SECTION 5
PATHOLOGY AND NEMATOLOGY

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Beech Bark Disease - Incidence and Severity

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Nature of Work: American beech, *Fagus grandifolia* Ehrh., is a native tree that has ornamental usage in parks, golf courses, and other large areas where use of very large trees are practical (1). The European beech, *Fagus sylvatica, is* more commonly used in landscapes, but American beech often out-grown and out-perform the European species when planted at the same time.

In forests, American beech is often a dominant or codominant member of the overstory. Beech trees are also an important source of food for wildlife. Beech nuts are a major component of fall mast.

American beech has been threatened for several decades by a disease-insect complex, beech bark disease, in the northeastern North American (2,4). The insect associated with this complex is the beech scale, *Cryptococcus fagisuga* Lindinger. This pest was introduced from European in the late 1800's to earlier 1900's (4). After scale infestations become severe, beech trees may be attacked by the fungus *Nectria coccinea* var. *faginata* Lohman, A. M. Watson, and Ayers (4,5). In 1993, beech bark disease was discovered on the North Carolina - Tennessee border in Great Smoky Mountain National Park (GSMNP) (C. Johnson, NPS, personal communication).

Results and Discussion: Ten permanent plots have been established to observe insect infestations and disease epidemics in GSMNP. Scale infestations were high at three sites, low at four other sites, and absent at three sites. Fungal infection was rated high at one site where beech scale infestations was also high. At this site tree mortality was observed.

Signs and symptoms of the disease-insect complex include female scales (<1mm in diameter) covered by white wool-like threads of wax. Bark of trees with heavy infestations of scales was encrusted with these wool-like tufts. Infestations were most often observed in areas of rough bark and mechanical injuries. Symptoms of fungal infection included strips of dead bark that were slightly depressed. Sexual fruiting bodies were on dead bark and were spherical, bright to dark red, <1mm in diameter, and occurred in small to large clusters.

Significance to Industry: Beech bark disease, a devastating disease-insect complex, was introduced to the northeastern United States from Europe at the turn of century. This disease has recently been observed on American beech trees in North Carolina and Tennessee. Beech bark disease poses a new threat for beech trees in ornamental and forest settings in the southeastern United States.

Literature Cited

1. Dirr, M. A. 1990. Manual of Woody Landscape Plants: Their identification, ornamental characteristics, culture, propagation and uses. Stipes Pub. Co. Champaign, IL. 1007 p.

2. Houston, D. R. 1975. Beech bark disease - the aftermath forests are structured for a new outbreak. J. For. 73 (10):660-663.

3. Houston, D. R. 1982. Proceedings of I.O.F.R.O. Beech Bark Disease Working Party Conference. Hamden, CO. 140 p.

4. Johnson, Warren T. and Lyon, Howard H. 1991. Insects that feed on trees and shrubs. 2nd Ed. Comstock Pub. Assoc. Ithaca, NY. 560 p.

5. Shigo, A. L. 1972. The beech bark disease today in the northeastern United States. J. For. 70 (5): 286-289.

Efficacy of Fluazinam for Control of Brown Patch of Tall Fescue Sod Caused by *Rhizoctonia solani*

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Nature of Work: Brown patch caused by *Rhizoctonia solani* Kuhn is the most destructive disease of tall fescue *(Festuca arundinacea* Schreb.). In Tennessee brown patch is widespread in tall fescue sod from May to mid-July. Patches range from 6 in to 1 yd in diameter. Disease management includes monitoring cultural practices such as irrigation and fertilization. Turf areas should be irrigated infrequently, but thoroughly to a depth of 6 in. Fertilization is scheduled during September to April to avoid lush growth during late Spring and early Summer. Many turf type tall fescue cultivars are moderately to highly susceptible to brown patch (2,3). It has been suggested that narrow leaf blades and dense canopies of turf type tall fescue create a microenvironment more favorable to brown patch (3). Chemical control is often needed to maintain high quality tall fescue sod. The objective of this study was to evaluate a new experimental fungicide with the common name fluazinam (ISK Biotech, Mentor, OH) for control of brown patch.

Materials and Methods: Test 1 was initiated at a sod farm in Davidson Co. on June 8,1993. The test was established on an irrigated tall fescue field of a blend of 'Arid', 'Bonanza' and 'Rebel II' turf type tall fescues. Plots were 10'x15' with 4 replications per treatment. Treatments were arranged in a randomized complete block design. Treatments, rates/1000 sq ft and spray intervals for the 1993 field trial included: iprodione (Chipco 26019 FIO) 2.0 fl oz/14 day; mancozeb (Fore Flowable) 12.6 oz/7 day; fluazinam 500F 0.5 fl oz/14 day; and chlorothalonil (Daconil 2787F) 6 fl oz/14 day.

Test 2 was initiated at a sod farm in Davidson Co. on June 2, 1994. The test was established on an irrigated tall fescue field of a blend of 'Titan', 'Trident' and 'SR8300' turf type tall fescues. Plots were 5'x10' with 4 replications per treatment. Treatments were arranged in a randomized complete block design. Treatments, rates/1000 sq ft and spray intervals for the 1994 field trial included: mancozeb (Fore Flowable) 6.4 fl oz/ 14 day, propiconazole (Banner 1.1 E) 2 fl oz/14 day, chlorothalonil (Daconil 2787F) 6.0 fl oz/14 day; fluazinam 500F 1 fl oz/14 day and 2 fl oz/28 day; iprodione (Chipco 26019 50WP) 2 oz/14 day.

Fungicides in both tests were applied with a CO_2 backpack sprayer with 8008 flat fan nozzles at 40 psi. Fungicides were applied in the equivalent of 3 gal of water/1000 sq ft.

Results and Discussion: Fluazinam was as effective at controlling brown patch as industry standards chlorothalonil, iprodione, mancozeb and propiconazole (Table 1 & 2). Fluazinam provided excellent control of brown patch when applied at 14 or 28 day intervals during periods of high disease pressure.

Significance to Industry:Fluazinam provided excellent control of brown patch of tall fescue 28 days after application. Fluazinam is not only very efficacious against *Rhizoctonia solani,* but also several fungi that are common plant pathogens of ornamental plants including *Phytophthora cinnamomi (1) .*

Literature Cited

1. Benson, D. M. 1993. Efficacy of fluazinam for control of phytophthora root rot of azalea caused by *Phytophthora cinnamomi.* Proceedings of the Southern Nursery Research Conference. Vol. 38:198-199.

2. Burpee, L. L. 1992. Assessment of Resistance to *Rhizoctonia solani* in tall fescue based on disease progress and crop recovery. Plant Disease. 76:1065-1068.

3. Giesler L. J. and G. Y. Yuen. 1994. Host factors affecting brown patch disease severity in tall fescue. (Abstr.) Phytopathology (In Press).

Table 1. Efficacy of fluazinam for control of brown patch of tall fescue, 1993.

Treatment	% Disease		
	June 22	July 1	July 6
fluazinam 500F	0.3 B*	0.0 B	0.5 C
Chipco 26019 FLO	0.0 B	0.3 B	0.3 C
Daconil 2787F	0.0 B	0.8 B	3.0 B
Fore Flowable	0.0 B	0.0 B	0.3 C
Untreated	7.5 A	11.3 A	26. 3 A

*Means within a column with the same letter are not significantly different as determined by Duncan's Multiple Range Test (P=0.01).

Table 2. Efficacy of fluazinam for control of brown patch of tall fescue, 1994.

Treatment	% Disease		
	June 16	June 29	July 13
fluazinam 500F	0.5 D*	0.0 C	0.0 B
fluazinam 500F (28 day)	1.0 D	0.3 BC	1.0 B
Chipco 26019 50WP	0.8 D	0.5 BC	1.8 B
Daconil 2787F	0.5 D	0.5 BC	1.3 B
Fore Flowable	2.0 CD	0.8 BC	0.8 B
Banner 1.1E	3.0 BC	2.0 B	1.0 B
Untreated	56.3A	82.5 A	76.3A

*Means within a column with the same letter are not significantly different as determined by Duncan's Multiple Range Test (P=0.01).

Efficacy of Fluazinam for Control of Phytophthora Crown Rot of African Violet Caused by *Phytophthora parasitica*

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Nature of Work: Phytophthora crown and root rot of African violet *(Saintpaulia ionantha H.* Wendl.) caused by *Phytophthora parasitica* can be a devastating disease. Entire flats of cuttings and plants may be lost due to plant to plant spread via splashing water or contaminated growing media. Symptoms may include stunting, wilting and a dark brown-black necrosis spreading from the crown to petioles and leaves of infected plants. Control is based on sanitation, fungicide drenches (2) and resistant cultivars (3,4).

Recently, fluazinam, an experimental fungicide, (ISK Biotech, Mentor, Ohio) has been shown to have activity against *Phytophthora cinnamomi (1).* The objective of this experiment was to evaluate fluazinam for control of phytophthora crown rot of African Violet caused by *Phytophthora parasitica.*

Materials and Methods: Rooted violet cuttings of 'Manitoba' and 'Angelika' were transplanted into 4 inch plastic pots of Promix BX and grown for 3 weeks. Two isolates of *Phytophthora parasitica* from African violet were grown for two weeks on sterilized oat grains. Pots were infested by placing 3 colonized oat grains below the surface of the growing medium and adjacent to each plant. Each pot was drenched with 100 ml of fungicide solution. Fungicides were applied either preventatively (24 hr prior to inoculation) or curatively (24 hr after inoculation). Subdue was used as the standard fungicide for comparison. There were four replications for each treatment arranged in a randomized complete block design. Plants were rated for symptoms of crown rot 14 days after inoculation using a rating scale previously published (2).

Results and Discussion: Fluazinam protected 'Manitoba' from crown rot when used preventatively at the 2 and 4 oz rates; and curatively at all rates tested (Table 1 & 2). Ratings for fluazinam treated plants were comparable to those treated with Subdue. 'Angelika' was not affected by the inoculum and appear to be highly resistant to phytophthora crown rot. 'Manitoba' treated with the 4 oz rate of fluazinam exhibited moderate chlorosis.

Significance to Industry: Fluazinam shows promise as a fungicide drench to protect African violets from phytophthora crown rot. Further studies need to be conducted to pinpoint efficacious rates that do not cause phytotoxicity and to determine the residual activity against this disease.

Literature Cited

1. D. M. Benson. 1993. Efficacy of fluazinam for control of phytophthora root rot of azalea caused by *Phytophthora cinnamomi.* Proceedings of the Southern Nursery Association Research Conference Vol. 38:198-199.

2. Ploetz, R. C. and A. W. Engelhard.1980. Crown and root rot of gloxinia and other gesneriads caused by *Phytophthora parasitica.* Plant Disease 64:487-490.

3. Strider, D. L.1978. Reaction of African violet cultivars to *Phytophthora nicotianae var. parasitica.* Plant Disease Reptr. 62:112-114.

4. Strider, D. L. 1979. Evaluation of Melodie and Optimara African violets for resistance to phytophthora rot. Plant Dis Reptr. 63:382-384.

Table 1. Efficacy of fluazinam for preventative control of phytophthora crown rot of African violet.

Treatment	oz/100gal	Manitoba	Angelika
Fluazinam 500F	1 oz	3.5* AB**	1.0 A
Fluazinam 500F	2 oz	1.3 C	1.0 A
Fluazinam 500F	4 oz	2.0 BC	1.0 A
Subdue 2E	1 oz	1.3 C	1.0 A
Infested,Untreated	——	4.0 A	1.3 A
Uninfested,Untreated	——	1.3 C	1.0 A

*Average disease ratings of four plants in a treatment. 1 = no disease; 2 = slight disease, < 25% of total leaf surface necrotic, no detectable stem necrosis; 3= moderate disease, 25-50% of total leaf surface necrotic, stem partially girdled; 4= severe disease, 50-75% of total leaf surface necrotic, stem completely girdled; 5= dead, 75-100% total leaf surface necrotic, stem completely girdled. Disease means in a column followed by the same letter are not significantly different at the 1 % level according to DMRT.

**Means within a column with the same letter are not significantly different as determined by Duncan's Multiple Range Test (P=0.01).

Table 2. Efficacy of fluazinam for curative control of phytophthora crown rot of African violet.

Treatment	oz/100gal	Manitoba	Angelika
Fluazinam 500F	1 oz	2.0* BC**	1.0 A
Fluazinam 500F	2 oz	1.5 BC	1.0 A
Fluazinam 500F	4 oz	3.3 AB	1.0 A
Subdue 2E	1 oz	2.5 BC	1.0 A
Infested, Untreated	——	4.5 A	1.3 A
Uninfested, untreated	——	1.0 C	1.0 A

*Average disease ratings of four plants in a treatment. 1 = no disease; 2 = slight disease, < 25% of total leaf surface necrotic, no detectable stem necrosis; 3= moderate disease, 25-50% of total leaf surface necrotic, stem partially girdled; 4=severe disease, 75-100% of total leaf surface necrotic, stem completely girdled; 5= dead, 75-100% total leaf surface necrotic, stem completely girdled.

**Means within a column with the same letter are not significantly different as determined by Duncan's Multiple Range Test (P-0.01).

Ineffectiveness of Garlic Extracts for Controlling Dogwood Anthracnose in Field Tests

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Nature of Work: Extracts of garlic *(Allium sativum L.)* have been reported to be bactericidal and fungicidal against certain plant and animal pathogens both in laboratory tests and greenhouse trials (1,3). In previous studies in our laboratory, 5 and 10% aqueous solutions of extracts from fresh garlic cloves were fungicidal for both spores and mycelial plugs of a number of isolates of *Discula destructiva,* the dogwood anthracnose fungus (2). The objective of the present study was to test the effectiveness of a 10% garlic solution in controlling dogwood anthracnose in field studies using container-grown seedlings placed under naturally-infected *Cornus florida* trees.

Three treatment groups were established with 4 replications. Each group consisted of five two-yr-old seedlings of *C. florida* previously established in 1-gallon plastic containers. The trees were placed in randomized positions under the canopies of naturally-infected mature *C. florida* trees showing definitive symptoms of dogwood anthracnose at the Coweeta Hydrologic Laboratory near Otto, NC. Trees were sprayed to run off, biweekly, with a hand-held sprayer for 12 weeks beginning May 18, 1993, and ending August 10, 1993. Trees in Group 1 were sprayed with distilled water, those in Group 2 with chlorothalonil (Daconil 2787 4.17F, 0.32 oz/gal) and those in Group 3 with 10% garlic solution. All sprays were prepared just prior to use and contained a spreader sticker (Dupont, 4 oz/100 gal). The garlic solution was made by homogenizing fresh garlic cloves in distilled water (10 g/100 ml), removing the solids by filtration (Whatman, GF/C), and storing the filtrate on ice until use.

Leaves were examined visually at 1-2 wk intervals and were considered infected if lesions typical of dogwood anthracnose were present. No attempts were made to isolate *D. destructiva.* The percent infected leaves was calculated for each treatment group in each replication. Results were evaluated by standard analyses of variance and Duncan's Multiple Range Test.

Results and Discussion: Data from all replications (20 seedlings/treatment) was pooled in the final analysis. The percent infected leaves in all treatment groups increased over time (Fig. 1). The Daconil-treatment group was significantly different from the controls for all observation periods (Tab. 1). At week 12, the final observation time, 17.9% (214/1197) of the Daconil-treated leaves were infected compared with 61.4% (588/958) for the control group. The garlic treatment slightly reduced the percent infected leaves at all observation times except 7 weeks, but the differences were not significant except at 4 and 12 weeks (Tab.1). In addition, an undesirable side-effect of the garlic treatment was the increased growth of *Cladosporium sp.* on the adaxial surface of the leaves resulting in a black unsightly fungal growth. Both the garlic and

Daconil treatments significantly reduced leaf abscission. At week 12, there was 38.2% (366/958) leaf-drop for the controls, 20.7% (228/1102) for the garlic-treatment group, and 12.2% (146/1197) for the Daconil-treatment group.

Significance to Industry: Unpurified foliar sprays of extracts of fresh garlic cloves were ineffective under the conditions used in this study for the control of dogwood anthracnose on container-grown seedlings of *C. florida* and encouraged the unsightly growth of *Cladosporium sp.* on the adaxial surface of leaves. A biweekly-spray of Daconil was effective in controlling the percent infected leaves and in reducing leaf abscission, but did not prevent the development of leaf lesions. Additional studies are needed to determine if the effectiveness of garlic treatments could be improved with purification of the extracts, different spray schedules or different methods of application.

Literature Cited

1. Ark, P. A. and J. P. Thompson. 1959. Control of certain diseases of plants with antibiotics from garlic *(Allium sativum L.).* Plant Dis. Reptr. 43:276-282.

2. McElreath, S. D., J.-M. Yao and F. H. Tainter. 1993. Effect of garlic extracts on dogwood anthracnose fungi. Proc. Southern Nurserymen's Assoc. Research Conference 38: 195-197.

3. Tansey, M. R. and J. A. Appleton. 1975. Inhibition of fungal growth by garlic extract. Mycologia 67:409-413.

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FIGURE 1

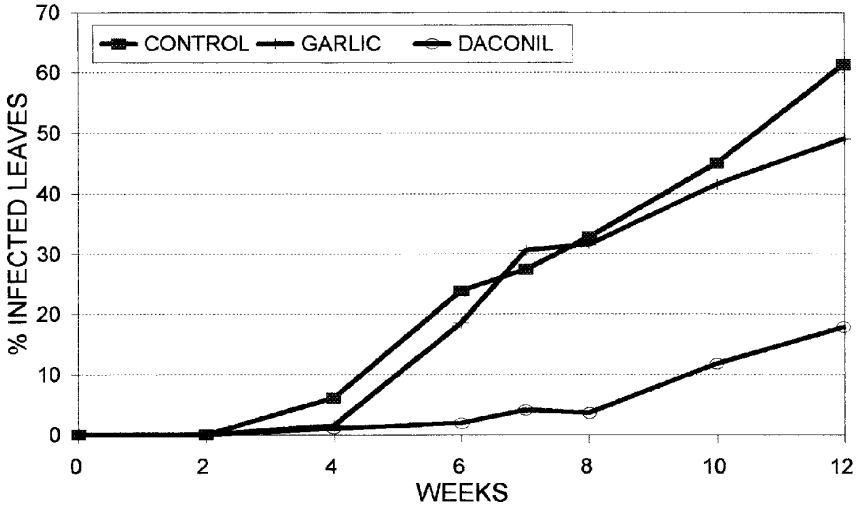

TABLE 1

COMPARISON OF TREATMENT GROUPS
(Percent infected leaves)

WEEK	2	4	6	7	8	10*	12*
CONTROL	0	6.1 a**	23.7 a	27.4 a	32.8 a	45.1 a	61.4 a
GARLIC	0	1.5 b	18.6 a	30.6 a	31.6 a	33.2 a	49.1 b
DACONIL	0	1.1 b	2.0 b	4.1 b	3.6 b	11.8 b	17.9 c

* Number of infected leaves includes abscised leaves.
** Duncan's Multiple Range Test (Means within a column with the same letter do not differ significantly).

In Vitro Responses of *Cornus florida* callus to Partially Purified Culture Filtralte of *Discula destructiva*

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Nature of Work: Dogwood anthracnose, caused by the fungus *Discula destructiva*, has descended the Appalachian mountains from the northeast since its description by Daughtrey and Hibben (1983). In some locations at higher elevations almost every flowering dogwood has been killed. Dogwoods in many urban forested areas in the northeastern United States have also been affected. At locations such as the presidential retreat, Camp David, only a few survivors remain. Whether these are escapes or have some degree of disease resistance is now one of the major areas of investigation in the Forest Pathology laboratory at Clemson University. The severity of dogwood anthracnose and recent lower-elevation outbreaks in South Carolina and Virginia has focused renewed attention on the need to comprehensively understand the basic biology of the infection processes and develop genetic and/or cultural controls for this disease.

Evidence to date suggests that fungal toxins are involved in the injury to dogwood tissues during *D. destructiva* infection and colonization. Necrosis in leaves with few visible hyphae strongly supports the hypothesis that a toxic metabolite may be active in lesion formation in pathogenesis (Walkinshaw and Anderson 1991). Several toxins from *D. destructiva* culture filtrates have been isolated and chemically distinguished (Ventkatasubbaiah and Chilton 1991, Wedge et al. 1993a). Characteristic symptoms of dogwood anthracnose and dose-responses of toxic metabolites in in vitro bioassay studies indicate that *D. destructiva* is producing toxic metabolites with auxin-like plant growth regulator (PGR) modes of action (Wedge et al. 1993b). The specific experimental goal of this project was to develop a reliable and quantitative tissue culture system to detect resistance to toxins in culture filtrate from *Discula* species and characterize their etfects.

Results and Discussion: A tissue culture system in which dogwood calli were challenged by a sublethal stepwise exposure to partially purified culture filtrate (PPCF) obtained from D. destructiva liquid culture was used. The PPCF was produced by a purification procedure combining ultrafiltration, lyophilization, and rotary evaporation which yielded several biologically active low molecular weight compounds. Sublethal levels of exposure to PPCF were determined to be between 1 and 10% by prescreening *C. forida* calli with 0.1, 1.0 and 10% culture-filtrate-amended tissue culture media. Nine 5 x 1.5 mm callus discs cut from a single clonal line of established callus were placed on 90 mm petri dishes. Murashige-Skoog media was amended in 4 combinations: 3 mg/l naphthaleneacetic acid (NAA) and 1 mg/l benzyladenine (BA) or 3 mg/12,4-dichlorophenoxyacetic acid (2,4-D) and 1 mg/1 BA, each containing PPCF or potato dextrose broth (PDB) used as the control. Calli were grown for 4 weeks on media treatments and callus wet weights were recorded at transfer. Selection was initiated on 2.5% PPCF-amended tissue culture media and calli were sequentially stepped to 5.0%

and 7.5% PPCF. Callus cultures were maintained at 25±C under mixed fluorescent lamps with light levels of 47±2 µmoles and 12 h photoperiods.

The experiment utilized a completely randomized design with 3 selection levels, 4 media combinations, 7 replicates and an initial n=9 for each replicate. Analysis of variance of mean wet weights indicated that selection level main effects (2.5%, 5% and 7.5%) were highly significant, $F_{2,16}$=98.15, p<0.001. Media amendment main effects (2,4-D, NAA, PPCF or PDB) were highly significant, $F_{3,33}$=52.31, p<0.001. Separation of mean callus weights using Tukey HSD indicated that 2,4-D and PPCF treatments were significantly inhibitory to dogwood callus at all selection levels (Figure 1). Separation of mean callus weights using Tukey HSD indicated that NAA and PPCF treatments were significantly stimulatory to dogwood callus at all selection levels (Figure 2). Callus mean weights were significant for all treatment combinations except PDB at 7.5% selection level. We conclude from these experiments that *Discula* toxic metabolites have a PGR mode of action and may work synergistically with other PGRs.

Significance to Industry: A reliable and quantitative detection scheme is essential in developing toxin resistant germplasm in *C.florida*. Culture filtrates of *D.destructiva* are being used to develop in vitro resistance in *Cornus forida* to toxic metabolites (Wedge et al. 1994) The availability of disease resistant dogwood germplasm for conventional breeding programs is of great importance to the long term survival of *C. florida* as a horticultural commodity as well as a forest species. Knowledge of the physiological and toxicological responses of dogwood anthracnose is crucial to developing a successful disease management strategy. Information gained from basic research will provide horticulturists with cutting edge information concerning disease progression and mechanism of action from which unique biologically based treatments can be incorporated into environmentally sound plant health care strategies.

Literature Cited

1. Daughtrey, M. L, and C. R. Hibben. 1983. Lower branch dieback, a new disease of northeastern dogwoods. (abs.) Phytopathology 73:365.
2. Venkatasubbaiah, P. and W. S. Chilton. 1991. Toxins produced by the dogwood anthracnose fungus *Discula* sp . J . Nat. Prod . 54: 1293- 1297.
3. Walkinshaw, C. H. and R. L. Anderson. 1991. Histology of *Cornus florida* L. leaves infected naturally and artificially by *Discula* sp. USDA For. Ser., Res. Note SE-360. 4 p.
4. Wedge, D. E., S. D. McElreath, and F. H. Tainter. 1993a. A bioassay for studying toxic metabolites of *Discula destructiva*. Phytopathology 83:1393 Abs.
5. Wedge, D. E., S. D. McElreath, and F. H. Tainter. 1993b. Bioassay of toxic metabolites from fungi associated with dogwood anthracnose. Proc. Southern Nurserymen's Research conference 38:43-45.
6. Wedge, D. E. and F. H. Tainter. 1994 Use of culture filtrates of *Discula destructiva* to develop resistance in *Cornus forida*. In Vitro Cellular and Developmental Biology. 30(3):60 Abs.

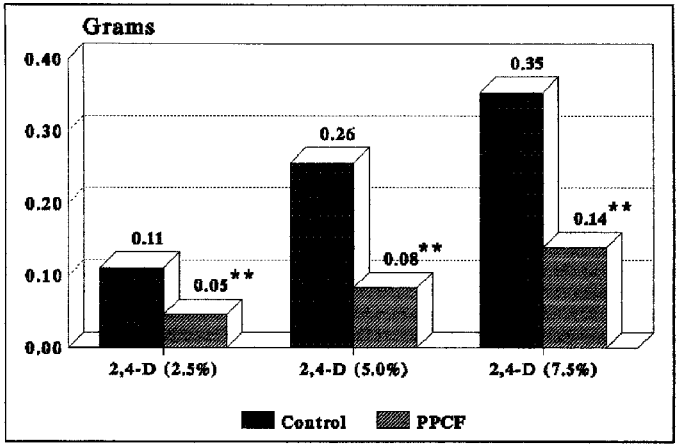

Figure 1. Wet weights of *C. florida* callus on Murashige-Skoog media amended with 3mg/l 2,4-D, 1 mg/l BA and PPCF or control indicate significant inhibition of dogwood callus growth when PPCF is combined with 2,4-D.

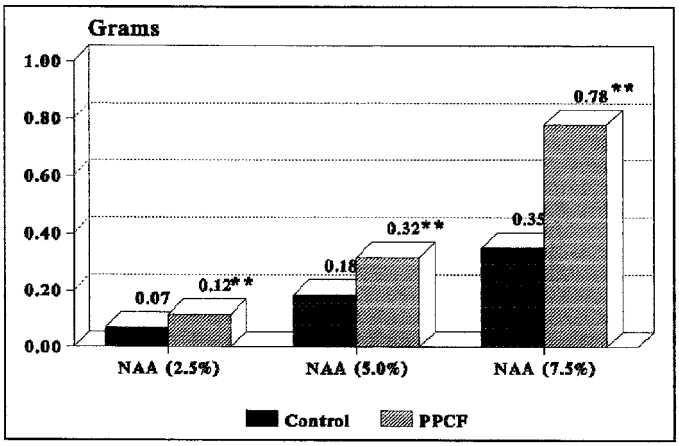

Figure 2. Wet weights of *C. florida* callus on Murashige-Skoog media amended with 3mg/l NAA, 1 mg/l BA and PPCF or control indicate significant stimulation of dogwood callus growth when PPCF is combined with NAA.

Newer Chemicals Fail to Control Leaf Nematodes on Hiemalis Begonia

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Nature of Work: Leaf nematodes *(Aphelencoides* spp.) have a wide-host range and are often very destructive to begonia (1). Control of these nematodes has been achieved in the past by certain chemical sprays, hot-water treatment, and sanitation or combinations thereof (2, 3, 4). However, recent environmental constraints and health concerns associated with several of the 'older' chemicals, suggest that newly developed chemicals, with different modes of action, may be potential nematicides. The purpose of this study was twofold, first to evaluate a group of compounds on three cultivars of begonia infested with *Aphelencoides fragariae* to determine efficacy and second, to select the most effective compounds and investigate efficacy at different rates of application.

In the first experiment, the compounds evaluated and rates (expressed as amount of formulated material per 100 gallons) used were: abamectin, 0.15 EC, 1 pt; azadirachtin, 3%, 0.4 gal; bifenthrin, 1.75 EC, 1 pt; carbosulfan, 4 EC, 1 pt; cyromazine, 75 WP, 0.25 Ib; diflurobenzuron, 25 WP, 1 Ib; fenoxycarb, 25 WP, 2 Ib; imidacloprid, 2 EC, 1 pt; and oxamyl, 2 L, 2 pt. Oxamyl was included as a standard for comparative purposes. [Trade names are provided in Table 1.] Each treatment was applied on four dates, one week apart, to both inoculated and noninoculated plants. The experimental design was a randomized block with four treatment replications in the inoculated plants and two replications of treatments in the noninoculated (controls).

In the second trial one cultivar (Apricot Beauty) was chosen for treatments. The treatments, selected on the basis of results in the first trial were: carbosuifan, 4 EC, at 1 pt, 1 qt, and 2 qt/100 gal; cyromazine, 75 WP at 0.25, 0.5, and 1 Ib/100 gal; diflurbenzuron, 25 WP, at 0.25, 0.5, and 1.0 Ib/100 gal. These treatments were compared to an oxamyl standard of 2 pt/100 gal and a water check. The experimental design was a randomized block with 10 replications of each treatment. Sprays were applied once a week for three weeks. In both trials leaf nematode populations were determined one week following the bst spray and nematode counts adjusted to standard leaf weight (1.0 g). The mean number of nematodes counted for each sample in the second trial was transformed to $\log_{10}(x+1)$ before the data were analyzed by the GLM Procedure. The mean values were separated by the T test at $\underline{P} = 0.05$.

Results and Discussion: All three cultivars of begonia were highly susceptible to leaf nematodes, and each were quite variable in the nematode population per gram of leaf tissue. In the initial evaluation oxamyl (Vydate) was the only chemical which resulted in a reduction of nematode populations on all cultivars (Table 1). The population in the oxamyl-treated plants averaged 31% less than the water controls across all cultivars. Carbosulfan (Advantage) and diflurbenzuron (Dimilin) resulted in slight reductions of the populations, whereas other materials had no effects.

Three applications of carbosulfan, diflurobenzuron or cyromazine at three rates each failed to control leaf nematode on Apricot Beauty, whereas oxamyl resulted in significantly fewer nematodes than the controls. These data, transformed and adjusted for weight of plant sample, are provided in Table 2. Although, oxamyl (Vydate), at 2 pts/100 gal, resulted in the lowest population of nematodes, numbers were not significaritly less than the 0.5 and 2.0 lb rate of carbosuHan or the 0.25 and 0.5 rate of diflurabenzuron.

Significance to Industry: Control of leaf nematodes by newer chemicals, such as insect growth regulators, may not be as effective as are the organophosphates such as oxamyl. Growers of leaf nematode susceptible plants should maintain strict sanitation to minimize losses until recommended chemical controls can be developed with effective materials or techniques.

Literature Cited

1. Lehman, P.S. 1969. A disease of begonia caused by a foliar nematode, *Aphelencoides fragariae.* FL Dept. Agric. & Consumer Serv., Div. of Plant Industry. Nematology Circ. No. 164.

2. Powell, C.C., R.M. Riedel, and V.R. Walter.1975. The effect of aldicarb on *Aphelencoides fragariae* on Rieger begonia Plant Disease Reporter 59: 370-372.

3. Qiu, J. B.B. Westerdahl, R.P. Buchner, and C.A. Anderson. 1993. Refinement of hot water treatment for management of *Aphelencoides fragariae* in strawberry. Supplement to J. of Nematology 25: 795799.

4. Riedel, R.M. and C.C. Powell.1974. Control of *Aphelencoides fragariae* on Rieger begonia with oxamyl. Plant Disease Reporter 58: 911 -913.

Table 1. Number of nematodes recovered per gram leaf after four chemical applications to three begonia cuitivars.

Chemical (Trade name)	Application Rate/100aal	Number of Nematodes/gram X 10^3 Pia Elisa	Apricot Beauty	Petra
Control (water)	—	40.5	7.2	6.3
Oxamyl (Vydate 2 L)	2 pts	0.8	0.9	0.4
Bifenthrin (Biflex 1.75 EC)	1 pt	16.3	1.2	13.9
Carbosuifan (Advantage 4 EC)	1 pt	8.7	2.0	6.5
Abamectin (Avid 0.15 EC)	1 pt	9.1	19.8	13.5
Diflurbenzuron (Dimilin 25 WP)	1 lb	5.0	2.3	5.7
Fenoxycarb (Precision 25 WP)	0.5 lb	5.2	29.3	9.5
Imidacloprid (Marathon 2 F)	1 pt	24.2	16.1	4.5
Azadiractin (Azatin 3%)	0.4 gal	22.2	3.7	3.0
Cyromazine (Citation 75 WP)	0.25 lb	15.4	5.8	7.1

Table 2. Ranking of chemicals for leaf nematode (Ashelencoides fragariae) control on Apricot Beauty begonia after three applications.

Chemical	Rate/ 100 qal	Nematodes/gram
Oxamyl	2.0 pts	105.2 [Z] b [Y]
Carbosulfan	1.0 pt	173.3 ab
Diflurobenzuron	1.0 lb	173.5 ab
Diflurobenzuron	2.0 lbs	198.4 ab
Carbosulfan	2.0 qts	207.4 ab
Carbosulfan	1.0 qt	241.0 a
Control	- - - -	245.5 a
Diflurobenzuron	4.0 lb	250.1 a
Cyromazine	0.251b	257.7 a
Cyromazine	0.5 lb	263.6 a
Cyromazine	1.0 lb	267.2 a

[Z] Transformed data: $\sqrt{\log_{10}(X+1)}$.

[Y] Means followed by the same letter are not significantly different by T test (P =0.05). LSD = 121.35

Resistance of *Cornus kousa* Taxa to Dogwood Anthracnose and Powdery Mildew

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Nature of Work: Evaluation of different species of dogwoods has shown considerable variation in susceptibility to *Discula destructiva,* the causal pathogen of dogwood anthracnose (6). Kousa dogwood has generally been found to be more resistant to dogwood anthracnose than is flowering dogwood (1, 5); however, variations in resistance among taxa of kousa dogwood have been noted. For example, Windham and Trigiano (6) reported that one selection of kousa dogwood *(C. kousa* var. *chinensis)* was relatively susceptible to *D. destructiva* while another unnamed selection of kousa was found to be resistant. Identification of taxa of kousa dogwood with greater resistance to dogwood anthracnose would provide valuable information for selecting disease resistant dogwoods for planting in areas where the disease is prevalent. Similarly, selection of taxa with natural resistance to powdery mildews would aid in minimizing this problem in the landscape. The objective of this project was to evaluate 20 different taxa of dogwood including cultivars of *C. kousa* and hybrids between *C. kousa and C. florida* for resistance to dogwood anthracnose and powdery mildew.

Cultivars of kousa dogwood included: 'Autumn Rose', 'Big Apple', 'China Girl', 'Elizabeth Lustgarten', 'Gay Head', 'Greensleeves', 'Julian', 'Milky Way', 'Milky Way Select', 'Moonbeam' (P.P. No. 3482), 'Steeple', 'Temple Jewel', and 'Wolfeyes' (syn. 'Princeton Variegated'). See Jaynes, et al. (1993) and Orton (1993) for cultivar descriptions. The cultivar designation 'Milky Way' does not necessarily represent an individual clone (Orton, 1991). 'Milky Way' is a cultivar name given to a group of seedlings grown from open pollinated sources. The 'Milky Way' cultivars included in this experiment were clonal and were propagated from a single 'Milky Way' tree. Similarly, 'Milky Way Select', is a clonal selection made from seedlings of 'Milky Way'. Hybrids between kousa and flowering dogwoods included: Aurora® (*C. x* 'Rutban', P.P. No. 7205), Constellation® (*C. x* 'Rutcan', P.P. No. 7210), Celestial™ (*C. x* 'Rutdan', P.P. No. 7204), Ruth Ellen® (*C. x* 'Rutlan', P.P. No. 7732), Stardust® (*C. x* 'Rutfan', P.P. No. 7206), and Stellar Pink® (*C. x* 'Rutgan', P.P. No. 7207). See Orton (1993) for descriptions. In addition, seedlings of flowering dogwood were included for comparison. On May 11, 1993 the plants were moved to the US Forest Service Bent Creek Experimental Forest, Asheville, NC and placed in a mixed hardwood forest beneath the canopy of a grove of native flowering dogwoods that were infected with *D. destructiva* and *M. pulchra*. The containerized plants were arranged in a completely randomized design, with 3 - 4 replicate trees. In addition to naturally occurring inoculum, the plants were artificially inoculated with a suspension of dogwood anthracnose spores (conidia) in water applied with a hand held sprayer on May 27, 1993 and June 24, 1993 with 10,000 and 20,000 spores•ml^{-1}, respectively.

Results and Discussion: Dogwood anthracnose. By the end of October, all plants eventually developed symptoms of dogwood anthracnose (Table 1.). The kousa dogwood cultivars 'Wolf Eyes', 'Moonbeam', and 'Autumn Rose' and the flowering dogwood seedlings were found to be highly susceptible with 100% of the total leaf area affected per plant. Plant survival in Fall 1993 for 'Wolf Eyes', 'Moonbeam', 'Autumn Rose', and *C. florida* was 0, 0, 33, and 0%, respectively. Dogwood anthracnose was confirmed on leaves of all of these taxa. Following overwintering, there were no surviving plants of these four taxa and dogwood anthracnose was confirmed in stems of all taxa except flowering dogwood which was severely decomposed. The taxa 'Steeple', Stardust®, Stellar Pink®, 'Milky Way', and Celestial™ were found to be resistant to dogwood anthracnose as indicated by ≤ 1% of total leaf area affected, 100% survival through the following spring, and no detection of the disease in stem tissue. The remaining cultivars including 'Milky Way Select', 'Gay Head', Constellation™, 'Julian', 'Temple Jewel', 'Elizabeth Lustgarten', 'Big Apple', Aurora™, 'China Girl', Ruth Ellen™, and 'Greensleeves' were found to be intermediate in resistance.

Powdery mildew. By late October, 5 taxa including 'Elizabeth Lustgarten', 'Steeple', Stardust®, Constellation®, and Ruth Ellen® were infected (Table 2). Three of the hybrid cultivars (Stardust®, Constellation®, and Ruth Ellen®) were most heavily infected with over 70% of the total leaf area affected per plant. The disease organism was identified as *Microsphaera pulchra*.

Significance to Industry: Results from this study demonstrate considerable variation in resistance of kousa dogwood cultivars and hybrids to both dogwood anthracnose and powdery mildew. Where these diseases are prevalent, selection of resistant taxa is recommended. None of the taxa were found to be immune to dogwood anthracnose, yet some plants were found to be resistant to the disease. These plants include: *C. kousa* 'Steeple', the clone of *C. kousa* 'Milky Way' used in this study, *C*. x Stardust™, *C.* x Stellar Pink™, and *C*. x Galaxy™. Plants found to be resistant to powdery mildew included the kousa dogwood cultivars 'Milky Way Select', the clone of 'Milky Way' used in this experiment, 'Gay Head', 'Julian', 'Temple Jewel', 'Big Apple', 'China Girl', and 'Greensleves' as well as the hybrids Stellar Pink™, Galaxy™, and Aurora™.

Literature Cited

1. Holmes, F.W. and Hibben, C.R. 1989. *Field evidence confirms Cornus kousa dogwood's resistance to anthracnose*. J. Arboric. 15:290-291.

2. Jaynes, R.A., Brand, A.J. and Arnow, J. 1993. *Kousa Dogwood.* Amer. Nurseryman. 178(10):40-47.

3. Orton, E.R., Jr. 1991. *Cornus kousa var. chinensis 'Milky Way' and name recognition in the nursery industry*. Comb. Proc. Int. Plant Prop. Soc. 41:441-442.

4. Orton, E.R., Jr. 1993. *A family of dogwoods: Three showy relatives welcome spring with clouds of bloom.* Fine Gardening. March/April.

5. Santamour, F.S., Jr., McArdle, A.J. and Strider, P.V. 1989. *Susceptibility of flowering dogwood of various provenances to dogwood anthracnose.* Plant Disease 73:590-591.

6. Windham, M.T. and Trigiano, R.N. 1993. *Dogwood anthracnose resistance in Cornus species*. Proc. Southern Nurserymen's Association Res. Conf. 38:188-190.

Table 1: Disease severity ratings, survival, and pathogen confirmation for cultivars of *C. kousa* (*C.k.*), *C. kousa* x *C. florida* (*C. x*) hybrids, and *C. florida* (*C.f.*) subjected to *Discula destructiva.* Disease severity ratings include percent of leaves infected per plant (P), average percent of area affected on infected leaves (L), and percent of total leaf area affected per plant (PxL).

	Disease Severity, 10/20/93			Survival (%)		Disease Confirmation	
Taxa	P	L	PxL	Fall 93	Spring 94	Leaves	Stem
C. *k.* 'Steeple'	10	5	0	100	100	+	-
C. x Stardust®	7	7	1	100	100	+	-
C. x Stellar Pink®	12	5	1	100	100	+	-
C. *k.* 'Milky Way'	8	7	1	100	100	-	-
C. *k.* 'Milky Way Select'	15	5	1	100	66	-	+
C. x Celestial™	20	5	1	100	100	+	-
C. *k.* 'Gay Head'	30	8	2	100	33	+	+
C. x Constellation®	38	7	3	100	33	+	+
C. *k.* 'Julian'	35	10	3	100	50	-	+
C. *k.* 'Temple Jewel'	35	15	6	100	66	-	+
C. *k.* 'Elizabeth Lustgarten'	95	15	14	100	100	+	-
C. *k.* 'Big Apple'	96	25	24	100	75	-	-
C. x Aurora®	52	38	35	100	66	+	-
C. *k.* 'China Girl'	53	40	35	66	66	-	+
C. x Ruth Ellen®	62	40	37	66	33	+	+
C. *k.* 'Greensleves'	100	55	55	66	33	+	+
C. *k.* 'Autumn Rose'	100	100	100	33	0	+	+
C. *k.* 'Moonbeam'	100	100	100	0	0	+	+
C. *florida*	100	100	100	0	0	+	-
C. *k.* 'Wolf Eyes'	100	100	100	0	0	+	+
$LSD_{0.05}$	37	40	42	45	71	N/A	N/A

*PxL was calculated as the mean of the products of P and L for each replicate. For that reason, the product of the mean P and mean L will not necessarily equal PxL.

Table 2: Disease severity ratings including: percent of leaves infected per plant (P), average percent of leaf area affected on infected leaves (L), and percent of total leaf area affected per plant (PxL) for powdery mildew evaluated on 20 taxa of dogwoods during 1993.

	Disease Severity, 10/25/93		
Taxa	P	L	PxL
C. x Stellar Pink®	0	0	0
C. k. 'Milky Way Select'	0	0	0
C. k. 'Milky Way'	0	0	0
C. x. Celestial™	0	0	0
C. k. 'Gay Head'	0	0	0
C. k. 'Julian'	0	0	0
C. k. 'Temple Jewel'	0	0	0
C. k. 'Big Apple'	0	0	0
C. x Aurora®	0	0	0
C. k. 'China Girl'	0	0	0
C. k. 'Greensleves'	0	0	0
C. k. 'Elisabeth Lustgarten'	7	10	1
C. k. 'Steeple'	40	20	12
C. x Stardust®	95	75	71
C. x Constellation®	100	90	90
C. x Ruth Ellen®	100	98	98
$LSD_{0.05}$	18	9	8

*PxL was calculated as the mean of the products of P and L for each replicate. For that reason, the product of the mean P and mean L will not necessarily equal PxL.