VERTICILLIUM WILT ON-FARM COTTON CULTIVAR VARIETY EVALUATIONS

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Abstract

Verticillium Wilt is caused by *Verticillium dahliae*, which colonizes the vascular cylinder of the plant and causes defoliation, stunting, and yield loss. Thirteen cotton varieties were planted and evaluated for resistance to *V. dahliae*. The trial was planted on the Isbell farm in Northwest Alabama. Plots were six rows each, and approximately 500 feet long. The field was irrigated, when needed, with a center pivot irrigation system. Disease ratings were taken September 20. Ten feet sections of the third row in each plot were observed for total number of plants, and stems were cut longitudinally to assess disease incidence. Disease severity ratings of foliar symptoms were evaluated on a scale from 1-5 with 1 having no foliar wilting, 3 having interveinal chlorosis and necrosis of the leaves, and 5 having completely defoliated plants. Four replications of each variety were counted. Petioles were taken from infected plants of each variety and re-isolated to confirm the presence of *V. dahliae*. In regards to disease severity, the top thirty percent of plants displaying the least amount of foliar symptoms and the most resistant varieties were BX 1347 GLB2, FM 1944 GLB2, PHY 339 WRF, and DP 1044 B2RF. None of these varieties received averaged scores exceeding 3. In terms of disease incidence, the resistant check FM 1944 GLB2 had the lowest number of plants with darkened vascular systems. PHY 339 WRF, DP 1044 B2RF, DP 1321 B2RF, ST 6448 GLB2, ST 4946 GLB2, DP 1133 B2RF, DPLX 12R224 B2R2, BX 1347 GLB2, and DP 1137 B2RF all displayed vascular staining and average percent of disease incidence ranged from 45.5-68.1%. These percentages were statistically similar and performed better than the susceptible varieties but below the resistant check.

Introduction

This disease was first recorded in Virginia in 1918 by Carpenter who noted its presence on Upland cotton. Currently, it is present throughout the world affecting major cotton producing countries such as Australia, Brazil and China. In the United States, it is present in most states in the cotton belt. Approximately, ten million acres of cotton are grown in the U.S, and 97% is planted with Upland cotton (Jefferson and Gossen, 2002). Cotton production is greatly reduced by the presence of fungal pathogens. Cotton losses from Verticillium wilt for the U.S. are approximately 480 billion bales lost between the years of 1990-2011 (Disease Database, 1996). Verticillium wilt is a serious disease in North Alabama that causes a decline in plant health and a decrease in yields. It is caused by the soil born fungus *V. dahliae,* which colonizes the root and then moves upward in the vascular system of the plant. This colonization of the vascular system prevents water movement giving the plant a wilted appearance. Symptoms in Alabama are not noted until later in the season when boll formation is occurring and the plant prematurely begins to defoliate. Defoliation leads to stunting and yield decrease from the lack of photosynthetic activity. Verticillium wilt causes stunting, lack of lateral growth, and decreases in yield, fiber quality, and seed quality (Bugbee and Sappenfield, 1970; Xiao and Subbarao, 1990).

Verticillium wilt is often a difficult pathogen to control, with limited management options. Disease severity increases with the addition of irrigation and fertilization, two very expensive inputs for cotton that should result in yield increases. Producers are forced to use different tolerant cultivars to combat yield loss. Although producers must use these tolerant varieties, there has been little research conducted on cultivar response to *V. dahliae*. Rotation to a non-host such as a monocot will reduce disease; however, due to restrictions of farm labor and machinery, this is not an economical route. Chemical and biological controls can help reduce disease severity, but due to cost increases gross income decreases; thus, it may not be an option for many farmers. Several cotton cultivars produced by different seed companies are planted in Alabama every year. Little is known about the response to a majority of pathogens until they are released and tested in applied field settings. The research performed is important to inform

growers of their best option in heavily infested areas. A survey of the most widely grown cotton cultivars in the state and their severity responses, and incidence responses to Verticillium wilt can better inform producers about the potential financial losses that can be incurred with this pathogen.

Methods

Thirteen commonly grown cotton varieties were planted and evaluated for resistance to *V. dahliae*. The varieties are listed in Table 1. The trial was planted in a producer's field in Colbert County located in northwest Alabama (34N 47' 53.65" 87W 56' 37.93"). The dominate soil types found, were Decatur silt loam (24% sand, 49% silt, 28% Clay) and Emory silt loam. Plots were organized to be six rows each, and approximately 500 feet long. The field was irrigated, when needed, with a center pivot irrigation system. Disease ratings were taken during the month of September when foliar disease symptoms were visible. Ten feet sections of the third row in each plot were evaluated for disease incidence and severity. The total number of plants and stems were cut longitudinally to assess disease incidence, as seen in Figure 1. Disease severity ratings of foliar symptoms were evaluated on a scale from 1-5 with 1 having no foliar wilting, 3 having interveinal chlorosis and necrosis of the leaves and 5 having completely defoliated plants Figure 2. Four replications of each variety were counted. Petioles were taken from infected plants of each variety and re-isolated to confirm the presence of *V. dahliae.* Yields were not taken due to an early season frost on the 26th of October. The average temperatures for that area are a high of 72ºF and a low of 48 ºF, however what was observed was a high of 68 ºF and a low of 32 ºF. Statistics were analyzed using JMP® 10.0 (Copyright © 2013, SAS Institute Inc., Cary, NC, USA). Data were analyzed by ANOVA and means were compared using Tukey-Kramer HSD (α =0.10).

Figure 1: Vascular discoloration due to *Verticillium dahliae* in the cotton vascular tissues.

Figure 2: Foliar interveinal chlorosis and necrosis.

Results

The results from the disease severity ratings were slightly variable between treatments; however, differences did appear when means were compared. Two cultivars had the lowest disease severity rating of the thirteen that were tested, Bayer Experimental (BX) 1347 GLB2 and the resistant check Fiber Max (FM) 1944 GLB2. Both cultivars had average visual rating of less than 2. The two cultivars that had the highest ratings were Deltapine Experimental (DPLX) 12R224 B2R2 and Phytogen (PHY) 375 WRF. Both cultivars had average scores above 4, meaning the plants were almost completely defoliated. Disease incidence had statistical differences among treatments. The resistant check, FM 1944 GLB2, had the fewest number of plants with discoloration in the vascular cylinder, less than 35% of the plants had signs of the disease. The twelve other cultivars had higher percentages of vascular discoloration. Comparing the data between disease incidence and severity to find a correlation has shown an interesting result. There is a moderate correlation (R^2=.5482) Between visual symptoms and the signs of the disease in the vascular system. Verticillium species were isolated on water ager from petioles of all varieties. There were no significant differences between the amounts of *Verticillium* spp. isolated from the thirteen different cultivars. All petiole tissues cultured were colonized with *Verticillium* spp. Two different species were found in the state, *V. dahliae* as seen in figure 3, and *V. albo-atrum* in figure 4. Both species were found in the northern part of the state, however only *V. albo-atrum* was found in the mid to southern part of the state. According to the Commonwealth

Mycological Institute, *V. dahliae* is characterized by its whorled, hyaline, and tentatively erect conidiophore with phialids ranging in size from 16-35 x 1-2.5 µ. Conidia are found at the tip of the phialids. Microsclerotia arise centrally spreading outward and are dark in coloration. In appearance microsclerotia are swollen almost globular cells with a variable shape of elongate to irregularly spherical. Microsclerotia can range in size from 15-50 µ. *V. albo-atrum* is slightly different in regards to its morphological characteristics. Conidiophores are more abundant and less erect than *V. dahliae*. They are also hyaline vertically branched phialids projecting out of each node. Phialids range in size 20-30 x 1.4-3.2 µ. Similar to *V. dahliae*, *V. albo-atrum's* conidia are found at the tip of the phialids. The primary factor separating the two species is the formation or absence of microsclerotia. *V. albo-atrum* is absent of microsclerotia but forms dark resting mycelium. The resting mycelia are swollen between septa and never bud to microsclerotia. Dark resting mycelium can range in size 3-7 µ. Verticillium wilt is an economically important disease in the northern half of the state indicating that *V. dahliae* is more pathogenic species in the state of Alabama in 2013.

Table 1. Cotton cultivar results for disease severity and disease incidence ratings

Cotton Cultivars		Disease Severity	Disease Incidence Percentages
1	BX 1347 GLB3	1.75 d*	57.0 % ab
2	DP 1044 B2RF	2.25 cd	46.1 % ab
3	DP 1133 B2RF	2.88 abcd	55.4 % ab
4	DP 1137 B2RF	3.50 abc	67.8 % ab
5	DP 1321 B2RF	3.00 abcd	51.7 % ab
6	DPLX 12R224 B2R2	2.88 abcd	56.3 % ab
7	DPLX 12R242 B2R2	4.25 a	78.4 % a
8	FM 1944 GLB2	2.00 cd	31.3 % b
9	PHY 339 WRF	2.25 cd	44.8 % ab
10	PHY 375 WRF	4.00 ab	72.6 % ab
11	PHY 499 WRF	3.25 abcd	48.1 % ab
12	ST 4946 GLB2	3.25 abcd	55.4 % ab
13	ST 6448 GLB4	2.63 bcd	52.9 % ab
Mean (P < 0.10)		2.913	55.2%

* Means followed by the same letter do not differ significantly at the 0.1 level of probability

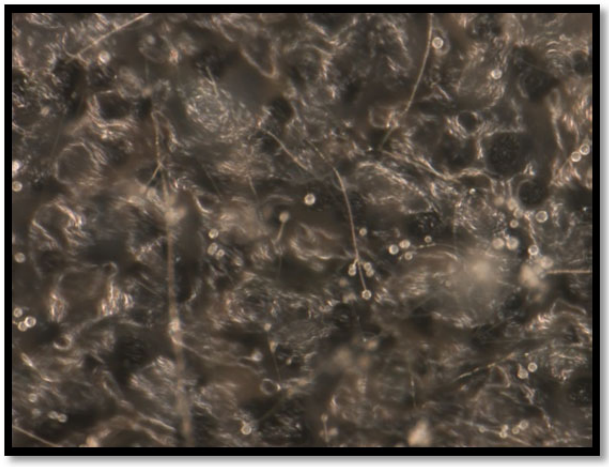

Figure 3: *Verticillium dahliae*

Figure 4: *Verticillium albo-atrum*

Summary

The results from the first year of tests indicate BX 1347 GLB2 and FM 1944 GLB2 supported the lowest disease severity score, and FM 1944 GLB2 had the lowest disease incidence for this trial. The varieties with low disease severity scores and high disease incidence would be considered tolerant to the disease if they also supported high yields. Yields would help definitively place theses cultivars in the tolerant category; however, yields are unavailable for this growing season. The correlation shows that visual symptoms only account for approximately half the disease present in the field. Cotton varieties are often taken off the market to make way for new and improved varieties or to

avoid resistance build up; continuing cultivar testing is needed to inform producers of responses to pathogens, particularly such as yield injuring pathogen such as Verticillium wilt.

Two species of Verticillium were isolated from cotton petioles, unlike the Fusarium wilt fungus. Verticillium is found throughout the plant in the vascular system. Both species, *Verticillium dahliae* and *Verticillium albo-atrum*, were found in the northern part of the state. *Verticillium dahliae*, and *V. albo-atrum's* were often found together in the same fields in north Alabama where wilt was present. In the southern half of the state, Verticillium wilt is extremely uncommon. Only *Verticillium albo-atrum* was found in the southern half of the state. This could be due to the consistently higher temperatures commonly observed in the area. *Verticillium albo-atrum* was isolated from symptomatic cotton in the southern and central areas of the state and may be more adapted to the warmer temperatures found there.

References

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