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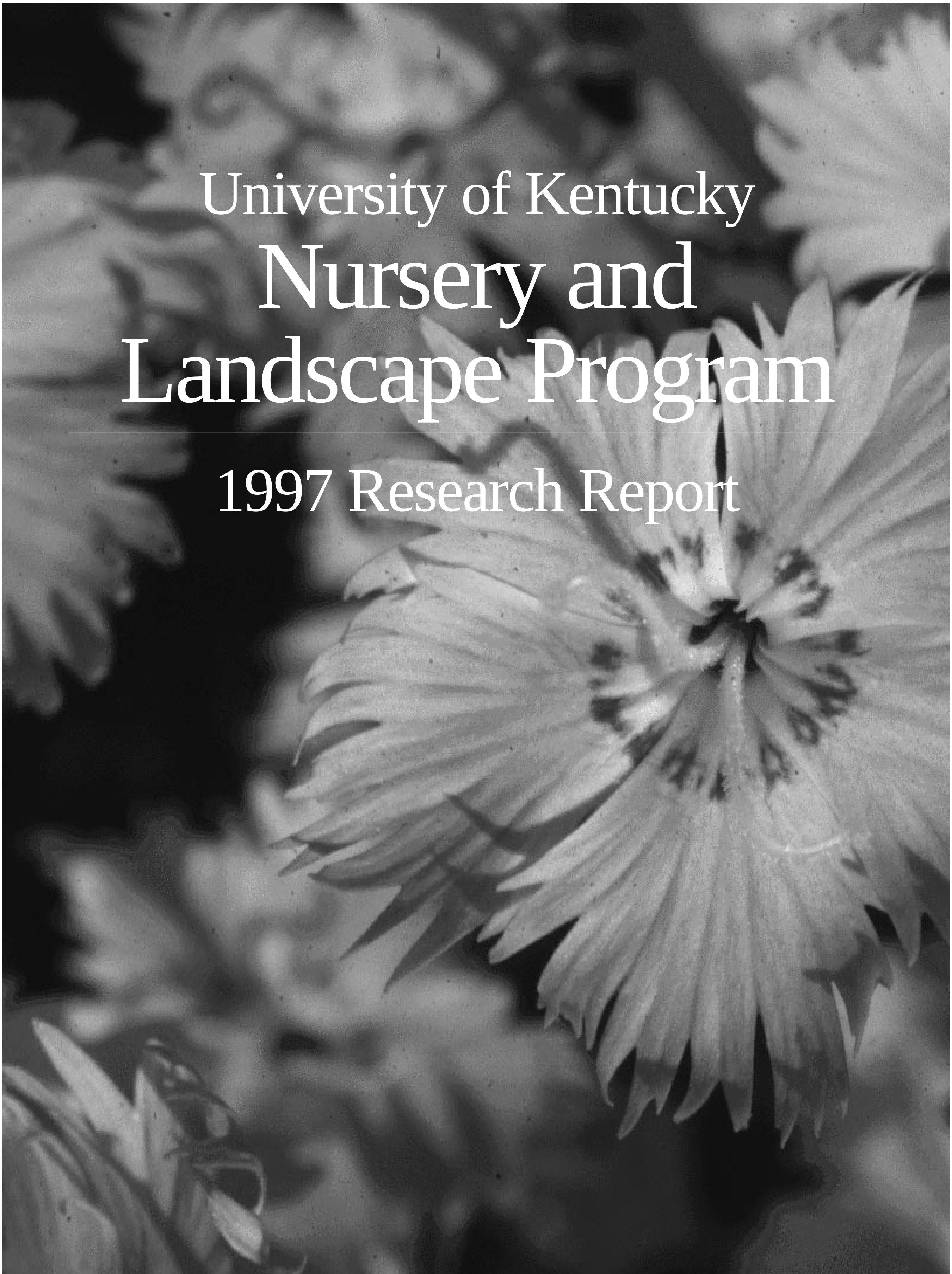
University of Kentucky Nursery and Landscape Program

1997 Research Report



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

UK Nursery and Landscape Program

Faculty, Staff, and Student Cooperators

ABOUT OUR COVER

Dianthus gratianopolitanus 'Bath's Pink' is one of the Theodore Klein Plant Award winners for 1999. 'Bath's Pink' is a cheddar pink that was divided and distributed by Jane Bath. 'Bath's Pink', one of the best of the pink flowering cultivars, has excellent foliage that forms a year-round thick ground cover. Theodore Klein Plant Award Winners are selected by plant professionals for unique ornamental characteristics and the ability to successfully perform in Kentucky.

Horticulture and Landscape Architecture

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1997 UK Nursery and Landscape Program Overview

Dewayne Ingram, Chairperson
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We are pleased to offer this 1997 research report as a means of sharing information generated from the UK nursery and landscape research program. Many faculty, staff, and students from several departments have contributed to this effort. The primary areas of emphasis reported here include 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, do not hesitate to contact us.

Although the purpose of this publication is to report research results, we have included 1997 highlights of our Extension program and undergraduate and graduate degree programs addressing the needs of the nursery and landscape industries.

Extension Highlights

In addition to the more visible activities, such as the state and area educational programs, the nursery and landscape Extension program addresses the needs of the commercial industry and consumers of our products and services in more subtle ways. We provide training for county Extension agents so they can more effectively serve our clientele. Publications, videos, slide sets, newsletters, articles in state and national industry magazines, newspaper articles, radio spots, and television programs are important elements of our Extension program. Other activities include the Plant Disease Diagnostic Clinic, soil testing and interpretative services, and problem diagnosis and solving services. The outreach capacity of the Arboretum on the UK campus increases each year. Although there are many facets to the Extension program conducted by the team of subject matter specialists and county agents, two examples are offered here.

Plant Disease Diagnostic Clinic

The Plant Disease Diagnostic Clinic is an educational component of the UK College of Agriculture, which is staffed by the College's plant pathology department. With a very heavy load of 4,000 plant specimens annually, it is regarded as one of the top laboratories of its kind in the country. Branches of the laboratory are located on the UK campus in Lexington and at the West Kentucky Research and Educational Center in Princeton. The plant pathologists who run the laboratory diagnose diseases of all types of plants and are supervised by four UK faculty members. They are also backed up by appropriate UK entomologists, horticulturists, and agronomists as needed. The laboratory is intended to complement the educational mission of these faculty members. The Clinic does not provide a diagnostic service; it provides educational information that reinforces state and county Extension programs. Samples are submitted through the county Extension offices, and the diagnostic responses go back to the client and the county Extension agent. The responses not only educate growers and clients on the state of their specific plant specimens, but the results also educate the county agent who in turn extends the information to other clients.

Newsletters—An Avenue for Rapid Information Dissemination

The Extension faculty in the nursery and landscape program utilize several newsletters to disseminate timely and important information to the nursery and landscape industries and the gardening public. The *Green Thumb* has been published at least six times annually for the last 21 years by Dr. Mary Witt, who retired in September. This newsletter contains original contributions by our faculty and is designed to increase the knowledge, skills, and successes of the gardening public. A larger number of enthusiastic and discriminating consumers mean a larger market for the commercial nursery and landscape industries. We also publish the *Kentucky Pest News* and the *HortNews* in hard copy and electronic formats for commercial clientele. Articles are routinely published in state industry newsletters and magazines, such as *Kentucky Nursery News and Views* and *The Kentucky Arborist*, and in national outlets, such as the *American Nurserymen* and the *Southern Nurserymen's Association Research Conference Proceedings*.

Undergraduate Program Highlights

We offer areas of emphasis in horticultural enterprise management and horticultural science within a plant and soil science Bachelor of Science degree. Here are a few highlights of our program in 1997:

- The plant and soil science degree program has more than 125 students in the 1997 fall semester, of which almost $^1/_2$ are horticulture students and another $^1/_3$ are turfgrass students.
- We believe that a significant portion of an 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. Opportunities in 1997 included (1) a 4-week study tour of western Europe led by Drs. McNiel and Geneve; competition in Dallas, Texas, by the Associated Landscape Contractors of America (ALCA) Team, (Dr. Robert McNiel, faculty advisor); (3) two industry tours: horticulture enterprises and gardens between Kentucky and

Texas (March) and greenhouse and nursery enterprises in Kentucky (November).

- Undergraduate and graduate students presented research results at the Southern Nurserymen Association's Research Conference, the Eastern Region International Plant Propagators' Society, and the American Society for Horticultural Science.
- Students accompanied faculty to regional, national, and international meetings. These included the American Society for Horticultural Science Annual Conference; Kentucky Landscape Industries Conference and Trade Show; Garden Centers of America, National Landscape Association Management Clinic; International Floriculture Short Course; Southern Nurserymen Association Trade Show; and Eastern Region International Plant Propagators' Society.

Graduate Program Highlights

The demand for graduates with a M.S. or Ph.D. in horticulture, entomology, plant pathology, agricultural economics, and agricultural engineering is high. Our M.S. graduates are employed in industry, the Cooperative Extension service, secondary and post-secondary education, and governmental agencies. Last year, there were 13 graduate students in these degree programs conducting research directly related to the Kentucky nursery and landscape industry.

The Influence of Ontological Age on Adventitious Bud and Shoot Formation in North-American Pawpaw Nodal Explants

Cindy Finneseth, Desmond Layne, and Robert Geneve
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Nature of Work

Current clonal propagation methods for the North-American pawpaw (*Asimina triloba* L. Dunal) are limited to budding and grafting techniques (5). No work has been published detailing a micropropagation system for the pawpaw, but Callaway (1) indicated limited success in regenerating shoots using leaf tissue. Successful micropropagation systems have been developed for related *Annona* species (2).

The ease with which a plant can be established in culture is often a direct result of ontogenetic age. Ontogenetic maturity is reached when a plant obtains the ability to flower, but for many species the maturation process is accompanied by a reduction in juvenile characteristics making mature source explants more difficult to stabilize in culture than juvenile source explants (3).

The objective of this research was to observe the effect of ontological age on adventitious bud and shoot development of pawpaw nodal explants in culture. Explants from a juvenile source (seedlings), mature sources (forced stems), and from shoots produced on root pieces were used to study the effect of ontogenetic age during the establishment phase.

Stratified seeds were germinated in a 25 C growth chamber. Approximately 12 weeks after planting, seedlings had 6 to 10 nodes. Mature wood explants were obtained from dormant stems (10 to 40 cm in length) collected from 26 genetically different mature, flowering trees. Stems were forced in beakers in a 25 C growth chamber. After 6 weeks, shoots had expanded to $\geq$10 cm**.** Explants were also obtained from shoots produced on root pieces. Root pieces ($\geq$5 mm diameter, 10 to 12 cm length) were obtained from mature trees. Shoots were forced on root pieces kept in a 22 C greenhouse, and after 20 weeks shoots had expanded to   10 cm.

Single node explants were excised from each source, washed, and surface disinfested. After rinsing, single explants (1 to 3 cm) were inserted vertically and cultured on 20 ml of MS medium supplemented with 10 μM BA and 0.1 μM TDZ in 25- by 150-mm test tubes closed with polypropylene caps. Medium pH had been adjusted to 5.8 ± 0.1 before autoclaving and solidified with 6 percent Bacto-agar (Difco Laboratories, Detriot, MI). Culture tubes were kept in racks on shelves in a culture room under 16 hrs of 20 mol sec^{-1} m^{-2} of light provided by cool, white fluorescent bulbs. Culture room temperature was 25 C.

Explant transfer and data evaluation occurred at 2-week intervals, and the percentage of explants with elongating axillary shoots was recorded. Axillary shoots were determined as the number of shoots (> 2 mm in length) arising from a leaf axil. Formation of adventitious buds (<0.5 cm) and shoots (0.5 cm) was also recorded at each transfer interval**.** Adventitious buds and shoots were determined as buds and shoots arising at any location on the explant other than in a leaf axil.

Results and Discussion

Within 4 weeks, 60 percent of the seedling explants had expanded axillary buds (Table 1), but no axillary bud elongation was observed on explants from mature stems or shoots from root cuttings. After 6 weeks in culture, 72 percent of the seedling explants had expanded axillary buds, and 88 percent of the expanded shoots ($\geq$3 cm) were suitable for subculture (data not shown). At 8 weeks, axillary buds elongated on all seedling nodal explants, and multiple adventitious buds and shoots formed. At this same time, axillary shoot elongation occurred in 42 percent of the explants from shoots produced on root cuttings. Mature source explants had no axillary shoot elongation or adventitious bud formation, and many explants darkened in culture. Adventitious bud or shoot formation was not observed on explants from shoots produced on root cuttings or explants from mature stems. Mature source explants were maintained in culture, and after nearly 7 months, axillary bud expansion occurred in 4 percent of the explants (data not shown).

The effect of ontogenetic age on explant performance was seen with the inability of explants from the 26 mature sources to respond in culture. Of the 551 mature explants, 72 percent were successfully disinfested, but only 4 percent survived in the culture environment. Most of the mature explants turned black and lost tissue integrity. Only the small percentage of explants from mature sources that survived showed some axillary tissue proliferation after approximately 7 months in culture. Shoots produced on root cuttings did not respond as rapidly or at the high percentages of the seedling explants, but the explants did respond in culture. Seedling explants, an ontologically juvenile source, responded rapidly *in vitro*.

Discoloration of the medium was observed for all explant sources. Explant exudation caused a reddish-brown discoloration of the medium at the basal end of the explants. However, the apical portion of most explants appeared healthy. Explant exudation has been documented in many species, including other Annonaceae members, and has been attributed to phenolics and polyphenoloxidase in the medium (4).

Significance to Industry

Although tissue from mature sources is difficult to establish in culture, this study indicates that a successful micropropagation system can be developed for pawpaw. The ontological age of the explants must be considered. When using explants from mature sources, additional time is required to induce explant responses. In addition, shoots produced on pawpaw root cuttings provide an alternative explant source for tissue culture studies. Seedling tissue can be used for preliminary dose response, rooting, and acclimatization studies and is quickly and easily obtained at any time of the year. This study provides preliminary information about the effect of ontological age on establishment of explants, but additional research is needed addressing the subsequent stages of micropropagation in developing a system for the North-American pawpaw.

Table 1. Percentage of North-American pawpaw (*Asimina triloba*) explants showing axillary bud elongation of seedling, shoot produced from root, and mature source nodal explants after 4, 6, and 8 weeks of culture on an MS medium with 10 μM BA and 0.1 μM TDZ

	Weeks in Culture		
Explant Source	**4**	**6**	**8**
Seedling (n=25)	60 %	72 %	100 %
Root shoot (n=42)	0	0	42
Mature (n=551)	0	0	0

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The Effect of Early Radicle Pruning on Root and Shoot Development in Cherrybark Oak and Swamp White Oak Seedlings

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Nature of Work

Oak species are a popular and useful ornamental in home and commercial landscapes. There is a need for growers to produce oaks efficiently and quickly. Oaks possess dominant tap roots that can grow in circles when produced in containers (2). The capability to produce a vigorous root system is needed to support vigorous shoot growth and leaf area expansion (1).

The objective of this study was to determine if removing the radicle tip could induce new lateral root growth at the point of pruning and produce a more fibrous root system. Two species of oaks with notable differences in growth patterns were compared to observe if radicle pruning induced root regeneration in a species-dependent manner. Swamp white oak acorns (*Quercus bicolor*) were collected and directly sown into flats containing MetroMix 360 (Scott's) and put under greenhouse conditions to germinate. Cherrybark oak acorns (*Quercus falcata pogodifolia*) were collected and stratified in the refrigerator (5 C) for 4 months before planting in a medium of MetroMix 360 (Scott's). Red oak acorns were also placed under standard greenhouse conditions to germinate.

After germination, radicles were measured and grouped according to length (cm) for both species. The tips were removed from radicles measuring to 4, 7, and 10 cm. Uncut radicles of the same corresponding length served as controls. Acorns were replanted in 12-inch Anderson-band containers and placed back in the greenhouse under standard conditions. Overhead irrigation was applied as needed with Peter's 15-5-15 fertilizer in solution at 200 ppm. Both species were evaluated for root dry weight, shoot dry weight, shoot height, and number of new-branched roots at the cut surface and leaf area. Samples for each treatment ranged from 4 to 8 plants.

Results and Discussion

Swamp white oak increased in leaf area, shoot height, and dry weight when radicles were pruned to 7 and 4 cm compared with their uncut controls of the same length (Table 1). Root dry weight decreased suggesting that the tap root was not as prominent and that a more branched root system was produced. Radicles pruned to 10 cm showed no improvement when compared with the control.

Cherrybark oak increased in leaf area, shoot height, and shoot dry weight with the radicle tips removed at 10 and 7 cm (Table 1). Root dry weight also decreased in a manner similar to the white species. Radicles pruned to 4 cm showed no significant increase in measurements.

Removing the radicle tip increased shoot biomass and substantially reduced the root-to-shoot ratio especially in the swamp white oaks (Table 2). This reflected a reduction in tap root size in favor of a more branched root system. This type of root structure could be capable of further regeneration producing a better quality transplant (3).

Swamp white oak and cherrybark oak reacted differently to the pruning treatments. The swamp white oak responded to the removal of the radicle tip more than the cherrybark oak (Table 3). A larger number of branched roots were formed at the removal point on the swamp white oaks compared with the cherrybark oaks. This suggests that the impact of radicle pruning was species dependant.

Significance to Industry

Pruning the radicle tip increased root regeneration, especially in the swamp white oak. These preliminary data suggest that treatments to remove the radicle (i.e., physical removal, copper treatment, or air pruning) could be effective tools for producing container-grown oak liners with a more fibrous root system.

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Table 1. Biomass in two oak species after removal of the radicle tip at 10, 7, or 4 cm

Swamp White Oak		Leaf Area (cm^2)	Shoot Dry Weight (grams)	Shoot Height (cm)	Root Dry Weight (grams)
10 cm	Intact	761.0	6.7	30.0	4.7
	Removed	525.9	4.5	24.0	2.6
7 cm	Intact	344.5	3.3	17.3	3.3
	Removed	538.9	5.0	30.0	2.6
4 cm	Intact	460.0	4.6	21.3	3.7
	Removed	644.9	6.7	31.5	3.4
Cherrybark Oak					
10 cm	Intact	350.7	3.4	31.0	2.3
	Removed	538.0	4.9	32.3	1.9
7 cm	Intact	305.7	3.2	28.3	1.8
	Removed	460.0	4.4	31.0	2.3
4 cm	Intact	543.4	4.5	32.3	1.8
	Removed	331.3	2.9	30.8	1.5

Table 2. Branch root formation at the site of tip removal in two oak species cut at 10, 7, or 4 cm

		Number of Branch Roots	
Treatment		Swamp White Oak	Cherrybark Oak
10 cm	Intact	0.70	0.68
	Removed	0.58	0.39
7 cm	Intact	1.0	0.56
	Removed	0.52	0.52
4 cm	Intact	0.80	0.40
	Removed	0.51	0.52

Table 3. Branch root formation at the site of tip removal in two oak species cut at 10, 7, or 4 cm

	Number of Branch Roots	
Treatment	Swamp White Oak	Cherrybark Oak
10 cm	5.7	4.0
7 cm	9.0	2.7
4 cm	8.3	3.3

Eastern Redbud (*Cercis canadensis*) Toxicity with Increasing Rates of Sulfentrazone

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Nature of Work

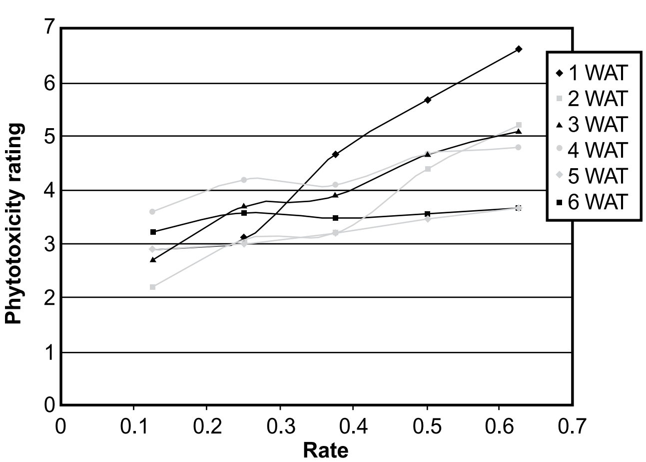
Sulfentrazone, an experimental herbicide from the FMC Corporation, has shown promising results for long-term weed control in field trials with ornamentals by controlling weeds, such as morning glory and yellow nut sedge, that are difficult to manage with currently labeled products (1). This compound has recently been labeled for use in both soybeans and tobacco. A possible hindrance to the labeling of sulfentrazone for use in ornamentals is the phytotoxicity that occurs in certain sensitive ornamental species.

Sulfentrazone works by inhibiting protoporphyrinogen oxidase in the chlorophyll biosynthetic pathway in susceptible plants. As a result, a phytodynamic toxicant (protoporphyrin IX) builds up, leading to membrane disruption. Sulfentrazone is absorbed by both the roots and shoots of plants, which turn necrotic and die shortly after exposure to light. Postemergence application of sulfentrazone, resulting in foliar contact of weeds, can cause rapid dessication and necrosis in affected species, particularly smaller ones (2,3).

In a field trial using sulfentrazone during 1996, eastern redbud *(Cercis canadensis)* exhibited foliar damage, but phytotoxicity ratings were not noted because the damage resembled Botryosphaeria canker, a common disease of redbuds in this area. After much discussion about that trial, an experiment was designed to determine if sulfentrazone had detrimental effects on *C. canadensis* and if increasing rates were related to increased phytotoxicity.

C. canadensis liners measuring 18 to 24 inches were planted in 3-gallon containers in April 1997 using a medium consisting of pine bark and expanded shale (2:1 by volume). The plants were allowed to leaf out completely and establish new roots. Sulfentrazone 80 wettable powder (WP) was applied in May 1997 at increasing rates for a total of 6 treatments (0.125, 0.25, 0.375, 0.5, and 0.625 lb active ingredient per acre (AIA), plus a control). Ten single plants were used for each treatment, arranged in a completely randomized design of 60 plants. Plants were watered using trickle irrigation. Treatments were applied using a CO_2 pressurized backpack sprayer calibrated to 26 GPA using 8004 nozzles at 30 lbs psi at the boom. Plant phytotoxicity ratings were taken weekly after herbicide application, measured on a scale from 0 to 10 (0 representing no phytotoxicity and 10 representing plant death). Plants were harvested 6 weeks after treatment (WAT). At that time, a visual root rating was taken using a scale numbered 0 to 10 (0 representing no root damage compared with the control and 10 representing plant death). Shoot and root dry weights were determined after drying for 2 days in a 40 C oven.

Figure 1. Sulfentrazone Toxicity on *Ceris canadensis*.



Results and Discussion

Phytotoxicity ratings are reported in Table 1 and Figure 1. Phytotoxicity appeared as a reddish-brown necrotic area around the leaf margin, eventually spreading throughout the whole leaf. A more severe form of phytotoxicity was exhibited as current season stem death in some plants. At 1 WAT, phytotoxicity increased with increasing sulfentrazone rates as expected. At 2 WAT, we observed increasing phytotoxicity with increasing rates, but this response was not as linear or exponential with increasing rate. This phenomenon occurred because the more severely damaged plants were producing new growth that was undamaged, while the plants that initially had less damage were exhibiting increasing toxicity. By 4 WAT, response was similar among all treatment combinations, with a difference of only 1.2 between the lowest and highest rates. The higher rates had a considerable amount of new growth by this time, thereby negating some of the initial negative effects of sulfentrazone. An explanation for the continued decline of the plants sprayed with lower rates could be that the higher rate effects were initially so severe that the stressed plant temporarily shut down growth and translocation processes, no longer absorbing the herbicide, while the plants sprayed with lower rates continued to absorb the herbicide readily, allowing continued translocation throughout the plant. By 5 and 6 WAT, there were no significant differences among the rates of sulfentrazone. The phytotoxicity ratings from visual analysis were slightly higher at 6 WAT, due to abnormal growth noticed on the new leaves of plants in all treatments, indicating sulfentrazone phytotoxicity persisted 6 weeks after treatment.

At 6 WAT, plants were harvested, and a visual root rating was given to each plant (Table 2). Roots were then separated from shoots and placed in a drying oven for 2 days. At this time, root and shoot dry weights were measured in grams (Table

2). The visual root rating increased with increasing sulfentrazone rates, but dropped at the highest rate. The shoot dry weight followed a similar trend, decreasing with increasing sulfentrazone rates, but increased again at the highest rate. These observations could be attributed to the fact that the plants sprayed with the highest rate of sulfentrazone started to show new growth earliest after the initial treatment and had the most time to regenerate. The root dry weights showed no significant difference among sulfentrazone treatments, although there were differences visually. Future experiments could utilize more replications to evaluate treatment effects.

Significance to Industry

Sulfentrazone, an experimental herbicide by the FMC Corporation, shows promise for long-term weed control in ornamentals. However, the phytotoxicity it causes in some plants is a hindrance to labeling for use on ornamentals. Continued research on the phytotoxicity of sulfentrazone could eventually lead to the release of a dependable, long-term herbicide with low toxicity for use in the nursery industry.

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Table 1. Phytotoxicity ratings (means)

Treatment	Rate	1 WAT	2 WAT	3 WAT	4 WAT	5 WAT	6 WAT
Sulfentrazone 80 WP	0.125	2.9 c	2.2 c	2.7 c	3.6 b	2.9 a	3.2 a
Sulfentrazone 80 WP	0.250	3.1 c	3.1 c	3.7 bc	4.2 ab	3.0 a	3.6 a
Sulfentrazone 80 WP	0.375	4.7 b	3.2 bc	3.9 abc	4.1 ab	3.2 a	3.5 a
Sulfentrazone 80 WP	0.500	5.7 ab	4.4 ab	4.7 ab	4.7 a	3.5 a	3.6 a
Sulfentrazone 80WP	0.625	6.6 a	5.2 a	5.1 a	4.8 a	3.7 a	3.7 a
Control	0.000	0.0 d	0.0 d	0.0 d	0.0 c	0.0 b	0.0 b
LSD at p <0.05	—	1.54	1.29	1.28	0.95	1.04	0.92

Means in a column followed by the same letter are not significantly different by the Waller-Duncan K-ratio T test (k = 100, p = 0.05).
WAT = weeks after treetment.
WP = wettable powder.

Table 2. Root and shoot evaluation (means)

Treatment	Rate	Root Rating	Root Dry Weight (grams)	Shoot Dry Weight (grams)
Sulfentrazone 80 WP	0.125	5.4 c	7.86 b	13.76 ab
Sulfentrazone 80 WP	0.250	6.0 bc	7.86 b	11.19 bc
Sulfentrazone 80 WP	0.375	7.3 ab	4.65 b	7.85 cd
Sulfentrazone 80 WP	0.500	7.7 a	3.88 b	6.02 d
Sulfentrazone 80 WP	0.625	6.4 abc	6.75 b	9.17 bcd
Control	0.000	0.0 d	13.88 a	17.97 a
LSD at P <0.05	-	1.64	4.40	4.87

Means in a column followed by the same letter are not significantly different by the Waller-Duncan K-ratio T test (k = 100, p = 0.05).
WP = wettable powder.

Taxus Response to Differential Concentration and Timing of Pendimethalin Application

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Nature of Work

Suspected herbicide phytotoxicity injury in the nursery industry initiated our interest in this project. Industry reports indicated that phytotoxicity damage had occurred when pendimethalin was used for weed control in the production of *Taxus*. Initial reports stated foliar death occurred where herbicide application had resulted in foliage contact. Reports have indicated plant injury occurred but not total plant loss. Our interest was to determine if pendimethalin application was the cause of *Taxus* injury, and if so, if it was due to application at early growth stage or rate or formulation of material applied.

An established field planting of 24- to 30-inch *Taxus media "Densiformis"* was used for this experiment. Treatment plots measured 12 feet by 7 feet, with three plants per plot. Five treatments were used on three spray dates, for a total of 15 treatments replicated three times. The treatments were pendimethalin (Pendulum) 3.3 emalsifiable concentrate (EC) at 2, 4, and 8 pounds active ingredient per acre (AIA), pendimethalin (Pendulum) 60 wettable granule (WG) at 4 pounds AIA, and a control. The spray dates were April 28, May 13, and May 30, 1997. Treatments were applied over the top of the plants using a CO_2 pressurized backpack sprayer calibrated to 26 GPA using 8004 nozzles at 30 lbs psi at the boom. New growth on the *Taxus* was approximately 1 inch in length on April 28, 1997.

Results and Discussion

Plant phytotoxicity was measured on a scale from 0 to 10 (0 representing no phytotoxicity and 10 representing plant death). Spray date one was evaluated on May 12, spray date one and two were evaluated on June 3, spray date one, two, and three were evaluated on June 18. Evaluation on July 7 was not performed because no visible change in foliage was observed. Once dead foliage was observed, evaluations were continued for all three spray dates on August 28 and September 30, 1997.

Phytotoxicity during the May 12, June 3, and June 18 ratings consisted of slight foliar discoloration. No change had occurred by July 7, and the plot was not rated. This was different from what was reported in the nursery industry where foliar death was reportedly occurring within weeks. By mid-August, foliar injury had become more pronounced, and ratings were resumed on August 28 and September 30. Phytotoxicity increased in intensity as the season progressed. Final level of damage was still unknown on September 30. With the EC formulation, phytotoxicity increased as the rate increased from 2 to 8 pounds (Table 1). Although the WG formulation initially caused more severe discoloration during the first ratings, by the September rating damage was less than that of the

Table 1. Phytotoxicity ratings (means) on *Taxus* after treatment with pendimethalin

Treatment	Form	Rate and Unit	Application Date	May 12 Rating	June 3 Rating	June 18 Rating	August 28 Rating	September 30 Rating
Pendulum	3.3 EC	2.0 lb AIA	April 28	0.0 b	0.1 b	0.4 abc	0.6 fg	1.1 e
Pendulum	3.3 EC	4.0 lb AIA	April 28	0.1 ab	0.1 b	0.5 ab	1.1 def	1.4 de
Pendulum	3.3 EC	8.0 lb AIA	April 28	0.3 ab	0.1 b	05. ab	1.9 cd	2.3 c
Pendulum	60 WG	4.0 lb AIA	April 28	0.4 a	0.4 a	0.7 a	1.0 def	1.1 e
Control			April 28	0.0 b	0.0 b	0.0 e	0.0 g	0.0 f
Pendulum	3.3 EC	2.0 lb AIA	May 13		0.1 b	0.1 de	1.9 cd	2.1 cd
Pendulum	3.3 EC	4.0 lb AIA	May 13		0.1 b	0.2 bcde	3.3 a	3.9 ab
Pendulum	3.3 EC	8.0 lb AIA	May 13		0.2 ab	0.2 bcde	3.0 ab	4.3 ab
Pendulum	60 WG	4.0 lb AIA	May 13		0.2 ab	0.4 abc	1.2 cdef	1.1 e
Control			May 13		0.0 b	0.0 e	0.0 g	0.0 f
Pendulum	3.3 EC	2.0 lb AIA	May 30			0.3 bcd	1.2 cdef	1.9 cd
Pendulum	3.3 EC	4.0 lb AIA	May 30			0.2 cde	1.7 cde	3.7 b
Pendulum	3.3 EC	8.0 lb AIA	May 30			0.4 abc	2.1 bc	4.7 a
Pendulum	60 WG	4.0 lb AIA	May 30			0.3 bcde	0.8 efg	1.0 e
Control			May 30			0.0 e	0.0 g	0.0 f
LSD (P=0.05) Standard Deviation				0.29 0.16	0.25 0.15	0.31 0.19	0.91 0.54	0.82 0.49

Means in a column followed by the same letter are not significantly different by the Waller-Duncan K-ratio T test (k = 100, p = 0.05).
AIA = active ingredient per acre; EC = emulsifiable concentrate; WG = wettable granule.

EC formulation. Besides causing foliar discoloration, the most severely affected plants also exhibited stunted growth of newly emerged shoot tissue.

This class of herbicides is known to influence root system growth and has strong adsorption to soil. Little information is available on foliar uptake or injury associated with woody landscape plants. For turfgrass, pendimethalin will be retained on and within the foliage (1). Exposure to sunlight and high temperatures are thought to contribute to initial pendimethalin dissipation (1). Temperatures were below normal for Lexington, KY, during our initial treatment. Varying levels of rainfall occurred immediately after application on each treatment date (Table 2). Rainfall apparently had limited influence on *Taxus* injury and growth; however, the influence of mild temperatures is unknown. Mild temperatures may contribute to the slow development of severe phytotoxicity. Photos were taken September 16, 1997.

Significance to Industry

Pendimethalin, at levels of 2 to 8 pounds per acre, may inhibit new shoot development for cutting propagation in *Taxus*. The slow rate of phytotoxicity symptom development could mean that cuttings taken from treated plants may fail after entering the propagation cycle.

Literature Cited

1. Stahnke, G.K., P.J. Shea, D.R. Tupy, R.N. Stougaard, and R.C. Shearmen. 1991. Pendimethalin dissipation in Kentucky Bluegrass Turf. Weed Sci. 39: 97-103.

Table 2. Weather data for Lexington, KY., for the 7-day period following herbicide application

Treatment Time	Date	Air Temperature Maximum	Air Temperature Minimum	Precipitation
Date One	April 28	56	47	Trace
	April 29	67	40	
	April 30	78	46	0.32
	May 1	57	47	0.04
	May 2	76	46	0.19
	May 3	61	47	1.03
	May 4	64	41	
Date Two	May 13	61	41	Trace
	May 14	71	46	0.09
	May 15	61	42	0.06
	May 16	60	33	
	May 17	73	48	0.08
	May 18	84	61	0.02
	May 19	82	64	0.37
Date Three	May 30	75	54	0.06
	May 31	66	63	2.85
	June 1	70	62	0.53
	June 2	79	52	0.07
	June 3	72	57	0.01
	June 4	65	53	
	June 5	67	53	Trace

Weed Control in Commercial Nurseries with Emulsifiable Concentrate and Granular Formulations of Thiazopyr

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Nature of Work

The experimental herbicide thiazopyr was evaluated for weed control and for tolerance to six field-grown, ground cover plant species. On May 9, 1997, at the University of Kentucky's horticultural research farm, six plant species (Table 1) were transplanted into a cultivated test plot. The test consisted of ten treatments and a control replicated three times in a randomized complete block design. Each treatment plot was 10 feet by 40 feet. Transplants were planted in rows spaced at 3-foot intervals, with plant spacing in the rows at 3-foot intervals. There were six transplants of each species in each replication except for ajuga, which had only three transplants in each replication. Following planting, approximately 1.5 pounds of nitrogen (ammonium nitrate) was applied to the entire test area. Because of the abundance of rain this spring, irrigation was not necessary for the duration of the test. On May 21, 1997, herbicide applications were made. Granulars were applied with a Gandy drop spreader, and sprayables were applied with a CO_2 pressurized backpack sprayer using 8004 spray tips calibrated to apply 26 GPA. Thiazopyr was formulated alone as both a emulsifiable concentrate (EC) and a granular (G) and in combination with oxyflurofen as a granular (G) (Table 2). Rout® and Gallery® were used as industry standards.

Treatments were rated visually both for weed control and injury to the ground covers. Weed control ratings were on a 0 to 100 scale (0 = no control, 100 = complete control). Injury ratings were taken on a 0 to 10 scale (0 = no injury, 10 = completely dead plant). Weed control ratings were taken 4, 8, and 12 weeks after treatment (WAT). Injury ratings were taken 2, 4, 6, and 8 WAT.

Results and Discussion

Seven weed species were rated (Table 3). Tables 4 and 5 show weed control ratings. With the exception of Gallery, annual grass control was excellent (> 98 percent) with all herbicide treatments at 4, 8, and 12 WAT. Annual grass control with Gallery was excellent (> 95 percent) at 4 and 8 WAT, but by 12 WAT annual grass control had slipped to 71 percent. Except for the 1.0 lb/AIA (pounds/active ingredient per acre) rate of the EC formulation of thiazopyr, at 12 WAT control of yellow nut sedge was poor with all treatments. Fair to excellent control of morning glories was observed with all but the Gallery herbicide treatments at 4 and 8 WAT. However, at 12 WAT only the thiazopyr treatments were providing fair to good control. All but the 0.5 lb/AIA rate of the thiazopyr granular provided excellent control (>88 percent) of common lambs-quarters at 4, 8, and 12 WAT. All herbicide treatments provided fair to good control of lady's thumb, honeyvine milkweed, and smooth pigweed at 4, 8, and 12 WAT. Overall weed control at 12 WAT was fair to poor with all herbicide treatments. At 12 WAT the best overall weed control rating was recorded with the 1.0 lb/AIA rate of the EC thiazopyr (76 percent), and the worst rating was recorded with Gallery (8.3 percent). The overall weed control ratings were skewed low because of a Johnson grass infestation. These herbicides were not expected to control Johnson grass; however, the EC formulation did provide suppression of Johnson grass, and this is reflected in the higher overall control ratings (data not presented).

Ground cover injury (Tables 6 and 7). In general, when using either the EC or G formulations of thiazopyr, there was little to no injury to any of the ground covers tested. With English ivy, wintercreeper, and ajuga, there was some unacceptable damage (>3) at 2 WAT, but by 8 WAT most of the plants had grown out of the unacceptable injury. The same trend is true with the oxyfluorfen formulations, only the degree of damage was greater. With most of the treatments, injury to the ground covers was unacceptable (>3) at 2 WAT. However, by 8 WAT all but the hostas had outgrown their unacceptable injury.

Significance to Industry

Thiazopyr, a new experimental herbicide, provided good weed control of annual grasses and most broadleaves, while providing a minimum of injury to the ground cover species tested.

Table 1. Ground cover plant species tested

Common Name	Scientific Name
Day Lily	*Hemerocallis species*
Hosta	*Hosta plantaginea*
Ajuga	*Ajuga repens*
English Ivy	*Hedera helix*
Common Periwinkle	*Vinca minor*
Wintercreeper	*Euonymus fortunei*

Table 2. Treatments

Treatment Number	Herbicide	Formulation	Rate Applied (Lb/AIA)
1	Thiazopyr	2 EC	0.5
2	Thiazopyr	2 EC	1.0
3	Thiazopyr	0.5 G	0.5
4	Thiazopyr	1.0 G	1.0
5	Thiazopyr (0.5 %) / Oxyfluorfen (1.5 %)	2.0 G	1.5 (0.375 / 1.125)
6	Thiazopyr (1.0 %) / Oxyfluorfen (1.5 %)	2.5 G	2.5 (1.0 / 1.5)
7	Thiazopyr (0.5 %) / Oxyfluorfen (2.0 %)	2.5 G	2.5 (0.5 / 2.0)
8	Thiazopyr (1.0 %) / Oxyfluorfen (2.0 %)	3.0 G	3.0 (1.0 / 2.0)
9	Rout (Oxyfluorfen (2.0 %) / Oryzalin (1.0 %))	3.0 G	4.0 (2.67 / 1.33)
10	Gallery (Isoxaben)	75 DF	1.0
11	Control		

EC = emulsifiable concentrate; G = granular; AIA = active ingredient per acre; DF = dry flowables.

Table 3. Weeds species

Common Name	Scientific Name	Abbreviation
Annual Grass Species	**Main representatives:** *Seteria faberi, Echinochloa crus-galli,* and *Panicum dichotomiflorum*	ANGR
Yellow Nut Sedge	Cyperus esculentus	CYES
Morning Glory Species	**Main representatives:** *Ipomoea lacunosa* and *I. hederacea*	IPSP
Lady's Thumb	*Polygonum persicaria*	*POPE*
Common Lambs-quarters	*Chenopodium album*	*CHAL*
Smooth Pigweed	*Amaranthus hybridus*	*AMHY*
Honeyvine Milkweed	*Ampelamus albidus*	*AMAL*

Table 4. Weed control ratings by means (4 WAT)[a]

Treatments[b]	Rate Lb/AIA	ANGR	CYES	IPSP	POPE	CHAL	AMHY	AMAL	OVERALL
Thia 2 EC	0.5	100 a	81.7 ab	80 bc	97.7 a	100 a	91.7 a	97.7 a	73.3 abc
Thia 2 EC	1.0	100 a	92.7 a	81.7 bc	96.7 a	100 a	99.3 a	99.3 a	92.3 a
Thia 0.5 G	0.5	100 a	73.3 bc	75 c	75 b	78.3 b	68.3 b	91.7 ab	46.7 d
Thia 1.0 G	1.0	100 a	86.7 ab	81.7 bc	95 a	100 a	93.3 a	90 ab	83.3 ab
Thia (0.5%) + Oxy (1.5%) 2.0 G	1.5	100 a	81.7 ab	85 b	98.3 a	100 a	96 a	73.3 bc	53.3 cd
Thia (1.0%) + Oxy (1.5%) 2.5 G	2.5	100 a	85 ab	98 a	100 a	100 a	99.3 a	94.3 ab	86.7 a
Thia (0.5%) + Oxy (2.0%) 2.5 G	2.5	100 a	81.7 ab	97.3 a	100 a	99.7 a	97.7 a	91.7 ab	68.3 a-d
Thia (1.0%) + Oxy (2.0%) 3.0 G	3.0	100 a	86.7 ab	99.3 a	100 a	100 a	100 a	91.7 ab	79.3 ab
Rout 3.0 G	4.0	100 a	75 abc	97.7 a	100 a	100 a	100 a	61.7 c	60 bcd
Gallery 75 DF	1.0	99.7 b	61.7 c	0 d	91.7 a	100 a	97.7 a	90 ab	20 e
Control		0 c	0 d	0 d	0 c	0 c	0 c	0 d	0 e
LSD (P = 0.05)		0.30	18.38	8.28	11.09	8.23	9.79	21.06	24.65

[a]Means within a column followed by the same letter are not significantly different at p = 0.05 as determined by Duncan's multiple range test.
[b]Thia = thiazopyr, Oxy = oxyfluorfen.
EC = emulsifiable concentrate; G = granular; AIA = active ingredient per acre; DF = dry flowables.

Table 5. Weed control ratings by means (12 WAT)[a]

Treatments[b]	Rate Lb/AIA	ANGR	CYES	IPSP	POPE	CHAL	AMHY	AMAL	OVERALL
Thia 2 EC	0.5	100 a	65 ab	88.3 a	90 ab	91.7 bc	84.3 c	98.3 a	61.7 ab
Thia 2 EC	1.0	100 a	86.7 a	70 abc	91.7 ab	100 a	98.7 ab	93.3 a	76.7 a
Thia 0.5 G	0.5	100 a	46.7 bc	83.3 ab	63.3 c	0 d	84.3 c	95 a	31.7 cd
Thia 1.0 G	1.0	100 a	63.3 ab	63.3 abc	80 bc	88.3 c	89.3 bc	85 a	46.7 bc
Thia (0.5%) + Oxy (1.5%) 2.0 G	1.5	100 a	20 cd	50 c	99.3 a	90 c	94.3 ab	75 a	28.3 cd
Thia (1.0%) + Oxy (1.5%) 2.5 G	2.5	100 a	40 bc	66.7 abc	98.3 a	99.3 ab	98.3 ab	91 a	36.7 bc
Thia (0.5%) + Oxy (2.0%) 2.5 G	2.5	100 a	43.3 bc	58.3 abc	96.7 ab	96 abc	96.7 ab	85 a	43.3 bc
Thia (1.0%) + Oxy (2.0%) 3.0 G	3.0	100 a	43.3 bc	78.3 abc	100 a	99.3 ab	100 a	80 a	46.7 bc
Rout 3.0 G	4.0	100 a	38.3 bc	55 bc	100 a	99.3 ab	100 a	73.3 a	30 cd
Gallery 75 DF	1.0	71.7 b	33.3 bcd	6.7 d	83.3 ab	100 a	100 a	94.3 a	8.3 de
Control		0 c	0 d	0 d	0 d	0 d	0 d	0 d	0 e
LSD (P = 0.05)		15.48	35.79	31.42	17.34	8.33	9.61	26.45	26.59

[a]Means within a column followed by the same letter are not significantly different at p = 0.05 as determined by Duncan's multiple range test.
[b]Thia = thiazopyr, Oxy = oxyfluorfen.
EC = emulsifiable concentrate; G = granular; AIA= active ingredient per acre; DF = dry flowables.

Table 6. Injury ratings by means (2 WAT)[a]

Treatments[b]	Rate Lb/AIA	Day Lily	Hosta	Ajuga	English Ivy	Periwinkle	Wintercreeper
Thia 2 EC	0.5	0.3 de	1.3 b	3.3 bcd	3.7 b	2 ab	2.7 a
Thia 2 EC	1.0	0.7 cde	1.3 b	2.7 cd	3.3 b	1.3 ab	3.7 a
Thia 0.5 G	0.5	1.7 bcd	1.3 b	3.3 bcd	4.7 b	2.7 ab	2 ab
Thia 1.0 G	1.0	1 cde	1.3 b	2.7 cd	3.7 b	2.7 ab	2.3 ab
Thia (0.5%) + Oxy (1.5%) 2.0 G	1.5	4 a	4.7 a	7 a	5 ab	2.3 ab	2.7 a
Thia (1.0%) + Oxy (1.5%) 2.5 G	2.5	2.7 ab	4.7 a	5 abc	4.7 b	2.7 ab	3.3 a
Thia (0.5%) + Oxy (2.0%) 2.5 G	2.5	3 ab	4.7 a	5.7 ab	7 a	2.3 ab	2.7 a
Thia (1.0%) + Oxy (2.0%) 3.0 G	3.0	4 a	6.3 a	3.3 bcd	4.3 b	2 ab	3 a
Rout 3.0 G	4.0	2 bc	6.0 a	5.7 ab	5 ab	3.3 a	3 a
Gallery 75 DF	1.0	0 e	0 b	1.3 de	4 b	3 ab	2 ab
Control		0 e	0 b	0 e	0 c	0 b	0 b
LSD (P=0.05)		1.36	1.95	2.62	2.24	3.14	2.35

[a]Means within a column followed by the same letter are not significantly different at p = 0.05 as determined by Duncan's multiple range test
[b]Thia = thiazopyr, Oxy = oxyfluorfen.
EC = emulsifiable concentrate; G = granular; AIA = active ingredient per acre; DF = dry flowables.

Table 7. Injury ratings by means (8 WAT)[a]

Treatments[b]	Rate Lb/AIA	Day Lily	Hosta	Ajuga	English Ivy	Periwinkle	Wintercreeper
Thia 2 EC	0.5	1 cde	1.7 cd	0 b	1.7 ab	1.7 abc	1.3 a
Thia 2 EC	1.0	1 cde	1.3 cd	1 ab	2.0 ab	2 abc	0.7 ab
Thia 0.5 G	0.5	0.3 de	1.7 cd	0.3 ab	1.7 ab	0.3 bc	0.7 ab
Thia 1.0 G	1.0	0.7 de	2.3 c	0 b	1 bc	2.3 abc	0.7 ab
Thia (0.5%) + Oxy (1.5%) 2.0 G	1.5	1.3 bcd	2.7 bc	1 ab	1 bc	1.3 abc	0.7 ab
Thia (1.0%) + Oxy (1.5%) 2.5 G	2.5	2 abc	4.7 a	0.3 ab	2.7 a	2.7 ab	0.7 ab
Thia (0.5%) + Oxy (2.0%) 2.5 G	2.5	2.3 ab	5 a	1 ab	2 ab	1.7 abc	1 a
Thia (1.0%) + Oxy (2.0%) 3.0 G	3.0	2.7 a	4.3 ab	1.7 a	2 ab	2.3 abc	1.3 a
Rout 3.0 G	4.0	2.3 ab	6 a	0.7 ab	2 ab	3.3 a	1.3 a
Gallery 75 DF	1.0	0.7 de	2 c	0.3 ab	2 ab	1.7 abc	0.7 ab
Control		0 e	0 d	0 b	0 c	0 c	0 b
LSD (P = 0.05)		1.22	1.94	1.51	1.16	2.38	0.95

[a]Means within a column followed by the same letter are not significantly different at p = 0.05 as determined by Duncan's multiple range test.
[b]Thia = thiazopyr, Oxy = oxyfluorfen.
EC = emulsifiable concentrate; G = granular; AIA = active ingredient per acre; DF = dry flowables.

Insect Biodiversity in Turfgrass and the Role of Natural Enemies in Suppression of Black Cutworms

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Nature of Work

The black cutworm, *Agrotis ipsilon*, is an important pest of turfgrasses. Many golf courses apply insecticides to manage cutworms and reduce their damage on putting greens and tees, but little is known about the factors that normally keep these pests in check. We are studying the natural enemies that inhabit different turfgrass habitats and their importance in reducing cutworm infestations. Awareness of these interactions can help in designing pest control tactics that conserve these natural buffers. We had four objectives to guide our research in 1997.

Objective 1 was to determine which natural enemies feed on cutworm eggs and larvae in the turfgrass environment. Three 24-hour observation cycles were done to document cutworm egg and larval predation when exposed on four different lawns on the UK campus.

Objective 2 was to identify the major predatory insects that occur in golf turf, lawns, and meadows. For this, we used season-long pitfall trapping. At the Champions and Idle Hour golf courses, 120 traps were distributed among three different fairways at each golf course. Traps were collected and reset every 2 weeks during the summer 1997. Sixty pitfall traps were also set and monitored at the same intervals at two different meadows, as well as another 60 traps among six different home lawns in Fayette County, KY.

Objective 3 was to assess predation on eggs of cutworms and Japanese beetles, *Popilia japonica*, on putting greens and fairways at two local golf courses. Grass cores (6-inches diameter) on which cutworm eggs had been laid the previous night were exposed overnight on putting greens, fairways, and roughs. Similarly, small open petri dishes with soil and 10 Japanese beetle eggs were buried just under the thatch. Predation rates were compared between the different turf sites.

Objective 4 was to survey ant species present on six putting greens at each of five different golf courses in Fayette County, KY. We wanted to learn what species are responsible for mounds formed on putting greens, as this damage may warrant control.

Results and Discussion

Objective 1. Twenty-four hour observations on UK campus lawns showed that cutworm eggs were attacked primarily in the evening by ants of the species *Lasius neoniger*. Another ant species, *Formica schaufussi*, attacked second to fourth instar cutworm larvae at any time of day or night. Predation rates were very high.

Objective 2. The most abundant predators found in golf course fairways, home lawns, and meadows were the ants *Lasius neoniger* and *Solenopsis molest* together with various mites, spiders, ground beetles, and rove beetle species.

Objective 3. When cutworm and Japanese beetle eggs were exposed on fairways or roughs, predation overnight was higher on roughs than on the fairways on both golf courses (Figures 1 and 2). When cutworm eggs were exposed overnight on greens (6-inch diameter grass cores), 92 to 95 percent were eliminated in one night by *Lasius neoniger* workers.

Objective 4. Surveys of golf course putting greens showed that the most abundant ant species again was *Lasius neoniger*.

Preliminary Conclusions

Although there are many reports of ant predation in agricultural and forestry settings, very little is known about the role of ants as predators in golf courses and lawns. While it is still early in this research, we will continue to investigate ants as predators in 1998. It appears that the most common predators of black cutworm eggs in golf courses and lawns of Fayette Co., KY, are the ants *Lasius neoniger* and *Solenopsis molesta*. More information about how to control pest insects while conserving ants and other natural enemies is needed.

Figure 1. Predation on Black Cutworm Eggs.

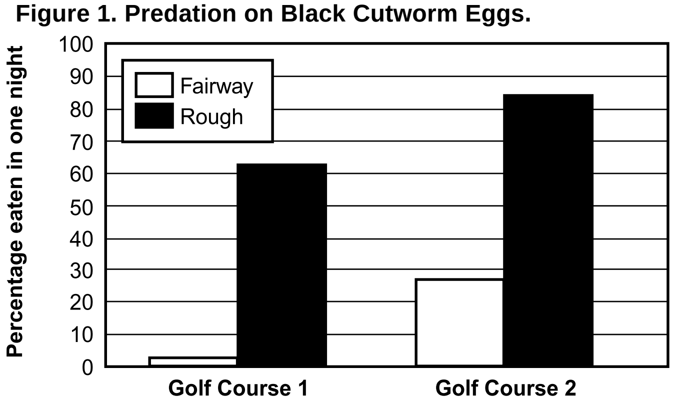
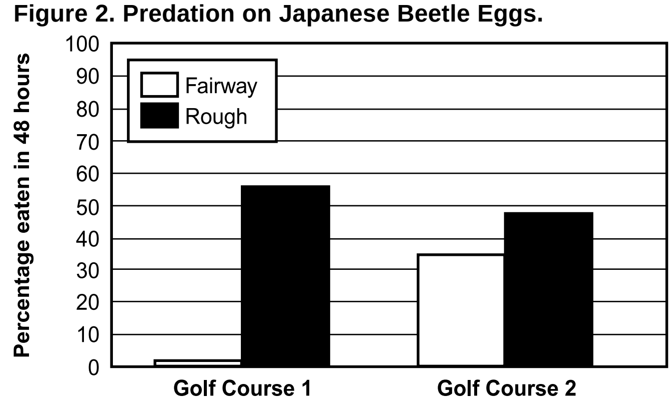


Figure 2. Predation on Japanese Beetle Eggs.



Significance to Industry

The role of ants on golf courses is a double-edged sword. This work indicates that the pest ants that form mounds on golf putting greens represent mainly one species. In other turfgrass habitats, e.g., lawns, roughs, and fairways, ants are beneficial and have tremendous impact on pest populations. Conservation of these natural controls is important for sustainable pest management. Although the ant *Lasius neoniger* appears to be more beneficial than detrimental, further work needs to be done to accurately assess its role and management on golf courses.

Day and Night Activity in the Japanese Beetle (*Popillia japonica* Newman)

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Nature of Work

Daily patterns of feeding, mating, egg laying, and other activities of Japanese beetles are poorly known. We have been studying the beetles' feeding and flight behavior during day and night to understand the habits of this important pest.

We monitored beetles during two 24-hour periods in midsummer and recorded feeding activity and amount of damage at different times. Data were obtained for six 4-hour intervals during each 24-hour cycle and related to air temperatures during these periods. Mesh bags were placed over branches before beetle flight, so that the shoots used in the experiment were undamaged before the trials began. Every 4 hours beginning at 6 a.m., ten males and ten females were collected from nearby foliage and placed within the bags. This was replicated on four trees. Day 1 was done on Royalty crab apple, and day 2 was done on Redmond linden. After each 4-hour period the location of beetles was noted, and the branch was removed. Three independent evaluators then rated the damage level of each leaf and recorded the number of damaged leaves on each branch.

Results and Discussion

Beetles caused the greatest damage (25 percent overall defoliation of branch) during the 4-hour period from 2 to 6 p.m. on both days. During the warmest part of day 1 (10 a.m. to 2 p.m.), the beetles caused 18 percent defoliation. The warmest part of day 2 was between 2 and 6 p.m., which coincided with the heaviest feeding. On day 1, the beetles caused an average of 18 percent defoliation during each of the four periods during daylight. Feeding activity decreased after sunset, but the beetles still caused a small amount of damage (< 3 percent) after dark. On day 2, there was considerable feeding (> 20 percent damage) during each 4-hour time period between 10 a.m. and 10 p.m. However, temperatures were quite low in the morning and after midnight, and there was little feeding. Indeed, nothing was eaten between 2 and 6 a.m. These observations show that Japanese beetles will feed sparingly at night when temperatures are warm. However, most damage occurs between midmorning and midafternoon.

Significance to Industry

Japanese beetles are important landscape pests, both as adults and larvae. Understanding the beetles' daily activites could help to refine control tactics, such as improved timing of control actions.

Ecology and Management of the Horned Oak Gall Wasp (*Callirhytis cornigera*) on Pin Oak

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Nature of Work

The horned oak gall wasp, *Callirhytis cornigera*, infests pin oaks, *Quercus palustris*, grown as street trees and in other urban settings. This wasp has two generations per year, forming woody twig galls in the spring generation and leaf galls in the summer (1). Gall density varies widely among neighboring trees, but the reasons for this are unclear. We tested three hypotheses to explain variation in gall density among trees: (1) the "plant vigor hypothesis," which suggests that vigorously growing plants are more susceptible to attack by certain types of insects, especially gall-formers; (2) the "plant stress hypothesis," which suggests that stressed plants are more susceptible to insect attacks; and (3) the "demic adaptation hypothesis," which suggests that insects that are closely associated with their hosts (such as gallmakers) can become adapted to a particular host's defenses, allowing them to reach outbreak densities.

Causes for variation in gall density on 34 pin oaks on a horse farm in Central Kentucky were studied in 1997. Trees were categorized as uninfested or lightly, moderately, or heavily infested. Parameters of tree stress, including growth, budbreak phenology, root starch, and leaf nutrient and tannin content, were tested for relationships with gall density. Tree height was measured with a clinometer, and radial diameter was measured from increment cores. Root sections were chiseled from trees and analyzed for winter carbohydrate reserves. Leaves were collected and analyzed for total nonstructural carbohydrate, nitrogen, and tannin content because of the potential effects of these factors on the summer gall wasp generation. To test the demic adaptation hypothesis, wasps were transferred from heavily infested donor trees onto lightly or heavily infested other trees or back onto their original hosts. We then measured success of leaf gall initiation. The seasonal biology of the gall wasp (e.g., emergence periods, activity period in trees) and its associated parasites also were studied to determine when this pest might best be targeted for control.

Results and Discussion

Gall density was not tightly linked with tree vigor or stress. Radial diameter did not differ among trees in the 10-year interval from 1987 to 1996, although it was greater in uninfested and lightly infested trees in 1996. Uninfested trees had significantly greater heights, but leaf and root carbohydrate levels showed no pattern with respect to gall density. Leaf tannin and nitrogen contents also did not significantly differ among tree categories. Results of the transfer experiment supported the demic adaptation hypothesis. The number of leaf galls and the number of galled leaves per shoot were significantly higher on the original host trees (donor trees) than on lightly infested trees.

We made progress in determining timing of gall wasp and natural enemy activity. The first generation emerged from the twig galls from early April to early May and laid eggs in swollen buds. Leaf galls did not begin forming until after larvae hatched from eggs on the expanding leaves. Based on laboratory dissections, first generation females (from twig galls) had the potential to lay up to 300 eggs in buds. Galls appeared to form at the oviposition site. Parasitic wasps attacking the twig gall generation emerged after the gall wasp emergence, whereas a huge emergence of parasites occurred before leaf gall wasps emerged. Gall wasp emergence from leaf galls was mainly from August through late September in 1997. Newly initiated twig galls began developing as early as August and have been growing rapidly since then. They are thought to need 2 or more years to reach full size (2). We will continue to monitor the growth of 40 new twig galls for the next 2 years.

In 1998, we will determine the host range of the horned oak gall wasp and test several strategies for controlling this pest at different stages of gall wasp development.

Significance to Industry

This research clarifies the effects of a galling insect on tree health and provides insight into the causes of gall outbreaks. Specifically, this research will identify specific tactics by which arborists can effectively manage this perennial problem in the urban environment. At present, there are no research-based recommendations for controlling this pest. Results will be reported at various professional meetings, through publications in scientific and trade journals, and in Extension bulletins.

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Why Does the Japanese Beetle Feed on Some Woody Plant Species, but Not Others?

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Nature of Work

The Japanese beetle (JB), *Popillia japonica* Newman, is a highly destructive defoliator of woody landscape and nursery plants. Although the JB feeds on nearly 300 plant species, there are many plants that are quite resistant. We investigated why the JB feeds on some plant species and not others. Eight woody plant species were chosen for study on the basis of Fleming's (1) resistance ratings. Four of these are highly susceptible plants: sassafras (*Sassafras albidum*), littleleaf linden (*Tilia cordata*), purpleleaf plum (*Prunus cerasifera*), and Virginia creeper (*Parthenocissus quinquefolia*). The others are plants that reportedly are highly resistant: tulip tree (*Liriodendron tulipifera*), lilac (*Syringa vulgaris*), dogwood (*Cornus florida*), and Bradford pear (*Pyrus calleryana*).

Methods, Results, and Discussion

Our first goal was to confirm the susceptibility ratings of the eight species. Paired choice tests were done between all possible combinations of susceptible and resistant species. For each test, leaf disks were cut with a cork borer, and four disks, two susceptible and two resistant, were presented in an alternating array within a circular cage. Three female JB introduced to each cage were allowed to feed until about 75 percent of the preferred plant material was consumed, or 8 hours. Amount of leaf tissue consumed then was measured. The results confirmed reported ratings for susceptibility or resistance of the selected plant species. In all tests, susceptible species were consumed much more than reportedly resistant species.

We also wanted to study the consequences for JB survival and fecundity when beetles fed upon susceptible or resistant foliage. Would the JB eat nonpreferred plants when given no other choice? Groups of beetles were kept in cages and fed fresh leaves from each of the susceptible and resistant test species for 3 weeks. Some groups received no food at all. Moist soil was provided as an egg-laying site. Eggs and surviving JB were counted after 7, 14, and 21 days. Survival and fecundity were significantly higher for JB that fed on susceptible species. Interestingly, JB survived fairly well on lilac, a reportedly resistant species, even though their egg production was much lower than when fed susceptible species. Fecundity and survival on all plant species were greater than for those offered no food, indicating that the resistant plants were not acutely toxic.

Next, we wanted to determine what physical and chemical leaf factors might be important in host selection. Fully expanded outer canopy leaves (or leaflets) were collected and measured for area, thickness, relative toughness, and water content. Other leaves were freeze-dried and ground to a powder for chemical analysis. Samples were then analyzed for nitrogen, sugars (glucose, fructose, and sucrose), tannins, and saponins. Foliar nitrogen is an estimator of protein content. Sugars are known to be feeding stimulants for JB. Tannins and saponins are compounds often cited as feeding deterrents. Conventional theory suggested that susceptible species might be lower in thickness and toughness, because such tissues are harder to chew, and higher in water content, because many insects favor succulent food. Further, susceptible species were expected to be higher in nitrogen and sugar and lower in tannins and saponins. We found differences among individual plant species for each of the studied parameters; however, there was no general pattern that would explain why one group is more or less resistant than the other. Thus, none of the measured physical and chemical factors appears to be solely responsible for resistance.

We then studied the importance of cuticular waxes in selection of food plants by JB. Beetles were offered a choice between intact leaves or those with waxes removed by dipping in chloroform (2). Feeding on Bradford pear and lilac increased on chloroform-dipped leaves, suggesting presence of feeding deterrents in epicuticular wax of those species. Feeding on linden and plum was greater on nondipped foliage, perhaps because of feeding stimulants in the surface wax. Based on these results, we studied the beetles' response to extracts of leaf waxes. Wax extracts taken from Bradford pear or plum were applied to plain filter disks to test for phagostimulation or to sucrose-treated disks to test for deterrence. JB will eat sucrose-treated disks, so this is a useful way to test for deterrent substances.

On plain disks there was no phagostimulation from either pear or plum wax. Surprisingly, on the sucrose-treated disks, the wax treatments were not a deterrent. In fact, feeding was greater on sucrose-treated disks with wax than on sucrose-treated disks alone, suggesting that the combination of wax and sugar is especially palatable.

We also found that beetles would feed readily on normally resistant Bradford pear leaves that had been frozen and then thawed. Freezing and thawing appears to cause cellular disruption and mixing of internal leaf constituents, resulting in chemical reactions that deactivate the internal resistance factors. Frozen-thawed leaves became more palatable with increased thaw time, and there was less feeding on leaves boiled directly from the freezer than on leaves thawed several hours before boiling. This is good evidence for enzymatic involvement in the degradation of feeding deterrents. Aerobically thawed leaves had much more feeding than anaerobically thawed leaves, suggesting that the deterrent-degrading reactions are oxygen dependent. JB reared on frozen-thawed Bradford pear leaves had much higher survival and fecundity than JB reared on normal leaves, suggesting that this normally resistant plant is nutritionally suitable once the deterrents are deactivated.

Significance to Industry

Understanding the basis of JB feeding preference is important because the beetles are so destructive to woody ornamental plants. Identification of resistance factors could lead to plant protection, possibly by genetic engineering of resistance factors into susceptible plant species.

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Impact of Two Novel Soil Insecticides, Halofenozide (Mach2®) and Imidacloprid (Merit®), on Beneficial Invertebrates in Turf

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Nature of Work

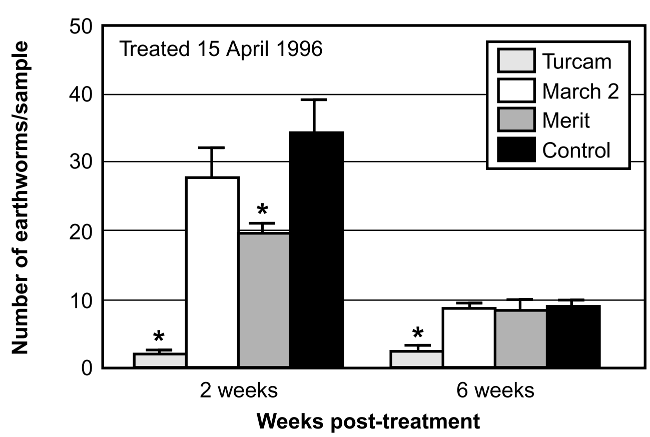
Turfgrass is a multibillion dollar a year industry that has grown considerably during the past few decades. Insecticides are widely used to suppress various pests, but this can sometimes have adverse side effects that should be considered when making management decisions. For example, the use of conventional insecticides can reduce or eliminate such beneficial invertebrates as earthworms that are important for thatch degredation. Excessive thatch can result in stressed turf, which is more susceptible to pests. Some insecticides can kill natural enemies (predators and parasites), which can increase the likelihood of secondary pest outbreaks or pest resurgences. Halofenizide (Mach 2®; Rohmid L.L.C.) and imidacloprid (Merit®; Bayer Inc.) are two novel insecticides that recently were labeled for turf. Mach 2 is a molt-accelerating compound. It mimics the action of ecdysone, the insect molting hormone, causing target insects to prematurely molt and die. Merit acts selectively on insect nerves, targeting the postsynaptic nicotinic acetycholine receptor site. Both compounds have very low toxicity to vertebrates, including humans, pets, and wildlife, but their impact on beneficial invertebrates was not known. We therefore studied the effects of the compounds on earthworms, predators, and other beneficial invertebrates in turfgrass.

We tested these insecticides in both the laboratory and the field. Effects on earthworms were studied by sampling worm populations in treated or untreated turf plots. Soil cores were removed from the same treated areas and the soil microfauna were extracted and counted. Local golf courses allowed us to treat out-of-play areas to examine the effects of the insecticides on beneficial insects. Plots were treated in May or June, and populations of ants, spiders, rove beetles, and ground beetles were monitored for 12 weeks thereafter. Predation on eggs, larvae, and pupae of the black cutworms and eggs of Japanese beetles was compared between treated and untreated sites. Finally, we studied contact, dietary and residual toxicity, and sublethal effects of the insecticides on a common ground beetle (an abundant predator in turf). Bendiocarb (Turcam®), a widely used carbamate, was used as standard for all experiments.

Results and Discussion

Turcam caused the most severe reductions in earthworm populations (Figure 1). Merit caused slight reductions in earthworm abundance, but populations recovered by 6 weeks post-treatment. Mach 2 caused no detectable mortality on either the earthworm populations. Turcam caused the most severe reductions in soil microfauna, including springtails and mites; Merit had lesser effects, and Mach 2 caused no reductions. None of the insecticides significantly reduced the seasonal abundance of ants, spiders, rove beetles, or ground beetles. Other predators, such as hister beetles and predatory larvae, were affected during early summer but recovered by midsummer. None of the insecticides caused any reduction in predation on Japanese beetle eggs, but fewer black cutworm larvae were preyed upon in Turcam- and Merit-treated turf for 1week post-treatment. However, predation rates had returned to normal by 2 weeks post-treatment. Predation rates of black cutworm eggs and pupae were not reduced by any of the treatments. Turcam caused high levels of acute mortality of ground beetles in the contact, dietary, and residual tests. Merit caused temporary moribundity in some tests, but most beetles recov-

Figure 1. Effects of turfgrass insecticides on earthworms. Asterisks denote means that were significantly lower than the untreated controls.



ered within 3 days. However, Merit-intoxicated ground beetles were more vulnerable to predation by ants. Mach 2 had no apparent adverse effects on ground beetles. These results suggest that Merit and Mach 2 pose relatively little threat to beneficial insects through contact with dry residues on treated turf. However, predators can sustain sublethal effects, including temporary intoxication, if they are hit by spray or feed on food items contaminated with Merit. By comparison, the carbamate standard had severe adverse effects on earthworms and caused high acute mortality of a beneficial predator.

Significance to Industry

This study provides important information about environmental side effects of Mach 2 and Merit, two new soil insecticides. These results suggest that these new turf insecticides have less impact on beneficial invertebrates than does a widely used carbamate. Turf managers now have the option of using target-selective insecticides that provide good control of pests while having less impact on beneficial and nontarget species.

What Factors Affect Two-spotted Spider Mite Populations on Burning Bush?

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Nature of Work

Burning bush, *Euonymus alata*, is commonly planted in landscapes for its brilliant red fall foliage. In Kentucky, the two-spotted spider mite, *Tetranychus urticae* Koch, is the major pest and can cause premature leaf abscission in high-population densities. This project sought to explain why mites reach outbreak levels at some sites but not others. We speculated that environmental factors, such as plant location (full sun or near structures), water availability, or plant nutrients, might increase the reproductive rate of the mites by providing them with a more suitable environment or a better quality host, resulting in rapid population buildup.

Shading effects were tested using three levels: full sun, 30 percent shade, or 60 percent shade. A plot of 18 *Euonymus* were planted in pot-in-pot production on a site at Spindletop Research Farm. Shade huts (1.07 meters high, 1.5 meters wide at the base) were placed over the plants. The shrubs were allowed to break bud under their respective treatments. In July, the plants were infested with 50 female mites each. Mite populations were allowed to build and were sampled in September.

The hypothesis that higher temperatures might encourage mite outbreaks on *Euonymus* planted close to structures was tested in a plot with 24 shrubs planted near or away from a 9.75-meter cylinder block wall. The wall was constructed on an east-west line and was painted flat black. Plants were placed 0.6 meters and 6.1 meters away from the wall on the north and south sides. Plants were infested in July and were subsequently sampled in September as above.

To study effects of water stress and fertility regime on mite buildup, 36 *Euonymus* were planted in pot-in-pot production as above. Fertility level and watering regimes were manipulated. The two fertility regimes were no fertilizer added and fertilized with Osmocote 16-8-12 at label rate. The three watering regimes were (1) well watered (watered three times daily), (2) cyclic drought (watered once every other day), and (3) chronic drought (watered at wilting point). The well-watered and cyclic regimes were watered with an automatic time clock, and the chronic drought plants were watered by hand. Natural rainfall was excluded from the plants by covering the plot with plastic. The plot was mulched to prevent excess heat from affecting the plants. Plants were infested and sampled as above.

Results and Discussion

Sun versus Shade. Total mite populations and total number of leaves infested did not differ significantly between the three shade levels. Leaf parameters including water content and thickness did differ significantly; leaves of full sun plants had the highest water content and were the thickest. Chronic drought plants had the lowest leaf water content and thinnest leaves.

Proximity to Structures. Both proximity to the wall and direction (north or south side) significantly affected mite populations and total number of leaves that were infested (Figure 1). In general, mite populations were higher on plants close to the wall and on the south side. As expected, temperature readings were highest on the south side near the wall. The wall effect was greater on the south side than on the north side. However, there were no differences in leaf characteristics among the different planting locations.

Water Stress and Nutrition. Well-watered plants had significantly more mites and total number of leaves infested than did cyclic or chronic drought-stressed plants (Figure 2). Fertilization had no effect on mite populations or total leaves infested. Pressure bomb readings showed that well-watered plants were under the least amount of stress, chronic drought plants were under the greatest stress, and cyclic drought plants were under intermediate stress. Well-watered plants had the greatest water content and thickness, whereas chronic drought-stressed plants had thinner, less succulent leaves. A visual color

Figure 1. Effect of direction and placement by wall on total mite population.

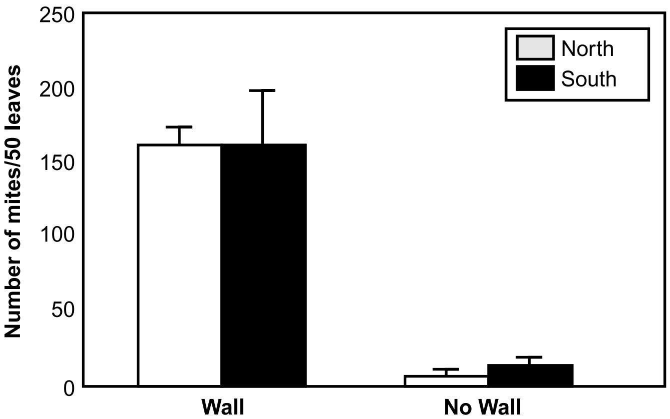
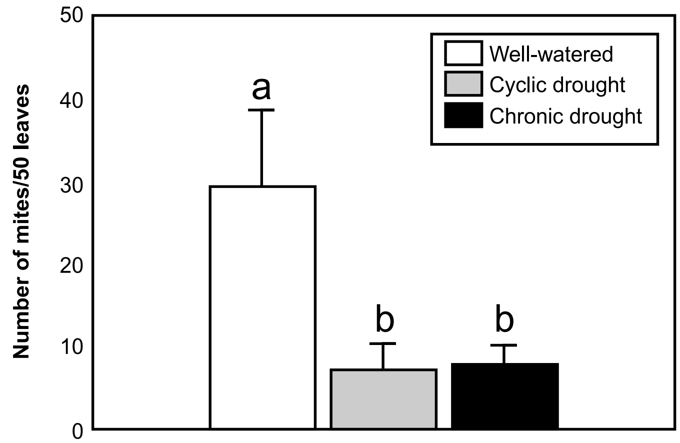


Figure 2. Effect of irrigation and regime on total mite population.



rating showed that plants well watered and fertilized had the best (red) fall color, whereas chronic drought and nonfertilized plants had the least amount of fall color.

Significance to Industry

By identifying the environments that provide two-spotted spider mite populations with optimal reproductive conditions, we may be better able to predict where outbreaks will occur. These locations should be the first areas in the landscape inspected for mites. Mites appearing in high-risk plantings can be targeted for early treatment. This will provide better control with reduced need for multiple treatments later in the growing season. This could prevent the spread and further growth of two-spotted spider mite populations.

Controlled Atmosphere Anoxia Treatments as a Disinfestation Technique for Arthropod Pests in Greenhouses

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Nature of Work

Western flower thrips and two-spotted spider mites are difficult to control in greenhouse production because of their cryptic habits, insecticide resistance, and a limited palette of effective pesticides. Nonchemical control tactics and new technology are needed if these pests are to be effectively managed. Research has shown that controlled atmosphere (CA) conditions can be used to eliminate pests on stored agricultural commodities. CA is used extensively for fruit and vegetable crops, as well as some cut flowers. Off-shore and domestic propagule production (cuttings and plugs) involves shipping plant material over long distances and time. We believe that CA technology can be adapted to eliminate arthropod pests, such as mites, thrips, and aphids, from greenhouse propagules. The objective of this project is to investigate conditions (temperature, relative humidity, gas mixtures, and time) that influence the effectiveness of anoxia (low oxygen) treatments against greenhouse pests.

Materials and Methods

For these experiments, minicontrolled atmosphere chambers were constructed. Ultrahigh purity compressed nitrogen was used to create the anoxic conditions. Nitrogen was metered and delivered to each chamber at a set flow rate. Compressed air was used as a control gas. Ranges of temperatures are being tested, but data presented reflect 20^{O} C (68^{O} F) temperatures. Exposure times varied between 6 to 24 hours. Pests were collected from laboratory colonies and placed in cages made from small (50-millimeter diameter) vented petri dishes. Each cage had a layer of moistened cotton padding on which a 50-millimeter leaf disc was placed. Ten individuals of a particular pest species were confined in each cage and placed in the treatment chamber. In some experiments additional cages were added to compensate for any lost individuals.

Results and Discussion

Adult western flower thrips, aphids, and two-spotted spider mites were tested in separate trials. Anoxia treatments were effective against all-mentioned pests with varying results. For example, two-spotted mites had 80 to 100 percent mortality in four of eight replicates of the experiment, while the other four replicates had considerably lower mortality. Western flower thrips, after 12 hours of 100 percent nitrogen, had 100 percent mortality (Figure 1). Likewise, aphids exposed to the same atmosphere achieved 100 percent mortality in 6 hours (Figure 2).

Additional experiments were done to determine effects on plant material in the system. Plugs of impatiens, petunias, and begonias were placed in 100 percent nitrogen environments for 6, 12, or 24 hours in separate trials. Impatiens and begonias showed little to no adverse effects, whereas begonias were damaged after 6 hours and completely killed at 12-hour exposures. Plug experiments were also conducted with thrips present. These experiments suggested that presence of plant material can reduce anoxia-induced mortality, perhaps through oxygen production or effects on relative humidity. Experiments are underway to examine these possible confounding factors.

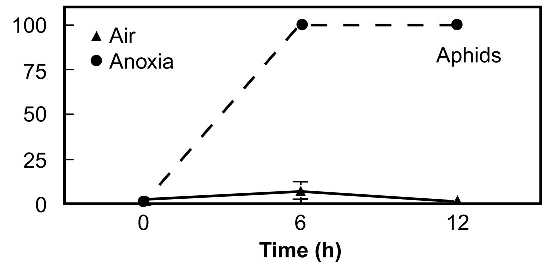

Figure 1. Percent mortality of aphids exposed to compressed air (▲) and 100 percent nitrogen (●) at 20°C.

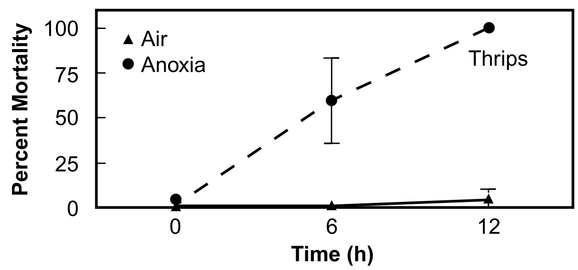

Figure 2. Percent mortality of thrips exposed to compressed air (▲) and 100 percent nitrogen (●) at 20°C.

Significance to Industry

Several years ago, nursery inspectors quarantined geranium cuttings coming from an offshore producer. It was suspected that two exotic pests were being shipped into the United States. The response was to treat most of the geranium boxes with methyl bromide, resulting in tremendous crop loss and expense to the growers. Pest movement, domestic or internationally, is a problem, and any means for managing it would be an asset to growers. This project is evaluating a novel means by which floricultural crops could be rendered pestfree before shipment or upon receipt by a grower.

Landscape Trees as Hosts of Bacterial Leaf Scorch Caused by *Xylella fastidiosa* in Kentucky—1997

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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* (11). Bacterial leaf scorch has been reported in coastal US states from New York to Texas and recently in Kentucky in bur, pin, red, and shingle oak; sycamore; sugar maple; and sweetgum (1,3,4,5,6,9,10). We have also detected the disease in Southern Indiana, and it has been diagnosed in Tennessee. Thus, it is now found in noncoastal eastern US 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 can take place over a period of 5 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 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. The objective of this continuing research is to confirm the presence of *Xylella* in new hosts showing symptoms of bacterial leaf scorch disease in Kentucky.

Results and Discussion

In surveys of trees from 1989 to 1997, bacterial leaf scorch was found in 16 Kentucky cities and towns distributed statewide. Affected counties include Boyle, Caldwell, Campbell, Christian, Daviess, Fayette, Garrard, Hardin, Henderson, Hopkins, Jefferson, Jessamine, McCracken, Oldham, Pulaski, Union, and Warren. The following landscape trees are now known to be hosts of bacterial leaf scorch in Kentucky:

(a) Oaks, including bur, pin, red, shingle, and white.
(b) Maples, including red, silver, and sugar.
(c) Other deciduous trees, including sweetgum and sycamore.

The disease is most serious and widespread on oaks, especially pin oaks. In some urban areas, mature pin oaks with bacterial leaf scorch have declined to such a great extent that they are now being removed. In at least one instance, a bur oak, only 15 to 20 years old died from this disease. The disease is not widespread on maples and sweetgums in Kentucky; however, these hosts represent our most recent finds; e.g., the infected silver maple was found only in the past year. Bacterial leaf scorch-infected elms and mulberries, confirmed hosts in other states, have not been found in Kentucky.

Significance to Industry

Arborists, landscapers, and nurserymen in Kentucky need to know about the susceptibility of landscape trees to bacterial leaf scorch disease to effectively serve their customers.

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Dogwood Anthracnose in Kentucky, 1996-1997

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

Nature of Work

Dogwood anthracnose caused by the fungus *Discula destructiva* is a serious problem in Kentucky's forests and is a threat to trees in heavily shaded landscapes. Through specimens received in the UK plant pathology department's plant disease diagnostic laboratory (UKPDDL.), we are able to monitor this disease as it affects the trees of clients in the state.

Results and Discussion

Dogwood anthracnose was confirmed in one additional Kentucky county in 1997; thus, the disease is now reported from 61 of Kentucky's 120 counties, based on diagnoses confirmed by the UKPDDL. Table 1 lists the Kentucky counties having dogwood anthracnose.

Forest dogwoods. In forests, anthracnose is found primarily in eastern Kentucky counties, and even there it is very sporadic; in some stands, anthracnose is easily located, while in others one must search for the disease. It is found most frequently infecting dogwoods in heavily shaded locations on north-facing slopes and along streams. Return examinations of infected trees show progressively more lower branch dieback from one year to the next.

Landscape dogwoods. Despite a cool, wet, late spring and early summer weather in 1997, anthracnose is present at relatively low levels in landscape dogwoods. In most cases, the disease is more severe in heavily shaded landscapes, on pink flowering dogwoods, and on trees growing under stressful conditions. Because of the increased incidence and severity of dogwood powdery mildew during the past 5 years, dogwood anthracnose is not perceived to be as serious a problem of landscape dogwoods in Kentucky as it once was. In contrast, the severity of dogwood powdery mildew on certain valuable landscape specimens has been great enough to warrant recommendations of fungicide applications for disease control.

Significance to Industry

Knowing where dogwood anthracnose exists in Kentucky will enable arborists, nursery managers, and landscapers to plan how to manage potential dogwood anthracnose outbreaks in the landscape and nursery.

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Table 1. Kentucky counties where dogwood anthracnose has been confirmed

1989 - 1992		1993 - 1994			1995 - 1997
Bell	Knott	Boone	Johnson	Menifee	Bullitt
Breathitt	Laurel	Boyd	Kenton	Morgan	Garrard
Campbell	Lee	Boyle	Knox	Nelson	Green
Carter	Madison	Christian	Lawrence	Nicholas	Jessamine
Clark	Marshall	Clay	Leslie	Pike	McLean
Daviess	Perry	Elliott	Letcher	Pulaski	Russell
Fayette	Powell	Floyd	Magoffin	Robertson	Shelby
Fleming	Rowan	Grant	Martin	Rockcastle	
Greenup Hardin	Scott	Harlan	Mason	Warren	
Jefferson	Wolfe	Henderson	McCracken	Wayne	
		Jackson	McCreary	Whitley	

Evaluation of Fungicides for Dogwood Powdery Mildew

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Departments of Plant Pathology, Entomology, and Horticulture and Landscape Architecture

Nature of Work

Dogwood powdery mildew caused by the fungus *Microsphaera* sp. is damaging to the health and aesthetic qualities of *Cornus florida* (2). The first observable symptom is a small whitish or chlorotic leaf spot. Growth of the pathogen causes the leaves to become distorted, develop reddish splotches, and interveinal and marginal necrosis or leaf scorch with or without dark red to brown borders. Landscape dogwoods are often especially prone to powdery mildew because the scorch and discoloration symptoms can be enhanced by exposure to sunlight and dry soil conditions. Premature mottling and yellowing can also develop. In this experiment, we evaluate fungicides for their efficacy in preventing dogwood powdery mildew (1,3).

Powdery mildew control was evaluated at the University of Kentucky horticultural research farm near Lexington in research plots consisting of four individual trees of four different *C. florida* cultivars as part of a larger planting established in 1990. The 1997 fungicide trial consisted of biweekly applications for all treatments except one, which was applied monthly. Some treatments began in May as preventive treatments, and others began in June after disease symptoms appeared. Table 1 describes application timing details. Treatments were arranged in a randomized complete block, and the last application was made August 18.

Powdery mildew was evaluated biweekly by estimating the percentage of leaves with any symptoms of powdery mildew (incidence), by estimating the mean percentage of leaf area affected on infected leaves (severity), and by recording the estimate as 0 to 10 with 10 = 100 percent. A general index of powdery mildew was calculated by arc sign square root transformation of incidence times (severity/100). Data were analyzed using PC SAS GLM and Duncan's New Multiple Range Test (k = 100, p = 0.05).

Spring weather was harsh with hard frosts occurring in April and on May 1 and May 17 (the day after the 100 percent frost-free date). Rain also was a daily occurrence during June and early July. Frost- damaged twigs and branches were removed, but suckers were allowed to regrow to increase inoculum. The first signs of powdery mildew were detected on May 30 on *C. florida*. Powdery mildew incidence increased, especially in early July, reaching 100 percent by July 9 on susceptible trees.

Results and Discussion

Disease pressure in the plots was high, and unsprayed trees were severely affected by the fungus. Results of the fungicide evaluations are presented in Table 1. Because of excess rain in late spring and early summer, treatments often were not applied on schedule or were washed off. Despite these difficulties, both Rubigan AS treatments, both Banner MAXX treatments, and the Cleary's 3336 treatment reduced disease and improved aesthetic quality. Adequate disease control by season's end can be achieved by beginning fungicide applications in June, even after symptoms have begun to appear.

Significance to Industry

In order to maintain optimal health of established dogwoods, the industry needs to be aware of the relative efficacy of selected fungicide treatments. This report provides useful information to that end and, furthermore, should alert industry managers and workers about the seriousness of dogwood powdery mildew.

Literature Cited

1. Doney, J., J. Hartman, M. Johnson, W. Fountain, and R. McNiel. 1997. Control of powdery mildew of dogwoods. *In*: Proceedings of Tenth Dogwood Anthracnose Workshop, September, 1997, Lexington, KY, p. 47.
2. Pirone, P.P. 1978. Diseases and pests of ornamental plants. John Wiley & Sons. New York. 566 pp.
3. Windham, A., and M. Windham. 1997. Chemical control of powdery mildew of dogwood. *In*: Proceedings of Tenth Dogwood Anthracnose Workshop, September 22-25, 1997, Lexington, KY, p. 46.

Table 1. Effect of fungicide treatments and timing on dogwood powdery mildew index (representing incidence and severity) and disease progression evaluated in July and September 1997

Treatment and Rate/100 Gallons	Application Starting Date	Number of Applications	Powdery Mildew Index		
			July 3	July 9	Sept. 4
Rubigan AS, 8 oz	May 16	6	0.13 a	0.29 a	0.49 a
Banner MAXX, 4 oz	May 16	7	0.22 a	0.35 ab	0.51 a
Rubigan AS, 8 oz - monthly	June 12	3	0.37 ab	0.42 ab	0.60 a
Banner MAXX, 4 oz	June 12	5	0.39 ab	0.48 abc	0.68 a
Cleary's 3336, 8 oz	June 26	4	0.40 b	0.65 c	0.51 a
Bayleton 25 TO, 4 oz	June 12	5	0.33 ab	0.56 bc	1.22 b
Water Check, Sprayed Biweekly	May 16	7	0.67 c	0.71 c	1.09 b
Probability > F			0.008	0.006	0.001

Means in a column followed by the same letter are not significantly different by the Waller-Duncan K-ratio T test (k = 100, p = 0.05).

Reactions of Dogwood Cultivars to Powdery Mildew

Jack Doney, John Hartman, Monte Johnson, William Fountain, and Robert McNiel
Departments of Plant Pathology, Entomology, and Horticulture and Landscape Architecture

Nature of Work

Dogwood powdery mildew caused by *Microsphaera* sp. is damaging to the health and aesthetic qualities of *Cornus* spp (4). The first observable symptom is a small whitish or chlorotic leaf spot. Growth of the pathogen causes the leaves to become distorted, develop reddish splotches, and interveinal and marginal necrosis with or without dark red to brown borders. Landscape dogwoods are especially prone to powdery mildew because the scorch and discoloration can be enhanced by exposure to sunlight and dry soil conditions. Premature mottling and yellowing can also develop. In this experiment, we evaluated dogwood species and cultivars for their reaction to powdery mildew (3,5).

Powdery mildew was evaluated on research plots consisting of 11 cultivars of four *Cornus* spp. established at the University of Kentucky horticultural research farm near Lexington in 1990-93 (1,2). When these evaluations were made, there were ten *C. mas* (one cultivar), seven *C. kousa* (two cultivars), eight *C. kousa* x *C. florida* hybrids (three cultivars), and 35 *C. florida* (five cultivars). Powdery mildew was evaluated biweekly by estimating the percentage of leaves with any symptoms of powdery mildew (incidence), by estimating the mean percentage of leaf area affected on infected leaves (severity), and by recording the estimate as 0 to 10 with 10 = 100 percent. A general index of powdery mildew was calculated by arc sign square root transformation of incidence times (severity/100). Data were analyzed using PC SAS GLM and Duncan's New Multiple Range Test (k = 100, p = 0.05).

Spring weather was harsh with hard frosts occurring in April and on May 1 and May 17 (the day after the 100 percent frost-free date). Rain was a daily occurrence during June and early July. Frost-damaged twigs and branches were removed, but suckers were allowed to regrow to increase inoculum. The first signs of powdery mildew were detected on May 30 on *C. florida*. Powdery mildew incidence increased, reaching 100 percent by July 9 on susceptible trees.

Results and Discussion

Disease pressure in the plots was high and susceptible cultivars were severely affected by the fungus. Results of the cultivar evaluations are presented in Table 1. All *C. florida* cultivars, with the exception of Cherokee Brave are uniformly susceptible to powdery mildew. Of the others, *C. mas* is immune, *C. kousa* is resistant, and the *C. florida* x *C. kousa* hybrids, along with *C. florida* Cherokee Brave, are intermediate. A progressive increase in the disease index, reflecting both incidence and severity, occurred from early June to early September.

Significance to Industry

In order to install and maintain sustainable landscapes, the industry needs to be aware of the relative susceptibility of plant materials to important diseases. This report provides useful information to that end and, furthermore, should alert industry managers and workers about the seriousness of dogwood powdery mildew.

Literature Cited

1. Doney, J., J. Hartman, M. Johnson, W. Fountain, and R. McNiel. 1995. Reactions of dogwoods to diseases and cold temperature injury, 1994. Biological and Cultural Tests 10:66.
2. Doney, J., J. Hartman, M. Johnson, W. Fountain, and R. McNiel. 1997. Control of powdery mildew of dogwoods. *In*: Tenth Dogwood Anthracnose Workshop, September 22-25, Lexington, KY, p.47.
3. Hagan, A.K. et al. 1997. Evaluation of dogwood selections for resistance to powdery mildew and spot anthracnose, 1996. Biological and Cultural Tests 12:58.
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Table 1. Powdery mildew index (representing incidence and severity) for 11 *Cornus* selections during the 1997 growing season.

Species and Cultivar	June 10	July 3	July 9	August 3	Sept. 4
C. mas (Cornelian Cherry)	0.00 a	0.00 a	0.00 a	0.00 a	0.00 a
C. kousa (Milkyway)	0.00 a	0.00 a	0.01 a	0.10 a	0.10 a
C. kousa (National)	0.00 a	0.00 a	0.04 ab	0.02 ab	0.02 ab
C. florida x C. kousa (Galaxy)	0.01 a	0.01 a	0.29 bc	0.21 abc	0.20 abc
C. florida x C. kousa (Stardust)	0.30 a	0.12 ab	0.40 cd	0.50 cd	0.40 abcd
C.florida x C.kousa (Constellation)	0.01 a	0.12 ab	0.30 c	0.24 abc	0.40 abcd
C. florida (Cherokee Brave)	0.00 a	0.00 a	0.25 abc	0.31 bc	0.49 bcde
C. florida (wild type)	0.09 a	0.34 bc	0.41 cd	0.51 cd	0.65 cde
C. florida (Barton White)	0.03 a	0.32 bc	0.50 cd	0.51 cd	0.71 de
C. florida (Cloud Nine)	0.03 a	0.43 c	0.62 d	0.49 cd	0.78 de
C. florida (Cherokee Chief)	0.03 a	0.49 c	0.63 d	0.66 d	0.90 e
Probability > F	0.06	0.0001	0.0001	0.0001	0.0013

Means in a column followed by the same letter are not significantly different by the Waller-Duncan K-ratio T test (k = 100, p = 0.05).

Dogwood Disease Research Meeting

John Hartman
Department of Plant Pathology

Nature of the Work

The Tenth Dogwood Anthracnose Workshop was held in Lexington on September 22-25, 1997. At this meeting, plant pathologists from throughout the eastern US with interest in dogwood diseases gathered to discuss their current observations and research findings (1).

Results and Discussion

Dogwood powdery mildew. Dogwood powdery mildew is becoming a more serious problem than anthracnose, especially in landscapes. Tennessee researchers have determined the relative resistance of several *Cornus* species to be as follows: immune, *alternifolia, alba,* and *sericea*; resistant, *kousa*; intermediate, *kousa* x *florida*; susceptible, *alba elegantissima, ammomum, capitata, macrophylla,* and *nuttallii*; and for the most part very susceptible, *florida*. Of 24 *C. florida* cultivars tested, all were very susceptible except Cherokee Brave, which is resistant early in the season but is infected by season's end. UK research done by Jack Doney and co-workers, but with fewer cultivars, essentially confirms these results. A dieback of the *C. florida* x *C. kousa* hybrids, possibly caused by winter injury, is also being observed.

In Kentucky, we have found that under very high disease pressure, fungicides, such as Rubigan, Banner MAXX, and Cleary's 3336, when applied biweekly beginning just after bloom, reduce powdery mildew and improve aesthetic quality of the trees. Depending on disease pressure, application of some fungicides, such as Rubigan and Banner MAXX, can be effective at monthly intervals. Tennessee research essentially confirmed our results and also showed the fungicides Systhane and Immunex to be very effective, but horticultural oils were ineffective.

Finally, there is some controversy whether dogwood powdery mildew is caused by *Microsphaera pulchra, Phyllactinia guttata*, or other fungi, each having very different cleistothecia (fungal fruiting structures). *P. guttata*, a powdery mildew of many shade tree hosts, has cleistothecia that are known to be easily moved, so finding cleistothecia of this fungus on dogwood could be the result of contamination. It is difficult to find cleistothecia on mildew-infected dogwoods in any case, but when they occur, we normally see *Microsphaera* on dogwood here. Researchers still do not know why dogwood powdery mildew is so much more widespread now than it was a few years ago.

Dogwood anthracnose research. A Georgia US Forest Service pathologist has learned that rainfall is critical to infection, lesion expansion, inoculum production, and continuation of the epidemic. In fact, a 2-week dry period in spring or summer substantially stops the epidemic. She also found that leaf wetness duration for infection is long (24 to 48 hours), which suggests that fungicide treatments may not be needed except in the wettest seasons. Although the optimum light level for dogwood is 30 percent of ambient, light levels in the forest can be as low as 2 percent of ambient, which could increase susceptibility to disease. In the forest, dogwoods growing in recent clearcuts have less anthracnose. Simulated acidic rainfall applied to the soil increases anthracnose severity, but application only to leaves and foliage does not. Finally, she found that *C.Kousa* is more tolerant to open sites and to dogwood anthracnose than *C. florida*. Tennessee researchers, using molecular biology techniques, have accumulated evidence that supports the theory that *Discula destructiva* is an introduced pathogen. *D. destructiva* has been shown to produce in culture toxins that cause plant necrosis, according to work done at Clemson University.

Dogwood anthracnose geographic distribution. Natural infections of dogwood anthracnose in the East are now found in Appalachian regions from Northeast Alabama to New York and Connecticut. It has spread into Ohio, Indiana, and possibly into Michigan and Missouri according to researchers tracking spread of the disease. In Kentucky, serious dogwood anthracnose is mainly confined to the eastern forests. In some regions, enormous numbers of trees have died. For example, it was reported that in North Carolina, 217 million forest dogwoods are infected by or have died from dogwood anthracnose, and in Tennessee forest survey plots, dogwood mortality due to the disease has increased from 11 percent to 39 percent the past 5 years. One researcher concluded that the disease has not spread rapidly into new areas in recent years because just about all the highly susceptible trees in disease-favorable environments, such as the high elevation Appalachian forests, have already been killed. A map of the southeastern US indicating relative dogwood anthracnose hazard ratings, prepared by a US Forest Service pathologist from North Carolina was shown. Dogwood anthracnose risks in Kentucky are highest in the extreme southeast areas of the state.

Dogwood anthracnose education. A New York Extension specialist provided a history of dogwood anthracnose in the East from its 1977 discovery in New York by P.P. Pirone to the present time and told how the US Forest Service, the news media, and the University Cooperative Extension Service have all provided good publicity and educational information about this disease. Candace Harker and Donna Michael, of UK, described dogwood problem educational efforts at the local level. A World Wide Web page on this topic, first featuring the *Growing and Maintaining Healthy Dogwoods* brochure, is being prepared by US Forest Service pathologists.

Insects, birds, and anthracnose. Monte Johnson of UK reported on clearwing borers in dogwoods, indicating that contrary to conventional wisdom, *kousa* dogwoods are susceptible to dogwood borers. Conidia of *D. destructiva*, the dogwood anthracnose fungus, survived in convergent lady beetle frass and were capable of infecting dogwoods in greenhouse studies by University of Tennessee researchers. There are dozens of Kentucky wild birds that are dependent on dogwood fruit for food. Some, such as cardinals, make more attractive mates because their red plumage is enhanced by eating dogwood fruit according to Sunni Lawless, Kentucky Department of Fish and Wildlife Resources. The discussion that followed centered on how insects and birds might be spreading the disease (strongly suspected but not yet proved) and the difficulties of working with these subjects (one cannot experiment with migratory birds, and chicken-based research does not seem applicable).

Workshop-related tours. A tour at Natural Bridge State Park revealed that dogwood anthracnose in the forest was more severe than we see in landscapes and was causing extensive lower branch dieback, whereas powdery mildew in the forest appeared to be less severe. Locally, our dogwood cultivar and powdery mildew fungicide trials at the UK horticultural research farm allowed participants to see for themselves the difference between healthy and diseased dogwoods. Many participants saw the same effects at the UK summer landscape plants field day in July at the same location.

Significance to Industry

Sharing research information about dogwood diseases with the landscape industry benefits arborists, nursery managers, and landscapers by keeping them up to date on these issues.

Literature Cited

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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.

Making a diagnosis involves a great deal of research into the possible causes of the plant problem. Most visual diagnoses involve microscopy to determine what plant parts are affected and to identify the microbe involved. In addition, many specimens require special tests, such as moist chamber incubation, culturing, enzyme-linked immunosorbent assay (ELISA), electron microscopy, nematode extraction, or soil pH and soluble salts tests.

Computer-based laboratory records are maintained to provide information used for conducting plant disease surveys, identifying new disease outbreaks, and formulating educational programs. Much of the 1997 growing season was very favorable for landscape plant diseases. Kentucky landscapes experienced fluctuating winter temperatures, late spring cool weather and frosts, incessant late spring and early summer rains, and dry late summer and fall weather, each of which contribute to the development of different kinds of diseases.

Results and Discussion

Deciduous tree diseases. The various anthracnose fungi on *Discula* (ash), *Kabatiella* and *Discula* (maple), *Apiognomonia* (sycamore and oak) were very active. In spring, infected ash leaves littered the ground, and sycamores were forced to push out three to four new flushes of growth as a result of anthracnose-caused loss of shoots and foliage. Anthracnose was even found on beech and on yellowwood this year. Spring rains also resulted in unusually high levels of cedar rusts (*Gymnosporangium* spp) of hawthorns and of flowering crab apple scab (*Venturia inaequalis*) this year. Rust susceptible hawthorns showed significant tip dieback following twig infections in the tree, while scab susceptible crab apples were practically defoliated by August. Dogwood powdery mildew (*Microsphaera* sp.), a disease of little importance 5 years ago, now has become very serious in many landscapes. Oak leaf spot (*Tubakia* sp.), along with oak anthracnose, are severely affecting some established, but young, red oaks, causing twig and branch dieback. Branch dieback also follows many years of bacterial leaf scorch (*Xylella fastidiosa*) symptoms in large, mature pin oaks. Oak leaf blister (*Taphrina coerulescens*) and maple tar spot (*Rhytisma acerinum*), though widespread this year, are not damaging diseases.

A widely observed abiotic weather-related problem of *Prunus* species, maples, especially Japanese maples, and other woody plants was the sudden collapse of shoots and foliage at the first onset of warm weather in June. This dieback could be attributed either to winter freeze or spring frost injury to cambium and phloem tissues. A variety of canker diseases could later be found on many of these same cold-injured woody plants.

Needle evergreen tree diseases. Pine problems persist. Maturing Austrian and Scots pines continue to die from tip blight (*Sphaeropsis sapinea*) and pine wilt nematode (*Bursaphelenchus xylophilus*). We observed established white pines declining either from root disturbance or from having been planted into soils with high clay content, high pH levels, or heavy compaction.

Shrub diseases. Two uncommon problems, rose rust (*Phragmidium mucronatum*) and lilac bacterial blight (*Pseudomonas syringae*), were observed this year. Black root rot (*Chalara elegans*) of hollies remains a problem. *Taxus*, junipers, and other shrubs suffered root rot (most likely *Phytophthora* spp.) worsened by high soil moisture levels. Rhododendrons facing environmental stresses, such as cold, heat, drought, or poor soils, showed cankers (*Botryosphaeria dothidea* and others), which caused wilt and branch dieback. Azalea leaf and flower gall (*Exobasidium vaccinii*) was common.

Perennial and annual plant diseases. Iris leaf spot (*Heterosporium*) was devastating in some locations. Southern stem blight (*Sclerotium rolfsii*) was common on hostas and other perennials. Rusts (*Puccinia* spp) of geranium and of hollyhock were widespread.

Landscape lawn diseases. Powdery mildew (*Erisiphe* sp.) and rust (*Puccinia* sp.) appeared in Kentucky bluegrass and perennial ryegrass lawns in spring and summer. Tall fescue root and crown infections (*Rhizoctonia solani*) were noticed this season.

Significance to Industry

To serve their clients effectively, landscape industry professionals, such as arborists, nurserymen, 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.

Literature Cited

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Evaluation of Annual Flowers in the Landscape

Sharon Bale
Department of Horticulture and Landscape Architecture

Annual flowers were evaluated at the UK Arboretum and Quicksand, KY, locations. Although the spring and summer weather conditions were not conducive to optimum plant growth and development, the wet, cool, and long spring and dry summer provided a rough test for plants being evaluated. A summary of observations from the 1997 trials follows.

Agastache Butterfly Delight - (Burpee) Rabbits feasted on the plant early in the season. Plants recovered and produced a significant display of bloom from late July until frost.

Crepis rubra -(Royal Horticulture Society) Plants are approximately 12 inches tall and produce a profuse number of light pink blooms early in the season. This is a short-lived annual, which begins to set seed in early July. Although it will not last the entire season, it is an excellent small cut flower for early bouquets. This is the second year this plant has been grown. In the first season, the rabbits completely obliterated the plant. This year the rabbits feasted, but the plant was able to recover.

Emilia jauanica - (Thompson and Morgan) Small orange-red to yellow blooms are produced until frost. Plants will reseed during the season. This plant is a nice addition to the cut flower garden. The small thistle like blooms are excellent filler material and have an acceptable vase life.

Leonotis leonurus Staircase - (Thompson and Morgan) No bloom is produced until late August. This plant caused a lot of comments. Plants are very vigorous, up to 6 feet tall. When the blooms finally appeared, there were no middle-of-the-road comments. People either loved the plant and thought the blooms were unique and interesting, or they thought it was ugly and had no garden potential. A small number of these plants tucked away in the back of a border bed might produce a pleasant surprise late in the season.

Monarda didyma Panorama Mix - (Park) No bloom the first season.

Petunia Purple Wave and Pink Wave Rabbits caused some problems early in the season. Although Purple Wave did not perform as well as expected this season it is still by far the best performer in this area. Pink Wave has a more erect habit, and the color was not as consistent as might be expected. The plant should still be considered a good choice. The Surfinia petunias are also a good choice, but they were a gourmet rabbit treat this season.

Rudbeckia Indian Summer - A consistently good performer. Powdery mildew can be a problem.

Salvia splendens Salsa Series - (Goldsmith) This series was planted in two different locations. One bed was somewhat protected while the other location was not. Soil in both locations had been amended with compost the previous fall. Plants located in the protected bed tolerated the wet conditions, established well, and produced a consistent display throughout the season. Those in the more exposed bed suffered an 80 percent loss during the wet weather. Color range of this series is very attractive.

Verbenas

Homestead was spectacular. Although the hardiness of this plant can be questionable, enough plants generally survive to produce a satisfactory display. Plants received no special maintenance, had no disease problems, and tolerated some frost. We have acquired some other verbenas that are suppose to be similar to Homestead in growth habit but produce other colors. Comparisons will be made at a later date.

The Tapien Series did not do much until late summer. When the plants finally began to produce blooms, the wait was worth it. These low-growing plants became a solid mass of blooms and received very favorable comments from visitors to the Arboretum. The plants tolerated some frost. These verbenas must be grown in full sun. In semishade, few blooms were produced.

Sweet Potatoes

Ipomoea Tie Dye—(Park) The variegated foliage and bicolor blooms were very attractive.

Ipomoea Blackie—This plant is extremely vigorous. The dark coloration of the leaves is very effective as a contrast plant. It is not quite as vigorous when grown in containers but still a good choice for the trailing habit.

Ipomoea batata (pink, green and white foliage)—I obtained this plant in North Carolina. It had no cultivar name. The variegated foliage of this plant is not as large as Blackie, nor is the plant as vigorous. It can, however, be quite effective in the garden. Cuttings root easily, but stock plants need bright light and high heat.

Ipomoea Margarita—I obtained a plant late in the season. Look for this one in the Arboretum next season. The lime-green foliage is a sharp contrast to Blackie but has the same size, shape, and apparent vigor.

It was my understanding that these ornamental sweet potatoes did not really produce tubers, but we certainly dug sweet potatoes this fall. Taste trials will begin later.

The extreme wet conditions early in the growing season produced significant problems with many of the plants. Those that were lost because of these conditions are listed below.

- Antirrhinum Chimes Mix - (Goldsmith Seed)
- Antirrhinum Liberty Mix - (Goldsmith Seed)
- *Brachycome iberidifolia* Bravo Violet, Bravo White, and Bravo Dunkelblau - (Benary Seed).
- *Cerinthe* major - (Thompson and Morgan)
- *Dianthus barbatus* Auricula Eyed Mixed - (Thompson and Morgan)
- *Dianthus chinensis* Magic Charms Mixed - (Goldsmith)
- *Dianthus chinensis* Princess Mix - (Goldsmith)

Wet weather was not the only garden adversary; rabbits and chipmunks were also a problem. *Gazanias* were prime rabbit food. Chipmunks declared war on the geraniums. The Maverick series must be delicious. Some Maverick White and Salmon did survive and performed well; with consistent dead heading, the plants produced full flower heads throughout the season.

Survival of Fall-planted Hydrangeas

Winston Dunwell and Dwight Wolfe
Department of Horticulture and Landscape Architecture

Nature of Work

A research project on hydrangeas grown for cut flowers has been initiated at three University of Kentucky Horticulture Research Centers. We were fortunate to be one of those sites at the West Kentucky Research and Education Center at Princeton. On October 20, 1996, 24 liners each of 24 hydrangea cultivars were planted. The field had been prepared by plowing and discing before planting. No soil amendments, fertilizer, or surface mulch was applied. The plants were rated for winter survival by Research Technician June Johnston on May 6, 1997.

Each liner was rated based on the following numerical system:

0 = the whole plant died
1 = the top died, but slight regrowth from the base
2 = the top died, but vigorous regrowth from the base of the plant
3 = some stem dieback occurred, but there is growth on the stems
4 = only the terminals died back, the rest of the plant is growing
5 = the whole plant is growing

Results and Discussion

The results of the evaluation (Table 1) show a significant difference in the ability of hydrangea cultivars to survive a winter following fall planting. In spite of the winter of 1996-1997 being considered relatively mild, the hydrangea cultivar Blue Billow and those cultivars listed below it in Table 1 suffered serious losses.

The plants were provided by Spring Meadow Nursery, (616)-846-4729. For cultivar descriptions please consult their catalog.

Table 1.Winter survival ratings of *Hydrangea*.

Cultivar	Rating[1]
Hydrangea paniculata Boskoop	4.7
H. paniculata Pink Diamond	4.6
H. paniculata Tardiva	4.0
H. paniculata White Moth	4.0
H. paniculata Unique	3.7
H. arborescens Annabelle	3.5
H. paniculata Kyushu	3.4
H. quercifolia Alice	3.0
H. paniculata Peewee	2.9
H. macrophylla Blue Billow	1.5
H. macrophylla Pink Beauty	0.0
H. macrophylla Teller White	0.8
H. macrophylla Domotoi	0.8
H. macrophylla Cardinal Red’	0.7
H. macrophylla Sister Terese	0.7
H. (hybrid) Coerulea Lace	0.5
H. macrophylla All Summer Beauty	0.5
H. macrophylla Merritt Supreme	0.4
H. macrophylla Goliath	0.3
H. macrophylla Alpenglow	0.2
H. macrophylla Nikko Blue	0.2
H. macrophylla Glowing Ember	0.2
H. macrophylla Variegata	0.2
H. serrata Serrata Preciosa	0.2
LSD (0.05)	0.5

[1] Mean of 24 liners.

University of Kentucky
Nursery and Landscape Program Fund Update

The UK Nursery and 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 UK 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.

A Fund Development Committee established a minimum goal of $35,000 per year to support UK programs. Broad participation by Kentucky nursery and landscape firms in this program would help a dedicated, hard-working faculty and staff accomplish more for you.

A total of $11,315 was given in 1996 though 20 cash contributions ranging from $10 to $2,155. More than $8,900 has been contributed this year through October 1997. Most of these funds have 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 from existing plots.

Twelve companies have each committed to contribute at least $10,000 during a 10-year period. Those contributing at this level can designate an individual or couple as University of Kentucky Fellows and members of the Scovell Society in the College of Agriculture.

Although larger firms are encouraged to make at least a $10,000 commitment, all nursery and landscape businesses must contribute an appropriate amount for us to make the desired impact. All contributors will be recognized in the annual report and their names added to a handsome plaque to be 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).

The UK Nursery and Landscape Advisory Committee advises the chairperson of the UK horticulture and landscape architecture department on the use of available funds to benefit the industry through research and education and assists in the continued development of the fund. The Committee members are appointed to 3-year terms and represent the various segments of the industry and geographic areas. The Committee meets at least annually to review planned activities and how funds will be used. All industry personnel are welcome to attend the meetings of the Advisory Committee. The 1997 Advisory Committee included Casey Schott (Leichhardt Landscape Company), Mike Land (Hillcrest Nursery), Greg Ammon (Ammon Wholesale Nursery), Bob Broadbent (Broadbent Nursery), Pat Dwyer (Dwyer Landscaping, Inc.), Stephen Hillenmeyer (Hillenmeyer Nursery), Bob and John Korfhage (Korfhage Landscape and Designs), Melvin Moffett (Snow Hill Nursery), Bob Ray (Bob Ray Company), Gene Ryan (Valley Hill Nursery), Lee Squires (Cave Hill Cemetery), Herman Wallitsch, Jr. (Wallitsch Nursery), and Charles Wilson (Wilson's Nursery).

We have attempted to contact every Kentucky nursery and landscape business. If you have not received information on how to participate in this program or if you have questions about the fund and how to contribute, contact Dr. Dewayne Ingram, (606/257-1601), one of the Advisory Committee members, or a UK Horticulture faculty member.

Those individuals and companies contributing to the UK Landscape Fund in 1997 (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.

UK Nursery and Landscape Fund Fellows

Gregory L. and Melanie G. 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 (Memorial)
Lillard's Nursery

Daniel S. Gardiner
Watch Us Grow of Kentucky

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

Fred and Jenny Wiche
Fred Wiche Lawn and Garden Expo

Bob and Tee Ray
Bob Ray Company

Stephen and Chris Hillenmeyer
Hillenmeyer Nurseries

Larry and Carolyn Sanders
James Sanders Nursery, Inc.

1997 Contributors

(through December 1)

Associates (> $500)
Mike Ray, Carl Ray Landscape
Charles Wilson, Wilson's Nursery

100 Club (> $100)
Steve King, Stonegate Gardens
Mike Land, Hillcrest Nursery

Donor (< $100)
Anthony Aulbach
Sandy Duncan, George W. Hill and Company, Inc.
Dr. Dewayne Ingram

Industry Organizations
Kentucky Nursery and Landscape Association

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

AgroEvo, Wilmington, DE
American Cyanamid, Wayne, NJ
Ammon Wholesale Nursery, Burlington
B&R Spray Systems, Lexington
BASF Corporation, Research Triangle Park, NC
Bayer Corp., Kansas City, MO
Benary Seed, Germany
Berryhill Nursery, Springfield, OH
Boone Gardinere Landscape Co, Louisville
Bunton Co., Louisville
Center Hill Nursery, Smithville, TN
Century Equipment-Toro, Cincinnati, OH
Champions Golf Course, Lexington
David Leonard, Consulting Arborist, Lexington
DowElanco, Indianapolis, IN
Flowerwood Nursery, Loxley, AL
FMC, Philadelphia, PA
George Ball, Inc. W. Chicago, IL
Goldsmith, Gilray, CA
Green Ridge Tree Farm, Elizabethtown
Griffin Corporation, Valdosta, GA
J. Frank Schmidt Nursery, Boring, OR
Hillcrest Nursery, Richmond
Hillenmeyer's Nursery, Lexington
ICI Americas, Wilmington, DE
Idle Hour Golf Course, Lexington
Leichhardt Landscape Company
Loius' Flower Power Shops, Lexington
Marriott's Griffin Gate Resort Hotel, Lexington
Midwest Landscape Network, Florence
Monsanto, St. Louis, MO
National Nursery Products, Louisville
Natrop Landscape Supply
Novartis Corp., Greensboro, NC
Nursery Supplies Inc., Chambersburg, PA
Red Barn Nursery, Nicholasville
Rick Pitino
Rohm and Haas, Philadelphia, PA
Rosehill Greenhouses, Eminence
Schott Gardens, Bowling Green
Sherman Nusery, Charles City, IA
Smithers-Oasis, Kent, OH
Snow Hill Nursery, Shelbyville
Steve Foltz, Cincinnati, OH
Stinson Nursery, Shelbyville
The Scotts Company, Marysville, OH
Tieco-Jacobsen, Louisville
Transplant Nursery, Lavonia, GA
United Horticultural Supply, Louisville
Valhalla Golf Club, Louisville
Valley Hill Nursery, Springfield
Vigoro Industries, Chicago, IL
W.A. Cleary Chemical Corp., Somerset, NJ
Wight Nursery, Inc., Westlake, OH
Wilson's Nursery, Frankfort
Wurth Farms, Paducah
Xenia Power Equipment-John Deere, Nicholasville
Yoder Brothers, Pendleton, SC
Zenica Professional Products, Wilmington, DE

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Kentuckiana Greenhouse Association
National Turf Evaluation Program
Urban and Community Forestry Program, Kentucky Division of Forestry
UK Nursery/Landscape Fund
UK College of Agriculture Alumni Association
U.S. Department of Agriculture, National Research Initiative
U.S. Golf Association

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