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College of Agriculture, Food and Environment
Agricultural Experiment Station

PR-741

Nursery and Landscape Program
2012 Research Report

UK Nursery and Landscape Program

Edited by Winston Dunwell

Faculty, Staff, and Student Cooperators

About the Cover

Magnolia xloebneri 'Merrill' is a 2013 Theodore Klein Plant Award Winner. Merrill Magnolia's fragrant white flowers are seen in early spring. *Magnolia xloebneri* is a deciduous small tree that is frequently grown as a large shrub. It resulted from a cross of *M. kobus,* Kobus Magnolia and *M. stellata,* Star Magnolia, which Michael Dirr says in the Manual of Woody Landscape Plants "The hybrids are among the most beautiful of all magnolias—". Merrill Magnolia is the best of those hybrids. It is hardy over a broad range—seeming from Georgia to Canada, maintains a height of between 20 and 30 feet, has such a profusion of blooms that it appears as a mountain of white, grows to mature size quickly (a benefit to the nursery industry), has attractive medium green foliage, roots easily from softwood to semi-hardwood cuttings taken in early to late summer. It has (not always) typical somewhat showy magnolia red fruit hanging from the follicles by threads in the fall. The cultivar is named for Elmer Drew Merrell, eminent scientist, Director of The New York Botanical Garden,1929 to 1935, and Director of the Arnold Arboretum, 1935-1946.

Nursery and Landscape Program

Contents

Determining the Carbon Footprint of Tree Production Systems Using Life Cycle Assessment

Dewayne L. Ingram, Horticulture Department

Nature of Work

Terms such as “sustainability”, “green” and “reduced carbon footprint” are being used in conversations and product promotions. Consumers have increasingly higher expectations for products and services that are more sustainable in terms of natural resources and global warming potential (GWP), as well as the health and safety of producers and consumers. The green industry, especially the production and use of trees, would be expected to have long-term positive environmental impact. However, research to understand how system components of the production and use of landscape plants contribute to environmental impacts such as GWP is lacking.

`Tree production, like the production of any product, requires the investment of energy that results in the release of greenhouse gases into the atmosphere. Greenhouse gases (GHG), primarily carbon dioxide, nitrous oxide and methane, are increasing in the atmosphere and human activity is contributing to that, primarily through the consumption of fossil fuels (2,5). These GHGs each have a different potential impact on global warming but are expressed in relation to the GWP of carbon dioxide, or CO_2-equivalents (CO_2e). GWP, or stated another way, the carbon footprint of a product, is expressed as the kilograms of carbon dioxide-equivalent emissions resulting from the production, distribution and use of that product.

Life cycle assessment (LCA) is a tool used to quantify the environmental impact of products or services. LCA is a systematic process accounting for environmental impacts of interrelated input components and processes of a product or practice during its complete life cycle, cradle-to-grave (1).

A research project has been initiated to use LCA to study the impact of production components on the carbon footprint of field-grown trees and their subsequent life in the landscape. Interviews with nursery managers in the region have been used to define specific production system protocols for two field-grown, spade-dug trees; a 2-inch caliper, red maple (*Acer rubrum*) and a 6 to 7-ft tall, 2-inch caliper Colorado blue spruce (*Picea pungens*).

The production model for the red maple consisted of rooting cuttings in ground beds for one year and transplanted them to the field for one year before being transported to a field nursery where the tree would be grown in the field for four years. The model production system for the blue spruce involved production of a 2+2 liner from seed in a nursery in the Upper Midwest that was then shipped to Kentucky for a five-year production cycle in a field nursery. Every product used in production, such as fertilizer, chemical, plastic, etc., as well as the use of specific equipment for given times, were inventoried for each of these two production systems. The footprint of each input product and the fuel and lubricants used by the equipment was determined according to international guidelines (2,5) and a variety of published databases.

It was assumed that the finished trees would be transported 250 miles to a landscaper who would transplant it into a suburban site suitable for its growth. The red maple was assumed to live for 60 years and the blue spruce for 50 years before being cut down, chipped and used as mulch.

Unlike most products, plants take CO_2 from the atmosphere and sequester carbon to varying degrees in wood. Trees sequester more carbon than shrubs and large trees sequester more carbon than small trees. Therefore, the weighted impact of carbon sequestered during the production and useful life was determined for each species using growth models in the U.S. Forest Service’s Center for Urban Forestry Research; CUFR Tree Carbon Calculator (7). Carbon emissions from tree take-down and disposal activities, as determined from interviews with arborists, were also inventoried. More details of the life cycle model for these two trees and specifications of component GHG emissions are available in articles published in science journals (3,4).

Results and Discussion

The cutting-to-landscape carbon footprint of a 2-inch caliper, field-grown, spade-dug, red maple was calculated to be 8.2 kg CO_2e (3). The seed-to-landscape of the Colorado blue spruce from the other study was estimated to be 13.5 kg CO_2e (4). The primary difference in the carbon footprints between these two studies were due to a more inclusive measure of the GWP of fuel in the spruce study. Kendall and McPherson (6) reported that 4.6 and 15.3 kg CO_2e were emitted in the production and distribution of trees grown in #5 and #9 containers, respectively, at Monrovia Nursery in California.

In both production systems, equipment use had the greatest impact on the products’ carbon footprint. For the red maple, fuel and electricity consumption from cutting-to-landscape accounted for 86% of GHG emissions during production. Over 56% of GHG emissions from material and equipment use in production resulted from material and equipment use in harvesting (Figure 1.) The carbon footprint of the tree from pesticides applied during production was only 7% of associated GHG emissions from all input materials and input materials accounted for less than 14% of the tree carbon footprint. The weighted positive impact of carbon sequestration during the red maple’s 60-year useful life was 901 kg CO_2. After deducting the GHG emissions from take-down and disposal, the net positive impact of the red maple was estimated to be 800 kg CO_2e.

For the blue spruce, 76% of the carbon footprint during production was in harvesting. The weighted positive impact of carbon sequestered during the useful life was 593 kg CO_2 and take-down and disposal emitted 148 kg CO_2e, resulting in a net positive, life-cycle impact of 431 kg CO_2e. It should be noted that the information published here does not consider the indirect impact of reducing energy use in buildings from shading or evaporative cooling of a strategically placed tree.

The ability to query the model to assess potential impacts of modifying specific practices is an important feature of LCA. For example, if the assumed cull rate of the finished red maple tree was increased from 5% to 10%, the carbon footprint for each marketable tree would be 6% greater. Reducing the transport distance of the finished red maple by 25% would decrease the cutting-to-landscape carbon footprint by 16%. If the production time for the blue spruce was increased from five to six years, the carbon footprint of the spruce would only increase 0.412 kg CO_2e, or 3% of the seed-to-landscape carbon footprint.

LCA has proven to be an effective tool to the carbon footprint of tree production system components and to estimate the life-cycle impact of trees on the environment. Such information should prove useful to nursery managers and the consuming public as they make production system and purchasing decisions. Additional work is needed to link the input costs and market consequences to the carbon footprint of production components.

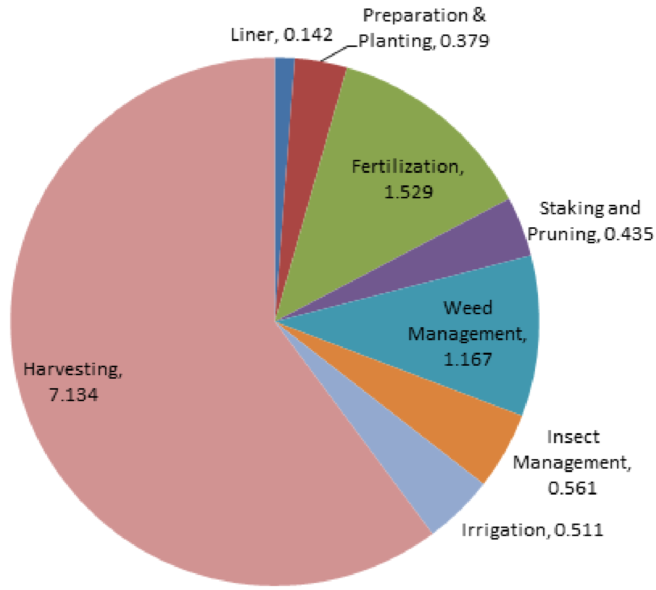

Figure 1. The impact of specific system components (materials plus equipment use) on the carbon footprint (kilogram of CO2e) of a 2-inch caliper red maple tree during the field production phase to the farm gate. [Copied from a previous publication: Ingram (3)]

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Substrate Heat Buildup and Evaporation Rate Differs between Plastic and Alternative One Gallon Nursery Containers

Susmitha Nambuthiri and Robert Geneve, Horticulture Department

Significance to the Industry

Supra optimal root zone temperature of container-grown plants limits plant growth and quality. High substrate temperature can cause water stress, reduce photosynthesis, and increase respiration resulting in impaired plant growth and development. Reducing absorption of solar radiation and increasing heat exchange in the production container can reduce supra optimal substrate temperature. The current study discusses the impact of container type on substrate temperature and drying rate. The results demonstrate that the fiber nursery containers showed reduced substrate heat buildup and had a higher evaporation rate compared to black plastic containers.

Nature of Work

The importance of keeping substrate temperature below 100°F (37.8°C) to avoid root injury is well documented (1). However, during warmer months in the south eastern states it is common for the substrate temperature in black walled plastic containers to exceed 107.5°F (42°C) for several hours (1). Although container color has a greater impact overall, porous containers (clay, paper, peat, etc.) showed a slower rise in root zone temperature than non-porous (plastic, glass, paraffin protected, etc.) containers due to high latent heat of vaporization of water (2,3). One way to deal with heat stress is to use alternative containers such as those with porous container walls to improve heat exchange between the substrate and environment. In addition, increased substrate evaporative cooling can occur in containers made from alternative materials compared to solid, polyethylene containers (4). The objective of this study was to evaluate the heat buildup and dry down rate of substrate in different alternative and plastic containers. The study was conducted at the University of Kentucky. Four types of one gallon nursery containers were evaluated. They included a conventional black plastic container (C400, Nursery Supplies® Inc.); a white plastic container (Proven Winners, LLC); and two pulp-based biocontainers: Kord® Fiber Grow (FNP 0707, ITML Horticultural Products) and 7X7RD (Western Pulp Products Co.). The containers were filled with equal quantities of an 85% pine park: 15% peat (vol/vol) substrate. The substrate was wetted to saturation and allowed to drain prior to filling each container. The containers were permitted to equilibrate to room temperature for 30 minutes prior to initiating the experiments.

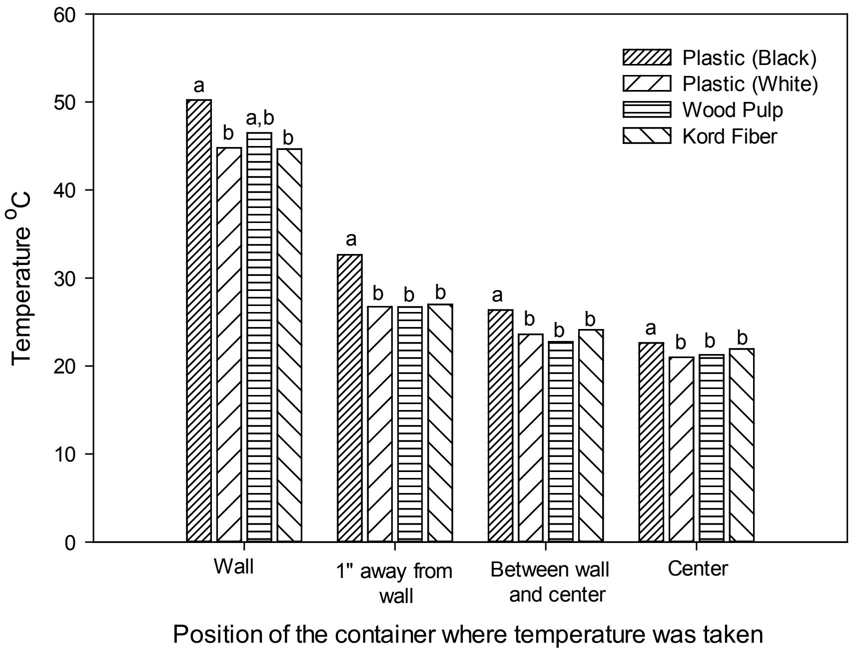

Figure 1. Mean temperature build up on different parts of one gallon containers and their substrate after exposure to 200 WŸm-2 flux density for 90 minutes. Pairs of means with the same letter are not significantly different from each other (Holm-Sidak method, P>0.05).

Heat transfer from the side wall to the substrate

The experiment was conducted under standard laboratory conditions with an ambient air temperature of 68°F (20°C) with five replicates per container type. Two incandescent (100 watts each) bulbs, about one inch apart from each other in a tandem fixture were placed 6 inches (15.2 cm) away from the container sidewall to provide heating for 90 minutes. After 90 minutes, radiation flux density reflecting off the container wall was measured using a pyranometer (LI-200, LI-COR® Biosciences, Lincoln, NE) connected to a LICOR-1400 data logger. After turning the light off, the temperature of the container wall was measured using an InfraRed thermometer (Extech Instruments, Nashua, NH) aimed approximately 3 inches (7.4 cm) away from the wall. The wall temperature was measured at 2, 6 and 8 inches (5, 15.2 and 20 cm respectively) below the container rim. Temperature at one inch (2.54 cm) depth of the substrate was measured using a digital thermometer (Fisher scientific) at one inch (2.54 cm) away from the container wall, half the distance between the container wall and at the center of the container (about 3.5 inches away from the container wall).

Moisture evaporation from the container under a controlled environment

The experiment was conducted in a controlled environment chamber with temperature and humidity control (Parameter Generation and Control, Black Mountain, N.C.). A temperature of 89.6°F (32°C) and 45% relative humidity was maintained to provide a vapor pressure deficit (VPDair) of 2.6 k Pa inside the chamber. Weight measurements of the containers were taken hourly for eight hours until there was no significant weight change. There were five replicates for each nursery type container.

Results and Discussion

Flux density reflected from container wall was 19.3, 171.0, 95.9 and 117.5 for the black, white, wood pulp, and Kord containers, respectively. The temperature of the side wall in the black plastic container heated to above 122°F (50°C) after 90 minutes. The substrate temperature (20°C at the start of the experiment), showed a 10.8°F (6°C) increase in black plastic containers compared to the white and fiber containers at one inch away from container side wall and a 5.9°F (3.3°C) increase 2 inches (5.1 cm) from the side wall (Figure 1).

The substrate drying rate under controlled environment showed an increased rate in the fiber containers compared to plastic containers. The moisture loss after 8 hours was 8.6, 8.8, 13.4, and 10.8% for the black, white, wood pulp, and Kord containers, respectively.

It was evident from the study that the heat buildup in a conventional black plastic container is significantly greater than fiber containers and that this was partially related to the ability to absorb or reflect short wave radiation. Therefore, fiber containers could improve plant production and quality by reducing the substrate temperature (4). The increased evaporation from fiber containers could result in increased water demand for plants grown in these containers compared to plastic containers. Future research will study the impact of temperature on water use in the field-grown plants in the plastic versus alternative containers.

Acknowledgements

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Sustainable Ground Cover Production for More Sustainable Kentucky Landscapes

Susmitha S. Nambuthiri and Dewayne L. Ingram, Horticulture Department

Nature of Work

The demand for ground cover plants in residential and commercial Kentucky landscapes is increasing due to their aesthetic appeal, enhanced environmental impact by reducing storm water runoff velocity, controlling weeds of landscapes and low-maintenance requirements. Current production protocols require that these plants be priced relatively high due to production time requirements in a protected environment. The increasing variety of plant materials suitable for use in mass as ground covers is providing more opportunities for consumers and landscape designers. However, traditional woody-ornamental production systems are often inefficient and costly for these small plants. The cost of the large number of plants required to cover an area is often a limiting factor considering most landscape installation budgets. Also, many consumers view the production of ground covers in individual plastic containers as an unsustainable practice. Conversations with landscapers reveal their need for "just-in-time" availability of perennial groundcover plants locally. Landscapers are also seeking increased labor efficiency in establishing ground cover beds.

Bio-degradable and plantable containers made from paper, straw, compost, wood fibers, peat, coir fiber, rice hulls and bioplastics that commonly range in size from 2-inch to 6-inch in diameter are becoming available in sizes appropriate for ground cover production. Use of ecofriendly containers for producing ground cover plants could make the businesses more "green" and enhance customer acceptance. A sustainable production system must be designed with a high rate of product turn-over per square foot in a low-input, semi-controlled environment. A range of plant materials must be producible in this system to meet identified market requirements.

The study was conducted in 2012 at the UK Horticulture Research Farm in Lexington, KY. The objective was to evaluate selected ground cover plant performance in plantable containers during production and after transplanting into the landscape. *Ajuga reptans* 'Bronze Beauty,' *Lamiastrum galeobdolon* 'Herman's Pride,' *Sedum telephium* 'Vera Jameson' and *Lamium maculatum* 'Beacon Silver' plugs from 72-count flats (approx. 1.5-inch diameter cells) were supplied by Emerald Coast Growers in Pensacola, FL through McHutchison Inc.. Plants were transplanted into one of four test containers on a 6 to 8-week interval from March 2012 to September 2012. Containers tested include standard 3-inch round plastic containers in 10-count flats, 3.5-inch (90mm) Ellepot® in 10-count flats, 3.25-inch (80mm) SoilWrap^{TM} in 12-count flats, and 3-inch Jiffy peat pots in 10-count flats. Each species was transplanted to three flats of each container tested. The plant and container treatment combinations were factorially arranged in a randomized complete block design in order to assess productivity at various transplanting dates. Plants were fertigated once with 200 ppm N from Peters Excel 21-5-20 and top dressed with 3.5 g of Osmocote Plus 15-9-12. Plants were moved to a 24 ft x 50 ft non-heated, naturally-ventilated, quonset-style shade house (50% shade) with a single-layer clear plastic cover. Beginning in April, the end doors were opened during mid-day and in May the plastic from the lower 3 ft of sidewalls were removed and end doors were left open. Data taken included plant size (Growth Index = average width in two directions x height) and quality, ease of landscape establishment and weeks to a finished product for each species.

On July 5, 2012, *Ajuga* and *Lamiastrum* cultivars that had been grown for 6 weeks in the quonset house were transplanted into a cleaned and tilled field plot. Plants grown in Ellepot®, SoilWrap^{TM} and peat containers were planted in a prepared field plot along with plantable container on 1-ft centers in a triangular arrangement in two blocks per species. The containers were removed from plants grown in standard plastic containers before planting. The time required for transplanting a whole flat for each pot type was recorded to assess the transplanting time requirements for each container type. The plots were mulched with pine bark and watered by hand as needed. Plant growth and ground coverage were analyzed using SigmaScan Pro 5.0 image analysis software (SPSS Science, Chicago) from digital images taken monthly from the same height and using a fixed focal length (1). SigmaScan Pro 5.0 in the Trace Mode was used to analyze images to measure individual plant growth and ground coverage over time. Accuracy of the method was assessed each time using the known area of a frame that was used to border each plot. Final images were taken on September 2012, as later it became difficult to measure individual plant growth because of high overlapping plant canopies. Three plants were dug from each plot on November 7, 2012 and above-ground shoots and roots extending from the original container into the field soil were harvested, washed and oven dried before being weighed. The monthly average maximum air temperature reported by Kentucky Mesonet ranged from 90°F in July to 53°F in September and monthly average minimum temperature ranged from 70°F in July to 43°F in November. The plants accumulated 2100 growing degree days or heat units during their 4 months growth in landscape.

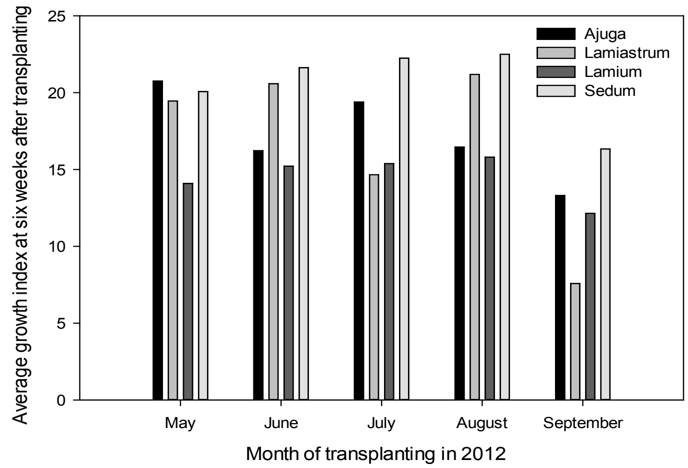

Figure 1. Average growth index of *Ajuga reptans* 'Bronze Beauty', *Lamiastrum galeobdolon* 'Herman's Pride', *Lamium maculatum* 'Beacon Silver' and *Sedum telephium* 'Vera Jameson' measured at 6 weeks after transplanting to 3" to 3.5" (80 mm to 90 mm) plantable or standard plastic containers.

Results and Discussion

The *Sedum* cultivar was ready for transplanting earlier than the other three species in all transplanting dates considering its largest growth index (average of width in two directions and height) recorded at 6 weeks after transplanting into the test containers (Figure 1). The container type did not significantly impact growth index of any species. The growth index of all species was statistically similar to each other in each month of transplanting. *Sedum* produced growth index averaging 22 for all transplant dates except September and *Lamiatrum* followed the same trend of large growth and produced an average growth index of 19. *Ajuga* showed larger growth index in plants transplanted in May (21) and July (19), than in June, August and September transplants. *Lamium* produced largest growth (19) from June to August and lowest growth index was observed in September transplants. All species transplanted in September produced significantly lowest growth index compared to the other transplanting dates; *Ajuga* (13) Lamiastrum (8), *Lamium* (12) and *Sedum* (16). The decreased air temperature, growing degree days and day length could have contributed to the decreased plant growth.

Using the monthly image analysis of the *Ajuga* and *Lamiastrum* transplanted to field plots, it was observed that *Ajuga* grew at a faster rate and the *Lamiastrum* appeared to cover the area more slowly. In a two-month field growth period, the *Ajuga* plants grown in standard plastic pots, Ellepot® and SoilWrap™ produced almost 3 times more ground coverage than the plants grown in peat pots.

The percentage of ground coverage of Ajuga plants over the initial plant growth was the largest for standard plastic pots (222%) followed by Ellepot® (210%) and SoilWrap™ (195%); whereas the plants grown in peat containers produced the smallest growth (138%) during the two-month period. Lamiastrum grew slower and increased ground coverage in the two months by only 107% (standard plastic pots), 133% (Ellepot®), and 69% (SoilWrap™); whereas plants grown in peat containers decreased ground cover by 10%. By September 13th, eight weeks after transplanting to the field, the *Ajuga* plants were intertwined and approaching complete coverage of the planted area where as some of the *Lamiastrum* plants, especially in the peat pots, were lost and that loss could have been due to heat and water stress in August.

At the November harvest of plants transplanted to a field plot in July (four months after transplanting), *Ajuga* produced a mean number of 55 off-shoots arising from below the soil surface and number of off-shoots was not influenced by the container type. The influence of container type on the shoot and root production of *Ajuga* and *Lamiastrum* measured after final harvest from the field plot are presented in Table 1. The mean dry weight of *Ajuga* roots extending from the original container substrate and above ground shoots was largest if grown in Ellepot®; averaging 23.4 g. Plants in SoilWrap™ and standard plastic pots produced very similar shoot and root growth, whereas plants grown in peat pots produced the lowest shoot and root dry weight. The SoilWrap™ and Ellepot® containers were breaking down after 12 weeks of production whereas most of the peat pots stayed intact and possibly restricted root development.

Table 1. Average shoot and root dry weight (g) of *Ajuga reptans* 'Bronze Beauty' and *Lamiastrum galeobdolon* 'Herman's Pride', grown in four container types and transplanted in the field for four months (July – November).

	Ajuga reptans 'Bronze Beauty'					*Lamiastrum galeobdolon* 'Herman's Pride'			
	Standard	Ellepot®	SoilWrap™	Peat		Standard	Ellepot®	SoilWrap™	Peat
Shoot	151.4b	225.2a	135.3b	115.9c		16.8b	37.1a	20.2b	7.8c
Root	16.2b	23.4a	16.3b	13.9b		17.0a	9.0a	11.8a	12.3a

Means with the same letter in a row are not significantly different from each other. Tukey's method, P>0.05.

The mean root dry weight of Herman's Pride plants at harvest did not show significant variation with container type. The mean shoot dry weight was statistically similar for plants grown in Ellepot® (37.1 g), SoilWrap™ (20.2 g), and plastic (16.8 g) containers. Plants grown in peat pots produced significantly low (7.8 g) shoot growth. It was evident from the results of this one-year study that the plants grown in alternative containers such as Ellepot® developed superior plants and plants grown in SoilWrap™ performed similar to that of plants grown in standard plastic containers. The water wicking nature of peat pots along with their slow degradation in the landscape could have negatively affected plant performance, especially in a dry summer like we have experienced in 2012. *Sedum* and *Ajuga* are candidates for rapid turnover systems for ground cover plant production.

Significance to the Industry

The transplanting date impacted all four species, with June to August transplanting producing large growth index in six-week periods, whereas plants transplanted in September showed decreased growth resulting from cool and short days. All plantable containers (3 to 3.5-inch diameter) except peat containers used in the study had no negative impact on the growth and performance of *Ajuga* and *Lamiastrum* in the landscape. Ellepot® and SoilWrap™ containers were almost completely degraded in the field and thus did not impact plant root development after planting. At this point, nursery managers should select among the containers studied based on plant growth and performance. Plants studied in this system were generally marketable in 6 to 8 weeks regardless of transplanting date between March and September, and would have been beyond peak quality at 10 to 12 weeks.

Acknowledgements

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Operation Pollinator: Bringing Golf Courses to Life

Emily K. Dobbs and Daniel A. Potter, Department of Entomology
Emails: emkdobbs@gmail.com; dapotter@uky.edu; fax: 323-1120; tel: 859-257-7475

Nature of the Work

Operation Pollinator for Golf Courses (OPGC), a program started in the United Kingdom that is being implemented on hundreds of European golf courses, seeks to help reverse the serious decline of native pollinators and other beneficial insects by creating pollen and nectar-rich habitats in out-of-play areas. We are initiating an OPGC program for central Kentucky golf courses - the first such project in North America. Our objectives are to 1) Evaluate wildflower mixes adapted to the US transitional climatic zone for cost and ease of establishment, and to provide guidelines for establishment. 2) Evaluate attractiveness of those mixes and individual wildflower species to bumblebees, butterflies, and other wild pollinators. 3) Provide settings for educational workshops; develop educational materials to help promote the value of flowering perennials in pollinator conservation. 4) Stimulate increased use of Kentucky-grown perennial plants.

We have collaborated with Applewood Seed Company, Sharon Bale (Horticulture), and Syngenta turf scientists to develop a simple bee-specific wildflower seed mix, a complex bee-specific wildflower seed mix, and a butterfly-specific wildflower seed mix (Table 1). All of the selected wildflower species are native to Kentucky, most are perennial, and the remainder are hardy self-seeding annuals. We have established plots to compare the three wildflower mixes and a control on five golf courses in the Lexington, KY area and one on Spindletop, the university research farm (Figures 1 - 5). Plots were prepared for seeding and seeded using a modified protocol from the original Operation Pollinator sites in Great Britain. The planting process was completed by September 13, 2011, and sites were ready for initial evaluations in Summer 2012, though not all plants were well established at that point, and the final evaluations will occur in Summer 2013. Due to extreme temperatures and drought in Summer 2012, plots will be reseeded in Fall 2013.

Evaluation of Pollinator and Wildflower Populations

Wildflower establishment was evaluated via photographic manipulation in the 2012 (Figure 1) growing season and will also be evaluated in Summer 2013. A series of six photos were taken of each plot each month starting in June. The photos were analyzed for floral coverage using the “Select” tool in the program Gimp™. Phenological sequence of bloom was also recorded via weekly visual inspections of each plot.

Pollinators in each plot were evaluated by using yellow “bee bowls” filled with soapy water (to trap bees) and by performing hand collections from each flowering species. Bee bowls were elevated to the height of dominant

Table 1. Native seed mixes to be tested in Phase I Operation Pollinator for Golf Courses in the transitional climatic zone

1 Fallow (weedy) control	n/a	
Seed mix (species)	**Common name**	**% of mix**
2 Simple bee mix		
Seed mix (species)	**Common name**	**% of mix**
Aquilegia canadensis	Eastern Columbine	6.81
Coreopsis lanceolata	Lance-Leaved Coreopsis	27.25
Echinacea purpurea	Purple Coneflower	27.25
Monarda fistulosa	Bergamot	1.77
Rudbeckia subtomentosa	Sweet Black-Eyed Susan	4.50
Symphyotrichum novae-angliae	New England Aster	1.77
Ratibida columnifera	Prairie Coneflower	3.41
Tradescantia ohiensis	Ohio Spiderwort	27.25
2 Diverse bee mix		
Seed mix (species)	**Common name**	**% of mix**
Agastache foeniculum	Lavender Hyssop	0.77
Aquilegia canadensis	Eastern Columbine	2.97
Asclepias tuberosa	Butterfly Milkweed	5.94
Coreopsis lanceolata	Lance-Leaved Coreopsis	11.87
Coreopsis tinctoria	Plains Coreopsis (annual)	0.74
Echinacea purpurea	Purple Coneflower	11.87
Echinacea tennesseensis	Tennessee Purple Coneflower	11.87
Eryngium yuccifolium	Rattlesnake Master	5.94
Gaillardia pulchella	Annual Gaillardia (annual)	11.87
Helianthus annuus	Wild Sunflower (annual)	11.87
Monarda fistulosa	Bergamot	0.77
Penstemon digitalis	Smooth Penstemon	1.48
Ratibida columnifera	Prairie Coneflower	1.48
Rudbeckia subtomentosa	Sweet Black-Eyed Susan	1.96
Symphyotrichum novae-angliae	New England Aster	0.77
Tradescantia ohiensis	Ohio Spiderwort	11.87
Zizia aurea	Golden Alexander	5.94
3 Butterfly mix		
Seed mix (species)	**Common name**	**% of mix**
Agastache foeniculum	Lavender Hyssop	0.97
Allium cernuum	Nodding Pink Onion	3.72
Asclepias tuberosa	Butterfly Milkweed	7.45
Cassia hebecarpa	Wild Senna	3.72
Coreopsis lanceolata	Lance-Leaved Coreopsis	14.89
Dalea purpurea	Purple Prairie Clover	7.45
Desmanthus illinoensis	Illinois Bundleflower	7.45
Echinacea purpurea	Purple Coneflower	14.89
Eryngium yuccifolium	Rattlesnake Master	7.45
Liatris spicata	Gayfeather	14.89
Rudbeckia hirta	Black-Eyed Susan	1.86
Solidago rigida	Rigid Goldenrod	1.86
Verbena bonariensis	Purpletop Verbena	1.86
Verbena stricta	Hoary Vervain	3.72
Veronicastrum virginicum	Culver’s Root	0.37
Zizia aurea	Golden Alexander	7.45

bloom (Figure 4) and left out for 24 hours. Bee bowl sampling was conducted every month, beginning in June. At the peak of bloom for each successful wildflower species, hand collections of pollinators were performed from individual flowers (Figures 2 and 3). Twenty-five pollinators were collected from each wildflower species at each site. Pollinators were pinned, and will be identified to family and species based on keys and reference specimens in the UK Insect Collection. Species diversity and richness will be compared between flower species and blends.

The Spindletop OP site was featured in three educational tours at the 2012 UK Turfgrass Field Day, and the Marriott/Griffin Gate Site was featured in a neighborhood newsletter. Our OP project was also featured in TurfNet, a national trade magazine. Signs identifying the plantings as a UK project were developed and set up at each study site. An educational brochure with color photos of signature pollinators will be developed for distribution at the cooperating golf courses (and others as well).

Significance to the Industry

Much of the US public views golf courses as being incompatible with environmental conservation. Current initiatives (e.g., Golf and the Environment, Environmental Institute for Golf, Audubon Sanctuary Program) are working to change that perception (Held and Potter 2012). The US Golf Association Wildlife Links Program encourages superintendents to "establish native flowering plants to ensure availability of pollen and nectar throughout the growing season" but no specifics about which mixes to use, how to establish them, or documentation of their benefits. By providing that information, this project will also benefit other landscape managers seeking to establish pollinator-friendly habitats for conservation, public relations, and outreach education. This should help promote interest in Kentucky-grown perennials for establishing pollinator conservation sites.

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Figure 1. A well-established plot in early June 2012.

Figure 2. A syrphid fly on plains coreopsis *(Coreopsis tinctoria).*

Figure 3. A halictid bee on lance-leafed coreopsis *(Coreopsis lanceolata).*

Figure 4. An elevated bee bowl.

Figure 5. Black-eyed Susan *(Rudbeckia hirta).*

2012 Landscape Plant Disease Observations from the University of Kentucky Plant Disease Diagnostic Laboratory

Julie Beale, Paul Bachi, Brenda Kennedy, Sara Long and Nicole Ward, Plant Pathology Department

Nature of Work

Plant disease diagnosis is an ongoing educational and research activity of the U. K. Department of Plant Pathology. The department maintains two branches of the Plant Disease Diagnostic Laboratory (PDDL), one on the Lexington campus and one at the Research and Education Center in Princeton. Two full-time diagnosticians and a full-time diagnostic assistant are employed in the PDDL, while Extension Specialist Dr. Nicole Ward provides diagnostic and disease management expertise in landscape ornamental crops.

Nearly 3,500 plant specimens were examined in 2012. Of those samples, 38% were landscape ornamental plants (1), with 28% of those submitted from commercial nursery or greenhouse production systems, or from professional landscape companies. In addition to receiving physical diagnostic samples, the PDDL also provides a web-based digital consulting system in which Extension agents submit images for consultation on plant disease problems. The digital consulting system is especially useful in providing assistance with landscape tree and shrub diseases and disorders as whole plants are often difficult to submit to the PDDL. In 2012, 42% of digital consulting requests involved landscape and nursery plants.

Plant disease diagnosis involves a great deal of research into the possible causes of plant problems and utilizes various techniques to identify pathogens. Most visual diagnoses require microscopy. Occasionally, specimens may require special tests such as moist chamber incubation, isolation onto culture media, enzyme-linked immunosorbent assay (ELISA), nematode extraction, or soil pH and soluble salts tests. The laboratory also utilizes polymerase-chain-reaction (PCR) testing which, although more expensive than methods mentioned above, allows more precise and accurate diagnoses.

Computer-based laboratory records are maintained for use in plant disease surveys, identification of new disease outbreaks, and formulation of educational programs. Information from the laboratory also forms the basis for timely alerts of landscape disease problems through the *Kentucky Pest News* newsletter, Facebook page, radio and television programs, and plant health care workshops.

Unusual weather patterns during 2012 impacted all crops, including landscape ornamentals. The onset of warm temperatures occurred earlier than normal in spring, and heat and drought conditions characterized spring through early summer weather. March was the warmest on record in Kentucky, while June was the second driest on record (2). The absence of early season rains and cool temperatures at the time of leaf emergence in shade trees reduced the incidence of anthracnose, crabapple scab and certain other fungal foliar diseases. However, high temperatures and high humidity with low rainfall favored development of powdery mildew. Even though drought did abate in most of the state (with the exception of far western Kentucky) by late July to August, drought stress enhanced tree decline from root or vascular diseases in many locations. High temperatures combined with irrigation promoted anthracnose and stem rot diseases in many herbaceous ornamental plantings.

The following important or unusual diseases were observed:

Deciduous trees

- Dogwood powdery mildew (*Erysiphe*)
- Goldenraintree, magnolia, maple and serviceberry canker (*Botryosphaeria*)
- Oak bacterial leaf scorch (*Xylella*)
- Ornamental pear fireblight (*Erwinia*)
- Redbud and tuliptree wilt (*Verticillium*)
- Yellowwood anthracnose (*Gloeosporium*)

Needle evergreens

- Leyland cypress canker (*Seiridium* and *Botryosphaeria*)
- Pine needle spot (*Dothistroma*)
- Pine tip blight (*Sphaeropsis*)
- Spruce needle cast (*Rhizosphaera*)
- Arborvitae, fir, pine, spruce and taxus root rot (*Phytophthora*)

Shrubs

- Boxwood canker (*Volutella*)
- Cherry laurel, pieris and rhododendron root rot (*Phytophthora*)
- Crape myrtle web blight (*Rhizoctonia*)
- Holly black root rot (*Thielaviopsis*)
- Honeysuckle leaf blight (*Insolibasidium*)
- Rhododendron canker (*Botryosphaeria*)
- Rose downy mildew (*Peronospora*) and powdery mildew (*Podosphaera*)
- Rose rosette (virus)

Herbaceous annuals and perennials

- Catharanthus, pansy and petunia black root rot (*Thielaviopsis*)
- Chrysanthemum wilt (*Fusarium*)
- Hollyhock rust (*Puccinia*)
- Impatiens downy mildew (*Plasmopara*)
- Liriope anthracnose (*Colletotrichum*)
- Phlox and hollyhock charcoal rot (*Macrophomina*)
- Petunia root/crown rot (*Rhizoctonia*)

Significance to Industry

Plant diseases play a significant role in production and maintenance of nursery and landscape plants in Kentucky. The first step in effective disease management is accurate diagnosis of the problems. The PDDL assists the nursery and landscape industry of Kentucky in this effort. In order to serve their clients effectively, Extension agents as well as industry professionals, such as arborists, nursery operators, and landscape installation and maintenance companies, should be aware of recent plant disease history and the implications of diseases for future production or landscape maintenance. This synopsis of plant disease occurrences is provided to assist nursery and landscape professionals with that task.

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Nursery Survey for Phytophthora ramorum in Kentucky, 2012

Julie Beale and Sara Long, Department of Plant Pathology; Janet Lensing, Katie Kittrell, Jennie Condra and John Obrycki, Department of Entomology

Background

Phytophthora ramorum, the cause of Ramorum blight and sudden oak death, continues to be a problem on the west coast in California and Oregon. This disease, first observed in California in the mid 1990s, causes the widespread death of many oak and tanoak species. Other hosts for this pathogen include: camellia, rhododendron, viburnum, mountain laurel and many others. A complete host list can be found at: http://www.aphis.usda.gov/plant_health/plant_pest_info/pram/. Symptoms of *P. ramorum* infection on these hosts vary depending on the species and weather conditions, but include leaf spotting, leaf tip necrosis and twig dieback. Regulations and quarantines have been established to limit the spread of this pathogen, but concerns still remain about potential movement in contaminated nursery stock. Methods of long distance spread of the pathogen include movement of plants, plant parts, soil and water. The Appalachian region is considered to be a high risk area for the establishment of *P. ramorum* because several of the native plant species in the region are identified as hosts and appropriate weather conditions occur often.

Nature of the Work

The nursery survey for *P. ramorum* in Kentucky was continued through the 2012 growing season. This survey, a collaborative effort 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 has been ongoing each year since 2004. Procedures for collecting and testing followed protocols established by the USDA-APHIS-PPQ. In 2012 samples consisted of symptomatic leaves collected within or around commercial nurseries and rhododendron leaves used as "baits" in irrigation ditches, ponds, or other bodies of water in or around the nursery. This water baiting technique is often used in forest settings, but is also useful in nurseries with various sources of surface water. A total of 289 samples were collected as part of the survey. Two hundred fifty-five samples had foliar symptoms suggestive of general *Phytophthora* infection and 34 samples were collected from water baiting. The nurseries in the survey were found across the state in 24 counties: Boone, Boyle, Calloway, Campbell, Carter, Daviess, Fayette, Franklin, Graves, Grayson, Greenup, Henderson, Jefferson, Jessamine, Kenton, Lincoln, Mason, McCracken, Mercer, Nelson, Scott, Taylor, Union and Whitley. These samples were double bagged and sent to the Plant Disease Diagnostic Laboratory (PDDL) in Lexington for testing. An immunological test, enzyme-linked immunosorbent assay (ELISA), was used at the Lexington PDDL as an initial screen of all samples collected. This assay detects the presence of proteins typical of several plant pathogens in the genus *Phytophthora*, including *P. ramorum*. DNA was then extracted from samples testing positive via ELISA for general *Phytophthora* infection. Extracted DNA samples were sent to USDA-APHIS approved testing laboratories for further identification via polymerase chain reaction (PCR).

Results

Of the 255 plant samples collected, 43 tested ELISA positive for infection by *Phytophthora* species and of the 34 water bait samples, 27 tested positive for infection by *Phytophthora* species, bringing the total number of positive samples to 70. Extracted DNA from the 70 ELISA positive samples was sent to USDA-APHIS approved testing laboratories for species identification through PCR. The *P. ramorum* PCR test for each of these samples was negative. *Phytophthora ramorum* was NOT found in the state of Kentucky in 2012. Results are summarized in Table 1.

Table 1. Number and plant species sampled and results of ELISA assays for *Phytophthora* in general and PCR for *Phytophthora ramorum* during the nursery survey for *Phytophthora ramorum* in Kentucky in 2012.

Plant Species	Number of Samples	ELISA positive-*Phytophthora* sp.	PCR positive-*P. ramorum*
Rhododendron	142	33	0
Viburnum	72	1	0
Pieris	37	8	0
Kalmia (Mt. Laurel)	3	1	0
Camellia	1	0	0
Water Bait (Rhododendron leaves)	34	27	0
Total	289	70	0

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