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Resistance of Muscadine Grapes to Angular Leaf Spot (*Mycosphaerella angulata* Jenkins) in North Florida

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Abstract. **Angular leaf spot is a common but rarely studied disease of muscadine grapes (*Vitis rotundifolia* Michx.) in the southeastern United States. During 1994 and 1995, we performed two field evaluations of angular leaf spot on 30 muscadine cultivars. Based on disease severity data, no cultivar was immune to angular leaf spot; however, 'Albermarle', 'Doreen', 'Higgins', 'Noble', 'Regale', 'Scuppernong', 'Southland', and 'Summit' showed high degrees of resistance. 'Alachua', 'Darlene', 'Dixie Red', 'GA-3-9-2', 'Jane Bell', 'Janet', 'Jumbo', 'Pam', and 'Rosa' were susceptible.**

The muscadine grape is native to the southeastern United States and is a classic southeastern fruit (Olien, 1990). Besides its distinct fruity, "musky", aroma, its resistance to Pierce's disease (*Xylella fastidiosa* Wells et al.) makes it the only grape that can be successfully grown in coastal regions of the southeastern United States.

Angular leaf spot disease of muscadine grapes, caused by *Mycosphaerella angulata*, is commonly found in the southeastern United States. The asexual stage of the pathogen was first described by Ellis and Everhart (1902) in Alabama as *Cercospora brachypus*. Jenkins (1942) identified the sexual stage of the fungus and assigned the scientific name, *M. angulata*.

Mycosphaerella angulata appears to attack specifically muscadine grapes. Other grape species such as *Vinis vinifera* L. and its hybrids are not affected under natural conditions (Jenkins, 1942). *Mycosphaerella angulata* infects only muscadine leaves, causing angular to irregular lesions when the symptoms are fully expressed (Jenkins, 1942; Milholland, 1990). Symptoms of angular leaf spot disease are fairly easy to recognize late in the season. Further development of the disease may inhibit normal photosynthesis and result in serious defoliation. Preharvest infection can slow or stop berry development before maturity. After harvest, vines are further damaged due to reduction of normal carbohydrates storage, which is critical for growth in the following season (Winkler et al., 1974). The weakened muscadine vines become more vulnerable to injury by unfavorable factors, such as winter cold. Yield loss due to angular leaf spot has not been thoroughly assessed but is believed to be among the most severe of all the known muscadine diseases in the Southeast (Bertrand et al., 1994).

Despite the wide regional distribution and the importance of angular leaf spot of muscadines, little research has been done on this disease. In this study, we evaluated 30 muscadine cultivars for their resistance to angular leaf spot in northern Florida during 1994 and 1995. Results from this study will provide the baseline information for further genetic research of the disease. The disease evaluation data will also be helpful in disease resistance breeding programs and cultivar recommendations for muscadine growers in northern Florida.

Materials and Methods

Muscadine cultivars. Thirty muscadine cultivars (Table 1) were planted at the Center for Viticultural Science and Small Farm Development, Florida A&M Univ., Tallahassee, between 1980 and 1982. The vines were trained to single-wire vertical trellis. Twenty of the 30 muscadine cultivars are triplicates, seven duplicates, and three single vines (Table 1). Cultivars were grown in the spacing interval of 3.6 × 3.6 m. No fungicides or insecticides were sprayed in the two growing seasons when the disease evaluations were performed. All plants were subjected to the same cultural practices.

Disease evaluation. The first field disease evaluation was done on 4 and 6 Sept. 1994; the second evaluation was on 22 Sept. 1995. In both cases, all the vines were still vegetatively active when disease evaluations were performed. Angular leaf spot disease was confirmed by microscopic examination of lesion tissues for the presence of *Cercospora* conidia. Disease severity was estimated as follows: Mature leaves of muscadine cultivars were randomly inspected on vine across the canopy of each cultivar (one to three vines, depending on the availability) (Table 1). Each leaf was rated by estimating the percentage of the lesion area over the total leaf area and recorded as: 0 for 0%, 10 for 1% to 10%, 20 for 11% to 20%, 30 for 21% to 30%, 40 for 31% to 40%, 50 for 41% to 50%, and 60 for >50%. The total number of rated leaves from each cultivar was 67 in 1994 and 69 in 1995. Means were calculated and used to represent disease severity of each cultivar.

Data analysis. Paired *t* test was performed on severity means of 1994 and 1995 to detect if there was significant difference between the 2 years. Duncan's multiple range test was used to rank all the cultivars based on their severity means. All the statistical analyses were performed with a SAS package (release 6.07, 1989; SAS Institute, Cary, N.C.).

Results and Discussion

Disease severities or means of infection percentage per leaf range from 11.7 ('Scuppernong') to 49.7 ('Dixie Red') in 1994 and from 9.3 ('Albermarle') to 40.0 ('Jumbo') in 1995 (Table 1). None of the cultivars evaluated was completely resistant or immune to angular leaf spot. This result agrees with a study reported by Jenkins (1942). However, results from Duncan's multiple range test ($\alpha = 0.01$) indicate that there are significant differences in the degree of disease resistance among all the cultivars evaluated.

Multiple comparison tests are commonly used to analyze disease susceptibility or resistance data (Kummuang et al., 1996; Smith et al., 1996). We grouped the cultivars into three subjectively defined categories: R (resistant) with low severity, S (susceptible) with high severity, and a middle group (Table 1). In 1994, cultivars with means followed by sequence letters including h were considered to be the middle group, resulting in 10 R and 12 S cultivars. In 1995, cultivars with means followed by sequence letters including i were the middle group leading to 10 R and 11 S cultivars.

Since paired *t* test results indicate that there were significant severity variations between 1994 and 1995 ($P > 0.0058$), we rated disease resistance on a yearly base. Eight cultivars were R and nine S in both years. These cultivars are considered to be resistant or susceptible. Those judged R were 'Albermarle', 'Doreen', 'Higgins', 'Noble', 'Regale', 'Scuppernong', 'Southland', and 'Summit'; those judged S were 'Alachua', 'Darlene', 'Dixie Red', 'GA-3-9-2', 'Jane Bell', 'Janet', 'Jumbo', 'Pam', and 'Rosa'.

Disease severity was generally lower in 1995 than in 1994 (Table 1). Since this study was performed under field conditions, the occurrence of relatively large variations from year to year is not surprising. We speculate that environmental factors played an important role in causing the variations. The weather in 1994 was wet early in the year and mild over the growing season, while 1995 was dry in the spring and stormy late in the summer. These differences could affect disease development

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Table 1. Resistance of 30 muscadine cultivars to angular leaf spot (*Mycosphaerella angulata*).

Cultivar	Origin	Vines tested (no.)	Year of disease evaluation 1994 Severity[z]	1994 Rating[y]	1995 Severity	1995 Rating[x]	Final rating
Alachua	UF[w]	3	42.3 b–e	S	30.9 d–f	S	S
Albermarle	NCSU[v]	3	14.8 lm	R	9.3 n	R	R
Carlos	NCSU	3	23.9 h–j		22.1 ij		
Chief	MSU[u]	2	23.9 h–k		23.1 ij		
Cowart	UGA[t]	3	23.6 h–k		24.7 ij		
Darlene	ISON[s]	3	38.8 c–f	S	30.4 d–g	S	S
Dixie	NCSU & UF	2	26.4 h		23.8 ij		
Dixieland	ISON	2	25.7 hi		34.6 b–d	S	
Dixie Red	ISON	3	49.7 a	S	38.1 b–d	S	S
Doreen	NCSU & MSU	2	14.1 lm	R	17.4 kl	R	R
Fry	UGA	3	36.3 ef	S	24.0 ij		
GA-23-45	UGA	2	14.8 lm	R	22.5 ij		
GA-3-9-2	UGA	2	42.4 b–e	S	30.3 d–g	S	S
GA-9-11-2	UGA	3	27.7 h		36.9 a–c	S	
Higgins	UGA	3	16.3 lm	R	15.0 lm	R	R
Jane Bell	ISON	3	45.5 a–c	S	34.3 b–d	S	S
Janet	ISON	1	47.3 ab	S	33.4 c–e	S	S
Jumbo	UGA	3	39.5 c–f	S	40.0 a	S	S
Nesbitt	NCSU	3	43.3 a–d	S	25.9 g–i		
Noble	NCSU	3	16.1 lm	R	17.6 kl	R	R
Pam	ISON	3	34.2 fg	S	29.4 e–h	S	S
Pink Hunt	NCSU	3	38.2 d–f	S	26.3 f–i		
Regale	NCSU & MSU	3	19.1 i–l	R	20.7 jk	R	R
Rosa	ISON	2	46.7 ab	S	30.1 d–g	S	S
Scuppernong	NC[r]	3	11.7 m	R	16.9 kl	R	R
Southland	MSU	1	18.6 j–m	R	10.6 mn	R	R
Sugar Pop	ISON	1	24.8 h–j		17.5 kl	R	
Summit	UGA	3	16.4 lm	R	13.4 l–n	R	R
Triumph	UGA	3	17.6 k–m	R	25.0 h–j		
Welder	UF	3	28.6 gh		14.7 l m	R	
		Mean =	28.9		24.6		

[z]Mean separation by Duncan's multiple range test at $\alpha = 0.01$.
[y]Cultivars with means followed by sequence letters without h are either S (susceptible, higher severity) or R (resistant, lower severity).
[x]Cultivars with means followed by sequence letters without i are either S (susceptible, higher severity) or R (resistant, lower severity).
[w]University of Florida, Leesburg.
[v]North Carolina State Univ., Raleigh.
[u]Mississippi State Univ., Meridian.
[t]University of Georgia, Griffin.
[s]Ison's Nursery & Vineyards, Brooks, Ga.
[r]Traditional cultivar from North Carolina.

by either changing the pathogen population dynamics, altering the host resistance mechanisms, or both.

Muscadine breeding programs that only target high fruit quality traits could result in cultivars that may succumb to angular leaf spot, and other diseases, when favorable environmental conditions for disease epidemic occur. Jenkins (1942) found that a parent of some good-quality cultivars was extremely susceptible to angular leaf spot and suggested that disease resistance should be considered in the selection of breeding parents. Results from this study show that angular leaf spot is still a problem in commonly grown cultivars. The potentially destructive effects of angular leaf spot disease should not be ignored in muscadine breeding programs.

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