PR-450

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE

2001 Nursery and Landscape Program

Research Report

Nursery and Landscape Program

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

ABOUT OUR COVER
Hamamelis x *intermedia* 'Arnold Promise', one of the later flowering witchhazel hybrids, is a Theodore Klein Plant Award winner for 2002. Theodore Klein Plant Award winners are selected by plant professionals for unique ornamental characteristics and the ability to successfully perform in Kentucky.

The Hamamelis x *intermedia* hybrids are spectacular winter-flowering deciduous large shrubs or small trees that can grow to be 20 feet tall. The blooms have excellent fragrance, and cut flowering stems can be a pleasant addition to the winter home environment. There are many other great cultivars that can add to the January-March landscape, a time when a bright spot in the garden is greatly appreciated. Bernheim Forest has a large *Hamamelis* cultivar collection grouped together for public viewing and evaluation. Interesting cultivars include 'Diane', 'James Wells', 'Moonlight', 'Carmine Red', 'Jelena', and 'Primavera'.

UK Nursery and Landscape Program

Faculty, Staff, and Student Cooperators

Horticulture
Faculty
Robert Anderson
Sharon Bale
Jack Buxton
Paul Cappiello
Win Dunwell
Richard Durham
Bill Fountain
Robert Geneve
Dewayne Ingram
Robert McNiel
Mark Williams

Technical Staff
Shari Dutton
June Johnston
Sharon Kester
Kirk Ranta
Dwight Wolfe

Farm Staff
Darrell Slone
Janet Pfeiffer
Dave Lowry

Students
Steve Elkins
Philip Gonsiska
Shubin Saha
Delia Scott

Agricultural Economics
Faculty
Tim Woods

Biosystems and Agricultural Engineering
Faculty
Richard Gates
Richard Warner

Student
Erin Wilkerson

Agronomy
Faculty
Tim Phillips
A. J. Powell

Entomology
Faculty
Daniel Potter

Technical Staff
David Held

Students
Jerome Gels
Philip Gonsiska
Jamee Hubbard
Callie Prater
Michael Rogers

Plant Pathology
Faculty
John Hartman
Lisa Vaillancourt

Technical Staff
Paul A. Bachi
Julie Beale
Etta Nuckles

Students
Jennifer Flowers
Sabine Pauly
Dominique Saffray
Jean-Bernard Magnin

UK Arboretum
Director
Marcia Farris

Grounds Manager
Susan Capley

Nursery and Landscape Program

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UK Nursery and Landscape Program Overview—2001

Dewayne Ingram, Chair

Department of Horticulture

The faculty, staff, and students in the UK Nursery and Landscape Program are pleased to offer this 2001 Research Report. This is one way we share information generated from a coordinated research program involving contributions from several departments in the College of Agriculture. The 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.

Dr. Mark Williams joined our faculty in January 2001. He has a research and teaching position in landscape horticulture and will focus on weed management. Dr. Williams has already become a valuable member of our team serving the Kentucky nursery and landscape industries.

We are also excited about our new leadership at UK. President Lee Todd is providing exceptional leadership at UK and throughout the state. In the College of Agriculture, we have a new dean. Dr. Scott Smith assumed that role in January 2001 with Dr. Oran Little's retirement. Dr. Nancy Cox was hired to fill the Associate Dean for Research position that was vacated by Dr. Smith. Dr. Cox was previously at Mississippi State University. Dr. Walter Walla has retired as the Associate Dean for Extension, and Dr. Larry Turner, chair of UK's Biosystems and Agricultural Engineering Department, has accepted the position effective January 2, 2002.

As part of restructuring and decentralizing the UK administration, the College of Agriculture has been given administrative responsibility for the UK-Lexington Fayette Urban County Government Arboretum. Under the previous administration, the arboretum was the responsibility of the Vice-Chancellor for Administration. Faculty from several College of Agriculture departments have provided programmatic leadership for the arboretum since before it was an arboretum. Faculty in Horticulture and Landscape Architecture were instrumental in establishing the arboretum and using it for Extension and teaching activities. Faculty from Forestry, Plant Pathology, Entomology, and Agronomy have also assumed leadership roles in arboretum program development. Construction of the first phase of our visitors' center will be completed in January. The arboretum has made significant strides in the past several years, and it has an even brighter future.

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/landscape industries.

Extension Highlights

Extension programs targeted to Kentucky's nursery and landscape industry include highly visible activities and some more subtle ones. The statewide and area educational conferences and seminars are probably the most visible. Publications, videos, slide sets, newsletters, articles in state and national industry magazines, newspaper articles, radio spots, and television programs are important, visible elements of our Extension program. More subtle activities include training for County Extension Agents so they can more effectively serve our clientele, the Plant Disease Diagnostic Clinic, soil testing and interpretative services, and diagnosis and problem-solving services. We are delighted to see that the outreach capacity of the arboretum on the UK campus increases each year for the industry and consumers.

Although there are many facets to the Extension program conducted by the team of subject matter specialists and county agents, our program directed to evaluate and promote garden flowers is highlighted this year. We have built a *statewide network of demonstration gardens to evaluate garden flowers and show people how to grow and use them*. Dr. Robert Anderson, Extension Horticulturist, spearheaded the network, which is comprised of and supported by the UK Horticulture Department, County Extension Agents for Horticulture, the UK Arboretum, the Louisville Zoo, the Kentuckiana Greenhouse Association, and the Kentucky Department of Agriculture's Value-Added Grant Program. Although the largest evaluation site (15,000 square feet) was located at the Horticulture Research Farm in Lexington, demonstrations were established and maintained at the Purchase Area Master Gardener Garden in Paducah, the UK West Kentucky Research and Education Center in Princeton, the Hardin County Master Gardener Garden in Elizabethtown, the Louisville Zoo, the UK Arboretum, the Boone County Master Gardener Garden in Burlington, the Campbell County Master Gardener Garden in Highland Heights, and the Pulaski County Master Gardener Garden in Somerset. In addition to materials to initiate the expanded landscape garden evaluation project, the KDA Value-Added Grant Program and the Kentuckiana Greenhouse Association funded the printing and distribution of "Kentucky Gardens with Kentucky Flowers" banners to 70 greenhouses in 46 counties across the commonwealth.

Undergraduate Program Highlights

The department offers areas of emphasis in Horticultural Enterprise Management and Horticultural Science within a Plant and Soil Science Bachelor of Science degree. Following are a few highlights of our undergraduate program in 2001:

The Plant and Soil Science degree program has nearly 100 students in the fall semester of 2001, of which almost one half are horticulture students and another one-third are turfgrass students. Eleven horticulture students graduated in 2001.

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 2001.

- A three-week study tour of New Zealand was led by Drs. McNiel, Dunwell, Geneve, and Anderson involving 14 students.

- Horticulture students competed in the 2001 Associated Landscape Contractors of America (ALCA) Career Day competition at Colorado State University in March (Drs. Robert McNiel and Mark Williams, faculty advisors).

- Students accompanied faculty to the following regional/national/international meetings, including the American Society for Horticultural Science Annual Conference, the Kentucky Landscape Industries Conference and Trade Show, the Southern Nursery Association Trade Show, the Green Industry Expo, and the International Plant Propagators' Society.

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 eight 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. For example, graduate students presented research results at the Southern Nursery Association's Research Conference in Atlanta, and several presented their work during a session of the 2002 Kentucky Landscape Industry Conference and Trade Show.

State and Federal Funding for Kentucky Horticulture Infrastructure and Support

The Kentucky Horticulture Council was organized in 1991 as an umbrella organization representing the breadth of Kentucky horticulture, including the nursery and landscape industries. It is comprised of the president and a representative from 13 industry associations related to horticulture in the commonwealth. The Kentucky Nursery and Landscape Association, the Kentucky Arborists, the Kentuckiana Greenhouse Association, and the Louisville Nursery Association are members of the Kentucky Horticulture Council. The current officers of the council are C.A. "Ottie" Pantle, Jr. (Chair), Charles Wilson (Vice-Chair), and Will Southerland (Legislative Committee Chair).

Over the past ten years, the Horticulture Council has been developing a strategic plan for the industry in cooperation with the UK horticulture program and the Marketing Division of the Kentucky Department of Agriculture. They have presented this strategic plan as the Perspective for Horticultural Opportunities in Kentucky to the state legislature and several agricultural leadership groups. In January 2001, the Council submitted a proposal for funding research, extension, and marketing infrastructure development to the Agriculture Development Board. The Agriculture Development Board has the responsibility to utilize Phase I Tobacco Settlement Funds to support the continued development of Kentucky's agriculture. In its September 2001 meeting, the Agriculture Development Board approved a revision of that proposal and authorized the board staff to work with the Kentucky Horticulture Council to direct $2.4 million to partially fund the proposal for a two-year period. I assume the arrangement for this will be completed by the time this research report is in print. Details of the funded proposal will be available through the UK Horticulture home page <www.uky.edu/Ag/Horticulture> and will be discussed at the 2002 Kentucky Landscape Industries (KLI) Conference and Trade Show.

In addition, Senator Mitch McConnell championed through the U.S. Congress a special grant in the USDA budget to establish the New Crop Opportunities Center in the UK College of Agriculture. UK Horticulture is serving a leadership role in this center and has allocated research funds to support four research projects in horticulture. One of those projects relates to landscape plant selection and production. There is already a significant amount of information on alternative crops available through the Center's Web page <www.uky.edu/Ag/NewCrops>. A display and informational materials about the New Crop Opportunities Center will be available at the KLI Trade Show.

Design of a Propagation Unit that Independently Controls Atmospheric and Medium Moisture

Shubin Saha, Sharon Kester, Erin Wilkerson, Jack Buxton, and Robert Geneve, Department of Horticulture

Nature of Work

Micropropagation consists of four stages that include establishment, multiplication, rooting, and acclimatization. Acclimatization involves the shift from a heterotrophic (sugar-requiring) to an autotrophic (free-living) condition and the acclimatization of the microplant to the outdoor environment (2). It requires that the propagule be slowly moved from a condition of low light and high humidity to ambient greenhouse conditions. Plant loss during the acclimatization phase can be a serious impediment to commercial micropropagation of some crops (4).

The three key factors for optimal acclimatization are relative humidity, temperature, and irradiance (3). The objective of this experiment was to control atmospheric moisture independent of medium moisture in order to study their relative importance during the acclimatization process. This was attempted using controlled water tables in constructed Plexiglas growth chambers. The basic design uses a controlled water table irrigation system (1). The system utilizes capillary mats, which draw from a water trough across a bench top surface. Either a 100-percent cotton material (muslin) or a thicker woven 100-percent cotton was used as the top of the chambers to provide high humidity (5).

Two-foot square chambers were constructed using Plexiglas and fitted with controlled water tables (Figure 1). The water tables were adjusted by raising and lowering the float valves at 1-cm intervals. The top of the chambers contained either constantly wet fabric or a solid Plexiglas lid. Fabrics evaluated were either muslin or woven cotton.

The temperature and relative humidity were recorded at one-hour intervals. Data were collected utilizing a computer and a data logger program and presented as daily means.

A preliminary study evaluated rooting of eastern redbud (*Cercis canadensis*) microcuttings. Seedling explants were treated in vitro with 100 mM IBA for 10 days before being moved to the acclimatization chambers.

Results and Discussion

Using the capillary mat watering system installed within an enclosed propagation chamber increased relative humidity by approximately 50 percent compared to the external room (Table 1). There was also a difference in humidity due to the type of material used for the top (Table 1). The chamber with muslin cloth averaged a relative humidity of 85 percent in comparison to 90 percent maintained by the woven cotton.

Moving the perched water table in the capillary mat reservoir 4 or 6 cm below the level of the bench reduced the amount of water in Oasis blocks on the capillary mat by 12 to 25 percent, respectively, regardless of the relative humidity in the

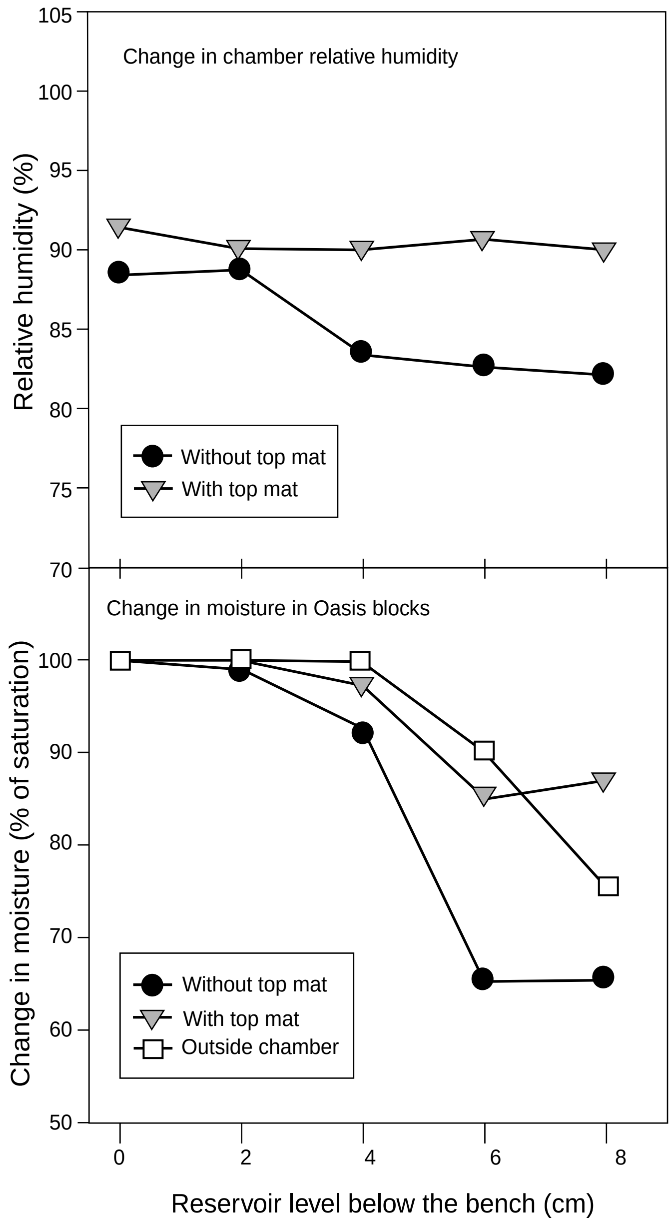

Figure 1. Changes in humidity and moisture content.

Table 1. Impact of available water in the capillary mat subirrigation system on relative humidity within propagation chambers.

Relative Humidity (%)			
External	No fabric top	Top using muslin	Top using woven cotton
37.5	55.2	85.5	89.8

propagation chamber (Figure 1). Reducing the water potential in the capillary mat had no effect on relative humidity in chambers with a moist fabric top. However, reduced moisture in the capillary mat also reduced relative humidity in chambers without a fabric top (Figure 1).

In a preliminary study using redbud microcuttings, rooting percentage and number of roots per rooted cutting suggest that chambers provide an adequate environment for cutting survival (Table 2). In future studies, these chambers will permit the evaluation of acclimatization in microcuttings by independently changing atmospheric and medium moisture to determine the relative importance of each on the growth of microcuttings following acclimatization.

Significance to the Industry

One of the problems presented to nursery managers buying rooted cuttings from tissue culture is appropriate acclimatization. This research is designed to address some of the basic environmental questions concerning proper conditions for acclimatization in difficult plants.

Table 2. Root formation in eastern redbud (*Cercis canadensis*) microcuttings in propagation chambers.

Treatment	Rooting Percentage	Number of roots per rooted cutting
Water table (0 cm) No fabric top	77 %	7.9

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Production and Economics

Irrigation and Pruning Influence on Hydrangea Dried Cut-Flower Production

Winston Dunwell, Dwight Wolfe, Robert McNiel, and Sharon Bale, Department of Horticulture

Nature of Work

Cut flowers from field-grown hydrangeas are a potential alternative source of income for Kentucky growers, and early production can increase financial returns on one's investment. Typically, *H. macrophylla* cultivars are grown for the cut-flower market, while other species such as *H. arborescens*, smooth hydrangea; *H. paniculata*, panicled hydrangea; and *H. quercifolia*, oakleaf hydrangea, have been grown as landscape plants (1,2). Interest has been expressed in *H. arborescens* and *H. paniculata* as fresh cut and dried flowers by wholesale distributors (6). Expansion of the cut-flower production mix to include these hydrangea species could create specialty-niche markets for Kentucky growers.

A hydrangea cut-flower cultivar trial was established at the University of Kentucky Research and Education Center at Princeton in the spring of 1998 (4,5,7). The planting consisted of 12 plants each of nine cultivars allocated to 12 rows (blocks) in a randomized block design. The nine cultivars included one *H. aborescens* cultivar, 'Annabelle'; one *H. quercifolia* cultivar, 'Alice'; and seven *H. paniculata*, panicled hydrangea, cultivars, 'Boskoop', 'Pink Diamond', 'Unique', 'Kyushu', 'Tardiva', 'Pee Wee', and 'White Moth'. A planting with trickle irrigation was established in the spring of 1999. It consists of six *H. paniculata* cultivars, 'Pink Diamond', 'Unique', 'Kyushu', 'Tardiva', 'Pee Wee', and 'White Moth', allocated to eight rows (blocks) in a randomized block design. In the autumn of 2000, alternate rows of each planting were pruned to ground level. The number of stems per plant, stem length, and bloom length were recorded.

Results and Discussion

'Alice', 'Annabelle', and 'Boskoop' were not included in the irrigated planting. Pruning significantly affected the average number of stems per plant for all cultivars except for 'Annabelle' and 'White Moth', which showed no significant response to pruning (Table 1). 'Kyushu' and 'Pee Wee' produced the largest numbers of stems when pruned and irrigated. Not pruning the plants resulted in stems less than the 36 inches in length needed for the cut-flower market (2).

Pruning 'White Moth' under irrigation resulted in vigorous long stems (Table 2) that tended to continue growing and not produce blooms. Plants of 'White Moth' that were pruned and not irrigated also did not produce any blooms. *H. quercifolia* flowers on year-old wood (3) and, as expected, the pruned plants of 'Alice' did not flower (Table 3).

'Kyushu' was the only cultivar that produced significantly longer blooms when not pruned. This was true for both the irrigated and non-irrigated plantings. A limiting factor to marketability of 'Kyushu' may be the observation that blooms do not have as many showy sterile flowers as 'Pink Diamond', 'Unique', or 'Pee Wee'.

Table 1. Number of stems per plant as affected by pruning and cultivar for irrigated and non-irrigated plantings of Hydrangea cultivars at the University of Kentucky Research and Education Center at Princeton, KY.

Cultivar	Pruned	Not Pruned	Mean	Pruned	Not Pruned	Mean
	Non-Irrigated Planting			Irrigated Planting		
	Average Number of Stems Per Plant					
Alice	0.0	23.4 *[1]	13.4			
Annabelle	14.2	16.7 ns	15.4			
Boskoop	7.8	29.0 *	19.3			
Kyushu	11.3	54.0 *	32.7	14.8	115.5 *	65.1
Pee Wee	5.0	24.3 *	14.7	12.8	112.0 *	62.4
Pink Diamond	11.2	41.3 *	26.3	19.8	49.5 *	34.6
Tardiva	7.5	21.7 *	14.6	12.0	95.8 *	53.9
Unique	18.2	37.0 *	27.6	24.8	86.3 *	55.5
White Moth	0.3	0.8 ns	0.5	1.3	4.3 ns	2.8
Mean	- -	- -	18.6	- -	- -	45.7
LSD (P=0.05)	- -	- -	7.4	- -	- -	20.9

[1] "*" and "ns" indicate that mean in previous adjacent column is either significant or not significant, respectively, at the 0.05 probability level from mean in column.

Table 2. Average stem length as affected by pruning and cultivar for irrigated and non-irrigated plantings of Hydrangea cultivars at the University of Kentucky Research and Education Center at Princeton, KY.

Cultivar	Pruned	Not Pruned	Mean	Pruned	Not Pruned	Mean
	Non-Irrigated Planting			Irrigated Planting		
	Average Length (inches) per Stem					
Alice	- -	10.0	9.9			
Annabelle	20.5	18.4 ns[1]	19.5			
Boskoop	30.2	16.1 *	22.5			
Kyushu	41.4	17.3 *	29.4	54.3	17.0 *	35.6
Pee Wee	43.3	15.3 *	29.5	52.4	14.9 *	33.7
Pink Diamond	35.8	16.0 *	25.9	39.2	17.1 *	28.1
Tardiva	38.2	16.2 *	27.2	50.8	19.5 *	35.2
Unique	33.2	15.5 *	24.3	38.7	18.6 *	28.6
White Moth	- -	12.9	13.0	78.2	16.6 *	37.2
Mean	- -	- -	24.4	- -	- -	32.9
LSD (P=0.05)	- -	- -	3.8	- -	- -	3.9

[1] "*" and "ns" indicate that mean in previous adjacent column is either significant or not significant, respectively, at the 0.05 probability level from mean in column.

Table 3. Average bloom length as affected by pruning and cultivar for irrigated and non-irrigated plantings of Hydrangea cultivars at the University of Kentucky Research and Education Center at Princeton, KY.

Cultivar	Pruned	Not Pruned	Mean	Pruned	Not Pruned	Mean
	Non-Irrigated Planting			Irrigated Planting		
	Average Bloom Length (inches)					
Alice	- -	3.5	3.6			
Annabelle	3.5	3.1 ns[1]	3.3			
Boskoop	5.3	3.4 *	4.2			
Kyushu	5.0	7.2 *	6.1	7.2	8.7 *	8.0
Pee Wee	5.0	4.1 ns	4.5	7.5	5.5 *	6.5
Pink Diamond	6.8	5.0 *	5.9	7.3	5.3 *	6.3
Tardiva		5.5	3.9	4.7	8.1	5.8 *6.9
Unique	5.0	3.4 *	4.2	7.7	4.6 *	6.2
White Moth	- -	5.4	5.3	7.2	5.5 *	6.0
Mean	- -	- -	4.7	- -	- -	6.7
LSD (P=0.05)	- -	- -	1.2	- -	- -	0.9

[1] "*"and "ns" indicate that mean in previous adjacent column is either significant or not significant, respectively, at the 0.05 probability level from mean in column.

Significance to the Industry

Under the conditions found in this study, 'White Moth' does not appear to be a good *H. paniculata* cultivar for hydrangea cut-flower production. All other *Hydrangea* cultivars show potential for producing white fresh and tan dried cut flowers. The 'Kyushu' characteristics of producing large numbers of stems (115 stems) and longer blooms (8.7 inches) when not pruned and irrigated need to be studied further. Modifying production practices could result in a plant that produces large blooms and has a stem of adequate length for a specialty market.

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Container Production of Passion Flower

Robert Geneve, Mark Williams, and Sharon Kester, Department of Horticulture

Nature of Work

Passion flowers are members of the genus *Passiflora* and are among the most beautiful and exotic flowers in cultivation. They are rarely grown outside of botanic gardens and arboreta. Passion flower is a high-value crop with the potential for summer container sales marketed in a fashion similar to other tropical vines like *Bougainvillea* and *Mandevilla*.

Most passion flower hybrids and cultivars are easily grown from cuttings. However, there is limited information on commercial container production of passion flower. Therefore, the objective of this study was to evaluate the effect of fertilizer and plant growth regulator treatment (Bonzi) on plant growth in container-grown passion flower.

In late February, two-node cuttings of *Passiflora* 'Blue Bouquet' (*P. caerulea x P. amythestina*) were treated with IBA (1,000 ppm in talc) and stuck in Oasis rooting cubes. Cuttings were placed in an intermittent mist bed (5 sec. every 10 min.) with bottom heat (75°C). After two weeks cuttings were well-rooted and moved to 4-inch plastic containers with a peat/bark medium (Scott's 360 Metro mix). Greenhouse conditions were maintained with day/night temperatures of 65°/55°F. Plants were fertilized with a 100-ppm fertilizer solution (Peter's 20-10-20) at each watering.

Plants were moved to 5-quart (Nursery Supplies, Inc. Classic 500) containers on May 15, 2001, and maintained in an outdoor nursery under trickle irrigation. The medium used was southern pine bark. Each container was treated with slow-release fertilizer (Osmocote 14-14-14) at 1, 5, 10, or 15 grams per container and 300 ml of Bonzi (paclobutrazol) at 0, 50, or 100 ppm. Half the plants were retreated with an additional 500 ml of Bonzi at 25 or 50 ppm on June 15. Plants were harvested after two months of growth (July 15) and evaluated for number of stems, stem length, node number, dry weight, and flower number.

Results and Discussion

Fertilizer had the biggest impact on shoot length (Figure 1) and flowering (Figure 2) in passion flower vines. There was a linear increase in shoot length as fertilizer concentration increased. The recommended level of fertilization is approximately 14 grams per container. There were approximately twice as many flowers in plants produced with 15 grams of fertilizer compared to other fertilizer treatments.

Bonzi reduced overall shoot length and was more effective at the higher rates. Multiple applications further limited shoot growth (Figure 1). There were very little interaction effects between fertilizer concentration and Bonzi application. Single applications of Bonzi reduced total stem length by 20 percent averaged over fertilizer treatment. This is similar to our preliminary greenhouse studies, where Bonzi at 50 ppm applied once reduced plant height by 28 percent. Multiple applications of Bonzi limited growth compared to the control by 41 percent (50 ppm followed by 25 ppm) and 53 percent (100 ppm followed by 50 ppm).

Flower number was greatest in plants treated with 15 grams of fertilizer (Figure 2). At this rate of fertilizer, Bonzi reduced flower number. However, there was no significant effect of Bonzi on flower number at the other fertilizer concentrations.

Significance to the Industry

This is the first report on container production in a desirable passion flower cultivar. It proved to be a fast-growing container plant with high market potential. Commercially acceptable plants were produced using 15 grams of slow-release fertilizer. A single application of Bonzi at 50 ppm reduced internode length and overall plant height to produce a more compact plant. However, flower production was delayed.

Figure 1. Total shoot length after two months of passion flower treated with different levels of Bonzi and fertilizer.

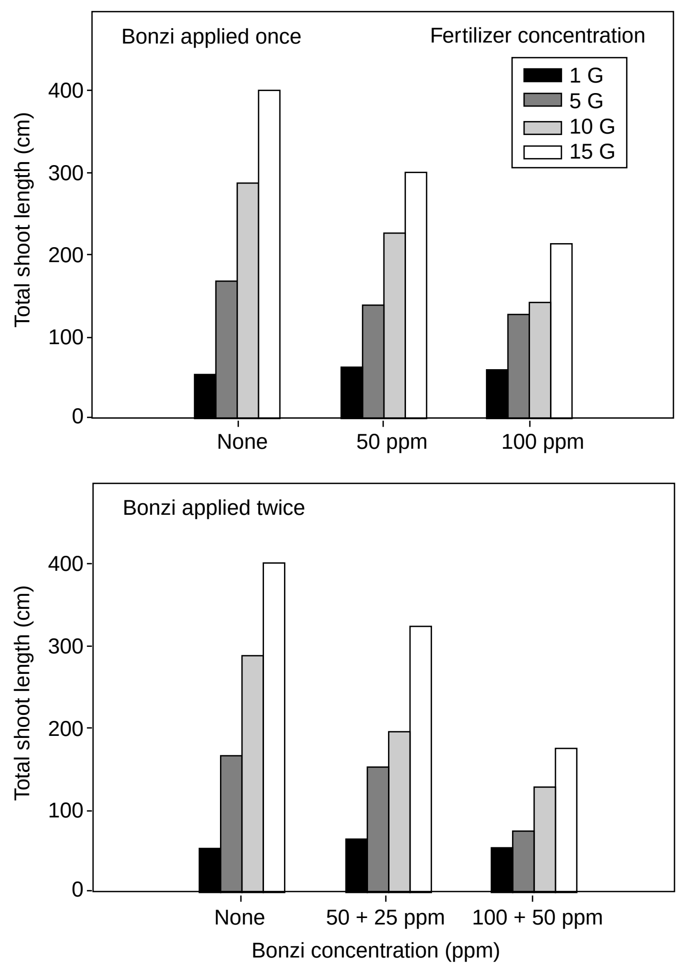
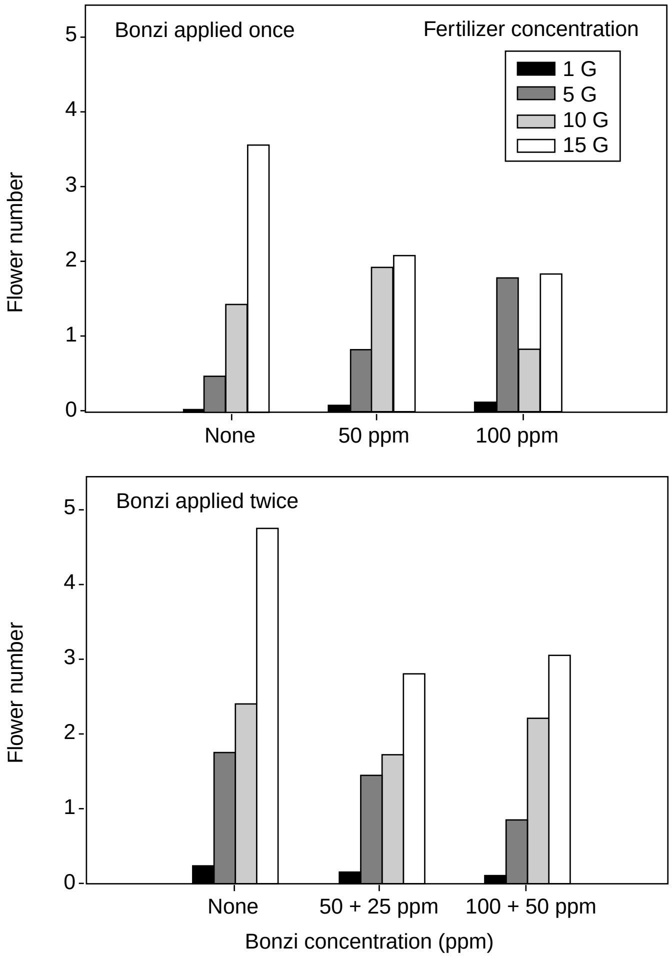


Figure 2. Flower number after two months of passion flower treated with different levels of Bonzi and fertilizer.



Target-Selective Insecticides Help to Conserve Beneficial Natural Enemies and Pollinators on Golf Courses

Jerome Gels and Daniel A. Potter, Department of Entomology

Nature of Work

Landscape managers are constantly alert for insect pests, but it is doubtful that they often give much thought to the many innocuous or beneficial invertebrates that inhabit their turf. Some, such as tiny springtails and soil mites, aid in breakdown of grass clippings and other plant litter and in nutrient recycling. Earthworms admittedly are a nuisance when they deposit their castings on closely mowed playing surfaces, but those "sins" must be weighed against their benefits in aerifying and enriching the soil, enhancing water infiltration, and breaking down thatch (1). Healthy turf also harbors many predatory insects and spiders, as well as parasitoids—tiny wasps or flies that parasitize grubs and caterpillars. Our long-term research has shown, time and again, that conserving natural enemies helps to buffer lawns and golf courses against pest outbreaks (2,3).

Lawns and golf course roughs also are frequented by honeybees and native pollinators, such as bumblebees, that forage on flowering weeds such as white clover or dandelions. Habitat fragmentation, pesticide poisonings, diseases, and parasites are causing bees and other pollinators to disappear at alarming rates, so much so that the USDA has warned of an impending pollination crisis. Honeybees, an introduced species, have been particularly hard-hit, placing greater demands on native pollinators. Lawns, landscapes, and golf courses can help to sustain insect pollinator populations by providing suitable habitat and nectar sources that may be deficient in surrounding urban areas.

The 1990s saw marked changes in the types of insecticides used on turf and landscapes. Traditional organophosphates and carbamates that are broadly toxic were supplanted, in large part, by newer, target-selective insecticides such as pyrethroids, imidacloprid (a chloronicotinyl), and halofenozide (a molt-accelerating compound). But are the newer insecticides really less toxic than traditional ones insofar as conservation of beneficial species? To find out, we evaluated their potential impact on predatory insects, earthworms, and pollinators such as bumblebees that forage in weedy turf.

In a two-year field study, turf plots were treated with imidacloprid or halofenozide in late May or June, followed by irrigation as is recommended for grub control. For comparison, other plots were treated with bendiocarb, a broad-spectrum carbamate, or else left untreated. We monitored the insecticides' impact on predator populations using pitfall traps and also sampled earthworms and other beneficial soil fauna. Periodically, we challenged the plots by exposing lab-reared prey (eggs, larvae, or pupae of black cutworms or eggs of Japanese beetles) to determine if the treatments had disrupted natural enemies enough to reduce predation on these pests. Finally, efficacy against the targeted pests was evaluated by sampling white grub populations in late summer. In related tests, effects of exposure of predators to nonirrigated versus irrigated spray residues were compared.

Effect of exposure of bumblebees to insecticide residues was evaluated by treating mixed stands of turf and flowering white clover with various insecticides, with or without post-treatment irrigation. Bumblebee hives, purchased from a commercial source, were confined in large, screened field cages erected over the turf. The bees were allowed to forage for several weeks, and then the hives were sacrificed to evaluate colony health.

To determine if exposure to the insecticide-treated turf adversely affects bee behavior, we monitored worker foraging activity, as well as each colony's defensive response to a disturbance. For the latter tests, an investigator wearing a bee suit entered each field cage and "threatened" the hive by whacking it three times with a 30-cm wooden ruler. The number of bees that responded by attacking the intruder was recorded. We also observed native bumblebees' response to treated or untreated plots with turf and white clover to determine if bees avoid insecticide-treated areas.

Results and Discussion

Halofenozide (MACH2®) had no measurable adverse effects on earthworms and other beneficial soil organisms, predators, or bumblebees in our tests (4,5). Its spectrum of activity seems to be restricted to caterpillars and certain beetle larvae, especially white grubs. As expected, our applications in late May provided excellent (>90 percent) season-long control of Japanese beetle and masked chafer grubs. Imidacloprid (Merit®) also gave excellent (>90 percent) residual control of white grubs. Granular or liquid applications followed by irrigation had relatively low impact on earthworms and predators and no measurable adverse effects on bumblebees. Although imidacloprid is systemic, our results suggest that it is not translocated into pollen or nectar, at least not at levels that are harmful to bees.

In contrast, we found that exposure to nonirrigated imidacloprid spray residues caused neurotoxic effects (e.g., paralysis, impaired walking) in predatory beetles, as well as decline of bumblebee colonies that were confined on treated turf/clover stands. Notably, post-treatment irrigation, as would be recommended for grub control, substantially reduced the adverse effects on predators and eliminated them for bees.

Some of the traditional broad-spectrum carbamates and organophosphates, by comparison, can have severe impact on beneficial species. Bendiocarb, for example, reduced earthworm populations by >90 percent, and it also caused high acute mortality of predators. Exposure to nonirrigated residues of bendiocarb, chlorpyrifos (Dursban), or cyfluthrin (Tempo) caused decline of bumblebee colonies foraging on turf with flowering weeds.

Significance to the Industry

Our studies indicate that the new types of turf and landscape insecticides generally are less hazardous to beneficial insects than traditional organophosphates or carbamates.

Halofenozide, in particular, is compatible with conservation of earthworms, predators, and pollinators. Imidacloprid (Merit), followed by irrigation as normally is applied for grub treatments, also had little impact on beneficial species. Spray applications of imidacloprid, organophosphates, carbamates, or pyrethroids do have the potential to harm bees and other pollinators if the residues are present on flowering weeds. Turf and landscape managers can minimize this hazard by post-treatment irrigation, mowing flower heads before treatment, use of granular formulations, chemical weed control, or avoiding spray applications of insecticides during periods when weeds such as clover or dandelions are in bloom. This work shows that selective use of modern insecticides can be compatible with conservation of beneficial species.

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PEST MANAGEMENT—INSECTS

Is Companion Planting a Strategy for Protecting Roses against Japanese Beetles?

Phillip Gonsiska, Callie Prater, David W. Held, and Daniel A. Potter, Department of Entomology

Nature of Work

The use of non-host odors for the protection of plants from pests is based on the concept of associational resistance. Associational resistance occurs when a plant is protected from herbivory when associated with (e.g., growing near) other plant species that may produce masking or repellent odors that interfere with a pest's host location behaviors. For example, potato beetles, which orient upwind to the odor of solanaceous plants, are repelled by some non-host plants. Perhaps the most familiar application of this concept is companion planting in gardens.

Organic Gardening magazine and other such sources suggest that ornamental and vegetable crops can be protected using companion planting. For example, nasturtiums reputedly repel cucumber beetles and provide pollen and nectar resources for beneficial insects. In addition, garlic chives are reportedly repellent to all pests of roses. Given that adult Japanese beetles (JB) exploit plant-produced volatiles to locate plants, the presence of non-hosts in a common garden may protect susceptible hosts, like roses, from attack by JB. The objective of this project is to evaluate the use of companion planting to reduce or eliminate feeding on roses by JB.

We tested the use of non-host plants—garlic chives (*Allium schoenoprasum*), rue (*Ruta graveolens*), and toxic zonal geranium (*Pelargonium ´ hortorum* 'Orbit Red')—to protect roses against damage from JB. Both garlic chives and rue are non-hosts of JB and distinctively aromatic. Zonal geranium is included because it induces temporary paralysis in JB and may therefore be an effective companion plant. In this experiment, two 'Ultimate Pink' roses were planted in a common garden plot (2.0 x 3.3 m) with 13 plants of one of the previously mentioned companion species. These species have a maximum height less than a blooming rose, thus eliminating the possibility of the companion species acting as a physical barrier. All plots were established during May 2001 in a stand of low maintenance turf at the University of Kentucky Spindletop Farm. The companion species, planted 61 cm apart, will completely surround both rose plants (122 cm apart). Five plots for each respective companion species and a rose-only control were established with at least 3 m of turf between them. After planting, all exposed soil in the plots was covered with about 10 cm of hardwood mulch.

During the peak of JB flight (21 July–31 July), plants were monitored for the presence of beetles. The number of beetles present on both the blooms and foliage was recorded on six separate days during that period. Coincidently, the total number of open rose blooms in each plot was recorded.

Results and Discussion

Across all days, the number of rose blooms in each plot was not significantly different for all treatments. On three of the six dates, the rose plots planted with red geraniums had significantly more JB than control plots. No treatment significantly reduced the number of beetles relative to control plants that had no companion species.

Despite testimonials of their success by gardeners, alternatives such as companion planting have been largely untested as a strategy to reduce feeding damage by JB. These results suggest that Japanese beetles are able to locate roses despite the presence of these companion species. The use of companion planting, however, may prove effective for insects that have more restricted diets and require specific host cues to recognize a plant as a host.

Management of adult JB feeding is solely dependent on short-residual insecticides or feeding deterrents. The pervasive nature of the beetle on highly preferred hosts limits the effectiveness of both of these options. The best alternative is, therefore, to prevent or reduce recruitment of beetles to preferred hosts. Our results suggest that these companion species had no negative effect on beetle recruitment. If some nonhost odor could be identified, however, septa containing this odor could be attached to a susceptible plant to prevent recruitment.

Acknowledgments

Bear Creek Gardens (Jackson and Perkins roses)

PEST MANAGEMENT—INSECTS

Evaluation of Floral and Foliar Susceptibility of Roses to Japanese Beetles

David W. Held and Daniel A. Potter, Department of Entomology

Nature of Work

Shortly after its accidental introduction to the United States, the adult Japanese beetle (JB), *Popillia japonica* Newman was noted feeding on cultivated roses. Although it can potentially feed on more than 300 species of plants, the beetle is one of the primary commodity pests of roses in the eastern United States and Canada. The severity of feeding damage appears greater for roses because JB will feed on both the flowers and foliage. Despite this documented association, there has only been one published study of susceptibility among roses (1). In that study, there were no significant differences in defoliation among the 53 rose cultivars tested because field populations of beetles were so large.

In the present study, attributes of flowers such as fragrance, color, bloom size, and complexity were evaluated for influence on recruitment of JB using artificial blooms. Anecdotal accounts and past observations by USDA entomologists suggested that pale color flowers and red flowers were most prone to attack. Artificial blooms, of exact size and petal count, were painted by hand with paints that were custom mixed to visually match seven colors of flowers: red, white, yellow, mauve, apricot, orange, and pink. One bloom of each color was then attached to a potted rose that had all real blooms removed. Each pot was then baited with a whole JB floral lure to standardize the volatiles from each plant. These potted roses with artificial blooms were then placed 3 m apart in the rough of local golf courses around Lexington, where beetle flight appeared the greatest. Plants were patrolled and the number of beetles that landed on each flower color was recorded.

For tests of bloom size and complexity, artificial flowers were also used, but all were painted yellow using the same paint mixture previously mentioned. Bloom sizes, 8 and 15 cm diameter, were chosen to represent the extremes of bloom size. Bloom complexity, measured by petal count, was represented by yellow-painted artificial blooms with either 13 or 28 petals. The 13-petal flower was made by cutting petals from a 28-petal flower with scissors. These artificial flowers are models of a typical single- or double-flowered rose, respectively. For both tests, blooms were again attached to real potted roses with all flowers removed. Flower size and complexity were tested on separate plants. In both cases, however, each treatment was represented by two blooms arranged opposite each other on the plant. These plants were baited with a new floral lure and placed in an out-of-play area on local golf courses around Lexington. The number of beetles landing on each flower treatment was recorded.

The influence of fragrance was tested using four cultivars of roses representing two heavy (Fragrant Cloud and Tiffany) and two light fragrance (Sunbright and Touch of Class) flowers. Potted plants were blocked by the number of open blooms and placed 3 m apart in a field on Spindletop Farm. The number of beetles recruited to those plants was evaluated three times per day for three days. While most of the beetles landed in the flowers, beetles found on the foliage were also counted.

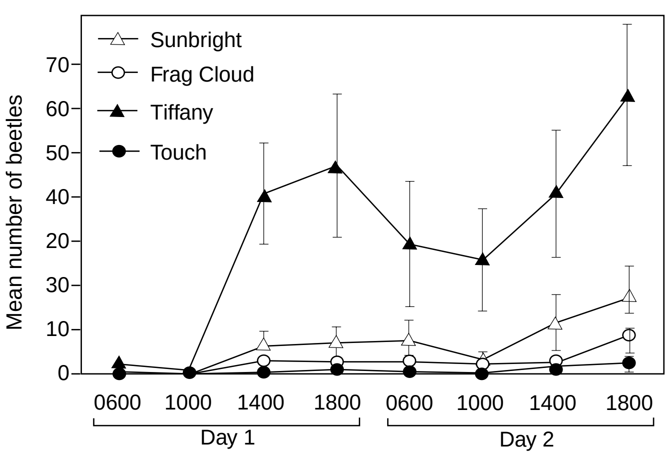
The effect of foliage characteristics was also evaluated. A randomized complete block of 14 rose cultivars representing either distinct color (light, dark, medium green) or sheen (glossy, matte, or leathery) categories was established at the research farm. Each category was represented by at least two cultivars. Foliage from each category was collected and tested in a laboratory choice test with JB. In this test, comparisons were made between colors and sheen. A separate laboratory no-choice test was conducted with all varieties to determine relative consumption.

Results and Discussion

Beetles landed significantly more often on yellow and white flowers than the other colors. In another trial, however, the number of beetles landing on pink and apricot-colored flowers were not different from either the white or yellow. When presented with yellow flowers differing in size, beetles landed significantly more often on the larger (15 cm diam) than the smaller flower. Beetles did not discriminate between artificial blooms differing by petal count across all three trials. The results suggest that JB is visually discriminating between flowers in the presence of a standard fragrance. Preliminary trials with colored blooms conducted without a whole floral lure failed to recruit beetles. The influence of visual stimuli appears to be limited by the presence of an olfactory stimulus, i.e., the floral lure.

The field test using cultivars of roses indicated that Tiffany, a heavy fragrance rose, recruited significantly more beetles than the other three cultivars. Fragrant Cloud, the other heavy fragrance rose, was not significantly different from the light-scented rose cultivars. This suggests that heavy fragrance does not predispose a rose to attack as anecdotal evidence has suggested. The present study did not evaluate season-long defoliation but specifically the initial recruitment of beetles. Our data suggest that beetles arrive at roses at different rates. Such a phenomenon may be very important given the reduced populations of JB seen presently in central Kentucky. Once damaged, a host plant becomes more attractive and thus more prone to attack by JB. If beetles are less likely to initially colonize certain cultivars, then this could translate to reduced damage later in the season.

Figure 1. Variability in recruitment of JB to cultivars of rose.



In choice and no-choice tests of foliage characteristics, JB did not discriminate between color or sheen of foliage. Likewise, there was no difference in amount of foliage consumed among the 14 cultivars of rose tested. Roses growing in the field plot at the farm where blooms were continually removed sustained little to no feeding damage by JB. Additional roses planted on that same site and allowed to freely bloom were repeatedly attacked. This suggests that presence of a floral display, or fragrance, greatly influences rose susceptibility to JB.

Significance to the Industry

The objective of this project was to investigate the influence of the attributes of hybrid tea rose foliage and flowers that affect recruitment of adult Japanese beetles (JB). Our data suggest that JB arrive at roses at different rates based upon floral characteristics like color and fragrance. Such a phenomenon may be very important because, once damaged, a plant becomes more attractive to additional beetles. In addition, roses without flowers appear less attractive to beetles. Therefore, a potential management strategy may be to remove blooms from plants that are in production as a means of protecting them from attack.

Acknowledgments

Bear Creek Gardens
Jackson and Perkins Roses

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Biology and Management of Calico Scale, a Severe Pest of Trees in Kentucky Landscapes

Jamee L. Hubbard and Daniel A. Potter, Department of Entomology

Nature of Work

Calico scale, *Eulecanium cerasorum*, is a pest of a variety of woody plants in urban landscapes. Calico scale was apparently introduced into the San Francisco, California, area in the early 1900s from Asia and has since spread to Kentucky and surrounding states through the transport of infested plant material. In recent years, calico scale has reached outbreak proportions in urban areas of Central Kentucky on maples, honeylocust, sweet gum, hackberries, and many other tree species. The scale encrusts the branches and covers the leaves of trees. This pest is a phloem feeder, and, in large numbers, feeding can result in branch and limb dieback. Trees may be directly killed by calico scale feeding or severely weakened, consequently succumbing to woodborer attacks, drought, or other stresses. It produces copious amounts of honeydew, which may coat automobiles and other objects under infested trees. Honeydew encourages growth of sooty mold fungus that blackens foliage and bark and may interfere with photosynthesis.

During the past five years, severe outbreaks of this pest have occurred on Central Kentucky horse farms, golf courses, and street plantings. The impact of this outbreak is extensive because there has been little research on the pest's biology or control.

The focus of our research was to study the biology of calico scale and determine insecticides and application methods that can be used in the urban landscape. We observed the life cycle and behavior of calico scale from late February to early October. Scales were noted on honeylocust, *Gleditsia triacanthos*; hackberry, *Celtis occidentalis*; Norway maple, *Acer platanoides*; sweetgum, *Liquidambar styraciflua*; and yellowwood, *Cladrastis kentukea*. Eggs and crawlers were counted from females obtained from these trees to determine if there are any differences in scale fecundity between tree species.

Additionally, we conducted two experiments on local horse farms, testing five insecticides and two application methods to target first instar settled crawlers in late spring and early summer. In our first experiment, a pyrethroid spray (bifenthrin, Talstar® Lawn and Tree Flowable) was applied with a pressurized sprayer to the entire canopy of five red maple trees, *Acer rubrum*, along a fencerow on 29 May 2001. The spray solution included Breakthrough® spreader/sticker at a rate of 0.31 ml per liter solution. A systemic organophosphate (dicrotophos, Mauget Injecta-a-cide B™) was injected into five red maple trees on 28 June 2001. Insecticides were applied at a rate listed to control scale insects. Five trees were left untreated. Total and dead crawlers were counted 14 days after application.

In our second experiment, six insecticide treatments were applied to individual sugar maple, *Acer saccharum*, shoots on a single tree. Six trees along a fencerow on the same horse farm were treated. Insecticides were applied with a hand sprayer to runoff on 23 June 2001. Treatments included a Talstar Lawn and Tree Flowable (bifentrhin), Orthene® Turf, Tree and Ornamental Spray 97 (acephate), an insecticidal soap (Safer® Brand), and an insecticidal summer oil (Superior Miscible Spray Oil). All insecticides were applied at rates listed for scale insects. All insecticide solutions included Breakthrough spreader/sticker at a rate of 0.31 ml per liter solution. Additionally, a treatment of water and Breakthrough and an untreated control were included. Total and dead crawlers were counted 14 days after treatment.

Results and Discussion

The following life cycle is based on observations made during spring-summer 2001. Calico scale completes its development in a single year. Large adult females, which are black and white checkered, are present on the woody tissue in the spring. In late April, the females begin to suck large amounts of sap, and they swell to about 6.0 mm long and 5.5 mm high. At this time, eggs are being produced underneath the female. Mean number of eggs found ranged from 1,401 to 3,858, with the highest number occurring under females from honeylocust trees and the lowest number occurring under females from Norway maple trees. Around 11 May in Central Kentucky, females begin to turn brownish and become crusty, which is followed by egg hatch later. After hatch, the first instar nymphs (also called crawlers), which are pinkish in color and are no more than 0.75 mm long, begin to crawl to the leaves. Some nymphs will be windblown to other trees. When the nymphs get to the leaves, they will insert their mouthparts and settle (then called settled crawlers) on the leaves to feed throughout the summer. They will become more yellowish and grow to approximately 1.0 mm in length. Mean number of crawlers emerging from females ranged from 487 to 2,835, with the highest number emerging from females from honeylocust trees and the lowest emerging from females from Norway maple trees. In mid-September, the same crawlers begin moving back to the woody tissues, where they stay for the duration of the winter and early spring. After they are settled on the woody tissue, they molt to the second instar, which is black and has a harder waxy coating. In late winter to early spring, they molt to the third instar stage, and then the cycle repeats.

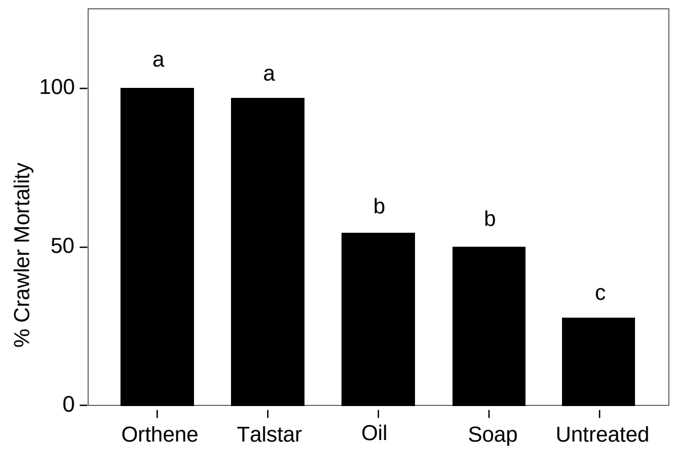
The results of the control studies yielded variable results based on application method. For whole canopy treatments, trees treated with Talstar or Inject-a-cide B yielded 65.6 or 42.0 percent mortality, respectively. Crawler mortality on untreated trees was 28.9 percent. All treatments were significantly different from each other.

We obtained better control on trees where individual shoots were sprayed. Mortality resulting from all treatments was significant. Talstar and Orthene achieved nearly 100 percent control (Figure 1). This higher rate of control is likely due to thoroughness of coverage. Both of these experiments will be repeated next year.

Significance to the Industry

The objective of this project was to study the biology of calico scale, construct a life cycle summary, and provide management options to arborists and horse farm managers. We determined that Orthene and, more importantly, Talstar, a reduced-risk pyrethroid, controlled settled crawlers best when applied thoroughly. Despite marginal control, Inject-a-cide B has potential as a low-risk insecticide treatment because the possibility of drift is eliminated with this application method. Low-toxicity insecticidal soap and insecticidal oil achieved average (. 50 percent control) control of settled crawlers. This research provides valuable information to arborists on calico scale biology and management. Additional research is currently under way to assess the natural enemy complex and determining pressures governing outbreaks in urban landscapes.

Figure 1. Percent crawler mortality due to treatment with foliar insecticides.



Pest Management—Insects

Biology and Conservation of the White Grub Parasitoids *Tiphia vernalis* and *Tiphia pygidialis*

Michael E. Rogers and Daniel A. Potter, Department of Entomology

Nature of Work

Tiphia wasps are the dominant group of parasitoids that attack white grubs. These wasps burrow into the soil where grubs are feeding on the roots of plants, deliver a sting to temporarily paralyze a grub, and then proceed to lay an egg on its victim. Upon hatching, the wasp larva, attached to the outside of its host grub, pierces the host's integument and feeds on the body fluids, leading to the weakening and eventual death of its host. The wasp larva then spins a cocoon in the soil in which it overwinters and emerges the following year as an adult wasp. We have found two species of *Tiphia* wasps to be abundant in landscapes throughout Central Kentucky: *Tiphia vernalis*, an introduced species of wasp that attacks Japanese beetle grubs, and *Tiphia pygidialis*, a native species that attacks masked chafer grubs. Little work has been done on the biology and conservation of these wasps. The focus of our research is to study the biology of *Tiphia* wasps and then apply this information to conserve and increase the benefits received from these wasps.

Results and Discussion

By monitoring the wasp flight over a two-year period, we found that *Tiphia vernalis* is active in Kentucky from the first week of May through the second week of June. *Tiphia pygidialis* is active from the first of August until the first week of October. Yellow pan traps were effective for monitoring early-season activity of *T. vernalis*, whereas both species could be monitored with a 10 percent sugar water solution. Parasitism of masked chafers averaged 15 to 20 percent at several golf courses but was as high as 62 percent in localized areas of high grub density.

Cues used by *Tiphia* to locate grubs below ground were examined by use of a glass observation chamber, positioned horizontally to allow observation of wasp behavior in the soil. Wasps were found to locate their victims by following species-specific scent trails left by the grub as it moves through the soil. Wasps showed an even stronger response to frass from their host grubs. Additionally, wasps were able to distinguish between frass from different grub species. This is the first study to show how *Tiphia* wasps locate grubs underground.

Wasps were found to be host specific, attacking only certain species of grubs. When offered Japanese beetle, masked chafer, or May beetle grubs, *T. vernalis* parasitized only Japanese beetles. *Tiphia pygidialis* were tested with the aforementioned grub species, plus green June beetle, two exotic species, European chafer and Oriental beetle and a Californian species of chafer, *Cyclocephala pasadenae*, which is not encountered by *T. pygidialis* in Kentucky. In general, only masked chafer grubs, including the Californian species, were attacked. In one case, however, *T. pygidialis* parasitized and completed larval development on a third-instar European chafer.

The relationship between the developing larval *Tiphia* and its host also was examined. Ten observation chambers resembling ant farms, vertical in position, were used to examine behavioral response of grubs to their developing parasite. In the observation chambers, comparisons were made between the depth of parasitized and non-parasitized grubs. Field experiments were also conducted to examine this behavior. Results of these experiments show that shortly after being parasitized, grubs quit feeding on grass roots and move down into the soil to depths as much as 20 cm. A second set of experiments where the egg was removed from parasitized grubs showed that both venom from the wasp's sting and constant feeding by the larval *Tiphia* are responsible for the change in grub movement patterns.

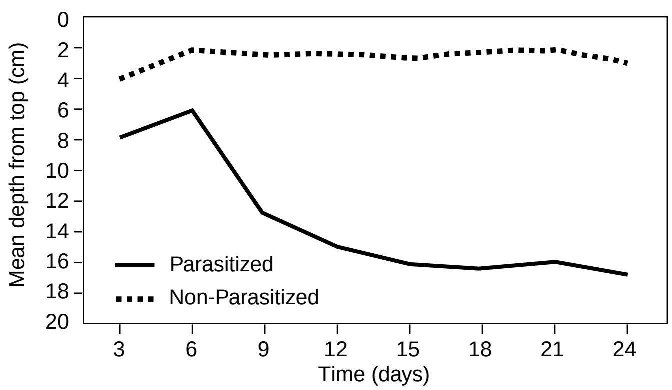


Figure 1. Premature descent of parasitized grubs from the root zone in ant farms versus movement patterns of non-parasitized grubs over a 24-day period.

Speculating that *Tiphia* wasps manipulate juvenile hormone levels in parasitized grubs causing them to prematurely descend, we collected hemolymph from parasitized and non-parasitized grubs and compared JH titers. Results showed changes in JH titers between grubs at different stages of parasitism; however, more work is needed to determine the exact nature of these changes.

Dilute sugar sprays were applied to small turf plots in an attempt to attract *Tiphia* wasps and increase parasitism of grubs. Although large numbers of wasps were attracted and observed feeding on the sprayed grass, no grubs were parasitized in sprayed plots. In adjacent, unsprayed turf, however, up to 37 percent of the grub population was parasitized. This indicates that sugar sprays applied near, but not directly on, grub-infested turf may increase the rate of parasitism. A second experiment examined distance from sugar sprays and amount of parasitism. This test was inconclusive with similar rates of parasitism at all distances from the sugar sprays. This test will be repeated on a much larger scale in the coming year.

Fall and spring blooming perennial flower gardens were planted and monitored to determine if flowers can be used to attract and retain *Tiphia* wasps in an area. Few wasps were found on any of the spring blooming flowers, and no wasps were found on the fall blooming species. Observation of the gardens did show that a large number of other parasitic wasps and bees were visiting the flowers, suggesting that these were indeed attractive, nectar-producing plants. Sugar water sprays applied near the gardens attracted large numbers of wasps, suggesting that *Tiphia* wasps were present in the area and do not commonly use flowers as a food source.

Significance to the Industry

We will continue to study the biology of these two *Tiphia* wasp species in 2002. Having determined the manner in which *Tiphia* locate their hosts while in the soil, we will now focus on the manner in which the wasps locate patches of grubs from a distance. The evaluation of sugar sprays as a means of increasing parasitism rates in localized areas will continue. In addition to the field tests designed to answer this question, lab assays will be conducted to determine if provision of sugar sprays will increase wasp longevity and fecundity. The nutritional benefits of host feeding will also be examined to determine if this behavior does indeed reduce wasps' reliance on floral resources. Other means of conserving beneficial *Tiphia* populations will also be examined. Potential effects of soil insecticide residues (e.g., imidacloprid, halofenozide) on wasp longevity, and sub-lethal effects such as ability to locate hosts below ground, will be examined. Such information, together with understanding of the wasps' seasonal activity, may enable turf managers to modify timing of pest control actions so as to conserve beneficial *Tiphia* populations and still control grub outbreaks.

Landscape Plant Disease Observations from the Plant Disease Diagnostic Laboratory

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

Nature of Work

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

Making a diagnosis involves a great deal of research into the possible causes of the plant problem. Most visual diagnoses involve microscopy to determine which 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. Computer-based laboratory records are maintained to provide information used for conducting plant disease surveys, identifying new disease outbreaks, and formulating educational programs.

The 2001 growing season in Kentucky provided mostly normal temperatures and adequate rainfall. Following a seasonably normal fall, December 2000 was 10 degrees colder than normal. March and April were significantly drier than normal, with April having much above-normal temperatures. Mild April temperatures were interrupted with a sharp freeze on April 18. Summer rains reached seasonal norms, with July receiving excess rainfall (7.3 inches for the month). Some regions were dry in late summer.

Woody plants that were not fully hardened before the cold December temperatures suffered winter injury symptoms the following summer. The dry early spring weather influenced the levels of primary infections for some foliar diseases. However, with the return of mostly normal rainfall, the rest of the 2001 growing season was favorable for foliar diseases of landscape plants.

Results and Discussion

Deciduous tree diseases

Winter injury was seen on twigs and branches of a variety of woody landscape plants as browning of cambial and phloem tissues. Affected plants showed branch dieback as the weather warmed up in spring. Warm April weather and timely light showers during bloom provided conditions for severe and widespread fire blight (*Erwinia amylovora*) outbreaks on flowering pears and crab apples. Below normal rainfall in April was not enough to thwart widespread infections of the cedar rust (*Gymnosporangium juniperi-virginianae*, *G. clavipes*, *G. globosum*) fungi. Hawthorn leaves, fruits, and shoots were especially heavily infected with cedar-quince and -hawthorn rust. Flowering crab apple scab (*Venturia inaequalis*) was less active due to the dry April, and the maple, dogwood, ash, and sycamore anthracnose fungi (*Kabatiella*, *Discula*, and *Apiognomonia*) were also less active this year. Dogwood powdery mildew (*Microsphaera, Phyllactinia* spp.) continues to be a problem. Bacterial leaf scorch (*Xylella fastidiosa*) was easily detected visually on red and pin oaks in late summer. ELISA and real-time PCR tests showed that *Xylella fastidiosa* also resides in symptomless grasses, shrubs, and vines in the landscape. Significant numbers of large, mature pin oaks in most Kentucky urban areas are dying from bacterial leaf scorch. Bacterial leaf scorch was also diagnosed in American elm for the first time in Kentucky. A related disease, Pierce's disease, caused by a different strain of *X. fastidiosa*, was found in Western Kentucky. Verticillium wilt (*Verticillium dahliae*) appeared especially on catalpa, and also on golden raintree, maple, redbud, smoke tree, and tulip poplar. Tuliptree tar spot (*Rhytisma liriodendri*) appeared in several instances.

Needle evergreen tree diseases

Maturing Austrian and Scots pines continue to die from tip blight (*Sphaeropsis sapinea*) and pine wilt nematode (*Bursaphelenchus xylophilus*). Juniper tip blight (*Kabatina juniperi*) was evident in some locations.

Shrub diseases

Boxwood shoot blight (*Volutella buxi*) was especially widespread this year. Black root rot (*Thielaviopsis basicola*) of holly, inkberry, Japanese holly, and boxwood remains a serious problem. Roses this year were diagnosed with rose rosette disease. Rhododendron root rot (*Phytophthora* sp.) and canker (*Botryosphaeria* sp.) were significant.

Perennial and annual plant diseases

Daylily rust (*Puccinia hemerocallidis*), a new disease, was found in three Kentucky locations. Black root rot (*Thielaviopsis basicola*) of annuals such as petunia and pansy was a problem in many flower beds in spring and again in fall. Southern blight (*Sclerotium rolfsii*) appeared on Rudbeckia. Root rot (*Pythium* sp.) also affected many landscape flowers, especially impatiens, geranium, daylily, begonia, and liriope. Bacterial blight (*Xanthomonas pelargonii*) was observed on geranium.

Landscape lawn diseases

The usual spectrum of turfgrass diseases appeared throughout the growing season. Perennial ryegrass gray leaf spot (*Pyricularia grisea*) was fairly serious this year.

Significance to the Industry

The first step in appropriate pest management in the landscape 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 provides useful information for landscape professionals.

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Latent Infections of Austrian and Scots Pine Tissues by *Spheropsis sapinea*

Jennifer Flowers, Etta Nuckles, John Hartman, and Lisa Vaillancourt, Department of Plant Pathology

Nature of Work

Sphaeropsis tip blight (formerly known as Diplodia tip blight) is a common, worldwide disease of more than 30 pine species and other conifers. Newly infected shoots stop growing and quickly die. Typical symptoms of *Sphaeropsis sapinea* infection include stunted shoots with necrotic, stunted needles, resinous cankers, and a general decline of the tree (1). In Kentucky, the disease is severe enough that trees infected for several successive years are often removed from the landscape long before they become mature (80 years in their native environment) (2). A survey was made in the region to determine if the pathogen is present in asymptomatic shoots and needles of Austrian and Scots pine. Asymptomatic shoots were tested from diseased trees and from asymptomatic, apparently healthy trees.

Diseased and asymptomatic shoots were collected from diseased and healthy trees growing mainly in Kentucky, but also from Illinois, Indiana, and Ohio. Pine tissues were surface disinfested and plated onto acidified potato dextrose agar using standard fungal isolation techniques. *Sphaeropsis* isolations were confirmed by subculturing the fungus on water agar with sterilized pine needles and observing development of pycnidia on these needles. For sample collections made locally, the fungus was also isolated from different surface-disinfested tissues dissected from asymptomatic Austrian pine shoots. Fungal isolates were tested for pathogenicity on 3-year old Austrian pines in the greenhouse.

Results and Discussion

This study documents latent infection of Austrian and Scots pine tissues by *Sphaeropsis sapinea*, the causal agent of Sphaeropsis tip blight disease (3). Nearly half of the sampled Austrian and Scots pine trees that appeared to be completely healthy had detectable latent *S. sapinea* infections. More than half of the symptomless shoots on visibly diseased Austrian and Scots pine trees were also latently infected with *S. sapinea*. The degree of latent infection was significantly higher in trees with more than 20 percent infected branches than those with less than 20 percent infection. *S. sapinea* was isolated from symptomless shoot stems, needles, buds, immature and mature cones, and male flowers. In symptomless infected shoots, the fungus was primarily associated with the bark and phloem tissues. Six isolates of *S. sapinea* from symptomless Austrian and Scots pine shoot tissues were pathogenic on Austrian pine seedlings in the greenhouse. Greenhouse inoculations may also result in no symptoms (26 percent of the time), but in most cases (90 percent of the time) the fungus can be recovered 5 cm beyond the inoculation site. It is not known why some inoculations result in latent infections while others do not. The presence of *S. sapinea* in symptomless tissues of tip blight-diseased trees has important implications for disease management.

Significance to the Industry

Information on Austrian pine tip blight identification, disease progress, and prognosis made in Lexington can be extended to Austrian pines in other regions of the state. This knowledge may assist landscape architects and managers in deciding whether to use Austrian pine in the landscape. Indeed, for longevity and ease of maintenance, Austrian pines may not be a good choice for Kentucky landscapes. The finding that the fungus already exists in the tree or parts of the tree before symptoms develop could have an enormous impact on tip blight disease management decisions.

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A PCR-Based Protocol to Determine if *Sphaeropsis sapinea* Is Present in Asymptomatic Tissues of Austrian Pines

Jennifer Flowers, Sabine Pauly, John Hartman, and Lisa Vaillancourt, Department of Plant Pathology

Nature of Work

Sphaeropsis tip blight (formerly known as Diplodia tip blight) is a common, worldwide disease of over 30 pine species and other conifers. Typical symptoms of *S. sapinea* infection include stunted shoots with necrotic, stunted needles, resinous cankers, and a general decline of the tree. These symptoms lead to significant economic losses of native and exotic pines in managed plantings. Our surveys of diseased and asymptomatic Austrian and Scots pine have revealed that latent infections of asymptomatic tissues by *S. sapinea* are common. However, culturing asymptomatic pine tissues to isolate the fungus destroys the tissue, preventing further studies of latent infections.

Objective

Develop a polymerase chain reaction (PCR) protocol to enable future studies of latently infected shoots.

Approach

S. sapinea specific primers were developed from the ITS regions of the rRNA gene cluster, and the specificity of the primers was tested on closely related fungi and other fungi that were isolated from pine tissues.

Fungal culture and DNA extraction

Twenty-two Kentucky *S. sapinea* isolates, eight South African isolates, two Wisconsin isolates of the 'A' morphology, and six 'B' morphology Wisconsin isolates, were single spored using a Micro Score Spore Cutter. The DNA of each isolate was extracted using a CTAB method. The complete ITS regions including the 5.8s rRNA gene were amplified and sequenced. Fungi commonly cultured from pine tissue were also single spored using a Micro Score Spore Cutter, and DNA was extracted using a CTAB method. The ITS regions were amplified and sequenced and a multiple sequence alignment was made using the GeneTool-Lite program. Fungal identification was based on colony and spore morphology and ITS sequences.

Primer design

Potential primers corresponding to areas of the ITS sequences that were unique to *S. sapinea* were identified using the Seqanal program. A forward primer (S.sapFOR2) and a reverse primer (S.sapREV2) were made that would be specific to *S. sapinea* ITS sequences.

PCR conditions

Optimal primer and magnesium chloride concentrations and annealing temperatures were established to reduce the likelihood of non-specific binding.

Results and Discussion

DNA from *S. sapinea,* or plant tissue infected with *S. sapinea,* produces a 300 base pair PCR product when amplified with the primer pair S.sapFOR2 and S.sapREV2. DNAs from closely related fungi and fungi commonly found in pine tissue are not amplified with the primer pair S.sapFOR2 and S.sapREV2. However, a common lab contaminate, *P. brevicompactum*, was amplified in preliminary experiments. The technique was further refined so that this contaminant was not amplified.

Sensitivity of the PCR assay allows detection of as little as 2.856 fg DNA/ml. This is equivalent to less than half of an average fungal genome.

Besides being a useful tool for future studies of latent *S. sapinea* infection, this species-specific protocol may be helpful in other studies that rely on culturing *S. sapinea* out of pine tissue. When culturing from pine tissue, *S. sapinea* may become overgrown by other fungi found in pine tissue or misidentified as another fungus. The PCR protocol is also faster and more sensitive than culturing.

It will be important to identify an appropriate sampling regime before this PCR protocol can be put to practical use for field studies. Tissue must be sampled without killing or even stressing the remainder of the shoot if the shoot is to be useful for further study. Our previous work has shown that *S. sapinea* is confined primarily to the bark and phloem in latently infected Austrian pine shoots. *S. sapinea* can also be found in asymptomatic needles, where it is confined primarily to the fascicle sheath.

Needle sheaths, especially on infected shoots, contain high numbers of fungal spores. Spores can easily be observed germinating on this tissue.

On Austrian pine shoots, terminal buds tend to show more latent infection than side buds.

Significance to the Industry

With the development of a sensitive and specific PCR-based DNA test probe as well as an appropriate sampling regime, it may be possible to tell if a pine tree is infected with *S. sapinea* long before it ever shows symptoms. More importantly, this probe can be used as a tool to study the fungal and plant genetics affecting the shift of the pathogen from latent to active status. By knowing the mechanism behind this shift, basic research such as this could provide a way to block the shift either by changing host plant genes or by making environmental changes that would keep the fungal genes from being expressed in the host.

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Injections with Fungicides for Management of Pine Tip Blight: A Continuing Study

John Hartman, Jennifer Flowers, Lisa Vaillancourt, Jean-Bernard Magnin, Jerry Hart, and Larry Hanks,
Department of Plant Pathology, Physical Plant Division, and Pampered Properties, Inc.

Nature of Work

Tip blight disease, caused by the fungus *Sphaeropsis sapinea*, is a major problem of Austrian pine (*Pinus nigra*) in the landscape (1). Control by pruning or spraying is difficult and usually ineffective; most affected trees eventually die or are removed (2). Young trees that are not yet producing cones are rarely affected by tip blight. It has been suggested that a primary source of inoculum may be old infected cones and that young trees escape due to lack of locally produced infective propagules. However, we have found that the tip blight fungus is present in healthy parts of trees (found in more than 70 percent of symptomless twigs) or in healthy young trees (17 percent), living as a latent pathogen or possibly as an endophyte within the twigs (3,4). This study is intended to determine whether fungicide injection can prevent new infections and further spread of tip blight disease (5). We hope to also determine whether injection of pines with fungicides can eradicate *S. sapinea* from within infected/infested pines and the impact of fungal eradication on disease.

Two distinct groups of UK campus Austrian pines were selected for injection treatments as described below: Experiment 1, mature diseased (1 to 50 percent tip blight) Austrian pines (six replicates) and Experiment 2, maturing mostly not-diseased Austrian pines (10 replicates). Disease symptoms were evaluated in mid- to late summer each year by estimating the percent of diseased shoot tips per tree. Diseased branches previously removed for sanitation purposes were included in the estimate. During July 2000 and again in July 2001, shoot and needle samples (two each) from asymptomatic and diseased shoots were collected from each treated tree and the pathogen cultured on acidified PDA using standard microbiological techniques. The fungal cultures were identified and confirmed microscopically following inoculation of autoclaved pine needles.

Experiment 1

Sixteen 22-year-old diseased Austrian pines located on traffic islands on the UK campus received one of four treatments. Treatments, arranged in a randomized complete block design and replicated on four individual trees, consisted of injections at labeled rates of a) oxycarboxin (Carboject), b) debacarb (Fungisol), c) tebuconazole (Tebuject), and d) water used as controls. In 1999, treatments were made 8 May (capsules removed 12 May; water controls injected 18-22 May), when the candles of the pines were partly elongated. In 2000, treatments were similarly made 6-9 May (capsules removed 16 May), and in 2001 on 5 May (capsules removed 17 May). Due to the demise of several of the traffic island trees in the first year, eight additional 20-year-old trees located around the perimeter of a UK campus parking lot nearby were injected in May 2000 and 2001. Trees have been grouped into randomized complete blocks, and each treatment is now replicated five or six times with each replicate being an individual tree.

Experiment 2

From a group of 71 mostly disease-free 13- to 14-year-old Austrian pines forming a screen planting on the UK campus, 40 trees were injected in 1999, 2000, and 2001 as described above. The experiment was designed as a randomized complete block experiment with 10 replicates.

Results and Discussion

Tip blight disease ratings

Tip blight disease ratings for both Experiment 1 and Experiment 2 are presented in Table 1. After three years of injections, trees in Experiment 1 continue to die. Disease ratings for these mature trees have increased 168 to 207 percent from 1999 to 2001. There is no noticeable treatment effect on disease rating. For Experiment 2, the younger, less-diseased trees are gradually increasing in disease levels (Table 1). In 1999, there was no noticeable disease in this plot; by 2001, disease ratings ranged from 11 to 13 percent, again showing no noticeable treatment effect.

Table 1. Three-year disease ratings (percent blighted shoot tips) for Experiment 1, mature diseased UK campus Austrian pines (six replicates [four replicates begun in 1999 and the rest in 2000]) and for Experiment 2, maturing, less-diseased Austrian pines (10 replicates).

Austrian pine trees		Experiment 1				Experiment 2	
Treatment	Rating year	Range	Average*	Average for original trees	Original trees' disease percent vs 1999	Range	Average
1 - Fungisol	1999	1-85	28	28	100	0	
	2000	1-100	23	32	125	0-<1	
	2001	4-100	40	56	200	0-25	11
2 - Tebuject	1999	1-90	51	38	100	0	
	2000	1-100	44	62	129	0-<1	
	2001	1-100	51	70	184	5-20	11
3 - Carboject	1999	9-52	34	34	100	0	
	2000	5-70	31	49	144	0-<1	
	2001	5-100	41	57	168	5-40	12
4 - Water	1999	23-35	29	29	100	0	
	2000	5-60	33	46	159	0-<1	
	2001	5-100	42	60	207	5-30	13

* Percent disease decreased from 1999 to 2000 because new, less-diseased trees were added after the first year.

Recovery of the pathogen from pine shoots

Diseased shoots yielded significantly higher levels of the pathogen in culture than did asymptomatic shoots from the same trees (Table 2). *S. sapinea* was isolated from all diseased shoots, whereas the fungus was isolated from only five or six of 10 asymptomatic shoots. In 2000, a lower proportion of Fungisol-treated trees yielded the fungus from symptomless shoots than from the other treatments. Treatment differences were not noticed in 2001. During the injection process, it was noticed that some of the capsules soon filled with pitch from the tree. Thus, it is difficult to know whether or not all capsules were actually emptied into the injection sites.

Significance to the Industry

Information on injections as a management tool for Austrian pine tip blight may provide insights on the biology of the fungus and its host and potential control of the disease. This knowledge may assist landscape architects and managers in deciding whether to use Austrian pine in the landscape. Indeed, unless efficient control measures are developed, for longevity and ease of maintenance, Austrian pines may not be a good choice for Kentucky landscapes. If treatments can induce tree recovery or eradicate the fungus that already exists in the tree or parts of the tree before symptoms develop, this information will have an enormous impact on tip blight disease management.

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Table 2. Isolation of *Sphaeropsis sapinea* from UK campus pines: Experiment 1, mature diseased Austrian pines (six replicates). Experiment 2, maturing less-diseased Austrian pines (10 replicates) treated with fungicides via trunk injections. Percent shoots yielding *S. sapinea* in culture (two samples per tree).

Austrian pine trees	**Experiment 1**		**Experiment 2**			
Treatment and sample health status	**Percent recovery of *S. sapinea***		**Percent recovery of *S. sapinea***		**Proportion of trees with *S. sapinea***	
	2000	**2001**	**2000**	**2001**	**2000**	**2001**
1 - Fungisol, symptomless shoot	55.0 a *	50 a	7.5a	16.7 a	1:10	6:10
3 - Tebuject, symptomless shoot	40.0 a	50 a	17.5a	30.0 a	5:10	5:10
7 - Water, symptomless shoot	66.7 a	60 a	22.5a	25.0 a	5:10	5:10
5 - Carboject, symptomless shoot	45.8 a	100 a	25.0a	26.3 a	7:10	5:10
4 - Tebuject, diseased shoot	75.0 a	100 a	68.8 b	86.7 b	8:8	10:10
8 - Water, diseased shoot	79.2 a	100 a	75.0 bc	94.4 b	6:6	10:10
2 - Fungisol, diseased shoot	80.0 a	100 a	79.2 bc	100 b	6:6	10:10
6 - Carboject, diseased shoot	66.7 a	100 a	87.5 c	93.3 b	6:6	10:10

* Means in a column followed by the same letter are not significantly different; Waller-Duncan K-ratio t-test (K = 100, p = 0.05).
Fungisol = debacarb; Carboject = oxycarboxin; Tebuject = tebuconazole.

Presence of *Xylella fastidiosa* in Symptomless Landscape Hosts

John Hartman, Dominique Saffray, and Julie Beale, Department of Plant Pathology

Nature of Work

Landscape trees have long been afflicted with leaf scorch symptoms caused by environmental factors such as root damage, road salt, and drought, and by wilt diseases caused by fungi (2). The association of xylem-limited bacteria with shade tree leaf scorch symptoms was first made in 1980 (7). In 1987, the bacterium associated with leaf scorch was described as a new species, *Xylella fastidiosa* (12). Bacterial leaf scorch has been reported in coastal U.S. states from New York to Texas, and in Kentucky in bur, pin, red, white, and shingle oak; sycamore; sugar, silver, and red maple; American elm and sweetgum (1,3,4,5,6,9,11). The disease is now being detected in southern Indiana and southern Ohio and has been diagnosed in Tennessee: thus, it is found throughout the eastern United States.

In oak, scorch symptoms first appear in late summer in individual branches where leaves show dead margins with green tissues near the main veins and leaf petiole. Often there is a fine yellow or reddish zone between brown and green tissues. Many affected leaves drop prematurely. In succeeding years, the late summer leaf scorch progresses to all parts of the tree. Gradually, infected trees suffer a chronic decline with branch dieback affecting more of the tree each year. Secondary factors can contribute to the tree demise, and eventually the tree needs to be removed. Tree decline, from first discovery of the disease to removal, may take place over a period of five to 10 or more years. It is not known how *X. fastidiosa* causes leaf scorch and defoliation of landscape trees, but water stress due to xylem occlusion seems to be the most likely cause (8).

In the UK Plant Pathology Department's Plant Disease Diagnostic Laboratory, we used an enzyme-linked immunosorbent assay (ELISA) developed for *X. fastidiosa* ("Pathoscreen-Xf," Agdia Inc., Elkhart, IN) to detect the bacterium. When positive ELISA results are obtained from a new host or new geographic location, we confirm our findings by using electron microscopy to observe occluded xylem tissues and to observe the causal agent with its typical scalloped or undulating cell walls. Recently, a rapid-cycling real-time polymerase chain reaction (PCR) technique (California Seed & Plant Lab., Inc., Elverta, CA) has been employed to corroborate the ELISA test. Indeed, PCR has been used to identify *X. fastidiosa* in alternative host plants (10).

The objective of this work was to determine whether nearby landscape plants not showing scorch symptoms might harbor the bacteria. Leaf samples from grasses, perennial flowers, shrubs, and trees growing in Lexington, Kentucky, landscapes were collected from areas where bacterial leaf scorch was endemic in nearby oak trees and from areas where diseased trees were absent. A total of 202 samples representing 60 plant genera were collected. Samples were refrigerated at 40°F overnight and then dissected, macerated, and tested for presence of *X. fastidiosa* using the ELISA test. Surgical gloves were used to avoid contamination, and additional samples were collected and sent off for testing via rapid-cycling real-time PCR.

Results and Discussion

To our surprise, many landscape plants not showing scorch symptoms nevertheless test positive for *X. fastidiosa* (Table 1). It is not known if they harbor even the same strain of the bacterium since ELISA and PCR test for presence of any strain of *X. fastidiosa* and not just those causing scorch in trees. If it is the same strain of the pathogen, are the symptomless plants getting it from the oaks, or do these plants provide a reservoir of bacteria that are then carried to the trees? It is also not known whether the same insect vectors feed on the symptomless hosts and also oaks and other trees. Some of the plants such as perennial ryegrass and Kentucky bluegrass are so widespread in the landscape that they are impossible to avoid. This research perhaps raises more questions than it answers.

Table 1. Some symptomless plants tested for *Xylella fastidiosa*

Plant name	Number tested	Number strongly (+)	Number (-)	Verified by PCR
Perennial ryegrass	23 *	17	2	yes
Kentucky bluegrass	15	8	3	yes
Nimblewill	7	3	0	not tested
Tall fescue	3	2	0	not tested
Prostrate knotweed	5	3	2	not tested
Osmanthus	22	16	0	yes
Honeysuckle	11	5	2	yes
Vinca minor	5	3	1	yes
Andromeda	3	1	2	not tested

Plants that never tested strongly positive for *X. fastidiosa* (numbers tested).
Ajuga (1), Azalea (1), Beech (2), Bermudagrass (1), Cotoneaster (1), Crabapple (2), Smooth crabgrass (1), Creeping Charlie (1), Dandelion (5), Daylily (2), Flowering Dogwood (10), Winged Euonymus (1), Wintercreeper Euonymus (4), Red Fescue (1), Forsythia (2), Gingko (1), Wild Grape (1), American Holly (2), Hosta (1), Hydrangea (1), English Ivy (2), Katsura tree (-), Linden (1), Liriope (1), Honey Locust (2), Japanese Maple (1), Mockorange (2), Morning Glory (1), Oxalis (1), Pachysandra (1), Plantain (5), Plum (1), Common Ragweed (1), Redbud (1), Smoke Tree (1), Mock Strawberry (2), Viburnum (2), Wild Violet (3), Virginia Creeper (3), and Walnut (1).
* Missing data are (+/-) for the ELISA test.

Significance to the Industry

Bacterial leaf scorch is a major concern for arborists, nursery operators, and landscape managers because it is a very destructive disease. Specific insect vectors of the bacteria in Kentucky landscapes are still unknown. This study is a first step towards understanding the epidemiology of this disease. Continued studies on the existence of possible reservoir host plants may provide a means for understanding this disease and managing it.

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Pest Management—Diseases

Bacterial Leaf Scorch Testing Protocol Investigation

John Hartman, Dominique Saffray, and Julie Beale, Department of Plant Pathology

Nature of Work

Bacterial leaf scorch caused by *Xylella fastidiosa* is a devastating disease to street and landscape trees in Kentucky (1). In the UK Plant Pathology Department's Plant Disease Diagnostic Laboratory we used an enzyme-linked immunosorbent assay (ELISA) developed for *X. fastidiosa* ("Pathoscreen-Xf," Agdia Inc., Elkhart, IN) to detect the bacterium. For laboratory testing, we often receive specimens that are old, dried out, or of insufficient quantity. The objective of this research was to determine how small a sample could be used and still get good detection and to see how long samples could be allowed to dry out and still get good detection.

Results and Discussion

Pin and red oak leaves with distinct scorching symptoms were collected from landscape trees for this test.

Assay of leaf tissue parts and quantity

Leaf petioles were removed from infected leaves, and a series of ELISA tests was performed on ½, 1, 2, 4, and 8 leaf petioles macerated and extracted for the assay. In another test, scorched parts of leaf blades were separated from the still-green parts of the leaf, and each was assayed using ELISA. All quantities and locations of leaf tissue gave strongly positive test results.

Assay of dried leaf samples

Infected, scorched leaves of red oak and pin oak were collected and placed indoors on a desk top at ambient temperature. Using the ELISA test, leaves were assayed for *X. fastidiosa* after drying on the desk top for 0, 2, 5, 7, 9, 12, 14, 49, 51, 54, 56, 58, 61, and 63 days. All samples gave strongly positive test results.

When specimens with distinct scorch symptoms are used in the ELISA assay, there are enough bacteria present in the leaf petioles that even a half petiole is a sufficient quantity of plant sample for a positive test result. For plants not infected with the bacterium (negative controls), we know that as many as 30 leaf petioles can be used and still not get a positive result. Furthermore, specimens that are allowed to dry out for two months are not at risk for losing their reactivity in ELISA testing.

Significance to the Industry

Improved testing protocols will enable the UK Plant Disease Diagnostic Laboratory to better evaluate the presence of bacterial leaf scorch in specimens sent to the lab. Improved testing has benefits to the landscape and nursery industry in Kentucky.

Literature Cited

1. Hartman, J.R., B.C. Eshenaur, and U.E. Jarlfors. 1995. Bacterial leaf scorch caused by *Xylella fastidiosa*: A Kentucky survey; a unique pathogen; and bur oak, a new host. Journal of Arboriculture 21:77-82.

Landscape Performance of Verbena: 1997-2001

Bob Anderson and Sharon Bale, Department of Horticulture

Nature of Work

Verbenas are primarily used for hanging baskets and mixed containers because they have bright and unique flower colors and fast growth suited to container production. These same characteristics suit landscape use, so we have evaluated verbenas for landscape use. Verbenas are seldom used in Kentucky landscapes. Annual verbena has always been rated as mediocre for summer performance in Kentucky because it must be cut back strongly in midsummer and loses three weeks or more of summer flowering for that reason. The non-patented vegetative verbenas have not been used here, even though they are used in southern landscapes. The introduction of many new patented varieties has increased the interest in this group of plants.

In general, the newer verbenas are propagated from cuttings to maintain the phenotypic characters. Some vegetative verbenas are marginally hardy across the state: some winters they survive, some winters they don't. 'Homestead Purple', 'Lilac Time', 'Fiesta' and *V. peruviana* are relatively hardy while others are less hardy as landscape perennials. A landscaper or gardener will have to rethink how to use verbenas in the landscape. 'Lilac Time' was in full flower April 15, 2000, and was as spectacular as creeping phlox and flowered much longer. Verbenas seem to be summer garden plants, but most are really best in spring, early summer, and fall. This could be due to a temperature or photo-period response or something as simple as insufficient fertilizer or water, but we have no data to confirm details. The types that seem more similar to *V. tenuisecta*, seem to go out of flower for six to eight weeks from mid-July through August, while those more similar to *V. canadensis* produce more flowers all summer. All the types flower very well in spring, early summer, and fall.

The new verbenas are derived from a number of verbena species and selections. It is difficult to determine the true genetic background of the current plants, but they fall into general categories by leaf appearance and plant size. When I saw *V. goodingii* in the desert scrub in the mountains of northern Mexico, it seemed surprisingly similar to many of the vegetative verbenas. But the heritage of each type is in question because the breeders have not explained the origins of their patented plants.

Trial Results

The verbena trials have been completed at the University of Kentucky Arboretum and at the Horticulture Research Farm. In general, maintenance practices would be considered low: fertilizer once per month and water as needed.

Types derived from V. *canadensis* and probably V. *goodingii*, V. *peruviana*, and V. *tenuisecta*

These verbenas have larger, less divided leaves. 'Temari', 'Lanai', and 'Tortuga' verbenas flowered all summer and fall, while the others flowered sparsely in midsummer. 'Temari Patio Blue' was the best of all verbenas in 2000. It flowered well all summer and produced a large mass of plants 24 inches tall. The Temari varieties remain our favorite after four years of trials. The unique or strong colors of Tortuga White, Red, and Hot Pink were attractive in the garden, but the plants did not perform as well as the others. 'Lanai' varieties have replaced 'Tortuga' varieties in 2001, and their performance was almost as good as the 'Temari' varieties.

Excellent Landscape Performance

'Temari'—'Patio Blue'—blue, 12 to 24 inches tall; outstanding performance in 2000, continuous flowering spring to fall. These plants were shipped with disease in 2001 and demonstrated only good landscape performance. ('00-'01)

'Homestead Purple'—purple, 6 to 10 inches tall; usually hardy, aggressive, coarse growth all summer as long as it gets water and fertilizer. ('96-'01)

'Temari'—'Bright Red', 'Cherry Blossom Pink'—6 to 10 inches tall; these verbenas are aggressive and vigorous; they flower very well in spring, early summer, and fall and maintain uniform flowering the rest of the summer. ('98-'01)

Good Landscape Performance

'Blue Princess'—blue, 8 to 15 inches tall; not hardy but has great potential as an annual especially in containers, good summer flowering. ('99-'01)

'Escapade Red'—red, 6 to 10 inches tall, spreading vigorous variety new in 2001, nearly a match for 'Temari Bright Red' but goes out of flower in mid- to late summer. ('01)

'Fiesta'—pink/red, 6 to 8 inches tall, mottled blooms are very attractive; must be cut back after bloom to promote rebloom. ('98-'01)

'Lanai'—'Bright Pink', 'Light Purple', 'Purple w/eye', 'Rose', 'Royal Purple', 'Scarlet'—New for 2001, a uniform series, all cultivars quite equal in performance, almost as good as the best 'Temari' varieties, vigorous but less aggressive than the 'Temari' varieties. ('01)

'Lilac Time'—lilac, 6 to 8 inches tall, was in full bloom April 15, 2000, earliest blooming of all the verbenas; should be cut back after bloom to promote rebloom. ('98-'01)

'Mabel's Maroon'—burgundy, 6 to 10 inches tall, vigorous, good flowering. ('01)

'Rapunzel'—'Burgundy', 'Purple w/eye'—6 to 10 inches tall, spreading vigorous varieties new in 2001, nearly a match for 'Temari' varieties but goes out of flower in mid- to late summer. ('01)

'Summer Breeze'—bright rose, 8 to 14 inches tall, vigorous, great color. ('01)

'Temari'—'Burgundy', 'Violet', 'White'—6 to 10 inches tall, these verbenas are less vigorous than other 'Temari' varieties. ('98-'01)

'Temari'—'Patio Pink', 'Patio Rose', 'Patio Hot Pink'—These varieties were shipped incorrectly identified and badly diseased. No ratings in 2001.

'Tortuga'—'Double Purple', 'Hot Pink', 'Peach', 'Red', 'White'—moderate vigor, good floral performance spring, summer and fall, bright and vibrant flower colors, seemed susceptible to disease (especially powdery mildew) and less heat tolerant. 'White' is the strongest and 'Double Purple' is the weakest in the series. ('00-'01)

Mediocre Landscape Performance

'Abbeyville'—light blue, 6 to 8 inches tall, begins bloom early but must be cut back to promote rebloom. ('98-'01)

'Appleblossom'—pink, 6 to 8 inches tall, blooms later in the spring than others but must be cut back to promote rebloom. ('98-'01)

'Batesville Rose'—burgundy rose, 6 to 10 inches tall, not hardy, grows well but few summer flowers. ('98-'01)

'Dorothy Burton'—pink, grows well but few summer flowers. ('01)

'Greystone Daphne'—lavender, 6 to 8 inches tall, not as hardy as some others. ('98-'01)

'Pink Sunrise'—pink, 6 to 8 inches tall, not hardy, grows well but few summer flowers. ('98-'01)

'Snowflurry'—white, 6 to 8 inches tall, not reliably hardy, some plants did overwinter performance. ('98-'01)

'Sparkler'—'Red/White', 'Violet/White'—6 to 10 inches tall, eye-catching bicolor flowers, low vigor, poor summer flowering, new cultivars for 2001. ('01)

'Spitfire'—'Burgundy/White', 'Carmine', 'Pink/Red', 'Violet/White'—6 to 10 inches tall, eye-catching bicolor flowers, low vigor, poor summer flowering, new cultivars for 2001. ('01)

'Wildfire Dark Lavender'—lavender, 8 to 12 inches tall. ('00-'01)

Verbena canadensis—lavender, 8 to 12 inches tall. ('01)

Types derived from *Verbena tenuisecta* and other species and types

These verbenas have smaller leaves that are finely cut. In general, these plants do not flower well in midsummer but flower profusely in spring, early summer, and fall. Plus, they are frost tolerant. Tapien verbenas have been better in our trials.

Excellent Landscape Performance

'Tapien'—'Salmon'—New in 2001, produced more significantly more flowers than the other 'Tapien' varieties, 3 to 6 inches tall, vigorous, aggressive plants that form a low-growing mat. ('01)

Good Landscape Performance

'Tapien'—'Blue Violet', 'Rose Pink'—3 to 6 inches tall, vigorous, aggressive plants that form a low-growing mat. ('98-'01)

Mediocre Landscape Performance

'Aztec'—'Lavender', 'Pink Magic'—4 to 10 inches tall, moderate vigor. ('99-'01)

'Babylon'—'Lilac', 'Neon Rose', 'Silver', 'Light Blue'—4 to 10 inches tall, moderate vigor, excellent colors. ('00-'01)

'Maonetti'—bicolor flowers, lavender and white, 8 to 12 inches tall, low vigor, poor summer flowering. ('01)

'Rainbow Carpet'—'Lavender', 'Pink', 'Purple', 'Red', 'Rose'—8 to 12 inches tall, moderate vigor, unique flower form with more globose heads, poor summer flowering. ('01)

Verbena peruviana, small red flowers, 2 to 3 inches tall, low-growing habit makes this one rather unusual; consider for a very low ground cover; may be cut back to promote rebloom. ('98-'01)

PLANT EVALUATION

Evaluation of Ground Covers at the UK Arboretum

Richard Durham and Shari Dutton, Department of Horticulture

We are in the second year of evaluating ground covers at the University of Kentucky Lexington Fayette County Arboretum. Here we will report on winter survival of perennial ground covers planted in May 2000 and comment on several tropical foliage species that are being evaluated as annual ground covers.

Winter Survival

Several cultivars of English Ivy (*Hedera helix*) were planted in 2000 and were evaluated for initial establishment. Cultivars planted included 'Baltica', 'Duck Foot', 'Gold Baby Plus', 'Hermania Plus', 'King's Choice Plus', 'Spetchley', and 'Silver Lace Plus'. Winter survival and continued performance were evaluated in 2001. Of these cultivars, two performed poorly with regard to winter survival. 'Duck Foot' was completely killed, and 80 percent of the plants of 'Spetchley' were killed during winter 2000-2001. Therefore, these cultivars should not be used in Kentucky landscapes. The other cultivars have filled in nicely and will continue to be evaluated for hardiness.

All of the *Sedum* established in 2000 exhibited good winterhardiness. The species and cultivars evaluated include *Sedum* 'John Creech', *Sedum kamtchaticum*, *Sedum reflexum*, *Sedum* 'Rosy Glow', and *Sedum spurium* 'Fuldaglut'. All of these selections have filled in well with the exception of 'Rosy Glow', which continues to grow very slowly. The low arching stems of 'Rosy Glow' also make it difficult to appreciate the maroon flowers produced in later summer. The other sedums are much more upright and range in height from 2 to 3 inches for 'John Creech', 3 to 4 inches for *S. kamtchaticum*, and 'Fuldaglut', and 8 inches for *S. reflexum*.

Two types of lavender were established in 2000. Fringed green lavender (*Lavender dentata*) was not winterhardy; however, English lavender (*Lavender angustifolia*) was hardy with only 20 percent of the plant not overwintering.

A collection of five cranesbill geraniums were also planted in 2000. All of these were hardy and have filled in well. *Geranium sanguineum* 'Striatum' appears to be particularly suited for use as a ground cover due to its low growth (4 to 5 inches tall) and spread (~18 inches after two growing seasons).

Annual Ground Covers

Evaluation of many of these species began in 2000; however, the use of small transplants, drought conditions, and lack of supplemental fertilizer likely compromised the performance of many of these plants. Therefore, we have repeated these entries in 2001. Plants installed were in 3-inch pots rather than plugs; most plants were planted on 6- to 8-inch centers; slow release fertilizer was added to the hole (1 tablespoon Osmocote) at time of planting; and two additional applications of soluble fertilizer in irrigation water were applied during the growing season. In general, growth of these plants was much improved over the 2000 growing season.

- *Cissus rhombifolia*—Grape Ivy. This plant performed exceptionally well during the 2001 growing season. The use of larger transplants (3-inch pots rather than plugs) and increased fertilization allowed plants to completely fill in from the initial 6-inch spacing within six weeks and reached a height of 8 to 10 inches. The plants were growing in semi-shade. Future studies will look more closely at optimal spacing and sun exposure.
- *Setcreasea purpurea*—Purple Heart Ivy. Remarkably some of these plants overwintered, although in low frequency (5 to 10 percent), from the previous year in a bed that was not planted in *Setcreasea* in 2001. As with the *Cissus*, larger plant size, closer spacing, and increased fertilization allowed these plants to fill in rather quickly. However, the increased fertility appeared to increase the internode length and give the plants a leggy appearance. The arching stems reached heights of 12 to 14 inches. With increased vigor, these plants also exhibited more leaf curl due to water stress causing them to be unattractive. This trade-off of rapid growth versus less attractive growth may reduce the potential for *Setcreasea* as an annual ground cover.
- *Zebrina pendula*—Wandering Jew. These plants were placed in a shady location and given the same fertilizer treatments as *Cissus* and *Setcreasea*. Plants rapidly filled the space and became quite large. While the usual plant habit is prostrate with ascending tips, some of the stems reached 2 feet in height. The plants were very attractive and functioned as a ground cover, but fertilizer should be used more sparingly, perhaps less slow-release fertilizer in the planting hole and no additional fertilization in the irrigation water.
- *Gibasis pellucida*—Tahitian Bridal Veil. *Gibasis* was evaluated for the first time in 2001. Plants were transplanted from 3-inch pots and spaced at 6-inch intervals. Fertilization was as described for other species above. The plants filled in well after approximately six weeks and were very attractive. The dark green, fine-textured, ivy-like foliage was highlighted with small, white flowers. The plants were grown in light shade and reached a height of 10 to 12 inches. Future studies with this plant will look at optimal spacing for establishment and sun exposure.
- *Fuchsia* 'Cape Moonraker'. Plants were evaluated for the first time in 2001 and established similar to *Gibasis* except the plants were grown in heavier shade. The plants were more slow to fill in than *Gibasis* and flowered poorly. However, the light green foliage highlighted by red stems and petioles was attractive. The plants reached a height of 6 to 8 inches. This selection probably deserves another look in 2002 in a sunnier location.
- *Acalypha hispida* var. *repens*—Trailing Chenille Plant. These plants were evaluated for the first time in 2001 and established similar to *Gibasis* except they were planted in full sun. The plants were very slow to establish and fill, and the desired effect of the 3-inch, red flower spikes was not realized. The stems were prostrate and plants reached a height of only 2 to 3 inches. This plant would serve the landscape better in locations where it can be suspended or trail from a supporting structure, such as a bed wall or hanging basket. It was not effective as a ground cover.
- *Bacopa* 'Snowflake'. These plants were evaluated for the first time and established similar to *Gibasis*. The plants were slow to spread but were attractive by the end of the growing season, especially due to their very low growth habit (1 to 2 inches) and small white flowers. The plants may have benefited from additional fertilization and will be evaluated next season with regard to fertilization and sun exposure.

2001 Perennial Garden Flower Trials at the University of Kentucky Horticulture Research Farm

Bob Anderson and Kirk Ranta, Horticulture Department

Annual and perennial garden flowers have been evaluated for many years at the University of Kentucky. Trials have occurred at the University of Kentucky Arboretum since 1993. These trials were expanded at the Horticulture Research Farm in 1999 and 2000 with grants from the Kentucky Department of Agriculture and the Kentuckiana Greenhouse Association. USDA grants for the USDA New Crop Opportunities Center allowed expansion of the trials to more than 20,000 square feet of trial gardens in Lexington. Additionally, demonstration gardens have been established at eight locations across the state (listed below). We plan to add additional demonstration gardens in other areas of the state in 2002.

The collection of perennials in our ongoing trials continues to expand. All these plants are in the plots at the Horticulture Research Farm in Lexington and were visited by growers and landscapers during our Summer Field Day on September 14. It is difficult to evaluate perennials for only one or two years. However, ratings appear to be clear after the second summer for some. In general, those that have grown well for two seasons are marked (++) and those that have not done too well (-); those unmarked need more time to determine a rating.

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

Mexican Hyssop
Agastache 'Tutti Frutti' ('01)

Arkansas Amsonia
Amsonia hubrectii ('01)

Artemisia
Artemisia absinthium 'Huntington Gardens' ('01)

Aster
Aster apellus 'Triumph' ('00-'01) (-), *Aster laevis* 'Bluebird' ('00-'01) (++), *Aster latiflorus* 'Prince' ('00-'01) (++), *Aster novi-belgii* 'Celeste' ('01), *Aster novi-belgii* 'Purple Monarch' ('01), *Aster novi-belgii* 'Snow Cushion' ('00-'01), *Aster novi-belgii* 'White Swan' ('00-'01) (++), *Aster novi-belgii* 'Winston Churchill' ('01), *Aster novi-belgii* 'Woods Purple' ('00-'01), *Aster x frikarti* 'Monch' ('00-'01), *Asteromea mongolica* ('01), *Kalimeris mongolica* 'Variegata' ('00-'01) (++)

Astilbe
Astilbe 'Sprite'

Cream False Indigo
Baptisia pendula ('01)

Willowleaf Oxeye
Buphthalum salicifolium 'Sun Wheels' ('00-'01) (-)

Feather Reed Grass
Calamagrostis acutifolia 'Karl Foerster' ('00-'01) (++)

River Oats, Northern Sea Oats
Chasmanthium latifolium (++) ('00-'01)

Garden Mums
Ajania pacificum 'Pink Ice' ('00-'01), *Chrysanthemum* 'Hillside Pink' ('01), *Chrysanthemum yezoense* ('00-'01), *Dendranthema rubellum* 'Clara Curtis' ('00-'01), *Dendranthema rubellum* 'Mary Stoker' ('00-'01)

Coreopsis
Coreopsis 'Tequila Sunrise' ('01), *Coreopsis* rosea 'American Dream' ('01), *Coreopsis verticillata* 'Moonbeam' ('00-'01) (++)
Crocosmia crocosmiifolia 'Venus' ('00-'01)

Maiden Pink
Dianthus deltoides 'Brilliant' ('01)

Cone Flower
Echinacea pallida ('00-'01), *Echinacea paradoxa* ('00-'01), *Echinacea purpurea* ('00-'01) (++), *Echinacea purpurea* 'Magnus' ('00-'01) (++), *Echinacea simulata* ('00-'01), *Echinacea tennessensis* ('00-'01) (++)

Silver Prairie Grass
Erianthus alopecuroides ('00-'01)

Oregon Fleabane
Erigeron 'Azure Fairy' ('00-'01) (-)

Hardy Ageratum
Eupatorium coelestinum ('01)

Wand Flower
Gaura lindheimeri 'Siskiyou Pink' ('01)

Cranesbill, Hardy Geranium
Geranium 'Dusky Rose' ('00-'01), *Geranium cantabrigiense* 'Blokova' ('00-'01), *Geranium cantabrigiense* 'Karmina' ('00-'01), *Geranium cinereum* 'Ballerina' ('00-'01), *Geranium clarkei* 'Kasmir Purple' ('00-'01), *Geranium maculata* 'Claridge Druce' ('00-'01), *Geranium phaeum* 'Samobor' ('00-'01)

Sneezeweed
Helenium 'Coppella' (++) ('00-'01)

Sun Rose
Helianthemum 'Annabel' ('01), *Helianthemum nummularium* 'Double Red' ('01)

Sunflower
Helianthus mollis ('00-'01)—Downy Sunflower, *Heliopsis* 'Loraine Sunshine' ('00-'01) (++)—False Sunflower

Daylily
Hemerocallis 'Stella d'Oro' ('01) (++)

Alum Root, Coral Bells
Heuchera x brizoides 'Bressingham Hybrid' ('01), *Heuchera micrantha* 'Palace Purple' (++) ('00-'01)

Garden Hibiscus
Hibiscus moscheutos 'Disco Bell Pink' ('00-'01), 'Disco White' ('00-'01), 'Kilimanjaro Red' ('01), 'Ranier Red' ('01), 'Mauna Kea' ('01), 'Etna Pink' ('01), 'Matterhorn' ('01)

Statice
Limonium latifolia ('00-'01)

Lobelia
Lobelia speciosa 'Fan Burgundy' ('01)

Maltese Cross
Lychnis coronaria 'Angel Blush' ('01), *Lychnis flos-jovis nana* 'Peggy' ('01)

Maiden Grass
Miscanthus sinensis 'Morning Light' ('01) (++)

Bee Balm
Monarda didyma 'Jacob Cline' ('01), 'Marshall's Delight' ('01)

Catmint
Nepeta 'Dawn to Dusk' ('00-'01) (++), *Nepeta* 'Subsessilis' ('00-'01) (++), *Nepeta faassenii* 'Six Hills Giant' ('00-'01) (++)

Ornamental Oregano
Origanum laevigatum 'Herrenhausen' ('01)

Fountain Grass
Pennisetum alopecuroides 'Hameln' ('01) (++)

Beard Tongue
Penstemon barbatus 'Prairie Dusk' ('01), *Penstemon digitalis* 'Husker Red' ('00-'01), *Penstemon fruticosa* 'Purple Haze' ('01)

Russian Sage
Perovskia atriplicifolia ('00-'01) (++)

Fleeceflower
Persicaria amplexicaule 'Firetail' ('01), *Persicaria bistorta* 'Superbum' ('01)

Garden Phlox
Phlox maculata 'Miss Lingard' ('00-'01) (++), 'Natasha' ('00-'01) (++)

Prairie Coneflower
Ratidiba columnifera 'Mexican Hat' ('00-'01) (++)

Black Eye Susan
Rudbeckia fulgida 'Goldsturm' ('00-'01) (++)—Cone Flower, *Rudbeckia subtomentosa* ('00-'01) (++)—Sweet Black Eye Susan, *Rudbeckia triloba* ('00-'01) (++)—Brown Eye Susan

Meadow Sage
Salvia 'Blue Hill' ('00-'01), *Salvia* 'Blue Queen' ('00-'01), *Salvia lyrata* 'Burgundy Bliss' ('00-'01), *Salvia nemorosa* 'May Night' ('00-'01) (++), *Salvia superba* 'Blue Hill' ('00-'01), *Salvia superba* 'Snow Hill' ('00-'01)

Pincushion Flower
Scabiosa caucasica 'Perfecta Alba' ('00-'01), *Scabiosa columbaria* 'Butterfly Blue' ('00-'01), *Scabiosa columbaria* 'Pink Mist' (++) ('00-'01)

Kaffir Lily
Schizostylis coccinea ('00-'01)

Sedum
Sedum spectabile 'Autumn Joy' ('00-'01) (++), *Sedum spectabile* 'Brilliant' ('00-'01), *Sedum spurium* 'Vera Jameson' ('00-'01) (++)

Meadowsweet
Spirea latifolia ('00-'01)

Stokes Aster
Stokesia laevis 'Blue Danube' ('00-'01) (-), 'Klaus Jellito' ('00-'01), 'Mary Gregory' ('00-'01) (-), 'Purple Parasols' ('00-'01), 'Silver Moon' (-) ('00-'01)

Mulleins
Verbascum 'Helen Johnson' ('00-'01), *Verbascum* 'Jackie' ('00-'01)

Speedwells
Veronica 'Fascination' ('00-'01), *Veronica* 'Giles van Hess' ('00-'01), *Veronica* 'Goodness Grows' ('00-'01), *Veronica* 'Spring Dew', *Veronica* 'Waterperry' ('01), *Veronica* 'White Jolanda' ('00-'01) (++), *Veronica alpinia* 'Alba' ('01), *Veronica austriaca* 'Crater Lake Blue'('00-'01), *Veronica longifolia* 'Sunny Border Blue' ('00-'01) (++), *Veronica peduncularis* 'Georgia Blue' ('01), *Veronica spicata* 'Icicle' ('00-'01), *Veronica spicata* 'Noah Williams' ('00-'01), *Veronica spicata* 'Red Fox' ('00-'01)

Acknowledgments

We wish to thank the staff gardeners at all our garden locations for all their help with these trials. We are pleased to work with such knowledgeable and hard-working horticulturists across the state. Please take some time next year to visit these trial and demonstration gardens:
Purchase Area Master Gardener Garden, Paducah
UK West Kentucky Research and Education Center, Princeton
Hardin County Master Gardener Garden, Elizabethtown
Louisville Zoo, Louisville
UK Arboretum, Lexington
Boone County Master Gardener Garden, Burlington
Campbell County Master Gardener Garden, Highland Heights
Pulaski County Master Gardener Garden, Somerset

Notes on Garden Flowers at the UK Arboretum

Sharon Bale and Shari Dutton, Department of Horticulture

Annuals

The following are some annual flowers that were grown for the first time at the UK Arboretum and some general favorites.

***Amaranth gangeticus* (Elephant Head Amaranth)**—Very coarse textured plant with large droopy chenille-type blooms. Plants are approximately 18 inches tall. They were quite showy in the garden until mid-August. Then the foliage appeared to be the victim of ravages by the insect world. In truth, the little yellow finches that we love so much went nuts. If you don't think birds will nibble at the foliage of a plant, believe me, it happens. This plant as well as Swiss Chard 'Bright Lights' were favorites.

***Begonia x semperflorens* 'Lotto Scarlet', 'Lotto White', 'Lotto Pink'**—Plant performance was similar to other fibrous begonias, with one exception. Blooms are significantly larger than others. A 1½-inch bloom diameter was not uncommon. This is a must for the garden next year.

***Calistephus chinensis* 'Duchess Mix', 'Compliment Mix', 'Gala Mix', 'Gala Carmine'**—Seed was not sown until early May because we were interested in bloom being produced later in the growing season. Plants bloomed in mid-August. All were uniform and had strong stems that did not require staking. All were uniform in habit, 20 to 24 inches tall. Would be an excellent addition to the home cut garden as well as making a dramatic display until mid-September. China Asters only bloom for a limited period of time and then decline rapidly. Successive plantings could extend the bloom time. These very attractive plants evoked many favorable comments.

***Cardoon gigante* (Cardoon)**—These large, exotic-looking plants were rather hidden in the bed at the walking entrance to the garden. The gray-green foliage is quite coarse and the thistle-like appearance may not appeal to everyone, but they certainly have some potential for a "different look" in the garden. If planted in full sun, purple, thistle-like blooms will be produced in late summer. Plants are spectacular as a tall specimen plant in large mixed containers. Plants can reach a height of 3 feet and an equal diameter. (May be hardy in the right location but doesn't appear to be aggressive.)

Cleome 'Linde Armstrong'—Something new in the world of Cleomes. Forget those large plants that produce an overabundance of seeds and can be a problem in the garden. 'Linde Armstrong', named for two Georgia gardeners, is vegetatively propagated. Plants are only 12 to 14 inches tall and the blooms could be described as "petite" cleomes. Light lavender-pink blooms are produced all summer. Plants are uniform, and the foliage is a dark blue green. This plant may not be able to stop traffic with a long distance show, but it is certainly worthy of praise. We definitely have to have a repeat display of this plant. It should also be tried in containers.

***Coleus x blumei* 'Giant Exhibition Palesandra'**—May be thought of as just another coleus, but the dark purple foliage is a great contrast plant for others. Plants are produced from seed. Plants average about 18 inches tall and have large foliage.

***Ipomoea batata* 'Ace of Spades'**—What? Another sweet potato!! This one has a similar color to 'Blackie', but the foliage is heart-shaped and the plants don't appear to be quite as vigorous. Still a good plant for contrast in the flower bed or container.

Lantana 'Miss Huff'—May not be just another Lantana. This plant was touted as maybe being a little more hardy than most Lantanas. I'm not ready to say it is a perennial, but *it did overwinter*. The bed was lightly tilled and verbenas planted. Then all of a sudden here comes 'Miss Huff'. The question is whether this is good or bad. Plants are robust, 3 feet tall, and bloom freely until frost. The plants will be left alone, and we'll see what happens next spring.

Nicotiana 'Sweet Scented Sylvestris'—While other nicotianas suffered after a period of wet weather, this plant is a show stopper. Plants are approximately 24 to 28 inches tall and produce a fireworks display of drooping white blooms. Plants bloomed from midsummer until September. We had a little trouble with seed germination. We need to work on our techniques because this plant is a must for next year.

***Torenia fournieri* Duchess 'Burgundy', Duchess 'Pink', Duchess 'Blue and White', Duchess 'Light Blue', Duchess 'Deep Blue'**—Uniform plants approximately 6 inches tall. Plants bloomed from the time they were planted until late September. Flowers are not that showy from a distance but are very attractive when viewed at close range. Seed pods turn a purplish color and add to the display. Seed set does not appear to hurt vigor.

***Zinnia elegans* 'Benary's Giant Mix'**—Good color mix, stem length, bloom size, and all those other things you would want from a cut and come-again flower with the exception of one little thing: All those disease problems that plague gardeners wanting cut zinnias all season are still a problem with this plant.

Canna 'Cleopatra'—Tony Avent refers to this plant as the "schizophrenic canna." He's right. A highly variable chimera, the foliage and stems are a mixture of green and purple black in random patterns. Flowers arising from green stems are yellow and those coming from the dark side are red. What a fun plant! It attracted a great deal of attention. 'Bengal Tiger' became a favorite for using in containers across campus. I believe there will be more variety next season.

Canna 'Stuttgart'—This canna is not new—it just became cheap enough for us to purchase it. Who cares about the flowers? The green and white variegated foliage is attractive enough to get your attention.

***Salvia leucantha* 'Santa Barbera' PPAF**—Although not hardy, this plant is a dwarf version of Mexican sage. Blooms don't appear until mid-September, but let's face it, the woolly blue blooms are worth waiting for even if an early frost cuts the season short.

Salvia 'Anthony Parker'—This a new plant to the garden. Generally I don't make comments regarding hardiness for several years. In the case of this plant. I think the hardiness is predictable. 'Anthony Parker' is a hybrid of *Salvia leucantha* 'Midnight' and *Salvia elegans*, pineapple sage. Since neither parent is hardy, there is no reason to expect this plant to be hardy. Like its parents, the plant blooms late in the season. One plant can make a statement. Plants are approximately 3 feet tall with a spread of 3 feet. Blooms are deep blue, not as woolly looking as *S. leucantha* but still very showy.

All-America selections results: Yes, there are some nice plants that are designated as winners. Unfortunately, according to AAS rules, no information can be released to the public until September 2002. Call me next September, and I'll tell you what I think.

Perennials

Verbenas—When you try to push the hardiness envelope, sometimes things just don't work out. The only verbena that made it through last winter was *Verbena peruviana*. We even lost 98 percent of verbena 'Homestead', which had been hardy in the garden for years. 'Lilac Time', 'Appleblossom', 'Fiesta', *V. canadensis*, and 'Blue Princess' still have a place in the garden. If they overwinter, consider it a bonus. The year that 'Lilac Time' was in full bloom on April 15 is enough to keep the plants in consideration.

Salvias—Whatever ugly weather caused the demise of the verbenas created problems for the salvias as well. Salvia 'Big Pink', *Salvia uglinosa* spread like crazy, Salvia 'Black and Blue' had no trouble, but all the others with the exception of *Salvia koyamae* didn't make it. *Salvia koyamae* is a strange plant. It produces a rosette of woolly grey foliage. Most people would never guess that this is a salvia. The plants are supposed to be biennial and die after they bloom. This plant bloomed this year and it was something. A tall spike of white flowers appeared in midsummer. The plant is still there—who knows what will happen next?

Information from Other Locations

Lavenders—Questions from home gardeners as well as those interested in alternative crops such as lavender prompted the decision to plant a variety of lavenders for evaluation. A large replicated plot was established on a farm outside Bloomfield, Kentucky, and a smaller, non-replicated plot was established at the Horticulture Research Farm in Lexington. The following plants were included at these two locations:

Lavandula stoeches pedunculata
Lavandula heterophylla
Lavandula dentata 'Green Fringed', 'Goodwin's Creek'
Lavandula angustifolia 'Fred Boutin', 'Jean Davis', 'Hidcote', 'Martha Roderick'

Lavandins—Lavandins are hybrids of English lavender, *Lavandula angustifolia x* longer stem spike lavender *Lavandula latifolia* which results in sterile hybrids, Lavandula x intermedia.

Lavandula x intermedia 'Provence' was included in both plots. *Lavandula x intermedia* 'Grosso' was grown at the UK Arboretum.

Lavandula angustifolia 'Jean Davis' was the only cultivar that survived the winter of 2000-2001. Kentucky soils and weather conditions just aren't the best complement to lavenders.

Hydrangeas—Project in cooperation with Dr. Terry Jones, Dr. Bob McNiel, and Dr. Win Dunwell with assistance from Darrell Sloane, Shari Dutton, and Mort Turner.

Plants are primarily being evaluated for their potential as cut stems for the florist trade. General garden performance is also being considered.

Hydrangea macrophylla—Why won't my hydrangea bloom? The answer to this question is not an easy one. For years it was thought that these hydrangeas bloomed on old wood. If they are all killed back to the ground in Kentucky, then why do some people have *Hydrangea macrophyllas* that bloom? Well, they don't all bloom on old wood. Some are considered remonatant hydrangeas and will develop buds on new growth. We aren't the only states looking at hydrangeas. Georgia and North Carolina have extensive trials. The bottom line seems to be: Plant as many cultivars as you can find and see what happens. So far the following cultivars have at least produced some blooms: *Hydrangea macrophylla* 'All Summer Beauty', 'Alpenglow', 'Blue Billow', 'Coerula Lace', 'Domotoi', 'Goliath', 'Heinrich Seidel' (Glory of Aalsmeer), 'Madame Faustin Travouillon', 'Merritt Supreme', 'Nikko Blue', 'Pia' (Pink Elf), 'Pink Beauty', and 'Teller White'. It appears that plant maturity may also be a factor. We are continuing to add new cultivars to the trial as they become available.

Hydrangea paniculata—The following cultivars are planted in replicated plots at Quicksand, Kentucky, and Princeton, Kentucky: 'Pink Diamond', 'Pee Wee', 'Boskoop', and 'Tardiva'. These plants do have potential for the commercial cut flower market because they are available from the Holland market. These four cultivars offer a range of bloom time that could provide cut material from late July until September. Bloom quality, stem length, and number of stems per plant are not a problem. These are easy to grow and seem to have few if any problems. The key is the ability to ship. If Holland can ship them to the United States, it can be done. We need further work on vase life and conditioning procedures necessary to get this product through the shipping chain. Of course, the ability to market the product is also a consideration.

Hydrangeas for Cut Flowers: Two Years of Bloom Date Observations

Winston Dunwell, Dwight Wolfe, and June Johnston, Department of Horticulture

Nature of Work

This work is a continuation of work previously reported on cut-flower hydrangeas. Hydrangeas were planted into a cut-flower trial in April of 1998. The plants were spaced at 12 feet between rows and 10 feet between plants in the row. All plants were cut back as part of a dried-flower harvest in October 2001. Irrigation was provided to eight replications of six cultivars. Twelve replications of nine cultivars are in a nonirrigated plot Throughout the growing season the plots were observed weekly to record the date of first bloom. Date of bloom can be compared as irrigated versus nonirrigated and to the first season's (1998) bloom date in the irrigated plots (Table 1).

Results and Discussion

H. paniculata 'Kyushu' had four replications of eight that did not bloom until 10 September 2001. As there were no blooms on *Hydrangea quercifolia* 'Alice', it will not be cut back this year. *Hydrangea quercifolia* will be a two-year production cycle.

Table 1. Hydrangea 1998 and 2001 dates of bloom.

Irrigated Cultivar	Date of First Bloom 2001	Non-irrigated Cultivar	Date of First Bloom
Hydrangea aborescens 'Annabelle'	not in plot	*Hydrangea aborescens* 'Annabelle'	25Jul01 (08Jun98)
Hydrangea quercifolia 'Alice'	no bloom	*Hydrangea quercifolia* 'Alice'	no bloom
Hydrangea paniculata 'Boskoop'	not in plot	*Hydrangea paniculata* 'Boskoop'	25Jul01 (26Jun98)
Hydrangea paniculata 'Kyushu'	17Aug01	*Hydrangea paniculata* 'Kyushu'	27Aug01 (19Jun98)
Hydrangea paniculata 'Pee Wee'	not in plot	*Hydrangea paniculata* 'Pee Wee'	25Jul01 (14Jul98)
Hydrangea paniculata 'Pink Diamond'	25Jul01	*Hydrangea paniculata* 'Pink Diamond	25Jul01 (14Jul98)
Hydrangea paniculata 'Tardiva'	30Jul01	*Hydrangea paniculata* 'Tardiva'	6Aug01 (14Jul98)
Hydrangea paniculata 'Unique'	25Jul01	*Hydrangea paniculata* 'Unique'	25Jul01 (14Jun98)
Hydrangea paniculata 'White Moth'	10Sep01	*Hydrangea paniculata* White Moth'	25Sep01 (no bloom)

[1] Averages calculated using 11 plants.

Buddleia Cultivar Landscape Evaluation

Winston Dunwell and Paul Cappiello,[1] Department of Horticulture

Nature of Work

The second-year evaluation of 40 *Buddleia* species and cultivars has been completed at the nursery at the UK Research and Education Center at Princeton for the 2001 growing season. Buddleia, or butterfly bush, is an attractive, long-flowering shrub known for its long spike flowers that attract butterflies. Plants grown from cuttings and averaging 6 to 8 inches tall were planted 27 April 2000 on a 5-foot spacing in the row and between rows.

Results and Discussion

The date of first bloom was recorded for all cultivars. The survival of the cultivars is an ongoing part of the evaluation.

The plants have grown into each other and filled the 5-foot spacing. It would be recommended that spacing between plants be increased. The purple flowers of *B. yunnanensis* did not start blooming until 5 September 2001, but as stated in the 2000 report, stems with silver gray pubescent foliage and flower heads with some purple color, in September, have potential as cut stems and dried flowers.

Significance to the Industry

The long season of flowering makes Buddleia an attractive landscape plant. It has been speculated that there is interest in new and underutilized Buddleia cultivars for use in landscapes and butterfly gardens. Buddleias make good cut flowers. Following being cut to the ground, they will throw straight stems with multiple flowers on each. Future evaluations will be increased to include an additional 42 cultivars.

Table 1. *Buddleia* spread and height measurements.[2]

Species/Cultivar	Time of Bloom	Species/Cultivar	Time of Bloom
'Pink Delight'	5Jul01	'Flaming Violet'	5Jul01
'Fair Maiden'	5Jul01	'Golden Glow'	dead
'Deep Lavender'	5Jul01	'Orchid'	5Jul01
'Pink Charmer'	10Jul01	'Fascination'	5Jul01
'Centennial Purple'	10Jul01	'Lavender Beauty'	5Jul01
B. longifolia	dead	'Fascinating'	5Jul01
B. salvifolia	dead	*B. hemsleyana*	13Jul01
'Windy Hill Farm'	29Jun01	'Harlequin'	10Jul01
'Lavender Ice Cream'	6Aug01	'Dudley White'	10Jul01
'Hever Castle'	2Aug01	'Black Knight'	29Jun01
'Excellent Blue'	dead	'Dubonnet'	29Jun01
B. x *weyeriana* 'Sungold'	29Jun01	'Morgaine'	29Jun01
'Royal Red'	5Jul01	'Nano White'	10Jul01
'White Cloud'	10Jul01	*B. japonica*	dead
B. lindleyana 'Gloster'	30Jul01	*B. yunnanensis*	5Sep01
'Honeycomb' x *B. lindleyana*	30Jul01	'Ile de France'	29Jun01
'Ellen's Blue'	dead	'Golden Crown'	dead
'Honeycomb' x *B. lindleyana*	30Jul01	'Niche's Choice'	29Jun01
'White Bouquet'	dead	'Compact Lavender'	dead
'Fortune'	10Jul01	'Nano Indigo'	17Aug01

[1]Appreciation is expressed to Dwight Wolfe, June Johnston, and Hilda Rogers for assistance with this project.

[2] Names listed with cultivar name only are *Buddleia davidii.*

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

The UK Nursery/Landscape Fund was initiated in 1993 to provide 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. Many industry personnel recognized that a dependable, consistent supply of support funds would allow faculty to increase research and education programs addressing industry needs. Such an investment by the industry is wise and essential.

The majority of UK Nursery/Landscape Fund support has been utilized for student labor and specialized materials and equipment. These investments have allowed us to initiate new research and to collect more in-depth data.

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 committed to contribute 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 goal of the initial advisory committee was to develop the level of annual giving so that we could endow a fund from which the interest could be used to support this program. That goal became a reality in 1999-2000 with the encouragement of a state match, dollar for dollar, of private contributions to support research at the university. The Research Challenge Trust Fund was created by the Kentucky General Assembly at the recommendation of Governor Patton to assist UK in reaching the goal of becoming a top-20 public research institution by 2020. This program was funded again in the General Assembly for 2000-2001. The minimum amount to be matched in this phase of the program was increased to $50,000, committed over five years. The state funds for this match will go fast, and we must move quickly with any additional endowment contributions this winter and spring.

Endowments to Support Nursery/Landscape Research at the University of Kentucky

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 that will total more than $250,000 within five years have been established at the University of Kentucky to support nursery and landscape research through the Department of Horticulture.

Named endowments were established by a minimum of $25,000 commitment over five years. The 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 cash and pledges over three years totaling $34,000, which was matched with state funds. These funds were provided by continuing Fellows-level commitments redirected to the endowment and several one-time contributions.

UK Nursery/Landscape Advisory Committee

The UK Nursery/Landscape Advisory Committee consists of contributors to the fund and advises the chair of the UK Horticulture Department on the use of available funds to benefit the industry through research and education and assists in the continued development of the fund. Those individuals and companies contributing to the UK Landscape Fund in 2001 (through December 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.

Summary

The contributions of these industry leaders and the matching state funds will result in a family of endowments approaching a quarter of a million dollars within three years. Through the generosity and commitment of these leaders, we were able to take advantage of available state funds to make a real and lasting impact on our ability to serve the industry. Annual contributions will continue to be an important mechanism for industry to support this program. Without industry support, it is simply not possible for us to provide the quality research, extension, and teaching programs we all want.

The Research Challenge Trust Fund, which provides the 1:1 match for endowments to support research at UK, is the greatest opportunity afforded the industry to develop long-term support for the programs designed to support the industry. As was true last year, it is possible for several individuals and companies to pool their commitments to be contributed over the next five years to reach the $50,000 minimum required for the 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

Lillie M. Lillard and Noble Lillard (In Memoriam)
Lillard's Nursery

Daniel S.* Gardiner
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Daniel S.* and Saundra G. Gardiner
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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*

2001 Contributors to the UK Nursery/Landscape Fund and Endowments (through December 1)

Associates (> $500)
Mike Ray, Carl Ray Landscape

100 Club ($$100)
Gary A. Davis, Lawn Tamers
Bill Henkel, Henkel Denmark Inc.
Steve King, Kings Gardens
Clinton Korfhage, Clinton Korfhage Nursery Inc.
Robert Rollins, Greenhaven Inc.
Rudy Volz, R.L. Volz Landscaping & Nursery

Donor (< $100)
Anthony Aulbach
David Cornett
Michael Fugate
William C. Gardener II
Dr. Dewayne Ingram
Bob Osborne, Earl Thienemen's Greenhouse and Nursery
Elvin G. Thacker

Industry Organizations
Kentucky Nursery and Landscape Association

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