HRI's Mission:

To direct, fund, promote and communicate horticultural research, which increases the quality and value of ornamental plants, improves the productivity and profitability of the nursery and landscape industry, and protects and enhances the environment.

Susceptibility of *Cornus* Species to Two Genera of Powdery Mildew[1]

M.T. Windham[2], R.N. Trigiano[2], and A.S. Windham[2]
Department of Entomology and Plant Pathology
University of Tennessee, Knoxville, TN 37996-4560

Abstract

Powdery mildew disease severity was assessed in fourteen species of *Cornus*. Seedlings of *C. alternifolia*, *C. controversa* and *C. mas* were not infected with powdery mildew. One cultivar of *C. alba*, 'Bud's Yellow', was also not infected, whereas 'Ivory Halo' was parasitized with *Phyllactinia guttata*. Cultivars of *C. florida* ('Cherokee Brave', 'Cloud 9', and 'Cherokee Sunset') and lines of *C. kousa* (seedlings and clones of *C. kousa* var. *chinensis*) significantly differed in their susceptibility to powdery mildew. All trees of *C. florida* and *C. kousa* had thalli and cleistothecia of *Erysiphe pulchra* on abaxial and adaxial surfaces. Location of mycelia and cleistothecia of *P. guttata* on leaves were variable for blue berry dogwood species.

Index words: disease resistance dogwood, *Erysiphe pulchra*, *Microsphaera pulchra*, *Phyllactinia guttata*.

Species used in this study: tatarian dogwood (*Cornus alba* L.); pagoda dogwood (*C.* alternifolia); silky dogwood (*C.* amomum Mill.); giant dogwood (*C.* controversa Hemsl.); rough leaf dogwood (*C. drummondii* C. A. Mey); flowering dogwood (*C. florida* L.); kousa dogwood (*C. kousa* (Buerger ex Miq.) Hance); bigleaf dogwood (*C. macrophylla* Wallich.); cornelian cherry dogwood (*C. mas* L.); Pacific dogwood *C. nuttalli* Aud.); pale dogwood (*C. obliqua* Raf.); gray dogwood (*C. racemosa* Lam.); redosier dogwood (*C. sericea* L.); swamp dogwood (*C. stricta* Lam.).

Significance to the Nursery Industry

Powdery mildew of flowering dogwood (*C. florida*) has become a common disease in nurseries and landscapes throughout much of the eastern United States. Nearly all cultivars of flowering dogwoods are susceptible to powdery mildew, and costly chemical treatments are necessary to grow suitable trees for market. During the last decade, native dogwood species, mostly blue berry types, have become more popular in the nursery trade due to public demand for native plant species and for their perceived superior resistance to diseases. Disease resistant plants are less costly to grow than susceptible ones and allows producers to lower costs. However, these *Cornus* species have received little study concerning their resistance to diseases. In this paper, the response of 14 *Cornus* species to powdery mildew is reported. Individual plants of *C. alternifolia*, *C. controversa* and *C. mas* in this study were not susceptible to powdery mildew. However, the responses of other *Cornus* species to powdery mildew suggests that blanket statements concerning powdery mildew resistance for an entire species may be inappropriate. Nursery producers should either screen initial production of individual lines for resistance or obtain propagation materials from lines that have been tested by someone else.

Introduction

Powdery mildew of flowering dogwood (*Cornus florida*), first reported in 1887 (3), 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. The reason for the sudden onslaught of this disease is unknown. Mmbaga et al. (12) have suggested the organism that causes epidemics in flowering dogwood nurseries entered the United States on kousa dogwoods (*C. kousa*) from Japan.

Two organisms, *Microsphaera pulchra* Cooke and Peck (14) and *Phyllactinia guttata* (Wallr:Fr.) Lév.(10), have been associated with this disease. *Microsphaera pulchra* parasitises *C. florida* (red berry type dogwood with large showy bracts), whereas *P. guttata* parasitises *C. amomum* (blue berry type, bractless dogwood). Caution should be used when attributing a powdery mildew species to a specific species (9). *Microsphaera pulchra* has been placed in the genus *Erysiphe* [*Erysiphe* pulchra (Cooke & Breck) U. Braum & S. Takamatsu comb. nov.] based on rDNA ITS sequences (2), and the organism will be referred hereafter to as *E. pulchra*.

Powdery mildew spreads very rapidly in nurseries and landscapes. Infected trees of *C. florida* grow slowly and have reduced flowering, delayed leaf break in the spring and unusually high shoot death. In 1994 and 1995, many fields of flowering dogwoods were abandoned due to high incidence of powdery mildew infected trees, and researchers and nursery professionals scrambled to find ways to control the disease (6, 13, 19). Today, powdery mildew is managed with fungicide sprays applied at 14-day intervals from late spring until fall. High costs and increased labor associated with spraying have forced many small-volume growers to abandon dogwoods as a crop.

Considerable interest has focused on resistance to powdery mildew in *Cornus* species, especially in red berry types (8, 11, 15, 21). The frequency of resistance to powdery mildew in seedlings of *C. florida* to be 0.1% (18). Several cultivars of flowering dogwood were identified as being resistant to powdery mildew, but levels of resistance have been variable between studies or between years in the same study (8, 11, 21). Recently, three white-bracted cultivars of *C. florida* were described and patented as being consistently resistant to *E. pulchra* (20).

Resistance to powdery mildew in blue berry type dogwoods has been reported, but few species were evaluated (8, 11). Cleistothecia of either or both *E. pulchra* and *P. guttata* were observed on these speices (21). However, the significance of orientation of cleistothecial appendages of *P. guttata* described by Cullum and Webster (3) and Klein et al. (9) was

[1]Received for publication on August 2, 2004; in revised form August 5, 2005.

[2]Professors.

Table 1. Dogwood (*Cornus*) taxa examined for presence of powdery mildew thalli on abaxial (TAb.) and adaxial (TAd) surfaces of leaves, presence of cleistothecia of *Erysiphe* (sect. *Microsphaera*) *pulchra* on abaxial (EcAb) and adaxial (EcAd) surfaces of leaves, presence of cleistothecia of *Phyllactinia guttata* on the abaxial (PcAb) and adaxial (PcAd) surfaces of leaves and rated for powdery mildew disease severity (DS).

Cornus species	TAb.	TAd	EcAb	EcAd	PcAb	PcAd	DS[z]
C. alba 'Bud's Yellow'	–[y]	–	–	–	x	x	0a[x]
C. alba 'Ivory Halo'	+	+	–	–	+	+	3c
C. alternifolia	–	–	–	–	–	–	0a
C. amomum	–	+	–	–	x	+	4de
C. controversa	–	–	–	–	–	–	0a
C. drummondii	–	+	–	–	x	+	3cd
C. florida 'Cherokee Brave'	+	+	+	+	x	–	3cd
C. florida 'Cloud 9'	+	+	+	+	–	–	4de
C. florida 'Cherokee Sunset'	+	+	+	+	–	–	5e
C. kousa	+	+	–	–	x	–	2bc
C. kousa var. *chinensis*	+	+	+	+	x	–	4e
C. macrophylla	+	–	–	–	+	–	3cd
C. mas. 'Aurea'	–	–	–	–	x	–	0a
C. mas 'Golden Glory'	–	–	–	–	–	–	0a
C. mas 'Reston'	–	–	–	–	–	–	0a
C. nuttalli	+	+	+	+	x	–	5e
C. florida x *C. nuttalli* 'Eddie's White Wonder	+	+	+	+	–	–	5e
C. obliqua	–	+	–	–	x	+	3cd
C. racemosa	–	+	–	–	x	+	3cd
C. sericea	–	+	–	–	x	+	2b
C. stricta	–	+	–	–	x	+	3cd

[z]Abbreviations used in table are: – = thalli or cleistothecia not present; + = thalli or cleistothecia present; x cleistothecia present, but appendage orientation indicates cleistothecia were not produced at that location.

[y]Disease rating of 0 = no powdery mildew observed, 1, 2, 3, 4, and 5 = 2, 10, 25, 50, and 100% of foliage with signs of powdery mildew, respectively.

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

not considered. The objectives of the research presented in this paper were to evaluate a wide selection of *Cornus* species for resistance to powdery mildew, to determine where thalli of powdery mildew developed on the foliage, and to determine which species of powdery mildew parasitized the plant.

Materials and Methods

Plants (Table 1) were obtained in one-gallon containers or as bare root liners from nurseries (all Cornus species – 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 pine bark medium [amended with 0.62 kg/m^3 (1.5 lb/yd^3) 18–6–12 fertilizer, 1.45 kg/m^3 (3.5 lb/yd^3) dolomitic limestone, 0.83 kg/m^3 (2 lb/yd^3) 0–46–0 super phosphate, 0.94 kg/m^3 (2.25 lb/yd^3) gypsum ($CaSO_4$),) 0.62 kg/m^3 (1.5 lb/yd^3) Micromax (Grace Sierra, Milpitas, CA), and 0.83 kg/m^3 (2.0 lb/yd^3 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 by a overhead irrigation system that delivered approximately 1.3 cm (0.5 in) 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 27513) and means were separated using Student-Newman-Keul's Test (p = 0.05). The presence or absence of powdery mildew thalli (mycelia and conidia) on abaxial and adaxial sides of leaves was determined visually macroscopically and also by using a 10.2 cm (4 in) magnifying glass. Cleistothecia were observed using a magnifying glass and orientation of appendages was recorded. Cleistothecia were collected and examined microscopically for identification.

Results and Discussion

The response (disease severity) of the various species of *Cornus* differed to powdery mildew. 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 in cultivar responses were noted within *C. florida* and *C. kousa* in previous studies (8, 11, 15, 21), 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 (7, 8, 11, 21), variation in resistance within some species of *Cornus* suggests that generalizations of all individuals within a species of Cornus are resistance may be inappropriate.

Powdery mildew mycelia and conidia can be observed on both or only on one side of a leaf depending on the plant species and the species of powdery mildew (17). This type of variation also exists within *Cornus* species where powdery mildew thalli were observed only on the abaxial leaf surface of *C. macrophylla* and only on the adaxial leaf surface of *C. amomum*, *C. obliqua*, *C. racemosa*, *C. sericea*, and *C. stricta* (Table 1). Powdery mildew was found on both leaf surfaces of *C. alba* 'Ivory Halo', all cultivars of *C. florida*

and *C. kousa*, *C. nuttalli*, and *C. florida* x *C. nuttallii* 'Eddie's White Wonder'. Location of thalli was not associated with berry type (blue or red) or species of powdery mildew.

Infection of *Cornus* species by *E. pulchra* and *P. guttata* was confirmed by the production of cleistothecia on leaf surfaces. Orientation of cleistothecial appendages as described by Braun (1) and Cullum and Webster (3) was used to determine if observed cleistothecia from *P. guttata* were produced on a selected leaf or were disseminated to that leaf from another location (Table 1). Cleistothecia of *P. guttata* were observed to be formed on the abaxial leaf surface only of *C. macrophylla*, on the adaxial leaf surface of *C. amomum*, *C. drummondii*, *C. obliqua*, *C. racemosa*, *C. sericea* and *C. stricta* and on both surfaces of *C. alba* 'Ivory Hallo'. Cleistothecia of *P. guttata* formed on both leaf surfaces of *C. alba* 'Bud's Yellow', but mycelia were not observed on either leaf surface. The orientation of cleistothecial appendages indicated the cleistothecia were not produced on those leaves. No cleistothecia of *P. guttata* were formed on leaves of *C. florida* or *C. kousa*. However, cleistothecia of *P. guttata* were observed to have been disseminated onto abaxial leaf surfaces of leaves of plants infected with powdery mildew infections as was cautioned by Klein et al. (9). Cleistothecia of *E. pulchra* were observed to be produced on both surfaces of all cultivars of *C. florida*, one line of *C. kousa*, *C. nuttallii*, and *C. florida* x *C. nuttallii* 'Eddie's White Wonder'.

In summary, variation in susceptibility to powdery mildew (*P. guttata*) is apparent both within and between species of blue berry type dogwoods as has been previously described in red berry type dogwoods infected with powdery mildew (*E. pulchra*). Yarwood (22) stated that errors in the evaluation of host-parasite interactions could be made if ascocarps of one powdery mildew species became associated with leaves of another plant infected with another powdery mildew species. Klein et al. (9) found that errors could be made in identifying whether *E. pulchra* or *P. guttata* had infected a dogwood species if cleistothecial orientation was not considered and *Cornus* species were mixed in a resistance study so that cleistothecia from one plant could be disseminated to another *Cornus* species. Therefore, screening of powdery mildew resistance requires the examination of both leaf surfaces and determination of orientation of cleistothecial appendages to ascertain the source of cleistothecia of either powdery mildew species known to infect *Cornus*. Generalizations for resistance within any species of *Cornus* is dangerous and resistance claims should be limited to the individuals tested.

Literature Cited

1. Braun, U. 1987. A monograph of Erysiphales (powdery mildews) Beih. Nov. Hedwigia 89:1–700.

2. Braum, U. and S. Takamatsu. 2000. Phylogeny of *Erysiphe*, *Microsphaera*, *Uncinula* (Erysiphae) and *Cystotheca*, *Podosphaera*, *Sphaerotheca* (Cystotheceae) inferred from rDNA ITS sequences – some taxonomic consequences. *Schlechtendali*a 4:1–33.

3. Burrill. T.J. and F.S. Earle. 1887. Article VI. Parasitic fungi of Illinois. p. 387–428. Bul. Illinois State Lab. Natl. History. Part II. Vol. II. J.W. Franks and Sons. Peoria. IL.

4. Cullum, F.J. and J. Webster. 1977. Cleistocarp dehiscence in *Phyllactinia*. Trans. Br. Mycol. Soc. 68:316–320.

5. Cook, R.T.A., A.J. Inman, and C. Billings. 1997. Identification and classification of powdery mildew anamorphs using light and scanning electron microscopy and host range data. Mycol. Res. 101:975–1002.

6. Doney, J. and J. Hartman. 1997. Control of powdery mildew on dogwoods. Proc. of 10th Regional Dogwood Anthracnose Workshop. Lexington, KY. p 50–55.

7. Hagan, A.K., C.H. Gilliam, C.J. Keever, J.D. Williams, B. Hardin, and J. Eakes. 1997. Dogwood selections differ to their susceptibility to powdery mildew and spot anthracnose. Proc. of South. Nurs. Assoc. Res. Conf. 42:243–248.

8. Hagan, A.K., B. Hardin, C.H. Gilliam, C.J. Keever, J.D. Williams, and J. Eakes. 1998. Susceptibility of cultivars of several dogwood taxa to powdery mildew and spot anthracnose. J. Environ. Hort. 16:147–151.

9. Klein, L.A., M.T. Windham, and R.N. Trigiano.1998. Natural occurrence of *Microsphaera pulchra* and *Phyllactinia guttata* on two *Cornus* species. Plant Dis. 82:383–385.

10. McRitchie, J.J. 1994. Powdery mildew of flowering dogwood. Florida Dept. Cons. Serv. Plant Pathol. Circ. No. 368. 2 pp.

11. Mmbaga, M. and H. Sheng. 2001. Host resistance to *Microsphaera pulchra* in dogwood. Proc. of South. Nurserymen's Assoc. Res. Conf. 46:294–297.

12. Mmbaga, M., N.B. Klopfenstein, and K. Mee-Sook. 2000. Molecular genetic analysis of powdery mildew pathogens of dogwood. Proc. of South. Nurserymen's Assoc. Res. Conf. 45:237–241.

13. Olive, J.W., A.K. Hagan, J.R. Akridge, J.W. Olive, and K. Tilt. 1998. Evaluation of selected fungicides for control of powdery mildew of dogwood. Proc. of South. Nurserymen's Assoc. Res. Conf. 43:217–220.

14. Ranney, T.G., L.F. Grand, and J.L. Knighten. 1994. Resistance of *Cornus kousa* tax to dogwood anthracnose and powdery mildew. Proc. of South. Nurserymen's Assoc. Res. Conf. 39:212–213.

15. Ranney, G.T., L.F. Grand, and J.L. Knighten. 1995. Susceptibility of cultivars and hybrids of kousa dogwood to dogwood anthracnose and powdery mildew. J. Arboriculture 21:11–16.

16. Saenz, G.S. and J.W. Taylor. 1999. Phylogeny of the Erysiphales (powdery mildews) inferred from internal transcribed spacer (ITS) ribosomal DNA sequences. Can. J. Bot. 77:150–169.

17. Sinclair, W.A., H.H. Lyon, and W.T. Johnson. 1987. Diseases of Trees and Shrubs. Comstock Publishing Assoc. Ithaca, NY. 575 pp.

18. Windham, M.T. and W.T. Witte. 1998. Naturally occurring resistance to powdery mildew in seedlings of *Cornus florida*. J. Environ. Hort. 16:173–175.

19. Windham, M.T., A.S. Windham, and M.A. Halcomb. 1998. Chemical control of powdery mildew in flowering dogwood. Proc. of South. Nurserymen's Assoc. Res. Conf. 43:251–252.

20. Windham, M.T., W.T. Witte, and R.N. Trigiano. 2003. Three white-bracted cultivars of *Cornus florida* resistant to powdery mildew. HortScience 38:1253–1255.

21. Windham, M.T., W.T. Witte, R.N. Trigiano, S. Schlarbaum, and A.S. Windham. 1997. Reactions of *Cornus* species to powdery mildew. 1997. Proc. of South. Nurserymen's Assoc. Res. Conf. 42:227–231.

22. Yarwood, C.E. 1957. Powdery mildews. Bot. Rev. 23:235–301.