UK Nursery and Landscape Program

Faculty, Staff, and Student Cooperators

About Our Cover
Bignonia capreolata (Cross Vine), a 2006 Theodore Klein Plant Award Winner, is an underutilized southeastern native woody vine that is found across all of Kentucky. It is more frequent "in calcareous soil on river banks and cliffs and in ravines" (Wharton and Barbour, Trees and Shrubs of Kentucky 1973). The common name is a description of the cross-shaped branch pith. In full sun or partial shade it forms dense foliage and blooms prolifically. Semi-evergreen foliage of dark leathery green provides the perfect contrast for brilliant red-orange (occasionally scarlet), 5-lobed trumpet flowers that are a stunning yellow "inside" that runs out to the visibly obvious lips of the flower in late spring. The "outside" bloom color ranges from yellow-orange ('Tangerine Beauty') to bright red ('Atrosanguinea'). The flowers occur in beautiful showy clusters. This clinging vine is excellent for rock walls or arbors and is highly pest resistant. Small discs on the end of tendrils allow it to fasten to the bark of trees and wood and masonry structures. It propagates from seed with no pretreatment and will root in high percentages; 1000 to 3000 KIBA is beneficial in the 8-10 weeks it takes June-July cuttings to form roots.

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Nursery and Landscape Program

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UK Nursery and Landscape Program Overview—2007

Dewayne Ingram, Chair, Department of Horticulture

The UK Nursery and Landscape Program is the coordinated efforts of faculty, staff, and students in several departments within the College of Agriculture for the benefit of the Kentucky nursery and landscape industry. Our 2007 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 and Extension results, we have also highlighted below some of our undergraduate and graduate student activities that relate to the nursery and landscape industries.

Undergraduate Program Highlights

The department offers areas of emphasis in Horticultural Enterprise Management and Horticultural Science within a Horticulture, Plant and Soil Science Bachelor of Science degree. Following are a few highlights of our undergraduate program in 2006-2007.

The Plant and Soil Science degree program has 80 students in the fall semester of 2007, of which almost one-half are Horticulture students and another one-third are turfgrass students. Twelve horticulture students graduated in the 2006-2007 academic year.

We believe that a significant portion of an undergraduate education in horticulture must come outside the classroom. In addition to the local activities of the Horticulture Club and field trips during course laboratories, students have excellent off-campus learning experiences. Following are the highlights of such opportunities in 2007.

- Fifteen students participated in a 12-day study tour to Japan in May led by Robert McNiel, Robert Geneve, and Tom Nieman.
- Horticulture students competed in the 2007 Professional Landcare Network (PLANET) Career Day competition at Michigan State University in March (Robert McNiel, faculty advisor).
- Students accompanied faculty to the following regional/national/international meetings, including the American Society for Horticultural Science Annual Conference, Eastern Region—International Plant Propagators' Society, the Kentucky Landscape Industries Conference, Southern Nursery Association Research Conference and Trade Show, and the Mid-States Horticultural Expo.

Graduate Program Highlights

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

Hydrangea Production in Containers as a System to Generate Floral Cut Stems

Robert E. McNiel, Bonka Vaneva, John Snyder, and Sharon Bale, Department of Horticulture

Nature of the Work

Hydrangea macrophylla (*H.m.*) flowers inconsistently when field grown in the Ohio River Valley. To provide a consistent supply of flowering stems, cut-stem growers need alternate production capabilities. Inconsistent flowering is related to bud loss, likely due to cold temperatures. Using the nursery industry's over-wintering techniques of poly covered tunnels, eleven *H.m.* cultivars were grown in 19 L containers using a pine bark based substrate. Plants were covered directly with additional 6 mil poly for additional protection during winter temperatures below -12° C. Summer shade at 55% was provided. Plants were pruned to 25 cm during the dormant period and aluminum sulfate (24 g per application, 3 applications) was added to ten plants of each cultivar to create blue flowers. The normal pine bark-based substrate lacks aluminum and thus flowers are shades of red. Statistical analysis was completed using SAS.

Table 1. Evaluation of stems & flowers on *Hydrangea macrophylla* cultivars grown in containers during 2005.

Cultivar	Stem Count per Plant[x]	Stem Length > 30 cm *(%)*	Floral Width > 12 cm *(%)*	Floral Rating Scale 0-5	Harvest Length *(days)*	Mid-Harvest Date
All Summer Beauty (2 year)	19.0 cb	81 a	77 cdef	4.0 ef	28 cdef	24JUN
All Summer Beauty (1 year)	16.1cd	50 bcd	89 ab	4.3 cd	34 bcde	20JUN
Decatur Blue	12.3 de	45 d	71 fg	3.7 g	111 a	19JUL
Dooley	19.6 bc	85 a	73 ef	4.4 bc	19 fgh	23JUN
Mme Emile Mouillèré	18.3 c	75 a	75 def	4.1 de	24 efgh	21JUN
Fasan	15.3 cde	57 bc	82 bcde	4.0 ef	11 h	29JUN
Gén. Vic. de Vibrayé	16.6 cd	58 bc	75 def	4.1 de	45 b	19JUN
Harlequin	24.6 ab	48 bcd	77 cdef	4.1 de	27 defg	11JUL
Masja (2 year)	19.6 bc	87 a	82 abcde	4.5 bc	19 fgh	01JUL
Masja (1 year)	10.1 e	41 d	92 a	4.7 a	33 bcde	12JUL
Mathilda Gútges	18.1 c	50 bcd	85 abcd	4.3 cd	14 gh	30JUN
Nikko Blue (2 Year)	25.8 a	79 a	61 g	3.8 fg	40 bc	20JUN
Nikko Blue (1 year)	16.1 cd	62 b	87 abc	4.6 ab	39 bcd	22JUN
Parzival	30.2 a	62 b	69 fg	4.2 de	39 bc	9JUL

[x] Values within column followed by a different letter are different at $P = 0.05$ using Waller-Duncan K-ratio t Test.

Results and Discussion

Stems were harvested from 07JUN05 to 28SEP05 and rated for number, length, width, flower color and quality. Stems per plant varied from 10 for 'Masja' to 25-30 for 'Nikko Blue' and 'Parzival' (Table 1). Percentage of stems longer than 30 cm were significantly greater for 2-year-old 'Masja,' 'Dooley,' 'All Summer Beauty,' 'Nikko Blue' and 'Mme Emile Mouillèré' than for 1-yr -old 'Masja' or 'Decatur Blue.' Percentage of inflorescences with width greater than 12 cm varied from 61 % for 'Nikko Blue' (2 yr old), to 92 % for 'Masja.' Plants treated with aluminum produced shorter stems and narrower inflorescences than plants with no aluminum treatment. Flower quality rating, based on a scale of 1-5, ranged from 3.7 for 'Decatur Blue' to 4.7 for 'Masja' (2 yr old). Using the Royal Horticultural Society Colour Chart, a color was assigned to each flower. 'Mme Emile Mouillèré' was the least variable with seven colors. This contrasted with 'Decatur Blue,' 'Harlequin,' 'Masja' and 'Parzival' with each exhibiting over 40 colors (Table 2). Flower color occurrences and which color consisted of more than 10% of the total for each cultivar are listed in Table 2. Parzival exhibited a wide range of colors when treated with aluminum and no color exceeded 10% of the total. Median harvest date ranged from 19JUN05 for 'Générale Vicomtesse de Vibrayé' to 19JUL05 for 'Decatur Blue' (Table 1).

Significance to the Industry

Flower bud protection is possible. Acceptable stem numbers, lengths, and widths for the floral trade were produced in a container production system.

Table 2. Number of colors represented and top 3 colors when greater than 10% of color range.

Cultivar	Aluminum	Total No. Color Chips	Chip Colors with Three Greatest Frequency per Treatment *(most frequent on left)*		
All Summer Beauty (2 year)	No	20	84C	85C	92C
	Yes	15	100C	101C	100D
All Summer Beauty (1 year)	No	22	85C	75B	84C
	Yes	14	100C	100D	97B
Decatur Blue	No	28	N74D	73A	75A
	Yes	20	85C	100C	
Dooley	No	17	91C	76B	97B
	Yes	12	101C	100C	
Mme Emile Mouillèré	No	6	WHITE	69D	
	Yes	3	WHITE	N155A	
Fasan	No	16	63B	67C	61B
	Yes	23	N78B		
Gén. Vic. de Vibrayé	No	28	84C	75B	
	Yes	8	100C	101C	97B
Harlequin	No	21	63B	64C	
	Yes	24	72B	N82B	77B
Masja (2 year)	No	24	63B		
	Yes	26	N82B	N81C	
Masja (1 year)	No	15	73B	63B	68B
	Yes	17	86C	70B	N78C
Mathilda Gútges	No	19	93D	100C	85B
	Yes	14	93D	94C	98C
Nikko Blue (2 Year)	No	15	84B	84C	100D
	Yes	13	100C	101C	100D
Nikko Blue (1 year)	No	17	84C	85C	
	Yes	13	100D	100C	
Parzival	No	19	68B	73B	63B
	Yes	41			

Hydrangea Production in Tunnels as a System to Generate Floral Cut Stems

Robert E. McNiel, Bonka Vaneva, John Snyder, and Sharon Bale, Department of Horticulture

Nature of the Work

Hydrangea macrophylla buds produced during late summer have the potential of producing flowering stems the following year. Plants grown in the Ohio River Valley fields do not flower consistently because of bud loss due to cold temperatures during the winter or early spring. Firms desiring to produce cut stems for the florist industry or farmers' markets need to insure flower bud survival by protecting plants. Steel frame tunnels 4.9 x 29.3 meters were constructed and covered with 6 mil white poly during winter months. Six plants each of ten cultivars were planted directly into the ground on 1.2 meter centers into each of four replicated tunnels. During early winter, plants were pruned back to approximately 25 cm of the ground. An additional layer of 6 mil poly was placed directly over the plants during the coldest winter weather. Plants were fertilized in the spring with a controlled release fertilizer at manufactures recommended rate for a 7-gallon container. Tunnels were covered with shade cloth rated at 55% shade. Plants were watered naturally and supplemented with drip irrigation. Stems were harvested from 12JUN06 to 03NOV06 and rated for number, length, width, flower color and quality. Statistical analysis was completed using SAS.

Results and Discussion

Stems per plant varied from 5 for 'Harlequin' to 26–31 for 'Endless Summer,' 'Decatur Blue' and 'Oak Hill' (Table 1). Percentage of stems longer than 30 cm were significantly greater for 'Endless Summer,' 'Decatur Blue,' 'Oak Hill,' 'Penny Mac,' and 'Mme Emile Mouillèré.' Percentage inflorescence width greater than 12 cm varied from 75 % for 'Harlequin' to 85 % for 'Nikko Blue.' Flower quality rating, based on a scale of 1-5, ranged from 3.7 for 'Harlequin' to 4.3 for 'Endless Summer.' Harvest season ranged from 135 days for 'Oak Hill' to 13 days for 'Harlequin.' Using the Royal Horticultural Society Colour Chart, a color was assigned to each flower. 'Mme Emile Mouillèré' was the least variable with eight colors (Table 1). This contrasted with 'Decatur Blue,' 'Endless Summer,' 'Oak Hill,' and 'Penny Mac,' with each exhibiting over 40 colors. Colors were in the blue range except for white associated with 'Mme Emile Mouillèré' and red shades associated with 'Westfalen' and 'Harlequin.'

Significance to the Industry

Flower bud protection is possible. Acceptable cut stems for the floral trade were produced. Harvest time is extended by the remontant cultivars 'Decatur Blue,' 'Endless Summer,' 'Oak Hill,' and 'Penny Mac.'

Table 1. Evaluation of stems, flowers, and colors on *Hydrangea macrophylla* cultivars grown in a tunnel during 2006.

Cultivar	Stem Count per Plant	Stem Length > 30 cm (%)	Floral Width > 12 cm (%)	Floral Rating Scale 0-5	Harvest Length (days)	Mid-Harvest Date	Total No. Color Chips	Chip Colors with Three Greatest Frequency Over 10% per Treatment (most frequent on left)		
All Summer Beauty	13.8 d[x]	72.0 b	84.1 a	3.8 cd	92 d	19JUL	25	100C	97B	100D
Decatur Blue	27.0 b	91.0 a	81.4 a	4.2 ab	130 ab	12AUG	47	97B		
Mme Emile Mouillèré	14.1 d	90.0 a	75.5 a	4.1 abc	118 bc	10AUG	8	WHITE	N155A	
Endless Summer	26.6 b	91.1 a	81.8 a	4.3 a	133 a	18AUG	50	100C		
Harlequin	5.0 e	71.7 b	75.1 a	3.7 d	12 g	11JUL	12	63B	63A	
Mathilda Gútges	5.9 e	59.3 c	76.9 a	3.9 cd	36 f	17JUL	30	93D		
Nikko Blue	8.2 e	71.1 b	85.3 a	4.0 bcd	66 e	21JUL	26	100C	97B	100D
Oak Hill	31.9 a	89.2 a	77.4 a	4.2 ab	135 a	10AUG	45	100C	97A	97B
Penny Mac	21.3 c	88.7 a	85.0 a	4.2 ab	106 cd	01AUG	40	100C	97B	97A
Westfalen	6.6 e	73.3 b	84.8 a	4.1 abc	21 g	28JUN	17	63A	64B	63B

[x] Values within column followed by a different letter are different at $P = 0.05$ using Waller-Duncan K-ratio t Test.

Development of a Quantitative Color Analysis System for Hydrangea

John Snyder, Bonka Vaneva, Robert E. McNiel, and Sharon Bale, Department of Horticulture

Nature of the Work

In today's floral trade many species are ordered cultivar specific, but this is not true for *Hydrangea macrophylla*. The inability to order a specific color presents a problem. Color is a function of the cultivar, the environment, and their interactions. Colors can range from blue to red, with a myriad of intermediate shades. However, we have limited understanding of how the interactions between cultivar, environment, stage of development, etc., influence color. Thus, we wanted to develop a system for quantitative analysis of bloom color. The results herein present our progress.

Plants were grown using the nursery industry's overwintering techniques of poly-covered tunnels. Twenty plants of each of eleven *Hydrangea macrophylla* cultivars were grown in 19 L containers. Plants were covered directly with additional 6 mil poly for additional protection during winter when temperatures were below -12° C. Summer shade at 55% was provided. Plants were pruned to 25 cm during the dormant period and aluminum sulfate (three applications of 24g/plant) was added to ten plants to create blue flowers. With unamended pine bark-based substrate, flowers are usually shades of red. Based on a differential response to added aluminum (Al), two cultivars, 'Decatur Blue' and 'Mathilda Gútges,' were selected for initial evaluation, to better understand the potential value of quantitative color analysis. Flowering stems were harvested throughout the season as flowers attained full color, and flower color was visually matched with one chip in the Royal Horticultural Society Color Chart. Flowers were harvested from June through September, depending on cultivar.

For color analysis, each page of the Royal Horticultural Society Color Chart was scanned with a Canon 8600F digital scanner. The red, green, and blue components of each color patch were then obtained by use of image analysis software (1). The values of red, green, and blue components of each patch from the Royal Horticultural Society Color Chart were recorded. This system of color analysis is referred to as the RGB (red-green-blue) system or model.

For statistical analysis, the frequencies of the colors patch code were calculated for the two cultivars with and without added aluminum. Also for these two cultivars and Al treatments, the means, standard errors, and coefficients of variation for the red, green, and blue values were calculated.

After initial analysis of the red, green, and blue values for flower, the limitations of this system became apparent, especially in its ability to permit communication of flower color. We then decided to evaluate the Hue, Saturation, Value color system. Red, green, and blue values for each color chip were converted to their corresponding hue, saturation, and value parameters, according to the conversion provided by Cardani (2). All statistical procedures were conducted with SAS.

Results and Discussion

Frequencies of the most frequent chip codes from the Royal Horticultural Society Color Chart are presented in Figure 1 for flowers harvested from 'Decatur Blue' plants grown with or without added Al. From the data it is clear that frequencies of chip codes differed between the two treatments, and the most frequent code for each treatment can be identified. Also, from the data it can be determined that flower color varied within a treatment, but unless one is very familiar with the color chart, it is impossible to determine the extent of variation among these hydrangea flowers. Likewise, one can communicate the most frequent chip code, but without knowledge of the color chart, this information has little meaning.

Figure 1. Frequencies of the five most frequent color chip codes from the Royal Horticultural Society color chart for 'Decatur Blue' grown with and without added Al.

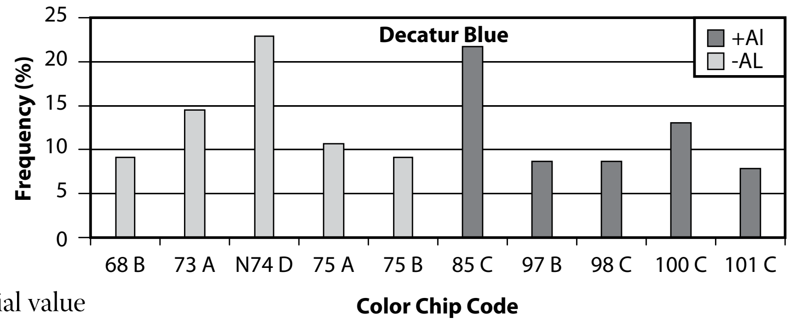


Figure 2. Results of red, green and blue color analysis of chip codes for 'Decatur Blue' and 'Mathilda Gútges' flowers grown with and without added Al.

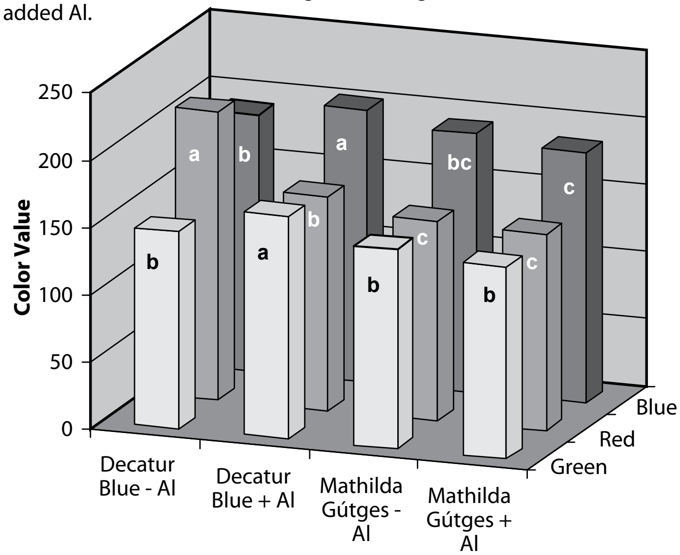
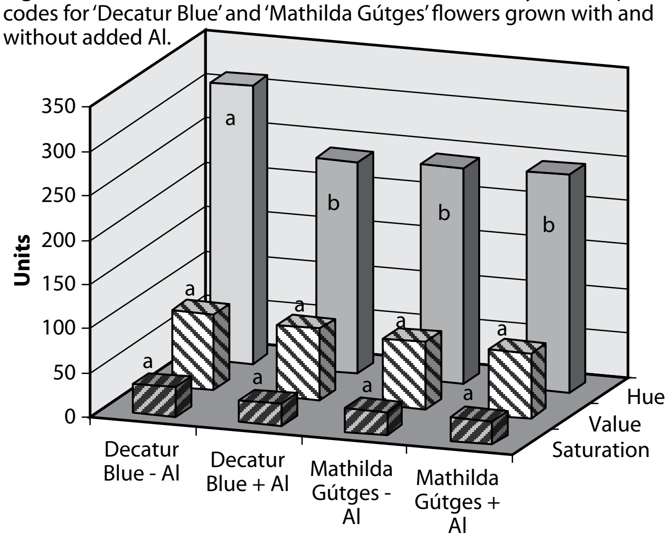


Figure 3. Results of hue, saturation and value color analysis of chip codes for 'Decatur Blue' and 'Mathilda Gútges' flowers grown with and without added Al.



Values for the RGB color analysis are presented in Figure 2. In this experiment 'Decatur Blue' responded as expected to Al treatment; flowers grown on plants treated with Al were more blue, and less red than those grown on untreated plants. As illustrated in Figure 2, the red and blue channels in the color analysis reflect this observed difference. Flowers harvested from plants of 'Mathilda Gútges' had similar colors, regardless of Al treatment. At this time the reasons for the lack of response of 'Mathilda Gútges' to Al treatment is under investigation. Means, standard errors, and coefficients of variability for the red, green, and blue color analysis of these two cultivars grown in the presence or absence of added Al are presented in Table 1. Based on the C.V. values, the colors were not highly variable throughout the season. The red channel was the most variable, and was more variable for Al treated cultivars. Blue was the least variable color channel. Analysis of color by splitting the chip colors into their respective RGB values provided an adequate mechanism to statistically analyze color, but it was very difficult to visualize the meaning of results. For example, without extensive additional information, it is nearly impossible to visualize the color of 'Decatur Blue' treated with Al based on the data in Table 1.

Another model for color is the Hue, Saturation, Value (HSV) model. It can be represented as a cone. Hue is the on the circular face of the cone, and hues are represented by angles. For example, 240° is blue, and 0 or 360° is red. White is the center of the circular face (0 saturation), and the close to the rim of the circle, saturation approaches 100. Also, at the center of the circle, the value (brightness) is 100 and decreases toward the apex of the cone to a value of 0, which is black.

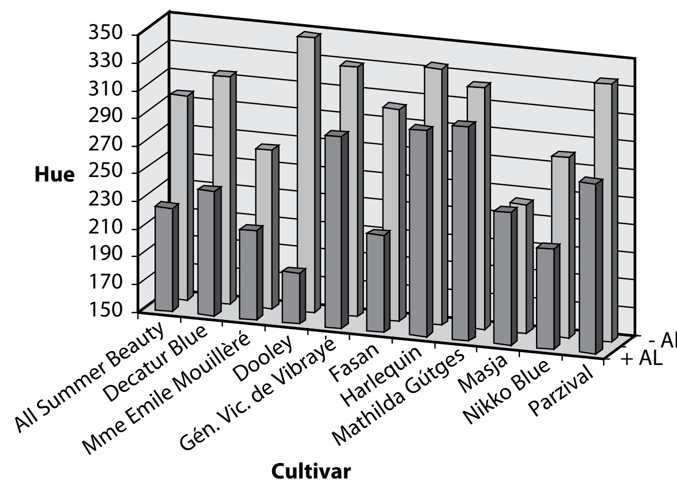
The data for 'Decatur Blue' and 'Mathilda Gútges' after conversion of RGB data to the HSV color model are presented in Figure 3. Among treatments and cultivars, saturation and value were similar. Flowers harvested from 'Decatur Blue' plants were pink or red (hue = 314°), and those flowers harvested from 'Decatur Blue' treated with Al, or untreated or Al-treated 'Mathilda Gútges' were blue (hue ~ 240°).

Figure 4 provides a comparison of hues for 11 cultivars grown with and without supplemental Al. With the exception of 'Mathilda Gútges,' hues were greater (more red) for the untreated plants, compared to plants grown with supplemental Al. 'Mme Emile Mouillèré' was the cultivar most responsive to added Al. Other cultivars appeared to have intermediate responses to Al supplementation.

Table 1. Average values obtained for red, green and blue color analysis, their means and coefficients of variation (C.V.), for 'Decatur Blue' and 'Mathilda Gútges' grown with and without added Al.

Cultivar	Al	Red Mean ± S.E.	Red C.V. (%)	Green Mean ± S.E.	Green C.V. (%)	Blue Mean ± S.E.	Blue C.V. (%)
Decatur Blue	No	214 ± 2.0	11	147 ± 2.0	15	191 ± 1.0	6
	Yes	159 ± 3.2	21	165 ± 1.7	11	202 ± 1.0	6
Matilda Gútges	No	148 ± 2.4	16	148 ± 1.4	9	192 ± 1.1	5
	Yes	147 ± 3.4	18	143 ± 2.2	12	186 ± 1.6	6

Figure 4. Hue values obtained from color analysis of Royal Horticultural Society color chips for eleven cultivars of Hydrangea, grown with and without supplemental Al.



Significance to the Industry

The use of image analysis to quantify colors in the Royal Horticultural Society Color Chart allowed us to conduct statistical analysis of Hydrangea flower color. It must be remembered that the original data used for analysis was based on a visual match of flower color with a color chip, which is a subjective process. Thus all subsequent data, while quantitative, remain subjective. That said, this approach appears to have value in providing a better understanding of how flower color may differ among cultivars and how flower color may change in response to factors such as added Al. Use of the HSV color description system has greater utility, because results are more easily understood and communicated.

Literature Cited

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Cutting Propagation and Shoot Regrowth in 'Rudy Haag' Compared to other Burning Bush Selections

Amy Poston, Chlodys Johnstone, and Robert Geneve, Department of Horticulture

Nature of the Work

Burning bush is a popular woody landscape shrub utilized by the landscape industry as an accent plant, hedge, or foundation planting. Unfortunately, burning bush has escaped cultivation throughout much of the Eastern United States. In Kentucky, burning bush has been listed as a severe threat, which is defined as "an exotic plant species, which possess characteristics of invasive species, spreads easily into native plant communities, and displaces native vegetation." Voluntary non-use of this plant is recommended in Kentucky (6). 'Rudy Haag' is a nearly seedless selection that could be utilized as an ecologically friendly alternative to other burning bush cultivars such as 'Compactus' (1). However, there is little information on nursery production or propagation of 'Rudy Haag.'

The objective of this study was to determine the impact of collection date and auxin treatment on burning bush selections including 'Rudy Haag' to assess if cutting propagation will not be a limiting factor for propagation and post-rooting shoot growth.

Materials and Methods

Softwood stem cuttings of burning bush selections were taken in May and June, 2005 and 2007. Four to 6-inch stem tips were treated with K-IBA as a quick dip solution, and stuck into 6-cell packs (3 ½" X 5 ¼" X 2 5/16"; Hummert International, Earth City, Mo.) with a 1:3 (v:v) ratio of perlite to 280-MetroMix (Sun Gro, Bellevue, Wash.). Flats of cuttings were placed in a greenhouse under intermittent mist set for at 10 seconds every 16 minutes with bottom-heat (24°C). After 30 days, the flats were removed from the mist bed and roots were evaluated. Following evaluation, plants were acclimated to greenhouse conditions and given a weekly application of a 200 ppm N liquid fertilizer solution (Peter's 20-10-20 Peat-lite Special, Scotts Company, Marysville, Ohio). Prior to over-wintering, the percentage of cuttings with new shoot growth was recorded.

In 2005, cuttings were treated with four levels of K-IBA (0, 1000, 3000, and 6000 ppm) with six replicate six-packs (72 cuttings total) per treatment. In 2007, cuttings were either untreated or treated with K-IBA at 6000 ppm with ten six-packs (100 cuttings total) per treatment. Rooting percentage and roots per cutting were evaluated 30 days after sticking. An arcsine transformation was applied to rooting percentage data, and mean separations were obtained using Tukey's HSD.

Results and Discussion

Cultivar, cutting date, and auxin treatment showed significant effects for rooting percentage and roots per cutting (Table 1). Initial experiments in 2005 found that burning bush cuttings generally rooted at higher percentages and with more roots per cutting after treatment with K-IBA at 3000 or 6000 ppm (data not shown). During 2005, cuttings rooted better when taken in May, while in 2007 June cuttings generally rooted with similar or higher percentages compared to May cuttings. On average, 'Rudy Haag' cuttings rooted at higher percentages and with more roots per cutting than either the species or 'Compactus.' In both years, 'Rudy Haag' was also less affected by cutting date (always > 70% rooting) compared to seasons where the species and 'Compactus' rooted below 20%. For the species and 'Compactus,' a K-IBA treatment at 6000 ppm generally improved rooting and in some cases dramatically increased rooting percentages from at or below 20% to over 70% rooting. The only major impact auxin had on 'Rudy Haag' cuttings was on roots per cutting.

In general, 'Rudy Haag' was easier to root from cuttings compared to the species (Table 1). The time cuttings were taken was the most significant factor in obtaining a high percentage of cuttings producing a high number of adventitious roots. In a previous study, 'Compactus' cuttings taken in June rooted at approximately 90–100%, with and without auxin at 2000 ppm, whereas cuttings taken in August rooted at approximately 45 and 70%, respectively (4). Seasonality, or the time that cuttings are taken, can have a significant effect on rooting of many woody ornamentals due to the physiological condition of the stock plants (3). In the current study, May cuttings rooted better than June cuttings in 2005; in 2007 cuttings rooted better in June. Stock plant environment could explain this apparent contradiction. In 2007, a severe freeze occurred in April after growth was initiated on the stock plants. This led to delayed development that could have made June cuttings in 2007 more similar to May 2005.

K-IBA treatment had a greater impact on root numbers per cutting than on rooting percentage except in those cases with the species or 'Compactus' where rooting percentages for untreated cuttings was less than 20% (Table 1). Similarly, Lee and Tukey (4) found that auxin application only showed dramatic increases in 'Compactus' cuttings taken when rooting percentages were low. 'Rudy Haag' cuttings rooted easily and therefore K-IBA had small affects on rooting percentage and a larger impact on root number. Auxin application may not be necessary when taking 'Rudy Haag' cuttings. 'Rudy Haag' is a slow growing burning bush cultivar. This may be due to a reduced capacity to produce or respond to gibberellin. Gibberellin impairment is consistent with the behavior of 'Rudy Haag' during rooting. Gibberellin is generally considered antagonistic to rooting (2), and a reduction in endogenous gibberellin content or responsiveness could result in the easy-to-root phenotype observed in 'Rudy Haag.'

For cuttings taken in 2005, 'Rudy Haag' cuttings showed a reduced capacity to flush new shoot growth following rooting compared to the species (Table 2). Overall, 'Rudy Haag' flushed new growth in only 6 percent of cuttings. For the species, cuttings had greater than a 95% capacity for new shoot growth when taken in May and an average capacity of 72.5% in cuttings taken in June. There was no apparent impact of IBA treatment on the capacity to flush new growth in the species regardless of the time cuttings were taken. In contrast, cuttings from the species 'Compactus' and 'Rudy Haag' all failed to initiate a new shoot flush following rooting in 2007 regardless (data not shown).

Production of new shoots following rooting was variable between years and cutting dates (Table 2). There was only significant regrowth for cuttings taken in May 2005 for the species. This is similar to work with privet (*Ligustrum ovalifolium*) that showed reduced rooting and decreased subsequent shoot growth in cuttings taken in September compared to those taken in June (5). 'Rudy Haag' showed more regrowth from May cuttings, but the percentage was considerably lower than the species. There was also an apparent auxin effect on regrowth with 'Rudy Haag' that eliminated regrowth for May cuttings. Auxin applied to cuttings may have a residual effect by suppressing bud-break or growth flushes post-rooting (3). In rose cuttings reduced shoot growth has been attributed to an auxin-induced increase in ethylene production inhibiting bud break (7).

Significance to the Industry

Burning bush has been recognized as an exotic invasive plant, and its use as a residential shrub is being discouraged. 'Rudy Haag' could replace current burning bush cultivars as an environmentally friendly alternative because it is nearly seedless. Unfortunately, 'Rudy Haag' is slower growing in the nursery compared to other burning bush cultivars such as 'Compactus.' The current research demonstrates that 'Rudy Haag' is easier to root than other burning bush selections tested, but that it does not re-grow readily following rooting. The best rooting and regrowth in 'Rudy Haag' cuttings was observed in cuttings taken early in the season without auxin application, but this may vary depending on stock plant environment.

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Table 1. Root formation in cutting from burning bush selections collected in May and June and treated with 0 or 6000 ppm K-IBA.

			2005		2007	
Cultivar	**Date**	**K-IBA [ppm]**	**Rooting** *(%)*	**Roots per Cutting**	**Rooting** *(%)*	**Roots per Cutting**
Species	May	0	85.2a	5.7d	55.6c	5.9d
		6000	88.8a	13.2b	55.3c	6.3d
	June	0	10.0c	0.2e	61.7bc	10.8c
		6000	71.3b	4.2d	77.8b	23.5a
'Rudy Haag'	May	0	92.5a	12.7b	72.2b	10.7c
		6000	93.5a	24.6a	81.5a	11.5c
	June	0	71.0b	3.9d	88.3a	16.5b
		6000	70.6b	9.4c	90.0a	26.7a
'Compactus'	May	0	-	-	71.7b	6.6d
		6000	-	-	83.3a	9.8c
	June	0	20.8c	0.5e	81.3a	9.0c
		6000	73.6b	7.0c	83.3a	15.3b

z Means followed by the same letter within a column for each year were not different (Tukey's HSD α= 0.05).

Table 2. New growth post-rooting of *Burning bush* and *Burning bush* 'Rudy Haag' (2005).

	Species *(%)*		**'Rudy Haag'** *(%)*	
IBA *(ppm)*	**May 15**	**June 28**	**May 15**	**June 28**
0	100	82	42	0
1000	100	96	0	4
3000	100	91	0	0
6000	100	96	9	0

Fascination Increases Growth of 'Rudy Haag' Burning Bush during Container Production

Amy Poston, Amy Fulcher, Winston Dunwell, and Robert Geneve, Department of Horticulture

Nature of the Work

Burning bush (*Euonymus alatus* (Thunb.) Sieb.) and its cultivars, especially 'Compactus,' are popular shrubs grown and sold by the landscape industry. Despite their popularity, these shrubs have been cited as escaping cultivation throughout much of the Eastern United States due to their abundant seed production and aggressive root systems allowing these plants to invade natural ecosystems and colonize disturbed areas (6). 'Rudy Haag' is a nearly seedless cultivar that could be utilized as an ecologically friendly alternative to other cultivars such as 'Compactus.'

Burning bush cultivars are considered slow growing during nursery production (8). Growth is typically limited to one growth flush in the spring (1). This is possibly due to deep bud rest that may require a cold treatment to induce breaking of terminal and lateral buds. 'Rudy Haag' has an even slower growth rate compared to other burning bush cultivars. It has been purported that 'Rudy Haag' has fewer branches and less extensive growth because it is more dwarf, therefore, requiring more time in the nursery to produce a plant of salable size. The additional time required to produce 'Rudy Haag' has slowed its use by the nursery industry as an alternative to other burning bush cultivars.

Growth regulators have been used to increase branching and promote elongation of axillary shoots in many foliage, bedding, and woody plants in order to produce more desirable plants and shorten the time of production. The use of cytokinin was successfully increased bud development and in some cases bud break in woody plants such as some cultivars of rose (7), azalea (2), and spruce (4), by releasing buds from apical dominance. The combination of cytokinin and gibberellin has also been used to induce a second flush of growth on other slow-growing woody ornamentals with summer dormancy applied to plants as a foliar spray in mid-June (5).

The objective of the current study was to evaluate the use of Fascination (a cytokinin plus gibberellin growth regulator) on the growth of 'Compactus' and 'Rudy Haag' burning bush during nursery container production.

Materials and Methods

Liners of 'Compactus' and 'Rudy Haag' burning bush (Spring Meadow, Grand Rapids, Mich.) were potted on April 12, 2006 into one or three gallon Classic (Nursery Supplies, Inc., McMinnville, Ore.) in southern pine bark (Barky Beaver, Professional Grow Mix, Moss, Tenn.), top-coated with 3-4 month Osmocote Plus 15-9-12 (Scotts Company, Marysville, Ohio) slow release fertilizer at a rate of 9 grams per gallon of container size, and trickle irrigated using one pressure-compensating line per gallon of container size.

Thirty plants were untreated or treated with 1500 ppm of Fascination (1.8% 6-benzyladenine: 1.8% gibberellin 4+7; Valent, Walnut Creek, Calif.) using a backpack sprayer to foliar runoff on July 26, 2006. Growth index [(Ht + (Wdt1 + Wdt2)/2)/2] and branching were evaluated at the end of the growing season in 2006 and 2007.

Results and Discussion

'Compactus' is commonly referred to as a dwarf burning bush cultivar, but 'Rudy Haag' plants were on average 30% smaller (Table 1). A single application of Fascination had a dramatic effect on plant size and branching for 'Rudy Haag' burning bush plants grown in either one or three-gallon containers and this effect carried over into the following season (Table 1; Figure 1). This is in contrast to 'Compactus' plants that were not significantly impacted by Fascination. Over 50% of treated 'Rudy Haag' plants showed a second flush of growth within two weeks of Fascination treatment. This translated into branch numbers that were comparable between Fascination-treated 'Rudy Haag' and 'Compactus' plants evaluated either in 2006 or again in 2007. However, treated 'Rudy Haag' plants were still smaller than 'Compactus' in both years (Table 1; Figure 2).

A single application of Promalin (BA + GA4+7) or BA alone at 2000 to 5000 ppm increased branching in other woody ornamentals such as 'Helleri' holly, 'Stoke's Dwarf' holly, and 'Formosa' azalea (3). Boxwood that has a similar growth pattern to burning bush showed similar results for inducing growth after application of Promalin as a foliar spray in mid-June (5).

The use of larger containers only slightly increased growth in both burning bush cultivars (Table 1). However, the use of Fascination induced a second flush of growth in 'Rudy Haag'

Table 1. Growth index and branching in *Euonymus alatus* 'Compactus' and 'Rudy Haag' plants grown in 1- and 3-gallon Classic containers treated with Fascination (1,500 ppm) in July 2006 and evaluated at the end of the growing season in 2006 and 2007.

Cultivar	Container Size	Plant Growth Regulator	2006 Growth index	2006 Branch Number	2006 Branching (%)	2007 Growth index	2007 Branch Number
'Compactus'	1 gallon	Water	23.2a[z]	21.8a	0	41.3a	63.8a
		Fascination	25.5a	22.8a	6.7	42.2a	66.8a
	3 gallon	Water	23.4a	22.0a	0	45.7a	69.8a
		Fascination	26.6a	23.4a	3.3	42.2a	66.8a
'Rudy Haag'	1 gallon	Water	15.4b	15.3b	0	27.4b	39.9b
		Fascination	24.1a	27.3a	53.3	32.5a	60.7a
	3 gallon	Water	18.2b	17.0b	0	31.6b	48.6b
		Fascination	24.2a	27.9a	63.3	36.7a	78.2a

z Means within a column for each cultivar followed by the same letter were not different as indicated by a single degree of freedom contrast between water and Fascination at each container size.

that greatly increased its size during container production. This could alleviate some of the constraints on nursery production of 'Rudy Haag' as ecologically friendly alternative to 'Compactus.'

Significance to the Industry

'Rudy Haag' is a nearly seedless cultivar of burning bush, making it suitable as an environmentally friendly alternative to other invasive cultivars. However, it is much slower growing than other currently used burning bush cultivars making it more costly to produce and limiting its acceptance by the nursery trade. A single application of Fascination (a cytokinin/gibberellin growth regulator) increased plant size and stem number in container-grown 'Rudy Haag' plants. This effect was carried over into the second production year. After the second growing season, 'Compactus' plants were still larger than treated 'Rudy Haag' plants, but the increased size and branching in treated 'Rudy Haag' plants allowed them to reach a salable size after the second season in a three-gallon container.

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Figure 1. Increased shoot growth in 'Rudy Haag' plants treated with Fascination in July 2006 and photographed in September 2007.

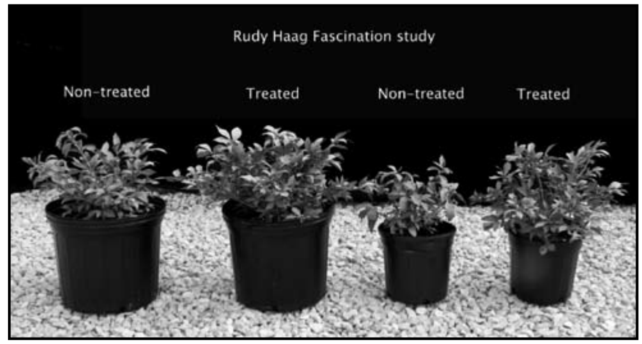
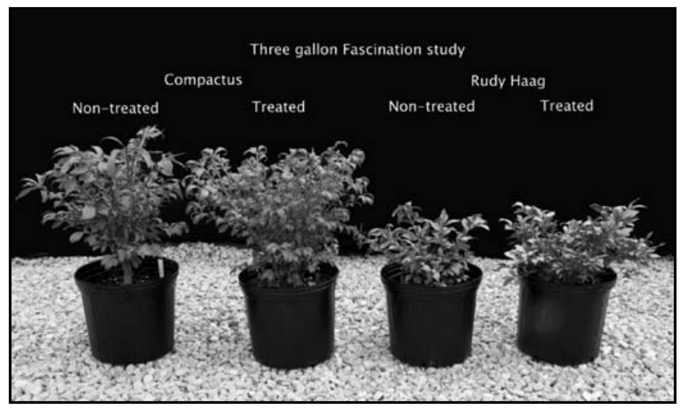


Figure 2. Comparison of 'Compactus' and 'Rudy Haag' plants treated with Fascination in July 2006 and photographed in September 2007.



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Fruit Production in 'Compactus' and 'Rudy Haag' Burning Bush

Cindy Finneseth, Robert Geneve, and Winston Dunwell, Department of Horticulture

Nature of the Work

Fruit display is often promoted by the horticultural industry as a desirable characteristic in landscape ornamentals, including burning bush (*Euonymus alatus* [L.]). However, prolific seed production is often cited in the literature and by invasive plant councils as an indicator of invasive potential (1, 3, 5). Cultivars of burning bush differ in fecundity; preliminary observations suggest that 'Compactus' produces far more fruit (seeds) per plant than 'Rudy Haag.' The causal mechanism of differential fruit set is not known.

The nearly fruitless nature of 'Rudy Haag' burning bush suggests that it could be an environmentally friendly alternative for currently marketed burning bush cultivars. This cultivar was discovered by the Kentucky nurseryman, Rudy Haag, and the most cited planting is at Bernheim Arboretum and Research Forest in Clermont, Kentucky. This cultivar may have a significant marketing advantage for Kentucky nursery producers if data to support a non-invasive character can be substantiated. No studies dealing with sexual reproductive biology in burning bush have been conducted. Therefore, the objective of this project was to document and compare fruit production of two burning bush cultivars, 'Rudy Haag' and 'Compactus' at two Kentucky locations.

'Compactus' and 'Rudy Haag' burning bush plants of flowering size were planted in field plots at the University of Kentucky Horticulture Research Farm, Lexington, Kentucky, and at the University of Kentucky Research and Education Center in Princeton, Kentucky, in spring 2005. There were eight plants of each cultivar at both locations with four blocks, each containing two plants of each cultivar on 6 ft x 6 ft spacing. Shredded hardwood mulch was applied after planting for weed control. In the first year, plants were watered to minimize transplant shock and aid in establishment. After the first year in the field, plants in Lexington received no supplemental irrigation or fertilizer application, but irrigation was supplied to the Princeton plants. In 2005, 2006, and 2007, all fruit from each plant was hand collected after the fleshy aril surrounding the seeds become visible through the capsule.

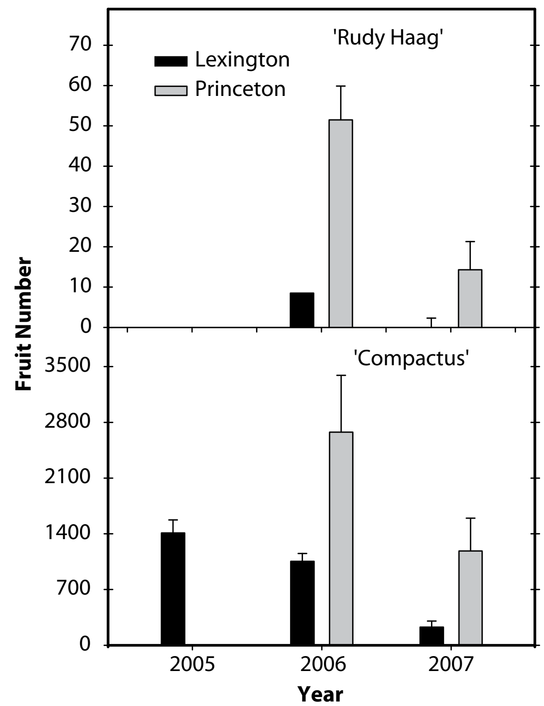
Results and Discussion

'Rudy Haag' burning bush produced significantly fewer seeds than 'Compactus' each year at both locations (Figure 1). Averaged over years and locations 'Rudy Haag' set only 1.1% of the fruits produced by 'Compactus.' Plants in Princeton receiving irrigation produced more fruit that those in Lexington for both 'Rudy Haag' and 'Compactus' most probably as a function of increased plant size. Fruit production in 2007 was lower than would be expected due to a spring freezing event that occurred during flowering.

Seed production is impacted by factors at the flower, inflorescence, and whole plant level. Common mechanisms responsible for low fruit production include limited pollen sources, lack of suitable pollinators, and infertility (2). In the current study, both 'Rudy Haag' and 'Compactus' were planted in close proximity and flowered at the same time. Insect pollinators were observed visiting flowers of both cultivars. There was clearly opportunity for cross pollination between cultivars, yet fruit set in 'Rudy Haag' remained very low (Figure 1). Also, numerous attempts to force pollinations between cultivars both in the field and greenhouse did not result in fruit set for 'Rudy Haag' plants. These observations suggest that pollen limitation and self-infertility were not the sources of fruitlessness in 'Rudy Haag' plants. This is important because several plants once thought to be fruitless (i.e. callery pear [*Pyrus calleryana*]) and purple loosestrife (*Lythrum salicaria*) were actually only self-infertile and subsequently developed into significant invasive plants because they began to produce fruit once additional cultivars that were suitable pollinators became available.

'Compactus' is recognized as the main source of invasive burning bush plants. Its cumulative 3-year fruit production for all plants at both locations was 6556 fruits compared to 74 fruits produced by 'Rudy Haag.' This represents nearly a 99% reduction in fruit set. Sheppard et al. (4) studying the invasive characteristics of scotch broom (*Cytisus scoparius*) in Australia estimated that a 62% reduction in seed set was needed for a species to be no longer considered invasive. Although the mechanism for reduced fruit set in 'Rudy Haag' plants remains unknown, this study clearly shows that 'Rudy Haag' fruit production exceeds

Figure 1. Fruit production in 'Rudy Haag' and 'Compactus' burning bush plants produced in Lexington and Princeton over three years.



the minimum suggested by Sheppard for reversing the invasive pattern of an invasive species.

Significance to the Industry

Burning bush is an economically important nursery species widely used in landscape plantings in Kentucky and other areas of the United States. Burning bush has been generally recognized as an exotic invasive plant species and at least two states have legislation in place to restrict importation and plant sales. A similar quarantine on plant production and sales in Kentucky would adversely affect many nursery operations. 'Rudy Haag' is a nearly fruitless burning bush cultivar that could replace current fruitful burning bush cultivars if it could be shown to a low risk potential for sexual regeneration. The current research documents the reduced fruit set in 'Rudy Haag' compared to 'Compactus' at two locations in Kentucky. It also demonstrates that reduced fruit production in 'Rudy Haag' was not due to self-infertility, as it remains nearly fruitless after opportunities to cross-pollinate with 'Compactus.'

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Irrigation Water Volume and Soluble Salt Levels in Two PNP Irrigation Delivery Systems

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Nature of the Work

Irrigation is essential in successful production of all crops. Increasing irrigation efficiency is the best water-conservation practice that growers can adopt when facing a water shortage or when they want to reduce water runoff. Correcting water-distribution problems is an important step in water conservation (1).

In pot-in-pot (PNP) production systems, irrigation efficiency is increased using drip irrigation for better water distribution. Less water is delivered more efficiently to the plant than overhead irrigation; reducing water used and fertilizer leached. The objective of this study was to evaluate irrigation water volume and nutrient loss in a PNP system using the Container Tender™ and a standard low volume spray emitter.

In July 2007, four species of common nursery stock (*Taxodium distichum* [Bald Cypress], *Betula nigra* [River Birch], *Quercus imbricaria* [Shingle Oak], and *Quercus bicolor* [Swamp White Oak]) were potted into 15-gallon containers (Nursery Supplies Inc., McMinnville, Ore.) with Barky Beaver Pro Grow Mix (Barky Beaver Mulch, Moss, Tenn.) and placed into 15-gallon socket pots in a PNP plot at the University of Kentucky Research and Education Center in Princeton for the remainder of the growing season. Each pot was fertilized at a medium rate of 180 grams of 17-5-12 Control Released Fertilizer (Harrell's Inc., Sylacauga, Ala.). Cyclic irrigation was applied at a recommended rate of 10-minute intervals at 10 a.m. and 2 p.m. (personal observation). Seven of each species have the Container Tender™ (TOH Products, Erlanger, Ky.) attached to standard drip irrigation tubing. The remaining seven of each species used low volume spray emitters.

The amount of water leached through the pot was recorded at monthly intervals. Soluble salt levels (EC) and pH of leachate were recorded monthly using the pour-through extraction method (2).

Results and Discussion

The amount of water delivered by the Container Tender™ was significantly less than delivered by spray emitters. Spray emitters delivered, on average, eight times more water than that of the Container Tender™. Water applied by spray emitters using cyclic irrigation of 2-10 minute intervals delivered 2.5 gallons (9.46L) per day. The same rate of 2-10 minute cycles using the Container Tender™ delivered 0.32 gallons (1.21L) per day. This suggests that the amount of water typically used in container production with spray emitters is excessive compared to the amount delivered by the Container Tender™ when similar growth is achieved with both methods of irrigation delivery.

All species receiving irrigation from spray emitters leached similar amounts of water from the bottom of the pot (0.38 gal); the trees irrigated with the Container Tender™ leached small amounts of water (0.03 gal). EC remained within the desirable range (0.8-1.5dS/m) recommended by the Southern Nurseryman Association's Best Management Practices (4) for plants in the Container Tender™ treatment (Table 1). However, soluble salt levels (EC) in plants in the spray emitter treatment were below the recommended levels on sampling dates for the last three months of the study. The pH levels for trees irrigated with both systems remained within the desirable levels (4.5-6.5).

There was no significant difference in caliper gain with either irrigation treatment (Table 2). The Container Tender™ distributes water more evenly across the substrate surface compared to spray emitters (personal observation). Comparable growth is not achievable by simply reducing the amount of water delivered (3). Distribution of water must be considered when using spray stakes or emitters to deliver less water.

Significance to the Industry

Water is the most consumed resource in nursery production. The Container Tender™ can save on the average of 2.2 gal of water per plant per day when used at the same time intervals as spray emitters. On a monthly basis, this is approximately 66 gallons of water saved per plant. A container nursery with an inventory of 5,000 15-gallon pots would use 330,000 gallons less every month. With an average growing season of 240 days, this could save over 2.6 million gallons of water per year. At a wholesale rate (Princeton Water and Wastewater, Princeton, Ky.) of $2.37/1000 gallons, $6,100 could be saved each year. This is of great significance not only to the grower in dollars but to the environment in conservation of natural resources.

Future studies will examine fertilization rates within low volume irrigation delivery systems and the benefit of the Container Tender™ as an alternative means of weed control for container nursery production.

Table 1. The average analysis of pH and soluble salt (EC of CRF and solution) levels for two irrigation delivery systems.

	Spray Emitters		Container Tender™	
	pH	**EC** *(dS/m)*	**pH**	**EC** *(dS/m)*
July 2007	5.9	1.3	5.9	1.4
Aug 2007	6.0	0.7	6.0	1.2
Sept 2007	6.0	0.5	6.0	1.1
Oct 2007	6.0	0.3	6.1	0.9

Table 2. Caliper gain (average in inches).

	Spray Emitters		Container Tender™	
Species	**July 07**	**Nov 07**	**July 07**	**Nov 07**
Betula nigra	0.65	0.68	0.64	0.67
Taxodium distichum	0.89	1.07	0.98	1.18
Quercus imbricaria	0.50	0.59	0.53	0.61
Quercus bicolor	0.54	0.57	0.55	0.59

Acknowledgments

The author would like to thank June Johnston and Hilda Rogers for their assistance and Byron Baxter of Dendrological Sales for providing the Container Tender™ products tested.

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Pour-through Growing Media Tests in Central Kentucky Greenhouses—2004-2006

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Nature of the Work

Greenhouse flower producers in Kentucky typically grow bedding plants in spring, garden mums in summer, and poinsettias in the fall. The bedding plant and poinsettia crops are grown in greenhouses, and a majority of garden mums are grown outdoors on a groundcover fabric. Growers that use greenhouses for garden mums use evaporative cooling or natural ventilation. Many small growers use their greenhouses only in the spring for bedding plants and hanging baskets.

Bedding plants are the most profitable of the three crops. Poinsettias have become a commodity with a low profit margin. Growers continue to raise poinsettias to keep employees year-round and to provide some cash flow. Garden mums are raised by greenhouse businesses and farmers who have no greenhouse business. Garden mum growers attempt to grow larger, better quality mums to increase profit.

The management of a plant nutrition program is very important to these Kentucky crops. Experienced growers rarely use soil tests to monitor the fertilizer program for their crops because they are familiar with the correct appearance of a successful crop. New growers rarely use soil tests because they do not understand their value. In addition, they have not learned enough about the intricacies of a good fertilizer program to adapt it to their greenhouse or garden mum operation. Pour Through growing media tests have been completed over the last three years supported by grants through the Kentucky Horticulture Council and from Kentucky Agricultural Development Board. These tests have been completed in greenhouses operated by experienced growers as well as novice growers.

Results and Discussion

Hundreds of pour-through growing media tests have been performed in the last 30 months. The results have been from high to low in a broad range. Yet, the average results of the tests are in the recommended ranges and indicative of the skilled growers that produce crops in Kentucky greenhouses. The average results of the pour-through tests are summarized in Table 1.

The poinsettia crop is typically started in August and fertigated fairly heavily through August and September and into late October. Typically, the type of fertilizer used is initially more acid, such as 20-10-20. As the days get shorter, light levels drop, and temperatures drop outside, growers switch to a calcium nitrate–based fertilizer, such as 15-0-15. The Pour Through tests show that even though the growing media electrical conductivity remains fairly constant, the pH rises slowly. This is because more basic fertilizers are used as the season progresses.

Test results from bedding plant and garden mum crops show that as growing media electrical conductivity rises, the media pH drops. These crops are fertigated predominately with acidic fertilizers, such as 21-5-20, 20-10-20, 20-20-20 or 21-7-7. Most growers apply heavier concentrations of fertilizer once plants start growing and reduce fertilizer levels to slow plant growth.

Table 1. Average Pour Through test results for growing media used to grow poinsettia, bedding plant, and garden mum crops 2004-2006 in Central Kentucky.

		Growing Medium	
Crop	**Month/Year**	**pH**	**Electrical Conductivity** *(mS/cm)*
Poinsettia	August 2004-2006	6.2	2.82
	September 2004-06	6.1	2.33
	October 2004-06	6.3	2.47
	November 2004-06	6.5	2.02
	December 2004-06	6.6	1.03
Bedding plants	February 2005 and 06	6.5	2.14
	March 2005 and 06	6.1	2.24
	April 2005 and 06	6.2	1.85
	May 2005 and 06	6.3	1.69
Garden mum	June 2004-06	6.7	1.17
	July 2004-06	6.4	1.78
	August 2004-06	6.1	2.93
	September 2004-06	6.6	0.49

Significance to the Industry

This report reinforces the idea that Pour Through growing media tests are a relatively easy way to monitor pH and EC in containers of flowering plants. A grower is not dependent on outside sources to determine the current nutrient status of the crop. A grower only needs a fairly inexpensive meter to conduct the measurements and will be able to monitor the growing media fertility. With the results, it is easy to make timely changes as needed.

This report also shows the relationship between fertilization concentration in growing media and pH management. As more fertilizer is applied, the effect on increases or decreases in the pH of the growing media, is increased. Growers can use this information to improve pH management and plant quality while reducing nutrient deficiencies and/or nutrient toxicities.

Garden Mum Plant Growth Regulator Evaluation

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Nature of the Work

Garden mums (*Chrysanthemum x morifolium*) are an important summer crop for greenhouse growers in Kentucky. Generally, markets determine the size of the plants that growers need to produce. There are many factors that determine final plant size, including planting date, number of plants per container, fertilization program, and use of plant growth regulators (PGRs). Most PGRs effectively reduce plant height, intensify plant color, produce a more rounded uniform plant, and improve the toughness of the plant. Growth rate and final size varies among cultivars, so PGRs may be necessary only on more vigorous cultivars.

PGRs are compounds that alter natural plant hormone activity, but the effectiveness varies from cultivar to cultivar. Rates that control the growth of less vigorous cultivars may be too low on vigorous ones. Most PGRs used in greenhouses control plant size and shape in relationship to container size. Two PGRs commonly used on garden mums are daminozide (B-Nine, Dazide) and paclobutrazol (Bonzi, Downsize, Paczol, Piccolo).

Daminozide is a commonly used growth regulator labeled for use on containerized plants in the floriculture industry and is generally considered safe because it has a short term effect and usually does not cause excessive control. Typical application rates are a 2500 to 5000 ppm foliar spray, depending on the sensitivity of the garden mum cultivar. It can be used at lower rates when applied in multiple treatments. Daminozide should not be used after flower buds have developed because flower size may be affected. Paclobutrazol is another commonly used growth regulator on floriculture crops. It is much more active than daminozide and absorbed by shoots and roots. Typical foliar application rates for garden mums are 50–200 ppm and media drench rates are 1–4 ppm.

Four garden mum cultivars, 'Bold Gretchen,' 'Mary,' 'Melissa,' and 'Wilma,' were used in the 2007 study. Pinched liners were received on Jul-3-07 from a local grower in 24 cell trays and transplanted to 8-inch mum pots (Nursery Supplies, Inc., Classic 550) in Sun Gro Metro-Mix 560 Coir (Sun Gro Horticulture Distribution Inc., Bellevue, Wash. 98008). Plants were moved to the greenhouse and were fertigated with Peters 20-10-20 Peat-Lite Special fertilizer (Scotts Company LLC, Marysville, Ohio 43041) at a rate of 150 ppm N and top-dressed with 1 teaspoon of Osmocote 15-9-12 (Scotts Company LLC, Marysville, Ohio 43041) from early July to mid September. The EC of the media was checked regularly by pour-through media analysis to maintain EC readings of 2.6 to 4.6 mS/cm. Media pH was maintained between 5.4 and 6.6. Late in the season, insecticides were applied to control caterpillars.

On Aug-01-07, the plants received the following treatments: (1) 3 ppm paclobutrazol media drench (2), 6 ppm paclobutrazol media drench (3), 1500 ppm daminozide foliar spray (4), 3000 ppm daminozide foliar spray (5), no treatment. At anthesis, plant height and diameter were recorded for each plant.

Results and Discussion

The cultivars used for this study were selected because they are considered moderately vigorous by the breeder. 'Wilma' and 'Mary' were new introductions in 2007. With the many variations in possible PGR treatments, cultivar selections, and growing conditions, it is challenging determining appropriate PGR rates to cover all situations. Consequently, it is usually prudent to use the lower label rate as a starting point and then evaluate whether or not a second application is needed.

Cultivar selection did not have a major effect on plant size when averaged over all PGR treatments. Only 'Wilma' was significantly shorter than 'Mary' or 'Bold Gretchen' (13% and 16%, respectively). Cultivar selection had no significant effect on plant diameter for any of the cultivars tested (Table 1).

Choice of PGR, application method, and application rate, appeared to have the most significant effect in this study. When averaged over all cultivars, the 6 ppm paclobutrazol media drench produced more compact plants. Plants were significantly shorter (18%), when compared to plants that received no PGR treatment (Table 2). Additionally, plants that received a 6 ppm paclobutrazol media drench had a significantly smaller diameter than those that received 1500 daminozide foliar spray and non-treated plants (15% and 22%, respectively). Although the 3 ppm paclobutrazol media drench and neither of the daminozide foliar spray treatments were significantly shorter than the non-treated plants, the plant diameter did show a response. The 3000 ppm daminozide spray and 3 ppm paclobutrazol drench both produced significantly smaller diameter plants than non-treated plants.

Neither paclobutrazol nor daminozide caused phytotoxicity or reduction in flower size at any of the concentrations used in this study. If only moderate height control is desired, paclobutrazol at 6 ppm media drench can be used. However, from the data, it is apparent that higher concentrations of both PGRs produce a greater response without causing any plant damage. Higher concentrations could be tested if more compact plants are desired.

Significance to the Industry

Garden mums are an important crop in Kentucky, and growers need to choose cultivars carefully for their specific market and production system. Breeders continue to improve garden mum characteristics and make them easier to grow and more appealing to consumers. With proper scheduling and careful cultivar selection, plant growth regulators may not be necessary. Nevertheless, PGRs can be a useful tool that growers can rely on to control growth and produce quality plants.

Table 1. Mean plant height and diameter for Chrysanthemum x morifolium 'Bold Gretchen', Mary,' Melissa,' 'Wilma' in summer 2007 averaged over plant growth regulator.

Treatment	Mean Plant Height *(in)*		Mean Plant Diameter *(in)*	
Wilma	14.9	a[z]	19.2	a
Melissa	16.1	ab	19.2	a
Mary	17.1	b	19.4	a
Bold Gretchen	17.8	b	20.3	a

[z] Means within a column followed by the same letter are not significantly different as determined by Tukey's HSD test. Alpha = 0.05.

Table 2. Mean plant height and diameter for Chrysanthemum x morifolium 'Bold Gretchen,' 'Mary,' 'Melissa,' 'Wilma' in summer 2007 averaged over cultivar.

Treatment	Mean Plant Height *(in)*		Mean Plant Diameter *(in)*	
6 ppm paclobutrazol drench	15.0	a[z]	17.3	a
3000 ppm daminozide foliar spray	16.1	ab	18.3	ac
3 ppm paclobutrazol drench	16.3	ab	18.3	ac
1500 ppm daminozide foliar spray	16.8	ab	20.4	bc
No treatment	18.2	b	22.3	b

[z] Means within a column followed by the same letter are not significantly different as determined by Tukey's HSD test. Alpha = 0.05.

Managing Maple Shoot Borer: Implementation in Kentucky Production Nurseries

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Nature of the Work

Maples (Acer spp.) are among the most important nursery crops in the United States, accounting for about 30% of the total annual sales of deciduous shade trees (1). They are fast-growing, offer diversity of form and autumn color, and are likely to be even more widely used now that invasive pests such as emerald ash borer, *Agrilus planipennis Fairmaire,* and sudden oak death/decline caused by the fungus *Phytopthora ramorum,* threaten other popular shade tree species.

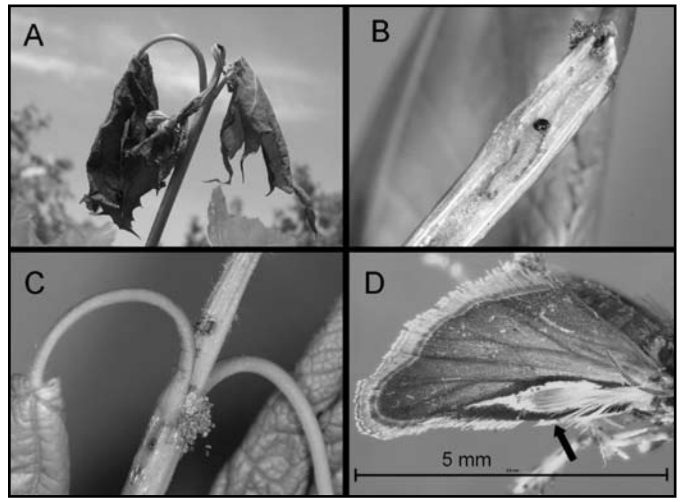
Maples usually thrive once established in landscapes but in production nurseries they are attacked by several insect pests that, left unmanaged, can cause significant economic loss. One such pest, the maple shoot borer [MSB] (*Proteoteras aesculana*), infests the growing terminals causing flagging and dieback (Figure 1). Infestation of the terminal shoot causes the tree to develop an undesirable fork that necessitates correctional pruning and the training of a new central leader. This requires time and labor and increases production costs, and even when performed successfully the tree usually develops a noticeable crook that reduces market value. Little has been published on the biology or management of MSB. We are studying this pest to learn when and how it infests the shoots, the flight period and number of broods per year, and other information needed for effective control.

Timing is critical for managing this pest because once the larva bores into the terminal shoot, death of the leader is inevitable. Hale and Halcomb (2) suggested applying a residual foliar insecticide once the first two pair of leaves has emerged to intercept the exposed larvae before they bore into the new shoots. That strategy can be effective but is perceived to require precise timing which can be difficult for growers to accommodate during the busy spring season, especially since maple species and cultivars vary in timing of leaf flush.

We recently made a breakthrough that will help in managing MSB. Pheromone gland-emitted compounds from female MSB reared from shoots were identified via gas chromatography/mass spectroscopy, with activity verified by electrophysiological challenge of male antennae (electroantennogram). Male MSB moths were captured in sticky traps baited with synthetic pheromone (Z8:12-OH). In 2006 and 2007 we monitored the flight period at four nurseries to determine when eggs are being laid, the key to timing preventive control. Moth flight starts in mid-March, peaking in April, followed by borers developing in new shoots from April to early June. In 2007 we tested a preventive control strategy integrating trapping, degree-days, and timed intervention with shoot sprays. Our goal was to define the window during which nursery growers can manage MSB during the busy spring planting and digging season.

Cardboard pheromone traps were operated February to November at four Kentucky production nurseries (Wearren and Son, Snow Hill, Hillcrest, and Wilson) to monitor seasonal moth activity. Thirty infested shoots were harvested weekly and dissected to track borer development.

Figure 1. Symptoms and diagnosis of *P. aesculana*: A) infested, flagged maple shoot in May; B) larva within damaged twig; C) expulsion of frass and silk from bored shoot; D) hindwing of male moth showing yellow hair pencil bordered by distinctive melanic sex scales (arrow) on the upperside of the costa of the hindwing.



Management of MSB was evaluated at three sites. Sites 1 & 2 were on different farms of Snow Hill Nursery, and Site 3 was at Wearren and Son Nursery. Four spray timings were evaluated at each site ranging from before bud break to when most of the shoots had flushed 2 pairs of young leaves about 2.5 cm long. Bifenthrin (Talstar Nursery Flowable, 7.9% AI, FMC, Philadelphia, Penn.) was used for all treatments. Subplots (replicates) consisted of six successive trees in a row which received the same spray timing, or were left untreated as controls, with an untreated buffer between each subplot. Timings were replicated five times at Site 1 (30 trees per timing, 150 total trees) and six times each at Sites 2 and 3 (36 trees per timing per site, 180 total trees per site). Sprays were applied with a 15-liter (4 gal) Solo backpack sprayer with a 71 cm (28 in) wand, 1.22 m (4 ft) hose and adjustable hollow cone nozzle at 6.5 ml product per 3.785 liters (22 fluid oz/100 gal) to wet the twigs and buds. The applicator stood on a 3 m (10 ft) aluminum stepladder to direct the spray downwards to minimize drift. New shoots were photographed to document stage of bud and leaf development on each spray date.

Efficacy was determined 8-9 May 2007 by examining the whole canopy of each tree for wilted or flagged shoots for which infestation was confirmed by presence of frass. Number of flagged shoots per six-tree subplot was compared among treatment timings, and numbers of trees having the terminal leader infested also were recorded. Infested shoots from the control trees (100 each from Sites 1 and 3) were held for emergence of adult moths.

Results and Discussion

Moth flight started in mid-March, peaking in late March and early April at the study sites (Figure 2). One spray application of bifenthrin any time between 21 March, before bud break, and 18-23 April, by which time the trees had flushed two pairs of small leaves, reduced the incidence of infested shoots by 96-100% (Table 1). Infestation pressure was especially heavy at Sites 1 and 3 averaging about 10 flagged shoots per tree in the control plots, with as many as 29 flagged shoots on a single tree. The percentage of control trees upon which the terminal leader was flagged ranged from 22-36% across the three sites.

Significance to the Industry

This research showed that infestations of the maple shoot borer, *P. aesculana,* a pest of maples in production nurseries, originate from moths that lay eggs in March and April. The prevailing strategy for managing this pest is to apply preventive sprays targeting the newly hatched larvae before they tunnel into elongating central leaders and other shoots. There is perception, however, that this is effective if done as soon as the first pair of leaves has emerged from the buds. A sex attractant lure was developed that, when used in sticky traps, enables monitoring of moth flight for spray timing. The temporal window for preventive control was shown to be broader than previously thought. Bifenthrin (Talstar) sprays applied any time from mid-March, before bud break, to mid-April, when most shoots had flushed two pairs of smal leaves, provided 95% control. This broader treatment window should provide flexibility for nursery growers needing to manage maple shoot borer during the busy spring planting period.

Figure 2. Flight activity of *P. aesculana* at Wearren and Son Nursery, Taylorsville, Ky., 2007, one of three sites used to evaluate preventive bifenthrin applications. Bars show total weekly captures in four traps baited with 250 µg of Z8-12-OH. Arrows show timing of applications, all of which provided good preventive control (see Table 1).

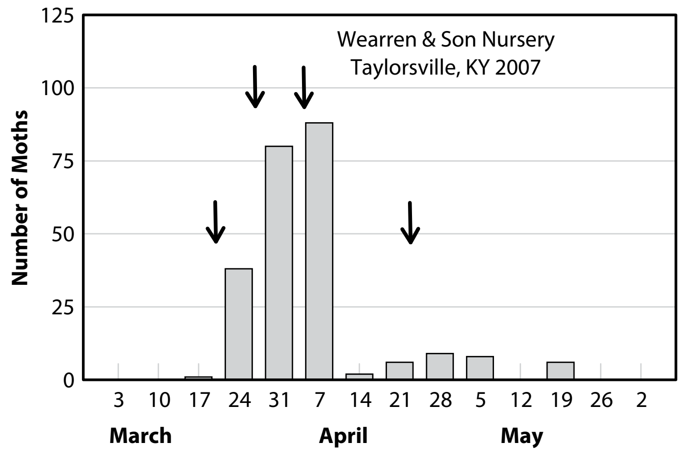


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Table 1. Effect of bifenthrin spray timing on *Proteoteras aesculana* infestation of October Glory (OG) or Red Sunset (RS) red maples at three nursery sites, 2007.

Site[a]/Cv	No. Trees	Treatment Date	Tree Growth Stage[b]	Flagged Shoots per 6 Trees *(Mean ± SE)*	Range per Tree	% Control	No. Trees With: ≥ 1 Shoot Flagged	No. Trees With: Terminal Leader Flagged
1/OG	30	21 Mar	TB	2.2 ± 0.6	0-2	96.0	9	2
		26 Mar	GTB	0 ± 0	0-0	100	0	0
		5 Apr	GTB/1PL	1.0 ± 0.6	0-1	98.1	4	0
		18 Apr	2PL	0 ± 0	0-0	100	0	0
		Untreated	-	55.2 ± 8.4	5-18	-	30	9
2/RS	36	21 Mar	TB	0 ± 0	0-0	100	0	0
		26 Mar	TB/GTB	0.3 ± 0.2	0-1	98.6	2	0
		5 Apr	GTB/1PL	0.2 ± 0.2	0-1	99.1	1	0
		23 Apr	2PL	0 ± 0	0-0	100	0	0
		Untreated	-	22.0 ± 5.8	0-12	-	31	13
3/OG	36	21 Mar	TB	1.1 ± 0.6	0-1	98.1	7	0
		26 Mar	GTB	0.2 ± 0.2	0-1	99.7	1	0
		5 Apr	GTB/1PL	0.8 ± 0.5	0-1	98.6	5	0
		23 Apr	2PL	0.2 ± 0.2	0-1	99.7	1	0
		Untreated	-	58.0 ± 13.5	1-29	-	36	8

[a] Sites 1 and 2: Snow Hill Nursery Farm and Lake sites, respectively, Shelbyville, KY; Site 3: Wearren and Son Nursery, Taylorsville, KY.
[b] TB = tight bud; GTB = green tip bud; 1PL = 1 pair expanding leaves, 2PL = 2 pair expanding leaves

Systemic Control of Calico Scale with Bark- or Soil-applied Dinotefuron (Safari®)

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Nature of the Work

Calico scale, an invasive soft scale pest of shade and ornamental trees, has reached outbreak levels in Kentucky and elsewhere in the eastern United States (1, 2). Heavily infested trees suffer branch dieback and may be severely stressed or killed. In spring, maturing females produce copious honeydew that attracts wasps and other nuisance insects and promotes growth of unsightly sooty mold. Honeydew falling on parked vehicles, decks, or other objects may require removal of infested trees. Hosts include sugar and Norway maple, sweetgum, honey locust, Japanese zelkova, dogwood, crabapples, and other cultivated trees, as well as wild hackberry.

Calico scale is univoltine, overwintering as second instars on twigs, branches, and trunks and molting to the adult stage in late March to mid-April in Kentucky (1). Females each produce several thousand eggs that hatch in mid- to late May. Crawlers disperse for 2-3 weeks, and nearly all of them settle on leaves by mid-June. In mid-summer settled crawlers molt to second instars, which continue feeding on leaves until just before leaf abscission in autumn when they move to overwintering sites on bark. In Kentucky, calico scale is a particular problem on horse farms where rows of single tree species are planted in narrow grassy strips bordering pastures or paddocks. Labeled grazing restrictions, concern about equine exposure to spray drift, and liability often preclude spraying on such sites. Similar concerns exist in urban landscapes. Systemic application via trunk or soil injection, soil drench, or basal trunk application can alleviate the hazard of spraying landscape trees. This trial was conducted to evaluate efficacy of Safari (dinotefuron), a nicotinoid with a favorable toxicological profile, via two methods of systemic application: soil injection or basal trunk spray in combination with Pentra-Bark (Agrichem, Medina, Ohio), a bark-penetrating surfactant.

The study site was two rows of mature zelkova trees (mean [± SE] trunk diameter: 10 ± 0.4 inches [25.4 ± 1 cm] at 1 m above ground) planted in full sun on either side of a lightly traveled road near the University of Kentucky Motor Pool, Lexington, Kentucky. Safari 20G was evaluated at 8.5 g product per inch diameter via high volume soil injection at 100 PSI pressure. The solution was injected 4-6 inches (10-15 cm) deep in a grid from 1-3 ft (30-91 cm) from the trunk, with 12-15 injection points per tree. Four trees were treated on each of two treatment dates, 18 April and 15 May 2007. Soil injections were made by Larry Hanks (ISA-certified consulting arborist).

A solution of Safari 20G and Pentra-Bark (13 oz Safari with 3.1 oz Pentra-Bark in 1.1 gal of water) was applied to runoff to bark of the trunk and bases of the main scaffold limbs (6 ft height to ground level) of another four trees on 18 April 2007. Calico scale females were not directly sprayed as they were higher up in the trees than where the sprays were applied.

Efficacy was evaluated 30 July to 2 August by sampling eight twigs (one from each cardinal direction in the lower and middle thirds (< 3 m and about 5 m height, respectively) of each tree canopy; 8 twigs per tree), removing the two most basal (oldest) leaves from each twig, and counting all living scale nymphs on the left half of the abaxial surface of each leaf (about 3000 total scales). Leaves and scales were examined under a binocular microscope. Living nymphs were yellowish and succulent; dead scales appear orange-brown, dried out, and when touched with a probe will easily flake off the leaf surface. Data were analyzed by one-way ANOVA with means separated by Dunnett's test for treatments versus control.

Results and Discussion

Results are summarized in Table 1. One of the control trees, a relatively small tree at the end of the row, was atypical in having very low numbers of scales (76, versus 587, 410, and 254 scales per sample for the other replicates). Data therefore were analyzed both with and without that tree (in the latter case, the outlier tree was entered into the data set as a "missing value"). Safari, particularly the application with Pentra-Bark, provided significant control of calico scale nymphs on the leaves, which should translate to fewer honeydew-producing adults next spring. We observed no obvious immediate kill of egg-laden females following either the April or May applications, so the aforementioned reductions are attributed to activity against the settled crawlers on the leaves.

Table 1. Efficacy of Safari 20 SG for systemic control of calico scale on mature *Zelkova serrata* trees in the landscape, 2007.

Treatment	Treatment Date	All Trees Included		Atypical Untreated Tree with Low Infestation Excluded	
		Live Scales per Sample	% Control	Live Scales per Sample	% Control
Untreated	-	332 ± 109		417 ± 96	
Soil injection	18 April	159 ± 33	52.1	159 ± 33*	61.9
Soil injection	15 May	119 ± 34*	64.2	119 ± 34*	71.5
Bark spray with Pentra-Bark	18 April	65 ± 29*	80.4	65 ± 29*	84.4

ANOVA results: for all trees; $F = 3.56$; df = 3, 12; $P < 0.05$; with atypical control tree excluded; $F = 9.41$; df = 3, 11; $P < 0.005$. Asterisk denotes mean is significantly lower than mean for untreated trees (Dunnett's test, $P < 0.05$).

Significance to the Industry

This research indicates that dinotefuron (Safari), especially when applied as a basal trunk application with Pentra-Bark, can provide good control of calico scale on mature zelkova trees. Efficacy of this approach warrants further evaluation against calico scale on additional sites and tree species, and against other species of soft and armored scale insects. This level of control is higher than previously obtained with trunk injections with imidacloprid or bidrin, or with soil injection of imidacloprid (2). If dinotefuron with Pentra-Bark works consistently as well as it did in this trial, it could provide a valuable tool for managing scale insect infestations on horse farms, streets, landscape settings, and other sensitive sites where canopy sprays are impractical.

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Managing Dogwood Root Rot Caused by *Rhizoctonia solani* in a Container Production System

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Nature of the Work

Dogwood is a high-value crop, with gross returns of $60,000 per acre possible (4). Dogwoods have traditionally been field produced and marketed as balled and burlapped plants, but recent consumer trends show an increased demand for container-produced plants (2). However, dogwoods have been difficult to grow in containers and commonly have poor vigor and high mortality (5).

Preliminary experiments and laboratory diagnostics showed that an impediment to dogwood container production is root rot caused by the fungus *Rhizoctonia solani. Rhizoctonia solani* is a common soil-borne fungus associated with root rot of a wide range of hosts (1). *R. solani* survives as a saprophyte in the soil and is capable of surviving for long periods of time. Rhizoctonia is spread by rain, irrigation, implements, and anything that carries field soil or substrate. Infected roots appear fleshy brown to iridescent color with few to no root hairs, causing inefficient water and nutrient uptake (3). Rapidly growing plants appear to resist infection even when environmental conditions are conducive for fungal growth; however, slowly growing young plants produced under stressful environments are more prone to infection (1). Determining an effective control for Rhizoctonia root rot disease would increase the percentage of plants that live and thrive and thus help create a viable and economically profitable production system.

RootShield® and PlantShield HC are biologically based fungicides containing a select strain (T-22) of the fungus *Trichoderma harzianum*. The T-22 strain colonizes the host plant rhizosphere, feeding on root exudates and thereby depleting nutrients and forming a barrier to pathogens. Use of biological control fungi, sometimes called biofungicides, provides a sustainable approach to controlling pathogens which may be beneficial to consumers, retailers, and nursery producers. Growers using biological controls can preserve water quality, reduce employee exposure to chemicals, and eliminate worker re-entry intervals. Retailers and wholesalers can market plants as sustainably produced, and these fungicides that are approved for certified organic production offer additional production and marketing advantages. Therefore, our objective was to evaluate Trichoderma-based fungicides for control of *Rhizoctonia solani* infections of *Cornus florida* in container production.

Bare root liners were potted into #3 trade-gallon containers (Nursery Supplies, Inc., McMinnville, Ore.) with Barky Beaver Professional Grow mix (Barky Beaver Mulch and Soil Mix, Inc., Moss, Tenn.) on February 23, 2007. Plants were grown in a greenhouse at the University of Kentucky, Lexington, until May at which time they were moved to a shade structure at the Horticulture Research Farm, Lexington, Kentucky, where they remained until the termination of the experiment. Plants were drenched with 3336™ (thiophanate –methyl) to control preexisting Rhizoctonia infections 45 days prior to applying fungicide treatments for the experiment. This was necessary because the *T. harzianum*-based fungicides are preventative and because inspection of the liners upon receipt showed a moderate to high amount of Rhizoctonia. They also were mildly infected with Pythium. Fungicide treatments, applied May 30, consisted of the following:

- Topdressing with RootShield® Granules, 4.5 g per plant, experimental application method
- Drenching with PlantShield HC, 2.8 g per 5 gallons of water, 1 quart per plant
- Drenching with 3336™, 5 ml per gallon of water, 1 quart per plant
- Drenching with a water control, 1 quart per plant

On June 26, a Rhizoctonia and Pythium infected root/substrate mix from a separate crop of container-grown *Cornus florida* was used as the source of inoculum. It was applied to the dogwoods by removing the root ball from the container, allowing a 1-inch layer of substrate to remain in the bottom of the container. Then 356 grams of root/substrate inoculum was placed evenly over the 1-inch layer of original substrate and the rootball was returned to the container and irrigated. Five extra batches of inoculum were prepared for quantification of pathogen levels. Subdue MAXX™ was applied to the plants on July 1 to eliminate the Pythium population from the inoculum, so that the effectiveness of the Trichoderma-based fungicide against Rhizoctonia could be assessed, as this was the pathogen of interest.

On July 19, data were collected to assess the efficacy of the fungicides. Two root/substrate cores were collected per plant. One core/subsample was used for a Rhizoctonia-specific ELISA assay; the other was used for root image analysis. On August 22 the plants were harvested, roots washed of substrate, and roots and shoots oven-dried at 55C. The experimental design was a randomized complete block with 8 replications, n=32. Data were analyzed at a p value of 0.05.

Results and Discussion

There were no significant differences among treatments for caliper, height, or plant appearance (Table 1), or for root weight or root length from core subsamples or in final root or shoot dry weights from whole plant harvests (Table 2). The ELISA detected no differences among Rhizoctonia levels from core subsamples (data not shown).

The lack of differences among treatments may be due to low pathogen presence in the inoculum source. While Rhizoctonia appeared abundant in microscopic examinations of the root/substrate mixture used as inoculum, ELISA test results from the inoculum source revealed that the average reading was similar to the negative control. The amount of inoculum may not have been sufficient to reveal treatment differences during the time between inoculation and the core sampling, however, the full duration of the experiment (58 days) was sufficient to detect differences. Most striking was that no plants died during the experiment. In previous experiments with *C. florida,* Pythium was found at low levels or not detected, therefore no Subdue MAXX™ was applied. In these cases, 30-50% of the *C. florida* died with root rot symptoms. This may indicate that while Pythium has not been detected in large numbers, it may be the relevant pathogen or that both pathogens are needed together to cause significant root rot.

Significance to the Industry

Flowering dogwood is a nursery crop with potential for increased container production. Controlling root rot is an essential component to successful container production of dogwood. Identifying sustainable methods of controlling root rot will greatly enhance survival and growth of container production of dogwood while promoting environmental stewardship. Biocontrols such as *Trichoderma harzianum* may be useful in root rot control as part of a sustainable container production program.

Acknowledgment

The authors wish to acknowledge Dr. John Hartman for his guidance.

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Table 1. Mean caliper, height, and above ground appearance of *C. florida* plants subjected to fungicide treatments.

Treatment	Caliper *(mm)*	Height *(cm)*	Plant Appearance[Z]
Water	21.2	86.4	3.3
3336™	21.0	83.1	3.3
RootShield® Granules	21.3	82.2	3.6
PlantShield HC	21.2	81.6	2.8
ANOVA p value	0.95	0.60	0.57

Z Plant Appearance Rating Scale: 0 - dead, no foliage, 1- alive with little or no foliage, 2 - foliage present but leaf curl and/or chlorotic, 3 - some leaf curl, 4 – green, healthy foliage , 5 - vigorous foliage growth and branch growth

Table 2. Core root and shoot dry weight averages for substrate cores and whole plants.

Treatment	Core Root Weight *(g/g dry substrate)z*	Core Root Length *(cm/g dry substrate)z*	Final Root Dry Weight *(g)y*	Final Shoot Dry Weight *(g)y*
RootShield® Granules Topdress	0.0096	8.9	33.1	34.5
3336™	0.0027	5.7	29.4	30.4
PlantShield HC Drench	0.0029	6.6	24.7	29.7
Water	0.0060	6.2	23.5	32.2
ANOVA P value	0.38	0.39	0.13	0.66

Z Sampled 24 days after inoculation with *Rhizoctonia*
Y Sampled 58 days after inoculation with *Rhizoctonia*

Early Detection Survey for *Phytophthora ramorum* in Kentucky in 2007

Patricia B. de Sá, Amy Bateman, and John Hartman, Department of Plant Pathology; Chris Barton, Rupal Patel, Katie Adank, Department of Forestry

Nature of the Work

Phytophthora ramorum causes Ramorum leaf blight, shoot dieback, and stem cankers on woody trees and shrubs, herbaceous plants, and ferns; on mature oak and tanoak trees this pathogen causes sudden oak death. A list of host plants and plants associated with *Phytophthora ramorum* is updated regularly and is available on the USDA-APHIS-PPQ at www.aphis.usda.gov/ppq/ispm/pramorum/pdf.

Some plants infected with *P. ramorum* may show mild leaf symptoms or shed symptomatic leaves and still be a source of spores that can initiate disease on healthy plants. The stem infection of trees that happens in sudden oak death can be initiated by spores from plants with leaves showing mild symptoms in close contact with the trees. Leaves on the ground can lead to the development of dormant structures that survive for a long time until there are suitable conditions for plant infection. Movement of infected plants and plant parts is believed to be the major pathway for long distance movement of this pathogen.

Phytophthora ramorum and many other Phytophthora species can spread in rain splash and irrigation water, and monitoring for *P. ramorum* in water in ponds and streams has been carried out in several locations within the United States. This can be done using methods such as baiting with leaves of susceptible plants or by water filtration. Leaf samples and filters are then assayed for presence of Phytophthora species and *P. ramorum* in particular.

An early detection survey of *P. ramorum* in Kentucky streams was conducted by scientists from the Department of Plant Pathology and the Department of Forestry at the University of Kentucky during 2007. The survey was funded and supported technically by the USDA Forest Service, Forest Health Protection and was part of a larger national survey. Eight perennial streams draining watersheds of at least 4,000 acres in areas of high risk for establishment of the pathogen were sampled. The level of risk was determined by presence of host plants, climate, and presence of potential pathways for introduction. Three watersheds were in forest areas and five in urban or semi-urban areas, four around Lexington and one in Florence.

Each watershed was sampled using rhododendron leaves placed in two net bags that were immersed in the water for periods of one to two weeks during five months. *Phytophthora propagules* in the water infect the leaves and the pathogen can be isolated from them. After the period of immersion in the stream the bags were retrieved, the leaves were double bagged, maintained at low temperature and taken to the Plant Pathology Diagnostic Lab (PPDL) at the University of Kentucky. Measurements of water temperature and pH were taken and small water samples were collected from each stream for future analysis should any sample test positive for *P. ramorum.*

It is not possible to determine if the lesions on a leaf are caused by *P. ramorum* by visual inspection; therefore, the pathogen has to be cultured in a selective culture medium for development of differentiating structures, or a method like PCR must be used. The leaves collected from one of the bags were used for isolation in selective medium at the PPDL and those from the second bag were sent to another lab for testing by PCR and confirmation of the results obtained in the Lexington lab.

Results and Discussion

Eight streams were baited over a five-month period and bait bags were placed within private property with consent of the owners where it was possible to do so. This allowed for protection of the bags against tampering and for easy access for researchers placing and collecting the bags. Streams not within private property were sampled with permission for sampling for research purposes from the appropriate organizations.

Two of the sampled streams baited, Clemons Fork and Coles Fork (with watersheds of 4,000 and 5,000 acres respectively), are located within the Robinson Forest a University of Kentucky Research Forest. A third forested stream, Indian Creek (7,700 acre watershed), is located within the Daniel Boone National Forest. The other five streams drain watersheds that receive water from urban and agricultural areas and include nurseries and garden centers. Cane Run Creek drains a watershed of approximately 10,000 acres that is subject to high tourist activity and animal transit. Town Branch is within a large watershed of 14,700 acres that receives drainage from downtown Lexington and agricultural areas. The South Fork of the Elkhorn Creek has a 6,500 acre watershed receiving runoff from urban areas of Lexington. North Elkhorn Creek has an 11,000-acre watershed that drains primarily agricultural parts of Lexington but also one of the largest new development sites in the city. Gunpowder Creek is within a 6,700 acre watershed that drains parts of Florence in northern Kentucky, including the Cincinnati-Northern Kentucky International Airport.

The survey was carried out for five months in eight streams sampled with two bags at each sampling period resulting in 80 baiting opportunities. Some bags were lost and sampling was not possible in two streams in late summer due to drought. At the end of the of the five-month sampling period there were 72 successful baiting trials yielding composite leaf samples for analysis. Leaves collected from one bait bag were used for isolations in the Plant Pathology Diagnostic Laboratory and many Phytophthora species were isolated, but not *Phytophthora ramorum.* The leaves collected from the second bag were sent to a partnering lab for analysis by PCR as an independent secondary diagnostic.

Phytophthora ramorum was not isolated by culturing, and no samples were positive in PCR for this pathogen in Kentucky in 2007.

Significance to the Industry

Like many other Phytophthora species, *Phytophthora ramorum* can move from infested areas in irrigation water and into streams and can be carried to start new infections. *P. ramorum* has been detected in water in California, Oregon, and two other states in streams draining nurseries that had plants infected with *P. ramorum.*

The USDA APHIS promoted the comparison of eight national-scale risk models for *P. ramorum,* and the North West coast and the central Appalachian Mountains were consistently considered high risk areas. *P. ramorum* has not been detected in the Central Appalachian Mountains, where its introduction could have serious consequences for the state of Kentucky. Forty-seven percent of the state is covered by 11.9 million acres of forests, many understory, mid-story and upper story plants found in these forests are known hosts of *P. ramorum.* A recent report showed that several plant species of major importance to the state and to the Appalachian range are susceptible to infection by *P. ramorum* (3). In 2005 and 2006 forest surveys were performed and no samples were collected that tested positive in PCR for *P. ramorum*; however the state is in a high risk area with many known susceptible plants (1, 2).

This pathogen is a nursery and forest problem and its introduction and establishment in the state could have a considerable impact on the nursery and forestry industries and cause substantial economic losses. Early detection and eradication of diseased plants followed by good practices for control of diseases in the nurseries are important to protect Kentucky's forest resources and forestry industry as well as the nursery and landscape industry from *Phytophthora ramorum.*

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National Nursery Survey for *Phytophthora ramorum* in Kentucky, 2007

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Nature of the Work

Phytophthora ramorum has been recognized as presenting a risk to the nursery industry and to rhododendrons and oak trees in landscaped and wild areas. National nursery surveys have been performed for several years to detect its presence and distribution in the United States. Regulations and quarantines have been established in attempts to control and limit the spread of this pathogen, and *P. ramorum* is at this time the major Phytophthora species of concern to the ornamental nursery industry in the U.S. It is the cause of Ramorum blight, a disease affecting many plants and known as sudden oak death when found on oak and tanoak trees. Although this pathogen affects mostly camellias, rhododendrons, viburnums, oaks and tanoaks, many woody shrubs and trees, herbaceous plants and ferns can also become infected and develop Ramorum blight with varying levels of severity. The USDA-APHIS-PPQ publishes on its website a list of plants that are classified as hosts of *P. ramorum* or as plants associated with it. A species or variety of plant is considered a host plant when *P. ramorum* can be isolated from it and grown in pure culture. The culture is then used to infect a healthy but otherwise identical plant, if this second plant develops the same disease and *P. ramorum* can be re-isolated from it, that plant variety or species is considered a host plant. An associated plant is one that is found infected by testing in the lab but for which the assay described above (Koch's postulates) has not yet been completed. Proven hosts are regulated in whole or in part and plants associated with *P. ramorum* are regulated as nursery stock. The complete list is updated regularly and can be viewed at: http://www.aphis.usda.gov/ppq/ispm/pramorum/pdf files/usdaprlist.pdf.

Similar lists have also been compiled in other countries and may be good references for those considering importing plants. The lists can be found at websites such as the DEFRA website in England, or the CDIA website in Canada.

The conditions in the nursery or in the greenhouse that are favorable for infection and expression of symptoms, are the presence of water on the leaves, shoots and stems for 12 hours a day for 10 days or more at temperatures between 37 °F and 82 °F. Some plants like camellias shed the infected leaves and may look like they are not infected. Even when symptoms are clearly visible correct identification should be done by a trained professional, either by isolation in selective culture media and analysis of morphological characteristics or by a method such as PCR. The long distance spread of *Phytophthora ramorum* is known to occur through the movement of infected plants, plant parts, soil and water. The Appalachian region is considered a high risk area for establishment of this pathogen if it were to be introduced, and there is great concern that *P. ramorum* could spread to native plants in woodlands and forests. A recent report showed that several plant species of major importance to Kentucky and to the Appalachian range are susceptible to infection by *P. ramorum* (3).

The National Nursery Survey in Kentucky in 2007 was performed by collaboration between the Department of Plant Pathology and the Office of the State Entomologist (Department of Entomology) at the University of Kentucky, and the USDA – APHIS. Procedures for collecting and testing were according to protocols established by the USDA-APHIS-PPQ. Thirty seven nurseries and retail outlets were surveyed for detection of *P. ramorum* mostly in central and eastern Kentucky, parts of the state that may be at higher risk for establishment of the pathogen. Risk was based on one of more of these factors: composition of native plants in the area, favorable climate and weather conditions and presence of nursery receiving plants from areas where the pathogen is present.

Research and experience in nurseries have indicated that six genera of plants seem to be very susceptible to infection and are considered high risk plants: Camellia, Rhododendron (excluding the type of azaleas that have small leaves), Viburnum, Pieris, Kalmia (mountain laurel) and Syringa (lilac). Samples of leaves, apical shoots and/or flower buds showing symptoms typical of Ramorum blight were collected mostly from the six high-risk genera. However, some samples were also taken from other plants showing suspicious symptoms. All samples were double-bagged and transported to the Plant Pathology Diagnostic Lab at the University of Kentucky for testing.

The samples were tested using ELISA; an assay based on immunological detection of proteins that are present in organisms in the genus Phytophthora and indicates infection by any one of several species. DNA was extracted from the samples that tested positive in ELISA and was sent to the USDA-APHIS for testing by PCR for *P. ramorum*, as required by the survey protocol.

Results and Discussion

Samples were collected from 36 nurseries and retail outlets in 18 counties: Boone Boyd, Boyle, Breathitt, Bullitt, Campbell, Clark, Fayette, Franklin, Jefferson, Jessamine, Johnson, Laurel, Nelson, Oldham, Pulaski, Shelby and Taylor. Of the 148 composite samples collected 26 samples tested positive in ELISA for the genus Phytophthora. DNA was extracted from the ELISA positive samples and was sent to the USDA-APHIS for testing by PCR, and no samples tested positive in PCR for *Phytophthora ramorum.* The results are summarized in Table 1. No samples tested PCR positive for *Phytophthora ramorum* in the nursery survey of 2006 in Kentucky, although it is likely that some plants were infected by another species of Phytophthora that is not necessarily as damaging as *P. ramorum*.

Table 1. Number and type of plants sampled and results of ELISA assays for *Phytophthora* in general and PCR for *Phytophthora ramorum* during the National Nursery Survey for *Phytophthora ramorum* in Kentucky in 2007.

Plant	Number of Samples	ELISA Positive	PCR Positive
Viburnum	75	3	0
Rhododendron	37	18	0
Pieris	10	3	0
Lilac	19	1	0
Mountain Laurel	4	1	0
Unidentified	3	0	0
Total	148	26	0

Significance to the Industry

In the United States in the years from 2004 to 2007 there have been reports of detection of *P. ramorum* in nurseries, forests, wild areas and streams. In some states it was only found in one nursery or in one stream. In most cases the pathogen was eliminated from the infested area and has not been found again in that same area or even in the same state. *P. ramorum* has not been found in forests outside of California and Oregon, but forest types with oak overstory and rhododendron understory are present in the Eastern U.S. and represent areas of high risk. *Phytophthora ramorum* regulations are periodically amended by the Animal and Plant Health Inspection Service (APHIS), USDA, the latest interim rule was published on February 27, 2007, and can be seen on the USDA-APHIS website. This rule and other quarantine orders are parts of the effort to prevent the spread of *P. ramorum* to non-infested areas of the United States.

P. ramorum was not detected in samples collected in 2007 and was not detected in the surveys of 2005 and 2006 (1, 2). Long distance spread of *Phytophthora ramorum* is believed to occur mostly by movement of infected plants from nurseries that have the pathogen. Infected plants may become a source of inoculum to healthy plants in the receiving nursery and in landscaped areas. The pathogen could spread to parks and to forests where rhododendrons and azaleas, viburnums, mountain laurel are oak trees are present. Early detection and eradication of diseased plants are important to protect the landscape and nursery industries in Kentucky.

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Evaluation of Root Flare Injection Treatments to Manage Oak Bacterial Leaf Scorch—2007

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Nature of the Work

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

Bacastat® is a commercial injectable form of oxytetracycline, an antibiotic used for management of bacterial diseases in agricultural crops and is active against gram negative bacteria such as Xylella. Mycoject® is also an injectable formulation of oxytetracycline. Cambistat® (paclobutrazol) is a plant growth regulator chemical which inhibits synthesis of the plant hormone gibberellin over a period of up to 3 years. Paclobutrazol is said to stimulate root development which could reduce bacterial leaf scorch symptoms.

In 2006, we were able to show that root flare injection of Bacastat in late spring delayed the appearance of scorch symptoms by 2-3 weeks. The best time for application of Bacastat is not known, so the objective of this research is to determine the springtime application timing that provides the best results in reducing summer and fall bacterial leaf scorch disease symptoms in pin oaks.

This research was conducted at Stone Street Farm in Lexington, a horse farm with a history of bacterial leaf scorch disease. Eighty mature pin oak trees with an average diameter of 22 inches (DBH) lining a long driveway and growing along the boundaries of the farm, were selected for this experiment. Except where indicated, treatments (Table 1) were made to trees not previously treated with Cambistat because of its lasting effects. Antibiotics were injected during May and June, 2007, into trees using a micro-injection technique. Due to an early April freeze which delayed leaf emergence, the first injections were made the second week in May when first leaves were fully expanded. Micro-injections were done with a reusable M3 device with an applicator capsule that allows pressurization. Applications were made through 15/64 inch diameter holes drilled into major root flares at the base of the tree and spaced 6-8 inches apart around the tree. Chemical uptake time using this system ranged from 10 to 30 minutes. Mycoject was applied similarly but with a much longer uptake time due to the more viscous formulation used. The 2007 Cambistat basal drench treatment was a re-treatment of some of the trees that had been treated in June, 2006. The chemical was applied to the soil at the base of selected trees at label rates depending on tree size. The eight treatments were replicated 10 times (5 times for the Cambistat re-treatment) and the experiment was established in a randomized complete block design.

Prior to 2007 treatment applications, on 18 October, 2006, when symptoms were prominent, trees were evaluated for bacterial leaf scorch symptoms so that trees representing stages of disease from 0 to 100 percent leaf scorch in 2006 could be distributed equally among the 2007 treatments. From these data, trees with varying levels of leaf scorch were equally assigned so that for each treatment group, average leaf scorch the previous

Table 1. 2007 Root-flare injection and basal drench treatments.

Treatment	Treatment Date	Formulation	Application method	Rate
Bacastat	8 & 9 May	Oxytetracycline hydrochloride	M3 re-usable micro-injectors	0.14 grams a.i. in 7.5 ml water/inch tree diameter (label rate)
Bacastat	29 & 30 May	Oxytetracycline hydrochloride	M3 re-usable micro-injectors	0.14 grams a.i. in 7.5 ml water/inch tree diameter (label rate)
Bacastat	18 & 20 June	Oxytetracycline hydrochloride	M3 re-usable micro-injectors	0.14 grams a.i. in 7.5 ml water/inch tree diameter (label rate)
Mycoject	1 June	Calcium oxytetracycline	Mauget micro-injectors	0.13 grams a.i. in 3ml suspension/inch tree diameter (label rate)
Cambistat	June 2006	Paclobutrazol	basal drench	4 grams a.i./inch tree diameter (rate F from Cambistat application rate card)
Cambistat	June, 2006	Paclobutrazol	basal drench	4 grams a.i./inch tree diameter (rate F from Cambistat application rate card)
Cambistat (repeat treatment, 5 trees only)	25 May			
Cambistat	June, 2006	Paclobutrazol + Oxytetracycline hydrochloride	M3 re-usable micro-injectors	4 grams a.i./inch tree diameter (rate F from Cambistat application rate card + 0.14 grams ai in 7.5 ml water/inch tree diameter (label rate)
Bacastat	15 & 17 May			
Untreated control				

Table 2. Effect of treatments on bacterial leaf scorch levels in 2007, expressed as a percentage of leaf scorch levels present the previous year on 18 October 2006.

Treatment	Treatment Date	Bacterial Leaf Scorch *(%)*						
		7 Aug	20 Aug	4 Sep	18 Sep	2 Oct	16 Oct	30 Oct
Bacastat micro-injection	8 & 9 May	0	0	13	26	63	78	117
Bacastat micro-injection	29 & 30 May	2	2	12	25	49	71	98
Bacastat micro-injection	18 & 20 June	2	2	10	30	60	78	124
Mycoject micro-injection	1 June	2	2	27	57	83	98	130
Cambistat basal drench soil application	2006	0	0	20	60	100	116	164
Cambistat basal drench soil application	2006	0	7	38	57	111	129	164
Cambistat application (5 trees only)	2007							
Cambistat basal drench soil application	2006	0	0	3	24	62	100	154
Bacastat micro-injection	15 & 17 May							
Untreated control		16	16	33	63	108	123	158

year was in the range of 40 to 50 percent. Thus no treatment was compromised by use on predominantly heavily diseased trees and compared with another treatment used on predominantly healthy trees. Beginning with first symptom appearance, trees were evaluated for percent scorch symptoms at about two-week intervals on 7 and 20 August, 4 and 18 September, and 2, 16, and 30 October 2007.

Results and Discussion

Results are presented in Table 2. Note that for all treatments, bacterial leaf scorch symptoms gradually increased from August through October. None of the treatments "cured" infected trees or prevented scorch symptoms from appearing by the end of the growing season. However, treatments using antibiotics generally delayed the onset of symptoms by 2-3 weeks. It appears that the late May Bacastat treatment provided slightly better results than the early May or mid-June treatments. Mycoject treatments did not appear to be as effective as Bacastat treatments. By mid-October 2007, the antibiotic-treated trees showed less scorch than the same trees showed in October 2006. Untreated trees, however, were more diseased than the previous year, which was expected since bacterial leaf scorch disease worsens progressively each year. It is not known whether the drought conditions in the summer of 2007 affected the treatments or disease expression. It appeared that healthy leaves remained greener a week or two longer into the fall, so final disease evaluations were made somewhat later in 2007 than in 2006.

Significance to the Industry

Kentucky landscape industry professionals are in need of a remedy for bacterial leaf scorch disease. Although treatments used in this experiment did not cure trees of bacterial leaf scorch, treatments that can delay symptoms by even a few weeks might prolong the useful life of infected trees. More experiments will be needed so that optimal treatment times and rates can be determined.

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The Role of Shearing in the Transmission of *Diplodia pinea* in Scots Pine Christmas Trees in Kentucky—2007 Update

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Nature of the Work

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

The location of infected shoots on diseased trees suggested the possibility that shearing or pruning a diseased tree could contribute to fungal dispersal. In 2005-2007, research was done to test this hypothesis on Scots pine Christmas trees. Two central Kentucky Christmas tree farms were used for the study. Tip blight disease severity levels were first determined for each tree on each farm. Disease severity was measured as the percentage of symptomatic versus asymptomatic tips on each tree. Samples were collected from tools after shearing by pressing adhesive tape against the blades, and the samples were then brought back to the lab for further analysis. Fungal colonies were cultured from the tapes, and confirmation of the colonies as *D. pinea* was done by spore identification.

Previously, the efficacy of Lysol® spray for disinfesting shearing tools was tested in the field. In that study, there was no difference in the number of viable *D. pinea* spores aquired on tools that had Lysol® applied to them versus untreated tools. The toxicity of Lysol® to *D. pinea* spores was tested in vitro. The percent germination of *D. pinea* spores when they were incubated in Lysol® solutions for various amounts of time was compared with other common disinfestants (ethanol, bleach, and isopropanol).

When tips are sheared, resin caps form on the wounds. To test the effect of the resin on *D. pinea* infection, artificial shearing was performed on 4-year-old potted Scots pines in the summer of 2006. The experiment was repeated in 2007. Tips were removed from four branches in the same whorl of the Scots pines. At 0hr, 6hr, and 24hr after cutting, 10µL of a

D. pinea spore suspension (1x106 per ml) was applied to each wounded tip via the addition of a pipette tip to the branch. A water control was also added at 0hr. Disease progress was assessed a few weeks after inoculation.

Tape press samples collected from shearing tools in the field in previous years suggested that the number of *D. pinea* spores that accumulated on the tools was typically low, less than 10 spores per collection. To determine whether the number of spores applied to a sheared tip plays a role in symptom development, different numbers of spores were applied to artificially sheared tips of 4-year old potted Scots pines in the summer of 2007. Spores were applied at 0, 100, 5000, or 10,000 per tip. Disease progress was assessed a few weeks after inoculation.

Results and Discussion

The average tip blight disease severity on one of the farms (Farm 2) increased significantly between 2005 and 2006, but then decreased between 2006 and 2007. In contrast, disease levels on Farm 3 were basically unchanged during the three years of the study (Figure 1). A decrease in disease severity will result if diseased tips removed by shearing are not replaced by new infections of elongating tips the following year. If new infections do not occur, it is possible to get rapid and drastic reductions in disease severity levels in a very short time.

On Farm 2, there was a significant correlation between the number of *D. pinea* spores recovered from tools in 2006 and the disease severity in 2007 on the trees that had been sheared with those tools; however, the correlation was weak ($p=0.02$, $r=0.22$). There was no significant correlation in 2005/2006. On Farm 3, the correlation was significant in both 2005/2006 ($p=0.01$, $r=0.19$) and in 2006/2007 ($p<0.01$, $r=0.32$), but once again, the correlations were weak. In both 2005 and 2006, the number of spores recovered from tools on both farms was not significantly different between the first and the last tree to be sheared in each group. There was no strong correlation between the disease severity on each tree, and the number of spores acquired on the tools the previous year after shearing the previous tree in the group. All of these data indicate that significant transmission of spores via the tools, resulting in new infections of the sheared tips, did not occur on these farms during this study.

The efficacy of Lysol® for inhibition of *D. pinea* spore germination in vitro was tested and compared with other recommended disinfestants (ethanol, bleach, and isopropanol) at various concentrations (5, 10, and 25%). Significantly fewer spores germinated in Lysol® than in ethanol and isopropanol at 5 and 10%. There was no significant difference among these three disinfestants at 25%. Spores germinated at statistically the same rate in all three concentrations of Lysol®. The efficacy of Lysol® as a disinfestant was most similar to bleach across all the concentrations tested (Figure 2). These data demonstrate that Lysol® is as toxic to *D. pinea* spores as bleach.

The effect of exposure time on the ability of Lysol® to prevent germination of *D. pinea* in vitro was also tested. Even after only 30 seconds of exposure, the germination rate was significantly reduced ($p<0.01$). Increasing the exposure time to Lysol® continued to decrease the germination rate up until 5 minutes, when maximum efficacy was achieved (Figure 3).

Figure 1. The average percent of Diplodia tip blight symptomatic tips on two farms in central Kentucky.

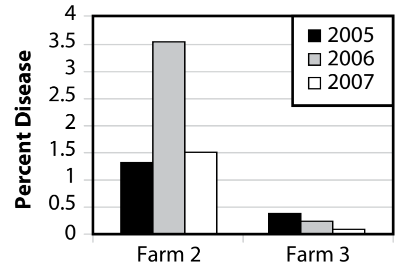


Figure 2. Average germination rate of *D. pinea* spores after 12 hr exposure to various concentrations of different disinfestants.

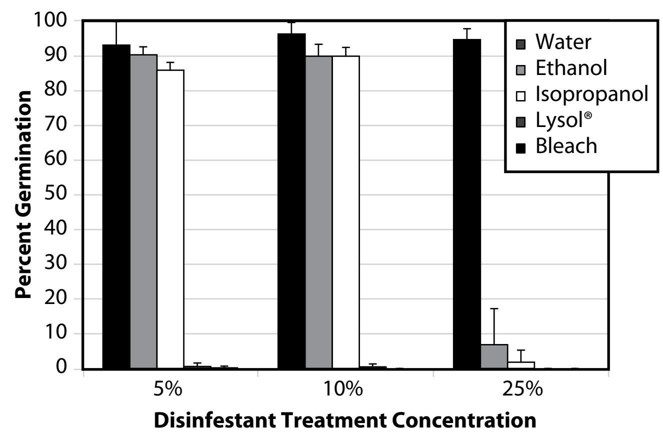
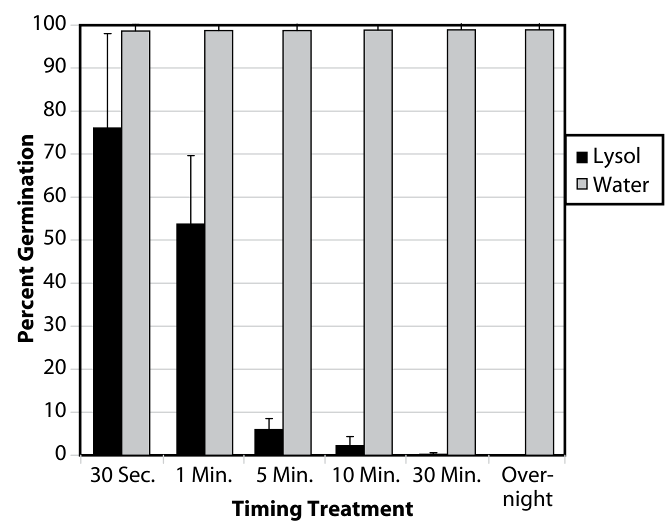


Figure 3. Average germination rate of *D. pinea* spores after exposure to 25% Lysol® Disinfectant Spray for various amounts of time.



Shoot necrosis (dieback) resulted when D. pinea spores were applied to Scots pine shoot tips after shearing; no necrosis occurred on the water controls. In both 2006 and 2007, the amount of tip dieback decreased as the time elapsed since shearing increased from 0 to 24 hours. In 2006, all except the

0 hr and 6 hr treatments were significantly different (Figure 4). In 2007, these differences were significant for all treatments ($p<0.01$, Figure 5).

The amount of tip dieback that resulted from application of 0, 100, 500, or 10,000 *D. pinea* spores to Scots pine shoot tips immediately after shearing was compared. The length of the necrotic lesion produced increased significantly as the number of spores applied increased. Only 22 of the 24 shoots (91.7%) that were inoculated with 100 spores developed tip blight symptoms. All of the shoots inoculated with higher spore concentrations became symptomatic. This indicates that a minimum of 100 spores must be applied to a freshly sheared tip in order to ensure the development of tip blight symptoms.

Significance to the Industry

Transmission of pathogens causing woody plant diseases by way of pruning tools is a common occurrence. Landscape industry workers are well advised to use sanitary measures such as use of disinfestants to avoid spreading disease while pruning or shearing plants. However, in this study involving Diplodia tip blight of pines, disease transmission via pruning tools does not appear to be very efficient.

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1. Bateman, Amy. 2007. The Role of Shearing in the Transmission of *Diplodia pinea* in Scots Pine Christmas Trees in Kentucky. M.S. Thesis, Plant Pathology Department, University of Kentucky.

Figure 4. Average Horsfall-Barratt disease ratings of 4-year-old Scots pines inoculated with *Diplodia pinea* at varying time intervals after shearing (2006).

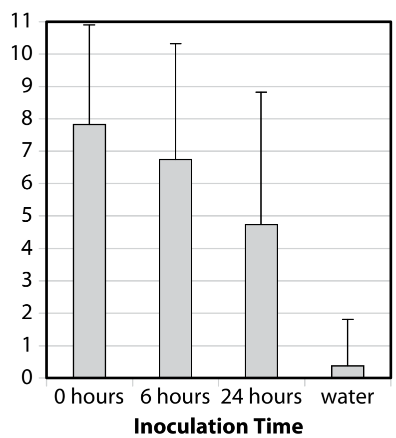


Figure 5. Average length of shoot necrosis of 4-year-old Scots pines inoculated with *Diplodia pinea* at varying time intervals after shearin (2007).

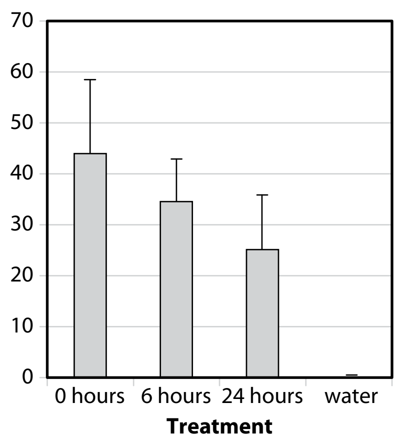
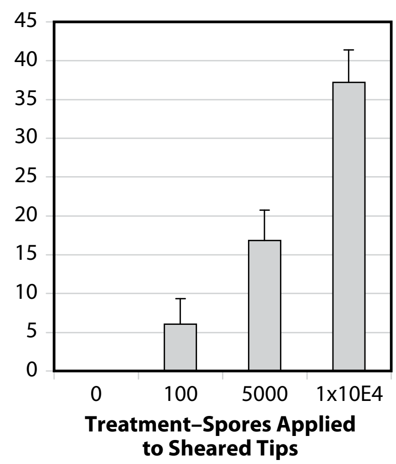


Figure 6. Length of shoot necrosis development after inoculating shoots of Scots pine seedlings with varying concentrations of *D. pinea* spores.



Detection of *Xylella fastidiosa,* Cause of Bacterial Leaf Scorch, in Kentucky Woody Plants, 2007

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

Nature of the Work

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

Laboratory detection of bacterial leaf scorch in leaves with scorch symptoms requires a special test, enzyme-linked immuno-sorbent assay (ELISA), involving immunological detection of proteins. This test, which is sensitive to low levels of Xylella cell wall proteins, is used routinely in the U.K. Plant Disease Diagnostic Laboratory (diagnostic lab) for specimens submitted by County Extension Agents statewide. Where new hosts or new geographic locations are involved it is important to verify these first-occurrences of the pathogen using another selective and sensitive test such as the polymerase chain reaction (PCR) which detects very small amounts of Xylella DNA.

Samples of plants with typical symptoms were collected in late summer and early fall by County Agents, and by individual clients and submitted to the diagnostic lab for testing. Additional samples were collected by U.K. plant pathologists for use in future research on determining X. fastidiosa sub-species. For testing, leaf petioles were removed from suspected scorched leaves and placed in fiber mesh-reinforced plastic bags containing extraction buffer. Samples were crushed in the bag using a tissue homogenizer, a tool utilizing a circle of ball bearings which rotate when attached to an upright power drill press. After samples were macerated, extracts were removed from the bags and ELISA and PCR tests were done following established protocols.

Table 1. Woody plant specimens submitted to the plant disease diagnostic laboratory that were found to be ELISA (+) and in some cases PCR (+) for bacterial leaf scorch in Kentucky, 2007.

Species	Common Name	ELISA Positives	PCR Positives[1]	County Locations
Acer platanoides	Norway maple	1	1	Fayette
A. rubrum	Red maple	3	2	Washington
A. saccharum	Sugar maple	4	3	Fayette, Franklin, Mercer
Celtis occidentalis	Hackberry	2	1	Fayette
Chionanthus virginicus	Fringe-tree	1	1	Fayette
Fraxinus americana	white ash	1	1	Fayette
Morus sp.	Mulberry	2	2	Fayette, Jefferson
Platanus occidentalis	Sycamore	3	1	Fayette
Quercus imbricaria	Shingle oak	1	1	Fayette
Q. macrocarpa	Bur oak	4	1	Fayette, Bourbon
Q. muehlenbergii	Chinquapin oak	1		Bourbon
Q. palustris	Pin oak	19	8	Fayette, Jefferson, Nelson, Christian
Q. rubra	Northern red oak	9	4	Fayette, Woodford
Q. shumardii	Shumard oak	1	1	Franklin
Vitis 'Vidal Blanc'	Grape	1[2]	1	Fayette

1 Samples collected for sub-species determination research were also tested using PCR.
2 X. fastidiosa from grape is probably a different subspecies than that from other woody plants.

Results and Discussion

Of specimens submitted to the diagnostic lab and collected for future research, oaks made up the bulk of the samples. Most of the species testing (+) for bacterial leaf scorch in 2007 were already known to be positive from work done in previous years. It appears that Shumard oak, white ash, Norway maple, and fringe tree may be new hosts for bacterial leaf scorch disease in Kentucky. Chinquapin oak might also be considered a new host, but it has not been confirmed by PCR testing. Totals of woody plant specimens testing ELISA and PCR positive are listed in Table 1.

Significance to the Industry

It is important for arborists, nursery owners, and landscape professionals to be aware of the extent of the host range for bacterial leaf scorch. This could affect species selection decisions for new and replacement landscape and nursery trees.

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2007 Landscape Plant Disease Observations from the University of Kentucky Plant Disease Diagnostic Laboratory

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

Nature of the Work

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

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

To assist county Extension agents in dealing with plant disease issues, we also operate a web-based digital consulting system utilizing photographic images. When the system is used to assist in diagnosis, the images can be used to help determine where best to collect samples for submission to the laboratory. The digital consulting system is especially useful in providing advice about landscape tree and shrub diseases and disorders because whole plants are difficult to send to the laboratory. Of more than 1200 digital consulting cases, 30-35% dealt with landscape and nursery plants.

The 2007 growing season in Kentucky was not kind to most woody landscape plants. January temperatures statewide were 6-7 degrees above normal and then February was the 11th coldest and 26th driest in the past 112 years. A particularly warm spring featured March and very early April temperatures 9-13 degrees above normal with 13-25 days having temperatures 70 degrees or above. Some locations had as many as 12 days above 80. These warm temperatures broke dormancy and accelerated flowering and shoot growth so that plant development was advanced by 2-3 weeks. Seventy and 80 degree F temperatures maximized fire blight development. A record-setting Easter-time freeze dropped temperatures drastically; indeed, in some Kentucky locations, the temperature dropped from 80 to 29 degrees on April 5. This was followed by 5 consecutive days with low temperatures below 30 degrees statewide, with lows of about 22 degrees for several nights, and with some locations falling to 18 degrees F. Summer was hot and dry with temperatures 90 degrees F or above for 44 days compared to 20 days in most years. Depending on the location, temperatures were above normal as much as 7 degrees F in May, 5 degrees in June, 2 degrees in July, 9 degrees in August, and 8 degrees in September. Severe drought conditions dominated throughout the summer, and rainfall was localized across the state. Some locations were as much as 16 inches behind in rainfall by the end of September.

With wetness affecting early season disease development, there were sufficient days with rain in most of Kentucky during March and the first days of April. Thus, there were limited opportunities for rain-based development of some spring plant diseases such as scab and cedar-quince rust; warm temperature combined with wet conditions favored fire blight, especially in the early-blooming flowering pears and crabapples.

This was a moderate year for landscape plant disease incidence with diseases favored by drought or spring freeze injury being the most common. The following important or unusual diseases were observed:

Deciduous trees

- Ash, dogwood, oak and redbud canker (*Botryosphaeria*) promoted by stresses relating to spring freeze and summer drought
- Ash, hickory, and maple anthracnose (*Discula* and *Kabatiella*) and dogwood spot anthracnose (*Elsinoe*)
- Crabapple scab (*Venturia*)
- Dogwood, oak, and tuliptree powdery mildew (*Microsphaera, Phyllactinia*)
- Flowering pear, serviceberry, and flowering crabapple fire blight (*Erwinia*)
- Flowering plum and flowering cherry black knot (*Apiosporina*)
- Hackberry, maple, oak and sycamore bacterial leaf scorch (*Xylella*)
- Honey locust and aspen leaf spot (*Cercospora*)
- Maple tar spot (*Rhytisma*)
- Oak Actinopelte leaf spot (*Tubakia*)
- Redbud wilt (*Verticillium*)

Many tree species

- Winter drying (broadleaved evergreens), spring freeze and summer drought-related woes including loss of bark and vertical trunk splits, especially on young trees

Needle Evergreens

- Leyland cypress blight (*Seridium*)
- Juniper tip blight (*Kabatina, Phomopsis*) and juniper rusts (*Gymnosporangium*)
- Pine tip blight (*Diplodia*) and needle casts (*Mycosphaerella, Lophodermium*)
- Taxus root rot (*Phytophthora*)
- White pine, spruce, and white fir root rot (*Phytophthora*)
- White pine blister rust (*Cronartium*) and white pine decline (physiological)

Shrubs

- Boxwood cold injury, canker (*Pseudonectria*) and root rot (*Pythium*)
- Euonymus powdery mildew (*Erysiphe*) and crown gall (*Agrobacterium*)
- Forsythia gall (*Phomopsis*)
- Holly black root rot (*Thielaviopsis*)
- Hydrangea leaf spot (*Cercospora*), root rot (*Phytophthora*)
- Rhododendron canker (*Botryosphaeria*)
- Rose black spot (*Diplocarpon*) powdery mildew (Sphaerotheca) and rosette (possible virus, leaf curl mite-transmitted)

Herbaceous Annuals and Perennials

- Aster, fuchsia, and geranium rusts (*Coleosporium, Puccinia*)
- Chrysanthemum wilt (*Fusarium*) and root rot (*Pythium, Rhizoctonia*)
- Daylily leaf streak (*Aureobasidium*) and cold injury
- Gaillardia white smut (Entyloma)
- Impatiens, pansy, and petunia black root rot (*Thielaviopsis*)
- Pachysandra stem canker and blight (*Volutella*)

- Phlox and sedum powdery mildew (*Oidium*)
- Balloon flower, begonia, dahlia, geranium, pansy, petunia, portulacca, rudbeckia, snapdragon, and zinnia root rots (*Pythium, Rhizoctonia*)
- Vinca canker and root and stem rot (*Phoma, Rhizoctonia*)

Significance to the Industry

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

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National Elm Trial—Kentucky Data, 2007

John Hartman and Ed Dixon, Department of Plant Pathology; Dan Potter, Cristina Brady, and Jenny Edelen, Department of Entomology; Jerry Hart, PPD-Grounds; William Fountain, Department of Horticulture

Nature of the Work

The National Elm Trial was established to evaluate landscape-suitable elm cultivars for disease and insect tolerance and for horticultural characteristics at 15 locations nationwide from California to Vermont and south to Kentucky. Locally, 14 elm cultivars were planted April 13-15, 2005, in a grassy area on the University of Kentucky campus in Lexington. An additional three cultivars were planted in April 2006 and three more cultivars in April 2007. Plots were located south and east of the sports complex across from the UK Arboretum entrance along Alumni Drive (North 38 deg, 1 min; West 84 deg, 30 min, elev. 990 ft). The site had been graded for construction some years before and consisted of a mixture of topsoil, subsoil, and construction debris. In the planting, a double-allée, each cultivar was replicated five times and arranged in a randomized complete block design. Additional randomized space was left in each block for elm cultivars to be planted in future years. Trees were staked as needed, watered during dry periods, and all trees were mulched over grass that had been killed with an application of Roundup herbicide.

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

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

Table 1. Size of elms, 2007; effect of elm cultivar on damage 5-9 April 2007 freeze.

Cultivar Number and Name *(from list above)*	Avg. Trunk Dia. *(in) dbh*		Avg. Height *(ft)*		Avg. Crown Width *(ft)*	Growth Stage *(April 5-9)*	Shoot, Leaf Tissue Freeze Damage[1]	Trunk and Bark Freeze Damage[2]
	2007	Increase from 2006	2007	Increase from 2006				
1. JFS Bieberich	1.3	0.4	12.0	1.0	3.4	green tip	tip burn	none
2. Emer II Allee	0.9	0.1	8.5	1.0	4.4	dormant	none	trunk cracks (2)
3. Frontier	0.9	0.2	10.6	0.6	3.9	first leaf appearing	dead	none
4. Homestead	1.3	0.2	11.5	0.3	4.8	shoots appearing	dead	small trunk cracks (1)
5. Morton Glossy	1.1	0.2	9.6	0.3	2.6	shoots appearing	dead	none
6. Morton Plainsman	1.4	0.3	10.8	0.2	5.1	shoots appearing	dead	trunk cracks (5)
7. Morton Red Tip	1.8	0.3	11.3	0.2	5.0	shoots appearing	dead	trunk cracks (4)
8. Morton Stalwart	1.6	0.2	11.9	0	4.3	shoots appearing	dead	none
9. Morton Accolade	1.3	0.2	10.5	0.3	3.5	shoots appearing	dead	trunk cracks (3)
10. New Horizon	1.5	0.3	10.9	1.5	3.1	first leaf appearing	dead	small trunk cracks (2)
11. Patriot	1.4	0.3	12.3	0.6	4.4	shoots appearing	dead	none
12. Pioneer	1.2	0.2	10.7	0.5	3.8	shoots appearing	dead	none
13. Prospector	1.5	0.4	10.4	0	4.3	first leaf appearing	dead	trunk cracks (3)*3*
14. Valley Forge	1.2	0.4	10.3	0.8	3.5	green tip	tip burn	none
15. Princeton	1.2	0.2	13.6	0.8	1.3	dormant	none	trunk cracks (3)
16. Jefferson	0.6	0.4	4.0	2.8	1.0	dormant	none	none
17. New Harmony	0.9	0.2	11.2	0.2	1.0	dormant	none	none
18. Athena	0.5		3.7		1.0	dormant	none	none
19. Everclear	0.4		4.6		1.0	dormant	none	none
20. Prairie Expedition	0.4		5.3		1.0	dormant	none	none

Trunk diameter taken at 4.5 ft except Jefferson, Athena Classic, and Everclear, which are shorter than 4.5 ft and were measured at 0.5 ft.
1 Foliage and shoot freeze damage assessed 12 April.
2 Trunk bark cracks evaluated 25 July; (number of trees out of 5 showing symptoms).
3 One tree with loose, peeling bark.

Trees came from the nursery as bare root transplants 5-8 ft tall (except 'Jefferson,' which was much smaller). In the plots, new trees were provided with supplemental water in spring just after planting, and all elms were watered periodically through a very dry summer. An exceptionally cold period in early April 2007 caused injury to already-emerged shoot and leaf tissue. Damage from the early April freeze was evaluated 12 April and 25 July. Tree trunk diameters were measured and tree height and width determined in summer. Japanese beetle damage was assessed on 28 July by estimating the percentage of foliage that was damaged by beetle feeding. Each tree was rated by two independent observers and their ratings were averaged to provide a single score per tree.

Results and Discussion

Results from the elm plots are presented in Tables 1 and 2. All of the elm cultivars are increasing in height and/or trunk diameter. All trees that were not dormant in early April showed shoot and leaf tissue freeze damage; all trees did re-leaf later from secondary buds. Trunk injury from early April freezing temperatures appeared on 'Emer II' Allee, 'Homestead,' 'Morton Plainsman,' 'Morton Red Tip,' 'Morton Accolade,' 'New Horizon,' 'Prospector,' and 'Princeton' elms. It is not known if the damage will affect the long-term health of these trees. There were significant differences in the average levels of Japanese beetle damage sustained by the different cultivars. 'Emer II' Allee, 'Everclear,' 'Frontier,' 'Athena,' and 'JFS Bieberich' elms appeared to be somewhat less attractive to Japanese beetle feeding; 'Homestead,' 'Prairie Expedition,' 'Morton Accolade,' 'Morton Plainsman,' 'Pioneer,' and 'Morton Glossy' appeared to attract more Japanese beetle feeding than most other cultivars.

Significance to the Industry

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

Table 2. Effect of elm cultivar on damage from Japanese beetle in 2007.

Cultivar No. and Name		Avg. % Defoliated by Japanese Beetle Feeding
4.	Homestead	87 a
9.	Morton Accolade	73 ab
20.	Prairie Expedition	73 ab
6.	Morton Plainsman	71 ab
12.	Pioneer	67 b
5.	Morton Glossy	60 bc
8.	Morton Stalwart	47 cd
7.	Morton Red Tip	43 cde
11.	Patriot	41 def
13.	Prospector	37 def
16.	Jefferson	33 defgh
14.	Valley Forge	28 defghi
15.	Princeton	25 efghi
17.	New Harmony	23 fghi
10.	New Horizon	20 ghij
1.	JFS Bieberich	17 hij
18.	Athena	15 hij
3.	Frontier	13 ij
19.	Everclear	13 ij
2.	Emer II Allee	02 j

Averages followed by the same small letter are not significantly different (LSD all pairwise comparisons test, P = .05)

Post-harvested Vaselife Evaluation on Two Cultivars of *Hydrangea paniculata*

Todd Leeson, Robert E. McNiel, John S. Snyder, Sharon Bale, and Winston C. Dunwell, Department of Horticulture

Nature of the Work

Hydrangea paniculata is noted as a species of hydrangea capable of producing stems longer than one meter and inflorescences that are 15-30 cm long. These attributes contribute to making this a floral cut stem for large arrangements such as special events, atriums, etc. Two cultivars were evaluated for post harvest life using four floral preservatives and two storage techniques. Floral preservatives included: Floralife Original Flower Food, Pokon & Chrysal Professional #3, Aquaplus and Flora Novus-XL (FNV) singly and in combination with FNV at manufacturer's recommended rates. Storage included: no storage and cold dry storage (2°C and 90% relative humidity). Stems were harvested between 9:00 and 10:00 a.m. and placed in hydration solution (Pokon & Chrysal Professional #2) for an hour. After hydration, stems were placed in treatments or storage for 4 days. Stems were divided into lots of 8 to provide 8 replications for each treatment. Each stem was placed in a tube with 500 ml of solution and held at 22°C in a lit room. Statistical analysis was completed using SAS.

Table 1. Vaselife or *Hydrangea paniculata* 'Unique' with and without dry storage.

Treatment 23JUL/27JUL 2003	Fresh (days)[1]	Stored (days)
Control (water pH = 7.8)	5.5 c	3.8 c
Florilife	11.9 a	10.5 a
Pokon & Chrysal	11.1 a	10.0 a
Aquaplus	7.6 b	7.4 b
Florilife + Flora Novus-XL	11.5 a	6.4 b
Pokon + Flora Novus-XL	11.6 a	9.3 a
Aquaplus + Flora Novus-XL	7.3 b	6.4 b
Flora Novus-XL	5.8 c	4.4 c

[1] Values within column followed by a different letter are different at $P < 0.05$ using t-Test.

Table 2. Vaselife or *Hydrangea paniculata* 'Tardiva' with and without dry storage.

Treatment 12AUG/16AUG 2003	Fresh (days)1	Stored (days)
Control (water pH = 7.8)	18 c	18 c
Florilife	25 a	25 a
Pokon & Chrysal	24 a	25 a
Aquaplus	23 ab	21 b
Florilife + Flora Novus-XL	25 a	25 a
Pokon + Flora Novus-XL	21 b	22 b
Aquaplus + Flora Novus-XL	21 b	21 b
Flora Novus-XL	18 c	18 c

[1] Values within column followed by a different letter are different at $P < 0.05$ using t-Test.

Results and Discussion

Stems were evaluated daily and with the first indication of wilt or discolor they were removed and the day was recorded. Between the two cultivars, there was a statistically significant difference in vaselife, with 'Tardiva' lasting over twice as long. Across all treatments, fresh treated stems lasted 1–4 days longer than stems which were stored. Stems of *H. p.* 'Unique' harvested on 23 JUL 03 that did not enter storage responded with post harvest longevity of 6 to 12 days (Table 1). Stems that were dry stored in a cut stem shipping box responded with post storage vaselife of 4 to 11 days (Table 1). Stems of *H. p.* 'Tardiva' harvested on 12 AUG 03 either was fresh treated or was dry stored in a cut stem shipping box. In both cases, fresh vaselife and post-storage vaselife were 18 to 25 days (Table 2). *H. p.* has the ability to flower for one month anytime from June to September with each cultivar covering part of the period. Floralife and Pokon & Chrysal were significantly better than Aquaplus in maintaining vaselife. Aquaplus was better than Control or Flora Novus-XL. Flora Novus-XL is classified as a vaselife extender for Hydrangea wilted flowers. By itself or in combination, it did not provide additional longevity when compared to the control.

Significance to the Industry

With 'Unique' and 'Tardiva,' responses to preservatives significantly vary and vaselife could be maintained even with a short period of dry storage.

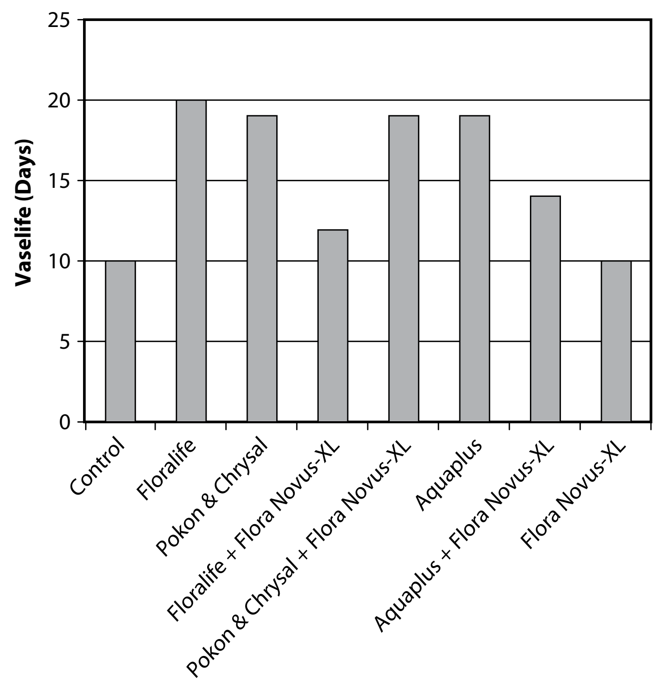
Post-harvest Vaselife Evaluation on Hydrangea arborescens 'Annabelle'

Todd Leeson, Robert E. McNiel, John S. Snyder, Sharon Bale, R. Terry Jones, and Winston C. Dunwell, Department of Horticulture

Nature of the Work

Hydrangea arborescens 'Annabelle' is a noted landscape plant in USDA hardiness zones 5 through 7, which includes a significant portion of central United States. The inflorescence is quite showy and has excellent stem length for use as a floral cut stem. Two evaluations were conducted to determine post-harvest life using four floral preservatives and three storage techniques. Floral preservative treatments included: Floralife Original Flower Food, Pokon & Chrysal Professional #3, Aquaplus and Flora Novus-XL singly and in combination with FNV at manufacturer's recommended rates. Storage treatments included no storage at two sites (UK Research Stations at Princeton and Quicksand, Kentucky), cold dry storage (Princeton), and cold wet storage (Quicksand) (2°C and 90% relative humidity). All stems were harvested between 9:00 and 10:00 a.m. Immediately after completion of harvesting, they were placed in hydration solution (Pokon & Chrysal Professional #2 at Princeton and Hydraplus at Quicksand) for an hour. After hydration, stems were placed in treatments or storage for 5-6 days. Stems were divided into lots of 8 to provide 8 replications for each treatment. Each stem was placed in a tube with 500 ml of solution and held at 22°C in a lit room.

Figure 1. Vaselife comparison between treatments at Princeton.

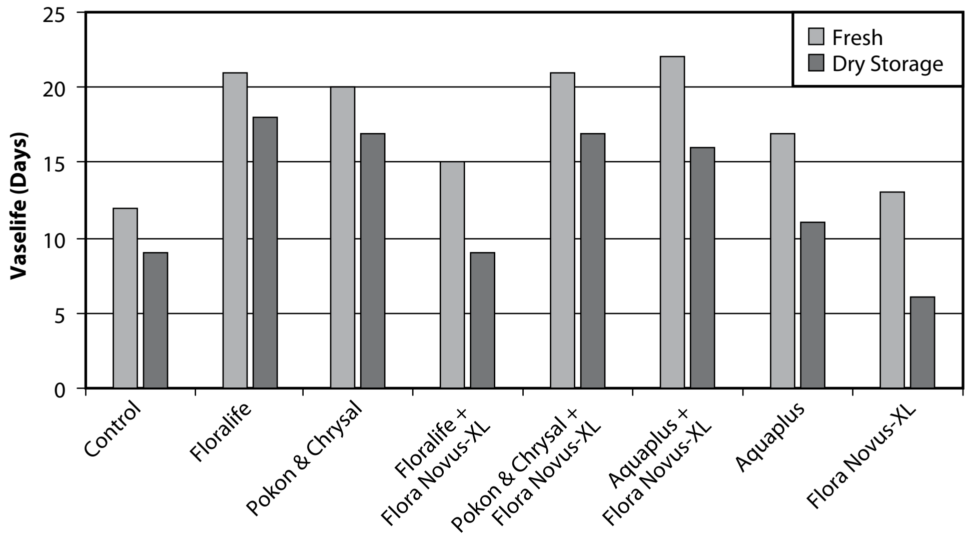


Results and Discussion

Stems were evaluated daily, and with the first indication of wilt or discolor they were removed and the date recorded. The vaselife of the cumulative stems treated at the Princeton site were significantly different when treated with either the Floralife or Pokon & Chrysal preservatives, whether alone or in combination with Flora Novus-XL(FNV), than with the Aquaplus preservative, whether alone or in combination with FNV, or the control (Figure 1). Stems harvested on 10 June 2003 (Princeton) that did not enter storage responded with post-harvest longevity of 12-22 days (Figure 2). Stem treated in Floralife or Pokon & Chrysal preservatives, whether alone or in combination with Flora Novus-XL(FNV), averaged 20 or more days of vaselife (Figure 2). Stems that were dry stored for 6 days in a cut stem shipping box responded with post-storage vaselife of 6-18 days (Figure 2). Floralife or Pokon & Chrysal preservatives, whether alone or in combination with FNV, averaged over 16 days of vaselife in addition to the 6 days in storage (Figure 2). No interaction occurred between preservatives and storage.

The vaselife of the cumulative stems treated at the Quicksand site were significantly different when treated with either the Floralife (FLF) or Pokon & Chrysal (PKC) preservatives, whether alone or in combination with Flora Novus-XL (FNV), than with the Aquaplus (AQP) preservative, whether alone or in combination with FNV, or the control (Figure 3). Stems harvested 25 June 2003 (Quicksand) that did not enter storage responded with post-harvest longevity of 11-18 days (Figure 4). Stem treated in Floralife (FLF) or Pokon & Chrysal (PKC) preservatives, whether alone or in combination with Flora Novus-XL (FNV), averaged 16-17 days of vaselife (Figure 4). Stems

Figure 2. Vaselife comparison between fresh vs. dry storage at Princeton.



that were wet stored 5 days in a Procona container responded with post-storage vaselife of 7-17 days (Figure 4). Floralife (FLF) or Pokon & Chrysal (PKC) preservatives, whether alone or in combination with Flora Novus-XL (FNV), averaged over 14 days of vaselife in addition to the 5 days in storage (Figure 4). A significant interaction did occur between preservative and storage when Floralife was used alone or in combination with FVN. Whether the stems were fresh or wet stored, vaselife was 17 days (Figure 4).

Significance to the Industry

Preservatives Floralife and Pokon & Chrysal approximately doubled the vaselife of *H.a.* 'Annabelle' compared to a water control. Storage shortened the vaselife of stems except in the case of Floralife-treated stems in combination with wet storage. The floral extender, FNV, did not increase vaselife beyond water control or preservative values whether stems were fresh or had been wilted during dry storage.

Figure 3. Vaselife comparison between treatments at Quicksand.

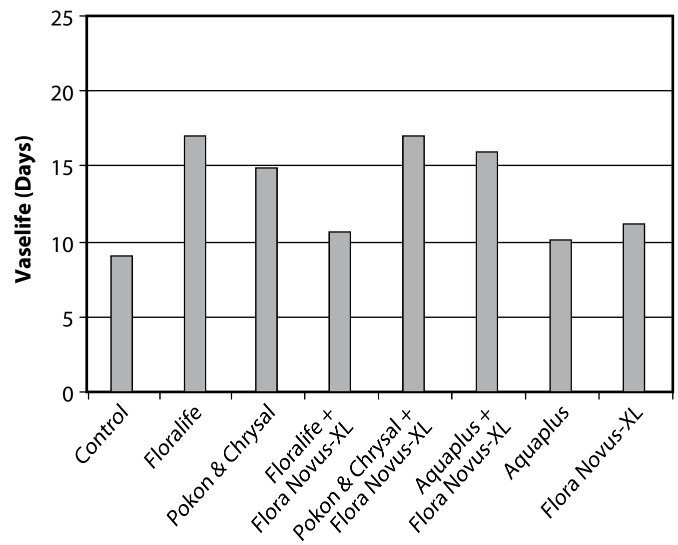
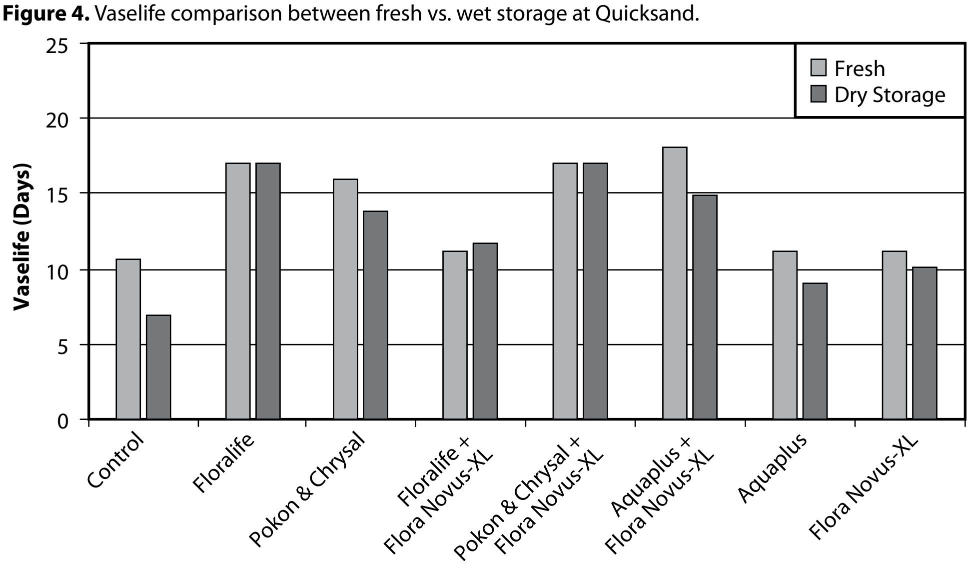


Figure 4. Vaselife comparison between fresh vs. wet storage at Quicksand.



2007 Garden Mum Cultivar Trial

Stephen Berberich, Robert Anderson, and Kirk Ranta, Department of Horticulture

Nature of Work

Garden Mums, *Chrysanthemum* x *morifolium*, are an important summer crop for growers in Kentucky, and they are a good choice for new growers since they are easy to grow and do not require a greenhouse structure. However, growers must select the appropriate cultivars for their market and production system, and choosing among the many available cultivars can be overwhelming. Plant breeders are constantly trying to improve plant characteristics such as plant habit, branch flexibility, foliage durability, and response time, so old cultivars are eliminated and new ones introduced each year.

Since 2004, trials have been conducted at the University of Kentucky Horticulture Research Farm in Lexington to evaluate Garden Mum cultivars. In 2007, four plants of 50 cultivars were planted, as rooted cuttings, on Jun-29. The 10 ft. by 56 ft. beds used in 2007 were the same plots used in previous trials. The soil beds were mulched with hardwood mulch and drip irrigation lines were installed. Each plant was topdressed with 1-tablespoon (15 grams) of Osmocote Plus 15-9-12 controlled release fertilizer (Scotts Company LLC, Marysville, Ohio 43041). The trial beds were sidedressed with ammonium nitrate at a rate of 5 lbs per 1000 ft2 on Jul-27 and with calcium nitrate at the same rate three weeks later. Plants were irrigated as needed throughout the growing season. No pesticides were used to control any insect or disease problems.

Results and Discussion

The 2007 growing season was characterized by above normal temperatures along with below normal rainfall until very late in the season (Table 1). These conditions reinforced the need for consistent and reliable irrigation. If plants are allowed to wilt, and consequently become stressed, shoot development and growth can be adversely affected. It is very important to keep plants actively growing or normal branching will not occur and flower buds may develop prematurely. Moreover, as a consequence of the weather, many cultivars flowered two to three weeks late because of heat delay as higher than normal night temperatures affected flower development.

Table 1. Lexington 2007 growing season monthly weather data.

Month	Avg. Temp. (° F)	Departure from Normal Temp. (° F)	Total Rainfall (inches)	Departure from Normal Rainfall (inches)
June	74	+2	2.47	-1.19
July	75	-1	3.69	+1.39
August	81	+6	3.82	-0.11
September	72	+4	0.88	-2.32
October*	67	+10	5.58	+3.01

* indicates partial month.

Table 2. Cultivar rating for landscape performance in 2007.

	Date Evaluated			
Cultivar	Sep-15	Sep-29	Oct-13	Mean
Cheryl	4.0	5.0	5.0	4.7
Denise	4.0	5.0	5.0	4.7
Flashy Gretchen	4.0	5.0	5.0	4.7
Raquel	4.0	5.0	5.0	4.7
Alberta	4.0	4.5	5.0	4.5
Alexis	3.5	5.0	5.0	4.5
Dark Triumph	4.0	4.5	5.0	4.5
Gentle Alberta	4.0	4.5	5.0	4.5
Natalie	3.5	4.5	5.0	4.3
Beth	4.0	4.0	5.0	4.3
Brandi	4.0	5.0	4.0	4.3
Bright Stephanie	4.0	4.0	5.0	4.3
Erica	4.0	4.0	5.0	4.3
Glenda	3.0	5.0	5.0	4.3
Grace	3.0	5.0	5.0	4.3
Gretchen	4.0	5.0	4.0	4.3
Jenna	4.0	5.0	4.0	4.3
Bold Gretchen	3.5	4.0	5.0	4.2
Bravo	4.0	4.5	4.0	4.2
Delightful Victoria	3.5	4.0	5.0	4.2
Lisa	3.0	4.5	5.0	4.2
Draga	3.5	3.0	5.0	3.8
Pam	3.0	3.5	5.0	3.8
Bethany	4.0	3.0	4.0	3.7
Bold Melissa	3.0	3.0	5.0	3.7
Dazzling Stacy	3.0	4.0	4.0	3.7
Debonair	4.0	3.0	4.0	3.7
Hot Salsa	3.0	4.0	4.0	3.7
Spicy Cheryl	3.0	4.0	4.0	3.7
Cecilia	2.5	4.0	4.0	3.5
Bianca	3.0	4.0	3.0	3.3
Harmony	3.0	3.0	4.0	3.3
Helen	2.0	4.0	4.0	3.3
Okra	3.0	4.0	3.0	3.3
Camille	2.5	3.0	4.0	3.2
Jessica	3.0	4.0	2.0	3.0
Festive Ursula	2.5	3.0	3.0	2.8
Barbara	3.0	3.0	2.0	2.7
Priscilla	2.0	3.0	3.0	2.7
Tabitha	2.0	3.0	3.0	2.7
Blushing Emily	2.0	2.5	3.0	2.5
Carmella	2.5	3.0	2.0	2.5
Brigitte	2.0	2.0	3.0	2.3
Golden Helga	2.0	2.0	3.0	2.3
Nicole	2.0	2.5	2.0	2.2
Fiery Barbara	2.0	2.0	2.0	2.0
Ursula	1.0	3.0	2.0	2.0
Zesty Barbara	1.0	2.0	3.0	2.0
Donna	2.0	1.5	2.0	1.8
Sunny Marilyn	1.5	2.0	2.0	1.8

(1 = poor, 5 = excellent)

As in previous Garden Mum trials, plants were rated on a 1 to 5 scale (1 = poor and 5 = excellent). Three ratings were made during the season (Sep-15, Sep-29, Oct-13) and these ratings were combined to create an average rating for the crop. The ratings were based on the following criteria: branching and growth habit; flower profusion, uniformity, color, longevity; and insect and disease resistance (Table 2).

Significance to Industry

These trials are a means to determine the landscape performance of currently available Garden Mum cultivars under the climatic conditions present in Kentucky and a way to evaluate cultivars that are new in the trade. Since the plants are grown and tested in landscape plots, they can be evaluated from a landscaper's perspective for maintenance and aesthetic quality. This information benefits growers, the landscape industry, and homeowners.

2006 Poinsettia Cultivar and Growth Retardant Evaluation

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

Nature of the Work

Poinsettia is the number one flowering pot plant sold in the United States. It remains a management-intensive crop that requires experience to produce a high-quality product. New cultivars are introduced annually. Thirty cultivars of poinsettia were evaluated with two growth retardant treatments to evaluate the response to plant growth regulating chemicals and the cultivar's relative need for height control treatment. Plants received two foliar applications of Cycocel or a foliar spray with Bonzi in this year's trials.

Thirteen rooted cuttings of each of 30 poinsettia cultivars were received from an Ohio grower and planted August 16, 2006, and pinched August 30. The plants were grown pot-to-pot until September 25, when they were placed at 16-inch centers. Disease and insect management used Banrot and Marathon II applied as a soil drench on October 2. Talstar and Avid were applied in mid-October for additional whitefly control. By November, a total of eight plants had died from root rot damage randomly across all cultivars. The fertilization program started with 20-10-20 and switched to 15.5-0-0 after 6 weeks (Table 1). Plants were hand-watered throughout the season. The fertilizer rate increased from 1.19 to 2.33 mS/cm from 20-10-20 and 15.5-0-0 was applied at 1.25 mS/cm. Municipal water was used for irrigation throughout the crop with average characteristics: pH – 7.6, EC – 0.47 mS/cm and alkalinity – 97 ppm. The night temperature set point was 65˚F until November when night temperatures were lowered to 60˚F. The day temperature set point was 80˚F.

Four plants of each cultivar were the untreated control. Five plants of each cultivar were treated with Cycocel as a foliar spray (1,500 ppm) on September 13 and October 5. Four plants of each cultivar were treated with a Bonzi foliar spray (15 ppm) on September 13th. Plant height was measured at anthesis for each cultivar.

Table 1. Summary of fertilization program and the poinsettia media tests in 2006.

Date	Media Test		Fertilizer Applied		
(2006)	**pH**	**EC ***	**EC ***	**PPM Nitrogen**	**Fertilizer**
8/28	5.9	1.96	1.40	212	20-10-20
9/8	5.7	1.66	1.19	180	20-10-20
9/14	5.6	2.85	1.60	250	20-10-20
9/29	5.4	4.56	1.85	280	20-10-20
10/5	5.6	4.30	2.33	353	20-10-20
10/12	6.5	1.61	2.33	353	20-10-20
10/20	6.5	2.36	1.25	185	15.5-0-0
10/31	6.6	1.93	1.25	185	15.5-0-0
11/6	6.4	2.09	0.40	None	None
11/17	6.4	1.72	0.35	None	None

*** -** mS/cm

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

Poinsettia Cultivar	Flowering Date *(2006)*	Avg. Height, Non-treated Control Plants *(in.)*	Avg. % Height Reduction from PGR Treatments
Amazing Pink	11/14	13.4	– 8.9
Arctic White	11/22	12.9	– 8.5
Avant Garde	11/22	13.4	– 6.7
Christmas Feelings	11/17	13.4	– 5.2
Christmas Feelings Jingle	11/17	13.0	– 10.8
Christmas Feelings Pink	11/22	13.5	– 8.9
Christmas Carol	11/13	13.0	– 7.6
Christmas Star	11/17	13.6	– 9.6
Christmas Star Bright Red	11/22	13.0	– 6.9
Christmas Star Burgundy	11/22	13.0	– 7.6
Christmas Time	11/13	13.8	– 7.8
Cinnamon Candy	11/17	12.0	– 0.1
Coco White 2000	11/17	13.4	– 11.2
Crème Caramel	11/14	14.9	– 13.4
Euroglory	11/17	14.8	– 14.2
Infinity Red	11/17	13.3	– 1.5
Malibu Red	11/17	11.6	– 3.4
Merlot	11/22	13.8	– 3.6
Merry Christmas	11/14	13.1	– 9.1
Premium Apricot	11/13	11.9	– 0.1
Premium Lipstick Pink	11/14	10.4	– 4.8
Premium Marble	11/14	10.4	+ 0.1
Premium Miro	11/14	11.4	– 7.9
Premium Picasso	11/13	11.5	– 0.1
Premium Red	11/14	11.1	– 2.7
Premium White	11/17	11.0	– 2.7
Santa Claus White	11/14	13.6	– 4.4
Silent Night	11/17	11.9	– 3.4
Silent Night Crimson Red	11/17	12.6	– 4.8
Twister Red	11/22	16.0	– 12.5

When the production trials were completed, poinsettia plants were taken to the UK Arboretum for a cultivar display. Random arboretum visitors (25) were asked to complete a survey that rated the cultivars on their perception of a high-quality poinsettia that they would purchase in a store.

Results and Discussion

The fertilizer program for the poinsettias generally met commercial standards for growing media pH and electrical conductivity throughout the crop production period (Table 1). Plants appeared normal throughout the study.

Poinsettia cultivars are different, but new cultivars were more uniform and generally shorter than older cultivars. The Premium series had the shortest cultivars across all colors, and heights were quite uniform (Table 2). The Premium series did not need growth retardant treatment and should be started early so plants will be large enough to meet commercial standards. The tallest cultivars were 'Crème Caramel,' 'Euroglory,' and 'Twister Red.' The cultivars that showed the most response to foliar sprays of Cycocel and Bonzi were 'Coco White,' 'Euroglory,' 'Crème Caramel,' and 'Twister Red.'

The plant growth regulator treatments did not have the same effect on the poinsettia cultivars (Table 3). Plants treated with Cycocel were the shortest on average. The single application of Bonzi at 15 ppm had a lesser effect but still reduced the plant height.

The subjective ratings of UK Arboretum visitors were similar to ratings by the authors (Table 4) for the general appearance of cultivars in the 2006 study.

Table 3. The treatment effects on finished poinsettia plant height (all cultivars).

Treatment	Avg. Height *(in.)*
Cycocel foliar spray	11.8
Bonzi foliar spray	12.2
Control	12.8

Table 4. Visual ratings completed by 25 visitors to the UK Arboretum, December 4-15, 2006.

Poinsettia Cultivar	Arboretum Visitor Rating[1]	Poinsettia Cultivar	Arboretum Visitor Rating[1]
Excellent		**Good**	
Infinity Red	4.50	Coco White 2000	3.35
Christmas Star	4.32	Premium White	3.35
Merlot	4.28	Santa Claus White	3.30
Arctic White	4.14	Premium Lipstick Pink	3.24
Merry Christmas	4.00	Christmas Feelings	3.11
Avant Garde	3.96	Christmas Feelings Jingle	3.04
Christmas Star Burgundy	3.94	Premium Apricot	2.95
Very Good		**Acceptable**	
Malibu Red	3.85	Amazing Pink	2.68
Premium Red	3.81	Crème Caramel	2.67
Silent Night Crimson Red	3.71	Christmas Time	2.62
Christmas Star Bright Red	3.68	Twister Red	2.48
Euroglory	3.68		
Silent Night	3.68		
Premium Miro	3.65		
Christmas Carol	3.65		
Premium Picasso	3.64		
Cinnamon Candy	3.55		
Christmas Feelings Pink	3.45		
Premium Marble	3.40		

[1] Poor = 1, Acceptable = 2, Good = 3, Very Good = 4, Excellent = 5

Significance to the Industry

Poinsettia continues to be a major crop in Kentucky. The use of plant growth regulators is vital for the production of quality plants. A grower should consider several factors in the planning stages for the fall crop. The first is the genetics of the variety and whether there is a need for a growth retardant treatment. The Premium varieties showed that they grow less than other cultivars and don't require growth retardant treatments. Second, a grower should consider what chemical treatment should be used and at what rate. The grower that wants only slight control could use the Bonzi spray of 15ppm. The grower that needs more control should use the Cycocel treatment, especially for the vigorous cultivars such as 'Twister Red,' 'Euroglory,' 'Coco White,' and 'Crème Caramel.' This evaluation will provide information to help growers consider the growth characteristics of these thirty cultivars and the possible effects of different PGR treatments on them.

2007 Garden Flower Trials: Results of Annual Flower Evaluations by Kentucky Master Gardeners

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

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

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

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

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

Photos and details about plant performance are continually added to the Kentucky Garden Flowers web site: http://www.uky.edu/Ag/Horticulture/gardenflowers, or simply go to the UK home page (www.uky.edu) and search for a plant name and you will be directed to the Kentucky Garden Flowers location. Average ratings of the 2007 trials are summarized in Table 1.

Table 1. The average visual rating of selected annual flowers grown at nine locations in Kentucky.

Common Name	Cultivar	Scientific Name	Average Rating
Globe Amaranth	QIS Mix	*Gomphrena globosa*	4.8
Narrow Leaf Zinnia	Persian Carpet	*Zinnia haageana*	4.7
Blood Flower	Red Butterfly	*Asclepias curassivica*	4.3
Common Zinnia	Pinwheel Mix	*Zinnia elegans*	4.3
African Marigold	Sunset Giants	*Tagetes erecta*	4.2
Texas Sage	Lady in Red	*Salvia coccinea*	4.1
Mexican Sunflower	Sundance	*Tithonia rotundifolia*	4.1
Blanket Flower	Sundance Bicolor	*Gaillardia x grandiflora*	4.0
Starflower		*Scabiosa stellata*	3.5
Chinese Spinach	Summer Poinsettia	*Amaranthus tricolor*	3.4
Sunflower	Lemonade Mix	*Helianthus annuus*	3.2
Mallow	Beauty Mix	*Lavatera trimestris*	3.3
Sunflower	Bashful	*Helianthus annuus*	3.1
Petunia	Wild Rose	*Petunia x hybrida*	2.9
Sweet Marigold	Anisata	*Tagetes lucida*	2.7

Kentucky Rain Garden Plant Selections: First Year Field Observations

Jim Lempke, UK Arboretum

Urban storm water runoff has become a major issue in Kentucky and across the United States. Flooding, erosion, and movement of pollutants during rain events have all been shown to place serious environmental and economic burdens on local communities. Recently, the "rain water garden" concept has become a common topic in many horticultural magazines and professional journals. In significant numbers, well designed wetland gardens have been shown to offer significant relief for urban storm water runoff. From individual homeowners to city engineers, Americans are looking at these strategies to slow down, filter, and infiltrate rain water runoff, while creating aesthetically pleasing spaces.

As interest and demand increases, designers and consumers will need access to accurate information about plant performance under alternating flooding and drying conditions. Successful implementation will depend on an understanding of local soils, local plant "communities" and local natural processes.

In 2006, the UK Arboretum (The State Botanical Garden of Kentucky), the Lexington-Fayette Urban County Government, and a private design firm, Parsons-Brinkerhoff, joined into a partnership to solve a longstanding flooding problem in a Lexington neighborhood. The design process that ensued became an example of cooperation among several stakeholders resulting in the construction of a 5-acre wetland exhibit in 2007. This paper outlines the initial efforts to vegetate a man-made, artificial wetland.

Plant Selection Guidelines

A major component of the plan included the use of native Kentucky wetland plant species that fit the following criteria: plants were selected to provide a diversity of structure (roots and foliage), species were selected that are listed as common or abundant in Kentucky (1), and species that would be "easy to grow" were chosen. Careful study of local ecosystem patterns, compatibility with engineering specifications, and aesthetic appeal were also considerations that helped guide plant selection.

Seed was collected for all herbaceous plants in the fall and winter of 2006 and submitted to cold-moist stratification for approximately 90 days. Plants were grown by Dropseed Nursery, Louisville, Kentucky, in deep-well flats to allow for development of large root system. Six-thousand plugs were transplanted into the field during the months of April, May, and June. Planting was made difficult by compacted soil left behind by heavy equipment traffic. After installation, plant care was further complicated by a severe summer drought, which necessitated water rationing. In spite of the difficult growing conditions, all herbaceous species planted had a 90% or greater survival rate.

Wetland Category Descriptions

Wetland plants were categorized using the system described by Reed (2) and used by Jones in *The Plant Life of Kentucky* (1). The wetness ratings help ecologists determine whether a plant has an affinity for growing in wet soils.

Zones were created (based on relative elevation) within the wetland basin to match plants to moisture requirements.

- OBL= Obligate wetland (the plant species is almost always found in wetlands)
- FACW=Facultative wetland (usually in wetlands but sometimes in non-wetland habitats)
- FAC=Facultative (just as likely to occur in wetlands as in non-wetland habitats)
- FACU=Facultative Upland (usually in non-wetlands but sometimes in wetlands)
- UPL= Upland (nearly always in non-wetland habitats, hardly ever in wetlands)

Table 1. Grass and sedge species.

Wetland Category	Common Name	Scientific Name	Rating[1]
FAC	Bottlebrush grass	*Hystrix patula*	v, f, s
FACU	River oats	*Chasmantheum latifolium*	v
FACU	Greasy grass	*Tridens flavus*	v
FACW	Straw-colored sedge	*Cyperus strigosus*	v
FACW	Stream bank Wild rye	*Elymus riparius*	v
FACW	Eastern gamagrass	*Tripsacum dactyloides*	v
FACW	Giant cane	*Arundinarea gigantea*	v
FACW+	Plume-grass	*Saccharum giganteum*	v
FAU-	Silky wild rye	*Elymus villosus*	v
OBL	Fox sedge	*Carex vulpinoidea*	v
FACW+	Soft rush	*Juncus effusus*	v

[1] v = plants achieved vigorous vegetative growth; f = plants flowered during growing season; s = plants ripened seed

Table 2. Wildflower species.

Wetland Category	Common Name	Scientific Name	Rating[1]
FAC	Blue mistflower	*Conoclinum coelestinum*	v, f, s
FAC	Foxglove beardtongue	*Penstemon digitalis*	v
FAC	Yellow wingstem	*Verbesina alternifolia*	v, f, s
FAC	Illinois bundleflower	*Desmanthus illinoensis*	v
FAC	Ironweed	*Vernonia gigantea*	v, f, s
FAC+	Dense blazing star	*Liatris spicata*	v
FACW	Joe-pye weed	*Eupatorium fistulosum*	v, f, s
FACW	Slender mountain mint	*Pycnanthemum tenuifolium*	v
FACW+	Sneezeweed	*Helenium autumnale*	v, f, s
FACW+	Blue vervain	*Verbena hastata*	v, f, s
FACW+	Rattlebox	*Ludwigia alternifolia*	v, f, s
FACW+	Cardinal flower	*Lobelia cardinalis*	v, f
FACW+	Great blue lobelia	*Lobelia siphilitica*	v, f
OBL	Swamp milkweed	*Asclepias incarnata*	v, f, s
OBL	Nodding bur marigold	*Bidens cernua*	v, f, s
OBL	Water horehound	*Lycopus americanus*	v, f, s
OBL	Wild hibiscus	*Hibiscus militaris*	v, f, s

[1] v = plants achieved vigorous vegetative growth; f = plants flowered during growing season; s = plants ripened seed

Table 3. Woody plant species.

Wetland Category	Common Name	Scientific Name	Rating[1]
OBL	Bald cypress	*Taxodium distichum*	v
OBL	Swamp-privet	*Forestiera acuminata*	v
OBL	Water locust	*Gleditsia aquatica*	v
OBL	Buttonbush	Cephalanthus occidentalis	v, f, s
FACW+	Black willow	Salix nigra	v
OBL	Water elm	Planera aquatica	v
FAC	Black gum	Nyssa sylvatica	v
FACW	Silky dogwood	Cornus ammomum	v
FACW	False Indigo bush	Amorpha fruiticosa	v

[1] v = plants achieved vigorous vegetative growth; f = plants flowered during growing season; s = plants ripened seed

Performance Ratings

Tables 1 and 2 list herbaceous species planted in the first year of the Arboretum Wetland Project, corresponding wetland category descriptions and performance ratings. (Key to ratings: v=plants achieved vigorous vegetative growth; f=plants flowered during growing season; s=plants ripened seed)

Table 3 lists woody plant species that were planted from nursery stock purchased at Kentucky nurseries or dug from Arboretum collections.

Additional species will be added and monitored during the second growing season of the Arboretum Wetland Project (2008).

Significance to the Industry

As new technology develops requiring the use of native plant species in design solutions, research on plant performance will become essential to the success of storm water projects and wetland restoration in Kentucky. Effective species recommendations, including functional, ecological and aesthetic considerations are not currently available to address local needs. Continued monitoring of projects currently under construction and improved communication by professionals could be a valuable resource for Kentucky land owners.

Literature Cited

1. Jones, R.L. 2005. Plant Life of Kentucky: An Illustrated Guide to the Vascular Flora. The University Press of Kentucky.
2. Reed, P.B. 1988. National list of plant species that occur in wetlands: Kentucky. National Wetlands Inventory, U.S. Fish and Wildlife Service, St. Petersburg, Fla.

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

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

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

A family of four endowments has been established to support the UK Nursery/Landscape program. Three of these are named endowments. This year, income from this family of endowments provided over $12,000 to support research for our industry. Results from many of the research projects in this report were partially supported by these funds.

Named endowments include:

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

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

We also met our goal of securing $50,000 in donations to match $50,000 in state funds to endow the Robert E. McNiel Horticulture Enrichment Fund. THANK YOU! This endowment honors Dr. McNiel and provides support for faculty and student travel on our study tours and for national student competitions.

Those individuals and companies contributing to the UK Landscape Fund in 2007 (through November 1) are listed in this report. Your support is appreciated and is an excellent investment in the future of the Kentucky nursery and landscape industries.

Contributions to support the UK Nursery/Landscape Program may be made to the annual gift account for immediate expenditure in the program or may be made to any one of the currently established endowments. For more information on how to contribute to an endowment or the annual giving program, please contact Dewayne Ingram at 859-257-1758 or the UK College of Agriculture Development Office at 859-257-7200.

UK Nursery and Landscape Fund and Endowment Fellows

Gregory L. Ammon
Ammon Wholesale Nursery
Patrick A. and Janet S. Dwyer
Dwyer Landscaping Inc.
Robert C. and Charlotte R. Korfhage
Korfhage Landscape and Designs
L. John and Vivian L. Korfhage
Korfhage Landscape and Designs
Herman R.* and Mary B.* Wallitsch
Wallitsch Nursery
Daniel S.* and Saundra G. Gardiner
Boone Gardiner Garden Center
Bob and Tee Ray
Bob Ray Company
Stephen and Chris Hillenmeyer
Hillenmeyer Nurseries
Larry and Carolyn Sanders
James Sanders Nursery Inc.
Robert* and Janice Corum
National Nursery Products
Herman, Jr., and Deborah Wallitsch
Wallitsch Nursery
Richard and Shirley Ammon
Ammon Landscape Inc.

**deceased*

2007 Contributors to the UK Nursery/Landscape Fund and Endowments

(through November 1)

Associates ($500 or more)

Design Six Landscape
Winston Dunwell
Pat Dwyer, Dwyer Landscaping Inc.
Bill Henkel, Henkel-Denmark, Inc.

100 Club ($100 or more)

Allen W. Bush
Dan R. Ezell
Lexington Lawn and Landscape, LLC
Melvin, Ernie and Mason Moffett, Snow Hill Nursery, Inc.
Sea's Lawn & Landscape

Donor (less than $100)

Dewayne and Pat Ingram
Katie Clark, Shooting Star Nursery

Industry Organizations

Kentuckiana Greenhouse Association
Kentucky Landscape Industries Trade Show
Kentucky Nursery and Landscape Association

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

A. McGill and Son Nursery, Hubbard, Ore.
Ammon Wholesale Nursery, Burlington
BioWorks®, Inc. Victor, N.Y.
Carlton Plants LLC, Dayton, Ore.
David Leonard, Consulting Arborist, Lexington
Dendrological Sales, Four Oaks, N.C.
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Harrell's Fertilizer Inc., Lakeland, Fla.
Hillcrest Nursery, Richmond
J. Frank Schmidt Nursery, Boring, Ore.
Kit Shaughnessy, Kit Shaughnessy Inc., Louisville
Larry Hanks, Consulting Arborist, Lexington
Oaks Pavers, Cincinnati, Ohio
Rainbow Treecare Scientific Advancements, Minneapolis, Minn.
Red Barn Greenhouses, Nicholasville
Rennerwood, Inc., Tennessee Colony, Tex.
Snow Hill Nursery, Shelbyville
Sungro Horticulture, Bellevue, Wash.
Sunny Ray's Nursery, LLC, Crestwood
The Scotts Company, Marysville, Ohio
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Waterford Valley Nursery, Taylorsville
Wilson's Nursery, Pleasureville

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Kentucky Agricultural Development Board
Kentucky Nursery and Landscape Association
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Urban and Community Forestry Program, Kentucky Division of Forestry
UK Integrated Pest Management Program
UK New Crop Opportunities Center
UK Nursery/Landscape Fund
USDA Animal and Plant Health Inspection Service
USDA Cooperative Agricultural Pest Survey
USDA Forest Service
USDA-IR4