be associated with *P. ramorum* and are also regulated as nursery stock. Several oak species are listed as hosts: southern red oak, coast live oak, canyon live oak, holm oak, California black oak, and Shreve's oak; in addition, all species and varieties of rhododendrons including azaleas are listed. The complete list can be viewed at: http://www.aphis.usda.gov/ppq/ispm/pramorum/pdffiles/usdaprlist.pdf.

Long distance spread of *Phytophthora ramorum* is believed to occur through the movement of infected plants, plant parts, and even soil. This quarantined pest may have been inadvertently introduced to states outside the regulated areas in California and Oregon on infected nursery stock in 2003, 2004, and 2005. There is great concern that *P. ramorum* may spread to parks and native woodlands in the United States from introduced infected ornamental plants and even soil, and that native plants in forest areas outside the West Coast may become affected. Nursery and forest surveys are under way in the United States, Canada, and Europe for early detection of this pathogen in efforts to stop its spread. The purpose of the National Nursery Survey and the National Forest Survey in the United States is early detection of *Phytophthora ramorum* in nurseries and forests so that the disease can be eradicated, if possible.

Kentucky nursery survey. A nursery survey was made in Kentucky during the summer of 2005, as a collaboration between the USDA-APHIS and the Office of State Entomologist and the Department of Plant Pathology at the University of Kentucky. This survey was part of a National Nursery Survey, and nurseries were inspected by USDA-APHIS personnel and nursery inspectors operating from the Office of the State Entomologist. Samples from plants showing symptoms similar to those expressed by plants infected by *P. ramorum* were collected, placed in double bags with zip closure, labeled, and sent to the Plant Pathology Department for analysis. All samples were tested using direct DAS ELISA (Double Antibody Sandwich Enzyme Linked Immunosorbent Assay) using antibodies that recognize proteins present in organisms in the genus *Phytophthora*. This assay detects *Phytophthora* to the genus level but is not sensitive enough to differentiate between the 50 different species in the genus *Phytophthora*, so samples that were ELISA-positive were tested further. Total DNA was extracted from the samples that were ELISA-positive, and the DNA was sent to the USDA-APHIS for testing by Polymerase Chain Reaction (PCR) using nested primers for amplification of *P. ramorum* DNA. This PCR method is one of the two most common approaches used for precise identification of *P. ramorum*. Another approach, which we did not use, involves isolating the pathogen in pure culture and growing it in PARP selective media and then having the spores identified under a microscope by a trained specialist.

Kentucky forest survey. The 2005 Kentucky forest survey was done as a collaboration between the USDA Forest Service, the Kentucky Division of Forestry, and the Plant Pathology Department at the University of Kentucky. The survey protocol used was designed by USDA Forest Service, Forest Health Monitoring, and sampling was based on a risk polygon map. The risk map was developed based on presence of oak species in the overstory and presence of the target host genera in the understory; locations of trace forward nurseries (nurseries that received camellias from a contaminated West Coast nursery in 2004); length of the period of moist weather and mild temperatures; and area outside the temperature extremes that limit the establishment of *P. ramorum*. The target host plants were plants in genera that are relatively abundant in forest settings, exhibit distinctive symptoms when infected with *P. ramorum*, and have been shown in other places to develop disease when exposed to *P. ramorum*. For the eastern United States forest survey in 2005, there were 11 target host genera: *Acer, Aesculus, Castanea, Fagus Hamamelis, Kalmia, Lonicera, Quercus, Rhododendron, Vaccinium,* and *Viburnum.*

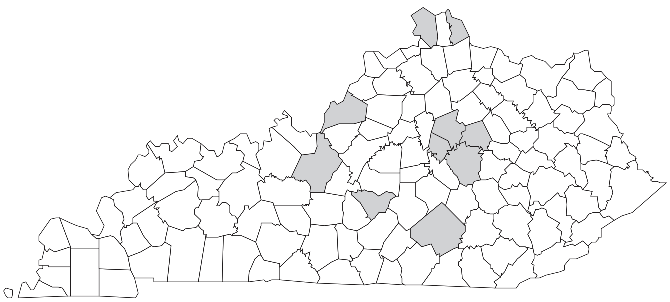
The survey was performed in the perimeter of six trace forward nurseries and in locations in high-risk oak forests rich in rhododendrons and mountain laurels. Because *P. ramorum* resistance spores are known to survive in soil that can be carried on hiker's boots and on vehicle tires, areas of high tourist traffic like national and state parks and some city parks were also sampled. In locations in general forest areas, four 100-meter transects were installed in the four cardinal directions from a central point. The width of each transect was determined by how far the surveyors could see from the transect line. GPS readings and other host and terrain data were taken, and samples were collected from target host plants showing suspicious symptoms and found in the transect area. For surveying nursery perimeters, four transects were placed on the perimeter of nurseries in such a way as to take advantage of the presence of target host plants.

Leaf and bark samples from plants showing symptoms similar to those expressed by plants infected by *P. ramorum* were collected, placed in double bags with zip closure, labeled and maintained at low temperature until they were analyzed in the laboratory at the Plant Pathology Department at the University of Kentucky. Replicate samples were shipped overnight to a collaborating regional laboratory for analysis and for confirmation of the results. Samples were tested by performing a DNA extraction and PCR with nested primers for *P. ramorum* identification. Tools used for sample collection were disinfested after each sample was taken to avoid spreading any disease to other plants.

Results and Discussion

Kentucky nursery survey. Approximately 30,217 plants in 105 nurseries and retail outlets were surveyed in 33 counties in Kentucky. Of all the nurseries surveyed, six nurseries were trace forward nurseries, that is, nurseries that received camellias from a contaminated West Coast nursery in 2004. A total of 26 samples were collected from nurseries in the following 10 counties: Boone (5), Campbell (4), Clark (1), Fayette (3), Hardin (1), Jefferson (7), Jessamine (2), Madison (1), Pulaski (1), and Taylor (1) (Figure 1).

Figure 1. Kentucky counties from which samples of plants showing symptoms resembling *P. ramorum* infections were collected during the National Nursery Survey in 2005.



One rhododendron plant showing symptoms similar to those caused by *P. ramorum* was found in the survey of the six trace forward nurseries. A sample was collected from this plant, and it was negative in ELISA for *P. ramorum*. Two samples from the other 25 samples collected tested positive in ELISA for the genus *Phytophthora*. DNA was extracted from these two samples and was sent to the USDA-APHIS laboratory for further testing by PCR, and the result was negative for *P. ramorum.* The results of plant sampling are summarized in Table 1.

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 2005.

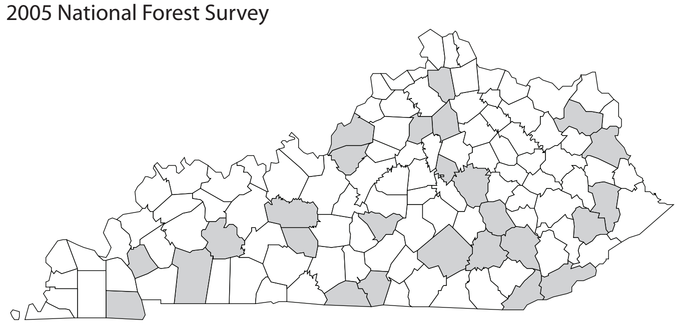
Plant	Number of Samples	ELISA Positive	PCR Positive
Azalea	3	0	0
Forsythia	1	0	0
Hydrangea	1	0	0
Kalmia sp	1	0	0
Peony	1	0	0
Pieris sp	3	0	0
Rhododendron sp	11	1	0
Rose	1	0	0
Viburnum sp	4	1	0
Total	26	2	0

No samples collected from Kentucky nurseries were found to be positive for *P. ramorum* in the 2005 nursery survey.

National nursery surveys for 2005 have been completed in nurseries in 49 states and in Puerto Rico; a total of 3,663 nurseries have been visited and 64,814 samples collected. Seven states were found to have nurseries with plants that tested positive for *P. ramorum,* and the number of nurseries in each of the seven states were: 55 in California, 20 in Oregon, 13 in Washington, four in Georgia, two in Louisiana, one in South Carolina, and one in Tennessee. In 2004, infected plants were found in nurseries in 22 states. The numbers from the 2005 National Nursery Survey show a reduction in the total number of states with nurseries with infected plants; however, the number of nurseries having infected plants in California, Oregon, and Washington has increased. It is also important to note that the number of plants that are found to be hosts to *P. ramorum* is also increasing, as noted by the revisions of the list of host and associated plans published by the USDA-APHIS on its Web site.

Kentucky forest survey. Thirty locations in 26 counties were surveyed in Kentucky (Figure 2).

Figure 2. Kentucky counties from which samples of plants showing symptoms similar to *P. ramorum* diseases were collected during the 2005 National Forest Survey



Survey locations were distributed as follows:

1) Six trace forward nursery perimeters: two in Jefferson County and one each in Jessamine, Franklin, Laurel, and Pulaski counties.
2) Four Kentucky State Forests: Pennyrile State Forest (Christian County), Tygart State Forest (Carter County), Kentucky Ridge State Forest (Bell County), and Kentenia State Forest (Harlan County).
3) Privately owned forest areas in the following counties: Muhlenberg, Clay, Jackson, Knott, Scott, Grant, Madison, and Bullitt.
4) Forest areas in the following state parks: Rough River State Recreation Park (Grayson County), Cumberland Falls State Resort Park (Pulaski County), Levi Jackson State Resort Park (Laurel County), Jenny Wiley State Resort Park (Floyd County), Yatesville Lake State Resort Park (Lawrence County), Carr Creek State Recreation Park (Knott County), Dale Hollow Lake State Recreation Park (Cumberland County), and Green River Lake State Resort Park (Taylor County).
5) Other forested areas: Land Between the Lakes National Recreation Area (Lyon County), Mammoth Cave National Park (Edmonson County), Tompkinsville City Park (Monroe County), and Murray City Park (Calloway County).

From the 30 locations surveyed in Kentucky in 2005, 42 leaf and bark samples from plants showing symptoms similar to those that might be caused by *P. ramorum* were collected. DNA was extracted from all samples, and PCR was performed to test for *P. ramorum*. No samples were found to be positive for *P. ramorum*. The list of target hosts and results of PCR reactions are shown in Table 1.

Table 2. Number of plants in each target genus sampled and results of PCR assays for *P. ramorum*, including plants showing foliar symptoms and trees from which bleeding cankers were collected during the National Forest Survey for *P. ramorum* in Kentucky in 2005.

Target Genus	Number of Samples	PCR Result
Acer	6	Neg
Aesculus	2	Neg
Hammamelis	1	Neg
Kalmia	7	Neg
Lonicera	2	Neg
Rhododendron	4	Neg
Vaccinium	5	Neg
Viburnum	2	Neg
Castanea	0	Neg
Fagus	2	Neg
Quercus	8	Neg
Ulmus	1	Neg
Carya	1	Neg
Platanus	1	Neg
Total	42	

P. ramorum has been found causing sudden oak death, Ramorum leaf blight, and Ramorum shoot dieback in three forest types in California and Oregon: California coastal evergreen forests, redwood forests with tanoak understory, and Oregon forests dominated by tanoak. In California, coast live oak, California black oak, Shreve's oak, and canyon live oak trees have been found to be susceptible to *P. ramorum* infection. Several species of oaks common in eastern forests, as well as sugar maple and black walnut, have been shown in greenhouse experiments to be susceptible to *P. ramorum.* Although greenhouse experiments show that a plant may become infected by this pathogen, the effect of this pathogen in eastern forests is not known. The USDA Forest Service and collaborating states are conducting surveys for detection of *P. ramorum* in nursery perimeters and in general forested areas; surveys have been completed in 28 states and, to date, and there were no confirmed positives. Thirty locations have been surveyed in Kentucky, and no samples were positive for *P. ramorum*.

Significance to the Industry

None of the nurseries surveyed in the state of Kentucky were found to have plants testing positive for *P. ramorum* in 2005. However, the long distance spread of *P. ramorum* via infected plants such as ornamental plants transported from contaminated nurseries is possible. There is great concern that if infected plants are introduced into the state, *P. ramorum* may spread to nurseries in Kentucky and then to parks and woodlands, where rhododendrons and azaleas, viburnums, and mountain laurel are native. Once infected, these plants may become a source of infection for the 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. This information will be useful to Kentucky arborists and to the nursery and landscape industries.

Acknowledgments

The forest survey was carried out 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; the USDA Forest Service for permission to sample in the Daniel Boone National Forest; to the private land owners who gave us permission to perform the survey and sample in their property and to Bernheim Forest, Land Between the Lakes National Recreation Area, and Mammoth Cave National Park.

National Elm Trial—Kentucky Data, 2005

John Hartman, Ed Dixon, Bernadette Amsden, and Nathan Jennings, Plant Pathology; Dan Potter and Bonny Seagraves, Entomology; William Fountain, Horticulture

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. 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 2006 or 2007. Trees were staked as needed and watered during dry periods, and all trees were mulched over grass that had been killed with an application of Roundup herbicide.

The 14 elm cultivars planted for this study include the following:

1. "Clone D" — *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*

Trees came from the nursery as bare root transplants about 5 to 8 ft tall. In the plots, trees were provided with supplemental water two times in April, four times in May, three times in June, and once each in July and August. Tree trunk diameters were measured on 16 June, and tree height and tree survival were measured and tabulated on 23 June. Japanese beetle damage was assessed on 12 August by estimating the percentage of foliage that was damaged by beetle feeding. Fall color evaluations were made on 7 November.

Results and Discussion

Results from the elm plots are presented in Table 1. Most of the trees survived the transplanting and the hot, dry weather that characterized the summer of 2005. There were significant differences in the average levels of Japanese beetle damage sustained by the different cultivars. Emer II and Homestead elms appeared to be somewhat less attractive to Japanese beetle feeding, while Morton Plainsman, Morton Accolade, Prospector, and Morton Stalwart appeared to attract more Japanese beetle feeding than most other cultivars. Many trees showed significant autumn defoliation by November. Fall color ranged from green-yellow to burgundy.

Significance to the 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. Elm survival, average size, damage from Japanese beetle and fall color in 2005.

Cultivar	Percent Survival	Average Trunk Diameter (in. dbh)	Average Height (ft)	Average Crown Width (ft)	Percent Foliage Feeding by Japanese Beetles*	Fall Color	Percent Autumn Leaf Drop
1. Clone D	100	0.61	9.1	1.5	48 cd	green-yellow	0
2. Emer II	60	0.42	5.0	1.3	20 ef	yellow to red	0
3. Frontier	100	0.45	9.2	3.2	39 d	burgundy	0
4. Homestead	100	0.46	10.2	2.3	18 f	green	0
5. Morton Glossy	80	0.64	9.0	1.9	58 abc	yellow-brown	70
6. Morton Plainsman	100	0.79	9.0	2.4	72 a	yellow-gold	0
7. Morton Red Tip	100	1.04	9.5	3.3	35 de	yellow-brown	60
8. Morton Stalwart	100	0.81	10.4	3.0	65 ab	yellow	60
9. Morton Accolade	100	0.69	9.4	2.1	66 ab	brown	95
10. New Horizon	100	0.40	6.4	1.3	38 d	green-yellow	0
11. Patriot	100	0.56	9.3	2.5	44 cd	green-yellow	0
12. Pioneer	100	0.55	9.0	1.6	49 bcd	green-yellow	0
13. Prospector	100	0.80	9.6	3.3	66 ab	green-yellow	70
14. Valley Forge	80	0.45	8.5	2.1	42 cd	yellow-gold	40

* In a column, means bearing the same letter are not significantly different (Waller-Duncan K-ratio test, P = 0.05).

Evaluation of *Hydrangea macrophylla* for Cut Stem Potential

Robert E. McNiel and Sharon Bale, Department of Horticulture

Nature of Work

Hydrangea macrophylla cultivars were evaluated for feasibility of Kentucky farms growing the crop for floral cut stems. Hydrangea cut flowers are currently being shipped from the West Coast, Canada, or Europe into Kentucky. *Hydrangea macrophylla* growing in Kentucky's landscapes are not dependable to always flower in all locations. Nurseries have been able to market the species as container-grown flowering plants. Nursery-grown container plants receive winter protection that protects flower buds. Nursery production techniques were used to produce plants that could yield cut stems for the floral industry.

Four cultivars (Table 1) were placed in five-gallon containers during summer 2003. These plants were overwintered in an unheated house covered with white opaque poly. Inside the house, the plants were covered directly with another sheet of poly during the coldest months. Every bud produced a stem and flower during the summer of 2004. The evaluations of these stems included a stem count, stem length, flower diameter, and flower quality.

During the summer of 2004, an additional seven cultivars were containerized. All 11 cultivars were again evaluated for the same four characteristics during 2005.

If flower buds are protected using the overwintering practices of the container industry, can plants grown in the ground be protected in a similar manner? During the summer of 2004, 10 cultivars (Table 2) were planted in the ground, and the site was covered by an overwintering house. These plants were also covered by an additional direct covering during the coldest months. During 2005, the plants were evaluated for stem count, stem length, flower diameter, and flower quality.

Results and Discussion

Two growth types were represented in the four cultivars grown in containers and evaluated in 2004. The stiff upright growth of Masja produced fewer stems during its first full year of growth compared to the other growth type (layered and bending) represented by Nikko Blue, Dooley, and All Summer Beauty (Table 1). During 2005, Masja was comparable to the three other cultivars in stem count. Nikko Blue had the highest stem count in both years. Decatur Blue was injured and thus had a reduced number of stems. Stem length was acceptable for each of the original four cultivars during both years. The additional seven cultivars were not as long as expected (14+ inches) except for Mme. Emily Mouillére during this first year.

Flower diameter during both years averaged between 4.8 and 6.1 inches. This is an acceptable size for the floral market. Floral rating is based on a scale of 0 to 5. Irregular flowers were common during 2004's evaluation as three of the cultivars were no better than 2.5. Masja was definitely the best of these cultivars for floral use. During 2005, all cultivars had a floral rating above 4 except for All Summer Beauty, Nikko Blue, and Decatur Blue. Acceptable product was produced on container-grown plants. However, the plants cannot remain in production over an extended time and will have to be replaced.

The plants grown in the ground and covered by an overwintering house were also evaluated during 2005. Stem count in the ground did not match the production of plants in containers. Stem production by Mme. Emily Mouillére, Westfalen, and Harlequin did not make double figures (Table 2). The average stem length tended to be short for industry standards across most cultivars. This may be a result of being in their first year of full growth. Average floral diameter was acceptable for all cultivars as they

Table 1. Cut stem characteristics from container-grown *Hydrangea macrophylla* cultivars.

	Stem Count		Stem Length		Floral Diameter		Floral Rating	
Name	**2004 (no.)**	**2005 (no.)**	**2004 (in.)**	**2005 (in.)**	**2004 (in.)**	**2005 (in.)**	**2004**	**2005**
All Summer Beauty	19.2 b	19.0	15.9	15.6	5.3	5.9	2.4 b	3.8
Masja	7.8 c	19.6	14.3	16.3	6.2	6.5	4.3 a	4.5
Dooley	21.8 ab	19.8	13.9	13.7	4.9	5.5	1.9 c	4.2
Nikko Blue	25.1 a	25.8	12.8	14.4	4.8	5.6	1.9 c	3.7
Fasan		15.3		12.2		6.2		4.0
Gen. Vic. DeVibrayé		15.9		13.0		6.1		4.3
Matilda Güteges		17.0		11.1		6.0		4.3
Mme. Emily Mouillére		18.3		14.3		5.9		4.1
Harlequin		24.0		11.6		5.6		4.0
Parzifal		29.2		13.5		5.6		4.2
Decatur Blue		8.2		9.0		5.4		3.6

averaged between 5.4 and 7.8 inches. All cultivars had an average floral rating above 4. Flowers with a 4 or 5 rating are assumed acceptable for wholesale sales to wholesale or retail florists.

Significance to the Industry

Hydrangea macrophylla can be protected during production in order to keep all potential flower buds viable. Either container production or field tunnel production in Kentucky will create a product that is salable to the floral industry. Cultivar differences do occur, and specific cultivars may move better in certain markets. Additional information will result from this experiment as plants age in the production system.

Table 2. Cut stem characteristics from tunnel-grown *Hydrangea macrophylla* cultivars.

Name	Stem Count 2005 (no.)	Stem Length 2005 (in.)	Floral Diameter 2005 (in.)	Floral Rating 2005
Nikko Blue	16.3	13.3	7.4	4.6
All Summer Beauty	16.0	13.0	6.7	4.6
Matilda Güteges	14.8	10.7	5.5	4.4
Oak Hill	14.0	13.0	6.4	4.6
Mme. Emily Mouilldére	3.1	14.8	7.3	4.7
Penny Mac	12.9	13.0	7.5	4.7
Endless Summer	10.7	11.5	7.8	4.5
Decatur Blue	10.6	12.4	7.5	4.6
Westfalen	9.1	10.5	5.7	4.5
Harlequin	3.9	9.9	5.4	4.1

Evaluation of Garden Mum Cultivars, 2004-2005

Joe Ulrich, Department of Horticulture

Garden mums, also called hardy mums or chrysanthemums, are the No. 1 summer floriculture crop grown in Kentucky. Mums are relatively easy to grow and less capital intensive compared to other crops that require a greenhouse structure.

These trials were initiated in 2004 at the Horticulture Research Farm in Lexington. Four plants of 50 cultivars were planted in mid-June. Evaluation of plant hardiness was a primary goal of these trials. Only three plants survived the winter of 2004-2005; two were from the variety 'Beth' and one from 'Golden Helga'. There was no protection provided, and the planting was in an open flat area consisting of well-drained silt loam soil.

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 varieties from three breeding companies were planted, with four plants representing each variety. The ground was mulched, and Preen, a pre-emergent herbicide, was applied at a rate of 1 oz/10 square feet. Ammonium nitrate was sidedressed at a rate of approximately 6 lb/1000 square feet soon after planting. A weekly liquid fertilizer application consisting of approximately 1 pound of 20-10-20 fertilizer was applied. Clear water irrigation was applied two to four times per week. Plant performance was evaluated by a general numerical rating for size, shape, number of flowers/buds, and overall appearance of plant. Winter hardiness will be evaluated in the upcoming winter.

Cultivars were evaluated for early performance on September 7 (Table1). Peak season performance was evaluated October 3. Plant performance was evaluated on a 1-to-5 scale, with 1 = poor and 5 = excellent. Many varieties did well with only a few being on the poor end of the scale. This demonstration showed the improvements in the newer varieties and the wide range of colors and shapes that are available to growers.

Table 1. Visual rating of early (September 7) and main season (October 3) performance of garden mum cultivars in 2005.

September 7 Rating	October 3 Rating				
5	**5**	**4**	**3**	**2**	**1**
Alberta	Bold Gretchen	Adonis Purple	Amor Dark Pink	Blushing Emily	Marilyn
Argos Orange	Cesaro	Agapi Pink	Anna	Bobwhite White	Golden Marilyn
Bold Gretchen	Gelati	Alberta	Argos Orange	Bravo	
Bright Stephanie	Sunny Brigitte	Bright Stephanie	Barbara	Caesar Bronze	
Cesaro	Sweet Jeanette	Brandi	Beth	Cecelia	
Cheryl		Cheryl	Bianca	Dark Grenandine	
Dark Triumph		Dark Triumph	Brigitte	Fenik Bronze	
Delightful Victoria		Delightful Victoria	Camille	Ginger	
Golden Helga		Denise	Camina	Gothic Purple	
Gretchen		Golden Helga	Caster Yellow	Harmony	
Radiant Lynn		Gretchen	Christine	Hermes Purple	
Rosy Victoria		Juno Yellow	Dazzling Stacy	Hot Salsa	
Spicy Cheryl		Manakin Red	Debonair	Jambo	
Sunny Denise		Pluto Red	Donna	Jennifer	
Sweet Jeanette		Rosy Victoria	Emily	Jessica	
Vanessa		Spicy Cheryl	Festive Ursula	Mars Orange	
		Spotlight	Fiery Barbara	Nicole	
		Stacy	Glenda	Rosepink Debonair	
		Stephanie	Glowing Lynn	Sunduro	
		Sunny Denise	Gold Crest Yellow	Sunny Marilyn	
		Tabitha	Grace	Thetis Yellow	
		Vanessa	Helen	Ursula	
		Vicki	Janice	Warm Megan	
			Jason White		
			Jenna		
			Julia		
			Legend		
			Linda		
			Lisa		
			Lucera		
			Megan		
			Messina		
			Mithra Maroon		
			Natalie		
			Okra		
			Pam		
			Radiant Lynn		
			Raquel		
			Red Remarkable		
			Royal Lynn		
			Sunny Bianca		
			Tracy		
			Zesty Barbara		

Poinsettia Cultivar and Growth Retardant Evaluation, 2004

Joe Ulrich, Department of Horticulture

Nature of Work

Poinsettia is the number one flowering pot plant sold in the United States. It remains a crop that takes some experience to be able to produce, and new cultivars are introduced annually. To evaluate cultivars and their relative need for height control, 20 cultivars of poinsettia were evaluated across 10 different growth-retardant treatments. The different treatments used Florel, Bonzi, B-nine, Cycocel, leaf removal and spray versus drench in the case of Bonzi.

The poinsettia plants were obtained as rooted cuttings from a Kentucky grower. They were planted on August 10 and pinched on August 27. Banrot was applied as a soil drench on August 30 and October 21. Marathon granular was applied on September 30, and plants were spaced on 15-inch centers. The fertilization program started with 20-10-20 and then alternated some with 15-0-0 (Table 1). The standard fertilizer rate ranged from 0.80 to 1.30 mS/cm using 20-10-20. The standard fertilizer rate with 15-0-0 ranged from 0.5 to 1.3 mS/cm.

The 20 cultivars were separated into 10 equal groups of 10 plants for the growth regulator treatments. Florel was applied as a foliar spray (500 ppm) on August 30 and September 8. Bonzi was applied as a foliar spray (30 ppm) on September 17, and Bonzi was applied as a soil drench (2 ppm) on the same day. B-nine was applied as a foliar spray (2500 ppm) on September 8 and 17. A tank mix of B-nine (1250 ppm)/Cycocel (1000 ppm) was applied as a foliar spray on September 8 and 17. Leaf removal occurred on August 30 with no chemicals applied. Cycocel (1500 ppm) was applied with one, two, or three applications on September 8, 17, and/or 30. The last treatment was an untreated control. Plant height was measured when anthesis occurred for each cultivar.

Table 1. Summary of fertilization program and the poinsettia media tests in 2004.

Date	Average pH	Average EC (mS/cm)	Injector EC Reading & Fertilizer
20 August	N/A	N/A	0.82 20-10-20
10 September	5.7	2.37	0.99 20-10-20
17 September	5.8	1.2	1.05 20-10-20
24 September	5.4	1.92	0.76 20-10-20, 1.19EC*
1 October	5.4	1.82	1.31 15-0-0
8 October	6.0	1.66	0.42 15-0-0
14 October	6.5	0.99	1.01 20-10-20
22 October	5.7	1.43	1.24 20-10-20
29 October	5.8	0.97	0.98 20-10-20, 0.85 15-0-0
8 November	6.1	1.9	1.18 20-10-20
12 November	6.3	1.04	N/A
19 November	5.9	1.48	1.30 20-10-20, 1.44 15-0-0
2 December	6.1	0.53	N/A

* EC reading after injector adjustment.

Results and Discussion

Poinsettia cultivars have different growth habits (Table 2). Enduring Pink, Monet Twilight, and Maren were the shortest cultivars. The biggest cultivars were Freedom Red, Plum Pudding, Winter Rose Red, Winter Rose White, and Winter Rose Pink. Some general observations are that Plum Pudding, Snowcap, and Freedom Red were vigorous cultivars that need a high level of growth control. The cultivars that showed the most response to different growth controls were Snowcap, Freedom Red, Monet Twilight, and Success Red.

Table 2. Plant growth regulator (PGR) effects on poinsettia plant height of different cultivars.

Variety	Flowering Date	Average Across PGR Treatments (in.)
Enduring Pink	Nov 22	12.9a*
Maren	Nov 22	13.3ab
Monet Twilight	Dec 2	13.9abc
Freedom White	Nov 19	14.3bcd
Prestige	Dec 2	14.6cde
Success Red	Dec 2	14.7cdef
Amazone Peppermint	Nov 19	14.7cdef
Freedom Jingle Bells	Nov 22	14.8cdef
Freedom Bright Red	Nov 19	14.9cdefg
Snowcap	Nov 22	15.3defgh
Freedom Marble	Nov 19	15.4efgh
Freedom Pink	Nov 22	15.4efgh
Cortez Burgundy	Dec 2	15.7fghi
Petoy	Nov 22	15.7fghi
Sonora Red	Nov 22	15.7fghi
Winter Rose Red	Dec 2	15.9ghij
Freedom Red	Nov 19	16.2hij
Winter Rose Pink	Dec 2	16.6ij
Winter Rose White	Dec 2	16.6ij
Plum Pudding	Nov 22	16.8j
Treatment Average		15.2

* Means with the same letter are not significantly different.

The plant growth regulator treatments did not have the same effect on the poinsettia varieties (Table 3). The Bonzi drench at 2 ppm had the greatest effect on the plants. The B-nine/Cycocel, leaf removal, Florel and Bonzi spray treatments all had above-average effects on the poinsettia plants. There was no difference in using Cycocel at 1500 ppm one time and using no control. The use of B-nine and Cycocel together had a greater effect than using them separately.

Table 3. The treatment effects on finished poinsettia plant height across cultivars.

Treatment	Average Height (in.)**
Bonzi drench	13.4a *
B-nine/Cycocel 2X	14.4b
Leaf removal	14.6bc
Bonzi spray	14.7bc
Florel 2X	15.1bcd
Cycocel 3X	15.4cd
B-nine 2X	15.7de
Cycocel 2X	15.8de
Control	16.5ef
Cycocel 1X	17.0f

* Means with the same letter are not significantly different.
** Contains the average height of 20 cultivars measured in inches.

Significance to the Industry

Poinsettia continues to be a major crop in Kentucky. The use of plant growth regulators is vital for producing quality plants. There are several factors that have to be considered before growing the crop. One is the genetics of the variety and whether there is a need for a growth-retardant treatment. The Enduring Pink and Maren varieties showed that they have less growth and do not require growth retardant. The next factor is what treatment should be used and at what rate. The grower who wants only slight control should consider B-nine and/or Cycocel. The grower who needs more control should consider using a Bonzi treatment, especially for the vigorous varieties like Snowcap and Plum Pudding. This evaluation will provide information to help growers consider the growth characteristics of these 20 cultivars and the possible effects of different PGR treatments on them.

Acknowledgments

The author would like to thank Robert Anderson, Extension floriculture specialist, and Kirk Ranta for their help and information in conducting and preparing this evaluation. Thanks to Sungro Horticulture Inc. for donation of media and fertilizer.

Annual and Perennial Plant Evaluations, 2005

Sharon Bale, Department of Horticulture

Even with irrigation available, this was one tough season for plants. While some did not perform as well as in years past, others withstood the harsh conditions and performed well.

All America Selection Winners

The winners this year were Dianthus 'Supra Purple', Diascia 'Diamonte Coral Rose', Nicotiana 'Perfume Deep Purple', ornamental pepper 'Black Pearl', *Salvia farinacea* 'Evolution'®, and Zinnia 'Zowie Yellow Flame'. The two outstanding plants for this area were 'Black Pearl' and 'Zowie Yellow Flame'. Ornamental peppers are becoming more popular, and 'Black Pearl'—with its round purple fruits that turn to a bright red and its deep purple foliage—is an excellent addition to any garden.

Zinnias are still an excellent choice for the cut garden, and 'Zowie Yellow Flame' adds a bicolor to the list of good garden cuts. The yellow and rosy pink blooms attract a great deal of attention. The plants are susceptible to all the disease problems associated with zinnias in this area, but the unique bloom makes it worth the trouble.

Annuals

The most talked about annual for the past two years has been Proven Winner, *Euphorbia hypercifolia* 'Diamond Frost'. The plants are 8 to 10 inches tall and produce dainty white blooms all season. Trial gardens all over the country are singing the praises of this plant. So far there have been no disease or pest problems, and the plant is very low maintenance. Not a show stopper from a distance, but a great bedding, edging plant. I was not as impressed with the plant in mixed containers.

Other Proven Winners also performed well. Mecardonia 'Goldflake'™ is a very low-growing plant with bright yellow flowers. While some growers in the area have had difficulty with this one in the greenhouse, we had no problems. The plants bloom all season and produce a bright yellow groundcover.

While we did not have trouble growing the Mercardonia, the Proven Winner phlox have given us trouble. The 'Intensia'® Series has great promise as a heat-tolerant annual phlox. We have had difficulty getting a good root system on the plant before going to the garden. The rabbits are also a problem with this plant.

The Proven Winner *Calibrachoa hybriden* 'Superbells'® series are another group of plants that perform well. This group of plants has the favor of many plant producers and breeders. They are great for hanging baskets and mixed containers, and we have been satisfied with their performance as bedding plants. They are all low maintenance with an explosion of colors and are readily available. Those in our trials were the Superbells® 'Tequila Sunrise', 'Light Pink', 'White', 'Trailing Blue', 'Plum', and 'Trailing Rose'.

Lantana may be on the hit list as an invasive weed in the Deep South, but in our area they are great summer annuals. The hedge-like habit and rapid growth make them an excellent addition to the garden as well as attractive in mixed pots. Proven Winner Lantana 'Tropical Fruit' had excellent color with slightly variegated foliage. Other Lantanas evaluated include 'Athens Rose' and 'Popcorn'. I obtained cuttings of these from the University of Georgia. Availability may be an issue with these plants, but if you can find them, they are worth a try.

One goal of the plant enthusiast is to try the new and different. We tried *Impatiens wallerana* 'Jungle Gold'. If a yellow impatiens is top on your list, then this is the plant for you. In my book, it is not that showy, and I won't cry if I don't have it to look at next year.

My fun plant is still *Nicotiana sylvestris*. This flowering tobacco is at least 4 to 5 feet tall and produces a "fireworks" display of white blooms all season if the declining bloom spikes are removed. Aphids and other pest problems associated with tobacco can be a problem, but in my book, the plant is worth it. It will self seed and may appear in other parts of the garden, but I don't see that as a real problem.

Perennials

The plant that attracted the most attention and favorable "ooh aahs" was *Penstemon strictus* 'Rocky Mountain'. The blue spike blooms in early summer were just outstanding. The plants were a little slow getting established and didn't produce many blooms the first season. The wait was worth it. Our source was Park Seed.

Each season brings more *Echinacea purpurea* cultivars hitting the market.. Two of these, 'Kims Knee High' and 'Doubledecker' have been in the trials for at least two years. 'Kims Knee High' is a shorter version of the typical plant and performs very well. 'Doubledecker', from Jellito Seed, is supposed to have a unique bloom. The uniqueness hasn't shown up that much.

Not all plants live up to their advertisement. Vinca 'Illumination' reverted after several years and did not maintain its variegated color. That one will go off the list.

While the vinca may not be that great, two plants that might be considered "on the edge" for this area have performed well. *Danae racemosa* and Amorphallus 'Konjac' *Danae racemosa* are commonly referred to as ruscus in the florist trade and are grown for the foliage. The plants are propagated from seed and are very slow growing. These are generally found as an understory plant. They are not going to take over the world, but for a "different" foliage plant for the garden, they might be just the right thing.

The Amorphallus 'Konjac' became a hidden treasure of sorts. The plant was overgrown by some shrubs and just about forgotten because it was not readily visible. When the plant finely came into bloom, the fact that it was out of sight was not an issue. Complaints about the dead animal in the bushes revealed this unique bloom. If you are not familiar with this plant, the blooms are extremely fragrant, but I didn't say pleasantly fragrant. This plant is not for everyone, but it will get some attention.

These are some comments about a few of the plants evaluated. The one thing that is certain, next season there will be plenty of new, different, or "we just couldn't get it before" plants to be grown and evaluated.

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 can 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 more than $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 $10,000 by early 2006 to secure the $50,000 match from state funds.

Those individuals and companies contributing to the UK Landscape Fund in 2005 (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 can 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. 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

2005 Contributors to the UK Nursery/Landscape Fund and Endowments

(through November 1)

Fellows (≥ $1,000)

Greg Ammon, Ammon Wholesale Nursery
Larry and Carolyn Sanders, James Sanders Nursery

Associates (≥ $500)

Frank M. Melton
Hillenmeyer Nurseries Inc.
Steve King, King's Garden
Kit Shaughnessy, Kit Shaughnessy Inc.
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Eric Sea, Sea's Lawn and Landscape
Glenn D. Yost

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Michael L. Fugate, Landesign
Dr. Dewayne Ingram

Industry Organizations

Kentucky Landscape Industries Trade Show
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:

Ammon Wholesale Nursery, Burlington
Ball Seed Company, W. Chicago, IL
Bernheim Arboretum and Research Forest, Clermont
David Leonard, Consulting Arborist, Lexington
Deibel's Greenhouses, Crestwood
DeVroomen Holland, Morrow, GA
Friends of the UKREC, Princeton
Harrell's Fertilizer Inc, Lakeland, FL
Hillcrest Nursery, Richmond
Holmlund Nursery, Boring,OR
J. Frank Schmidt Nursery, Boring, OR
Kit Shaughnessy, Kit Shaughnessy Inc., Louisville
Larry Hanks, Consulting Arborist, Lexington
Oaks Pavers, Cincinnati, OH
Phytotektor, McMinnville, TN
Rainbow Treecare Scientific Advancements, Minneapolis, MN
Red Barn Greenhouses, Nicholasville
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The Flower Potts, Kirksey
The Scotts Company, Marysville, OH
Ann Trimble, Trimble's Flowers, Princeton
UK Physical Plant Division, Grounds Department
Jim and Mary Wallitsch, Wallitsch Garden Center, Louisville
Waterford Valley Nursery, Taylorsville

Grants for specific projects have been provided by:

International Plant Propagators' Society—Eastern Region
Kentucky Horticulture Council Inc.
Kentucky Agricultural Development Board
Central Kentucky Ornamentals and Turf Association
Kentucky Nursery and Landscape Association
Kentucky Division of Forestry
Kit Shaughnessy, Kit Shaughnessy Inc.
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USDA Animal and Plant Health Inspection Service
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Issued 12-2005