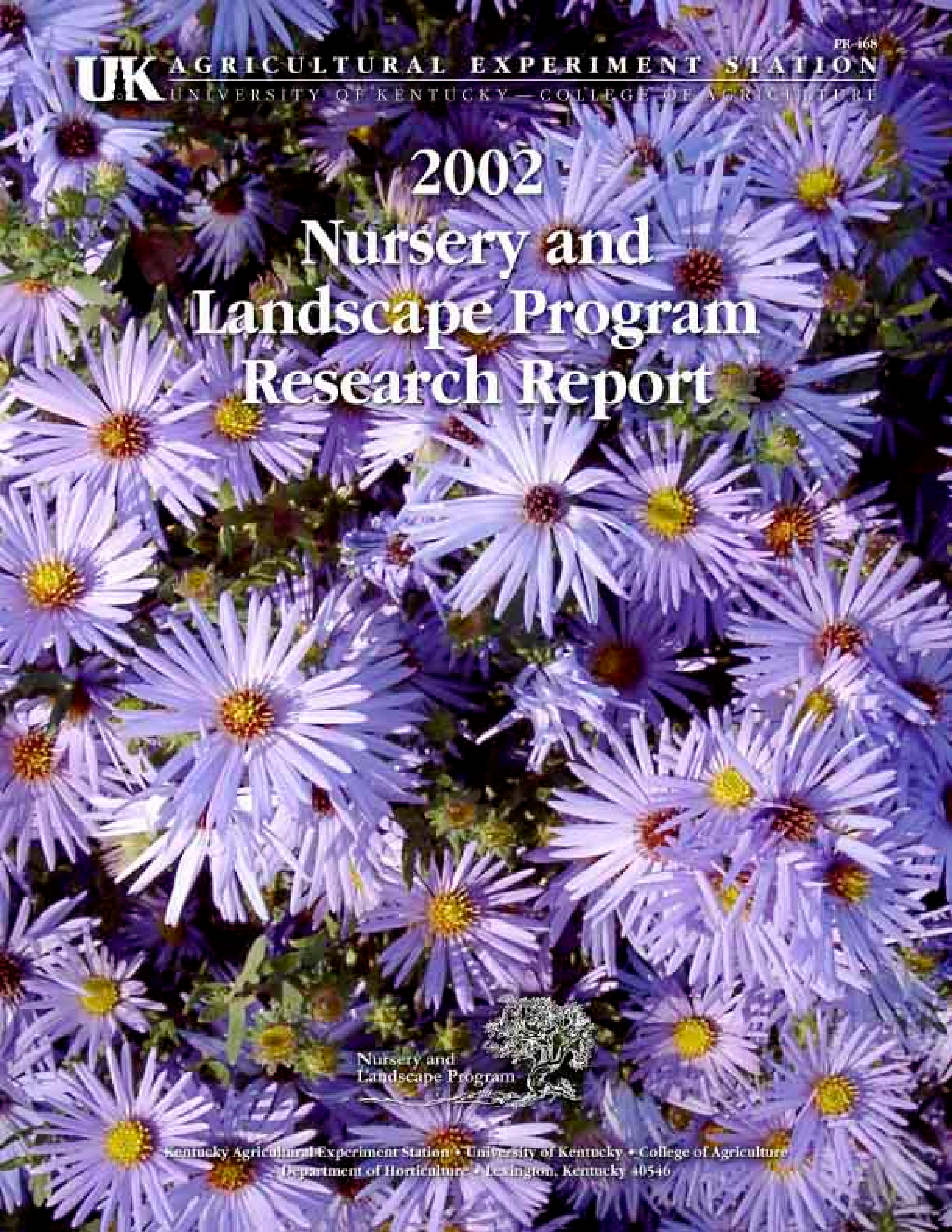


PR-468

UK AGRICULTURAL EXPERIMENT STATION

UNIVERSITY OF KENTUCKY—COLLEGE OF AGRICULTURE

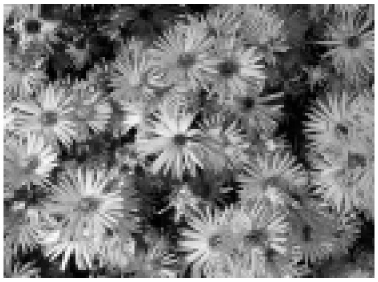
2002 Nursery and Landscape Program Research Report

Nursery and Landscape Program

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

UK Nursery and Landscape Program

Faculty, Staff, and Student Cooperators



About Our Cover

Aster oblongifolia var. *angustatus* 'Raydon's Favorite' is one of the Theodore Klein Plant Award Winners for 2003. Theodore Klein Plant Award Winners are selected by plant professionals for unique ornamental characteristics and the ability to successfully perform in Kentucky.

Aster oblongifolia, aromatic aster, is a native to Kentucky. Living up to its common name, the foliage, when brushed in passing, releases a "nice hint of mint" fragrance (Allan Armitage). 'Raydon's Favorite' aster is a dependable herbaceous perennial that provides a wonderful fall flower show. The simple ray flowers are blue-purple. The best season of flowering is September through October. Allen Bush received a piece of the plant from Raydon Alexander of San Antonio, Texas, with a note stating this aster was Raydon's favorite. Mr. Alexander had the plant "keyed out" with the result that it was believed to be originally from Lookout Mountain, Tennessee. The asters seen in October by the side of the road in Central Kentucky are *Aster oblongifolia*. This 3-foot tall by 2-foot to 3-foot wide mounding aster has done very well in Kentucky in a variety of landscape sites. Its hardiness zones are 5 to 9. It can be propagated by division in the spring or fall or cuttings taken in early summer.

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Nursery and Landscape Program

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Contents

UK Nursery and Landscape Program Overview—2002

Dewayne Ingram, Chair

Department of Horticulture

The faculty, staff, and students in the UK Nursery and Landscape Program are pleased to offer this 2002 Research Report. This is one way we share information generated from a coordinated research program involving teams of faculty, staff, and students from several departments in the College of Agriculture. The report has been organized according to our primary areas of emphasis: production and economics, pest management, and plant evaluation. These areas reflect stated industry needs, expertise available at UK, and the nature of research projects around the world generating information applicable to Kentucky. If you have questions or suggestions about a particular research project, please do not hesitate to contact us.

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

Extension Highlights

Our statewide and area educational conferences and seminars are probably the most visible activities of our Extension programs targeted to Kentucky's nursery and landscape industry. Publications, videos, slide sets, newsletters, articles in state and national industry magazines, newspaper articles, radio spots, and television programs are also important, visible elements of our Extension program. However, we are also engaged in a wide range of less visible but vital activities. More subtle activities include training for County Extension Agents so they can more effectively serve our clientele, the Plant Disease Diagnostic Clinic, soil testing and interpretative services, and diagnosis and problem-solving services. We were delighted to see that the outreach capacity of the arboretum on the UK campus increased significantly this year with the opening of the new visitors' center.

Although there are many facets to the Extension program conducted by the team of subject-matter specialists and county agents, program expansion provided through a Kentucky Horticulture Council grant from the Agriculture Development Board (tobacco settlement) funds is highlighted this year. Although most of the initial grant has been utilized to support expanded acreage of vegetables required by the three new marketing cooperatives, we were able to obtain an Extension Associate position for Nursery Crops in the western portion of the state. Amy Fulcher, who was a County Extension Agent for Horticulture in Hopkins County, has been hired in the position. Amy is a Western Kentucky University graduate and received an M.S. degree from North Carolina State University in nursery crop production. Amy is working in concert with Dr. Dunwell to provide additional support of the county agents and nursery managers and employees in the area. They have held several workshops and demonstrations and have established a demonstration pot-in-pot system at the UK Research and Education Center in Princeton. We are grateful for the additional funds to help us serve the nursery industry. The Kentucky Horticulture Council will be submitting a second proposal to the Agricultural Development Board for continuation of projects initiated this year and to enhance our ability to support the nursery and greenhouse industries.

Undergraduate Program Highlights

The department offers areas of emphasis in Horticultural Enterprise Management and Horticultural Science within a Plant and Soil Science Bachelor of Science degree. Following are a few highlights of our undergraduate program in 2002:

The Plant and Soil Science degree program has over 120 students in the fall semester of 2002, of which almost one half are horticulture students and another one-third are turfgrass students. Eleven horticulture students graduated in 2002.

We believe that a significant portion of an undergraduate education in horticulture must come outside the classroom. In addition to the local activities of the Horticulture Club and field trips during course laboratories, students have excellent off-campus learning experiences. Here are the highlights of such opportunities in 2002.

- A 18-day study tour of Belgium, France, Germany, Great Britain, and the Netherlands was led by Drs. McNiel and Dunwell involving 14 students.
- A one-week study tour of the nursery industry in Washington and Oregon was led by Drs. McNiel, Dunwell, and Geneve, involving 10 students.
- Horticulture students competed in the 2002 Associated Landscape Contractors of America (ALCA) Career Day competition at Illinois Central College in March (Drs. Robert McNiel and Mark Williams, faculty advisors).
- Students accompanied faculty to regional/national/international meetings, including the American Society for Horticultural Science Annual Conference, the Kentucky Landscape Industries Conference and Trade Show, the Southern Nursery Association Trade Show, the Green Industry Conference, and the International Horticultural Congress in Toronto.

Graduate Program Highlights

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

Extension Service, secondary and postsecondary education, and governmental agencies. Last year, there were nine graduate students in these degree programs conducting research directly related to the Kentucky nursery and landscape industry.

Graduate students are active participants in the UK Nursery and Landscape research program and contribute significantly to our ability to address problems and opportunities important to the Kentucky nursery and landscape industry. For example, graduate students presented research results at the Southern Nursery Association's Research Conference in Atlanta and the International Horticulture Congress in Toronto, and several will present their work during a session of the 2003 Kentucky Landscape Industry Conference and Trade Show.

The Robert E. McNiel Endowment

In the early 80s, the Horticulture Department realized that many of our graduates lacked exposure to the range of horticulture practices outside Ken tucky. The faculty made a commitment to provide at least one study tour opportunity per year to our students. Fulfillment of that commitment has primarily been through Dr. McNiel, who has often covered his travel expenses personally. He has led educational tours of industries and gardens throughout Kentucky, the United States, Europe, New Zealand, and China. Dr. McNiel has been a local, regional, and national leader for the Associated Landscape Contractors of America. He has assisted in their Student Career Days and has hosted this national event several times.

The Robert E. McNiel Horticulture Enrichment Fund is being endowed to honor Dr. McNiel and to provide support for faculty and student travel on our study tours. Dr. McNiel will be retiring within the next five years, and this is our opportunity to support future students wishing to participate in educational tours and activities. These study tours allow students to compare technology development at leading horticultural sites and research centers with application to horticulture in Kentucky and to determine the applicability of this technology to the Kentucky horticultural industries.

We are taking advantage of a unique opportunity through Kentucky's Research Challenge Trust Fund (RCTF). Any gift to this fund, or pledge made for payment over a five-year period, will be matched on a dollar-for-dollar basis. However, in order to be eligible for the match, we must have a minimum of $50,000 in gifts and/or pledges. As a result of UK's hosting of the Associated Landscape Contractors of America (ALCA) Student Career Days in 1999, there is a balance of $25,000, which ALCA has endorsed using for this effort. Therefore, we must raise $25,000 to match the $25,000 we already have in order to gain the RCTF match to create a permanent endowment of $100,000. Reaching the $50,000 level is crucial, or we lose the $50,000 RCTF match. We need your help. Please consider the opportunity to provide lasting support of our students and their education. Additional information is available by contacting me in the Horticulture Department (257-1601) or by calling the College of Agriculture Development Office (859-257-7200).

Aesculus parviflora Propagation by Layering

Robert E. McNiel and Steve Elkins, Department of Horticulture

Nature of Work

Aesculus parviflora (bottlebrush buckeye) has made many recommended lists during recent times. However, few plants are available on a regular basis in the nursery trade. Seed was the main method of propagation until the 1990s when Bir and Barnes (2) established a protocol for cutting propagation. Fordham (4), in his discussion of propagation of bottlebrush buckeye, devoted his explanation to seed, except for a final comment that root cuttings and root suckers can be a source. Seed availability, timing, or facilities may still limit this plant from being propagated in significant numbers by either seed or cuttings.

Layering has been recommended as a form of propagation for plants forming suckers by several authors during the 1900s (1,8). While addressing layering in one form or another, neither Mahlstede and Haber (7), Macdonald (6), Dirr and Heuser (3), nor Hartman et al. (5) define layering as a technique for bottlebrush buckeye. Bailey (1) addresses the benefits of wounding during the layering process. As a means of producing large numbers of bottlebrush buckeye with limited facilities and less dependence upon timing, we looked at mound layering. *Aesculus parviflora* were planted on the University of Kentucky Horticulture Research Farm during the early 1990s in north/south rows. During 1998 the plants were bush-hogged to the ground. Multi-stem regrowth occurred during 1999 and 2000. In August 2000 research was initiated in order to determine if rapid propagation could occur by mound layering A*esculus parviflora.* Sawdust was row mounded 18 inches deep and 3 feet wide around 41 plants. Starting in August 2000, three stems on 10 randomly selected plants were treated on a monthly basis. Treatments included cutting into non-rooting one- or two-year old stems near the base, treating with No. 3 Hormex, and keeping the stem gapped with a section of toothpick. A drip irrigation system was installed in the plot and scheduled to run 20 minutes twice a day at 9:00 a.m. and 2:00 p.m. One-GPH emitters were spaced every 2 feet along 2-inch diameter lines. Irrigation was turned off during the dormant months.

Results and Discussion

During March 2001, plants treated each of the previous months were evaluated for rooting. Plants treated August 2000 had roots formed at the wound site on 29 of 30 stems. Plants treated September 2000 had roots formed at the wound site on eight of 30 stems. No roots were found on stems treated during October through February. During November 2001, plants were again evaluated for rooting. Rooting had occurred on all plants treated through May 2001 (Table 1). The tendency was for more stems rooting (99%) for months (Aug., Sept., April, May) when treatments were on plants that were in active growth than when treated plants (84%) were in their dormant period (Oct. through March). A plant was left untreated, and during March 2001 three plants were completely pruned back to within 3 inches of the ground for comparison to the treated plants. At the November 2001 harvest time, the unpruned plant had 14 stems that were rooted, and the three pruned plants generated a total of 68 rooted stems on current season growth. No other wounding or hormone treatment occurred on these four plants. Stems on these plants rooted with the sawdust treatment of mound layering and irrigation. The other 37 original plants were also producing new stems during 2001. Between untreated old growth stems and new growth stems, an additional 617 rooted stems were removed from these 37 plants; an average of 16.7 rooted stems per plant.

Rooted stems had either new coarse or fine roots. Coarse roots were most common, and it was suspected that stems with fine roots might not survive. This was not tracked as to root type, but survival of rooted stems as liners was recorded. Rooted stems were placed in 3-quart containers and overwintered in an unheated Quonset house. Eighty-three percent of the stems from treated plants leafed out and developed into the liner stage (Table 1). Ninety-three percent of the stems from untreated plants leafed out and developed into the liner stage.

Table 1. Stems rooted and successfully established as a liner during month-by-month treatment.

Month	Rooted Stems	Survival in the Liner Stage
August , 00	30	28
September, 00	30	25
October, 00	25	22
November, 00	26	19
December, 00	25	19
January, 01	27	16
February, 01	25	23
March, 01	23	21
April, 01	30	27
May, 01	29	24

Significance to Industry

Rapid propagation of *Aesculus parviflora* through mound layering is very feasible. Mound layering without wounding and hormone treatment will generate rooted shoots. Stems that do not root under normal mound layering techniques will benefit from wounding and hormone treatment.

Literature Cited

1. Bailey, L. H. 1920. The Nursery Manual. Macmillan Pub., New York.
2. Bir, R. E., and H. W. Barnes. 1994. Stem cutting propagation of bottlebrush buckeye. Comb. Proc. Intl. Plant Prop. Soc. 44: 499-502.
3. Dirr, M. A. and C. W. Heuser Jr. 1987. The reference manual of woody plant propagation: From seed to tissue culture. Varsity Press, Athens, Georgia.
4. Fordham, A. J. 1987. Bottle brush buckeye (*Aesculus parviflora*) and its propagation. Comb. Proc. Intl. Plant Prop. Soc. 37: 345-347.
5. Hartmann, H. T., D. E. Kester, F. T. Davies Jr., and R. L. Geneve. 1998. Plant propagation principles and practices, 6th ed. Prentice Hall, New Jersey.
6. Macdonald, B. 1986. Practical woody plant propagation for nursery growers. Timber Press, Portland, Oregon.
7. Mahlstede, J. P., and E. S. Haber. 1957. Plant propagation. Wiley & Sons, New York.
8. Wells, J. S. 1985. Plant propagation practices. Amer. Nurseryman Pub., Chicago.

Pruning Influence on Shoot Development with Container-Grown *Aesculus parviflora*

Robert E. McNiel and Kirk Ranta, Department of Horticulture

Nature of Work

Aesculus parviflora (bottlebrush buckeye) has been awarded elite status by being named to several outstanding-plant lists or to state plant-recognition programs. Individual plants displayed in retail settings have not always had comparable sales appeal. Instead of irregular or tall lanky growth, it was thought that lower branched and more uniform plants would be more acceptable by the buying public. Research was established to evaluate stem number, placement, and length as influenced by pruning plants during production. Seeds were collected from *Aesculus parviflora* and planted on the University of Kentucky Horticulture Research Farm during the fall of 2000. The resulting seedlings (6 to 30 inches tall) were harvested in November 2001 and individually placed in 3-quart containers. Plants were overwintered in a 13 x 48-foot unheated Quonset house covered with opaque poly. During February 2002, 130 plants were divided into three groups of 40+ plants. Three treatments consisted of unpruned stems, stems cut back to within 2 inches of the substrate line, and stems cut back to within 6 inches of the substrate line. Data were analyzed by analysis of variance using the General Linear Models Procedure (SAS).

Results and Discussion

During June 2002, data were collected as new stem counts originating from two positions on the remaining plant: originating above substrate line or from the base or below the substrate line.

The average number of shoots per plant was determined by averaging the count from two positions on the plant (above and below the substrate line) (Table 1). Unpruned plants showed apical dominance within the population. This resulted in the fewest shoots per plant (0.81) as many terminal buds continued to elongate without producing many additional shoots either above or below the substrate line. Pruning encouraged additional bud break, whether pruned at 2 or 6 inches. Plants pruned at 6 inches had more of the stem remaining and thus had more buds. This yielded more total shoots (1.97) than plants pruned at 2 inches (1.58) (Table 1).

Plants pruned at 2 inches produced more shoots below the substrate line (1.90) than above the substrate line (1.26) (Table 3). Plants pruned at 6 inches produced more shoots from above the substrate line (2.47) than below the substrate line (1.47) (Table 4). For shoots that were produced, pruning did not influence average new shoot length (Table 1). Average new shoot length (in.) on unpruned plants did not differ from lengths on plants pruned at 2 or 6 inches (Table 1). Average total shoot length did present differences among treatments. On unpruned plants, average total shoot growth from below the substrate line (13.00) exceeded shoot growth originating above the substrate line

Table 1. Average total number of shoots per plant (including above and below the substrate counts) and average length of those shoots for three pruning treatments on *Aesculus parviflora*.

Pruning Treatment	Number of Shoots [y]	Average Length of Shoots [z] (in.)
Unpruned	0.81 C	5.17 A
Pruned at 2 inches	1.58 B	5.93 A
Pruned at 6 inches	1.97 A	6.20 A

[y] Means with the same letter for each variable are similar at $p \leq 0.01$; n = 260.

[z] Means with the same letter for each variable are similar at $p \leq 0.01$; n = 182.

Table 2. Total number of shoots and average total shoot length produced at two positions on plants that were not pruned.[z]

Position	Number of Shoots	Average Total Shoot Length (in.)
Above substrate	1.30 A	4.67 B
Below substrate	0.32 B	13.00 A

[z] Means in the same column with the same letter for each variable are similar at $p \leq 0.01$; n = 182.

(4.67) (Table 2). For plants pruned at 2 inches, no difference occurred for shoot growth for the below (14.75) and above (12.37) substrate positions (Table 3). For plants pruned at 6 inches, average total shoot length above substrate level (15.28) was statistically different from average total shoot length below substrate level (12.73) (Table 4).

Plants that were pruned did not produce flower buds, regardless of pruning height (data not shown). Unpruned plants did occasionally produce flower buds.

Significance to Industry

Plant branch height, compactness, and uniformity can be influenced by pruning *Aesculus parviflora* during container production practices. Pruning at 2 or 6 inches above the substrate line increased branching and improved the quality of the plant versus those unpruned. Pruning at 2 inches above the substrate line increased the number of stems arising from the base versus pruning at 6 inches. This should benefit the appearance of plants marketed in 3- or 4-quart container sizes. Work is continuing to see if either of these pruning heights will influence plant quality when it is moved to 3-gallon or larger production sizes. By achieving better quality in plant appearance through more stem development and lower branching, *Aesculus parviflora* may have better sales appeal at the retail level.

Table 3. Total number of shoots and average total shoot length produced at two positions on plants that were pruned at 2 inches.[z]

Position	Number of Shoots	Average Total Shoot Length (in.)
Above substrate	1.26 B	12.37 A
Below substrate	1.90 A	14.75 A

[z] Means in the same column with the same letter for each variable are similar at $p \leq 0.01$; n = 182.

Table 4. Total number of shoots and average total shoot length produced at two positions on plants that were pruned at 6 inches.[z]

Position	Number of Shoots	Average Total Shoot Length (in.)
Above substrate	2.47 A	15.28 A
Below substrate	1.47 B	12.73 B

[z] Means in the same column with the same letter for each variable are similar at $p \leq 0.01$; n = 182.

Acknowledgment

Statistical analysis was completed with the assistance of Dr. John Snyder, Department of Horticulture, University of Kentucky.

Use of Computer Imaging to Evaluate the Initial Stages of Germination in Woody Tree Seeds

Manjul Dutt and Robert L. Geneve, Department of Horticulture

Nature of Work

Seed germination begins with the initiation of water uptake by the dry seed and ends with the protrusion of the radicle from the fully imbibed seed. Measurement of initial water uptake is usually by measuring fresh weight gain, which is laborious and requires physical handling of each seed. Such techniques require pooling of seeds to make different samples to estimate average values and submit to statistical analysis. These methods do not record growth performance and variation on an individual seed basis. Dell Aquilla et al. (2) and McCormac and Keefe (8) have described image analysis systems to monitor the imbibition in cabbage and cauliflower seeds. Such techniques, though useful, require the setup of sophisticated and expensive equipment. The computer imaging system developed by Geneve and Kester (4) uses a simple Petri dish germination system that is inexpensive and amenable to automated capture of sequential digital images in real time.

In this study, the techniques developed by Geneve and Kester (4) were used to evaluate seed dormancy release in two woody legume species with different dormancy types. Honeylocust (*Gleditsia triacanthos* L.) seeds have physical dormancy and require scarification to allow imbibition. The objective was to show how this computer-aided system could document initial water uptake in seeds following physical or acid scarification. Eastern redbud (*Cercis canadensis* L.) seeds have physiological dormancy and require chilling stratification(6). In this case, radicle growth in excised embryos is an indicator of release from dormancy following chilling. Therefore, radicle length was measured on an hourly basis in nonchilled and chilled seeds to determine specific growth rates.

Seeds of honeylocust were acid scarified for 30 or 60 minutes in concentrated H_2SO_4 or physically scarified by nicking the center of the seed using a file. Seeds of redbud were treated with concentrated H_2SO_4 for 30 minutes and stratified at 4°C for four weeks. Non-stratified seeds were acid scarified but did not receive chilling. After four weeks, embryos were surgically removed from redbud seeds.

Two honeylocust seeds or four redbud embryos were placed in 6-cm-diameter plastic Petri dishes containing one piece of transparent cellulose film (Celorey-PUT, Cydsa Monterrey, Mexico). Honeylocust seeds were surface sterilized in 10% Clorox® solution for 10 minutes and washed in distilled water before being placed in a Petri dish containing 2 ml of distilled water. Petri dishes were sealed with Parafilm® and placed on a flat-bed scanner (HP Scanjet

5370 C with transparency adapter). The scanner was controlled using a SigmaScan Pro 5.0 for Windows (SPPC Science, Chicago, Ill.) macro written in Visual Basic that allowed for timed interval scans. For this experiment, scans were taken at hourly intervals. Gray-scale images (stored as 200 dpi, TIFF files) were analyzed using another SigmaScan® macro that allowed for batch processing of the various images in a short period of time. Data were recorded for percentage increase in seed size until radicle emergence for honeylocust and radicle length (mm) for three days in excised redbud embryos.

Results and Discussion

Seeds treated with concentrated H_2SO_4 for 60 minutes had a faster imbibition rate compared with seeds that were acid scarified for 30 minutes or physically scarified (Figure 1). Seeds treated with concentrated H_2SO_4 (60 minutes) reached 50% of their final imbibed size within 11 hours after imbibition, compared to 20 hours for physically scarified seeds (significant at P 0.01). Seeds treated with concentrated H_2SO_4 (30 minutes) remained small and did not imbibe much water or germinate for the study period.

According to Woodstock (9), hardseededness may be due to a compact arrangement of cellulose microfibrils in the cell wall, involving an irreversible change in micellar structure during maturation and dehydration of the seed. Honeylocust seeds have a palisade epidermal layer with thick-walled malpighian cells. Subsequently, 30-minute acid scarification was not enough to adequately scarify the epidermal layer leading to reduced imbibition.

There was less variation in the rate of water uptake between seeds treated with concentrated H_2SO_4 (60 minutes) compared to physically scarified seeds (Figure 2). This may be due to a larger and more uniform disruption of surface area cells in acid scarified seeds compared to a single wound site on the seed coat for nicking or may be due to the non-precise nature of physically nicking the seeds. However, Figure 2 does show how the imaging system can easily compute water uptake on a single seed basis for such an analysis.

Baskin et al. (1) suggested that in legume seeds the lens (strophiole) is the first place on the seed coat for water entry when hard seeds become permeable under natural conditions. In contrast, for acid scarified legume seeds, Liu et al. (7) showed a general reduction in the materials covering macrosclerieds throughout the seed. Therefore, rather than a single entry point for water, it would be anticipated that acid-treated seeds would show uniform water uptake over the entire seed surface. However, when water entry was followed on an hourly basis, acid-treated honeylocust seeds showed asymmetric water uptake across the seed with more water initially entering at the chalazal and micropylar ends that produced a "dumbbell"-shaped appearance (Figure 3). This suggests that the cells in the polar regions of the seed were more susceptible to acid scarification than cells in the middle of the seed.

Figure 1. Seed area in acid vs. physically scarified honeylocust seeds.

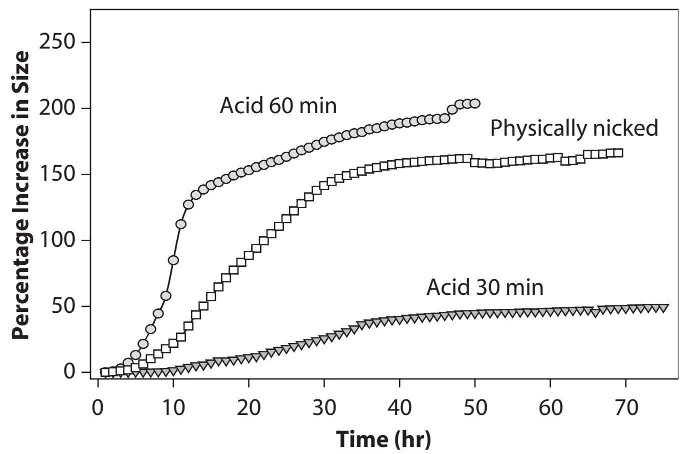


Figure 2. Impact of stratification on increase in size in individual honeylocust seeds.

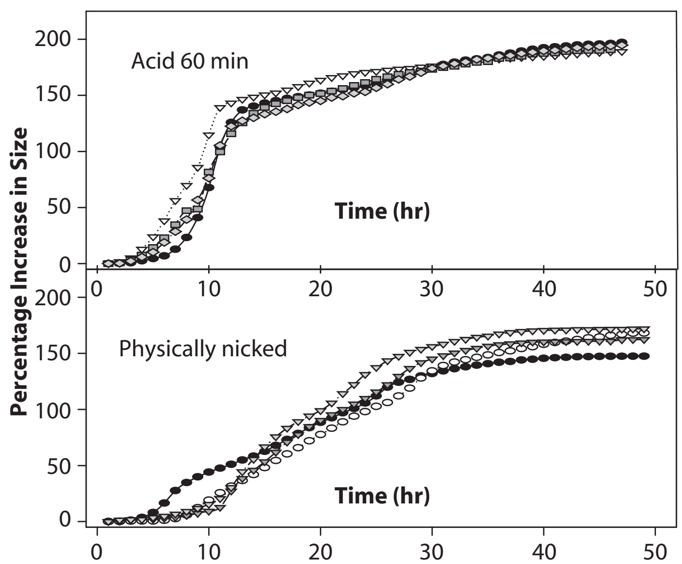
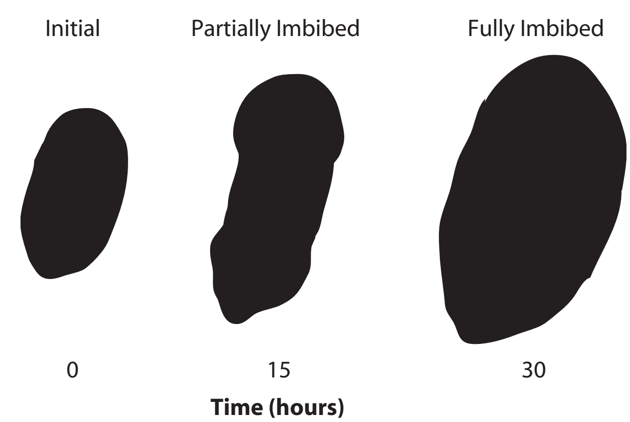


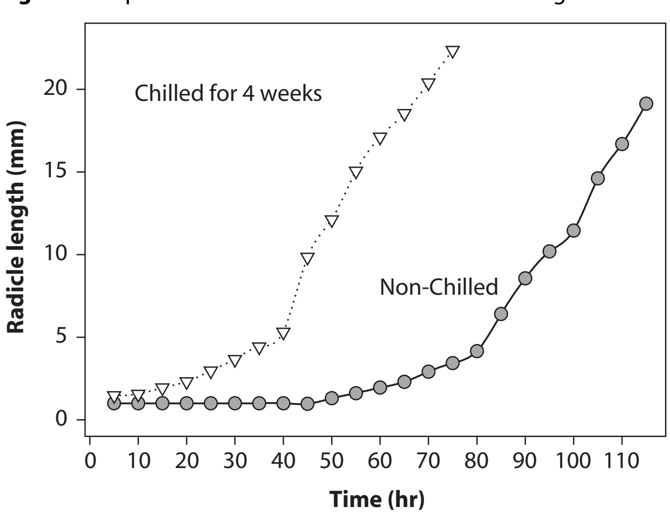
Figure 3. Water entry over the first 45 hours in honeylocust seeds treated with acid showing the "dumbbell" shape in partially imbibed seeds.



Physically scarified seeds showed initial water uptake at the point of nicking with water spreading from the center of the seed to the opposite ends of the seed or from one end to the other end of the seed depending on the initial nicking point. The sequential images captured by the flat-bed scanner allowed us to document the water uptake at hourly intervals and enabled us to see the position of water uptake in the honeylocust seeds as would not be possible by former techniques. One of the characteristics of seeds with non-deep or intermediate physiological dormancy is that the embryo shows increased growth potential following chilling stratification (5). Geneve (3) showed that isolated redbud embryos from chilled seeds grew faster than non-chilled embryos. However, these measurements were performed by hand and done every 24 hours. In contrast, using the computer-aided imaging system, radicle length could be measured every hour and a precise growth rate calculated with little researcher investment in time (Figure 4). As predicted, non-chilled redbud embryos took 48 hours to initiate growth and required 90 hours for radicles to reach 10 mm in length, while embryos chilled for four weeks initiated growth immediately and reached a radicle length of 10 mm in only 45 hours (Figure 4; significant at P 0.01).

The two experiments described in this paper demonstrated that sequential digital images captured with the flat-bed scanner can be used for a variety of growth-related aspects of seed germination. It enabled easy identification and analysis of water entry into seeds. This technique revealed changes in seed morphology that were previously undocumented for seeds with physical dormancy. This technique can also be used for assessing seeds with other types of dormancy. Also, the use of sequential imaging holds promise for an automated system to assess seed quality in seed lots.

Figure 4. Impact of stratification on redbud radicle length.



Significance to the Industry

Sequential digital images captured with the flat-bed scanner allowed for easy identification and analysis of water entry into seeds. This technique revealed changes in seed morphology that were previously undocumented for seeds with physical dormancy. Continued research will provide additional morphological details for seeds with other types of dormancy, including physiological and morphological dormancy. The use of sequential imaging also holds promise for an automated system to assess seed quality in seed lots. This will be important for determining initial seed quality after seed harvest and for evaluating quality in stored seeds that are experiencing deterioration.

Literature Cited

1. Baskin, J. M., C. C. Baskin and X. Li. 2000. Taxonomy, anatomy and evolution of physical dormancy in seeds. Plant Species Biol. 15:139-152.
2. Dell Aquila, A., J.W. Van Eck, and G.W.A.M. Van der Heijden. 2000. The application of image analysis in monitoring the imbibition process of white cabbage (*Brassica oleracea* L.) seeds. Seed Sci. Res. 10:163-169.
3. Geneve, R. L. 1991. Seed dormancy in eastern redbud (*Cercis canadensis*) . J. Amer. Soc. Hort. Sci. 116:85-88.
4. Geneve. R.L. and S.T. Kester. 2001. Evaluation of seedling size following germination using computer aided analysis of digital images from a flat-bed scanner. HortScience 36:1117-1120.
5. Hartmann, H.T., D.E. Kester, F. T. Davies Jr., and R. L. Geneve. 2002. Hartmann and Kester's Plant Propagation: Principles and Practices. Prentice-Hall Inc., Englewood Cliffs, New Jersey. Seventh edition.
6. Jones, R.O., and R.L. Geneve 1995. Seedcoat structure related to germination in eastern redbud (*Cercis canadensis* L.). J. Amer. Soc. Hort. Sci.120:123-127.
7. Liu, N.Y., H. Khatamian, and T.A. Fretz. 1981. Seed coat structure of three woody legume species after chemical and physical treatments to increase seed germination. J. Amer. Soc. Hort. Sci. 106:691-694.
8. McCormac, A. C., P.D.Keefe, and S. R. Draper (1990). Automated vigour testing of field vegetables using image analysis. Seed. Sci. Technol. 18:103-112.
9. Woodstock, L.W. 1988. Seed imbibition: a critical period for successful germination. J. Seed Technol. 12:1-15.

Evaluation of Cultural Practices for Container Production of Passion Flowers

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Nature of Work

Passion flowers are members of the genus *Passiflora* and are among the most exotic flowers in cultivation. The *Passiflora* genus includes many species and hybrids with a vast diversity of color and shape of flowers and foliage (5). Although most passion flowers are easily propagated from cuttings (2), there is little information available to growers about the cultural practices necessary for successful nursery production of these vines.

The overall objective of this project is to produce tropical vines with unusual flowers for the summer garden center container market using standard outdoor nursery production (Figure 1). This will require cultural practices that maximize growth and flower production.

In the summer of 2001, a preliminary study carried out using *Passiflora* 'Blue Bouquet' determined that fertilizer concentration had a significant impact on shoot length. Therefore, the objective of the current study was to evaluate effect of increasing fertilizer concentrations on shoot length, flower number, and biomass in several cultivars from diverse genetic backgrounds.

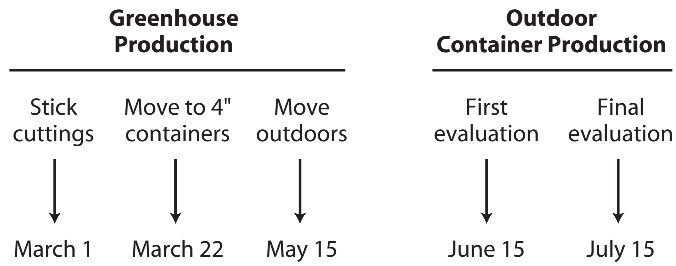
Four cultivars, *Passiflora* 'Blue Bouquet', *P.* 'Amethyst', *P.* 'Fledermouse', and *P.* 'Lady Margaret' were propagated from two node cuttings taken in early March, treated with indole-3-butyric acid (IBA) (1,000 ppm in talc), and stuck in Oasis rooting cubes. Cuttings were placed in an intermittent mist bed (5 sec. every 10 min.) with bottom heat (75°F). After three weeks, cuttings were moved to 4-inch plastic containers with a peat/bark medium (Scott's Metro Mix 360) and placed in the greenhouse. The greenhouse was maintained with day/night temperatures at 78/68°F. Plants were fertilized with a 100 ppm fertilizer solution (Peter's 20-10-20) at each watering.

Plants were moved to 5-quart containers (Nursery Supplies Inc. Classic 500) in Barky Beaver (Professional Grow Mix, Moss, Tenn. 38574) southern pine bark substrate on May 15, 2002, and moved to the outdoor nursery and placed on trickle irrigation. Each container was treated with slow-release fertilizer (Osmocote 14-14-14) at 15, 20, or 25 grams per container. The plants were harvested after two months of growth in the nursery (July 15) and evaluated for number of stems, stem length, number of nodes, dry weight, and number of flowers.

Results and Discussion

All cultivars, except *P.* 'Fledermouse' produced greater shoot length (Figure 2) and biomass (Figure 3) with 25 compared to 15 grams of fertilizer. *P.* 'Amethyst' and *P.* 'Blue Bouquet' showed the most significant increase in shoot length (72% and 50%, respectively) and biomass (92% and 49%, respectively).

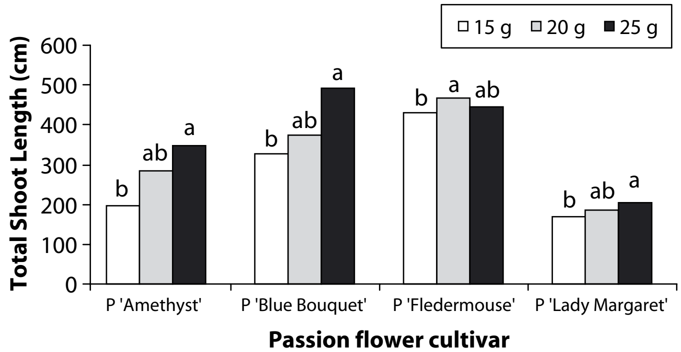
Figure 1. Production schedule for single-season container-grown passion flowers in Kentucky.



The results for flower numbers, though, were quite different. *P.* 'Fledermouse' and *P.* 'Blue Bouquet' showed no increase in flowering at higher levels of fertilizer. However, *P.* 'Amethyst' showed a 93% increase in flower number when fertilizer was increased from 15 g to 25 g and *P.* 'Lady Margaret' showed a 15% increase in flower number with the same increase in fertilizer (Figure 4).

One possible reason for these data is that, toward the end of the production cycle, the fertilizer was becoming depleted. Controlled release fertilizers such as Osmocote can increase nutrient release by as much as 30% for every 10°C increase in temperature (4). Therefore, nutrient loss can be quite severe during hot weather. During the nursery production phase, with the containers in direct sunlight, they can build up considerable heat, and the substrate temperature can rise well above ambient temperature (1). Furthermore, although the manufacturer's recommended rate of fertilizer for this size container is 14 grams, because of the high growth rate of passion flowers, a higher concentration may be necessary. Due to nutrient leaching and the effect of increased temperatures on the controlled release fertilizers, multiple applications may be necessary

Figure 2. Passion flower total shoot length after two months treated with different levels of fertilizer (Osmocote 14-14-14).



Within each cultivar, columns with the same letters are not significantly different (Tukey's HSD, P ≤ 0.05).

to prevent nutrient supply depletion as the season progresses (3).

A probable reason for the data on flower numbers is the genetic diversity of the plants studied. It is quite possible that some of these varieties will not flower early in the season regardless of cultural practices. Indeed, this is the most likely explanation for the results collected for flowering of *P.* 'Fledermouse' and *P.* 'Blue Bouquet'. Further evaluation is needed to determine is flowering is influenced by cultural practices or if flowering in these varieties is a factor of the plants' genetics.

Although *P.* 'Lady Margaret' had the shortest stem length of all varieties tested, it had the greatest number of flowers, and it had the highest bio-mass relative to stem length. It produced a plant with much heavier stems and leaves along with increased flowering. The increase in fertilizer concentration resulted in an increase in stem length, flower number, and bio-mass for *P.* 'Amethyst'. Two varieties, *P.* 'Fledermouse' and *P.* 'Blue Bouquet', both produced long stems; however, neither one had a significant number of flowers. Indeed, many of these plants had no flowers at all in the time allowed by the given production schedule. Ultimately, *P.* 'Lady Margaret' and *P.* 'Amethyst' showed the greatest promise and were most productive when grown using this production scheme.

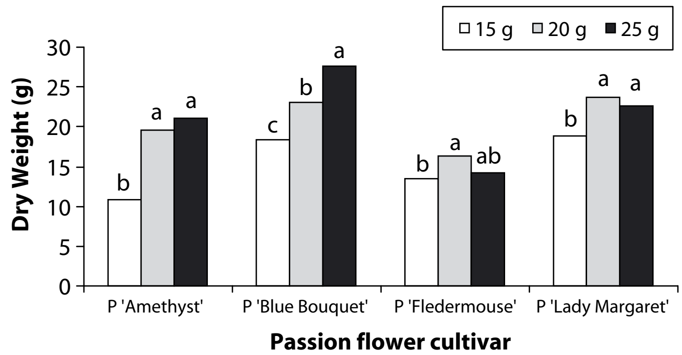
Significance to the Industry

This is the second report on studies carried out to evaluate the production of container-grown passion flowers. This study has shown that selected varieties can be successfully grown in Kentucky as a single-season crop using the production schedule presented above. Acceptable plants can be grown in the two-month production scheme in an outdoor nursery using one application of 25 grams of Osmocote 14-14-14 fertilizer. These plants have good potential as a high-value, container-produced plants for patio or garden use in a market where customers are looking for exotic, tropical vines.

Literature Cited

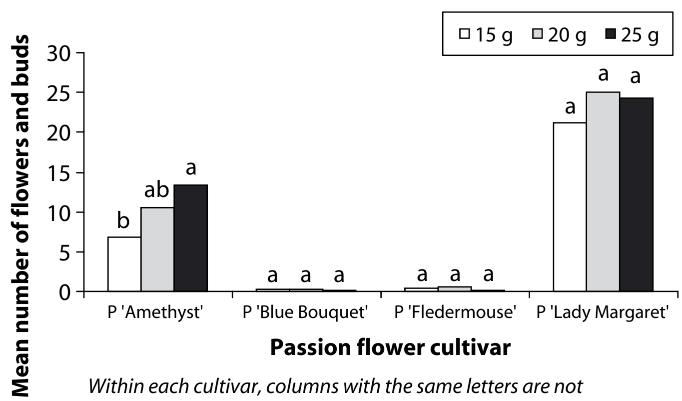
1. Cox, D. A. 1993. Reducing nitrogen leaching-losses form containerized plants: the effectiveness of controlled-release fertilizers. Journal of Plant Nutrition 16(3), 533-545.
2. Hale, B.S., R.L. Geneve, and R. Anderson. 2001. *Passiflora* (passion flower) species and cultivars for use as summer climbers in the southern landscape. Proceedings of Southern Nurserymen's Association Research Conference 46:353-355.

Figure 3. Passion flower dry weight after two months treated with different levels of fertilizer (Osmocote 14-14-14).



Within each cultivar, columns with the same letters are not significantly different (Tukey's HSD, P ≤ 0.05).

Figure 4. Mean number of flowers after two months treated with different levels of fertilizer (Osmocote 14-14-14).



Within each cultivar, columns with the same letters are not significantly different (Tukey's HSD, P ≤ 0.05).

3. Huett, D. O. 1997. Fertilizer use efficiency by containerized plants. Australian Journal of Agricultural Research 48:251-258.
4. Lamont, G. P., R. J. Worrall, and M. A. O'Connell. 1987. The effects of temperature and time on the solubility of resin coated controlled-release fertilizer under laboratory and field conditions. Scientia Horticulturae 32, 265-273.
5. Vanderplank, J. 1996. Passion Flowers. Cassell Pub. Ltd., London.

Use of Pelletized Poultry Litter as a Container Substrate

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Nature of Work

Kentucky has 2,050 (T. Pescatore, UK Poultry Extension Specialist, personal communication) poultry houses producing approximately 150 tons of animal waste per house each year (7). Poultry litter is potentially an inexpensive and readily available product for the Kentucky nursery industry. While studies have indicated that various sources and forms of composted animal waste can be used as a container substrate (1, 4, 5), literature indicates that 10 to 20% is the maximum amount by volume that can be utilized (6, 3, 2).

The objectives of this preliminary study were to determine if pelletized poultry litter could be used as a container substrate and, if so, determine the maximum amount of poultry litter that could be utilized.

Uniform rooted cuttings of *Euonymus fortunei* 'Emerald Gaiety', *Spirea* x *bumalda* 'Goldflame', and *Euonymus alatus* 'Compactus' were potted on August 9-10, 2000, into 3.8 liter (#1) containers with pine bark and 0, 5, 10, or 20% pelletized poultry litter (All Natural Organic Flower & Vegetable Fertilizer, 3-4-3, Plant Right Inc., Purdy, Mo.) by volume. The experiment was a randomized complete block design with 10 replications of each treatment. Plants were grown on a gravel pad with overhead irrigation, consistent with normal production practices at Metcalfe Landscaping and Garden Center, Madisonville, Kentucky. Plants were not topdressed with commercial fertilizer.

A visual assessment was made whether plants were alive or dead, and growth was measured on August 28, 2000. Plant quality rating criteria are shown in Table 1. Data were subjected to statistical analysis using ANOVA and mean separation.

Results and Discussion

For all species studied, addition of poultry litter did not significantly improve plant quality as compared to untreated plants (Tables 2 through 4). However, addition of poultry litter at 20% by volume significantly reduced quality for all three species, indicating that this level exceeds that which could be used in a nursery setting. For *Euonymus alatus* 'Compactus', substrate of 10% poultry litter significantly reduced plant quality.

Table 1. Criteria used to assess plant quality of three ornamental species grown in pine bark substrate supplemented with pelletized poultry litter.

Rating	Criteria
0	Dead
1	Alive, some burning or chlorosis
2	Alive, green, no new growth
3	< 1.5″ of new growth
4	1.5″ - 2.5″ of growth
5	> 2.5″ of growth

Table 2. Plant quality evaluation of *Euonymus alatus* 'Compactus' grown in pine bark substrate with addition of 0, 5, 10, or 20 percent poultry litter by volume.

Euonymus alatus 'Compactus'

Poultry Litter Concentration	Rating*
0	2 A
5	1.7 ± 0.48 A
10	0.4 ± 0.52 B
20	0 B

* Means followed by the same letter are not significantly different.

Table 3. Plant quality evaluation of *Euonymus fortunei* 'Emerald Gaiety' grown in pine bark substrate with addition of 0, 5, 10, or 20 percent poultry litter by volume.

Euonymus fortunei 'Emerald Gaiety'

Poultry Litter Concentration	Rating*
0	2.1 ± 0.32 A
5	2.3 ± 1.25 AB
10	1.8 ± 1.14 AB
20	0.3 ± 0.95 B

* Means followed by the same letter are not significantly different.

Table 4. Plant quality evaluation of *Spirea* x *bumalda* 'Goldflame' grown in pine bark substrate with addition of 0, 5, 10, or 20 percent poultry litter by volume.

Spirea x *bumalda* 'Goldflame'

Poultry Litter Concentration	Rating*
0	4.4 ± 0.84 A
5	4.8 ± 0.42 A
10	3.6 ± 1.17 A
20	0 B

* Means followed by the same letter are not significantly different.

Species Effect

Spirea x *bumalda* 'Goldflame' had higher plant quality than *Euonymus alatus* 'Compactus' under all treatment conditions.

Flies congregated and laid eggs on the bottoms of containers, creating unsavory working and retail sales conditions. In addition, a strong odor necessitated the experiment being relocated to a site further away from retail customer traffic. While this may not be a serious concern for wholesale nurseries, it may impact shipping to retail locations. Shrinkage of 25% was a concern observed in the pots containing 20% poultry litter.

Significance to the Industry

An abundance of poultry litter is found throughout many states in the southeastern United States. Poultry litter is an acceptable substrate in small quantities for some nursery crops. While some crops may tolerate 10%, a maximum of 5% by volume poultry litter should be observed for certain crops. Testing for the optimum percent poultry litter for each new crop is necessary. Testing each new source of poultry litter is also advised.

Literature Cited

1. Adkins, C. and T. Bilderback. 1997. Composted dairy cow manure as an amendment for nursery potting substrates. Proceedings of the SNA Research Conference 42:144-145.
2. Best management practices guide for producing container-grown plants. 1997. SNA, Marietta, GA.
3. Bilderback, T.E. and M.A. Powell. Using compost in landscape beds and nursery substrates. North Carolina State University Extension publication AG 473-14.
4. Bradley, G. J., M. H. Glass, and T. Bilderback. 1996. Dairy cow compost as a potting substrate for growing hybrid rhododendrons. Proceedings of the SNA Research Conference 41:128-129.
5. Flinn, C., R. Campbell, and T. Bilderback. 1997. The use of bioconverted swine biosolids as an amendment for potting media for commercial nursery production. Proceedings of the SNA Research Conference 42:146-147.
6. Inbar, Y., Y. Chen, and Y. Hadar. 1985. The use of composted slurry produced by methoanogenic fermentation of cow manure as a growth media. Acta Hort. 172:75-82.
7. Rasnake, M. Broiler litter production in Kentucky and potential use a nutrient source. University of Kentucky Extension publication AGR-168.

Acknowledgments

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Influence of Rose Fragrance and Color on Host Location by the Japanese Beetle

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Nature of Work

The Japanese beetle (JB), *Popillia japonica* Newman, is a voracious plant-feeding insect and a historic pest of roses (*Rosa hybrida*). Cultivated roses are described as "perhaps the most preferred" of all the ornamental plants (2). Beetles typically alight on blooms, due possibly to their presence on the plant, their alluring odor, or their striking colors. The characteristic top-down feeding pattern of Japanese beetles on tree hosts, like linden, suggest that these beetles may alight on rose blooms because of their presence on the plant, or plant height in general. Some rosarians have observed, in mixed plantings of hybrid tea roses, that taller plants are often attacked first before more compact flowering roses. Beetles are also attracted to a range of plant-produced volatiles, particularly those that are floral or fruity in nature. In fact, early USDA entomologists suggested that "odor is probably the most important factor in the beetle's selection of a plant" (1). Visual cues, like color, are also used in plant selection. Artificial flowers that are white and yellow are landed on by more beetles than other colors in the presence of a standard odor source.

In the present study, artificial rose flowers, or flower models, and potted hybrid tea roses with either red or yellow flowers were used to test the influence and interaction of height, fragrance, and color on selection of rose blooms by Japanese beetles. The objective of the first experiment was to determine the influence and potential interaction of bloom height, bloom color, and fragrance. In this experiment, a red and yellow flower model, of the same size, was attached to a stake placed in the center of a non-flowering potted rose. One flower of each pair was attached 23 cm above the other. There were four treatments (first being the upper, second lower, respectively); red versus yellow, yellow versus red, red baited versus yellow, yellow versus red baited. The bait was a rubber septa containing 10 ml Bulgarian rose oil concealed in the center of the flower model. This experiment was conducted in 4 h trials on two separate days. The number of beetles that landed on each flower model was recorded.

A second experiment evaluated the role of elevated plant height on recruitment of beetles. Potted flowering hybrid tea roses (Celebrity, yellow flowers) were transported to Spindletop farm in late July. Plants were paired so that each plant had the same number of blooms. One plant was then elevated 0.6 m above the ground using a plastic trash can. The second member of the pair was placed in the grass at the base of the can. The number of beetles that landed on the flowers and foliage of either plant was recorded over 4 h. The position of the plants was reversed after 2 h.

The third experiment evaluated the response of beetles to red- and yellow-flowered rose cultivars (Table 1) that varied in the strength of their fragrance, as indicated by the breeders. It is important to note that this classification of rose fragrance is subjective and variable. Nevertheless, the use of this non-quantitative variable provides a treatment structure that is amenable to further analysis if significant differences are found. This experiment was conducted during late July to early August 2002. Flowering potted plants were transported to Spindletop and placed adjacent to a soybean field where beetles were active. Plants were grouped by the number of open flowers and placed 1 m apart with 2 m between each replicate. Beetles were counted, then removed from plants over a 4-h period. Varieties tested in trial 2 are listed in Table 1. Plants in this trial were grouped by bloom number and arranged into replicates as previously described. The number of beetles landing on these plants was recorded for 4 h.

Results and Discussion

The first experiment with rose models showed that, among unscented flowers, significantly more beetles landed on yellow than red flowers. This confirms the results of previous work with flower models showing more beetles landing on yellow and white flowers. Among unbaited flowers, there was also no difference in the number of beetles landing on the upper or lower flowers for each color. When a yellow flower was paired with a baited red flower, however, the number of beetles landing on red, baited flowers was significantly more than the yellow flowers. This experiment suggests that the position of the flower on the plant is not as significant as the influence of color or odor. Likewise, the addition of fragrance to a less attractive red flower can make it significantly more attractive than a yellow flower. In general, the plants that had baited flowers had significantly more beetles than plants with unbaited flowers.

The second experiment evaluated whether Japanese beetles prefer plants based on plant height. The same experiment conducted with flowering canna, another preferred host of Japanese beetles, showed twice as many beetles on canna plants that were elevated relative to plants on the ground. For roses, there was no difference in the number of beetles between two individual roses of the same cultivar when one was 0.5 m taller. This relatively insignificant effect of height or position in these experiments suggests that observations of increased susceptibility may be attributed to qualities other than height, like fragrance intensity and bloom color.

The third experiment evaluated recruitment of beetles to various rose cultivars that differed in their bloom color (red or yellow) and fragrance intensity (light or moderate-heavy).

There was a significant difference in the number of beetles recruited to the cultivars evaluated during the 4 h trials. Between two lightly fragranced cultivars, Sunbright and Old Smoothie, Sunbright had significantly more beetles than Old Smoothie in both trials (Table 1). In trial 2, no beetles landed on the red-flowered, lightly fragranced cultivar, Opening Night. Among the distinctly fragrant cultivars, the average number of beetles attracted to the plants was either the same (trials 1 and 2) or significantly greater for yellow-flowered cultivars (trial 2, King's Ransom versus Night 'n'Day). In trial 1, both of the yellow varieties were not significantly different from Mirandy, a heavily fragranced red cultivar. In trial 2, there were significantly more beetles recruited to Sunbright than to any of the red-flowered cultivars. An interesting result was the significant difference among the yellow-flowered cultivars in both trials. Helmut Schmidt is described as having a moderate sweet tea fragrance unlike the more floral scents of the other varieties.

The results of tests with flower models and cultivars stress the importance of color and fragrance over height or bloom position. For example, Old Smoothie recruited relatively few beetles, but it was the tallest cultivar (about 1.5 m tall) used in the experiment, with all other cultivars ranging from 0.9 to 1.3 m. The role of odor is important to host selection by Japanese beetles; however, these results suggest that bloom color is an important secondary factor. Plant odors traveling on the wind generally serve to direct plant feeders in the direction of a host, whereas colors or contrasts may provide a more localized signal. Despite the presence of a highly attractive yellow flower, Japanese beetles continued to follow the fragrance to the less attractive red bloom.

Table 1. Attractiveness of select rose cultivars to Japanese beetles.

	Rose Cultivar	Flower Color	Fragrance Intensity	Mean (± SEM) Number of Beetles
Trial 1				
	Sunbright	Yellow	Light	40.3 ± 6.2 A
	Helmut Schmidt	Yellow	Moderate	17.3 ± 5.3 B
	Old Smoothie	Red	Light	1.3 ± 0.3 B
	Mirandy	Red	Heavy	21.3 ± 2 AB
Trial 2				
	Sunbright	Yellow	Light	25.7 ± 5.2 A
	King's Ransom	Yellow	Moderate	18.3 ± 1.9 A
	Helmut Schmidt	Yellow	Moderate	6 ± 1.5 B
	Old Smoothie	Red	Light	1.3 ± 0.7 B
	Night 'n' Day	Red	Moderate	4.3 ± 0.3 B
	Opening Night	Red	Light	0 B

Within each trial, means followed by the same letter were not significantly different (Tukey's HSD, $P < 0.05$).

Significance to the Industry

More than 90% of the Japanese beetles recruited to a rose land on the blooms. Since blooms appear to be the attractant, certain qualities like color and fragrance should vary the degree of susceptibility to Japanese beetles. Recruitment of beetles to selected rose cultivars and flower models in this study varied with color and fragrance intensity. For example, red-flowered cultivars appear to attract fewer beetles than yellow-flowered cultivars. Opening Night, a lightly fragranced, red-flowered cultivar did not recruit any beetles during the 4 h trial. Even though it is not resistant, cultivars like Opening Night, that have a less attractive bloom color and less fragrance appear to be visited less by Japanese beetles. Conversely, flowering roses that are visually attractive (white or yellow) or that have a more intense fragrance, even with red, appear to consistently attract more beetles. Although no rose is resistant to Japanese beetles, a possible alternative tactic is to choose cultivars with floral attributes that are less attractive to Japanese beetles.

Acknowledgments

Bear Creek Gardens
Jackson and Perkins Roses

Literature Cited

1. Fleming, W. E. 1972. Biology of the Japanese beetle. USDA Tech. Bull. 1449.
2. Hawley, I. M. and F. W. Metzger. 1940. Feeding habits of the Japanese beetle. USDA Circ. 547.

Compatibility of the Insecticide Imidacloprid with the Natural Enemy of Japanese Beetle Grubs, *Tiphia vernalis*

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Nature of Work

Tiphia wasps are the dominant group of parasitoids that attack white grubs. These wasps burrow into the soil where grubs are feeding on the roots of plants, deliver a sting to temporarily paralyze a grub, and then proceed to lay an egg on its victim. Upon hatching, the wasp larva, attached to the outside of its host grub, pierces the host's integument and feeds on the body fluids leading to the weakening and eventual death of its host. The wasp larva then spins a cocoon in the soil in which it overwinters and emerges the following year as an adult wasp. *Tiphia vernalis* is an introduced species of wasp that attacks Japanese beetle (JB) grubs. Abundant throughout landscapes in Central Kentucky, *T. vernalis* is active from mid-April through the first week of June parasitizing post-overwintered third-instar JB grubs. The extent to which JB grubs are controlled by *T. vernalis* varies at our study sites, ranging from 20 to 50% of the grub population parasitized. One factor that may be responsible for the differences in grub parasitism rates between study sites is the early-season application of grub insecticides. Imidacloprid (Merit), a commonly used grub insecticide, has a long residual effect in the soil. Because of its long residual, imidacloprid is sometimes applied as early as mid-April or early May for preventive grub control. This early application coincides with the activity of the spring-active *T. vernalis*. We therefore tested the effects of an early May application of imidacloprid on parasitism of JB grubs by *T. vernalis*.

We examined grub parasitism rates by *T. vernalis* in imidacloprid-treated and untreated field plots. Twenty-four PVC rings (39.0 cm diam × 10.2 cm height), arranged in a 3 × 8 randomized block design, were driven into the rough, consisting of primarily Kentucky bluegrass, at the Pendleton County Country Club near Falmouth, Kentucky. Thirty third-instar JB grubs were placed onto the surface of each ring and allowed to burrow into the soil. After 1 h, each ring was treated with imidacloprid (Merit 75 WP) at full label rate (0.4 lb [(AI]/acre; 0.45 kg [AI]/ha), half label rate (0.2 lb [AI]/acre; 0.225 kg [AI]/ha), or no treatment. After 21 d, the turf within each ring was excavated down to 20 cm, and all grubs and Tiphia cocoons were collected and taken back to the lab where grubs were examined for the presence of Tiphia larvae or eggs. A similar experiment was conducted in the lab to examine the effects of imidacloprid on grub parasitism rates as well as mortality, fecundity, and longevity of adult *T. vernalis*. Ten pots of perennial ryegrass were treated with either imidacloprid (Merit 75 WP) at the full label rate (0.4 lb [AI]/acre; 0.45 kg [AI]/ha), half label rate (0.2 lb [AI]/acre; 0.225 kg [AI]/ha) or left untreated. Ten JB grubs were placed into each core, and one female *T. vernalis* was then confined on the turf core by inverting a 12-oz clear plastic container with the bottom removed and replaced with a fine mesh screen, over the turf core. Prior to sealing of the containers, a plastic film canister lid containing a piece of dental wick moistened with 10% sugar water solution was placed on the surface of the turf core as a food source for the adult wasp. After 10 d, each core was broken apart and the grubs within examined for Tiphia eggs or larvae. Wasps were recovered from each core to determine mortality among the treatments. Wasps still alive were then monitored to determine long-term effects of exposure to imidacloprid on wasp longevity and ability to parasitize grubs.

The effect of imidacloprid application on wasp behavior was also examined. We determined whether wasps can recognize and avoid imidacloprid treated turf and whether imidacloprid treated turf impairs the wasps' ability to locate and recognize their host grubs. Ability of wasps to avoid imidacloprid treated cores was tested using a two-pot choice test. Ten pairs of perennial ryegrass turf cores (10.5 cm diam) placed in plastic containers of similar size were infested with 10 third-instar JB grubs. One core from each pair was treated with Merit 75 WP at the full label rate, while the other core was left untreated. Each pair of cores was then placed into a large clear plastic container with another container of equal size inverted over the first. This created an enclosure from which wasps could not escape. A piece of dental wick soaked in a 10% sugar water solution was placed in the bottom of each of the enclosures as a food source for the wasps. One female wasp was then introduced into each enclosure. After 10 d, each set of cores was broken apart and grubs examined for parasitism. The number of parasitized grubs in enclosures containing two untreated cores and enclosures containing one imidacloprid treated and one untreated core was compared to determine if wasps can avoid imidacloprid treated turf and the effect that a brief exposure may have on parasitism in nearby untreated turf.

The ability of Tiphia larvae to develop on hosts in imidacloprid-treated soil was examined. Sixty cores of perennial ryegrass were infested with parasitized and non-parasitized Japanese beetle grubs. Five non-parasitized third-instar JB grubs and five third-instar JB grubs bearing an egg of *T. vernalis* were placed into each core. Twenty cores were treated with Merit 75 WP at the full label rate, 20 cores at half label rate, and 20 cores were not treated. All cores were irrigated with 1.5 cm of water. Five cores of each treatment were sampled at 7, 14, 21, and 28 d after grubs were placed into the cores. The number of Tiphia larvae surviving, the instar of Tiphia present on the grubs at each sample date, and survival of grubs in pots treated with label rate and half label rate imidacloprid were compared to control pots.

Results and Discussion

Significantly fewer grubs were parasitized in field plots treated with imidacloprid at label and half label rate when compared to the untreated control plots (Figure 1). Similarly, there was significantly less parasitism when wasps were confined for 10 d on pots of turf treated with imidacloprid at label and half label rate (Figure 1). Despite the reduction in grub parasitism, confinement on imidacloprid-treated cores did not affect wasp survival. Only one wasp out of 30 died after being confined for 10 d on imidacloprid-treated or untreated cores. There was no significant difference in longevity of wasps confined on imidacloprid-treated cores versus untreated turf cores. Wasps from all treatments survived an average of 17.8 d after removal from turf cores. Despite no effect on mortality, exposure to imidacloprid did have a significant effect on wasp fecundity. Wasps that were previously confined on turf cores treated with imidacloprid at label rate laid significantly fewer eggs than wasps confined on untreated turf cores during the first 16 d after confinement. This effect eventually waned, with no significant difference in fecundity near the end of the experiment.

In two-pot choice tests, wasps parasitized fewer grubs when a turf core treated with imidacloprid was present with an untreated core than wasps confined on two untreated cores. Wasps confined with two pots of untreated turf containing grubs parasitized an average of 7.1 grubs, while wasps allowed to choose between a control and

Merit-treated pot containing grubs parasitized an average of 1.7 grubs. In Y-trail choice tests, wasps chose significantly more often trails containing Merit-treated frass over empty trails. When both arms of the Y trail were provisioned with frass and the frass on one arm treated with Merit, wasps showed no significant difference in trail choice.

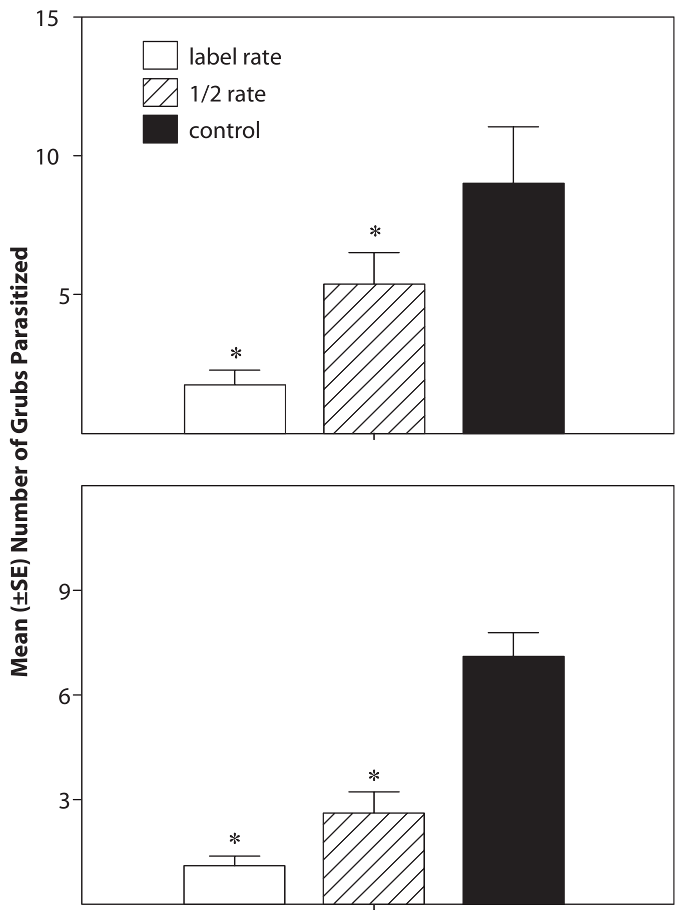
Wasps confined for 24 h to turf cores treated with Merit did not respond to the presence of frass from JB grubs in Y-trail choice tests, whereas wasps previously confined on untreated cores significantly chose more often the trail containing frass. Of the 20 wasps exposed to cores treated with Merit, two wasps chose the arm containing frass from *P. japonica*, while the rest of the wasps showed no response.

Although Merit application impaired the ability of adult Tiphia to locate and therefore parasitize host grubs, there was no detrimental effect on the developing wasp larvae. Once a grub was parasitized, survival and development time of wasp larvae on hosts in Merit-treated turf was not significantly different than that of wasp larvae developing on JB grubs in untreated turf.

Significance to the Industry

The results of this study show that early spring insecticide applications for grub control can dramatically reduce the benefits that Tiphia wasps provide in controlling turf-infesting Japanese beetle grubs. The insecticide Merit reduced Japanese beetle parasitism rates by inhibiting the wasps' ability to locate their host grubs in treated soil. When there is no need to target other early-season turf pests, it is recommended that preventive grub insecticide applications be applied after Tiphia flight (after the first week of June in Kentucky) to conserve benefits provided by these naturally occurring beneficial insects in controlling white grub populations.

Figure 1. (upper graph) Mean number of grubs parasitized by *Tiphia vernalis* in field plots treated with imidacloprid at label, half label rate, and untreated control. (lower graph) Mean number of grubs parasitized in laboratory by *T. vernalis* confined to pots of turf containing grubs. Each pot was treated with imidacloprid at label or half label rate or was untreated.



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

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Nature of Work

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

In recent years, severe outbreaks of this pest have occurred on Central Kentucky horse farms, golf courses, and street plantings. The focus of our research was to study the biology of calico scale on different hosts and to determine the most effective insecticides and application methods available for use in urban landscapes. We observed the life cycle and behavior of calico scale from late February to early October on horse farms around Lexington. Scales were noted primarily on honeylocust, *Gleditsia triacanthos*, hackberry, *Celtis occidentalis*, Norway maple, *Acer platanoides*, sweetgum, *Liquidambar styraciflua*, and sugar maple, *Acer saccharum*. Yellow sticky cards were placed in the canopies of four Norway maple trees and four hackberry trees to obtain crawler dispersal dates.

We conducted two experiments in 2002 with eight insecticides and three application methods to target first-instar settled crawlers (nymphs) in late spring and early summer or late third-instar settled nymphs on woody tissue in early spring. Our first experiment was designed to test the efficacy of a soil-injected systemic insecticide, applied at two different times, against adults and nymphs of calico scale. In this experiment, Merit 75 WP (imidicloprid) was injected into the soil, along the drip line, of seven sugar maple trees each on 19 December and seven additional sugar maples on 03 April 2002. Seven trees were left untreated as a control. Insecticides were applied at a rate listed to control scale insects (1 oz per inch DBH) and were based on DBH of the trees. The label recommends this insecticide be applied to the soil in the fall; however, we wanted to determine if a spring treatment would be equally effective. Treatments were evaluated 06 May and 17 June 2002 for efficacy against adults and settled crawlers, respectively. Most adults on the treated trees were situated in crotches of the lower branches and along the tree trunk; therefore, counts of adult scales were made by first measuring 3.0 m up the tree trunk from the ground and 30.5 cm laterally on the lowest four branches. Number of live adult scales was then counted and compared between treatments. Once crawlers had time to settle on leaves and feed for at least 14 d, 50 leaves were collected haphazardly from each tree canopy. Number of dead crawlers and total number of crawlers was determined by observation with a stereo microscope and percent mortality was compared.

Additionally, we tested two other systemic insecticide formulations. Four trees were injected in the root flare with Inject-a-cide B with Bidrin (dicrotophos) on 31 July 2002, 66d post-crawler hatch. Each bidrin-injected tree received one capsule (2 ml) of bidrin per 5.1 cm DBH. Another four trees were injected in the root flare with Imicide capsules, containing 4.0 ml of imidacloprid, on 9 August 2002, 75 d post-crawler hatch. Each imidacloprid-injected tree received one capsule (4.0 ml) of imidacloprid per 5.1 cm DBH. Five similar trees were left untreated. Leaves were evaluated 45 to 52 d after treatment.

A third experiment targeted pre-adult calico scale. A 2% oil mixture (Superior Miscible Spray Oil) was applied with a pressurized sprayer to the entire canopy of six hackberry trees on 6 March 2002, to target late third-instar scales on the woody tissue. Six additional trees were left untreated as a control. Additionally, individual shoots on non-treated trees were sprayed with a 2% oil mixture, 3% oil mixture, or water on 12 March 2002. Applications for this test were made with hand sprayers. All insecticidal oil solutions included Breakthru spreader/sticker added at 0.31 ml per liter solution. Treatments were evaluated 14 d after application.

Our fourth experiment targeted settled crawlers on leaves of hackberry trees. Six treatments were applied to individual hackberry shoots on a single tree. Six trees in a grove on the same site were treated. Insecticides were applied with a hand sprayer to runoff on 20 July 2002. Treatments included Talstar Lawn and Tree Flowable (bifentrhin), Orthene Turf, Tree and Ornamental Spray 97 (acephate), Sevin SL (carbaryl), an insecticidal soap (Safer Brand), and 2% insecticidal oil (Superior Miscible Spray Oil). All insecticides were applied at highest rates listed for scale insects. All insecticide solutions included Breakthru spreader/sticker as before. Additionally, a water-only treatment was included. Total and dead crawlers were counted 14 d after treatment and percent mortality was compared.

Results and Discussion

The following life cycle is based on observations made during spring-summer 2002. Calico scale completes its development in a single year. Large adult females, which are black-and-white checkered, are present on the woody tissue in the spring. In late April, the females begin to suck large amounts of sap, and they swell to about 6.0 mm long and 5.5 mm high. At this time, eggs are being produced underneath the female. Mean number of eggs found ranged from 1,401 to 3,858, with the highest number from females on honeylocust trees and the lowest number from females on Norway maple trees. Around 11 May in Central Kentucky, females begin to turn brownish and become crusty, which is followed by egg hatch later. After hatch, the first-instar nymphs, which are pinkish and are no more than 0.75 mm long, begin to crawl to the leaves. Some nymphs will be wind-blown to other trees. When the nymphs get to the leaves, they will insert their mouthparts and settle (then called settled crawlers) on the leaves to feed throughout the summer. They will become more yellowish and grow to approximately 1.0 mm in length. Mean number of crawlers emerging from females ranged from 487 to 2,835. Settled crawlers appear to molt to a second instar around mid- to late July, based on the observation of empty scale insect skins. In mid-September, the same crawlers will begin moving back to the woody tissue where they will stay for the duration of the winter and early spring. After they are settled on the woody tissue, they will molt to the third instar, which is black and has a harder waxy coating. In late winter to early spring, they start feeding on large amounts of tree sap, grow quickly, and molt to the adult stage.

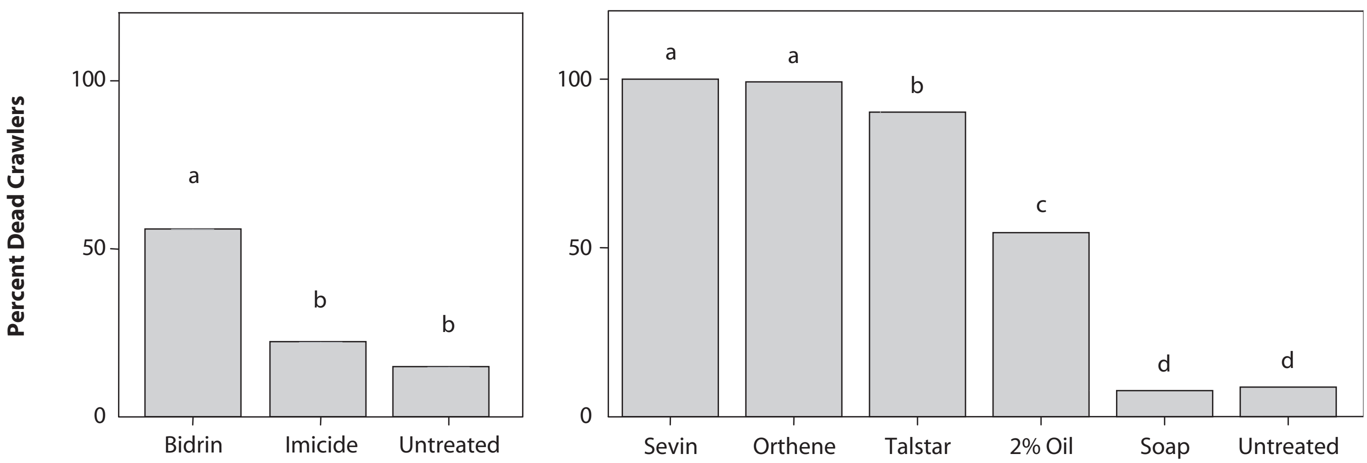
The winter and spring soil injections with Merit 75 WP, targeting first-instar settled crawlers, did not yield significant control of scales. The 2% oil sprays applied in early spring of 2002, targeting late-instar nymphs, also did not yield significant control of scales. Inject-a-cide B (bidrin) trunk injections yielded moderate control with 56% crawler mortality, but percent mortality on Imicide-injected trees did not differ significantly from that on untreated controls (Figure 1).

We obtained good to excellent control of settled crawlers on trees where individual shoots were sprayed to run-off with various insecticides. Mortality resulting from all treatments was significant. Seven, Talstar and Orthene achieved nearly 100% control (Figure 1).

Significance to the Industry

The objective of this project was to study the biology of calico scale, construct a life cycle summary, and provide management options to arborists and horse farm managers. We determined that Sevin, Orthene, and, more importantly, Talstar, a reduced-risk pyrethroid, controlled settled crawlers when applied thoroughly. Despite marginal control, Inject-a-cide B (bidrin) has potential as a low-risk insecticide treatment because the possibility of drift is eliminated with this application method. Efficacy of low-toxicity insecticidal soap, in this case, did not differ significantly from untreated shoots, whereas insecticidal oil achieved average (»50% control) control of settled crawlers. This research will help horse farm managers, golf course superintendents, and other urban landscape managers follow the progress of scale development and determine proper timing and management practices for controls of calico scale. Additional research is currently under way to assess the natural enemy complex and determining pressures governing outbreaks in urban landscapes.

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



Landscape Plant Disease Observations from the Plant Disease Diagnostic Laboratory—2002

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% are landscape plant specimens (1).

Making a diagnosis involves a great deal of research into the possible causes of the plant problem. Most visual diagnoses involve microscopy to determine what plant parts are affected and to identify the microbe involved. In addition, many specimens require special tests such as moist chamber incubation, culturing, enzyme-linked immunosorbent assay (ELISA), electron microscopy, nematode extraction, or soil pH and soluble salts tests. This year, the laboratory is gearing up for polymerase-chain-reaction (PCR) testing, which, although very expensive, will allow more precise and accurate diagnoses. Computer-based laboratory records are maintained to provide information used for conducting plant disease surveys, identifying new disease outbreaks, and formulating educational programs.

The 2002 growing season in Kentucky provided mostly warmer than normal temperatures and below normal rainfall. All months except May were warmer than normal, beginning with January having temperatures recorded at 7 to 10 degrees above normal. Significant freezes and frosts following warm periods were observed in late January, mid-February, early and late March, and late May. The most damaging was a March 4 freeze (4 to 6°F), occurring after bud break in Central Kentucky. Statewide, wet weather generally prevailed in March, April, and May, but dry weather was prevalent during June, July, and August. Rain was spotty, and some locales suffered severe drought, while others suffered only mild drought. Summer temperatures were well above normal in addition to being dry. Rains, heavy at times, returned in September and October.

Wet spring weather favored many foliar diseases, such as anthracnose, leaf spots, and scab. Extremely warm temperatures in April favored severe fire blight in the central and eastern portions of the state. Summer heat and drought were hard on all plants, especially those with inadequate root systems.

Results and Discussion

The following diseases of importance were observed this year:

Deciduous trees

- Woody landscape plants, especially flowering fruits had winter or spring freeze injury on twigs and branches.
- Crabapples, serviceberries, and flowering pears: fire blight (*Erwinia amylovora*).
- Hawthorn and crabapple: cedar rust (*Gymnosporangium juniperi-virginianae*, *G. clavipes*, *G. globosum*) fungi.
- Flowering crabapple scab (*Venturia inaequalis*) began in early spring.
- Maple, ash, and sycamore anthracnose (*Kabatiella*, *Discula*, and *Apiognomonia*), and dogwood spot anthracnose (*Elsinoe*).
- Dogwood powdery mildew (*Microsphaera*, *Phyllactinia* spp.).
- Red, scarlet, and pin oak bacterial leaf scorch (*Xylella*) in late summer.
- Hackberry bacterial leaf scorch (*Xylella*) found for the first time.
- Catalpa, maple, redbud, and magnolia wilt (*Verticillium*).
- Ash, dogwood, maple, redbud, and yellowwood canker (*Botryosphaeria*).
- Flowering plum black knot (*Apiosporina*) from previous year's infection.
- Elm, Dutch elm disease (*Ophiostoma*).
- Birch cv. 'Renaissance' leaf spot (*Septoria*).

Needle Evergreens

- Pine tip blight (*Sphaeropsis*), pine wilt nematode (*Bursaphelenchus*), needle casts (*Dothistroma*, *Lophodermium*), needle rust (*Coleosporium*), and ozone injury
- Juniper tip blight (*Kabatina*) and rusts (*Gymnosporangium*)

Shrubs

- Azalea gall (*Exobasidium*).
- Boxwood shoot blight (*Volutella*) and cutting rot (*Rhizoctonia*).
- Euonumus crown gall (*Agrobacterium*) and powdery mildew (*Erysiphe*).
- Holly, and boxwood black root rot (*Thielaviopsis*).
- Photinia leaf spot (*Entomosporium*).
- Rose black spot (*Diplocarpon*), powdery mildew (*Sphaerotheca*), and canker (*Leptosphaeria*).
- Rose rosette disease (possible leaf curl mite-transmitted virus) was very prevalent.
- Rhododendron canker (*Botryosphaeria* sp.).

Herbaceous Annuals and Perennials

- English ivy bacterial leaf spot (*Xanthomonas*).
- Iris leaf spot (*Heterosporium*).
- Peony gray mold (*Botrytis*) and red spot (*Cladosporium*).
- Periwinkle blight (*Phytophthora*).
- Petunia, and pansy black root rot (*Thielaviopsis*).
- Pansy leaf spot (*Cercospora*).

Landscape turfgrass

- Perennial ryegrass gray leaf spot (*Pyricularia grisea*).

Significance to Industry

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

Literature Cited

1. Bachi, P., J. Beale, J. Hartman, D. Hershman, W. Nesmith, and P. Vincelli. 2002. Plant Diseases in Kentucky—Plant Disease Diagnostic Laboratory Summary, 2002. UK Department of Plant Pathology (in press).

A Nested-PCR Protocol to Determine If *Sphaeropsis sapinea* Is Present in Asymptomatic *Pinus Nigra* Tissue

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

Nature of Work

Sphaeropsis tip blight (formerly known as Diplodia tip blight) is a common, worldwide disease of more than 30 pine species and other conifers. Typical symptoms of *S. sapinea* infection include stunted shoots with necrotic, stunted needles, resinous cankers, and a general decline of the tree. These symptoms lead to significant economic losses of native and exotic pines in managed plantings. Our surveys of diseased and asymptomatic Austrian and Scots pine have revealed that latent infections of asymptomatic tissues by *S. sapinea* are common (1). For diagnostic and research purposes, however, culturing asymptomatic pine tissues to isolate the fungus destroys the tissue, preventing further studies of latent infections. We have developed PCR primers that are specific and sensitive for *S. sapinea* and *Botryosphaeria obtusa* (a closely related fungus rarely found on surface-disinfested, symptomless Austrian pine tissues).

Objective

Develop a nested-PCR protocol utilizing the universal ITS primers and *S. sapinea*-specific primers to enable future studies of latently infected shoots.

Approach

A tissue sampling regime that allowed efficient identification of latently infected shoots without destroying them was developed and results of the nested-PCR were statistically compared to the results of the culturing technique.

Sampling regime

Based on previous studies, terminal buds and 0.6 cm diameter bark samples were chosen as the tissues that would be most likely to harbor *S. sapinea* and least likely to cause death of the shoot upon removal (2). The symptomless samples were surface disinfested and their DNA extracted using a CTAB method. *S. sapinea* DNA, if present, was amplified using the nested-PCR approaching utilizing the universal ITS primers and the *S. sapinea* specific primers (S.sapFOR3 and S.sapREV3). The sensitivity of the nested-PCR protocol was tested using known concentrations of purified *S. sapinea* DNA diluted in either noninfected Austrian pine terminal buds or bark samples.

Correlation between nested-PCR and culturing

Terminal buds and bark samples were recovered as described above from 114 symptomless shoots collected from 10 tip blight diseased Austrian pines on the University of Kentucky Lexington campus between December 2001 and March 2002. Each bud or bark sample was cut in half and surface disinfested. One half of each sample was cultured on nutrient media and the other half was used as a template for the nested-PCR. A Chi-square test was used to determine the degree of correlation between the two techniques.

Results and Discussion

- DNA from *S. sapinea*, or plant tissue infected with *S. sapinea*, produces a 350 base pair PCR product when amplified using this nested-PCR protocol.

- *S. sapinea* was most frequently isolated from bark samples located at the apex of the symptomless shoot in agreement with previous studies using shoot cross sections.
- Sensitivity of the PCR assay allows detection of 0.93 pg/ml *S. sapinea* DNA in the terminal bud and 10.4 pg/ml *S. sapinea* DNA in the bark sample. This is equivalent to less than 100 average fungal genomes.
- The correlation between the two techniques was statistically highly significant, with a Chi-square probability of <0.0001 (<0.05 is statistically significant).
- If the results are broken down for each tissue type, the bark samples had a much higher incidence of latent infection and better agreement between the results of the culturing technique and the nested-PCR protocol.
- Current observations of shoots sampled 10 months earlier for this study found that the bark wound had callused over and the shoots had elongated normally over the growing season.
- Besides being a useful tool for future studies of latent infection, this species-specific protocol may be helpful in other studies that rely on culturing *S. sapinea* out of pine tissue. When culturing from pine tissue, *S. sapinea* may become overgrown by other fungi found in pine tissue or misidentified as another fungus. The nested-PCR protocol is also faster and more sensitive than culturing (3).

Significance to the Industry

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

Literature Cited

1. Flowers, J., Nuckles, E., Hartman, J., and Vaillancourt, L. 2001. Latent Infections of Austrian and Scots Pine Tissues by *Sphaeropsis sapinea*. Plant Disease 85:1107-1112.
2. Flowers, J., Hartman, J., and Vaillancourt, L. 2001. A PCR-based protocol to determine if *Sphaeropsis sapinea* is present in asymptomatic tissues of Austrian pines. Phytopathology 91:S28 abstr.
3. Flowers, J., Hartman, J., and Vaillancourt, L. 2002. A nested-PCR protocol to determine if *Sphaeropsis sapinea* is present in asymptomatic *Pinus nigra* tissue. Phytopathology 92:S26 abstr.

Injections with Fungicides for Management of Pine Tip Blight—A Four-Year Study

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Nature of Work

Tip blight disease, caused by the fungus *Sphaeropsis sapinea*, is a major problem of Austrian pine (*Pinus nigra*) in the landscape (1). Control by pruning or spraying is difficult and usually ineffective; most affected trees eventually die or are removed (2). Young trees that are not yet producing cones are rarely affected by tip blight. It has been suggested that a primary source of inoculum may be old infected cones and that young trees escape due to lack of locally produced infective propagules. However, we have found that the tip blight fungus is present in healthy parts of trees (found in more than 70% of symptomless shoots), or in healthy young trees (17%), living as a latent pathogen or possibly as an endophyte within the twigs (3,4). This study is intended to determine whether or not fungicide injection can prevent new infections and further spread of tip blight disease (5, 6). We hope to also determine whether or not injection of pines with fungicides can eradicate *S. sapinea* from within infected/infested pines and the impact of fungal eradication on disease.

Two distinct groups of UK campus Austrian pines were selected for injection treatments as described below: Experiment 1, mature diseased (1 to 50% tip blight) Austrian pines (6 replicates) and, Experiment 2, maturing disease-free Austrian pines (10 replicates). Disease symptoms were evaluated in mid- to late summer each year by estimating the percent of diseased shoot tips per tree. Diseased branches previously removed for sanitation purposes were included in the estimate. During July 2000, and again in July 2001 and July 2002, shoot, bud, and needle samples (two each) from asymptomatic and diseased shoots were collected from each treated tree and the pathogen cultured on acidified potato dextrose agar (PDA) using standard microbiological techniques. The fungal cultures were identified and confirmed microscopically following inoculation of autoclaved pine needles.

Experiment 1

Sixteen 22-year-old diseased Austrian pines located on traffic islands on the UK Lexington campus received one of four treatments. Treatments, arranged in a randomized complete block design and replicated on four individual trees, consisted of injections at labeled rates of a) oxycarboxin (Carboject), b) debacarb (Fungisol), c) tebuconazole (Tebuject) and d) water used as controls. In 1999, treatments were made 8 May (capsules removed 12 May; water controls injected 18 May to 22 May), when the candles of the pines were partly elongated. In 2000, treatments were similarly made 6 May to 9 May (capsules removed 16 May), in 2001 on 5 May (capsules removed 17 May) and in 2002 on 29 May to 30 May and 8 June (capsules removed 22 June). Due to the demise of several of the traffic island trees in the first year, eight additional 20 year-old trees located around the perimeter of a UK campus parking lot nearby were injected in May 2000, 2001, and 2002. Trees have been grouped into randomized complete blocks, and each treatment is now replicated five or six times with each replicate being an individual tree.

Experiment 2

From a group of 71 disease-free 13- to 14- year-old Austrian pines forming a screen planting on the UK campus, 40 trees were injected in 1999, 2000, 2001, and 2002 as described above. The experiment was designed as a randomized complete block experiment with 10 replicates.

In vitro test of injected fungicides

The three fungicides, Fungisol, Tebuject, and Carboject were each tested in the laboratory and compared to water controls. Fungicides were incorporated into acidified PDA petri plates at rates ranging from 1ppm to 1,000 ppm. Plugs (4 mm diameter) of mycelium from actively growing cultures of *S. sapinea* were transferred to the plates. The length of fungal hyphae growth from the original plug was measured four days later. The test was replicated four times, and fungicide concentrations that just prohibited fungal growth were calculated as effective doses.

Results and Discussion

Tip blight disease ratings

Tip blight disease ratings for both Experiment 1 and 2 are presented in Table 1. After three years of injections, trees in Experiment 1 continued to die until 2002 when no new trees died. Depending on treatment, disease ratings for these mature trees in 2002 compared to 1999 have increased 121 to 245 per cent. Disease levels appear to be stabilizing in Fungisol-treated trees where 2002 disease levels had only progressed to 121% of 1999 disease levels. Disease levels for other treatments had progressed to about double the levels seen in 1999. For Experiment 2, the younger, less-diseased trees are gradually increasing in disease levels (Table 1). In 1999, there was no noticeable disease in this plot; by 2002, disease ratings ranged from 13 to 23 percent but showed no noticeable treatment effect.

Recovery of **S. sapinea** *from pine shoots*

In Experiment 1, *S. sapinea* was isolated from most of the diseased and symptomless shoots from 2000-2002 (Table 2). In Experiment 2, diseased shoots often yielded significantly higher levels of the pathogen in culture than did asymptomatic shoots from the same trees (Table 2). In Experiment 2, *S. sapinea* was isolated from all diseased shoots, whereas the fungus was isolated from only six to

Table 1. Three-year disease ratings (percent blighted shoot tips) for Experiment 1, mature, diseased, Austrian pines on the UK/Lexington campus (6 replicates [4 replicates begun in 1999 and the rest in 2000]), and for Experiment 2, maturing, less-diseased Austrian pines (10 replicates).

Austrian Pine Trees	Experiment 1					Experiment 2	
Treatment	Rating Year	Range	Average*	Average for Original Trees	Original Trees' Disease Percent vs. 1999	Range	Average
1 - Fungisol	1999	1-85	28	28	100	0	0
	2000	1-100	23	32	125	0-<1	trace
	2001	4-100	25	31	111	0-25	11
	2002	5-100	25	34	121	10-40	19
2 - Tebuject	1999	1-90	51	38	100	0	0
	2000	1-100	44	62	129	0-<1	trace
	2001	1-100	51	70	184	5-20	11
	2002	20-100	62	78	205	10-20	13
3 - Carboject	1999	9-52	34	34	100	0	0
	2000	5-70	31	49	144	0-<1	trace
	2001	5-100	41	57	168	5-40	12
	2002	5-100	42	60	176	10-75	23
4 - Water	1999	23-35	29	29	100	0	0
	2000	5-60	33	46	159	0-<1	trace
	2001	5-100	42	60	207	5-30	13
	2002	5-100	51	71	245	10-40	16

* Percent disease decreased from 1999 to 2000 because new, less-diseased trees were added after the first year. Fungisol = debacarb; Carboject = oxycarboxin; Tebuject = tebuconazole.

eight of 10 asymptomatic shoots. In 2000, a lower proportion of Fungisol-treated trees yielded the fungus from symptomless shoots than from the other treatments. Treatment differences were not noticed in 2001 and 2002. During the injection process, it was noticed that some of the capsules soon filled with pitch from the tree. Thus, it is difficult to know whether or not all capsules were actually emptied into the injection sites.

In vitro test of injected fungicides

The effective dose for complete inhibition of *S. sapinea* hyphal growth on PDA amended with fungicides can be determined from the data presented in Table 3.

Based on this test, Tebuject completely inhibited fungal growth at the rate of only 1ppm. The effective dose may be even lower, but this concentration was the lowest used. The effective dose of Fungisol needed to stop fungal growth occurred at 6 ppm, which is still good for most fungicidal applications. However, for Carboject, inhibition did not occur until fungicide concentrations were greater than 1,000 ppm.

Concluding Remarks

After four consecutive years of trunk and buttress root injections, disease progress may have been slowed significantly by injections of Fungisol. This treatment did not prevent death of some of the trees with advanced disease symptoms early in the experiment, but it did slow down the disease in survivor trees. From the *in vitro* test, Fungisol was active against the fungus at low levels. It is not known why injected Tebuject was ineffective even though possessing excellent fungicidal activity in the laboratory. We were unable to determine if any of the injected fungicides actually made it into the branches of injected trees. Fungicide injections did not appear to reduce levels of latent infections of *S. sapinea.* None of the fungicides prevented new infections or reduced disease severity in younger trees initially having no disease. This was the final year for this four-year project.

Significance to Industry

This work demonstrates that fungicide injections are not a very effective and practical way to manage Austrian pine tip blight disease. Injection treatments neither induced tree recovery nor eradicated the fungus already existing in trees or parts of trees before symptoms developed. Thus, landscape managers wishing to slow the onset and rapid spread of tip blight in existing Austrian pines will need to rely on cultural practices such as reducing environmental stresses like drought and shade in the growing site and to practice sanitation to reduce buildup of pathogen inoculum. Knowing that this disease is difficult to control may influence landscape architects and managers in deciding whether to use Austrian pine in the landscape. Indeed, unless other efficient control measures are developed, for longevity and ease of maintenance, Austrian pines may not be a good choice for Kentucky landscapes.

Table 2. Isolation of *Sphaeropsis sapinea* from UK Lexington campus pines: Experiment 1, mature, diseased Austrian pines (6 replicates), and Experiment 2, maturing, less-diseased Austrian pines (10 replicates) treated with fungicides via trunk injections. Percent shoots yielding *S. Sapinea* in culture (10 samples per tree).

Austrian Pine Trees	**Experiment 1**			**Experiment 2**					
	Percent Recovery of *S. sapinea*			**Percent Recovery of *S. sapinea***			**Proportion of Trees with *S. sapinea***		
Treatment and Sample Health Status	**2000***	**2001**	**2002**	**2000**	**2001**	**2002**	**2000**	**2001**	**2002**
1 - Fungisol, symptomless shoot	55 A	50 A	70 A	8 A	17 A	32 A	1:10	6:10	7:10
3 - Tebuject, symptomless shoot	40 A	50 A	88 A	18 A	30 A	20 A	5:10	5:10	6:10
7 - Water, symptomless shoot	67 A	60 A	80 A	23 A	25 B	45 AB	5:10	5:10	7:10
5 - Carboject, symptomless shoot	46 A	100 A	75 A	25 A	26 B	55 AB	7:10	5:10	8:10
4 - Tebuject, diseased shoot	75 A	100 A	100 A	69 B	87 B	90 BC	8:8	10:10	10:10
8 - Water, diseased shoot	79 A	100 A	100 A	75 BC	94 B	100 C	6:6	10:10	10:10
2 - Fungisol, diseased shoot	80 A	100 A	100 A	79 BC	100 B	100 C	6:6	10:10	10:10
6 - Carboject, diseased shoot	67 A	100 A	100 A	88 C	93 B	100 C	6:6	10:10	10:10

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

Table 3. Effect of different concentrations (in parts per million) of fungicides on *in vitro* growth of *S. sapinea* (in millimeters) after 4 days growth on acidified PDA amended with fungicide.

Fungicide and Concentration	**1 ppm**	**2 ppm**	**3 ppm**	**4 ppm**	**5 ppm**	**6 ppm**	**1,000 ppm**
Tebuject	0	0	0	0	0	0	0
Fungisol	66	64	38	23	8	0	0
Carboject	68	66	63	67	68	65	0
Water	64	63	69	65	64	67	65

Fungisol = debacarb; Carboject = oxycarboxin; Tebuject = tebuconazole.

Literature Cited

1. Sinclair, W., H. Lyon, and W. Johnson. 1987. Diseases of Trees and Shrubs. Cornell University Press. Ithaca, N.Y.
2. Hartman, J., G. Mussey, and W. Fountain. 1994. Evaluation of landscape Austrian pines for tip blight disease. University of Kentucky Nursery and Landscape Program Research Report, SR-94-1, p.31.
3. Hartman, J., Poupard, B., and Vaillancourt, L. 1999. Preliminary results on isolation of Sphaeropsis sapinea from landscape Austrian pines. University of Kentucky Nursery and Landscape Program, 1998 Research Report, PR-409, p. 28-29.
4. Hartman, J., S. Kihl, and L. Vaillancourt. 2000. Isolation of Sphaeropsis sapinea from landscape Austrian pines. University of Kentucky Nursery and Landscape Program, 1999 Research Report, PR-422, p. 17-18.
5. Hartman, J., J. Flowers, L. Vaillancourt, F. Moine, J. Hart, and L. Hanks. 2001. Injections with fungicides for management of pine tip blight - preliminary results of a new long-term study. University of Kentucky Nursery and Landscape Program, 2000 Research Report, PR-437, p. 17-18.
6. Hartman, J., J. Flowers, L. Vaillancourt, J.-B. Magnin, J. Hart, and L. Hanks. 2002. Injections with fungicides for management of pine tip blight - preliminary results of a long-term study. University of Kentucky Nursery and Landscape Program, 2001 Research Report, PR-450, p. 22-23.

Hackberry, Scarlet Oak, and Mulberry—New Kentucky Hosts of Bacterial Leaf Scorch Caused by *Xylella fastidiosa*

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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 (8). In 1987, the bacterium associated with leaf scorch was described as a new species, *Xylella fastidiosa* (13). Bacterial leaf scorch has been reported in coastal U.S. states from New York to Texas, and in Kentucky in bur, pin, red, white, and shingle oak; sycamore and London plane; sugar, silver, and red maple; American elm and sweetgum (1,3,4,5,6,10,12).

In oak, scorch symptoms first appear in late summer in individual branches where leaves show dead margins with green tissues near the main veins and leaf petiole. Often there is a fine yellow or reddish zone between brown and green tissues. Many affected leaves drop prematurely. In succeeding years, the late summer leaf scorch progresses to all parts of the tree. Gradually, infected trees suffer a chronic decline with branch dieback affecting more of the tree each year. Secondary factors can contribute to the tree demise, and eventually, the tree needs to be removed. Tree decline, from first discovery of the disease to removal may take place over a period of five to 10 or more years. It is not known how *X. fastidiosa* causes leaf scorch and defoliation of landscape trees, but water stress due to xylem occlusion seems to be the most likely cause (9).

In the UK Plant Pathology Department's Plant Disease Diagnostic Laboratory, we used an enzyme-linked immunosorbent assay (ELISA) developed for *X. fastidiosa* ("Pathoscreen-Xf," Agdia Inc., Elkhart, Ind.) to detect the bacterium. When positive ELISA results are obtained from a new host or new geographic location, we confirm our findings by using electron microscopy to observe occluded xylem tissues and to observe the causal agent with its typical scalloped or undulating cell walls. Recently, a rapid-cycling real-time PCR technique has been employed to corroborate the ELISA test. Indeed, PCR has been used to identify *X. fastidiosa* in alternative host plants (7, 11).

The objective of this work was to continue testing trees with scorch symptoms to determine whether or not these trees might harbor the bacteria. Leaf samples from trees growing in Lexington, Kentucky, landscapes as well as from elsewhere were collected for testing. A dozen samples of oak and other species with leaf scorch were sent from a colleague in Missouri. Until now, bacterial leaf scorch had not been identified in Missouri. In total, assays for *X. fastidiosa* were conducted on more than 190 specimens. Samples were typically refrigerated at 40°F overnight and then dissected, macerated, and tested for presence of *X. fastidiosa* using the ELISA test. Some samples were additionally tested using rapid-cycling real-time PCR.

Results and Discussion

The following trees heretofore not known to be hosts of bacterial leaf scorch in Kentucky were found positive for *X. fastidiosa*: 1) hackberry (*Celtis occidentalis*), several trees; 2) scarlet oak (*Quercus coccinea*), one tree; and 3) both American and white mulberry (*Morus rubra* and *M. alba*), several trees. The disease was additionally confirmed on hackberry and mulberry using rapid-cycling real-time PCR. From the Missouri specimens, bacterial leaf scorch was confirmed on pin oak and shingle oak. This was a first-ever confirmation of bacterial leaf scorch in Missouri. At this point, we do not know if *X. fastidiosa* in hackberry and mulberry is the same strain of the bacterium as is found in oak since ELISA and PCR test for presence of any strain of *X. fastidiosa* . It is also not known whether the same insect vectors feed on these various species of trees.

Significance to the Industry

Bacterial leaf scorch is a major concern for arborists, nursery operators, and landscape managers because it is a very destructive disease. Specific insect vectors of the bacteria in Kentucky landscapes are still unknown. This study expands the apparent host range of this disease. Continued studies using molecular methods to determine *X. fastidiosa* strain relationships are under way and may provide a means for understanding this disease and managing it.

Literature Cited

1. Anonymous. 1993. Bacterial leaf scorch of landscape trees. Center for Urban Ecology Information Bulletin. National Park Service. Washington, D.C. 4 pp.
2. Hammerschlag, R., Sherald, J., and Kostka, S. 1986. Shade tree leaf scorch. J. Arboric. 12:38-43.
3. Hartman, J.R., Eshenaur, B.C., and Jarlfors, U.E. 1992. Shingle oak, a new host for bacterial leaf scorch caused by Xylella fastidiosa. Phytopathology 82:498 (abstr).
4. Hartman, J.R., B.C. Eshenaur, and U.E. Jarlfors. 1995. Bacterial Leaf Scorch Caused By *Xylella fastidiosa*: A Kentucky Survey; A Unique Pathogen; and Bur Oak, A New Host. Journal of Arboriculture 21:77-82.
5. Hartman, J.R., U.E. Jarlfors, W.M. Fountain, and R. Thomas. 1996. First report of Bacterial Leaf Scorch Caused by *Xylella fastidiosa* on Sugar Maple and Sweetgum. Plant Disease 80:1302.
6. Hartman, J.R., Kaiser, C.A., Jarlfors, U.E., Eshenaur, B.C., Bachi, P.A., and Dunwell, W.C. 1991. Occurrence of oak bacterial leaf scorch caused by *Xylella fastidiosa* in Kentucky. Plant Disease 75:862.
7. Hartman, J.R., Saffray, D., and Beale, J. 2002. Presence of *Xylella fastidiosa* in symptomless landscape hosts. University of Kentucky Nursery and Landscape Program, 2001 Research Report, PR-450, p. 24-25.
8. Hearon, S.S., Sherald, J.L., and Kostka, S.J. 1980. Association of xylem-limited bacteria with elm, sycamore, and oak leaf scorch. Can. J. Bot. 58:1986-93.
9. Hopkins, D.L. 1989. *Xylella fastidiosa*: Xylem-limited bacterial pathogen of plants. Annual Review of Phytopathology 27:271-290.
10. Kostka, S.J., Sherald, J.L., Tattar, T.A. 1984. Culture of fastidious, xylem-limited bacteria from declining oaks in the northeastern United States. Phytopathology 74:803 (Abstr.)
11. McElrone, A., J. Sherald, and M. Pooler. 1999. Identification of alternative hosts of *Xylella fastidiosa* in the Washington, D.C., area using nested polymerase chain reaction (PCR). Journal of Arboriculture 25:258-263.
12. Sherald, J.L. and Kostka, S.J. 1992. Bacterial leaf scorch of landscape trees. J. Arboric. 18:57-63.
13. Wells, J.M., Raju, B.C., Hung, H.Y., Weisburg, W.G., Mandelco-Paul, L., and Brenner, D.J. 1987. *Xylella fastidiosa* gen. nov., sp. nov.: Gram-negative, xylem-limited, fastidious plant bacteria related to *Xanthomonas* spp. Int. J. Syst. Bacteriol. 37:136-143.

Black Knot Incidence in West Kentucky Nurseries

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Nature of Work

Black knot occurs in many *Prunus taxa* and is found throughout the United States (2). Black knot is found in nurseries, landscapes, and on unmanaged land. It is caused by the fungal organism *Apiosporina morbosa.* While it occurs in more than 24 species, it has not been documented in *Prunus* x *cistena* in Kentucky.

Black knot is easily recognized by swollen black galls along stems, twigs, or trunks (1). Mature galls contain the fruiting bodies of the pathogen. These fruiting bodies eject spores into the air in the spring during wet weather. Following spring infection, the branches may be swollen but otherwise normal in appearance. Trees may not readily show symptoms until late summer or fall. During the next growing season, the swelling continues and the bark separates. The area develops into the characteristic black knotty gall as the season progresses.

The purpose of this evaluation was to record the incidence of black knot in nurseries in West Kentucky in order to develop a knowledge base with which to assess 1) if black knot is being brought in on liners or developing from inoculum on wild cherry and plum trees in field margins, and 2) determine if *Prunus* x *cistena* may be resistant.

During September and October of 2002, purple-leaved plum liners from three different sources at 11 nurseries were examined for presence of second-year black knot, the characteristic black, rough galls.

Results and Discussion

Nursery "M" only supplied one taxa, *Prunus cerasifera* 'Thundercloud'. Of 74 liners from Nursery "M," none had a visible black knot infection. Nursery "G" also only supplied *Prunus cerasifera* 'Thundercloud'. Of 103 liners from Nursery "G," 74 were infected with black knot. Liners were so badly infected on the trunk that they had to be rogued.

Nursery "O" only supplied liners of *Prunus* x *cistena*. None of the 519 *Prunus* x *cistena* liners showed signs of black knot. Where black knot occurred, the age and maturity of the galls in growers' fields strongly suggests that the liners were diseased at the time of purchase.

The data show that 'Thundercloud' is susceptible to black knot. Nursery "G" appeared to be supplying contaminated plums, and Nursery "M", apparently did not. *Prunus* x *cistena* from Nursery "O" apparently was not contaminated with black knot; however, the data do not show whether or not *Prunus* x *cistena* is resistant or susceptible to black knot.

Significance to the Industry

Sanitation pruning and fungicide sprays for disease management cost nurseries untold amounts of chemicals and labor to produce a quality tree. Utilizing a quality source of liners can be critical in preventing black knot and other diseases, saving nurseries money and increasing profits. Growers interested in producing quality trees economically would be well advised to obtain their liners from reliable sources. In addition, identification of a black knot resistant *Prunus* would provide exceptional cost savings and marketing opportunities for Kentucky nurseries as well as garden centers and landscape contractors.

Literature Cited

1. Hartman, J.R., T.P. Pirone, and M.A. Sall. 2000. Pirone's Tree Maintenance. Oxford University Press, New York, N.Y.
2. Jones, R.K. and D.M. Benson, eds. 2001. Diseases of Woody Ornamentals and Trees in Nurseries. The APS Press, St. Paul, Minn.

Evaluation of Tropical Foliage and Flowering Plants as Annual Ground Covers at the UK Arboretum

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Nature of Work

Several species of plants have been evaluated during the past three years for their suitability as temporary (annual) ground covers in the landscape. None of these plants are frost tolerant and would have to be planted annually in the landscape after the threat of frost has passed. Plantings and observations have been conducted at the University of Kentucky-Lexington Fayette Urban County Arboretum. In 2002, we repeated observations for several species, added one additional species (Basket Grass, *Oplismenus hirtellus* 'Varigetaus') and added additional cultivars of three other species (Grape Ivy, *Cissis rhombifolia*; Licorice Plant, *Helichrysum petiolare*; and Bacopa, *Sutera jamesbrittenia*) for observation. Transplants were produced by rooting cuttings directly into 98-cell plug trays in the greenhouse and transplanting to 3-inch pots (three cuttings per pot) and grown on for four to six weeks. Transplanting to the Arboretum occurred between May 2 and May 10. At transplanting, 1 tablespoon of slow-release fertilizer (Osmocote 14-14-14) was incorporated into the planting hole with no additional fertilizer applied during the growing season. Plants were spaced on approximately 8-inch centers. Plants were watered as needed to maintain even soil moisture. Growing conditions for 2002 were unseasonably hot and dry.

Results and Discussion

Basket Grass—This highly decorative grass has variegated leaves of green and white stripes, with the white turning to pink when grown in high light. The leaves are 2 inches long, ½-inch wide, and borne on stems that reach a length of about 15 inches. When planted on 8-inch centers, the plants completely covered the growing area in two to three weeks and made an attractive, interlocking mat of foliage about 6 inches high. The plants were grown in full sun and leaf color was dark pink and green variegation. The plants showed some sensitivity (leaf burn) to cool temperatures by early October even in the absence of frost. However, ease of propagation and rapid spread makes this plant particularly promising as an annual ground cover.

Grape Ivy—This plant has performed exceptionally well in previous trials at the Arboretum. During 2002, we evaluated the standard species as well as the cultivar Ellen Danica, which has more deeply lobed leaf margins. The two types were grown side by side in semi-shade. The straight species continued to perform well as in previous trials, filling in rapidly and producing a cover of foliage 12 to 15 inches tall (growth was more upright than in previous years). However, 'Ellen Danica', although attractive, was less vigorous and did not fill as rapidly. 'Ellen Danica' was also somewhat more difficult to propagate. Therefore, we would recommend the standard grape ivy over 'Ellen Danica'.

Licorice Plant—'Limelight' was grown in 2001 but was planted in shade and did not perform well. In 2002, the species, *Helichrysum petiolare*, and cultivars 'Limelight' and 'Petite Licorice' were grown in full sun. 'Petite Licorice' performed extremely well and produced a cover of silvery green, fine-textured foliage in three to four weeks that was 6 to 8 inches high. Although the foliage was very attractive, 'Petite Licorice' produced flowers and seed heads that turned brown and detracted somewhat from the plant's appearance. The species and 'Limelight' showed infestation by a leaf miner that was followed by dieback of the leaves and stems. The species recovered with 50% of the plants having regrowth, while 'Limelight' failed to recover (complete dieback with no regrowth). Since the leafminer problem was not observed on 'Limelight' in 2001, we will evaluate these plants again in 2003.

Bacopa—'Snowflake' was grown in 2001 and performed very well. Along with 'Snowflake', 'Blue Showers', 'Lavender Showers', and 'Pink Penny Candy' were grown in 2002 in semi-shade. In general, the Bacopas established and filled very well after transplanting with complete fill between plants occurring within about three weeks. Good flowering was observed until early June when flowering diminished and did not resume significantly until mid-September. This was observed for all cultivars. Among the cultivars, 'Pink Penny Candy' had upright stems reaching about 6 to 8 inches tall, while the others were more prostrate and reached only 3 to 4 inches tall. In side-by-side comparisons, this made the lower-growing cultivars more attractive than 'Pink Penny Candy'. The lack of summer bloom was not as evident on 'Snowflake' in 2001 and may have resulted from excess heat during the 2002 growing season. The Bacopas appear to have potential as an annual ground cover, especially if cultivars or growing conditions can be identified that give season-long bloom. These and additional cultivars will be evaluated in 2003.

Tahitian Bridal Veil—Tahitian Bridal Veil was evaluated for the first time in 2001 and again in 2002. In 2002, plants were grown in full sun, semi-shade, and heavy shade. The plants filled in well after four to six weeks and were very attractive regardless of light exposure. Height was affected by light, with those in direct sun being slightly shorter (8 to 10 inches) versus those in semi- or heavy shade (10 to 12 inches). However, little flowering was observed for Tahitian Bridal Veil in 2002. Plants produced buds, but flowers failed to open until late in the season (September) when flowering was sporadic. This flowering pattern was noticed under all light conditions and was in contrast to the observations of 2001 when flowering occurred throughout the season.

Future work will look at additional cultivars of Bacopa, repeat the work with *Helichrysum*, and look again at Tahitian Bridal Veil, with the objective of finding cultivars and/or growing conditions that promote season-long flowering (Bacopa and Bridal Veil) and provide leaf-miner resistance (*Helichrysum*).

Acknowledgments

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Rudbeckia Taxa Evaluation

Amy Fulcher, Winston C. Dunwell, and Dwight Wolfe, Department of Horticulture

Nature of Work

Rudbeckia taxa comprise a group of about 30 annual, biennial, and perennial plants, all native to North America (1). Rudbeckia are in the *Asteraceae* family and display the daisy-type disc and ray flower typical of that family. They range in height from 6 inches for the smaller pot varieties to 80 inches. Many *Rudbeckia* taxa, like *R. hirta*, tolerate dry conditions, while others, such as *R. laciniata*, prefer moist conditions (2). Rudbeckia are considered easy to grow and thrive in full sun. Rudbeckia can be distinguished from other similarly shaped flowers by their alternate leaves, yellow, rust, and/or orange ray flowers, and raised disc or "eye."

Rudbeckia species and cultivars are valued native plants. In the last five years, landscape use of *Rudbeckia fulgida* var. *sullivantii* 'Goldsturm' (1999 Perennial Plant of the Year) has become increasingly popular in residential and commercial landscapes. The focus of this study was to evaluate several less common Rudbeckia species and cultivars for landscape adaptability.

Four to six plants of each taxa were planted at the University of Kentucky Research and Education Center in Princeton in the spring of 2002. Preen pre-emergent herbicide and Osmocote 5-19-12 (5 to 6 month release) were applied and plants were mulched. Plants were fertilized with Miracle Grow 15-30-15 at approximately 600 ppm nitrogen throughout the summer. The soil pH was maintained at 7.0. The planting was irrigated with a drip tube and was irrigated and weeded as needed. Plants were not staked or sprayed for diseases or insects. The maintenance schedule was designed to simulate the conditions of an average home landscape.

Data were collected approximately once per week from early June to late September on first bloom, bloom color, individual bloom size, bloom coverage (percent of the total plant covered by blooms), bloom period (weeks in bloom), plant height, and plant width. Observations were made on insect and disease incidence and cultural requirements, such as staking. Plants will be evaluated for winter hardiness.

Results and Discussion

First-year, preliminary data show that *R. fulgida* var. *sullivantii* 'Goldsturm' bloomed for the longest period of time, 10 weeks (Table 1). *Rudbeckia fulgida* 'Green Wizard' did not bloom at all.

Rudbeckia hirta 'Autumn Gold', 'Prairie Sun', 'Goldilocks', and 'Cherokee Sunset' had the greatest flower diameter.

Bloom coverage was not statistically different between taxa; however, the averages ranged from 31% to 62%. Only *Rudbeckia triloba* and *Rudbeckia hirta* 'Sonora' had season-long bloom coverage averages above 50%.

Table 1. First-year results of the *Rudbeckia* taxa evaluation.

Cultivar	Weeks in Bloom	Flower Diameter (in.)	Bloom Coverage (%)*	Plant Height (in.)[1]	Plant Width (in.)[2]
R. fulgida var. *sullivantii* 'Goldsturm'	10.0	2.8	36	18.3	27.5
Rudbeckia hirta 'Autumn Gold'	8.5	4.4	46	16.9	23.6
Rudbeckia hirta 'Prairie Sun'	8.5	4.2	40	24.9	22.8
Rudbeckia subtomentosa	8.0	3.3	41	45.3	48
Rudbeckia hirta 'Cherokee Sunset'	7.5	3.9	46	23.9	26.5
Rudbeckia hirta 'Sonora'	7.3	3.1	55	10.3	11.7
Rudbeckia hirta 'Toto Gold'	6.7	2.6	41	7.6	9.3
Rudbeckia triloba	6.0	1.3	62	41	27.5
Rudbeckia hirta 'Toto Lemon'	5.7	1.9	31	4.9	4.6
Rudbeckia hirta 'Toto Rustic'	5.3	2.1	38	5.6	4.8
Rudbeckia hirta 'Goldilocks'	5.3	4.0	38	20.5	30
Rudbeckia laciniata 'Herbstsonne'	1.3	3.4	42	55.5	43.8
Rudbeckia fulgida 'Green Wizard'	0	—	—	8.3	23.6
LSD $_{(P=0.05)}$	2.8	0.6	—	—	—

* Not statistically significant.
1 Average plant height, including flower stalks taken August 12.
2 Average plant width, including flower stalks taken August 12.

Plant height on August 12 ranged from *Rudbeckia hirta* 'Toto Lemon' at 4.6 inches to *Rudbeckia laciniata* 'Herbstsonne' at 55.5 inches.

Plant width on August 12 ranged from *Rudbeckia hirta* 'Toto Lemon' at 4.6 inches to *Rudbeckia laciniata* 'Herbstsonne' at 43.8 inches.

Flower observations

Rudbeckia hirta 'Prairie Sun' began the season with butter yellow outer portions of the ray flowers and darker, golden yellow interior portions of the ray flowers. The disc flowers began as a yellow-chartreuse color. As the season progressed and seeds developed, the disc color changed to brown, altering the aesthetic qualities of the flower. *Rudbeckia hirta* 'Autumn Gold' displayed variable flower color ranging from yellow to dark orange to rust-colored ray flowers. Flowering was variable on *Rudbeckia laciniata* 'Herbstsonne' with just two of the four plants developing flower stalks and flowers. *R. fulgida* var. *sullivantii* 'Goldsturm' did not have one of the highest bloom coverages in the study, but an established planting nearby began blooming earlier and bloomed as late into the season and appeared to have greater bloom coverage than the first-year plants in the evaluation.

Pest observations

Shining flower beetles were identified on *Rudbeckia hirta* 'Cherokee Sunset' but did not cause damage. Japanese beetles, spittle bugs, caterpillars, and cucumber beetles were noted on occasion but did not appear to cause any noticeable damage. *Rudbeckia triloba* was the exception, sustaining noticeable yet minor damage from Japanese beetles. Soldier beetles were identified in large numbers on the flowers of several varieties but caused no damage.

In July, several taxa began to display disease symptoms. On July 22, *Rudbeckia fulgida* 'Green Wizard' and *Rudbeckia hirta* 'Goldilocks' were diagnosed with rhizoctonia root and stem rot. All of the *Rudbeckia hirta* 'Goldilocks' and half of the *Rudbeckia fulgida* 'Green Wizard' died. As the season progressed, the *R. hirta* Toto series and *R. hirta* 'Sonora' also succumbed to rhizoctonia. By the end of September, plants of *Rudbeckia hirta* 'Autumn Gold', 'Cherokee Sunset', and 'Prairie Sun' had also died. Powdery mildew was noted on *Rudbeckia hirta* 'Autumn Gold' and *Rudbeckia hirta* 'Cherokee Sunset' in late August. *Rudbeckia fulgida* var. *sullivantii* 'Goldsturm' was diagnosed with cercospora leaf spot in October, after several incidences of rain. The symptoms associated with the cercospora were also present in April and May, during a period of wet weather.

Cultural and environmental observations

Rudbeckia laciniata 'Herbstsonne', *Rudbeckia subtomentosa*, and *Rudbeckia triloba* needed to be staked, possibly due to the high rate of nitrogen applied in the liquid fertilizer. In September *R. triloba* and *R. subtomentosa* exhibited symptoms consistent with ozone damage.

Significance to the Industry

Identification of adaptable, attractive, native perennials can provide landscape contractors, designers, and retailers with an expanded list of plants to market to the consumer as well as a wider selection of low maintenance plants for commercial landscapes.

Acknowledgments

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Literature Cited

1. Armitage, Allan. 1997. Herbaceous Perennial Plants. Stipes Publishing L.L.C., Champaign, Ill.
2. Armitage, Allan. Manual of Annuals, Biennials, and Half-Hardy Perennials. Timber Press, Portland, Ore.

Vase Life Study of *Hydrangea paniculata* Flowers: Results from Quicksand Trials

Sharon Bale, Terry Jones, Robert McNiel, and Mort Turner, Department of Horticulture

Nature of Work

Hydrangea paniculata cultivars 'Pee Wee', 'Kyushu', 'Tardiva', and 'Pink Diamond' were grown in trial plots at Quicksand and Princeton to evaluate their potential as a cut stem. Plants were cut back in the fall to approximately 6 inches in height. Plants produced tall, straight stems with large terminal infloresence. The stem length and bloom size indicated that plants grown in this manner could be desirable cut flowers. Plants generally produced 20 to 30 stems per plant.

Stems were harvested from the plots in Quicksand in 2002 when the first two rows of sterile florets had begun to open. Stems were cut to a 48-inch length, the length of a standard box used by the floral industry to ship flowers. No data were taken on stem length because producing an adequate stem length was not an issue. All the stems had to be reduced in length often by as much as 36 inches in order to fit in the box. All stems harvested received a one-hour pulse of the hydrating solution HydraQuick. Half the stems were placed in the vase life study at that time. The treatments were 1) a control of plain water (pH 7.2), 2) Aqua Flora as per package directions (flower preservative), and 3) Aqua Flora as per package direction plus the addition of Flora Novus XL (a chemical that is supposed to increase vase life when used with a preservative).

The other half of the stems were boxed in standard floral shipping boxes and stored dry in a cooler at 43° for three days. This would simulate a typical shipping period. Flowers were then processed again in the hydrating solution and received the same treatments.

Results and Discussion

Although the vase life time was statistically different for each of the treatments, the practical results showed that the stems have a five- to six-day vase life. This may not appear to be a great length of time, but it is adequate. Another group of stems were stored for six days and then placed in the vase life study. These also lasted for five to six days. This indicates that shipping plants long distances will not be a problem and that the flowers can be held in a cooler for a period of time before they are rehydrated without significant damage to the flower.

These flowers have a great deal of potential for the wedding, party, and funeral trade because they are large and showy. The need for an extended vase life is not as important in this situation. Since these flowers would command a fairly large price and are most suited to a certain type of event, the ability to ship them to other locations would be desirable. Another plus for this potential crop is the length of production. The cultivars chosen for this trial do not bloom at the same time. Harvesting stems could begin as early as mid-July and continue through September.

Note: The same study was conducted in Princeton. Results may vary because of the high pH of the water in Quicksand. Some information indicates that floral preservatives are not as successful in solutions with a high pH.

Why Don't My Hydrangeas Bloom?

Sharon Bale, Terry Jones, Robert McNiel, and Mort Turner, Department of Horticulture

Nature of Work

Whether for the commercial cut flower market or the home landscape, *Hydrangea macrophylla* produce two types of very desirable flowers, mopheads and lacecaps. Mophead hydrangeas are more desirable for the cut stem market, and both types are desirable for the home landscape. The belief that all of these hydrangeas produced blooms on old wood is not completely true. Some cultivars do require old wood to produce bloom; some are remontant, while others are simply hardier. The question is: Which cultivars fall into which category in Kentucky? The trial plot located at Quicksand is beginning to produce some interesting results. The plot was established in 1998 using extremely small plant material. Plants are just now reaching maturity.

Pruning

Since all *Hydrangea macrophyllas* appear to die back to the ground in Kentucky the notion of a "proper" pruning time did not seem to be relevant; rather, garden "clean-up" was the important point. (Leaves did break from the apparently dead stems of 'Pink Beauty'.) The trials at Quicksand were divided into two groups; one group was pruned in the fall, while the other group was pruned in the spring. In previous years, all plants were cut back in the fall. Significantly more blooms were produced on plants that were pruned in the spring.

Mulching

In addition to the differences in pruning time, a third of the plants were not mulched in the fall, while another third was mulched with straw and the final third mulched with wood chips. The wood chips were by-products from the wood utilization center and included a variety of wood sources. Mulching with wood chips increased the number of blooms produced.

Results and Discussion

If a specific cultivar of *Hydrangea macrophylla* has any potential for bloom in Kentucky. the bloom potential is increased by not pruning the plants at all or pruning in the spring and mulching the plants, preferably with wood chips.

Flower Color

Flower color is determined by the pH of the soil and the availability of aluminum. If aluminum is present and available to the plants, blue is going to be the predominant flower color regardless of the expected color of the cultivar. Flower color is not an issue in these trials yet.

Evaluation of the 14 cultivars located at Quicksand

Nikko Blue—Fall-pruned plants produced some blooms, but nothing like the bloom production of plants pruned in the spring and mulched with wood chips. This was by far the best performer in the trials. Plants established well and produced high quality mophead blooms.

All Summer Beauty—The next best performer. Twice as many blooms were produced on plants pruned in the spring and mulched as those pruned in the fall and mulched.

Teller White—The best lacecap in the trials, but the plants did not produce a large number of blooms.

Alpenglow/Glowing Embers—According to one source, these cultivars are the same. These plants produce very high quality blooms. In Quicksand, the flower color was a beautiful purple. Plants appear to be slower growing and more difficult to establish.

Blue Billow—Another lacecap type that produced a tremendous number of blooms. The blooms were hidden by the foliage, and the overall display was very poor.

Goliath—Not as prolific as the others, but the bloom quality was very good. This plant will remain in the trials in case plant maturity is a factor.

Pink Beauty—New growth emerged from the old stems of this cultivar. Plants did bloom, but the blooms were quickly overtaken by the foliage growth and were basically invisible. Bloom diameter was small, and no rebloom occured.

Coerula Lace—A lacecap type produced a limited show of poor quality blooms.

Merritt Supreme—Produced a few high quality blooms.

Cardinal Red—Plants have shown little vigor, were difficult to establish, and produce few blooms.

Serrata Preziosa—Produced no blooms.

Sister Theresa—Produced no blooms.

Domotoi—Produced no blooms

The evaluation of these 14 plants is just a beginning. We have more than 40 cultivars that are in various stages of evaluation. Several of these show better potential than the first cultivars evaluated.

All America Selections Winners

Sharon Bale, Shari Dutton, and Janet Pfeiffer, Department of Horticulture

AAS Flower Winners

The All America Selections trials evaluate new plant material produced from seed. Determination of the winners is based on plant performance in the garden. Approximately 32 trial gardens are located across the United States and Canada. Plants are only scored worthy of introduction if they perform better than the comparisons or are unique in some way. The 2002 Winners offer a variety of plants that perform well in Kentucky.

Cleome 'Sparkler Blush'—'Sparkler Blush' is one of the first hybrid cleomes. Plants maintain a uniform height and flower freely. The uniformity of this plant at a height of 3 to 4 feet makes this an ideal addition to the garden. The Sparkler Series should not be overlooked.

Ornamental Pepper 'Chilly Chili'—Plants perform as well as other ornamental peppers with the additional perk of nonpungent fruit. Child- and animal-friendly ornamental plants. The mild fruit is edible and can be used for flavoring. Plants are small and uniform in height and habit.

Petunia 'Lavender Wave'—Performs as well as other 'Wave' petunias. The pastel lavender color is very attractive and offers a nice relief from the somewhat harsh color of 'Purple Wave'. Good choice for containers or as a bedding plant.

Petunia 'Tidal Wave Silver'—Tidal wave is a good description. Silvery white blooms are borne on a plant that is extremely vigorous. Comments on this plant fall into the extremes. People either love it or hate it. In containers, the vigorous growth is very desirable. As a bedding plant, it may remind you of kudzu. Plants do not require pinching unless you wish to keep it from consuming neighboring plants.

Pansy 'Ultima Morpho'—Performs equal to other pansies. Plants have a distinct color combination of yellow and blue. Plants were evaluated on their performance from spring planting. Plant hardiness from fall planting was not evaluated.

Rudbeckia 'Cherokee Sunset'—Plant performance is similar to other rudbeckias. Bloom colors range from yellow to bronze. This plant may overwinter. We have never left it in the garden to see if this will occur. Does well as a cut flower for early fall arrangements.

AAS Bedding Plant Winners

AAS Bedding Plant trials are evaluated on the basis of their performance in the greenhouse. Flower Trial Gardens only evaluate these plants once they have been determined possible winners for their performance in the greenhouse. University of Kentucky does not participate in the bedding plant trials at the present time.

Vinca 'Jaio Scarlet Eye'—A very nice rose-colored flower with a small white eye. Performance equal to other vinca.

Geranium 'Black Velvet Rose'—Foliage has very distinct markings, is dark in color, and is attractive by itself. It is difficult to evaluate plant performance because the rabbits at the Arboretum love this plant.

Perennial Garden Flower Trials at the UK Horticulture Research Farm—2002

Bob Anderson and Kirk Ranta, Department of Horticulture

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

The collection of perennials in our ongoing trials continues to expand. We have nearly 1,000 individual plants in the perennial trials with more than 150 species and cultivars in the plots at the Horticulture Research Farm in Lexington. Our trials include the Perennial Plants of the Year from the Perennial Plant Association and some native plants. We now have three years' experience with some, so our ratings have many observations. However, our ratings should be used only as a guide to determine which perennials you might sell or use in Kentucky landscapes. In general, those that have grown well for two or more seasons are marked (++), and those that have not done too well (-); those unmarked need more time to determine a rating.

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

Mexican Hyssop

Agastache 'Tutti Frutti' ('01-'02) (-)

Arkansas Amsonia

Amsonia hubrectii ('01-'02) (+)

Artemisia

Artemisia absinthium 'Huntington Gardens' ('01) (-)

Aster

Aster apellus 'Triumph' ('00-'02) (-), *Aster laevis* 'Bluebird' ('00-'02) (++), *Aster latiflorus* 'Prince' ('00-'02), *Aster novi-belgii* 'Celeste' ('01-'02), *Aster novi-belgii* 'Purple Monarch' ('01-'02), *Aster novi-belgii* 'Snow Cushion' ('00-'02), *Aster novi-belgii* 'White Swan' ('00-'02) (++), *Aster novi-belgii* 'Winston Churchill' ('01-'02), *Aster novi-belgii* 'Woods Purple' ('00-'02), *Aster x frikarti* 'Monch' ('00-'02), *Aster oblongifolius* 'Raydon's Favorite' ('02), *Kalimeris mongolica* ('01-'02) (++), *Kalimeris mongolica* 'Variegata' ('00-'02) (++)

Astilbe

Astilbe 'Sprite' ('00-'02) (++)

Columbine

Aquilegia x hybrida 'Rose w/White Edge' ('02), 'Songbird Cardinal' ('02), 'Winky Red and White' ('02)

Cream False Indigo

Baptisia pendula ('01-'02)

Willowleaf Oxeye

Buphthalum salicifolium 'Sun Wheels' ('00-'02) (-)

English Daisy

Bellis perennis 'Galaxy Rose' ('02), 'Rose Border' ('02), 'Tasso Strawberry and Cream' ('02)

Feather Reed Grass

Calamagrostis acutifolia 'Karl Foerster' ('00-'02) (++), *Calamagrostis acutifolia* 'Overdam', ('02), Variegated Feather Reed Grass, *Calamagrostis brachytricha*, ('02), Korean Feather Reed Grass

River Oats, Northern Sea Oats

Chasmanthium latifolium (++) ('00-'02)

Garden Mums

Ajania pacificum 'Pink Ice' ('00-'02), *Chrysanthemum* 'Hillside Pink' ('01-'02), *Chrysanthemum yezoense* ('00-'02), *Dendranthema rubellum* 'Clara Curtis' ('00-'02), *Dendranthema rubellum* 'Mary Stoker' ('00-'02)

Shasta Daisy

Chrysanthemum (Leucanthemum) x superbum 'Becky' ('02)

Cumberland Rosemary

Conradina verticillata

Coreopsis

Coreopsis 'Tequila Sunrise' ('01-'02), *Coreopsis grandiflora* 'Domino' ('02), *Coreopsis grandiflora* ' Early Sunrise' ('02), *Coreopsis lanceolata* 'Baby Sun' ('02) - Lanceleaf Coreopsis *Coreopsis rosea* 'American Dream' ('01-'02), *Coreopsis verticillata* 'Moonbeam' ('00-'02) (++)

Montbretia

Crocosmia crocosmiifolia 'Venus' ('00-'02)

Pinks

Dianthus allwoodii 'Doris' ('02) - Allwood Pink, *Dianthus allwoodii* 'Frosty Fire' ('02) - Allwood Pink, *Dianthus deltoides* 'Brilliant' ('01-'02) - Maiden Pink, *Dianthus gratianopolitanus* 'Bath's Pink' ('02) (++) - Cheddar Pink

Cone Flower

Echinacea pallida ('00-'02), *Echinacea paradoxa* ('00-'02), *Echinacea purpurea* ('00-'02) (++), *Echinacea purpurea* 'Magnus' ('00-'02) (++), *Echinacea simulata* ('00-'02), *Echinacea tennessensis* ('00-'02) (++)

Silver Prairie Grass

Erianthus alopecuroides ('00-'02)

Oregon Fleabane

Erigeron 'Azure Fairy' ('00-'02) (-)

Hardy Ageratum

Eupatorium coelestinum ('01-'02) (++)

Joe Pye Weed

Eupatorium maculatum ('00-'02) (++), *Eupatorium maculatum* 'Carin' ('02), *Eupatorium maculatum* 'Gateway' ('02)

Hardy Fuchsia

Fuchsia magellanica 'Ricartonii' ('02) (-)

Wand Flower

Gaura lindheimeri 'Siskiyou Pink' ('01-'02)

Cranesbill, Hardy Geranium

Geranium 'Dusky Rose' ('00-'02), *Geranium cantabrigiense* 'Blokova' ('00-'02), *Geranium cantabrigiense* 'Karmina' ('00-'02), *Geranium cinereum* 'Ballerina' ('00-'02), *Geranium clarkei* 'Kasmir Purple' ('00-'02), *Geranium maculata* 'Claridge Druce' ('00-'02), *Geranium phaeum* 'Samobor' ('00-'02)

Sneezeweed

Helenium 'Coppella' (+) ('00-'02)

Sun Rose

Helianthemum 'Annabel' ('01-'02) (++), *Helianthemum nummularium* 'Double Red' ('01-'02)

Sunflower

Helianthus angustifolius 'Gold Lace' ('02), Swamp Sunflower, *Helianthus mollis* ('00-'02) - Downy Sunflower, *Heliopsis* 'Loraine Sunshine' ('00-'02) (++) - False Sunflower

Daylily

Hemerocallis 'Stella d'Oro' ('01-'02) (++)

Alum Root, Coral Bells

Heuchera x brizoides 'Bressingham Hybrid' ('01-'02), *Heuchera micrantha* 'Palace Purple' (++) ('00-'02)

Garden Hibiscus

Hibiscus moscheutos 'Disco Bell Pink' ('00-'02) (++), 'Disco White' ('00-'02) (++), 'Kilimanjaro Red' ('01-'02) (++), 'Ranier Red' ('01-'02) (++), 'Mauna Kea' ('01-'02) (++), 'Etna Pink' ('01-'02) (++), 'Matterhorn' ('01-'02) (++)

Crepe Myrtle

Lagerstroemia indica 'Supersonic Mix' ('02)

Statice

Limonium latifolia ('00-'02)

Lobelia

Lobelia speciosa 'Fan Burgundy' ('01-'02)

Maltese Cross

Lychnis coronaria 'Angel Blush' ('01-'02), *Lychnis flos-jovis nana* 'Peggy' ('01-'02) (-)

Marshallia

Marshallia grandiflora ('02) - Barbara's buttons, *Marshallia mohrrii* ('02)

Maiden Grass

Miscanthus sinensis 'Morning Light' ('01-'02) (++)

Bee Balm

Monarda didyma 'Fireball' ('02) - Petite Bee Balm, 'Jacob Cline' ('01-'02), 'Marshall's Delight' ('01-'02), 'Pink Supreme' ('02) - Petite Bee Balm

Catmint

Calamintha nepeta 'White Cloud' ('02) - Savory Calamint, *Nepeta* 'Dawn to Dusk' ('00-'02) (++), *Nepeta* 'Subsessilis' ('00-'02) (++), *Nepeta faassenii* 'Six Hills Giant' ('00-'02) (++), 'Walker's Low' ('02)

Ornamental Oregano

Origanum laevigatum 'Herrenhausen' ('01-'02) (++)

Wild Quinine

Parthenium integrifolium ('00-'02) (++)

Fountain Grass

Pennisetum alopecuroides 'Hameln' ('01-'02) (++)

Beard Tongue

Penstemon barbatus 'Prairie Dusk' ('01-'02), *Penstemon digitalis* 'Husker Red' ('00-'02) (++), *Penstemon fruticosa* 'Purple Haze' ('01-'02)

Russian Sage

Perovskia atriplicifolia ('00-'02) (++), 'Little Spire' ('02)

Fleeceflower

Persicaria amplexicaule 'Firetail' ('01-'02), *Persicaria bistorta* 'Superbum' ('01-'02)

Garden Phlox

Phlox maculata 'Miss Lingard' ('00-'02) (++), 'Natasha' ('00-'02) (++), *Phlox paniculata* 'David' ('02), 'Jill' ('02), 'Margie' ('02), 'Nicky' ('02), 'Robert Poore' ('02), *Phlox pilosa* 'Eco Happy Traveller' ('02) - Downy Phlox

Prairie Coneflower

Ratidiba columnifera 'Mexican Hat' ('00-'02) (++)

Black Eye Susan

Rudbeckia fulgida 'Goldsturm' ('00-'02) (**++**) - Cone Flower, *Rudbeckia subtomentosa* ('00-'02) (**++**) - Sweet Black Eye Susan, *Rudbeckia triloba* ('00-'02) (**++**) - Brown Eye Susan *Rudbeckia fulgida* var. *fulgida* ('02) - Cone Flower, *Rudbeckia hirta* ('02) - Black Eye Susan, 'Autumn Colors' ('02), 'Cordoba' ('02), 'Goldilocks' ('02), 'Indian Summer' ('02), 'Prairie Sun' ('02), 'Sonora' ('02), 'Toto Gold' ('02), 'Toto Lemon' ('02), 'Toto Rustic' ('02), *Rudbeckia laciniata* 'Herbstonne' ('02) - Cutleaf Cone Flower, *Rudbeckia occidentalis* ('02) 'Black Beauty'

Meadow Sage

Salvia 'Blue Hill' ('00-'02) (**+**), 'Blue Queen' ('00-'02) (**+**), 'May Night' ('00-'02) (**++**), 'Blue Hill' ('00-'02) (**+**), 'Snow Hill' ('00-'02) (**+**), *Salvia lyrata* 'Burgundy Bliss' ('00-'02) (**-**)

Pincushion Flower

Scabiosa caucasica 'Perfecta Alba' ('00-'02), *Scabiosa columbaria* 'Butterfly Blue' ('00-'02), 'Pink Mist (+)' ('00-'02)

Kaffir Lily

Schizostylis coccinea ('00-'02)

Sedum

Sedum spectabile 'Autumn Joy' ('00-'02) (**++**), 'Brilliant' ('00-'02), 'Stardust' ('02), *Sedum spurium* 'Vera Jameson' ('00-'02) (**++**)

Goldenrod

Solidago rugosa 'Fireworks' ('02)

Meadowsweet

Spirea latifolia ('00-'02) (**++**)

Prairie Dropseed

Sporobolis heterolepis ('02)

Stokes Aster

Stokesia laevis 'Blue Danube' ('00-'02) (-), 'Klaus Jellito' ('00-'02), 'Mary Gregory' ('00-'02) (-), 'Omega Skyrocket' ('02), 'Purple Parasols' ('00-'02), 'Silver Moon' (-) ('00-'02)

Mulleins

Verbascum 'Helen Johnson' ('00-'02), *Verbascum* 'Jackie' ('00-'02)

Speedwells

Veronica 'Fascination' ('00-'02), *Veronica* 'Giles van Hess' ('00-'02), *Veronica* 'Goodness Grows' ('00-'02), *Veronica* 'Spring Dew', *Veronica* 'Waterperry' ('01-'02), *Veronica* 'White Jolanda' ('00-'02) (**++**), *Veronica alpinia* 'Alba' ('01-'02) (**++**), *Veronica austriaca* 'Crater Lake Blue'('00-'02), *Veronica longifolia* 'Sunny Border Blue' ('00-'02) (**++**), *Veronica peduncularis* 'Georgia Blue' ('01-'02) (**+**), *Veronica spicata* 'Blue Carpet' ('02), 'Icicle' ('00-'02) (**+**), 'Noah Williams' ('00-'02), 'Red Fox' ('00-'02), 'Rose' ('02), 'Sightseeing' ('02)

Acknowledgments

We wish to thank the staff gardeners at all our garden locations for all their help with these trials. We are pleased to work with such knowledgeable and hard-working horticulturists across the state. Please take some time next year to visit these trial and demonstration gardens:

- Purchase Area Master Gardener Garden, Paducah, Kathy Keeney
- UK West Kentucky Research and Education Center, Princeton, June Johnson and Win Dunwell
- Warren County Master Gardener Garden, Bowling Green, Carol Lefever and Ruby Stein
- Hardin County Master Gardener Garden, Elizabethtown, Amy Aldenderfer
- Louisville Zoo, Louisville, Mark Zoeller
- UK Arboretum, Lexington, Susan Capley and Candace Harker
- Boone County Master Gardener Garden, Burlington, Mike Klahr
- Campbell County Master Gardener Garden, Highland Heights, Dave Koester
- Pulaski County Master Gardener Garden, Somerset, Beth Wilson.

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

The UK Nursery/Landscape Fund was initiated in 1993 to provide an avenue for companies and individuals to invest financial resources to support research and educational activities of the University of Kentucky to benefit the industry. Many industry personnel recognized that a dependable, consistent supply of support funds would allow faculty to increase research and education programs addressing industry needs. Such an investment by the industry is wise and essential.

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

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

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

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

Several Kentucky nursery/landscape industry leaders have seized the opportunity and made a significant and long-lasting impact on research to support our industry. Three named endowments and a general endowment that will total more than $250,000 within five years have been established at the University of Kentucky to support nursery and landscape research through the Department of Horticulture. This year, income from this family of endowments provided more than $12,000 to support research for our industry.

Named endowments were established by a minimum of $25,000 commitment over five years. The named endowments include:

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

The general **UK Nursery/Landscape Research Endowment** was established with cash and pledges over three years totaling $34,000, which was matched with state funds. These funds were provided by continuing Fellows-level commitments redirected to the endowment and several one-time contributions.

UK Nursery/Landscape Advisory Committee

The UK Nursery/Landscape Advisory Committee consists of contributors to the fund and advises the chair of the UK Horticulture Department on the use of available funds to benefit the industry through research and education and assists in the continued development of the fund. Those individuals and companies contributing to the UK Landscape Fund in 2002 (through November 1) are listed in this report. Your support is appreciated and is an excellent investment in the future of the Kentucky nursery and landscape industries.

Summary

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

The Research Challenge Trust Fund, which provides the 1:1 match for endowments to support research at UK, is the greatest opportunity afforded the industry to develop long-term support for the programs designed to support the industry. It is possible for several individuals and companies to pool their commitments to be contributed over five years to reach the $50,000 minimum required for a match, assuming additional state funds will be available in 2003. For more information on how to contribute to an endowment or the annual giving program, please contact Dewayne Ingram at 859-257-1758 or the UK College of Agriculture Development Office at 859-257-7200.

UK Nursery and Landscape Fund and Endowment Fellows

Gregory L. Ammon
Ammon Wholesale Nursery

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

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

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

Herman R.* and Mary B. Wallitsch
Wallitsch Nursery

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

Daniel S. Gardiner*
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.

Robert* and Janice Corum
National Nursery Products

Herman, Jr., and Deborah Wallitsch
Wallitsch Nursery

Richard and Shirley Ammon
Ammon Landscape Inc.

**deceased*

2002 Contributors to the UK Nursery/Landscape Fund and Endowments

(through November 1)

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Pat Dwyer, Dwyer Landscaping Inc.
Bill Henkel, Henkel Denmark Inc.
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J. Frank Schmidt Family Charitable Trust
Kit Shaughnessy, Kit Shaughnessy Inc.

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Industry Organizations
Kentucky Landscape Industries Trade Show
Kentucky Nursery and Landscape Association

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