Plant Pathology and Nematology

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Section Editor

Research Updates on Bacterial Gall of Loropetalum

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Index Words Sanitizers, copper resistance, cultivar resistance

Significant to Industry *Loropetalum chinense* is a major nursery crop for much of the Southeastern United States. The relatively new disease, bacterial gall of loropetalum (BGL) has caused major crop loss due to voluntary and/or regulatory disposal of infected plant material. Research is underway to develop best management practices to prevent this disease. Prevention through sanitization and exclusion along with copper sprays after pruning or damage are among current recommendations. Future research projects hope to evaluate cultivar resistance, sanitizer efficacy and growth regulators to reduce pruning.

Nature of Work Bacterial gall of Loropetalum (BGL) is a relatively new disease to the nursery industry. It was first identified as *Pseudomonas savastanoi* by Conner et. al., (1) and later renamed as a new pathovar, *P. amygdali* pv. *loropetali,* pv. nov by Harmon et al. (2). The symptoms of the disease are expressed as dark-colored galls or “knots”. Galls form on main stems, branches and twigs. As these galls grow, they eventually girdle the plant, causing dieback or death depending on the location. The bacterium is present on the surface of the plant existing epiphytically until a wound (from pruning, leaf scars, frost damage, hail etc.) allow entry into plant tissue.

Occurrences have been reported in Alabama, Georgia, Texas, Louisiana and Florida. In 2013 several large nursery growers reported disposing of over $1,000,000 worth of infected plant material through voluntary and/or regulatory enforcement. Bacterial diseases are difficult to control and currently there are no published recommendations for controlling this disease. In 2016, a concerted research effort was initiated to develop best management practices (BMPs) to help nursery growers BGL. This paper provides preliminary results of several experiments associated with work toward the development of BMPs.

Cultivar resistance trial
There have been some reports of varying degrees of olive cultivar resistance (4) to *P. savastanoi* pv. *savastanoi* and *P. amygdali* on almond *(5).* A trial was conducted to screen *Loropetalum* for resistance to BGL. On March 14, 2018 , 4 replicates of the following eleven cultivars were wounded and treated: ‘Purple Pixie’, ‘Purple Diamond’, ‘Zhu Zhou’, , ‘Carolina Midnight’, ‘Darmua’, ‘Ruby Parfait’, ‘Emerald Snow’, ‘Garnet Fire’, ‘Cerise Charm’, ‘Purple Plumleaf’, and ‘Ruby Snow’. A drop of either sterilized

distilled water or bacterial suspension was placed on a flat branch section or in a branch crotch angle and a sterile dissecting needle was pushed through the water drop (with or without bacterium) into the branch creating a wound. Concentration of bacterial suspension was not measured but amounted to one culture plate per 200 ml. Plants were placed in a complete randomized design in a greenhouse where they were hand watered. The trial was repeated a second time on July 18, 2018 with five replicates. Replicates of each cultivar were wounded with and without inoculum as before. Sanitizers were used to prevent cross contamination. On September 25, 2018, both trials were evaluated for the presence or absence of galls at the wound site.

Copper resistance trial

Copper products are commonly used to control bacterial diseases. Growers have reported use of copper products to control BGL without noticeable control of the disease, indicating the causal bacterium may have developed copper resistance. BGL samples (n=19) were obtained from Loropetalum growers across the state and were tested to determine their level of resistance to copper. Samples collected represent plants with no copper products previously applied, plants subjected to copper products, and plants with an unknown copper status due to their recent introduction to the nursery.

To determine the level of copper resistance, the bacterium was isolated from gall sections of each sample using PAF agar and pure cultures were prepared. DNA was extracted from each isolate, amplified using primers IAALF/R, specific to the iaaL gene of the species (3), sequenced, and compared to the type species from AL (GenBank accession KM593980) to confirm the identity of *P. savastanoi*. Sucrose peptone agar amended with different concentrations of $CuSO_4.5H_2O$ (0.00, 0.16, 0.32, 0.48, 0.64, 0.80, or 0.96mM) were used along with *P. syringae* strain A1513 (which will grow on 0.80mM $CuSO_4.5H_2O$) and strain A1487 (which does not grow on 0.16mM $CuSO_4.5H_2O$) as controls. Isolates and controls were streaked onto 10 replicates of each copper concentration. Cultures were incubated at 28^{o}C for 72 hours, and the minimum concentration that prevented colony growth was recorded. Strains able to grow on 0.32mM $CuSO_4.5H_2O$ or greater were considered copper resistant. Tests were repeated twice.

Phytotoxicity response to sanitizers in propagation

The effects of sanitizers used as a pre stick submersion were evaluated in plant response to rooting. The objective of this study was to determine the maximum rate and exposure time of hydrogen dioxide + peroxyacetic acid (Zerotol® 2.0) and sodium hypochlorite (bleach) effects on rooting. Each sanitizer was evaluated separately in two trials. A 3x3 factorial (concentration, time and concentration x time) was used in each trial to determine the effects and potential interactions in rooting. On July 25, 2018, 3 in (7.6 cm) firm cuttings of *Loropetalum chinense* ‘Ruby” were collected from plants in the landscape. The concentrations of Zerotol® 2.0 were a 0.3, 1.0 and 2.0 % solution with a 1, 3 or 6-minute complete submersion before sticking into fifty square cell (90 ml cell) inserts (T.O Plastics Inc., Clearwater, MN) in a 1:1:1 perlite: peat moss: vermiculite

substrate. Each treatment utilized 25 replicates arranged in a complete randomized design. Trays were placed under mist in a climate controlled greenhouse. Cuttings were harvested on September 13, 2018, 80 days after sticking. The second trial was also a 3x3 factorial but used a bleach (sodium hypochloride 6%) solution with concentrations of 10, 25, and 33% and submersion times of 1,3, and 6-minutes. Plants were rinsed for 5 seconds under municipal water after being submerged in the bleach solution. The trial was initiated on July 3, 2018 and was terminated 90 days after sticking (October 3, 2018). At termination, roots were rated using 1 to 4 quality scale (1 = poor with few roots, 2 = poor with moderate roots, 3 = good with medium root volume, 4 = good with full root system) immediately after rating, fresh weight of roots were taken by slicing off roots from stem cutting with a sterilized razor knife.

Results and Discussion In the cultivar evaluations, no differences were observed between the two trials ($p > 0.4525$). When the data were pooled no differences in susceptibility to gall disease were observed among cultivars. ($p = 0.3431$). The cultivar resistance trial did not reveal any promising results, as most inoculated varieties were nearly 100% positive for gall development at the inoculation site (Figure 1). Many of the non-inoculated plants also showed symptoms of gall. Fluorescent *Pseudomonads* are known to thrive as epiphytes and disease pressure would have been high in the overhead irrigated area where the study took place. Future studies should continue to evaluate additional cultivars.

Results of the copper resistance screening, revealed that 4 of the 19 isolates were identified as copper resistant. These copper resistant isolates represented only the plants that were known to be subjected to copper products. These results indicate that repeated copper applications may lead to copper tolerance. Currently there are few alternative chemical options available for rotation to prevent copper resistance.
In propagation study, rooting percentages were nearly 100% for both ZeroTol® 2.0 and bleach solutions. The control was omitted so a factorial analysis could be performed as no differences were detected between the control and any of the simple effects for both sanitizers. No interaction was found between concentration and submersion time for Zerotol® 2.0 or bleach solutions. No differences were found in root weight in the main effect of submersion times for both of Zerotol® 2.0 or bleach. No differences were found in the main effect concentration for Zerotol® 2.0; however, the 25% bleach solution produced cuttings with 40% greater root weight than the 33% solution. The 10% solution produced cuttings similar to both the 33 and 25% solutions. No differences were detected across all effects for both Zerotol® 2.0 and bleach solutions in root quality rating. Future work will include repeating both trials and evaluation of other sanitizers. Collaborators from USDA ARS are currently working on efficacy of these sanitizers on BGL.

Some growers have opted out of growing the crop in an effort to mitigate risk but many growers are able to grow clean crops through proper sanitation. Currently we are recommending copper treatments in the spring especially after pruning or any potential damage like bark splitting from freeze damage. Other research projects to be initiated

in 2019 include, copper product evaluations, growth regulators to reduce pruning and continuation of the propagation and cultivar trials.

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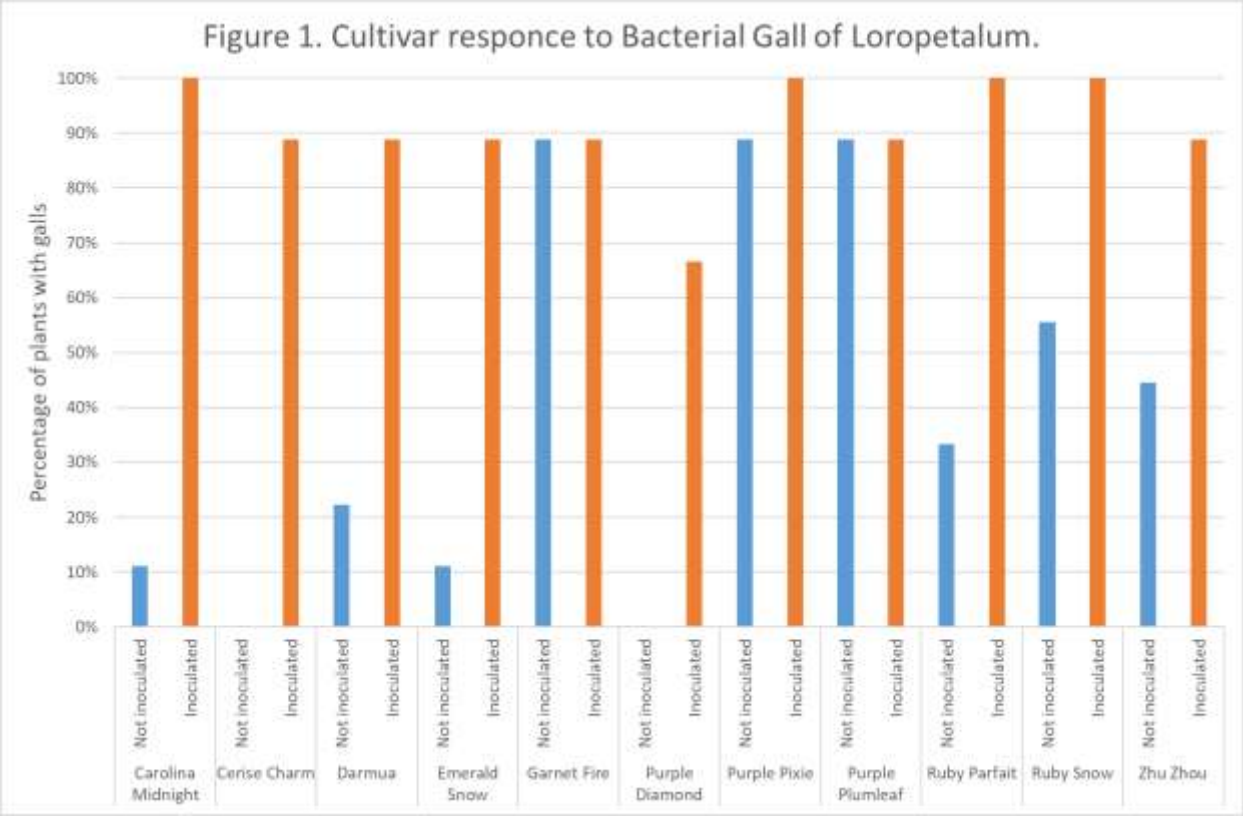

Table 1. Results from two way analysis of variance for ZeroTol® 2.0 concentration and submersion time.

	ZeroTol® 2.0 (P value)		Bleach (P value)	
ANOVA:	Weight	Rating	Weight	Rating
Concentration	0.465	0.9646	0.0975	0.7037
Submersion time	0.194	0.3618	0.0796	0.1004
Concentration x Time	0.215	0.2247	0.6329	0.4972

Main effect: Submersion time				
	ZeroTol® 2.0		Bleach	
Minutes	Weight (g)	Rating	Weight (g)	Rating
1	117 A[Z]	2.6 A	148 A	2 A
3	104 A	2.4 A	219 A	2 A
6	92 A	2.4 A	210 A	2 A

Main effect: Concentration					
	ZeroTol® 2.0			Bleach	
%	Weight (g)	Rating	%	Weight (g)	Rating
0.3	96 A	2.6 A	10	148 A	2 A
1	114 A	2.4 A	25	219 A	2 A
2	104 A	2.4 A	33	210 A	2 A

[Z]LS-means with the same letter are not significantly different

Utilization of Plant Endophytes for Control of Boxwood Blight

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Index Words Boxwood, boxwood blight, endophytes, biocontrol

Significance to Industry Boxwood blight caused by *Calonectria pseudonaviculata* (*Cps*) is a devastating disease affecting not only private and public gardens but also nursery, landscape and plant retail industries (1). The disease spreads fast and has been found in 28 states including all southern states except AL, AR, MS, OK and TX since it was first reported (2, 3). Due to the lack of resistant cultivars, eradication is often the only option when chemical fungicides and cultural practices fail to control the disease. Economic losses are enormous and a sustainable, effective and environmentally friendly alternative control method is urgently needed. Some endophytes that were recently isolated from boxwood effectively suppressed the *Cps* pathogen and boxwood blight disease and show great potential for fulfilling this need.

Nature of Work Endophytes are microorganisms that reside within various tissues of the host plant in a commensal or beneficial manner (4). Endophytes have received considerable attention for their potential as ideal biocontrol agents because of their abilities to promote plant growth and yield and to suppress plant pathogens (5, 6). However, none have been evaluated for control of boxwood diseases.

In this study, two boxwood endophytic strains SSG and SW belonging to *Burkholderia cepacia* complex and *Psuedomonas lacits,* respectively which inhibited *Cps* culture growth in dual culture assays were isolated and investigated for boxwood blight control. The isolates were grown in nutrient broth at 28 °C for 40 hours then centrifuged and resuspended in 0.01% Tween 20. *Cps* conidia were harvested from a 4-day old culture in fresh potato dextrose broth as described previously (7). Experiments were conducted with *Buxus sempervirens* 'Justin Brouwers' in 6-inch pots placed in plastic containers in the laboratory at 23 °C with a 9/15 h light/dark cycle. Plants were treated by spraying the foliage with 50 ml of a bacterial suspension at 10^8 CFU/ml or with 0.01% Tween without bacterial cells as the control. The containers were covered for one day to maintain humidity then uncovered for two days. The treated plants were then inoculated with *Cps* by spraying 20 ml of a conidia suspension at > 10^4 /ml and containers were covered for 2 days. Three days after removing lids from containers (5-day post inoculation (dpi) with *Cps*) disease incidence was assessed as the percentage of diseased leaves. Each experiment included three treatments containing three replicate plants arranged in a randomized complete block design and was repeated twice.

Experimental results were analyzed using data analysis functions in Excel. Means were separated by the least significant difference (LSD) at $P \leq 0.05$.

Results and Discussion Very good protection against boxwood blight was observed in plants treated with the endophytes SSG and SW (Fig. 1). Disease incidence in both treatments was significantly lower than the control ($P < 0.0001$) (Fig. 2). Between them, the efficacy of SSG was higher than SW, reducing disease by 99.6 % and 72 %, respectively. The efficacy of both isolates is higher than those of the recently reported bacterial and *Trichoderma* isolates from irrigation water and wild mushroom which reduced boxwood blight by about 60% (8, 9). Treatment with SSG provided nearly perfect protection for the highly susceptible boxwood cultivar tested. This efficacy for boxwood blight has never been reported for any currently available biofungicides which ranged from 0 to 44%; most of them were less than 10% (10). The efficacy of SSG is comparable to the chlorothalonil-based fungicide, Daconil (10, 11). Since SSG and SW are bacterial endophytes, their efficacy may persist throughout the production and trade process and continue into the landscape. Both endophytes, especially SSG, show great promise for biofungicide innovation and may be valuable components in the boxwood blight control tool box.

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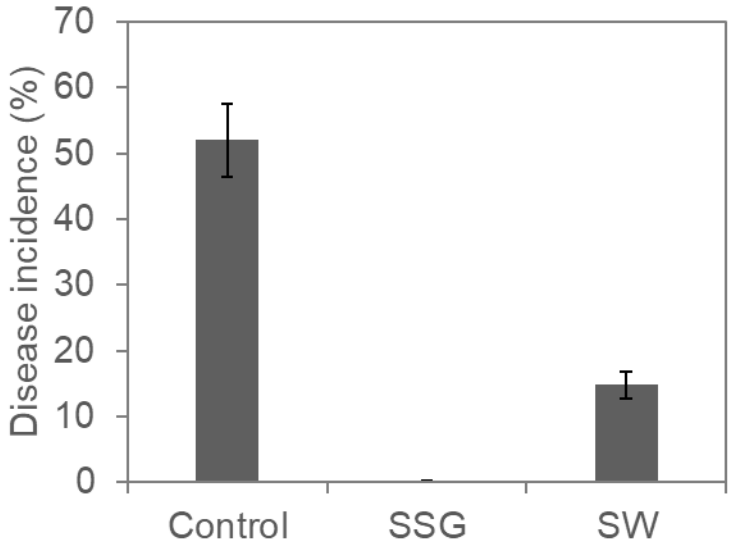

Figure 1. Symptoms on pretreated *Buxus semperveriens* " Justin Brouwers" 7 days after inoculation with *Calonectria pseudonarviculata.*

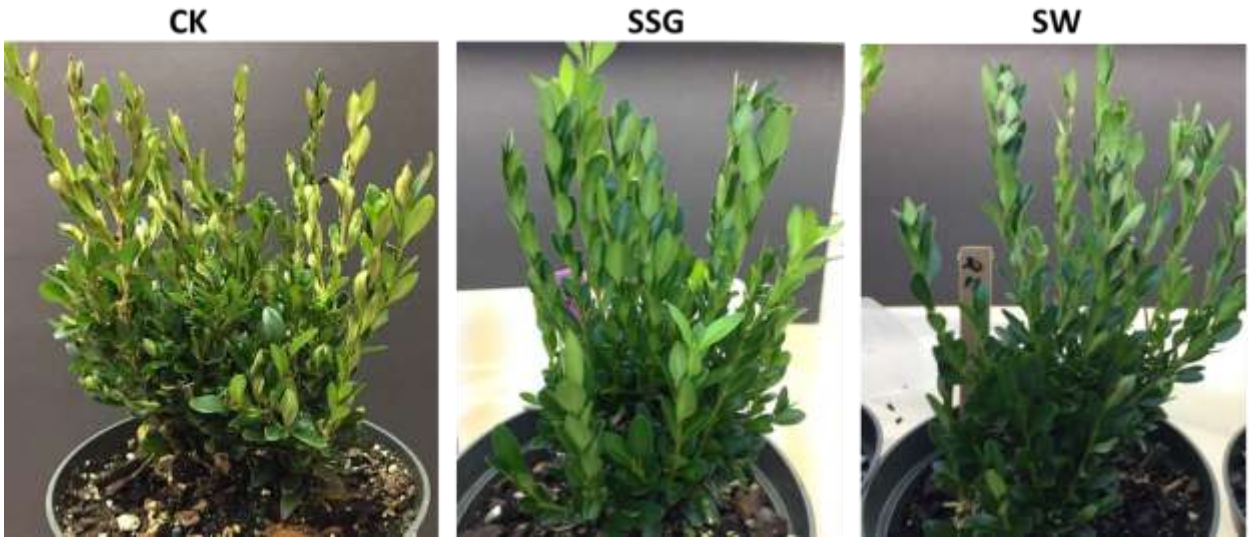

Figure 2. Boxwood blight incidence on pretreated plants.

Management of Cercospora Leaf Spot of Hydrangea with Fungicides and Biorational Products

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Index words Hydrangea, Cercospora leaf spot, fungicide and biorational products, *Cercospora hydrangea*

Significance to Industry The appearance, health, and market value of hydrangea can be significantly influenced by the impact of different diseases. Cercospora leaf spot (*Cercospora hydrangea)* is a destructive leaf disease of hydrangea in landscape and nurseries which can affect most of the hydrangea varieties. Low-maintenance landscape plantings are most susceptible to get this disease. On the bigleaf hydrangea (*Hydrangea macrophylla*) these spots turn light gray in color and are surrounded by a brown or purple halo. On the oakleaf hydrangea ((*H. quercifolia*) these spots appear angular in shape and are dark brown to purple in color. Fallen infected leaves are the main source of the causative fungus spores. These spores can spread very easily by wind and overhead irrigation. The following management systems such removing infected leaves, applying nitrogen containing fertilizer and surface watering (such as drip irrigation) can be used to reduce this disease level (1). Fungicides can be effective when first sign of leaf spots are observed. Multiple applications are needed for effective control of Cercospora leaf spot with a fungicide. Biorational products have gained increased attention of end-users for their environmental benefits and short worker re-entry interval. The rationale of this work is to present efficacy test results for hydrangea Cercospora leaf spot management to help nursery growers to make proper management decisions about fungicides and biorational products to use on their production.

Nature of Work Hydrangea is one of the most economically important nursery crops in the United States, with sales topping $120 million in 2014 (2). Hydrangeas are popular ornamental plants in both home gardens and commercial settings. Cercospora leaf spot is one of the most economically important diseases in container and field grown production of hydrangeas. Various products including fungicides and biorational products are available or in development that have the potential to contribute to the management of Cercospora leaf spot.

The objective of this study is to test the efficacy of biorational products and fungicides to control Cercospora leaf spot of hydrangea. Hydrangea (*Hydrangea macrophylla*) ‘Zaunkoenig’ x ‘Princess Juliana’ plants were potted in No. 5 nursery containers filled

with 100% pine bark substrate, which was amended with 0.48 lb of 19-5-9 Osmocote® Pro controlled release fertilizer, 0.06 lb of Micromax® micronutrient fertilizer, 0.04 lb iron sulfate and 0.01 lb Epsom salt per cubic feet of mix. Plants received additional 2.5 oz of 19-5-9 Osmocote® Pro in Apr and Jul. Four single-plant replications per treatment were arranged in a randomized complete block design outdoor under 56% shade at the Otis L. Floyd Nursery Research Center in McMinnville, TN (USDA Hardiness Zone 7a). Plants were irrigated for 3 minutes twice a day in Jun and for 4 minutes twice a day in Jul using micro bubbler emitters installed on short stakes. Treatments were Orkestra Intrinsic, Mural, Strike plus, ZeroTol, GreenClean Pro, Regalia, Mildew Cure and Triact. They were applied to run-off using a backpack CO_2-pressurized sprayer on a 7- or 14-day interval beginning on 21 Jun and ending on 5 Jul. Severity of Cercospora leaf spot resulting from natural infections and phytotoxicity were determined on 22, 24, 26 and 28 Jun; 5 and 12 Jul and were expressed as the percentage of foliage area affected. The area under the disease progress curve (AUDPC) was calculated according to the formula: $\sum([(x_i+x_{i-1})/2](t_i-t_{i-1}))$ where x_i is the rating at each evaluation time and (t_i-t_{i-1}) is the number of days between evaluations. Plant quality/acceptability was evaluated on 12 Jul using a scale of 1-9 where 1 is dead, 6 is commercially acceptable and 9 is a perfect plant. Average maximum temperatures for 21-30 Jun and 1-12 Jul were 90.0 and 88.8ºF; average minimum temperatures were 67.9 and 68.8ºF; and total rainfall was 1.65 and 2.33 in., respectively. Analysis of variance was performed using the general linear models procedure with SAS statistical software and means were separated using Fisher's LSD test.

Results and Discussion Cercospora leaf spot disease pressure was moderate to high in this trial with non-treated control plants showing 55.0% disease severity by 12 Jul (Table 2) and nearly 7.5% defoliation (data not shown). All of the treatments significantly reduced Cercospora leaf spot severity and area under the disease progress curve (AUDPC) throughout the experiment compared to the non-treated control. The treatments that most effectively reduced Cercospora leaf spot severity and the progression of disease were Orkestra Intrinsic, Regalia, Mural, GreenClean Pro and Mildew Cure. Phytotoxicity was observed as necrotic flecks and streaks on foliage of plants treated with GreenClean Pro (22.5%; data not shown). Non-treated control, GreenClean Pro and Triact-treated plants were not commercially acceptable due to disease severity or phytotoxicity at the end of the experiment (data not shown).
An integrated approach should be used to control Cercospora leaf spot in the nursery production. Results of this experiment indicate that fungicides Orkestra Intrinsic and Mural, and biorational products Regalia, GreenClean Pro and Mildew Cure provide control of Cercospora leaf spot. Nursery producers could benefit from using those fungicides and biorational products in a rotation plan to control Cercospora leaf spot in hydrangeas.

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Table 1. Treatments, active ingredients and rates.

Treatment	Active Ingredient(s)	Rate/A
Orkestra Intrinsic SC	Fluxapyroxad + Pyraclostrobin	6 fl oz/100 gal
Mural 45WG	Azoxystrobin + Benzovindiflupyr	7 oz/100 gal
Strike plus 50WDG	Triadimefon 1-(4-Chlorophenoxy)-3,3-dimethyl-1-(1 H-1,2,4-triazol-1-yl)-2-butanone	2.4 oz/100 gal
ZeroTol 2.0	Hydrogen dioxide + Peroxyacetic acid	2%
GreenClean Pro	Sodium carbonate peroxyhydrate	6 lb/100 gal
Regalia SC	*Reynoutria sachalinensis*	1%
Mildew Cure	Cotton seed oil, corn oil, garlic oil	1.5 fl oz/gal
GreenCure	Potassium bicarbonate	50 oz/100 gal
Triact 70EC	Clarified hydrophobic extract of neem oil	2%

Table 2. Effect of biorational products and fungicides on severity of Cercospora leaf spot disease on hydrangeas.

Treatment and rate	Application dates*	Cercospora leaf spot	
		Mean severity (%)(12 Jul)	AUDPC
Orkestra Intrinsic SC 6 fl oz/100 gal	1, 3	9.4 f**	142.0 f
Mural 45WG 7 oz/100 gal	1, 3	14.4 ef	240.2 def
Strike plus 50WDG 2.4 oz/100 gal	1, 3	17.5 cde	289. 6 cde
ZeroTol 2.0 2% (v/v)	1, 2, 3	22.5 bcd	332.7 bcd
GreenClean Pro 6 lb/100 gal	1, 2, 3	16.3 def	251.5 def
Regalia SC 1% (v/v)	1, 2, 3	11.9 ef	198.4 ef
Mildew Cure 1.5 fl oz/gal	1, 2, 3	16.9 c-f	265.6 def
GreenCure 50 oz/100 gal	1, 2, 3	24.4 bc	399.3 bc
Triact 70EC 2% (v/v)	1, 2, 3	29.4 b	447.3 b
Non-treated control		55.0 a	783.4 a

*Application dates: 1=21 June; 2=28 June; 3=5 July.

**Values are the means of four replications; treatments followed by the same letter within a column are not significantly different at $P \leq 0.05$.

Evaluation of Fungicide Rotations at Different Application Intervals for the Control of Powdery Mildew of Dogwood

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Index words *Cornus florida*, powdery mildew, fungicide, *Erysiphe pulchra*

Significance to Industry Powdery mildew is one of the most important diseases of dogwood (*Cornus* spp.) in containerized or field nursery, forestry and landscape settings since 1994 (1). There are two powdery mildew species that have been reported to infect dogwoods; *Erysiphe pulchra*, which is the more prevalent species, and *Phyllactinia guttata* (2). This disease is one of the most destructive diseases of flowering dogwood (*C. florida* L.) plants. In Tennessee, powdery mildew is most commonly found in late May until the first frost (3). When humidity is high, but the leaves are not wet, it is ideal circumstances for powdery mildew growth on dogwoods. Powdery mildew on dogwood can be managed easily with a variety of options. Variations in powdery mildew disease susceptibility occur within *Cornus* species, hybrids and cultivars. To control powdery mildew on susceptible dogwoods it is important to begin making preventive fungicide applications, when the weather or environmental conditions are conducive to disease development.

The rationale of this work is to present evaluation results of fungicide rotations at different application intervals for dogwood powdery mildew management to help nursery producers to make proper management decisions about fungicide rotation program.

Nature of Work Powdery mildew may cause cosmetic damage that cause chlorosis, reddish-brown patches, reduce growth by attacking tender shoots and leaf surfaces, premature defoliation, and flower blight. High relative humidity, moderate temperatures, and low light intensities favor disease development. When these conditions occur, the white, powdery appearance on plant foliage may develop. Powdery mildew spreads very quickly, with masses of conidia produced from each new infection. Therefore, preventative fungicide applications in a rotation are critical to control powdery mildew. Pathogen resistance to fungicides is well known and the performance of many fungicides has been affected to some degree by pathogens developing resistance. So, developing a fungicide rotation program using different modes of action, as indicated by their respective FRAC codes, is an important action in limiting risk of fungicide resistance development.

The objective of this study is to evaluate fungicide rotations at different application intervals for flowering dogwood powdery mildew management. Flowering dogwood (*C. florida*) cultivar 'Cherokee Princess' seedlings were potted in no. 1 nursery containers in Morton's no. 2 Grow Mix on 16 May. Each plant was top-dressed with 0.5 oz of 18-6-12 Osmocote Classic controlled release fertilizer. Ten single-plant replications per treatment were arranged in a randomized complete block design in a greenhouse at the Otis L. Floyd Nursery Research Center in McMinnville, TN. Flowering dogwood plants were watered with a drip irrigation system two times per day for 5 minutes. The initial fungicide application was made after observing the first symptoms of powdery mildew disease. Treatments were applied in a 14 or 21-day rotation program to run-off using a backpack CO_2-pressurized sprayer at 40 psi beginning on 8 Jun and ending on 10 Aug (Table 1). Control plants were sprayed with water. The severity of powdery mildew was evaluated on 15, 22 and 29 Jun; 6, 13, 20 and 27 Jul; 3, 10 and 17 Aug using a scale of 0-100% foliage area affected, and the area under the disease progress curve (AUDPC) was calculated according to the formula: $\sum([(x_i+x_{i-1})/2](t_i-t_{i-1}))$ where x_i is the rating at each evaluation time and (t_i-t_{i-1}) is the number of days between evaluations. Plant quality was evaluated on 17 Aug using a scale of 1-9 where 1 is dead, 6 is commercially acceptable and 9 is a perfect plant. Plant height and width were measured on 8 Jun and 17 Aug. Average maximum temperatures for 8-30 Jun, 1-31 Jul and 1-17 Aug were 80.2, 83.6 and 83.2ºF; average minimum temperatures were 61.0, 65.7 and 64.5ºF, respectively. Analysis of variance was performed using the general linear models procedure with SAS statistical software and means were separated using Fisher's least significant difference test.

Results and Discussion Powdery mildew infection occurred naturally in the greenhouse and disease pressure was moderate; the final (17 Aug) mean disease severity rating was 32.3% in the non-treated control plants (Table 2). Both fungicide rotation programs significantly reduced powdery mildew severity and disease progress compared to the non-treated control. The 14-day rotation program significantly reduced powdery mildew severity and disease progress compared to the 21-day rotation program. Plant width was not significantly different among treated plants on a 14-day schedule or 21-day schedule and non-treated control plants on 17 Aug. The 14-day rotation program resulted in a significantly greater plant height compared to the non-treated control. Phytotoxicity was not observed in any of the treated dogwood seedlings. Non-treated control plants were not commercially acceptable due to disease at the end of the experiment; however, all treated plants were commercially acceptable or better (data not shown).

To control powdery mildew diseases, it is important to begin making preventive fungicide applications when the weather or environmental conditions are conducive to disease development. Typically spray applications are made on a 7- , 14- or 21-day interval, depending upon the level of disease pressure. The spray rotation program tested here worked better at 14-day spray application intervals compared to the 21-day interval for the control of powdery mildew of flowering dogwood. By incorporating products that have both translaminar and systemic activity in fungicide rotation with

other protectant fungicides, nursery producers can likely extend their treatment interval while maintaining good protection.

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Table 1. Powdery mildew control- spray rotation program on flowering dogwood.

Treatment and rate/ 100 gal	Active ingredient	FRAC Code	Spray interval (days)
Mural 45WG 7 oz	benzovindiflupyr + azoxystrobin	11 + 7	14
alt Palladium WDG 6 oz	cyprodinil + fludioxonil	9 + 12	
alt Concert II 4.3SE 35 fl oz	chlorothalonil + propiconazole	3 + M05	
alt Palladium WDG 6 oz	cyprodinil + fludioxonil	9 + 12	
Mural 45WG 7 oz	benzovindiflupyr + azoxystrobin	11 + 7	21
alt Palladium WDG 6 oz	cyprodinil + fludioxonil	9 + 12	
alt Concert II 4.3SE 35 fl oz	chlorothalonil + propiconazole	3 + M05	
alt Palladium WDG 6 oz	cyprodinil + fludioxonil	9 + 12	
Non-treated control			