Pathology and Nematology

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Effects of Soybean Oil Formulations on Powdery Mildew and Photosynthesis of Dogwoods

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Index Words: Botanical oils, *Cornus florida* (L), *Microsphaera* spp.

Significance to Industry: Soybean oil is a safe bio-rational pesticide that reduces or delays the occurrence of powdery mildew on dogwood. Soybean oil applied in combination with adjuvants acceptable for organic production differed in powdery mildew management and in effects on leaf photosynthesis.

Nature of Work: Season-long applications of synthetic chemical fungicides often are used to control powdery mildew (2). Long-term use of chemicals may be unsustainable because resistance to some fungicides can develop (4). Disease control has been obtained by using horticultural and agricultural mineral oils, which have a low risk of resistance and phytotoxicity (3). Previous research in our laboratory showed that formulations of soybean oil differed in oil coverage, efficacy against insects, and effects on photosynthesis. Two experiments were conducted in a greenhouse at the University of Tennessee, Knoxville to evaluate the effects of new organic soybean oil formulations on powdery mildew and photosynthesis of 'Cloud Nine' dogwood trees.

Experiment 1: Forty-eight, 2-yr-old 'Cloud Nine' dogwood (*Cornus florida L.*) trees in 5 gal (18.5 L) containers were placed in a greenhouse at the University of Tennessee, Knoxville. Trees were sprayed until runoff with various refined soybean oil formulations at 1.5% of the total volume of water on 3 Oct, one day before exposure to powdery mildew. The formulations had soybean oil as the active ingredient and contained the following adjuvants (% of total volume of water): TNSOY20 (0.015% teric and 0.165 % termul), TNSOY21 (0.03% lauriciden), TNSOY22 (0.15% lecithin), TNSOY23 (0.015% lecithin and 0.075% MD experimental adjuvant), TNSOY24 (0.075% lecithin and 0.075% MD), and TNSOY25 (0.15% Latron B-1956 Spreader Sticker®)(Rohm and Hass, Philadelphia, Pa). Treatments of 1.5% Golden Natur'l® (93% soybean oil)(Stoller Enterprises, Inc. Houston, Texas) and water also were used. The lauriciden adjuvant is soap, lecithin is a by-product of the degumming process of soybean oil, MD is an experimental adjuvant, teric is a surfactant, and termul is an emulsifier. Trees were exposed to inoculum by placing potted dogwood trees with severe powdery mildew symptoms and signs among the experimental trees. The trees were arranged in a randomized complete block (RCB) design with six replications.

Experiment 2: A second set of 48 dogwood trees were sprayed 8 Oct, four days after initial exposure to powdery mildew with the same treatments and experimental design as used in Exp. 1.

Data Collection: Powdery mildew severity was rated visually using a modified eight-point scale (1): 1=0%, 2=1-3%, 3= 4-6%, 4= 7-12%, 5 =13-25%, 6= 26-50%, 7 =51-87%, and 8 = 88-100% of leaves with signs of powdery mildew. Net photosynthetic rates (Pn) were measured on one, randomly selected, fully expanded leaf per plant using a portable ADC-3 model infrared gas analyzer (ADC Inc., Hoddenson, UK). Data were analyzed by analysis of variance (ANOVA) using the General Linear Models (GLM) procedure and Duncan's Multiple Range Test (SAS 9.0, 2002).

Results and Discussion: *Experiment 1:* Formulations of soybean oil (1.5%) affected efficacy of powdery mildew control when sprayed one day before exposure to powdery mildew inoculum. Trees sprayed with Golden Natur'l, TNSOY22, TNSOY23, and TNSOY25 formulations one day before exposure to powdery mildew had less visual disease than control trees when rated on 23 Oct and 11 Nov (Table 1). Leaves sprayed with TNSOY22 and TNSOY25 had Pn rates that were 68% and 40% of control leaves, respectively, on 4 Oct (Table 2). By 14 Oct, the Pn rates of leaves treated with TNSOY22 and TNSOY25 were 83% of leaves sprayed with water.

Experiment 2: Plants sprayed with any soybean oil formulation, four days after initial exposure to powdery mildew inoculum, had lower powdery mildew ratings than the water treated leaves on 24 Oct (Table 3). TNSOY20, TNSOY21, TNSOY22, and TNSOY24 formulations still had less powdery mildew than the control trees on 5 Nov. All formulations reduced Pn rates by 14 Oct (Table 4). Only Golden Natur'l treated leaves recovered to rates similar to water treated leaves by 23 Oct. The TNSOY22 and TNSOY23 treated leaves had Pn rates 28% and 50%, respectively, of the control leaves on 8 Nov.

Our research indicated that plants sprayed with some of the soybean oil formulations, applied pre- or post-exposure to powdery mildew inoculum, had less visual powdery mildew than the water treated plants. Initially all formulations reduced photosynthetic rates. However, Pn rates for some treatments returned to rates similar to control plants by the end of the experiments. Leaves treated with TNSOY22 (containing lecithin) generally had less powdery mildew but also had lower Pn rates for the duration of the experiment. This could be attributed to oil effectively covering the powdery mildew but also suppressing leaf gas exchange. More work is needed to compare types and concentrations of adjuvants used with botanical oils and to asses efficacy of powdery mildew control as well as the duration and effect of foliar Pn suppression.

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Table 1. The effects of 1.5% soybean oil formulations on powdery mildew ratings when applied the day before exposure to powdery mildew[z].

		Powdery mildew ratings [y]	
Formulations	**Adjuvants**	**23 Oct**	**11 Nov**
Water (control)	–	3.5 a[x]	2.8 a
Golden Natur'l	–	2.0 bc	1.8 bc
TNSOY20	Teric/Termul	2.2 bc	2.1 abc
TNSOY21	Lauriciden	3.0 a	2.2 ab
TNSOY22	Lecithin	2.2 bc	1.4 c
TNSOY23	Lecithin/MD	2.0 bc	1.8 bc
TNSOY24	Lecithin/MD	2.7 ab	2.5 ab
TNSOY25	Latron B-1956	1.6 c	1.9 bc

[z] Trees were sprayed on 3 Oct and exposed to powdery mildew inoculum on 4 Oct.

[y] Powdery mildew scale: 1 = 0%, 2 = 1-3%, 3 = 4-6%, 4 = 7-12%, 5 = 13-25%, 6 = 26-50%, 7 = 51-87%, 8 = 88-100% of the foliage visually displaying powdery mildew.

[x] Means within a column followed by the same letter are not significantly different based on Duncan's Multiple Range Test, $P < 0.05$.

Table 2. The effects of 1.5% soybean oil formulations on net photosynthetic rates when applied the day before exposure to powdery mildew[z].

		Net photosynthetic rates (µmol•m^{-2}s^{-1})				
Formulations	**Adjuvants**	**2 Oct**	**4 Oct**	**14 Oct**	**23 Oct**	**8 Nov**
Water (control)	- -	9.7 [y]	8.7 a	7.2	7.8	5.6 ab
Golden Natur'l	- -	9.7	8.1 a	8.6	7.5	5.5 ab
TNSOY20	Teric/Termul	9.7	7.4 a	5.9	6.6	4.9 ab
TNSOY21	Lauriciden	10.1	7.4 a	8.3	7.5	6.4 ab
TNSOY22	Lecithin	10.0	5.9 ab	6.0	5.8	5.6 ab
TNSOY23	Lecithin/MD	9.7	7.3 a	7.4	7.3	5.5 ab
TNSOY24	Lecithin/MD	9.7	7.0 a	5.7	6.8	7.0 a
TNSOY25	Latron B1956	7.8	3.5 b	6.0	5.8	4.5 b

[z] Trees were sprayed on 3 Oct and exposed to powdery mildew inoculum on 4 Oct.

[y] Means within a column followed by the same letter are not significantly different based on Duncan's Multiple Range Test, $P < 0.05$.

Table 3. The effects of 1.5% soybean oil formulations on powdery mildew ratings when applied four days after exposure to powdery mildewz

		Powdery mildew ratings [y]	
Formulations	**Adjuvants**	**24 Oct**	**5 Nov**
Water (control)	- -	3.3 a[x]	2.3 a
Golden Natur'l	- -	2.0 b	2.0 ab
TNSOY20	Teric/Termul	1.4 bc	1.2 b
TNSOY21	Lauriciden	1.7 bc	1.4 b
TNSOY22	Lecithin	1.2 c	1.2 b
TNSOY23	Lecithin/MD	1.6 bc	1.5 ab
TNSOY24	Lecithin/MD	1.3 bc	1.4 b
TNSOY25	Latron B-1956	1.7 bc	1.6 ab

[z] Trees were exposed to powdery mildew inoculum on 4 Oct and sprayed on 8 Oct.

[y] Powdery mildew scale: 1 = 0%, 2 = 1-3%, 3 = 4-6%, 4 = 7-12%, 5 = 13-25%, 6 = 26-50%, 7 = 51-87%, 8 = 88-100% of the foliage visually displaying powdery mildew.

[x] Means within a column followed by the same letters are not significantly different based on Duncan's Multiple Range Test, $P < 0.05$.

Table 4. The effects of 1.5% soybean oil formulations on net photosynthetic rates when applied four days after exposure to powdery mildew[z].

		Net photosynthetic rates (µmol•m-2s^{-1})		
Formulations	Adjuvants	14 Oct	23 Oct	8 Nov
Water (control)	- -	9.8 a[y]	9.4 a	4.3 ab
Golden Natur'l	- -	6.8 b	8.2 ab	5.2 a
TNSOY20	Teric/Termul	4.3 bc	4.5 cd	2.8 ab
TNSOY21	Lauriciden	5.2 bc	5.8 bcd	4.4 ab
TNSOY22	Lecithin	2.7 c	3.3 d	2.2 b
TNSOY23	Lecithin/MD	5.0 bc	5.4 cd	2.7 b
TNSOY24	Lecithin/MD	4.0 bc	4.8 cd	2.9 ab
TNSOY25	Latron B-1956	6.4 b	6.7 bc	3.9 ab

[z] Trees were exposed to powdery mildew inoculum on 4 Oct. and sprayed on 8 Oct.

[y] Means within a column followed by the same letter are not significantly different based on Duncan's Multiple Range Test, $P< 0.05$.

Chemical and Biological Control of Powdery Mildew on *Phlox paniculata* L.

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Index Words: garden phlox, *Erysiphe cichoracearum*

Significance to Industry: Various fungicides, bio-rational compounds, and biological fungicides were evaluated for relative efficacy to control powdery mildew on *Phlox paniculata* L. 'Miss Pepper' under field conditions. The most effective materials included Eagle WSP, Eagle 20EW, Banner, Daconil Ultrex, Fungo 50 with and without Capsil, Zyban with and without Capsil, and Terraguard. Baking soda cocktail appeared to offer the best control of powdery mildew among the bio-rational products but likely would not replace fungicides for most growers and nurserymen. A solution of garlic also provided significant preventative control of powdery mildew relative to the water control.

Nature of Work: Powdery mildew, caused by *Erysiphe cichoracearum* L., is a major problem on certain cultivars of the common garden perennial *Phlox paniculata* L. This fungus disease is seldom lethal to phlox but does reduce the aesthetic quality of flowers and leaves (1). Control options for powdery mildew include selection of less susceptible cultivars, proper cultural practices, and the use of biological and chemical controls. The preferred method to control powdery mildew is to plant less susceptible cultivars. Biological (4) or fungicidal sprays (8) have been used commonly to control powdery mildew on garden phlox. Biological pesticides often have given inconsistent results and work best when used in a well-designed integrated pest management program and when used preventatively during the season before disease becomes established (4). Another option for powdery mildew control involves the use of bio-rational products. Bio-rational products include substances such as neem seed oil, horticulture oil, vegetable oil, Sunspray horticulture oil, baking soda, garlic, and compost tea (2, 5, 6).

Long-term and repeated use of some fungicides may result in the development of resistant strains of the pathogen. Powdery mildew fungi have developed resistance after repeated applications of certain fungicides (7). To avoid resistance problems, fungicides need to be alternated with others having different modes of action (7). Another potential problem with some fungicides is phytotoxicity (3). Proper selection of powdery mildew fungicides and the timing of applications can benefit disease management programs. The objective of this study was to determine the most effective therapy, or combination of therapies, for powdery mildew on *P. paniculata*. By using biological controls, bio-rational compounds, and fungicides on a susceptible cultivar, products were evaluated that are suitable for both the home gardener and the nursery industry.

P. paniculata 'Miss Pepper' plants were received in July of 2001. Miss Pepper was determined in a preliminary experiment to be susceptible to powdery mildew. The plants were shipped bare-root and planted in 4-L pots containing Sungrow Strong-Lite Universal mix (pine bark compost, peat, vermiculite, perlite) with an initial pH of 4.5. The plants were fertilized with 4.5 g127 oz of Scotts Osmocote® 14N-6P-11.6K at planting and placed in a 60% shade-structure. Plants were watered as needed using an overhead irrigation system. Treatments were applied to plants when the average shoot height was 10 cm. All treatments were applied on a preventative basis and initiated on 13 September 2001. The study consisted of 18 treatments and two controls (Table 1). Each plant was sprayed until runoff with an average spray volume of 25 ml (0.85 fl oz). The manufacturer's recommended rate and intervals were used unless otherwise specified. The bio-rational compound referred to as "baking soda cocktail" consisted of commercial baking soda (24 oz), Sunspray horticulture oil (1.4 gal), dormant oil (1.4 gal), and Capsil (0.076 gal) in 100 gal of water. The garlic treatment was prepared by adding 23 oz of minced garlic to 100 gal of water. Treatments were arranged in a randomized complete block design with six single plant replications. Disease developed from natural inoculum in the area.

Field-grown plants were visually rated for disease severity—percent leaf area affected by powdery mildew—at 2, 4, and 6 weeks after initial application of treatments. Plants also were evaluated on 25 October 2001 for visual evidence of chemical residue using a scale of 1 to 5 (1 = no visible chemical residue, 5 = heavy visible residue) and for phytotoxicity using a scale of 1 to 5 (1 = no phytotoxicity symptoms, 5 = severe phytotoxicity symptoms).

Results and Discussion: Good preventative control was provided by most of the fungicides in our field study. Fungicides that gave effective control were Eagle WSP, Eagle 20EW, Banner, Daconil Ultrex, Fungo 50 with and without Capsil, Zyban with and without Capsil, and Terraguard (Table 2). Fungicides that were moderately effective included Armicarb 100 at both concentrations, Heritage, and Camelot. Junction was not effective. In fact, a higher incidence of powdery mildew was noted for the Junction treatment relative to the control at the final rating date. The fact that Junction was not effective as a chemical control for powdery mildew in the field is supported by the manufacturer (*personal communication*, Griffin Chemical Company).

The baking soda cocktail appeared to offer the best control of powdery mildew among the bio-rational products (Table 2) but likely would not replace traditional fungicides for most growers and nurserymen. The biological treatment Plant Shield provided limited control for at least 6 weeks after the initial application (Table 2). Although Plant Shield did not result in the same level of control as the traditional fungicides, powdery mildew severity was significantly lower than that in the untreated control. Based on these results, Plant Shield also would not replace traditional fungicide use for most growers but might provide a viable alternative with additional corroborating research. A suspension of minced garlic provided significant preventative control of powdery mildew relative to the water control on all three rating dates (Table 2). The surfactant Capsil applied alone also provided significant control of powdery mildew on all three rating dates (Table 2).

Visual chemical residue was evident with Junction, Zyban plus Capsil, Plant Shield, and Daconil Ultrex (rating of 2 = low chemical residue; Table 2). All other treatments left no visual residue on the plants. No phytotoxicity was observed with any treatment and all plants displayed good appearance at the end of the trial. Several plants began to flower near the end of the study. No phytotoxicity and little chemical residue were observed in this trial. Overhead irrigation may have been a factor in this result since plants were rinsed.

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Table 1. Treatments used in this study.

Chemical Name	Trade Name	Preventative/ Curative Properties	Application Rate per 100 gal	Spray Interval (days)
myclobutanil	Eagle 20EW	both	5 fl oz	7
myclobutanil	Eagle WSP	both	6 oz	7
propiconazole	Banner	both	6 fl oz	21
chlorothalonil	Daconil Ultrex WDG	preventative	22.4 oz	7
thiophanate-methyl	Fungo 50 + Capsil	both	8 oz + 6 oz	14
thiophanate-methyl + mancozeb	Zyban	both	24 oz	7
thiophanate-methyl + mancozeb	Zyban + Capsil	both	24 oz + 6 oz	7
thiophanate-methyl	Fungo 50	both	8 oz	14
triflumizole	Terraguard	both	6 oz	7
potassium bicarbonate	Armicarb low	preventative	40 oz	7
potassium bicarbonate	Armicarb high	preventative	80 oz	7
azoxystrobin	Heritage	both	2 oz	14
copper salts (fatty and rosin acids)	Camelot	preventative	0.53 gal	7
mancozeb + copper hydroxide	Junction	preventative	24 oz	7
Trichoderma harzianum	Plant Shield	preventative	9 oz	7
sodium bicarbonate	baking soda cocktailz	preventative	-	7
potassium bicarbonate	baking soda		33 oz	7
garlic	garlic		23 oz	7
polyether-polymethylsiloxane-copolymer	Capsil		6 oz	7
water	control		-	7

[z]Baking soda cocktail = 24 oz baking soda + 1.4 gal Sunspray Horticulture Oil + 1.4 gal dormant oil + 0.076 gal Capsil per 100 gal water.

Table 2. Visual ratings of foliar residue, phytoxicity, and powdery mildew severity for treatments applied to *Phlox paniculata* 'Miss Pepper' in the field under 60% shade in 2001.

Treatment	Visual Ratings				
	Foliar Residue	Phytotoxicity	Powdery Mildew [z,y]		
	25 Oct	25 Oct	27 Sep	11 Oct	25 Oct
Eagle 20	1	1	0 c	0 c	0 e
Eagle WSP	1	1	0 c	0 c	0 e
Banner	1	1	0 c	0 c	1 e
Daconil Ultrex	2	1	0 c	1 c	1 e
Fungo 50 + Capsil	1	1	0 c	0 c	1 e
Zyban	1	1	0 c	1 c	1 e
Zyban + Capsil	2	1	0 c	0 c	2 e
Fungo 50	1	1	0 c	1 c	4 e
Terraguard	1	1	0 c	2 c	6 e
Armicarb low	1	1	1 c	4 bc	13 cde
Armicarb high	1	1	7 b	12 bc	18 cde
Heritage	1	1	2 c	10 bc	19 cde
Camelot	1	1	4 bc	11 bc	28 c
Junction	2	1	13 a	32 a	58 a
Plant Shield	2	1	2 c	10 bc	25 cd
Baking soda cocktail[x]	1	1	0 c	1 c	7 de
Baking soda	1	1	1 c	9 bc	18 cde
Garlic	1	1	6 bc	15 b	28 c
Capsil	1	1	1 c	4 bc	15 cde
Water control	1	1	15 a	33 a	45 b

[z] Means within a column followed by the same letter are not significantly different (P=0.05, Student-Newman-Keuls Test).

[y] Percent leaf area affected by powdery mildew.

[x] Baking soda cocktail = baking soda, Sunspray Horticulture Oil, dormant oil, and Capsil.

The Potential of Biorational Products in the Management of Insect and Foliage Diseases

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Index Words: Powdery mildew, black spot, Japanese beetle, roses, oak leaf hydrangea

Significance to the industry: Products that can be used as alternatives to conventional pesticides in insect and foliage disease control were identified. Kaolin (Surround®) was as effective as the insecticide Cabaryl (Sevin®). In addition, UltraFine Sunspray oil and the insecticidal soap M-Pede® also showed potential as alternatives to the insecticide Sevin in reducing Japanese beetle leaf feeding. Kaolin , UltraFine Sunspray, and M-Pede also were effective at reducing foliage diseases. These products are registered for use on ornamental plants. The household soaps (Equate, Ajax,) and potassium bicarbonate (Armicarb) were effective at reducing foliage diseases but were ineffective against insect pests.

Nature of Work: Compounds identified for powdery mildew disease management on dogwood include a potassium bicarbonate (Armicarb®) and several household detergents including Ajax®, Equate® (Mmbaga and Sheng, 2002). Weekly applications of these products individually or in rotation with a fungicides were as effective as applications of the traditional fungicides Banner® (propiconizole), 3336® (thiophanate-methyl), and Phyton 27® (copper sulfate pentahydrate) at recommended label rates every 14 days. The use of these biorational compounds alone or in rotations with traditional fungicides can reduce fungicide use by at least 50% (Mmbaga and Sauve 2004). Biorational products are relatively harmless to the environment and non-target organisms, and they also are less expensive than conventional pesticides. The objective of this project was to evaluate the potential of selected biorational products to control foliage diseases and insect pests on several other nursery crops.

Four nursery plant species were used in this study, *Hydrangea macrophylla* (hydrangea), *H. quercifolia* (oak leaf hydrangea), *Rosa* sp. (hybrid tea rose), *Photinia* × *frasei*. (red-tip photinia), and *Lagerstroemia indica* (crapemyrtle). All plants were purchased from commercial nurseries and planted in the field. Roses also were planted in a greenhouse and shade house. The effect of 10 biorational products, a triazole fungicide (Bayleton), a strobilurin fungicide (Compass), and an insecticide (Sevin SL 7) were evaluated on each plant species using a randomized complete block design with six single-plant replicates for each treatment. The products and rates of application are shown in each table (Tables 1-4); the fungicides and insecticide treatments served as standards for comparison. In each experiment, the non-treated control was sprayed with water. Plants were sprayed every 7-10 days beginning in late April to early May, when first evidence of foliage diseases was observed. Plants were

sprayed to run off using CO_2 - powered sprayers (12 psi pressure) with flat-fan nozzle. Treatments were terminated in October. This study was conducted in 2002 and 2003.

The main foliage diseases that will be reported from this study are powdery mildew (*Sphaerotheca pannosa*) and black spot (*Marssonina rosae*, anamorph *Diplocarpon rosae*) on roses, and bacterial leafspot (*Xanthomonas campetris*) on oakleaf hydrangeas. All diseases were evaluated on a 0-5 scale in which 1 = 0-10%, 2 = 11-25%, 3 = 26-50%, 4 = 51-75%, and 5 = 76-100% of the plant foliage showing symptoms. Although disease severity was evaluated monthly, this report will present data when disease severity was greatest. Data from crapemyrtle (powdery mildew) and photinia (Entomosporium leaf spot) will not be presented in this paper.

The primary damage from insect pests was attributed to feeding of Japanese beetle and other non-identified insects on foliage and flower petals. Percent of total leaf area damaged by insects was estimated for each plant species starting in May when symptoms of damage were first observed and the rating was terminated in late August when insect populations had declined and treatment effects became insignificant. Insect damage on flower petals was evaluated on a 0-10 scale: 0 = no damage and 10 = 100% damage. Petal ratings then were converted to percentages in which 1 = 10%, 2 = 20%, etc. All data were transformed by calculating sqareroot (X + 0.5), and data were analyzed by analysis of variance (ANOVA; Proc GLM) for a randomized complete block design using spray treatment as the main treatment effect (SAS/STAT, 1990; Schlotzauer and Littell. 1987). For data with a significant treatment × date interaction in two-way ANOVAs, differences among treatments were analyzed by one-way ANOVAS for individual sample dates; otherwise, data were pooled across sampling dates.

Results and Discussion: Roses developed powdery mildew in all plots in the field, shade house, and greenhouse, but black spot developed only in the shade house and field. In 2002, disease pressure was moderate and all the biorational products were better than the non-treated control (Table 1). In 2003, disease pressure was high in the greenhouse and moderate in the shade house and field (Table 1). Triact 70, M-Pede, UltraFine Sunspray oil, Equate, and Ajax were the best products for controlling black spot. Triact 70, M-Pede, Ultrafine Sunspray oil, Neem God, Equate and Ajax also were effective in controlling powdery mildew in greenhouse environment but were less effective in shadehouse and field conditions (Table 1). Although the triazole fungicide triadimefon (Bayleton 50 DF ®) is labelled for controlling powdery mildew of roses, it was only moderately effective on powdery mildew and black spot (Table 1). The strobilurin fungicide trifloxystrobin (Compass®) was used in combination with carbaryl (Sevin) and was also moderately effective at controlling both black spot and powdery mildew (Table 1).

A bacterial leaf spot caused by *Xanthomonas campestris* on oak leaf hydrangea persisted season-long and from one year to the next. Treatments with Surround, Neem Gold, M-Pede and Equate were the best products for controlling this disease (Table 2).

Feeding damage on foliage by Japanese beetles on roses was on leaves and petals and damage was highest in late July and early August. Plants in the shadehouse were more severely damaged than in the field, perhaps because in the field there were several choices of preferred plants. Japanese beetle feeding damage was clearly reduced by some of the treatments, but some treatments were not consistent (Tables 3). In general, Sevin and Surround were equally and consistently effective deterrents to leaf feeding damage on roses. UltraFine SunSpray oil and Equate also were good deterrents to leaf feeding damage, but they were not consistent (Table 3). Data with significant treatment by date interaction were analyzed for each individual sample dates. Feeding damage on Oak leaf hydrangea was mostly on leaves. Surround and Sevin were the best treatments followed by M-Pede, and Triact (low) (Table 4). Other products like Ajax®, M-Pede®, Equate®, and neem-containing products reduced the leaf damage compared to the non-treated control, but the data was not statistically significant probably because of high variation within treatments. Potassium bicarbonate (Kaligreen® and Armicarb™) and fungicide Bayleton were largely ineffective in deterring Japanese beetle feeding damage (Table 4). The neem-based products are known to have insect-repelling properties, but did not display strong repellence in this study. Surround® showed high potential, while M-Pede® demonstrated some possible potential in deterring damage from Japanese beetle on some dates.

Overall, the household soaps (Equate, Ajax,) were effective against pathogens but had little effect at deterring Japanese beetle leaf feeding. Potassium bicarbonate (Armicarb™ and Kaligreen®) and the neem-based products (Triact® 70 and Neem Gold) gave inconsistent results in reducing foliage diseases and were largely ineffective at reducing insect damage. Potassium bicarbonate (Armicarb™), potassium salt of fatty acids (M-Pede®), neem plant extract (Neem Gold®), and UltraFine Sunspray oil are labeled for use on ornamental plants and are commercially available.

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Table 1. Effect of biorational products at controlling black spot and powdery mildew on roses.

Treatment	Application rate	Highest Disease Severity (0-5 scale)[1]					
		Black spot		Powdery mildew			
		2002 Field	2003 Field	2002 Greenhouse	2003 Greenhouse	2003 Shade house	2003 Field
Equate	18.3 ml/L (= 1.8%)	1.5 cd	1.0 e	1.17 c	1.0 e	2.12 c	2.12 c
Ultra Fine	14.0 ml/L (= 1.4%)	1.8 bcd	1.5 bcde	1.33 bc	1.50 bcde	2.37 bc	2.37 bc
Ajax	18.3 ml/L (= 1.8%)	1.1 d	1.13 ed	1.08 c	1.13 de	2.0 c	2.00 c
Surround	30 g/L (25 lb/100 gal)	1.5 cd	1.75 bcd	-	1.75 bcd	2.37 bc	2.37 bc
Neem Gold	8.3 ml/L (= 0.83%)	-	1.87 bc	-	1.87 bc	2.0 c	2.00 c
Neem Gold	10.0 ml/L (= 1.0%)	2.2 abc	1.25 cde	1.8 3b	1.250 cde	2.37 bc	2.37 bc
M-Pede	8.3 ml/L(= 0.83%)	1.8 bcd	1.63 bcde	1.3 3bc	1.63 bcd	2.37 bc	2.37 bc
Armicarb	6.6 g/L (= 5.5 lb/100 gal)	1.3 cd	2.0 b	1.4 bc	2.0 b	2.0 c	2.0 0c
Bayleton	0.9 g/L (= 12 oz/100 gal)	2.1 bcd	2.0 b	1.4 bc	2.0 b	2.25 bc	2.25 bc
Triact 70	10.0 ml/L (= 1.0%)	1.2 cd	1.75 bcd	0.8 3c	1.75 bcd	2.62 ab	2.75 b
Triact 70	8.3 ml/L (= 0.83%)	-	2.0 c	-	2.0 b	2.12 c	2.12 c
Insecticide & fungicide[2]	0.3 g/L(= 4 oz/100 gal)	2.8 a2	1.05 bcde	-	1.5 bcd	2.12 c	2.12 c
Control		3.1 a	4.5 a.	3.25 a	4.5 a	3.87 a	3.87 a
$LSD_{(0.05)}$			0.65	0.67	0.66	1.0	0.60

[1] Mean values followed by same letter within a column are statistically similar at p= 0.05 on square root transformed data.

[2]The strobilurin fungicide Compass (trifloxystrobin) was applied starting early May and insecticide Sevin (carbaryl) was added in mid-June till the end of the season.

Table 2. Effect of biorational products at controlling bacterial leaf spot on oakleaf hydrangea in the field.

Treatment	Application rate	Highest disease severity (0-5 scale)	
		2002	2003
Surround	30 g/L (25 lb/100 gal)	0.67 d	1.5 c
Triact 70	8.3 ml/L (= 0.83%)	1.25 bcd	2.0 abc
Ajax	18.3 ml/L (= 1.8%)	1.0 cd	2.0 abc
Kaligreen	6.6 g/L (= 5.5 lb/100 gal.)	1.0 cd	-
Neem Gold	8.3 ml/L (= 0.83%)	1.17 bcd	1.67 bc
Ultra Fine Oil	14.0 ml/L (= 1.4%)	1.83 ab	2.33 a
M-Pede	8.3 ml/L (= 0.83%)	1.33 abcd	1.67 bc
Equate	18.3 ml/L (= 1.8%)	1.08 cd	2.0 abc
Armicarb	6.6 g/L (= 5.5 lb/100 gal)	1.42 abc	2.0 abc
Bayleton	0.9 g/L (= 12 oz/100 gal)	1.58 ab	2.17 ab
Sevin	0.3 g/L (= 4 oz/100 gal)	1.33 abcd	1.83 bc
Control		2.08 a	2.17 ab
$LSD_{(0.05)}$		0.77	0.50

[1] Mean values followed by the same letter within a column are not significantly different at $P = 0.05$ using square root transformed data.

[2] The strobilurin fungicide Compass (trifloxystrobin) was applied starting early May and the insecticide Sevin was used in mid-June until the end of the season.

Table 3. Mean percent of total leaf area damaged by Japanese beetle when plants were treated with different biorational products in 2003 in the field and shadehouse.

Treatment	Application rate	Roses[2] in the Field		Roses[2] in the Shadehouse	
		July 28	Aug 8	July 29	Aug 8
Sevin	0.3 g/L (= 4 oz/100 gal)	1.25 c	0.70 c	6.63 cd	4.50 c
Surround	30 g/L (25 lb/100 gal)	0.83c	1.13 bc	7.63 cd	7.50 c
Ultra Fine Sunspray Oil	14.0 ml/L (= 1.4%)	1.50 bc	1.42 bc	10.13 bcd	10.50 abc
Triact (Low)	8.3 ml/L (= 0.83%)	5.83 ab	2.60 bc	12.63 abcd	10.50 abc
Ajax	18.3 ml/L. (= 1.8%)	3.67 abc	5.60 ab	23.75 abcd	24.5 abc
Kaligreen	6.6 g/L (= 5.5 lb/100 gal.)			-	-
Armicarb	6.6 g/L (= 5.5 lb/100 gal)	2.67 bc	4.40 abc	20.00 abcd	17.50 abc
Neem Gold (High)	10.0 ml/L. (=1.0%)	-	-	28.25 abcd	17.75 abc
NeemGold (low)	8.3 ml/L (= 0.83%)	3.25 abc	3.60 bc	30.00 abc	23.75 abc
Equate	18.3 ml/L. (= 1.8%)	1.60 bc	2.90 bc	32.50 ab	23.50 abc
M-Pede	8.3 ml/L(= 0.83%)	2.00 bc	4.40 abc	35.00 a	27.75 ab
Triact (High)	10.0 ml/L. (=1.0%)	7.50 a	3.70 bc	18.75 abcd	30.00 a
Bayleton	0.9 g/L (= 12 oz/100 gal)	5.33 abc	5.33 abc	20.25 abcd	30.00 a
Control		5.17 abc	9.00 a	17.00 abcd	27.50 ab

[1]Data pooled from different dates June –August 2002. All dates have a sample size of n = 6. Mean values followed by same letter within a column are not significantly different according to analysis of variance (Proc GLM) least significant differences on square root transformed data (X +1 0.5).

[2]Data also was collected on August 22, but there were no significant differences among treatments.

Table 4. Mean percent of total leaf area damaged by Japanese beetle when oakleaf hydrangea plants were treated with different biorational products in 2002 and 2003 in the field[1].

Treatment	Application rate	2002			2003		
		18 July	31 July	14 Aug.	11 July	July 28	Aug. 8
Surround	30 g/L (25 lb/100 gal)	1.25 bc	1.25 c	0.92 cd	1.08 b	2.17 abc	1.17 d
Sevin	0.3 g/L (= 4 oz/100 gal)	0.33 c	0.67 c	0.67 d	0.583 b	0.5833 c	1.417d
M-Pede	8.3 ml/L(= 0.83%)	1.08 bc	3.58 bc	3.33 bcd	1.83 ab	3.750 a	1.58 cd
Triact (low)	8.3 ml/L (= 0.83%)				1.00 b	1.70 bc	1.917 bcd
Ajax	18.3 ml/L. (= 1.8%)	3.42 a	3.33 bc	8.42 a	4.42 a	3.67 a	1.917 bcd
Kaligreen	6.6 g/L (= 5.5 lb/100 gal.)	3.00 a	2.67 bc	3.58 abc	-	-	
Armicarb	6.6 g/L (= 5.5 lb/100 gal)	4.08 a	7.67 a	5.92 ab	3.00 ab	1.25 c	2.83 abcd
Bayleton	0.9 g/L (= 12 oz/100 gal)	1.08 bc	2.00 bc	4.17 abc	1.33 b	2.08 abc	2.83 abcd
Ultra Fine Sunspray Oil	14.0 ml/L (= 1.4%)	2.50 b	2.58 bc	3.58 abc	3.00 ab	3.33 ab	3.17 abcd
Equate	18.3 ml/L. (=1.8%)	4.25 a	3.67 b	3.33 abc	3.25 ab	2.00 abc	3.75 abcd
Triact (high)	10.0 ml/L. (=1.0%)	2.58 b	4.75 b	3.33 abc	1.50 ab	1.83 bc	4.42 ab
NeemGold (low)	8.3 ml/L (= 0.83%)	3.40 a	2.40 bc	1.40 cd	1.33 b	1.83 bc	4.750 a
Control		6.50 a	5.50 ab	5.17 ab	1.750 ab	3.33 ab	4.167 abc

[1] Means on dates with pooled data have a sample size of n = 30. All other dates have a sample frankm@blomand.netsize of n = 6. Mean values followed by same letter within a column are statistically similar according to analysis of variance (Proc GLM) on square root transformed data (X +1 0.5). Data from 21 June and 2 July had no significant differences.

A First Report of Daylily Rust in Tennessee

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Index Words: Rust, Daylily, Disease, *Hemerocallis, Puccinia hemerocallidis*

Significance to Industry: Daylily rust continues to be a serious problem for hobbyists and in the nursery industry. Infected plants continue to be shipped to retail garden centers by wholesale nurseries and hobbyists. Gardens in the Upper South and further north my have rust eradicated by the winter climates in these locales as the urediniospore stage of the fungus does not appear to survive in the absence of living host foliage. If this is the case, re-infestation will only take place if diseased plant material is brought into the garden or nursery.

Nature of Work: Daylily is one of the most widely produced perennial flowering plants in commercial wholesale nurseries in the Southeastern United States. Daylilies have a reputation as a time-tested perennial plant with few serious disease or insect pests. In August 2000, daylily rust, caused by *Puccinia hemerocallidis*, was identified on the cultivar Pardon Me by the University of Georgia Plant Disease Clinic (2). This was the first report of daylily rust in the United States.

In May 2001, daylily rust was observed in a retail garden center in Chattanooga, TN on daylilies received from a Texas wholesale container nursery. Daylilies from other sources at the garden center were free of the disease. By late 2001, daylily rust was reported in nearly 30 states in the Southeast, East, and Midwest regions of the United States.

Results and Discussion: Daylily rust was confirmed by the University of Tennessee Plant and Pest Diagnostic Center and by a USDA fungus identification laboratory in Beltsville, MD. Daylily rust was identified based on pustule and urediniospore morphology. Plants with rust at the garden center were destroyed by the Tennessee Department of Agriculture. Daylily rust was discovered at other locations in Tennessee: a small nursery in Lawrence County, a hobbyist garden in Williamson County and a botanic garden in Davidson County. The sources for the infected plants were daylily hobbyists in Florida and Georgia. The Tennessee Department of Agriculture placed a stop sale on the plants at the Lawrence County Nursery and the hobbyist garden in Williamson County.

The Williamson County hobbyist followed the protocol suggested by the National Plant Board: foliage of infected plants was removed and new growth was sprayed with fungicides labeled for rust diseases. As of June 2003, daylily

rust has not been observed in the Williamson County garden. Sanitation, the fungicide regime and the climate of Zone 6b all may have contributed to the eradication of rust in this garden.

The retail garden center in Chattanooga that was the location of the first report of daylily rust in Tennessee received additional infected plants from wholesale container nurseries during the summers of 2002 and 2003. The daylily plantings in the botanic garden in Davidson County have been monitored for rust and were free of the disease as of June 2003.

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Pilot Survey for *Phytophthora ramorum* in Nurseries in Tennessee, 2003

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Index Words: *Phytophthora ramorum*, Sudden oak death

Significance to Industry: In 2003, eleven nurseries were surveyed for the presence of *Phytophthora ramorum*. All of the plant material assayed was negative for *P. ramorum*.

Nature of Work: Eleven Tennessee nurseries that grow species of Kalmia, Pieris, Rhododendron, and Viburnum were selected for the pilot survey. Blocks of target plants were scouted for symptoms associated with foliar blights caused by *Phytophthora* spp. The number of plants scouted at each nursery, varied depending on the size of the nursery. At some nurseries, each block contained several hundred plants; in smaller nurseries, some blocks consisted of as few as a dozen plants. A sample, consisted of at least 10 leaves and or shoots with necrotic tissue. Leaves and shoots that had symptoms similar to those attributed to infection by *P. ramorum*, were placed in ziploc bags and stored in an ice chest on ice. If the samples were going to be stored overnight, they were placed in an ice chest with dry ice. All samples were transported to Knoxville and placed in an ultra low cooler (-80C) until the PCR assay could be conducted.

Symptomatic plant material (Figure 1) from high-risk nurseries was assayed for the presence of *Phytophthora ramorum* using a *P. ramorum*-specific nested PCR assay. Other than a few minor adjustments, the procedures for storing plant tissue, harvesting tissue for DNA extraction, processing harvested tissue with the DNeasy Plant Mini Kit from Qiagen, and performing the *P. ramorum*-specific nested PCR assay was followed exactly as described by Levy and Mavrodieva in the April 2003 report, "Evaluation of the PCR Detection and DNA Isolation Methods for Use in the *Phytophthora ramorum* National Pilot Survey." The main adjustment we made to the recommended procedure was to disrupt leaf samples individually prior to pooling. Specifically, Instead of pooling 10 leaf samples (100 mg total) from a single sample location we homogenized 10 mg from each symptomatic leaf separately in 100 µl of disruption buffer and then pooled 40 µl of the disrupted plant material to a total of 100 mg (400 µl). This required more disruption steps than if leaf samples were pooled tenfold but was deemed necessary as we found some plant material, especially rhododendron, to be very difficult to homogenize according to the recommendations (repeated freeze/bash cycles) when pooled. Poor sample disruption invariably led to very poor DNA extraction as determined by visualization on agarose gel or using a fluorometer. Separate homogenizations followed by pooling and DNA extraction consistently

provided high molecular weight DNA visible on an agarose gel. Once DNA was harvested from the pooled leaf samples, the *P. ramorum*-specific nested PCR assay was completed. In the case of stem or woody material, there was no attempt to pool samples; 10- to 100-mg samples were disrupted individually in 400 µl of disruption buffer, DNA was extracted, and the PCR-assay was conducted as recommended.

Results and Discussion: Samples (N=66) from eleven nurseries in eight counties were analyzed. In addition, we analyzed 31 forest samples collected from high-risk forest areas. Tissue homogenizations were completed for over 600 separate leaf and stem samples and DNA was extracted from 183 batched or individual leaf and stem samples. No samples tested positive for *P. ramorum* (Figure 2).

Figure 1. Typical symptoms on rhododendron shoots collected during the survey.

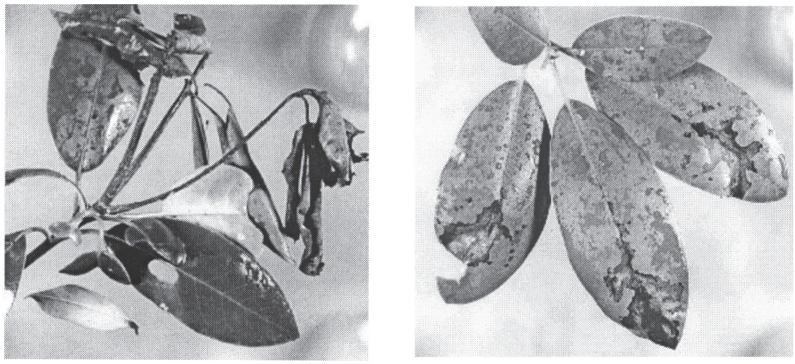
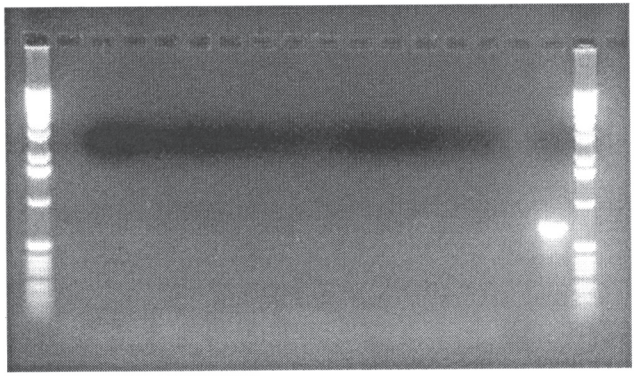


Figure 2. Results from the second round of the nested PCR assay that clearly shows the lack of any *P. ramorum*-specific DNA fragments in the samples. **PR**=*P. ramorum* positive control, L=ladder, B=blank lane, TE=1:500 dilution of first round TE w/no DNA, W=water control, and lanes 3-13 are plant samples collected from high-risk nurseries in Tennessee.



L 3 4 5 6 7 8 9 10 11 12 13 W TE D B Pr L

Peanut Hull Composting Temperatures and Implications for Viability of Sclerotia of *Sclerotium rolfsii*

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Index Words: Southern blight, container media

Significance to Industry: This research demonstrates that the temperatures reached during composting of peanut hulls for use in container mixes are sufficiently high to kill sclerotia of *Sclerotium rolfsii*, the pathogen causing southern blight on many ornamental crops.

Nature of Work: *Sclerotium rolfsii* is a fungal pathogen that causes the disease southern blight (also called stem rot, petiole rot, stalk rot, crown rot, and white mold) in hundreds of species of plants (3). *S. rolfsii* is widespread in areas with warm temperate winters such as the southern region of the United States (2). Susceptible crops include peanut, soybean, beet, sweet potato, and wheat among others. In addition, many ornamental plant species are susceptible to southern blight—including hosta, daylily, melampodium, and ajuga. *S. rolfsii* is a soilborne, facultative saprophyte capable of surviving in the soil for 2 to 5 yr. The fungus survives adverse environmental conditions by forming numerous, small, round sclerotia that are approximately 1 mm in diameter, which makes it difficult to manage this pathogen (1). Field studies with soil solarization in North Carolina showed a 62% reduction in mean number of viable sclerotia collected at depths of 10, 20, and 30 cm when mean maximum soil temperatures reached 39 C (103 F), averaged over those depths for 35 days, (5). Laboratory tests utilizing agar plates indicated that sclerotia were killed in 4-6 h at 50 C (122 F) or 3 h at 55 C (131 F) (4). Composted peanut hulls are a component of some commercial container mixes. This study was undertaken to determine the temperatures and exposure times required to kill sclerotia of *S. rolfsii* within a composted container mix and to compare these temperatures with those reached during controlled composting of peanut hulls for use in container mixes.

Sclerotia of *S. rolfsii* were produced on potato dextrose agar (PDA) from an isolate originally obtained from a tradescantia plant in Virginia. To determine the range of temperatures at which sclerotia survive within a container mix, 780 g of moist SunGro Sunshine SB 300 container mix was placed in a 2-liter beaker. Sterile filter papers (Whatman No. 1, 9 cm) were folded to form envelopes, and 10 sclerotia were placed in each envelope. Nine envelopes containing sclerotia were placed under the mix in each beaker. One beaker was placed at each of three temperatures: 43 C (110 F), 49 C (120 F), and room temperature (21-24 C [70-75 F]). Three of the folded filter papers containing sclerotia were removed from each beaker after 1, 3, and 7 days. The beakers were weighed daily and water was added as needed to maintain a consistent moisture content over the 7-day period. As the envelopes were removed from the beakers, sclerotia were

transferred aseptically to PDA plates and maintained at room temperature. The number of sclerotia that germinated and the number of days until germination was apparent were recorded for each temperature and exposure time treatment. The data were analyzed as a two-factor (temperature x exposure time) factorial experiment with mean separations by LSD, *P*=0.05.

On March 25, 2004, in an experiment to determine composting temperatures, peanut hulls previously stockpiled in larger windrows for up to 8 mo were placed in a compost windrow that was approximately 4.2 m (14 ft) H x 9 m (30 ft) W x 15 m (50 ft) L. Thirteen temperature sensors (WatchDog Model 100, Spectrum Technologies, Inc., Plainfield, IL) were arrayed in a cross section at the midpoint of the windrow as it was being constructed. Sensors were located along the vertical center and horizontal bottom half of the windrow, with additional sensors radiating outward within that half of the windrow to within 0.6 m (2 ft) of the surface (Fig. 1). Temperatures were recorded every 30 min for 14 days. Sensors were removed when the windrow was turned on April 8 and were reinstalled on April 27 when the windrow was turned for the second time. Temperatures were recorded until the sensors were removed on May 13, 2004.

Results and Discussion: There was a highly significant temperature × exposure time interaction (*P*=0.0001) for sclerotium viability. At room temperature, all sclerotia survived for 7 days (Table 1). At 43 C (110 F), all sclerotia survived for 1 day, a mean of 8.6 sclerotia out of 10 survived for 3 days, but all sclerotia were dead at 7 days (Table 1). When the temperature was 49 C (120 F), none of the sclerotia survived even for 1 day. Number of days to sclerotium germination also was effected differentially by temperature and exposure time. At room temperature or for 1 day at 43 C (110 F), germination occurred at 3 to 4 days but, when the temperature was 43 C (110 F) and exposure time was 3 days, it took a mean of 7.4 days for germination to occur (Table 1). These results are consistent with those of Mihail and Alcorn (4), who determined that sclerotia on agar plates survived for only 4 to 6 h at 50 C (122 F).

Peanut hull compost temperatures were never less than 43 C (110 F) at all locations during a 7-day period 1 week after construction of the windrow (Table 2), with the exception of the bottom location closest to the surface (#4 in Fig. 1). One month later, after the second turning, temperatures at all locations within the windrow exceeded 54 C (130 F) for a 7-day period (Table 2). These results indicate that the degree and duration of composting temperatures within compost windrow are sufficient to eliminate the sclerotia of *S. rolfsii* from thoroughly composted peanut hulls. Repeated turning of the windrow during a typical 8-week composting process should ensure that all of the composted material is exposed to a lethal temperature.

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Table 1. Effect of temperature and exposure time on viability and time until germination of sclerotia of *S. rolfsii*.

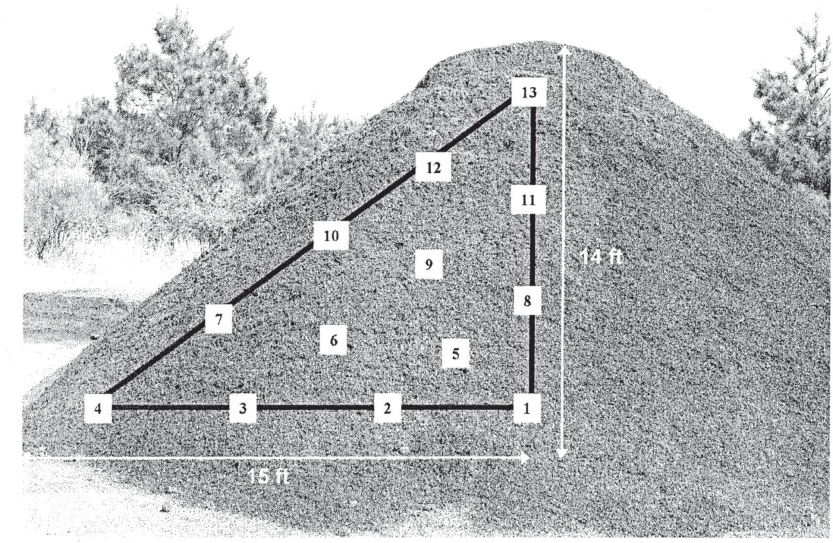
Temperature	Exposure time (days)	Viable sclerotia (no.)	Days until observed growth
21-24 C	1	10 a[z]	3 c
(70-75 F)	3	10 a	4 b
	7	10 a	3 c
43 C	1	10 a	3.6 b
(110 F)	3	8.6 b	7.4 a
	7	0 c	-
49 C	1	0 c	-
(120 F)	3	0 c	-
	7	0 c	-

[z] Means with the same letter within a column are not significantly different, LSD (P = 0.05).

Table 2. Peanut hull compost temperatures [degrees C (F)] over 7 days at various locations within a windrow (see Fig. 1) following initial construction and the second turning one month later.

	Week beginning April 1			Week beginning May 1		
Location	**Low**	**High**	**Mean**	**Low**	**High**	**Mean**
1	46 (114)	53 (128)	49 (121)	61 (142)	70 (158)	66 (151)
2	62 (143)	70 (158)	67 (153)	61 (141)	68 (154)	66 (150)
3	54 (129)	66 (151)	60 (140)	56 (133)	68 (155)	64 (147)
4	37 (99)	63 (145)	48 (118)	54 (130)	68 (155)	63 (145)
5	63 (145)	69 (157)	68 (154)	68 (155)	70 (158)	69 (157)
6	64 (147)	73 (163)	67 (153)	68 (155)	71 (159)	69 (157)
7	44 (111)	66 (151)	53 (127)	62 (144)	71 159)	67 (153)
8	66 (149)	72 (161)	69 (156)	66 (150)	73 (164)	69 (157)
9	69 (156)	76 (169)	72 (161)	78 (158)	73 (163)	72 (161)
10	53 (127)	69 (156)	60 (140)	65 (149)	73 (163)	69 (156)
11	68 (155)	72 (162)	70 (158)	68 (154)	73 (163)	71 (159)
12	54 (129)	73 (163)	61 (141)	69 (157)	77 (170)	73 (164)
13	72 (161)	77 (168)	73 (163)	62 (144)	69 (156)	67 (153)

Figure 1. Temperature sensor locations in the peanut hull compost windrow. The lowermost locations (#1- 4) were 2 ft above the ground, the uppermost location (#13) was 2 ft below the top of the windrow, and the outermost locations (#4, 7, 10, and 12) were 2 ft from the closest surface.



Resistance of Wax Begonia Cultivars to *Rhizoctonia solani* in Southern Landscapes

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Index Words: *Begonia semperflorens*, disease resistance, *Rhizoctonia solani*

Significance to industry: Identification of resistance in wax Begonia to *Rhizoctonia solani* should lead to identification of cultivars that are able to thrive under diverse production systems and environmental conditions. The use of better adapted cultivars will reduce the need for and risks associated with pesticide use and the costs of plant replacement in the landscape.

Nature of Work: Begonias are one of the most popular bedding plants grown in the United States. Wax begonias bloom year-round and have relatively few insect and disease problems (1). *Rhizoctonia solani* is one of the most common and persistent pathogens in flowering ornamental crops. It causes several diseases (including damping-off, root and crown rots, and stem and leaf blights) in more than 30 flowering plants grown as ornamentals (2). These diseases limit plant survival and increase costs during crop propagation and production and in the landscape. Wax begonias often do best in moderate to bright light in winter and partial shade in summer (1). Many cultivars thrive in bright light at cooler temperatures, but new groups of cultivars have been developed for use in warmer climates (1). While most of these grow well at higher air temperatures and can tolerate higher light intensities, high soil temperature combined with moderate soil moisture during the summer season may encourage growth of *R. solani* and, therefore, increase disease incidence and severity in southern landscapes (3, 4, 5). During the last three growing seasons, two cultivars of wax-begonias (Stara White and Stara Pink) have been observed to survive in field trials in Texas under full sun/summer conditions when most other cultivars were lost to soilborne diseases. Survival of these cultivars may be due to resistance to *R. solani* that kills susceptible cultivars maintained under the same conditions. The specific objective of this project was to assess relative resistance to *R. solani* in 12 commercial and experimental wax begonia cultivars under controlled conditions.

Trials were conducted in both a greenhouse and growth chamber at TAMU, College Station, TX in April through July, 2004. The isolate of *R. solani* used in the tests was one of five isolates obtained from infected begonias during 2003 field trials in Overton, TX. The selected isolate appeared to be the most virulent of the five in preliminary experiments. The inoculum was grown in a mixture of sterilized potato and soilless container mix (Metro-Mix 366, Scotts Co.). Liner size plants were grown from seed and established in plug trays. Inoculation was made when plants had 3-4 leaves, using standard methods (6). Plants were transplanted individually into 4-inch pots previously filled with potting mix, either with or without the inoculum (2 treatments). Five plants of each of 12 cultivars per treatment were included in the evaluation (2 treatments x 5 plants x 12 cultivars = 120 plants in each of two trials). The growth chamber trial was conducted at a constant temperature (25 ± 1 °C). Begonia cultivars included Stara (red, rose, pink,

and white) by Floranova Ltd, Vodka (red; included as a standard) and Party (white bronze leaf, rose pink green leaf, and pink bronze leaf) by E. Benary of Amercia Inc., and Ambassador (coral and deep rose) and two experimental cultivars (soft pink and rose) by Daehnfeldt Inc. Plants were evaluated for crown rot symptoms and disease severity seven times from 7 to 28 days after inoculation using a 1 to 5 rating scale, where 1=no symptoms, 2=symptoms detected, 3=symptoms prevalent, 4= symptoms extensive, 5=plant death. Area under disease progress curves (AUDPC) were calculated and used to compare cultivars using ANOVA methods. Whenever significant cultivar effects were found, means were compared to the commercial standard cultivar using Dunnett's method.

Results and Discussion: Plants that were not inoculated with the pathogen did not show disease symptoms during the test. This indicated that symptoms on treated cultivars were caused by our *R. solani* isolate and not by background contamination or resident fungi. There was a high variability in both the average disease ratings and AUDPC values—suggesting differences in susceptibility to *R. solani* in the 12 cultivars (Table 1.). Cultivars Stara Pink and Stara White received the lowest disease ratings and had the lowest AUDPC values of all cultivars. However, when compared against Vodka (commercial standard), only Stara White showed significant differences in the growth chamber test. The cultivar Experimental Variety Rose had the highest disease ratings and the highest AUPDC values of all cultivars. These values were significantly different than those from Vodka in both greenhouse and growth chamber tests suggesting this cultivar is highly susceptible to *R. solani* and may require further breeding efforts. Stara cultivars, specially Stara White and Stara Pink appear to have good tolerance to *R. solani* under our controlled conditions. This is consistent with our preliminary observations in the field. Results from these trials will be compared with results from on-going field plot evaluations with the same cultivars to corroborate findings.

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Table 1. Relative susceptibility of 12 wax begonia cultivars to *Rhizoctonia solani* in greenhouse and growth chamber trials.

	Greenhouse		Growth Chamber	
Cultivar	**Avg. Rank[1] (± SEM)**	**AUDPC[1] (95%CI)[2]**	**Avg. Rank (± SEM)**	**AUDPC (95%CI)[3]**
Ambassador Coral	2.2 ± 0.2	30.6 (23.7-37.5)	2.4 ± 0.2	38.7 (28.1-49.4)
Ambassador Deep Rose	2.0 ± 0.0	32.7 (30.6-34.7)	2.4 ± 0.2	39.3 (29.3-49.3)
Experimental Cultivar Soft Pink	3.4 ± 0.2	40.2 (36.2-44.2)	3.0 ± 0.0	43.2 (35.0-51.4)
Experimental Cultivar Rose	3.8 ± 0.4	55.8 (36.6-75.0)*	3.2 ± 0.4	52.2 (34.0-70.4)*
Party Pink Bronze Leaf	2.6± 0.4	31.2 (23.3-39.1)	1.4 ± 0.2	21.6 (14.3-28.9)
Party Rose Pink Green leaf	1.6 ± 0.2	24.9 (15.3-34.5)	1.8 ± 0.2	25.8 (17.2-34.4)
Party White Bronze leaf	2.0 ± 0.3	28.5 (18.2-38.8)	1.4 ± 0.2	23.4 (14.2-32.6)
Stara Pink	1.2 ± 0.2	20.7 (13.2-28.2)	1.8 ± 0.4	27.6 (16.5-38.7)
Stara Red	1.6 ± 0.2	20.7 (17.6-23.8)	2.4 ± 0.2	29.7 (21.2-38.2)
Stara Rose	1.8 ± 0.2	28.2 (18.9-37.6)	2.0 ± 0.0	30.9 (24.8-37.0)
Stara White	1.6 ± 0.2	20.7 (17.6-23.8)	1.4 ± 0.2	19.8 (16.7-22.9)*
Vodka	2.0 ± 0.0	28.5 (21.5-35.5)	2.4 ± 0.4	36.3 (18.0-54.7)

[1] Average ranking (± 1 Standard Error of the Mean) calculated from observations made 28 days after inoculation (n=5). AUDPC= Area Under Disease Progress Curve. CI = Confidence Interval.

[2] ANOVA: F= 9.9, d.f. = 11/48, P <0.0001

[3] ANOVA: F= 6.3, d.f. = 11/48, P <0.0001

* Significantly different (P<0.05) than the commercial standard cultivar- Vodka.

Inoculation Efficacy of the Medium Used for Suspension of *Puccinia hemerocallidis* Urediniospores

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Index Words: *Hemerocallis* spp., daylily, rust, *Puccinia* spp., germination, infection, inoculation

Significance to Industry: We present a reliable technique to point-inoculate daylily leaves with the daylily rust pathogen. This technique should be particularly useful to plant pathologists studying daylily rust and to hybridizers and plant breeders developing resistant cultivars.

Nature of Work: The ability of many rust fungi to germinate and infect host tissues seem to be relatively unaffected by the medium in which they are suspended. Suspensions of urediniospores are usually made with water, water plus Tween 20, 0.1% agar in water with and without a surfactant, or mineral oil (1,2,3,4). However, we observed a low success in infecting daylily leaves with urediniospores of *P. hemerocallidis* with water and 0.1% agar in water. Thus a study was conducted to measure the effect of various suspension media as well as inoculum placement and dispersal methods on the germination and infection of daylily by *P. hemerocallidis*.

Hemerocallis 'Pardon Me' that was free of daylily rust was obtained from a commercial nursery. Plants were divided into fans and potted into 1-gal nursery containers. Plants free of rust symptoms and signs were maintained by routine removal of leaves as pustules appeared and application of Spectrum 90 (0.6 g L^{-1}) or a combination of Talstar GH (9 ml L^{-1}) and Heritage (0.75 ml L^{-1}) three weeks prior to the start of an experiment.

Daylilies infected with *P. hemerocallidis* were maintained in a separate greenhouse. Urediniospores no more than 14 to 21 days old were collected by gently scrapping pustules with a scalpel blade. Urediniospores were suspended in various media, including: deionized water, mineral oil, 0.2% water agar (2 g of Difco agar L^{-1} of deionized water), 0.2% water agar plus 0.125% Tween 20 (by volume) in deionized water, 0.2% water agar plus 0.063% Nu-Film® 17 (Miller Chemical & Fertilization Corp., Hanover, PA), 0.2% water agar plus 0.125% Bio-90™ (KALO Inc., Overland Park, KS), and 0.2% water agar buffered to pHs of 4, 6, 8, and 10. Five, 6.5-µl drops of a medium with and without inoculum of 2.5×10^5 spores per ml were placed on individual leaves, beginning 3 cm from the leaf tip and spaced 1 cm apart along the leaf blade on the upper or lower surface. Individual leaves were a treatment unit and were spaced on a plant to avoid contact with other leaves. Drops were left intact or were dispersed by spreading with a rubber policeman. Inoculated daylily plants were held for 3 days at 100% relative humidity and then moved to and maintained in a greenhouse with a temperature range of 72 to 85°F. The number of pustules with urediniospores per leaf was recorded 16 to 20 days later.

A completely randomized design with three replications was used in all five experiments. Individual treatments were repeated in two to five experiments. Data were analyzed using the Proc ANOVA procedure of SAS (version 8.2; SAS Institute Inc., Cary, NC) and means were separated with Fisher's protected least significant difference test (LSD), P=0.05.

Results and Discussion: All three factors tested in this study (the medium in which urediniospores were suspended, placement of the inoculum on the upper or lower leaf surface, and application process as drops or dispersed drops) appeared to affect infection efficiency (Table 1). The greatest number of pustules resulted from urediniospores suspended in mineral oil and applied as dispersed drops to the lower leaf surface, in experiments one, two, and five. In experiment three, the greatest number of pustules resulted from application of urediniospores in mineral oil applied to the lower leaf surface, regardless of drop dispersal. In experiment four, pustules developed from urediniospores in mineral oil, but the number of pustules was greatest with spore suspended in Nu-Film® 17.

Placement of inoculum on the lower leaf surface was critical for the production of high numbers of pustules. However placement did not improve the number of pustules when urediniospores were suspended in deionized water and 0.2% agar. Deionized water and 0.2% agar adhered poorly to the leaf, which possibly affected dispersal of urediniospores and/or contact with the leaf. The addition of a surfactant (Tween 20 or Bio-90™) to the 0.2% agar or adjusting pH levels influenced inoculation success, but pustule numbers ranged from moderate to zero and the influence was not sufficiently favorable. Mineral oil and Nu-Film® 17 (an extracted plant oil) highly favored successful infection of *P. hemerocallidis* urediniospores resulting in high numbers of pustules. While oils possibly provide a medium that dries slower than water-based suspensions, the initial three days of high humidity provided moisture conditions suitable for infection regardless of the suspension medium. The oil-based suspensions apparently facilitated some part of the infection process, possibly orientation of mycelium growth or adherence of the mycelium and infection structures to the leaf surface. This study did not determine why the oil-based media helped infection.

Other researchers have achieved successful infection with *P. hemerocallidis* urediniospores suspended in water and 0.05% Tween when applied as a spray to all leaf surfaces (5). In those studies, a large quantity of spores was collected with a uniquely designed vacuum. Scraping spores from pustules was time consuming and resulted in an insufficient volume of spores to make the amount of spore suspension needed for spray application. An additional reason for this research was the use of point inoculations in histopathology research and in micro-tissue screening of daylily cultivars for resistance to daylily rust being developed in a breeding program.

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Table 1. Effects of spore suspension medium, leaf surface on which the spore suspension was applied, and dispersal of the spore suspension drops on infection efficiency of urediniospores of *Puccinia hemerocallidis* on Pardon Me daylilies.

Spore suspension medium	Leaf surface	Dispersal pattern	Mean number of pustules per leaf [z]				
			Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
0.2% agar	Upper	Drops	0.0	1.3 b	0.0	0.0	-
	Lower	Drops	0.0	20.3 b	0.0	4.3 b	-
	Lower	Dispersed	0.0	23.0 b	0.7 b	12.0 b	-
0.2% agar + Tween	Upper	Dispersed	0.0	3.0 b	0.0	0.0	-
	Lower	Drops	0.0	2.7 b	0.0	0.7 b	-
	Lower	Dispersed	0.0	32.0 b	0.0	0.7 b	-
Mineral oil	Upper	Dispersed	0.0	8.7 b	0.0	9.0 b	-
	Lower	Drops	5.0 b	46.7 b	81.7 a	14.3 b	52.7 b
	Lower	Dispersed	16.7 a	106.3 a	72.0 ab	0.7 b	137.7 a
0.2% agar + Nu-Film® 17	Lower	Dispersed	-	-	0.0	200.3 a	51.0 b
0.2% agar + Bio 90™	Lower	Dispersed	-	-	0.0	3.0 b	-
		LSD	8.2	58.7	76.4	53.0	54.5

[z] Data were analyzed by ANOVA and means were separated using Fishers protected least significant difference test (LSD; P=0.05). Means within a column with a letter in common are not significantly different. Values of zero with zero variance were not included in the analysis.

Effect of Plant Spacing on Microclimate and Rhizoctonia Web Blight Development in Container-grown Azalea

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Index Words: crop density, cultural control, environmental factors, binucleate *Rhizoctonia* sp., *Rhizoctonia solani*.

Significance to Industry: The results indicate that a spacing up to 9.5 inches between plants will not significantly decrease development of Rhizoctonia web blight in Gumpo azaleas. However, plant-to-plant contact should be avoided so the mycelia of *Rhizoctonia spp.* does not grow from the foliage of diseased plants to the canopy of healthy neighboring plants.

Nature of Work: Binucleate species of *Rhizoctonia* and *R. solani* cause web blight on azaleas (*Rhododendron* sp.) as well as other genera of woody plants produced in containers (3). Rhizoctonia web blight is a recurring problem on compact varieties of container-grown azaleas that first appears around late June to early July in the southeastern United States. Recommended control practices include 1) spacing plants to allow air movement to reduce humidity in the canopy, 2) applying fungicides when disease is present, 3) discarding diseased plants, and 4) sanitizing production areas after plants are moved by removing plant debris and treating the area with a disinfestant.

Increased spacing of plants, also referred to as decreased crop density, has been associated with a reduction in disease in many crop-pathogen systems. The factors affected by increased plant spacing include: reduced number of host target plants, increased distance that the inoculum of a pathogen must travel to contact plant tissue, and changes in environmental conditions (light, temperature, wind, and humidity) that affect plant and pathogen activity. Studies on plant density have shown that disease progress is reduced for some pathogens and crops but not for others (1). The nature of the host (e.g., its growth habit and rate) and the pathogen (e.g., mechanism of spore dispersal) impact the effect of plant spacing on disease development.

Rhizoctonia spp. require high humidity and warm temperatures to infect plant tissue (2,4). In a predictive brown patch model for ryegrass turf, relative humidity ≥95% for ∃8 hours and air temperatures ≥60EF were important for disease development (2). Yang and co-workers (4) found that regular periods of free moisture and a high density of plant cover contributed to expansion of Rhizoctonia aerial blight on soybeans.

The objective of this study was to correlate environmental conditions among azalea plants at different spacings with progress of Rhizoctonia web blight. During the summers of 2002 and 2003, disease severity was measured weekly on the inoculated center plant of plots consisting of 49 Gumpo azalea plants in a 7-by-7 configuration. Plant spacing within plots was set at 0, 2.375, 4.75, 7.125,

or 9.5 inches, and plots were arranged in three randomized complete blocks. Evaporative potential, leaf wetness, relative humidity, and temperature were monitored with electronic sensors adjacent to the center plant in each plot. The relationships between cumulative length of diseased stems and plant spacing and between selected environmental parameters and plant spacing were determined by regression analysis using PROC REG (SAS version 8.2).

Results and Discussion: Evaporative potential (Fig. 1) increased significantly with plant spacing, demonstrating better drying conditions in less dense plant spacings, but leaf wetness, relative humidity and temperature, summarized to reflect environmental requirements of *R. solani*, were not significantly different among spacing treatments. While plant spacing typically is recommended as a cultural control, plant spacing had no significant effect on disease severity in the 2 years of this study (Fig. 2). Disease increased steadily from mid-July to late August or early September and then decreased in both years. In southern Mississippi, periods conducive for web blight appear to exist weekly during most of the summer.

The two phases of disease progress for *R. solani* described for soybean by Yang et al. (4) of vertical growth out of the soil onto the plant, followed by vertical and horizontal growth up the plant and from plant to plant could apply to the leaf-to-leaf spread within the canopy of a single azalea shrub. The azalea cultivar Gumpo used in this study has a compact, rounded form with closely spaced branches down to the top of the container. Leaf wetness and elevated levels of relative humidity likely persist longer within the canopy, where the pathogen grows, than between canopies where instruments were set. This micro-climate within the canopy of a compact plant may have reduced the potential benefit of increased plant spacing.

Production of ornamental plants in containers in nurseries represents a different agricultural system with different micro-climate effects than row crops or turf. Ornamental plants in containers are produced on a non-soil surface (e.g., synthetic cloth, gravel, etc.) that may absorb and radiate heat differently than soil, and plants are irrigated more frequently during the time of year when temperatures favor Rhizoctonia web blight. The practice of frequent and abundant irrigation present a challenge to managing this disease in nurseries, regardless of plant spacing.

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Fig 1. Cumulative evaporative potential was measured with an atmometer near the center plant of a 7 x 7 plant plot. Symbols represent mean values and bars indicate standard errors. Means were significantly different at P<0.0001 in 2002 and 2003 based on regression analysis using PROC REG.

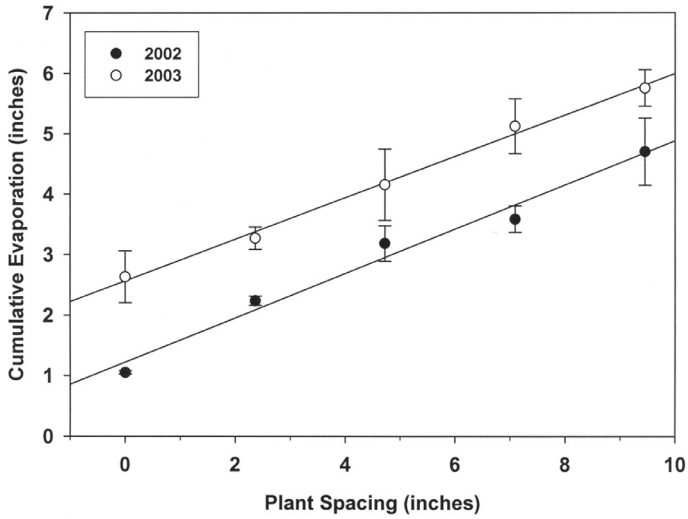
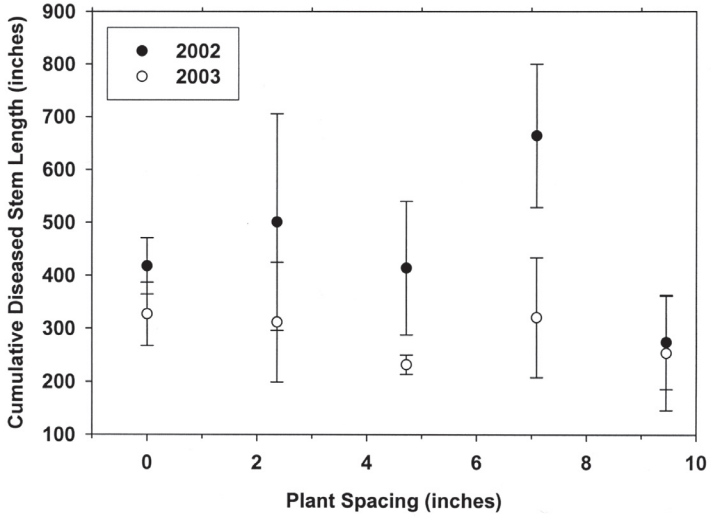


Fig 2. Cumulative total blighted stem length of the center inoculated plant of a 7 x 7 plant plot. Symbols represent mean values and bars indicate standard errors. Means were not significantly different at P=0.05 in 2002 and 2003 based on regression analysis using PROC REG.



Impact of Application Rate and Treatment Interval on the Control of Black Spot of Rose with Compass

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Index Words: Trifloxystrobin, *Diplocarpon rosae*, Heritage 50W, Daconil Ultrex, *Rosa* sp.

Significance to Industry: Compass 50W is a new broad-spectrum strobilurin fungicide that recently was registered for the control of a number of damaging diseases on a wide range of herbaceous and woody ornamentals, including black spot on rose. The activity of Compass 50W at 4 oz per 100 gal against black spot on rose was comparable to that obtained with the recommended rate of Daconil Ultrex applied on the same treatment schedule. Rates below 4 oz per 100 gal may not give consistent control of black spot regardless of the treatment interval. Further studies need to be done to determine the optimum application rate and treatment interval for the control of this damaging disease on rose. Exclusive use of a strobilurin fungicide such as trifloxystrobin or azoxystrobin (Heritage 50W®) eventually may result in a control failure due to resistance. To prevent such an occurrence, a strobilurin fungicide should make up no more than one-third of the total applications in a disease management program on a single nursery or greenhouse crop and no more than two applications of any strobilurin fungicide(s) should be made in succession. When tank-mixed with a fungicide with a different mode of action, applications of a strobilurin fungicide(s) may be included in no more than one-half of the treatments made to a specific crop or block of plants.

Nature of Work: Black spot, which is caused by the fungus *Diplocarpon rosae*, is the most common and destructive disease found on nearly all types of roses. Weather conditions in Alabama and other states in the southeastern United States are especially conductive to the development of this disease. On susceptible rose selections, considerable leaf spotting and premature leaf shed usually occurs within two months of leaf emergence in late winter to early spring. On many roses, premature leaf loss may exceed 50% to 75% by mid-summer and will remain at that level until the plants are defoliated by a hard frost.

In Alabama, weekly protective fungicide treatments are a critical component in a black spot control program on rose (2). Currently, chlorothalonil, which is sold under a number of trade names (e.g., Daconil Utrex®, Daconil Weather Stik® 6F, Ortho Garden Fungicide®), is among the most efficacious fungicides against black spot. However, applying chlorothalonil under hot, humid, sunny conditions often will result in a noticeable burning or bronzing of the leaves of many rose cultivars. In some trials, myclobutanil (e.g., Systhane, Eagle 20EW®, Immunox®) has proven nearly as effective in controlling black spot as chlorothalonil but repeated applications of this fungicide may result in shortening

of the shoot internodes (3). In contrast, Ortho Rose and Shrub Control®, which contains triforine, has proven relatively ineffective in controlling black spot (3,4).

Compass 50W®, which contains the strobilurin or QoI fungicide trifloxystrobin, is registered for the control of a wide range of diseases (e.g., powdery mildew, leaf spots, leaf blights, and Rhizoctonia diseases) on herbaceous and woody ornamentals as well as amenity turf. Residues of this fungicide are not only active on the leaf surface and bound in the leaf cuticle but also exhibit some translaminar movement through the layers of a target leaf and vapor redistribution (1). However, very little information is available concerning the influence of application rate and treatment interval on the trifloxystrobin efficacy against target diseases on herbaceous and woody ornamentals. This report summarizes the impact of application rate on the control of black spot on container-grown rose in a simulated nursery setting over a two-year period.

In 2002 and 2003, bare-root roses cv. Freedom were potted in No. 1 containers in a 3:1, v/v, aged pine bark:peat moss medium amended with 14 lb of 17-7-12 Osmocote, 6 lb of dolomitic limestone, 2 lb of gypsum, and 1.5 lb of Micromax per cubic yard of potting medium. Plants were maintained under 47% shade cloth on a clamshell bed and watered daily with overhead impact sprinklers. In both years, a randomized complete block design with five single-plant replications was used. The test plants were re-randomized following each fungicide application. Fungicides were applied from 1 February to 22 May 2002 and from 10 February to 10 June 2003 with a CO_2-pressurized sprayer. Sil-Spread non-ionic surfactant at a rate of 0.06% v/v was added to all Compass 50W and Heritage 50W treatments. Disease severity were assessed on 4 June 2002 and 5 June 2003 using a Horsfall and Barratt rating scale: 1 = no disease, 2 = 0 to 3%, 3 = 3-6%, 4 = 6-12%, 5 = 12-25%, 6 = 25-50%, 7 = 50-75%, 8 = 75-87%, 9 = 87-94%, 10 = 94-97%, 11 = 97 – 100%, and 12 = 100% of leaves damaged or prematurely shed due to black spot. In 2002, plant dimensions (width in two directions and height) also were measured on 4 June, and a growth index was calculated ([height+width1+width2]/3) to estimate overall plant growth. Significance of treatment effects was tested by analysis of variance, and means were separated with Fisher's protected least significant difference test (P= 0.05).

Results and Discussion: Since the monthly rainfall totals recorded during the 5-month study period in 2002 were below the historical average for the city of Mobile, black spot symptoms were relatively slow to develop and the unsprayed controls were not as heavily defoliated as expected (Table 1). When compared with the unsprayed control, all rates of Compass 50W that were applied at 1-, 2-, and 4-week intervals significantly reduced the incidence of black spot. Compass 50W at 1 oz per 100 gal of spray volume proved most effective at controlling black spot when applied every week. In contrast, 2.0 and 4 oz per 100 gal of Compass 50W gave excellent disease control when applied at 1- and 2-week intervals and, to a lesser extent, at 4-week intervals. In fact, those roses treated weekly with the two higher rates of Compass 50W remained free of black spot. When compared with the unsprayed control, Heritage 50W gave some protection but was not as effective as the two higher rates of Compass 50W applied on the same schedule. Roses treated with the 1 oz rate of

Compass 50W at 1- and 2-week intervals had a significantly higher growth index than the unsprayed controls while those receiving weekly treatments of the 4 oz rate of the same fungicide were significantly smaller. No other symptoms of phytotoxicity were associated with the use of Compass 50W.

In 2003, monthly rainfall totals throughout most of the late winter and spring exceeded the historical average for the city of Mobile. Again, application rate and treatment interval had a significant impact on the efficacy of Compass 50W for the control of black spot on rose (Table 1). In general, the effectiveness of Compass 50W against black spot improved as the application rate increased from 1 oz to 4 oz per 100 gal of spray volume; the best control was obtained with the 4.0 oz per 100 gal rate applied at 1- and 2-week intervals. As indicated by disease ratings of 2.0 and 2.3, symptoms on the roses treated with the 4 oz per 100 gal rate of Compass 50W were limited to light spotting of the leaves in the lower canopy. At the 2 oz rate of Compass 50W, similar black spot damage was noted on the roses treated at 1-, 2-, and 4-week intervals. While some reduction in disease severity was obtained with the 1 oz rate of Compass 50W applied on a 1- and 2-week schedule, the level of black spot control was not comparable to that obtained with Daconil Ultrex applied twice each month. Disease severity on the Heritage 50W treated roses and the unsprayed control was similar.

Application rate and treatment interval had a significant impact on the level of black spot control provided by Compass 50W. However, most Compass 50W treatments gave better black spot control in 2002 than in 2003 when disease pressure was lower. Across both years, the best black spot control with Compass 50W was provided by the 4 oz per 100-gal rate applied at 1- and 2-week intervals. In 2003, the level of control obtained with this rate was comparable to that provided by Daconil Ultrex applied on 2-week schedule. Additional long-term studies need to establish whether Compass 50W will provide a comparable level of black spot control as chlorothalonil without the foliar burn often associated with the summertime use of this fungicide.

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Table 1. Impact of application rate and treatment interval on the control of black spot of rose with Compass 50W at the Ornamental Horticulture Research Center in Mobile, AL in 2002 and 2003.

Treatment and Rate/100 gal	Treatment Interval (weeks)	Disease Severity Rating[z] 2002	Disease Severity Rating[z] 2003	Growth Index[y] 2002
Compass 50W 10 oz.	1	1.5 de [x]	3.3 cde	53.3 a
Compass 50W 1 oz.	2	3.7 b	4.5 bc	44.8 c
Compass 50W 1 oz.	4	3.8 b	5.8 a	50.1 abc
Compass 50W 2 oz.	1	1.0 e	3.2 def	50.2 abc
Compass 50W 2 oz.	2	1.5 de	4.0 bcd	51.3 ab
Compass 50W 2 oz.	4	2.7 c	3.8 cd	51.1 ab
Compass 50W 4 oz.	1	1.0 e	2.0 fg	37.8 d
Compass 50W 4 oz.	2	1.5 de	2.3 efg	45.9 bc
Compass 50W 4 oz.	4	2.3 cd	4.0 bcd	48.7 bc
Heritage 50W 4. oz.	2	3.0 bc	5.2 ab	48.7 bc
Daconil Ultrex 82.5 WDG 1.4 lb	2	---	1.5 g	---
Unsprayed Control	---	5.2 a	5.8 a	47.8 b

[z]Black spot was rated on a 1 to 12 Barratt and Horsfall rating scale.

[y]The growth index = (plant height + plant width 1 + plant width 2) / 3.

[x]Means within each column that are followed by the same letter are not significantly different according to Fisher's least significant difference (LSD) test (P=0.05).

Control of Powdery Mildew, Spot Anthracnose, and Cercospora Leaf Spot on Field-Grown Flowering Dogwood Trees

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Index Words: *Microsphaera pulchra, Elsinoe corni, Cercospora cornicola,* biological control, chemical control, Neem Oil Concentrate, SunSpray Ultra Fine Oil, Rhapsody, Eagle 40W, Systemic Fungicide, 3336 50W, myclobutanil, propiconazole, thiophanate-methyl

Significance to Industry: Powdery mildew and spot anthracnose are endemic diseases on flowering dogwoods in Alabama landscapes. A spring and summer fungicide program not only improved tree aesthetics, but the beneficial effects also carried through into mid-October as greatly enhanced fall color due to superior leaf retention. Impact of some fungicide programs was seen in the following spring in the form of spot anthracnose control, as well as a greatly improved floral display that resulted from the control of this disease. Fungicides that gave the broadest spectrum of disease control and enhanced tree aesthetics were Immunox, Eagle 40W, Systemic Fungicide, and 3336 50W. SunSpray Ultra Fine Oil damaged the leaves of flowering dogwood.

Nature of Work: Powdery mildew, which is caused by the fungus *Microsphaera pulchra*, is the most common disease on native seedling and clonal cultivars of flowering dogwood (*Cornus florida*). While powdery mildews on many ornamentals are considered largely cosmetic, seedling death, as well as reduced tree growth and vigor, have been associated with severe powdery mildew outbreaks on flowering dogwood (2, M. Windham *personal communication*). Although powdery mildew resistant cultivars are available, the majority of dogwoods sold in Alabama are susceptible native seedling trees and clonal cultivars (1).

Spot anthracnose, which is caused by the fungus *Elsinoe corni*, is most common on flowering dogwood trees growing in full sun. Although the impact of this disease on tree vigor probably is minimal, bracts and leaves of susceptible trees may be badly defaced and distorted (3). Relatively few flowering dogwood cultivars as well as native seedling trees are resistant to spot anthracnose (1).

The occurrence of Cercospora leaf spot, which is caused by the fungus *Cercospora cornicolais*, often is overlooked in landscape plantings of flowering dogwood. Symptoms do not become noticeable until late summer or early fall. Heavily spotted leaves quickly turn yellow and prematurely fall to the ground, starting with the leaves in the lower tree canopy. Heavily diseased trees usually are defoliated so early in the fall that there is little or no fall color.

The objective of this study was to compare the efficacy of Neem Concentrate and SunSpray Ultra Fine Oil with that of selected synthetic fungicides for the control of spot anthracnose, powdery mildew, and Cercospora leaf spot on flowering dogwood trees in a simulated landscape planting. In addition, the impact of fungicide inputs on the floral display and growth of flowering dogwood also was evaluated.

In February 2001, flowering dogwood trees cv. Rubra were transplanted from No. 5 containers into a Benndale sandy loam soil at the Brewton Agricultural Research Unit (USDA Hardiness Zone 8a). Prior to establishment, soil fertility and pH were adjusted according to the results of a soil fertility assay. Newly established trees were mulched with approximately 1 inch of aged pine bark following the installation of a drip irrigation system. On 25 February and 3 March 2003, 2.9 oz of murate of potash (0-0-60) and 2.1 oz of 16-4-8 fertilizer were evenly distributed. In addition, each tree was top-dressed with an additional 2.1 oz of ammonium nitrate (34-0-0) on 12 March and 16 April. A broadcast application of 1 lb of Gallery and 2 qt of Surflan per treated acre was made on 19 May. Additional grass control was obtained with directed applications of Finale. A randomized complete block design with five single-tree replications was used. Fungicide treatments were applied to drip with a CO_2-pressurized sprayer from 4 April to 1 July 2003 at the intervals listed in the tables. Incidence of spot anthracnose and powdery mildew, as well as the severity of Cercospora leaf spot-caused-leaf spotting and defoliation were rated using the Barratt and Horsfall rating scale: 1 = no disease, 2 = 0 to 3%, 3 = 3-6%, 4 = 6-12%, 5 = 12-25%, 6 = 25-50%, 7 = 50-75%, 8 = 75-87%, 9 = 87-94%, 10 = 94-97%, 11 = 97-100%, and 12 = 100% of the leaves damaged or prematurely shed. Ratings for spot anthracnose were taken on 23 April, 29 May, 18 June, and 16 July; powdery mildew ratings were recorded on 29 May, 18 June, and 16 July; and Cercospora leaf spot-caused leaf spotting and defoliation was rated on 18 August, 3 October, and 30 October. Significance of treatment effects were tested by analysis of variance, and means were separated with Fisher's least significant difference (LSD) test (P=0.05). Trees also were examined for symptoms of phytotoxicity.

Results and Discussion: In 2003, monthly rainfall totals were near normal for April, May, August, and September, were well above average for June and July, and were well below average for October. Daily temperatures were near normal and no extended periods of hot, dry weather occurred. Of the three diseases, spot anthracnose appeared first. Pinhead sized spots, which are characteristic of this disease, were first noted shortly after bud-break in early April and symptom development continued on newly unfurled leaves into June. When compared with the unsprayed controls, significant reductions in the incidence of spot anthracnose were obtained with all treatments except for the Neem Concentrate applied at 1- and 2-week intervals and weekly applications of SunSpray Ultra Fine Oil (Table 1). Immunox, Eagle 40W, Systemic Fungicide, and 3336 50W were equally effective at protecting flowering dogwood from spot anthracnose. Results similar to those recorded on 23 April for Immunox, Eagle 40W, Systemic Fungicide, and 3336 50W also were logged on 29 May, 18 June, and 16 July.

Onset of powdery mildew occurred between 23 April and 29 May. Noticeable disease spread occurred from late May through mid-July. As indicated by a 6.7 rating, the powdery mildew fungus colonized nearly 50% of the leaves on the unsprayed controls by 16 July (Table 1). On that same date, all of the fungicide treatments significantly reduced the incidence of powdery mildew compared to the unsprayed controls. Very little powdery mildew was observed on trees treated with Immunox, Eagle 40W, Systemic Fungicide, and 3336 50W, as well as those trees receiving weekly treatments of Neem Concentrate and Rhapsody. SunSpray Ultra Fine Oil applied at 1- and 2-week intervals and Neem Concentrate applied at 2-week intervals were not effective at controlling powdery mildew (Table 1).

Cercospora leaf spot, which was seen on a few scattered leaves as early as mid-June, did not intensify until late July. Defoliation due to Cercospora leaf spot, which rapidly accelerated in October, continued until all the leaves were shed in December. While all fungicides reduced the level of premature leaf shed, significant differences in disease severity between fungicide treatments were seen at all rating dates. The most notable reductions in Cercospora leaf spot were obtained with Immunox, Eagle 40W, 3336 50W, Systemic Fungicide and to a lesser extent with SunSpray Ultra Fine Oil and Neem Concentrate. Disease ratings for the Rhapsody-treated dogwood trees were similar to that noted for the unsprayed trees.

SunSpray Ultra Fine Oil was phytotoxic. A yellowish and dark green mosaic pattern, as well as interveinal chlorosis was seen on the treated plants; these symptoms were most noticeable on the trees treated weekly. When compared to the untreated control, a significant reduction in the rate of tree caliper growth was noted on the Systemic Fungicide and Eagle 40W-treated flowering dogwood (*data not shown*).

Fungicides applied in 2003 had a significant impact on spot anthracnose incidence on the bracts, percentage of aborted flower buds, and on flower bud formation in 2004 (Table 2). When compared with the unsprayed controls, all of the 2003 fungicide treatments except for Sun Spray Ultra Fine Oil reduced the disease incidence on the bracts, and significant differences in were noted among fungicide treatments. The least spot anthracnose damage was noted on the trees treated the previous year with Immunox, 3336 50W, Systemic Fungicide, and Eagle 40W. The reduction in disease incidence obtained with Neem Concentrate and Rhapsody was not comparable to that provided by Immunox, 3336 50W, and Systemic Fungicide.

With the exception of SunSpray Ultra Fine Oil, the number of aborted or damaged flower buds was higher in April 2004 on the unsprayed controls than for the fungicide-treated flowering dogwood (Table 2). In contrast, the fewest aborted buds were found on trees treated with Immunox, Systemic Fungicide, 3336 50W, and Eagle 40W. Among all the fungicide programs, only Neem Concentrate-treated trees had more flower buds than did the unsprayed controls (Table 2). Otherwise, number of flower buds on the fungicide treated and the unsprayed control trees were similar.

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Table 1. Control of spot anthracnose, powdery mildew, and Cercospora leaf spot on flowering dogwood cv. Rubra in a simulated landscape planting at the Brewton Agricultural Research Unit, 2003.

				Cercospora Leaf Spoty		
Fungicide and Rate per 100 gal	**Spray Interval (wk)[z]**	**Spot Anthracnose[xy]**	**Powdery Mildew[wy]**	**19 Aug**	**3 Oct**	**30 Oct**
Immunox 100 fl oz	2	1.7[v] e	1.0 d	1.0 b	3.0 de	5.0 c
Neem Concentrate 0.8 gal	1	4.8 ab	1.8 cd	1.0 b	4.0 cd	5.3 c
Neem Concentrate 0.8 gal	2	5.7 a	3.5 bc	1.5 b	4.8 bc	6.0 bc
Sun Spray Ultra Fine Oil 0.8 gal	1	4.8 ab	3.7 bc	1.0 b	4.7 bc	5.8 bc
SunSpray Ultra Fine Oil 0.8 gal	2	3.3 cd	4.6 b	1.8 ab	5.4 ab	6.4 b
Rhapsody 3 gal	1	4.0 bc	2.7 cd	1.3 b	5.7 ab	6.8 ab
Eagle 40W 8 oz	2	2.0 de	1.0 d	1.0 b	2.7 e	5.2 c
3336 50W 1 lb	2	2.2 de	1.8 c	1.0 b	2.5 e	5.0 c
Systemic Fungicide 0.4 gal	2	2.2 de	1.0 d	1.0 b	2.6 e	5.2 c
Unsprayed Control	---	5.3 a	6.7 a	2.5 a	6.3 a	7.8 a

[z]Fungicides were applied at the interval specified above from 4 April to 1 July 2003.

[y]Spot anthracnose, powdery mildew, and Cercospora leaf spot were rated on a 1 to 12 Barratt and Horsfall rating scale.

[x]Spot anthracnose ratings presented were recorded on 23 April.

[w]Powdery mildew ratings presented were recorded on 16 July.

[v]Means in each column were separated using Fisher's least significant difference (LSD) test (P=0.05).

Table 2. Impact of fungicide treatments applied in 2003 to dogwood trees cv. Rubra on the incidence of spot anthracnose on the bracts, percent aborted flower buds, and number of flower buds in April 2004.

Fungicide and Rate per 100 gal	Spray Interval (weeks)[z]	Spot Anthracnose Rating [y]	Aborted Flower Buds (%)	Flower Buds (no.)
Immunox 100 fl oz	2	2.0 d [x]	6.0 d	139 ab
Neem Concentrate 0.8 gal	1	4.7 c	43.3 b	156 a
Neem Concentrate 0.8 gal	2	5.0 bc	35.0 bc	108 abc
Sun Spray Ultra Fine Oil 0.8 gal	1	6.7 ab	53.3 ab	121 abc
SunSpray Ultra Fine Oil 0.8 gal	2	6.7 ab	66.7 a	54 c
Rhapsody 3 gal	1	4.7 c	41.7 b	104 ab
Eagle 40W 8 oz	2	2.7 d	16.7 cd	137 abc
3336 50W 1 lb	2	1.8 d	13.3 cd	123 abc
Systemic Fungicide 0.4 gal	2	2.4 d	12.0 cd	111abc
Unsprayed Control	---	8.3 a	75.0 a	65 bc

[z]Fungicides were applied at the interval specified from 4 April to 1 July 2003.

[y]Spot anthracnose, powdery mildew, and Cercospora leaf spot were rated on a 1 to 12 Barratt and Horsfall rating scale.

[x]Means in each column were separated using Fisher's least significant difference (LSD) test (*P*=0.05).

Reaction of Marigold Selections to Alternaria Leaf Spot

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Index Words: *Tagetes erecta, Tagetes patula*, African marigold, French Dwarf Marigold, *Alternaria tagetica*, Disease Susceptibility

Significance to Nursery Industry: African and French Dwarf marigolds are among the most widely planted flowering summer annuals. Alternaria leaf spot is a devastating disease of marigold that greatly reduces their beauty, vigor, and longevity in landscape plantings. Although differences in the rate of disease development were seen between commercial marigold cultivars, all eventually suffered from unacceptable and severe defoliation 14 to 16 weeks after plant establishment. Marigold cultivars that were least susceptible to Alternaria leaf spot were Little Hero Fire, Little Hero Yellow, and Bonanza Yellow. However, none of these marigold selections demonstrated a high level of disease resistance and all eventually suffered heavy damage. Additional research is required to identify a source of resistance among the many commercial and antique African, French dwarf, and hybrid marigold selections.

Nature of Work: Alternaria leaf spot, which is caused by the fungus *Alternaria tagetica*, is a widespread and destructive disease in landscape plantings of African and French dwarf marigold. Damaging outbreaks of this disease may also occur in flat- and container-grown marigolds in production greenhouses and retail outlets. The causal fungus is introduced into the greenhouse on infested seed and into the landscape on diseased plants (2). Once introduced, this fungus will aggressively attack current and future marigold plantings.

Tiny, brown, pinhead-sized spots on the older leaves around the base of the plant typically are the first symptoms seen. As the number of spots increases, diseased leave turn yellow, wither, and die. Typically, leaf death begins at the base of the main shoot just above the soil line and will continue until all but the youngest leaves have died. Highly susceptible marigold selections often succumb to Alternaria leaf spot. Frequent showers or excessive overhead watering accelerate the rate of disease development.

Avoiding outbreaks of Alternaria leaf spot on marigold presents a significant challenge. In Alabama and surrounding states, destructive outbreaks of this disease on marigold are almost inevitable. While Heritage 50W® (azoxystrobin) and Chipco GT® (iprodione) will protect marigold from Alternaria leaf spot, the required twice-monthly treatment schedule is costly and impractical (1). Immunox® (myclobutanil) and Daconil Weather Stik® (chlorothalonil), which are marketed to residential clientele, have little or no activity against this disease (1). Resistance is the best defense against an aggressive pathogen like *Alternaria tagetica* (2). However, information concerning the reaction of popular commercial marigold cultivars to Alternaria leaf spot is not available. The objective of this

study was to assess the susceptibility of selected commercial marigold cultivars to Alternaria leaf spot in a simulated landscape setting.

Flats of African (*T. erecta*) and French dwarf (*T. patula*) marigolds were purchased from retail outlets. Prior to planting in 2001 and 2002, 400 lb/A and 500 lb/A, respectively, of 13-13-13 fertilizer was broadcast and incorporated. Four plants of each cultivar were planted in a 1-foot square in a Benndale sandy loam soil at the Brewton Agricultural Research Unit (USDA Hardiness Zone 8a). Plots were mulched with aged pine bark shortly after planting. During the study period, calcium nitrate or potassium nitrate at 7 to 10 lb/A was applied at 1-week intervals through the drip irrigation system that was installed immediately after establishment. The plots were watered as needed. Corral 2.68G herbicide was broadcast a week after planting for pre-emergent weed control. Escape weeds were chopped with a hoe or pulled by hand.

Severity of Alternaria leaf spot was assessed 0n a 1 to 10 scale where 1 = no disease, 2 = a few leaf spots in lower canopy, 3 = light leaf spotting in lower and upper canopy, 4 = light leaf spotting with a low level of leaf death (≤10%), 5 = leaf spots noticeable with some leaf death (≤25%), 6 = leaf spots numerous with moderate leaf death (≤50%), 7 = heavy leaf spotting with considerable leaf death (≤75%), 8 = very heavy leaf spotting of few remaining leaves (≤90%), 9 = plants almost completely defoliated (<95%), and 10 = plant defoliated or dead. Disease ratings were taken in 2001 on 15 June, 5 July, 1 August, 26 August, and 20 September and in 2002 on 2 July, 25 July, 12 August, 27 August, and 2 October. Area under the disease progress curve (AUDPC) was calculated for each marigold cultivar. Significance of treatment effects were tested by analysis of variance and Fisher's least significant difference test (LSD; P=0.05) was used to separate treatment means.

Results and Discussion: At each rating date in 2001, significant differences in the severity of Alternaria leaf spot were noted among marigold cultivars (Table 1). Within one month of planting, symptoms on all cultivars were limited to light spotting of the leaves. In some instances, only one to a few spots was seen. By the July rating date, development of Alternaria leaf spot had accelerated. While noticeable leaf spotting was found on all cultivars, premature leaf death, as indicated by disease ratings above 3.0, was observed on seven marigold cultivars. By 26 August, heavy leaf spotting as well as moderate to severe leaf loss was noted on nearly all cultivars. At this point, Discovery Yellow and Little Hero Fire suffered from less premature leaf death than did the remaining marigold cultivars. With the exception of these marigold cultivars, disease ratings that were recorded in late August and late September did not differ appreciably. At all rating dates, Sweet Cream consistently had the highest Alternaria leaf spot rating. By the last two rating dates, very few, heavily spotted leaves remained on the shoots of this marigold cultivar.

In 2001, significant differences in the AUDPC vales were noted between the 15 marigold cultivars (Table 1). Discovery Yellow and Little Hero Fire had among the lowest AUDPC values. The AUDPC for Safari Yellow and Bonanza Yellow also did not differ significantly from those recorded for Little Hero Fire. As expected, the heavily damaged Sweet Cream marigold had an AUDPC value

that was significantly higher than that for the remaining marigold cultivars. Other marigolds with a high AUDPC value were Bonanza Bee and Inca Mix.

With the exception of Sweet Cream, very little Alternaria leaf spot damage was found on the majority of marigold cultivars on the 2 July 2002 rating date (Table 2). Alternaria leaf spot severity greatly intensified between the 2 July and 27 August rating dates. By the final rating date, the least leaf spotting and premature leaf death was noted on Little Hero Yellow and Bonanza Yellow while Sweet Cream again was the cultivar that suffered the heaviest Alternaria leaf spot damage.

In 2002, the AUDPC value for Sweet Cream was significantly higher compared with those for the other marigold cultivars in the trial (Table 2). Other marigold cultivars that had high AUDPC values and were most susceptible to Alternaria leaf spot were Inca Yellow, Discovery Yellow, and Bonanza Bee. In contrast, the lowest AUDPC values were recorded for Bonanza Yellow, Little Hero Yellow, Safari Queen, Safari Tangerine, and Janie Gold.

While none of the marigold cultivars demonstrated a high level of resistance to Alternaria leaf spot, significant differences in cultivar susceptibility to this disease were observed. In 2001 and 2002, Little Hero Fire and Little Hero Yellow, respectively, as well as Bonanza Yellow were less susceptible to Alternaria leaf spot than most of the remaining marigold cultivars. Generally, rate of disease development on the above marigold cultivars appeared to be slower, particularly in July and August, than was seen on other cultivars. By early fall, however, heavy leaf spotting as well as premature leaf loss, between 50% and 75%, was noted on Little Hero Fire, Little Hero Yellow, and Bonanza Yellow. Over the two-year study period, Sweet Cream was more susceptible to Alternaria leaf spot than any other marigold cultivar. Within four to six weeks of planting, considerable leaf spotting, as well as some premature leaf death was observed on this cultivar. By mid-summer, over 50% of the leaves in the canopy had withered and died. Other marigold cultivars that proved highly sensitive to Alternaria leaf spot included Inca Orange, Bonanza Bee, and possibly Discovery Yellow.

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Table 1. Severity of Alternaria leaf spot on selected cultivars of African and French dwarf marigold at the Brewton Agricultural Research Unit in 2001.

		Alternaria Leaf Spot Rating[y]					AUDPC
Cultivar	Type[z]	15 June	5 July	1 August	26 August	20 September	2001
Safari Orange	A	1.3 d[x]	2.8 cde	4.7 de	7.0 b	6.8 cd	462 cde
Safari Yellow	A	1.7 cd	2.8 cde	3.5 f	6.3 cd	6.8 cd	418 ef
Safari Scarlet	A	1.8 bcd	3.3 cd	4.8 cd	7.0 b	7.0 cd	485 bc
Discovery Yellow	A	2.3 ab	4.3 b	4.0 def	5.2 e	6.3 e	438 def
Little Hero Fire	F	1.8 bcd	3.0 cde	4.2 def	4.7 e	6.5 de	395 f
Sweet Cream	A	2.7 a	5.5 a	6.8 a	8.7 a	8.8 a	661 a
Bonanza Bee	F	1.5 cd	3.0 cde	6.0 ab	7.3 b	7.7 b	521 b
Bonanza Flame	F	1.7 cd	3.0 cde	4.7 de	6.3 cd	7.0 cd	454 de
Bonanza Orange	F	1.8 bcd	2.8 cde	5.0 bcd	7.2 b	7.2 bc	484 bcd
Bonanza Yellow	F	1.5 cd	2.3 e	3.7 ef	6.0 d	6.3 e	394 f
Disco Orange	F	1.5 cd	2.5 de	3.7 ef	7.3 b	7.2 bc	450 de
Perfection Yellow	A	2.0 bc	4.3 b	4.3 def	6.8 bc	6.7 cde	489 bcd
Orange Boy	F	1.8 bcd	3.5 bc	4.7 de	6.3 cd	6.8 cde	466 cde
Yellow Boy	F	1.2 d	3.3 cd	5.8 abc	7.0 b	7.0 cd	504 bc
Inca Mix	F	2.0 bc	4.3 b	5.0 bcd	6.8 bc	7.0 cd	510 bc

[z]Marigold type: A = African and F = French dwarf.

[y]Severity of Alternaria leaf spot was assessed on a 1 to 10 scale.

[x]Means within each columns that are followed by the same letter are not significantly different was according to Fisher's least significant difference (LSD; P=0.05) test.

Table 2. Severity of Alternaria leaf spot on selected cultivars of African and French Dwarf marigold at the Brewton Agricultural Research Unit in 2002.

		Alternaria Leaf Spot Rating[y]					AUDPC
Cultivar	Type[z]	2 July	25 July	12 August	27 August	2 October	2002
Safari Orange	A	1.7 c[x]	3.0 ef	5.4 cde	6.8 bc	7.2 f	473 ef
Safari Yellow	A	1.4 d	3.5 cde	5.6 bcd	6.4 bcde	7.1 fg	471 ef
Safari Tangerine	A	1.3 d	2.8 efg	5.2 def	6.4 bcde	6.6 h	440 fg
Safari Queen	A	2.0 bcd	2.6 fg	4.8 fg	6.2 def	8.3 c	438 fg
Discovery Yellow	A	2.6 b	3.8 bcd	6.0 ab	6.9 b	8.6 bc	532 bc
Discovery Orange	A	1.9 bcd	3.0 ef	5.7 bc	6.5 bcde	6.6 h	497 cde
Little Hero Yellow	F	2.0 bcd	3.2 def	4.9 efg	5.4 g	8.8 b	426 g
Sweet Cream	A	4.0 a	5.2 a	6.5 a	7.5 a	7.9 d	608 a
Bonanza Bee	F	1.2 d	4.5 ab	5.8 bc	6.8 bc	6.8 gh	515 bcd
Bonanza Orange	F	1.3 d	3.5 cde	5.1 def	6.1 efg	7.3 ef	449 fg
Bonanza Yellow	F	1.2 d	2.2 g	4.4 g	5.8 fg	7.6 de	411 g
Marietta Red	F	1.2 d	3.0 ef	4.8 fg	6.9 b	7.0 fg	467 ef
Disco Yellow	F	1.2 d	4.0 bc	5.0 ef	6.3 cdef	6.8 g	465 ef
Janie Gold	F	1.2 d	3.5 cde	5.2 def	6.0 efg	7.3 ef	445 fg
Inca Yellow	A	2.3 bc	3.8 bcd	5.6 bcd	6.8 bc	9.4 a	541 b
Inca Orange	A	1.8 bcd	3.2 def	4.9 efg	6.7 bcd	8.7 b	492 de

[z]Marigold type: A = African and F = French dwarf.

[y]Severity of Alternaria leaf spot was assessed 0n a 1 to 10 scale.

[x]Means within each columns that are followed by the same letter are not significantly different according to Fisher's least significant difference (LSD; P=0.05) test.

Efficacy of Chlorine on *Pythium* Species in Irrigation Water

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Index words: *Pythium*, irrigation water, decontamination, chlorination
Significance to Industry: Capturing surface water for irrigation is critical to sustain the production and growth of individual enterprises and the nursery industry as a whole, as global water scarcity and pollution rapidly spreads. How to minimize disease pressure associated with recycling irrigation is an emerging and serious question all growers face today. An immediate benefit of this study is provision of a procedure to ensure efficacy of chlorination for controlling Pythium pathogens in irrigation water.

Nature of Work: *Pythium* species are economically important pathogens of nursery crops. These pathogens typically are soilborne and, therefore, difficult to control once a plant is infected or soil and container mixes are contaminated. The pathogens usually attack root systems and progress gradually without obvious foliar symptoms until a plant is near collapse. As a result, Pythium diseases often receive less attention, are less likely to be controlled in a timely manner, and may result in more crop losses than those diseases displaying more obvious symptoms. The best strategy for managing Pythium diseases is prevention by eliminating or minimizing inoculum from all possible sources.

Among numerous potential sources of inoculum, irrigation water can be an important one for *Pythium* spp. as demonstrated for *Phytophthora* species (1). Species of *Pythium* and *Phytophthora* are closely related morphologically and genetically; they are in the same family taxonomically (3). *Pythium* spp. are 10 to 100 times more populous than *Phytophthora* spp. in irrigation water but have received much less attention in the scientific literature. This is partly due to the difficulty in identifying species of *Pythium*. Chlorination of irrigation water is an integral part of crop production at many nurseries and greenhouses. The objective of this study was to determine if current chlorination protocols recommended for management of *Phytophthora* spp. in irrigation water also will control Pythium pathogens.

A total of 15 isolates of *Pythium* spp. were tested for sensitivity to chlorine. Six of these isolates were recovered from nonchlorinated irrigation water, five from chlorinated water, and four from diseased plants. All isolates were tested at the same concentration of 1350 zoospores/ml. Zoospores were exposed 2 minutes to 0.25, 0.5, 1.0, 2.0, 4.0 or 8.0 ppm of free chlorine and spore suspensions were spread on the surface of PARP-V8 agar (2). Each isolate was tested 3 times. Additional tests were performed for those isolates surviving at 2 ppm or above. Developing Pythium colonies in each Petri dish were counted daily for chlorine treatments and untreated control (0 ppm).

Results and Discussion: Eleven of the 15 isolates did not survive any chlorine treatments of 2 ppm or above as illustrated in Figure 1. Four isolates produced a few colonies at 2 ppm or above in one or two of the three repeated tests (Figure 2). Isolate 17C2 produced two colonies at 2 ppm in one test; isolate 23J3 averaged 0.3 colonies at the same concentration in two tests. Isolates 4E1 and 5J5 produced a few colonies at 8 ppm in one test, but none at 2 ppm or above in the other two tests. These isolates only survived up to 1 ppm in the additional tests. These results suggest that the 2 ppm of free chlorine recommended at discharge points (risers or sprinklers) for management of *Phytophthora* spp in irrigation water. also should effectively manage zoospores of *Pythium* spp.

It must be noted that substantial numbers of colonies were recovered at 1 ppm for a majority of the isolates and that there essentially were no differences in colony recovery between 0.25 and 1.0 ppm of chlorine for most isolates. This chlorine response is considerably different from that of *Phytophthora* species (2). The reason for this is unknown. These results suggest that failure to maintain a concentration of 2 ppm of chlorine may expose ornamental crops in the production facility to Pythium diseases.

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Acknowledgements: This project was supported in part by the Floral Industry Research and Scholarship Trust.

Figure 1. Survival (colonies/Petri dish) of *Pythium sulcatum* isolated from irrigation water after being exposed 2 minutes to different chlorine concentrations; each line represents a separate trial.

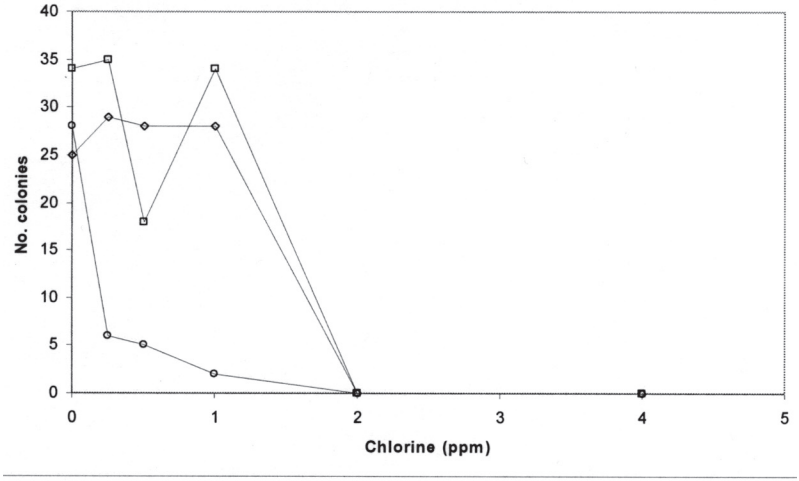
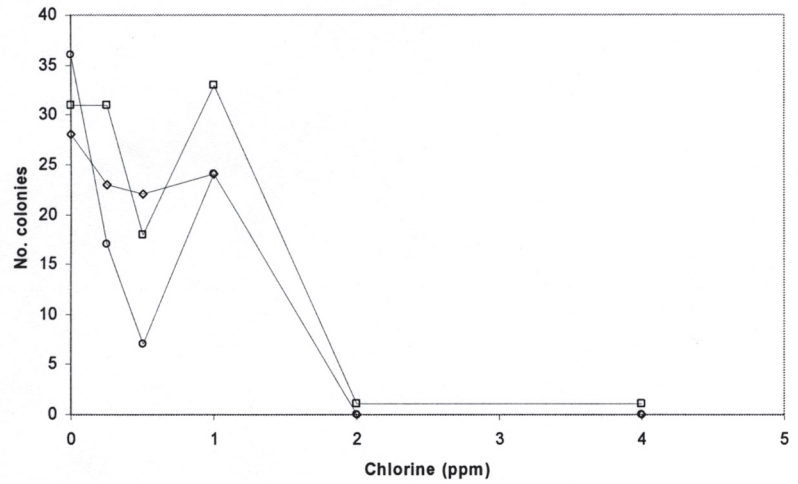


Figure 2. Survival (colonies/Petri dish) of *Pythium aphanidermatum* isolated from a diseased plant after being exposed 2 minutes to different chlorine concentrations; each line represents a separate trial.



Response of Bedding Plants to Heritage Maxx

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Index Words: Heritage Maxx, azoxystrobin, bedding plants

Significance to Industry: Due to the demand of asymptomatic foliage of bedding plants by consumers and the conducive environment for foliar diseases that bedding plants are produced in, new fungicides or new formulations of fungicides already labeled for these diseases will continue to be in demand The new formulation of an azoxystrobin fungicide, Heritage Maxx, did not adversely affect the foliage of tested plants but reduced the value of some bedding plants by burning or distorting blooms.

Nature of Work: Production of bedding plants is often impeded by fungal diseases on the foliage such as Alternaria leaf spot, Botrytis blight and Phytophthora aerial blight. These diseases are favored by the warm, humid conditions commonly found in production greenhouses and by spacing of plants too closely. Fungicides often are required for controlling these diseases. In 2003, we evaluated a new formulation of azoxystrobin, labeled as Heritage Maxx, for phytotoxic effects on a variety of bedding plants.

Fourteen species of bedding plants (Table 1) were treated with Heritage Maxx at a rate of 5 or 20 oz/100 gal (0.4 or 1.6 ml/l) and the plants were arranged in a randomized complete block design in a greenhouse with four replications. One replication for alyssum, bell pepper, black-eyed Susan, Canterbury bells, carnation, coneflower, cucumber, marigold, salvia, and tomato was a 606 cell pack containing six plants; one replication for coleus, geranium, and snapdragon was one plant in a 4-inch container. Plants sprayed with water served as controls. A spreader/sticker was not used in this experiment. The plants were sprayed once on a cloudy day (66 F = 19 C) on May 2, 2003. Plants were examined for symptoms of phytotoxicity three days later on May 5.

Results and Discussion: No symptoms of phytotoxicity were observed on the foliage of any plants sprayed with Heritage Maxx at either rate or on foliage or blooms of plants that served as controls (Table 1). Flower petals of snapdragons and marigolds sprayed with Heritage Maxx suffered severe burn (Table 1) at both rates of the fungicide. Petals of snapdragons and marigolds were distorted on plants sprayed at the high rate. Other plants in the study with abundant flowers were alyssum, carnation, geranium, petunia and salvia. No flowers on these plants exhibited phytotoxic symptoms.

Based on the variety of plants tested, Heritage Maxx could be used to control foliar diseases on bedding plants without flowers. However, if flowers are present, plants could be adversely affected by Heritage Maxx application and, therefore, the economic value of the plants would be reduced significantly.

Table 1. Phytotoxic effects of Heritage Maxx applied at 5 or 20 oz/100 gal on selected bedding plants.

Common Name	Latin Binomial	Plant Organs Examined	Level of Damage
Alyssum	*Alyssum saxatile*	foliage and flowers	none
Bell pepper	*Capsicum annum*	foliage	none
Black-eyed Susan	*Rudbeckia hirta*	foliage	none
Canterbury bells	*Campanula medium*	foliage	none
Carnation	*Dianthus caryophyllus*	foliage and flowers	none
Coleus	*Coleus blumei*	foliage	
Cone flower	*Rudbeckia laciniata*	foliage	foliage
Cucumber	*Cucumis sativus*	foliage	foliage
Geranium	*Pelargonium x domesticum*	foliage and flowers	none
Marigold	*Tagetes erecta*	foliage and flowers	foliage - none; petals burnt at all rates
Salvia	*Salvia splendens*	foliage and flowers	none
Snapdragons	*Antirrhinum majus*	foliage and flowers	foliage - none; petals burnt at all rates
Tomato	*Lycopersicon esculentum*	foliage	none

Host-Pathogen Interactions Between Cornus Species and Powdery Mildew

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Index words: dogwood, Cornus, powdery mildew, *Phyllactina guttata*, Erysiphe pulchra

Significance to Industry: Powdery mildew of flowering dogwood (*C. florida*) has become a common disease in nurseries and landscapes throughout much of the eastern United States. In this paper, the response of 14 *Cornus* species to powdery mildew is reported. Plants of *C. alternifolia, C. controversa* and *C. mas* were not susceptible to powdery mildew. However, one cultivar of *C. alba* was free of powdery mildew while another cultivar was rated as susceptible. Therefore, blanket statements concerning powdery mildew resistance for an entire species may be inappropriate. Nursery producers should either screen initial production of individual lines of *Cornus* species for resistance or obtain propagation materials from lines that have been tested by someone else.

Nature of work: Powdery mildew of flowering dogwood (*Cornus florida*) was rarely observed on dogwood prior to 1994 when serious outbreaks of the disease were reported in dogwood nurseries and landscapes in many areas of the eastern United States. Two organisms, *Erysiphe pulchra* (1) and *Phyllactinia guttata* (3), have been associated with this disease. Considerable interest has focused on resistance to powdery mildew in Cornus species, especially in red berry types (2, 4, 5, 6). Resistance to powdery mildew in blue-berry-type dogwoods has been reported, but either few species were evaluated (2, 4). The objectives of this research were to evaluate a wide selection of *Cornus* species for resistance to powdery mildew and to determine which species of powdery mildew parasitized the plant.

Plants (Table 1) were obtained in one-gallon containers or as bare root liners from nurseries (all species of *Cornus* other than *C. florida*—Owens Farms, Ripley, TN 38068; cultivars of *C. florida*—Commercial Nursery, Decherd, TN 37324). Plants were transplanted into containers (Zarn 2000, Zarn Inc., Reidsville, NC) containing a pine-bark medium [amended with 1.5 lb/yd^3 of 18-6-12 fertilizer, 3.5 lb/yd^3 of dolomitic limestone, 2 lb/yd^3 of 0-46-0 super phosphate, 2.25 lb/yd^3 of gypsum ($CaSO_4$), 1.5 lb/yd^3 of Micromax (Grace Sierra, Milpitas, CA), and 2.0 lb/yd^3 of epson salts ($MgSO_4$)]. Trees were placed under 50% shade cloth and arranged in a randomized complete block design with 10 replications (each replication was a single tree). Flowering dogwood trees infected and symptomatic for powdery mildew were placed as every fifth tree in the experiment. Trees were irrigated twice daily with na overhead irrigation system that delivered approximately 1.3 cm (0.5 inch) of water twice a day. Plants were maintained in this manner for 23 weeks (May 10-October 18).

Powdery mildew disease severity was determined by evaluating the foliage of each tree with the following scale: 0 = no powdery mildew observed, 1 = ≤2% diseased foliage, 2 = ≤10% diseased foliage, 3 = ≤25% diseased foliage, 4 = ≤50 % diseased foliage or 5 = ≤100% diseased foliage. Data for disease severity were analyzed using PROC ANOVA (SAS Institute, Cary, NC) and means were separated using Student-Newman-Keul's Test (P=0.05). Cleistothecia were collected and examined microscopically for identification.

Results and Discussion: Powdery mildew severity varied on the different species of *Cornus* (Table 1). Signs or symptoms of powdery mildew were not observed on any cultivar or seedling of *C. alternifolia, C. controversa*, and *C. mas* (Table 1). One cultivar of *C. alba*, 'Bud's Yellow', was free of powdery mildew whereas another cultivar, 'Ivory Halo', had thalli of powdery mildew on 25% of its foliage. Cultivars of *C. florida* and *C. kousa* also differed significantly in their susceptibility to powdery mildew. Although differences among cultivars were noted within *C. florida* and *C. kousa* in previous studies (2, 4, 5, 6), this is the first report of differential cultivar response to powdery mildew in cultivars of a blue-berry-type dogwood (*C. alba*). Although some species of *Cornus* have been identified as resistant to powdery mildew in this and other studies (2, 4, 6), variation in resistance within some species of *Cornus* suggests that generalizations that all individuals within a species of *Cornus* are resistance may be inappropriate.

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Table 1. Dogwood (*Cornus*) taxa evaluated for resistance to powdery mildew.

Cornus species	*E. pulchra* Present	*P. guttata* Present	Disease Severity
C. alba 'Bud's Yellow'	no	no	0 a[Z]
C. alba 'Ivory Halo'	no	yes	3 c
C. alternifolia	no	no	0 a
C. amomum	no	yes	4 de
C. controversa	no	no	0 a
C. drummondii	no	yes	3 cd
C. florida 'Cherokee Brave'	yes	no	3 cd
C. florida 'Cloud 9'	yes	no	4 d
C. florida 'Cherokee Sunset'	yes	no	5 e
C. kousa	yes	no	2 bc
C. kousa var. chinensis	yes	no	4 e
C. macrophylla	no	yes	3 cd
C. mas. 'Auorea'	no	no	0 a
C. mas 'Golden Glory'	no	no	0 a
C. mas 'Redstone'	no	no	0 a
C. nuttalli	yes	no	5 e
C. florida x *C. nuttalli* 'Eddie's White Wonder'	yes	no	5 e
C. obliqua	no	yes	3 cd
C. racemosa	no	yes	3 cd
C. sericea	no	yes	2 b
C. stricta	no	yes	3 cd

[Z] Numbers followed by the same letter are not significantly different according to Student-Newman-Keul's Test.

A New Ringspot Virus in Kalmia?

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Index Words: *Kalmia latifolia*, mountain laurel

Significance to Industry: Necrotic ringspot symptoms on foliage of mountain laurel plants were found at a Tennessee nursery. Infected plants may go undetected because symptoms, although vivid, may not be present throughout the growing season; they were not visible during spring and fall shipping seasons. Control of the virus can be achieved by inspecting new plants coming from propagation sources in the Pacific Northwest and rouging symptomatic plants or by monitoring and using symptomless plants for propagation material—i.e., plants should be inspected for symptoms on two-year-old leaves for several months after spring flush of foliage.

Nature of Work: Rhododendron necrotic ringspot virus had been reported on rhododendrons and mountain laurel in Oregon and British Columbia (1, 2) and similar symptoms have been reported on mountain laurel in England (1). Symptoms include black to gray to brown concentric ring patterns that form on two-year-old leaves shortly after growth begins in the spring; symptoms are not found on new foliage (1). In England, necrotic ringspot symptoms were associated with a loss of plant vigor. Reports of similar symptoms on mountain laurel have not occurred on plants in the southeastern United States.

While conducting a survey for sudden oak death in Tennessee Nurseries in May 2003, a number of blocks of mountain laurel were observed with symptoms similar to those described for Rhododendron necrotic ringspot virus (1). The results of surveying mountain laurel plants for necrotic ringspot symptoms are reported below.

Results and Discussion: Plants with necrotic ringspot symptoms were found in five of seven cultivars of mountain laurel at a nursery located in eastern Tennessee (Source A, Table 1). All symptomatic plants had vivid ringspot symptoms on two-year-old foliage (Figure 1) and no new flushes of spring growth were observed with any symptoms. Infected plants were three to four years old and had been propagated via tissue culture from the same production facility in Oregon (Source A). Plants from one block of cv. Sarah were all symptomatic whereas a second block of smaller plants of the same cultivar were symptomless but had come from a different propagator (Source B). In a block of cv. Ostho Red, plants that had ringspot symptoms were the same size and also were from source A whereas apparently healthy plants of the same cultivar had come from source B. A block of cv. Nathan Hale plants also had come from source A, but only one of 76 plants was symptomatic.

Infected plants of cvs. Olympic Fire, Ostho Red, Sarah, and Pale Beauty were removed from the nursery and relocated to a nursery compound on the

University of Tennessee campus for observation. During the course of the summer, symptoms became less distinct and disappeared by late July, 2003. Symptoms returned to all plants that had previously exhibited virus symptoms by June 1, 2004 but these symptoms had begun to fade by July 8, 2004. Plants that were symptomless in 2003 remained symptomless in 2004. Infected leaves collected in 2003 were sent to Agdia Incorporated (Elkhart, IN) and screened for Rhododendron Necrotic Ringspot Virus, but this virus was not detected in any of the leaves.

The long term affects of necrotic ringspot symptoms on mountain laurel plants are unknown although plants in England with similar symptoms were reported to have loss vigor (1). The plants at the Tennessee nursery were not displaying a decrease in growth compared to similar cultivars of the same age that did not have ringspot symptoms.

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Table 1. Incidence of necrotic ringspot symptoms in mountain laurel plants at a wholesale nursery located in east Tennessee.

Cultivar	Source[1]	Container size (gal)	Number of plants with symptoms	Number of plants without symptoms	% plants with symptoms
Kaleidoscope	B	3	0	29	0
Olympic Fire	A	3	92	0	100
Nathan Hale	A	3	1	75	1
Brides Maid	B	3	0	68	0
Ostho Red	A	3	18	48	27
Sarah	B	1	0	39	0
Sarah	A	3	48	0	100
Pale Beauty	A	3	80	0	100

Figure 1. Necrotic ringspot symptoms observed on two-year-old foliage of mountain laurel at a nursery located in eastern Tennessee.



Characterization of Potential Biological Control Agents for Dogwood Powdery Mildew

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Index Words: dogwood, yeasts, fungi, bacteria, biocontrol

Significance to Industry: Information from this study will be useful in the development of biological control of powdery mildew of dogwood. Biological control can be an important component of an integrated disease management system.

Nature of Work: It is well documented that epiphytic microorganisms that inhabit plant foliage play an important role in defense against pathogens (de Azerodo *et al.* 1998). Recently, microorganisms associated with plant foliage were isolated from flowering dogwood, and seasonal changes in the composition of fungi, yeast, and bacteria were reported (Mmbaga *et al.* 2003, Avila an Mmbaga 2001). Representative isolates were evaluated for potential biological control of dogwood powdery mildew, but the specific organisms were not fully characterized. Conventional identification of the large number of bacteria, fungi, and yeast isolates is time-consuming and cumbersome. The objective of this study was to characterize the isolates by using DNA analysis and information available in GenBank on the Internet and in literature.

Sample microbial epiphytes used in this study previously were isolated from two uncultivated natural habitats and recovered using leaf washings plated on growth agar media (Mmbaga *et al* 2003). Fungi, bacteria, and yeasts were cultured on potato dextrose agar (PDA), nutrient agar (NA), and wort agar (WA), respectively. Phenotypic morphological types of the isolates were evaluated for biological control of powdery mildew, and isolates that showed potential were selected. The different morphological types have been evaluated further and characterized using DNA analysis of the internal transcribed spacer (ITS) region, including the intervening 5.8S rRNA gene as described by White *et al*. (1990). DNA was extracted from pure cultures of all microorganisms using Qiagen DNeasy Plant mini Kit. Universal primer pairs, ITS_1 and ITS_4 were used to amplify DNA from fungi, primer pair NS1 and NS2 was used to amplify DNA from yeasts, and FGPL132-38 and FGPS6-63 5 were used to amplify DNA from bacteria. In addition to the primer pairs and DNA templates, each PCR reaction included 10 X PCR buffer, 25 mM of $MgCl_2$, 10mM of dNTPs, Taq polymerase, and sterile double distilled water (ddH_2O) in 50-µL reaction mixes. A Techne Progene™ (Princeton, NJ) thermal cycler was used with 94°C initial denaturization (5 min) followed by 42 cycles, 35 cycles, and 40 cycles for fungi, yeasts, and bacteria, respectively. Annealing was at 46°C (1 min 10 sec), extension at 72°C (1 min 40 sec), and one cycle of final extension at 72°C (7 min).

The PCR products were analyzed by electrophoresis in a 1.5% agarose gel in 0.5X TBE (Tris-Borate-EDTA) buffer. The gels were stained with ethidium bromide (0.5 µg/ml) and DNA was visualized using UV light. The PCR products were purified using the Quiagen PCR purification kit. Davis Sequencing Inc. at Davis, CA 95616 (http://www.davissequencing.com) sequenced the PCR products. The sequences were compared with information available in GenBank using Blast search. The results were compared with information documented in biological control studies.

Results and Discussion: Table 1 shows the list of fungi, yeasts, and bacteria that were previously evaluated for biological control of dogwood powdery mildew in dogwood (Mmbaga *et al*. 2003). Many of the organisms isolated from dogwood leaf surfaces previously have been reported to have ability to control plant pathogens of other plant species (Van Driesche and Bellows 1996). In this study, yeast populations on dogwood leaves were dominated by basidiomycetous types; *Crytococcus* spp. and *Aureobasidium pullulans* constituted 36% of all yeasts. *A. pullulans* previously has been reported as an effective biocontrol agent for many phytopathogenic fungi (Schena *et al* 2002). *A. pullulans; Cladosporium* spp., *Cryptococcus* spp., and *Sporobolomyces* spp. are saprotrophic microbes on plant foliage and also are considered as antagonists of plant pathogens (Andrew and Buck 2002; Guetsk *et al* 2001). Among the bacteria isolated from dogwood were isolates in the genera *Erwinia, Pseudomonas, Xanthomonas, Klebsiella* and *Bradyrhizobium*. Some of these bacteria have been reported as beneficial bacteria (Van Driesche and Bellows 1996).

Several isolates of *Acremonium* spp., *Ampelomyces* spp., and *Cladosporium* spp. were recovered in this study and these organisms have been reported as biological control agents for powdery mildew on other plants. The organisms that have been effective against powdery mildew are marked with an asterisk (*) in Table 1. In a study by Archer (2002), the mixture of *Acremonium* spp. and *Pseudomonas* spp. provided total protection against *Botrytis cinerea*. Such results indicate that biological control programs also should include mixtures of microorganism to improve the effective suppression of diseases; such work on powdery mildew of dogwood is in progress.

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Table 1. List of leaf surface microorganisms isolated from dogwood.

Microorganisms	Species identification	Percentage Match**	Role as phytodefense agent ***
Bacteria	*Arthrobacter luteolus**	99	
	*Bacillus spp.**	98	Suppress fungal disease[1]
	Bradyrhizobium spp.	100	Beneficial bacteria & Induce resistance in plant[1]
	Brachybacterium spp.	98	
	*Corynebacterium spp.**	99	
	*Curtobacterium spp.**	98	
	*Ewingella americana**	99	
	*Erwinia spp.**	100	Beneficial bacteria[2]
	Pseudomonas spp.	99	Suppress fungal disease and beneficial bacteria[2].
	Rhodoglobus spp.	99	
Yeasts	*Cryptococcus spp.**	99	Antagonistic competitor & UVR protection[2], [3]
	*Aureobasidium pullulans**	100	Polymorphic & antagonistic competitor[2], [3]
	Sydowia polyspora	99	
	Bullera spp.	99	
	Rhodotorula spp.	100	
	Rhodosporidium spp.	99	
	Sporidiobulus spp.	99	
Fungi	*Verticillium lecanii*	100	Induce resistance in plant
	*Acremonium spp**	100	Hyperparasite[1]
	*Ampelomyces quericinus**	99	
	*Cladosporium spp.**	100	Mycoparasite, UVR protection & antagonistic competitor[2], [3]
	*Ampelomyces humuli**	98	
	Penicillium glabrum	100	
	Penicillium verruculosum	98	
	Arthrinium spp.	100	
	Alternaria spp.*	100	
	Fusarium spp.	99	Induce resistance in plant and antagonistic competitor

* Tested microbes that had superior biocontrol potential on dogwood powdery mildew.

** The percent match with data in GenBank on the Internet.

*** Based on a literature search: [1]Archer 2002, [2]Van Driesche and Bellows 1996, [3]Lindow *et al.* 2002.

Evaluation of Fungicides for Control of Bacterial Blight of Dogwood

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Index Words: dogwood, *Cornus mas, Pseudomonas syringae*, bacterial blight, fungicides/bactericides.

Significance to Industry: Although bacterial leaf blight is not widely distributed, it is very destructive on *Cornus mas* and control measures are needed. This study has shown that copper-based fungicides such as Phyton-27 and Bordeaux mixture consistently reduced disease severity, and Agri-mycin and Camelot also were effective much of the time.

Nature of Work: In 1996, severe leaf blight, caused by *Pseudomonas syringae*, was observed in a Tennessee nursery that had received plants from Europe (Mmbaga, 1999). Characteristic symptoms of the disease consisted of dark brown necrotic lesions on the leaves and stems that coalesced to form severe blights on the foliage and dieback of young braches. The disease was prevalent in early spring when the weather was cool and wet (Mmbaga 1999); evidence was consistent with other reports on bacterial blights caused by *P. syringae* (Sinclair and Backman 1989, Sinclair *et al*. 1993, Anon 2000, Pscheidt *et al*. 2001). Although the disease has only been observed in few locations, it is very destructive and poses a serious problem to cornelian dogwood. The pathogen has the potential to spread with infected bud and to be disseminated by water splash. Information on the control of this disease is lacking. Therefore, this study was initiated to evaluate chemicals that could be effective at controlling the disease.

Genetically uniform plants were produced from stem cuttings from a susceptible mother plant and were grown in 5-gal plastic containers in a shade house in McMinnville, TN. Five chemicals were evaluated for controlling this disease: Phyton-27 (copper sulfate), Camelot (copper salt of fatty acids), Agri-mycin 17 (Streptomycin sulfate), Kocide 101 (Copper hydroxide), and Bordeaux mixture (Cupric sulfate + lime 8-8-100); rates are listed in Tables 1 and 2. A randomized complete block experimental design with six treatments and five single-plant replicates per treatment were used, and the experiment was repeated. The plants were first inoculated with the bacterium using a suspension of 10^8 colony forming units (cfu)/ml from 7-day-old cultures. An atomizer was used to deliver the inoculum uniformly. The inoculated plants were allowed to dry, were placed in a dew chamber at 20 C and 100% relative humidity (RH) for 24 hours, and then were moved to 24/15 C and 85% RH. Chemical treatments were initiated when the inoculated plants started showing first symptoms of the disease. In repeating the experiment, fungicide Basicop™ (Element copper 53%) was used instead of Kocide 101, which was not effective in the first year. The chemicals were applied by using a CO_2-pressurized sprayer and plants were sprayed to run off at 10-day application intervals. The experiment was terminated at the end of June or early

July when disease spread normally stopped and new leaves were symptom-free. Disease severity was evaluated using a rating scale of 0-5: 0= no infection, 1=1-10%, 2=11-25%, 3=26-50%, 4=51-75%, and 5=76-100% of the foliage showing disease symptoms. Data were analyzed by analysis of variance (Proc GLM) for a randomized complete block design with five replicates using chemical treatment as the treatment effect (SAS/STAT, 1990; Schlotzauer and Littell. 1987).

Result and Discussion: In 2003, frequent rains interfered with the initial spraying and keeping the products on the plants. Bordeaux mixture, Phyton-27, and Camelot were the best products at consistently reducing disease severity compared to the non-treated control (Table 1). In 2004, the non-treated control developed just as much disease as in 2003, but plants sprayed with Agrimycin and Phyton 27 developed very little infection (Table 2). Bordeaux mixture and Camelot also reduced disease severity significantly, but Basicop was not effective.

The copper-based fungicides and bactericides have been reported to control bacterial blight disease of soybeans and beans (Sinclair *et al.* 1993, Schwartz and McMillan 1989). Phyton 27 (Source Technology, Edina, MN) is a broad spectrum bactericide and fungicide that has been is labeled exclusively for ornamental crops and is recommended for numerous bacterial blights. In this study, Phyton 27 worked as well as Agrimycin or Camelot. Disease severity was less than what has been observed previously in the field nursery perhaps because in the field, plant foliage was available earlier in April when temperatures were most favorable. Bacterial blight of *C. mas* is favored by very cool temperatures with 20ºC to 23ºC (ref??). The choice of chemicals evaluated was based on their approval for use on dogwood, and the chemicals that were effective in these experiments should be useful to control the disease in the nursery. However, timely application soon after budbreak and before symptoms occurs appears to be important for effective disease control.

With the present emphasis on protecting the environment, there is a need to involve the use of alternative methods for disease control other than chemical pesticides. Field observations on infection development have shown that infection starts on the lower leaves and spreads up the plant (Mmbaga and Sheng, 1999). These observations suggest that infested debris from the previous season may be a source of inoculum. Cultural practice that eliminates previously infested debris may play a role in disease management. The removal of infested leaf debris and avoiding cuttings from previously infected material may be combined with the effective chemicals to eliminate the disease problem before it spreads.

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Table 1. Effectiveness of five fungicides/bactericides for control of bacterial blight of dogwood, Cornus mas, in 2003.

Treatments	Rate/ 100gal	Disease severity (0-5 scale)[1]				
		May 20	May 30	June 11	June 30	July 2
Phyton	3 fl oz	2.5 a [2]	2.5 b	2.8 bc	2.0 c	2.0 b
Bordeaux	16 lb	2.5 a	2.5 b	2.5 c	2.3 c	2.0 b
Camelot	3 pt	2.5 a	2.8 ab	2.5 c	2.0 c	2.0 b
Agri-mycin	1 lb	2.5 a	2.8 ab	3.0 abc	3.0 ab	3.0 b
Kocide	1 lb	3.0 a	3.0 ab	3.25 ab	2.5 bc	2.5 ab
Control		3.3 a	3.25 a	3.5 a	3.3a	2.3 ab

[1]Disease severity (0-5 scale): 0= no infection, 1=1-10%, 2=11-25%, 3=26-50%, 4=51-75%, and 5=76-100% of the foliage showing disease symptoms.

[2]Means with the same letter in each column are not significantly different. (P= 0.05)

Table 2. Effectiveness of five fungicides/bactericides for control of bacterial blight of dogwood, *Cornus mas*, in 2004.

Treatments	Rate/100gal	Disease severity (0-5 scale) [1]			
		17-May	27-May	9-Jun	16-Jun
Phyton 27	3 fl oz	0.8 a [2]	1.4 ab	1.2 a	1.2 a
Bordeaux Mixture	16 lb	1.0 a	1.6 b	1.8 a	1.6 ab
Agri-mycin	3 pt	1.0 a	1 .0 a	1.0 a	1.0 a
Camelot	1 lb	1.4 a	1.4 ab	1.8 a	1.8 ab
Basicop	2.5 lb	1.2 a	2.4 c	3.0 bc	3 .0 bc
Water			2.4 b	3.4d	3.2 c

[1]Disease severity (0-5 scale): 0= no infection, 1=1-10%, 2=11-25%, 3=26-50%, 4=51-75%, and 5=76-100% of the foliage showing disease symptoms.

[2]Means with the same letter in each column are not significantly different. (P= 0.05)

Control of Powdery Mildew on Container-grown Dogwood Trees Using the Biorational Fungicide MilStop™

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Index Words: *Cornus florida*, dogwood, *Erysiphe* (sect. *Microsphaera*) *pulchura*, powdery mildew, potassium bicarbonate

Significance to Industry: Daconil Ultrex™ and MilStop™ at the highest rates tested provided excellent control of powdery mildew when applied weekly. The other rates and application schedules evaluated significantly reduced disease severity and should provide growers with options for management of powdery mildew on dogwood.

Nature of Work: Since the early 1990's, powdery mildew has been a persistent problem on dogwoods in commercial nurseries and landscapes in the southeastern United States. The disease is caused by *Erysiphe* (sect. *Microsphaera*) *pulchura* and causes leaf distortion, loss of plant vigor, and stunting. Because of the serious damage caused by this pathogen, growers have had to increase fungicide applications. Due to the potential of fungicide resistance in this pathogen (1), fungicide screening is important to determine the efficacy, rates, and application intervals of new products. This trial was initiated to determine application rates and treatment intervals for MilStop™ that would be effective in controlling powdery mildew on dogwood in a commercial container nursery in southern Alabama.

Dormant budded white dogwood trees were potted in 2-gallon containers containing a 3:1 pine bark:peat medium amended with 14 lb of 15-9-12 Osmocote Plus™, 6 lb dolomitic limestone, and 2 lb gypsum per cubic yard. Treatments were applied 10 March through 10 October 2003. Fungicides were applied to run-off with a CO_2-pressurized sprayer. Four rates of MilStop™ were applied at 1- and 2-week intervals. Daconil Ultrex™, used as an industry standard, was applied at 1- and 2-week intervals. Disease incidence was rated visually on 16 June 2003 using the Horsfall and Barratt rating scale: 1= no disease, 2 = 0 to 3%, 3 = 3 to 6%, 4 = 6 to 12%, 5 = 12 to 25%, 6 = 25 to 50%, 7 = 50 to 75%, 8 = 75 to 87%, 9 = 87 to 94%, 10 = 94 to 97%, 11 = 97 to 100%, and 12 = 100% of the leaves damaged or prematurely shed. In addition to disease ratings, plants were examined for phytotoxicity.

Results and Discussion: All rates of and application intervals for MilStop™ and Daconil Ultrex™ significantly reduced powdery mildew severity (Table 1). At all rates of MilStop™ tested, a weekly spray interval was more effective at controlling powdery mildew than treatments applied every two weeks. The level of disease control significantly improved as the application rate increased from 1.25 to 10. Weekly applications of Daconil Ultrex™ at 1.4 lb. and MilStop™ at 10 lb/100 gal were the most effective treatments for managing powdery mildew on dogwood trees in this experiment. Phytotoxicity was not observed on any of the plants.

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Table 1. Effect of MilStop™ (potassium bicarbonate) application rate and treatment interval on the control of powdery mildew on flowering dogwood.

Fungicide	Rate (lb/100 gal)	Spray Interval (weeks)	Dogwood Powdery Mildew Rating[xyz]
MilStop™	1.25	1	5.5 cd
MilStop™	1.25	2	7.6 f
MilStop™	2.50	1	4.6 bc
MilStop™	2.50	2	6.6 e
MilStop™	5.0	1	4.3 b
MilStop™	5.0	2	6.8 ef
MilStop™	10.0	1	2.1 a
MilStop™	10.0	2	5.9 de
Daconil Ultrex™	1.40	1	2.0 a
Daconil Ultrex™	1.40	2	4.1 b
Untreated Control	--	--	9.0 g

[x] The incidence of powdery mildew on flowering dogwood was visually assessed using the 1 to 12 Horsfall and Barratt rating scale: 1= no disease, 2 = 0 to 3%, 3 = 3 to 6%, 4 = 6 to 12%, 5 = 12 to 25%, 6 = 25 to 50%, 7 = 50 to 75%, 8 = 75 to 87%, 9 = 87 to 94%, 10 = 94 to 97%, 11 = 97 to 100%, and 12 = 100% of the leaves damaged or prematurely shed.

[y] Disease ratings were recorded on June 16.

[z] Mean separation within columns was according to Fisher's least significant difference test (LSD, $P = 0.05$).

Genetic Diversity in Dogwood Selections Inferred from AFLP and Microsatellite-primed PCR

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Index Words: dogwood, *Cornus*, AFLP, microsatellite, PCR

Significance to the Industry: New flowering dogwood accessions can be used directly as cultivars or as parents in breeding programs. DNA analysis using AFLP and microsatellite-primed PCR analysis provided some indication on the genetic relatedness of new accessions and were useful in distinguishing different species of dogwood and in identifying the genetic backgrounds of new dogwood selections and DNA markers associated with disease resistance. Results from this study also showed that AFLP and microsatellite-primed PCR techniques are powerful tools in selecting new accessions for cultivar release, which should increase the genetic diversity in the dogwood population. Data from this study show that marker-assisted selection will help advance breeding efforts in dogwood.

Nature of Work: Powdery mildew is one of the most important diseases affecting flowering dogwood (*Cornus florida*), and the use of resistant cultivars is recognized as the best method for disease management. Selection and identification of flowering dogwood with powdery mildew resistance has been ongoing and more than ten dogwood accessions have been selected (Mmbaga and Sheng 2001). The genetic background and genetic diversity of these new accessions are unknown and classic genetic studies take a long time. Molecular approaches such as AFLP (amplified fragment length polymorphisms) and microsatellite-primed PCR (also called inter-simple sequence repeats) have provided effective and rapid tools for genetic mapping, marker-assisted selection, and genetic diversity analysis (Fang *et al.* 1997, Tsumura *et al*. 1996, and Tooley *et al.* 2000). The objective of this research was to analyze the genetic diversity in new powdery mildew resistant dogwood accessions of by using AFLP and msicrosatellite-primed PCR.

A total of 22 dogwood accessions were used in this research, including one accession of *C. nutalli* ('Boyd'), two accessions of *C. mas* ('Redstone' and 'Golden Glory'), two accessions of *C. kousa* ('Milky Way 'and 'China Girl'), three accessions of hybrids between *C. kousa* and *C. florida* ('Ruth Ellen', 'Celestial', and 'Stellar Pink'), six flowering dogwood (*C. florida*) cultivars ('Cherokee Brave', 'Cherokee Princess', 'Pygmy', 'Pink Beauty', 'World's Fair', and 'Sterling Silver'), and eight new flowering dogwood accessions. Dogwood genomic DNA was extracted from fresh leaves using the DNeasy Plant Mini Kit from Qiagen. AFLP analysis was conducted by using AFLP Analysis System I from Invitrogen Life Technologies following the protocol from the company. A total of 13 EcoR I / Mse I primer pairs (E-ACA/M-CTG, E-ACA/M-CTC, E-ACA/M-CTA, E-ACC/M-CAC, E-ACC/M-CAT, E-ACC/M-CTT, E-ACC/M-CAA, E-ACG/M-CAC, E-AGG/M-CAC, E-AGG/M-CTG, E-ACT/M-CAT, E-ACT/M-CAG, and E-AGG/M-CTT)

were screened on 16 dogwood accessions. The AFLP gel was visualized by using a silver staining procedure (Promega). AFLP data were analyzed using the package RAPDistance v1.04 (Armstrong *et al.*, 1995) and the multidimensional scaling (MDS) procedure of SAS (SAS Institute 1997).

Dogwood genomic DNA also was analyzed by using microsatellite-primed PCR in which 19 microsatellite primers $(CATA)^4$, $(CT)^{10}$, (CT)8, $(CA)^{10}$, $(AT)^5$, $(GA)^{10}$, $(TG)^{10}$, $(GGA)^4$, $(GTGTGG)^3$, $(CA)^5$, $(TA)^4$, $(TCCCAT)^2$, $(GTG)^5$, $(GAC)^5$, $(GACA)^5$, $(CAC)^5$, $(TGTC)^5$, $(GACA)^5$, $(GATA)^4$ were used to amplify the inter-repeat regions in the 22 dogwood selections. The microsatellite-primed PCR amplification was performed in a DNA thermal cycler following standard PCR procedures with modifications. Each 50 µl PCR reaction mixture consisted of 38 µl sterile ddH_2O, 5 µl of 10X PCR buffer, 3 µl of $MgCl_2$ (25 mM), 1.5 µl of dNTP (10mM total, 2.5 mM each), 1 µl of primer (50uM), 0.2 µl of Taq polymerase (Promega) (5u/µl), and 1.3 µl of template DNA (20ng/µl). PCR cycles consisted of an initial denaturation step at 94°C for 5 min followed by 42 cycles 1 min at 92°C (denaturation), 1 min at 30° to 60°C (annealing), 2 min at 72°C (extension). The annealing temperature was set depending on the primer Tm and usually at five degree less than the primer Tm (Tm – 5) was used. An extension cycle at 72°C for 5 min was used to terminate the reaction and finally at 4°C soak temperature. The PCR products were visualized in 1.2 to 1.5% agarose gels in 1X TBE and stained with ethidium bromide.

Results and Discussion: In AFLP analysis, more than 200 distinct DNA fragments were observed and genotypes were scored for the presence (1) or absence (0) of each fragment. A matrix of pair-wise Euclidean distances was obtained among the 16 accessions using the package RAPDistance from these data and the two-dimension scaling plot using multidimensional scaling (MDS) procedure of SAS was drawn from the Euclidean distance among the 16 accessions (Fig. 1). The hybrids Celestial and Stellar Pink separated from other genotypes, but the two hybrids were distant from each other (Fig.1). In the other 14 dogwood accessions, Pink Beauty and World's Fair were located together while Cherokee Brave, R26, Cherokee Princess, R26, and Pygmy formed one group; R25, MI-9, Sterling Silver, and MI-8 formed another group; R17, R14, and R10 formed separate individual groups far away from the other genotypes (Fig 1). These results indicated that (1) the two hybrids Celestial and Stellar Pink had different genetic backgrounds compared to the other flowering dogwood; (2) genetic diversity exists within flowering dogwood; (3) although the new accessions are a fairly small sample, they represent different groups; and (4) the eight new accessions had different genetic backgrounds. In the new accessions, R26 was very close to Cherokee Brave and Cherokee Princess; R23 was close to Cherokee Princess and Pygmy; and R25, MI8, and MI9 were close to Sterling Silver. Cherokee Brave has the best powdery mildew resistance in commercial cultivars of *C. florida*, while Sterling Silver has moderate susceptibility and Cherokee Princess and Pygmy are susceptible (Mmbaga *et al.* 2004). Because the new accessions have powdery mildew resistance, the five genetically diverse new accessions may substitute or complement their corresponding cultivars while the other three new accessions R17, R14, and R10 may be excellent resources as new genetic resources for new cultivars and dogwood breeding.

In microsattelite-primed PCR analysis, seven SSR primers $(GTGTGG)^3$, $(CA)5(TA)^3$, $(GTG)^5$, $(GAC)^5$, $(GACA)^5$, $(TGTC)^5$, and $(GATA)^4$ showed polymorphisms in the 22 dogwood accessions. Table 1 lists the most significant polymorphic bands amplified from the seven primers in the 22 dogwood lines. An example of the amplification pattern of DNA detecting primer $(GAC)^5$ fragments in 18 dogwood accessions are shown in Fig. 2. Four main observations were drawn from this research: species-specific markers were found in dogwood species. Three markers, $(GTGTGG)^3$_340 $(GTG)^5$_850 and $(GATA)^4$_660 observed only in *C. nutalli* 'Boyd' (Table 1) may be specific to *C. nutalli*. In the *C. kousa* genotypes and all hybrids with *C. kousa* showed polymorphism with primers $(GTGTGG)^3$ at 550 bp, $(GAC)^5$ at 690 bp, and $(GATA)^4$ at 610 bp. Two markers, $(CA)^5(TA)^4$_910 and $(GAC)^5$_870, were observed in all genotypes of *C. florida* and all hybrids with the other genotypes, thus indicating that the two markers were specific to *C. florida*.

Seven markers, $GATA)^4$_700, $(GATA)^4$_580, $(GTGTGG)^3$_890, $(GAC)^5$_790, $(GAC)^5$_480, $(GAC)^5$_520, and $(GACA)^5$_290, showed significant polymorphisms in 14 flowering dogwood accessions (column K to M in Table 1) . The marker $(GACA)^5$_290 was only present in Cherokee Princess and $(GATA)^4$_540 was only for Ruth Ellen. The primer $(TGTC)^5$ produced a different polymorphic pattern for each accession and 22 accessions showed 22 different polymorphic banding patterns. These results indicated microsatellite-primed PCR can been used to analyze genetic diversity in dogwood, and it is a powerful tool in marker-assisted selection for genetic traits such as disease resistance. Polymorphic band patterns were observed not only in different species but also within one species.

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Table 1. Seventeen markers in 22 dogwood accessions

Cultivar	Cornus species	A[1]	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	M
Boyd	*C. nutalli*	1_2	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Redstone	*C. mas*	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
Golden Glory	*C. mas*	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
Milky Way	*C. kousa*	0	0	0	0	1	1	1	1	0	0	1	0	0	0	0	0	0
China Girl	*C. kousa*	0	0	0	0	1	1	1	1	0	0	1	0	0	0	0	0	0
Ruth Ellen	*C. kousa x C. florida*	0	0	0	0	1	1	1	1	1	1	1	0	1	0	1	0	0
Celestial	*C. kousa x C. florida*	0	0	0	0	1	1	1	1	1	1	1	0	0	0	1	0	0
Stellar Pink	*C. kousa x C. florida*	0	0	0	0	1	1	1	1	1	1	1	0	0	0	1	0	0
Fragrant Cloud	*C. florida*	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	0	0
Cherokee Brave	*C. florida*	0	0	0	0	1	0	0	0	1	1	0	0	0	0	1	0	0
Cherokee Princess	*C. florida*	0	0	0	0	1	0	0	0	1	1	1	1	1	0	0	0	1
Pygmy	*C. florida*	0	0	0	0	1	0	0	0	1	1	1	0	1	1	0	0	0
Sterling Silver	*C. florida*	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0	0
R17	*C. florida*	0	0	0	0	1	0	0	0	1	1	0	0	1	0	1	0	0
MI7	*C. florida*	0	0	0	0	1	0	0	0	1	1	0	0	1	0	1	0	0
MI8	*C. florida*	0	0	0	0	1	0	0	0	1	1	0	0	1	0	1	0	0
MI9	*C. florida*	0	0	0	0	1	0	0	0	1	1	0	0	1	0	1	0	0
R14	*C. florida*	0	0	0	0	1	0	0	0	1	1	0	0	0	0	1	0	0
WR19	*C. florida*	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	0	0
R10	*C. florida*	0	0	0	0	1	0	0	0	1	1	0	0	0	0	1	0	0
R25	*C. florida*	0	0	0	0	1	0	0	0	1	1	0	0	0	0	1	1	0
R23	*C. florida*	0	0	0	0	1	0	0	0	1	1	0	0	1	0	1	1	0

[1]A=(GTGTGG)3_340, B=(GTG)5_850, C=(GATA)4_660, D=(GTG)5_610, E=(GTG)5_1000, F=(GTGTGG)3_550, G=(GAC)5_690, H=(GATA)4_610, I=(CA)5(TA)4_910, J=(GAC)5_870, K=(GATA)4_700, L=(GATA)4_580, M=(GTGTGG)3_890, N=(GAC)5_790, O=(GAC)5_480, P=(GAC)5_520, and Q=(GACA)5_290.

[2]0=the polymorphic band absent, 1=the band present.

Figure 1. A two-dimension scaling plot in sixteen dogwood accessions.

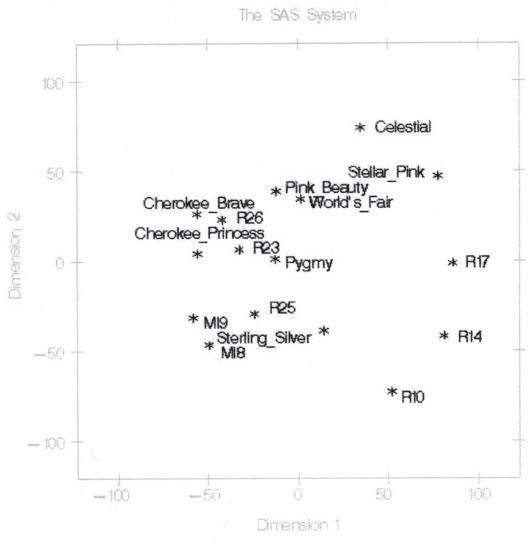
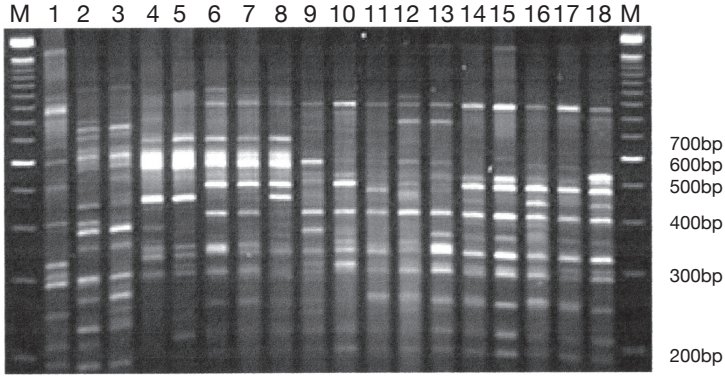


Figure 2. Amplification pattern of DNA detecting primer $(GAC)^5$ fragments in 18 dogwood accessions. Lane M is a 100 bp molecular-weight marker. Lanes 1 to 18 are from 18 dogwood accessions.



Evaluation of Chemical and Cultural Methods for Managing Foliar Nematodes on Woody Ornamental Crops in Nurseries

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Significance to Industry: There is a zero threshold level of tolerance for foliar nematodes on ornamental plants because of the short generation time, high reproductive capacity, and the ability of the nematodes to destroy the aesthetic value of the plant (1). The lack of effective management options is of particular concern because nursery crops are especially susceptible to foliar nematodes. In this research, we have demonstrated that the introduction of foliar nematode-infected material into a nursery environment can result in the rapid spread of the nematodes to healthy nursery stock. The identification or development of more effective control options will help promote higher standards and expectations for plant quality within the ornamental crops industry. Exclusion is currently the best option for controlling foliar nematodes.

Nature of Work: Foliar nematodes (*Aphelenchoides* spp.) are becoming increasingly common and injurious on a wide range of woody ornamental plants grown in nurseries. Plants in the genera *Lantana, Abelia, Salvia, Viburnum*, and *Buddleia* are among the 250+ known plant species susceptible to foliar nematodes (1), and are commonly infected hosts in nurseries. A 400% increase in the number of ornamental plant samples diagnosed with foliar nematodes was recorded between 1990 and 2000 at the North Carolina State University Plant Disease and Insect Clinic. Foliar nematodes are expected to become an even larger problem due to extremely limited management options available for control (2-6).

Foliar nematodes are microscopic roundworms that penetrate and feed within the leaf cells. These organisms generally will not kill a host plant, but they can cause plants to become unmarketable. Infected plants are unthrifty and severe defoliation of woody ornamentals is common in midsummer when the population of foliar nematodes is peaking. Foliar nematodes move by swimming in thin films of water on the surfaces of stems and leaves, and can be moved from plant-to-plant in splashing water.

A study was undertaken in Summer 2003 to assess how quickly foliar nematodes can spread from infected plants to healthy plants in a nursery setting under two different irrigation regimes. Twenty, nematode-free 1-gal *Lantana camara* 'Miss Huff' plants were intermixed with an equal number of foliar nematode-infected plants of the same cultivar in a completely randomized design. Overhead sprinklers irrigated plants in one experimental block, and plants in the second

block were irrigated by low-volume spray stakes that directed the water away from the foliage and onto the surface of the potting substrate. Ten symptomatic leaves per infected plant and ten leaves from each healthy plant were sampled at the beginning of the trial on 7 August to confirm the presence or absence of foliar nematodes using traditional extraction techniques. All plants were visually evaluated for symptoms and leaves were sampled and assayed for foliar nematodes one and two months later—on 8 September and 8 October.

Two miticides and a surface disinfestant were tested for efficacy against foliar nematodes in a nursery trial during Summer 2003 on naturally infected plants of *L. camara* 'Miss Huff' and *Buddleia davidii* 'White Bouquet' at a nursery in Pender Co., NC (Table1). The experimental design was a randomized complete block with 10 single-plant replications for each plant species. The experimental design was repeated, concurrently, in two, physically separated plots at the nursery. One plot was irrigated with overhead sprinklers, and the second plot was irrigated by low volume spray stakes. Plants were sampled for foliar nematodes on 7 August prior to the first spray application. For lantana, ten symptomatic leaves were randomly collected from each plant at each sampling date. For buddleia, three symptomatic leaves were randomly collected from each plant at each sampling date. Treatments were applied approximately every 7 days on 13, 20, 26 Aug and 3 Sep for a total of four spray applications to all plants. Treatments were applied until run-off using a hand-pump sprayer. Plants were re-sampled at 13, 27 or 30, and 42 days after the first spray application. Nematode counts were based on the fresh weight of the leaf tissue collected.

Results and Discussion: Spread of foliar nematodes from the infected lantana plants to healthy plants was rapid. By day 32, foliar nematodes had spread to 45% of the originally healthy plants in the low volume irrigated block and to 55% of the healthy plants in the overhead-irrigated block. At day 62, foliar nematodes had spread to 100% of the originally healthy plants in both the overhead and low volume irrigated blocks. There was no significant difference at day 62 in the nematode population between the initially healthy plants compared to the originally infected plants. While the rate of spread was slightly faster for plants irrigated by overhead sprinklers, the foliar nematodes were equally capable of spreading from infected to healthy plants under a low volume irrigation regime that promoted drier foliage. However, it was an unusually wet summer, and the rain could have confounded these results.

Pylon significantly reduced populations of foliar nematodes at the second, third, and fourth sampling dates compared to the non-treated controls for lantana grown under low volume irrigation, but there was no difference in populations among lantana grown under overhead sprinkler irrigation for any of the treatments. The Pylon treatment reduced the nematode population on buddleia at the third sampling date (12 Sep) for plants grown under low volume irrigation, and at the fourth sampling date (24 Sep) for plants grown under both irrigation methods. Consequently, none of the treatments were effective at eliminating foliar nematodes from infected plants under either irrigation regime. Pylon is labeled for control of foliar nematodes on nursery-grown ornamentals, but it is not labeled for outdoor use.

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Table 1. Foliar nematode populations (no. nematodes per gram of leaf tissue) on lantana and buddleia plants before and after treatment with three pesticides when grown under two different types of irrigation.

	Before Treatment		After Treatment					
Host	7 Aug		26 Aug		9-12 Sep		24 Sep	
Treatment and rate /100 gal	Lv[w]	Ovh[w]	Lv	Ovh	Lv	Ovh	Lv	Ovh
Lantana								
Floramite SC 2L 8 fl. oz	766 a[x]	712 a[x]	484 b[y]	591 a[y]	202 ab[y]	369 a[y]	1019 a[y]	1116 a[y]
Pylon 2SC 5.2 fl. oz	908 a	744 a	271 b	400 a	65 b	143 a	373 b	401 a
ZeroTol 27%L[z]	1272 a	342 a	934 a	335 a	289 a	449 a	1331 a	374 a
Non-treated control	1237 a	906 a	603 a	446 a	370 a	296 a	911 a	649 a
Buddleia								
Floramite SC 2L 8 fl. oz	109a[x]	36a[x]	319 a[y]	163 a[y]	1902 a[y]	476 a[y]	997 a[y]	516 a[y]
Pylon 2SC5.2 fl. oz.	145a	73a	425 a	34 a	31 b	100 a	21 b	2 b
ZeroTol 27%L[z]	101a	74a	314 a	131 a	1765 a	662 a	375 a	401 a
Non-treated control	104a	74a	453 a	104 a	865 a	434 a	1032 a	202 a

[z]Applied at 1.5 fl. oz /1 gal for the first application. The 0.5 fl. oz /1 gal rate was applied in all subsequent applications.

[y]Analysis of covariance using a log transformation was used to test the change in population based on the initial population, and Dunnets-Hsu's test was used to compare all treatments to the non-treated control for levels of significance in population changes among treatments at the level of *P*=0.05. Actual means are shown.

[x]Means by plant species within a rating followed by the same letter are not significantly different from each other according to Waller-Duncan k ratio, t-test, k=100, P=0.05.

[w]Irrigation method was by low volume spray stakes (Lv) or overhead sprinklers (Ovh).