COTTON CULTIVAR DISEASE INCIDENCE, SEVERITY, AND YIELDS WHEN CHALLENGED WITH VERTICILLIUM WILT IN THE TENNESSEE VALLEY REGION, 2019.

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Abstract

Verticillium wilt most often occurs in the Tennessee Valley region of Alabama and Tennessee causing a decline in plant health and yield. The only effective management option producers have is to select a Verticillium wilt tolerant cotton cultivar. The life span of cotton cultivars is often less than 5 years; thus, a producer must constantly look for cultivars that yield well when challenged with Verticillium wilt. Thus, the goal of this study is to identify cotton cultivars for best management by evaluating cotton cultivars for resistance as measured by disease severity and tolerance and by yield when challenged in Verticillium wilt fields. Cotton cultivars and lines were planted in commercial cotton fields naturally infested with *V. dahlia* in a strip plot design with four replications and at two locations. Ranking the cultivars by lint yield indicates DP 2012 B3XF, CP 9178 B3XF, DP 2038 B3XF, PHY 400 W3XF, and DP 1646 B2XF were the top five yielding cultivars in Alabama while PHY 360 W3XF, PHY 400 W3XF, DP1646 B2XF, DP 2012 B3XF, and ST 4550 GLTP ranked highest in Tennessee. Comparing the data between disease incidence and severity indicated a significant positive correlation (R^2=0.76954; $P < 0.000$) between visual foliar symptoms and the signs of the disease in the vascular system. Negative correlations between Verticillium wilt incidence and lint cotton yield (R^2= -0.77509; $P < 0.0001$) and Verticillium wilt severity and lint cotton yield (R^2= -0.63693; $P < 0.0001$) indicate that Verticillium wilt contributed to a 70% reduction of the cotton yield in 2019. Cotton cultivar selection is very important in a Verticillium wilt infested field.

Introduction

Losses from Verticillium wilt for the U.S., according to disease loss estimates, between the years of 1965-2018 are approximately 10 billion bales (http://www.cotton.org/tech/pest/index.cfm). Verticillium wilt most often occurs in the Tennessee Valley region of Alabama and Tennessee causing a decline in plant health and yield. Two *Verticillium* species have been found in in the Tennessee Valley region, *V. albo-atrum* Reinke and Berthold (Palmateer et. al., 2004) and *V. dahliae* Kleb., (Land et. al., 2016). *Verticillium dahliae* is considered the primary causal agent of Verticillium wilt in cotton and first colonizes the root and then moves upward through the vascular system of the plant (El-Zik, 1985). Typically, symptoms include wilting, lack of lateral growth, and decreases in yield, fiber quality, and seed quality (Wheeler et. al., 2012; Xiao et. al., 2000). Defoliation is thought to lead to yield reductions resulting from the lack of photosynthetic activity. Disease incidence is higher on heavier soils with higher clay and silt content and may be linked to the lower temperatures and higher moisture levels. Moist soils from irrigation enhance the incidence of Verticillium wilt in cotton. Irrigation cools the soil thereby enhancing pathogen survival and increasing infection rates. As the timing intervals of watering regiments increase, so do the disease incidences of cotton plants (Schneider, 1948). There are no fungicides recommended for management of Verticillium wilt in cotton. The only effective management option producers have is to select a Verticillium wilt tolerant cotton cultivar (Raper, et al. 2017). The number of cotton cultivars available to producers, however, is limited. The life span of cotton cultivars is often less than 5 years; thus, a producer must constantly look for cultivars that yield well when challenged with Verticillium wilt. The overall goal of this study is to identify cotton cultivars for best management by evaluating cotton cultivars for resistance as measured by disease severity and tolerance measured by yield to Verticillium wilt in the field.

Figure 1. Verticillium wilt symptomatic cotton plant (left); foliar symptoms including necrosis and chlorosis of the leaves (middle); and vascular browning discoloration typical of a Verticillium wilt infected cotton plant with a non-symptomatic plant adjacent to it (right) (infected plant on the right side) and *Verticillium dahlia* culture (right top) and whirled conidiophore (right bottom).

Materials and Methods

Cotton cultivars were planted in commercial cotton fields naturally infested with *V. dahliae* to determine cultivar disease response to Verticillium wilt under field conditions. Two field locations were selected for the 2019 tests based on severity of Verticillium wilt and the willingness of growers to participate in this research. Seed of adapted cultivars and experimental lines expected to be released in the next season were provided by AGRI-AFC, LLC of Land O'Lakes (Decatur, AL). Cotton cultivars and lines were planted in a strip plot design with four replications with plots being 1 row with a 40-inch row spacing by 150 to 200 linear row foot plots evenly spaced throughout the field locations. Verticillium wilt disease incidence and severity ratings were conducted near cotton plant maturity from 4 randomly selected 10-foot sections of row in each plot. Foliar symptoms of Verticillium wilt were evaluated on a scale from 1 to 5 as depicted in Figure 2. Plants were individually rated and averaged for a total plot disease severity rating. Vascular discoloration was determined by cutting the plant stem longitudinally exposing the vascular cylinder and the number of plants with a discolored vascular cylinder indicated the percent incidence (Figure 1 middle). Stem section with discoloration were collected for fungal isolation to confirm Verticillium spp. presence. Yields were collected at plant maturity from a measured section (71-118 ft) of each cultivar within each strip trial using a two-row plot cotton picker. Samples were ginned at the UT Cotton MicroGin to determine turnout. Data collected from the field trials were analyzed in SAS 9.4 (SAS Institute, Cary, NC) using the PROC GLIMMIX procedure. LS-means were compared between the cultivars using the Tukey- Kramer test at significant level of $P \leq 0.05$. PROC CORR was used to determine relationships between disease incidence, severity, and yield.

Results

Verticillium wilt disease percent incidence and severity ratings were variable between the cotton cultivars and locations. Disease incidence was more severe in TN and ranged from 51 to 91 % of the plants of each cultivar with vascular staining. The lowest Verticillium wilt incidence percentage was observed in ST 5471 GLTP, ST 5600 B2XF, and NG 3930 B3XF in the TN location (Fig. 2). These cotton cultivars had the lowest percentage of plants with vascular discoloration and disease severity ratings of 2.6 or less. Disease incidence in AL ranged from 8 to 38 % of the plants of each cultivar which was significantly lower disease than in the TN location ($P > 0.05$). The highest Verticillium wilt incidence was measured in CP 9178 B3XF, PHY 400 W3FE, and NG 4936 B3XF in the AL location. These cotton cultivars had the highest percentage of plants with vascular discoloration and disease severity ratings of 2.5 to 3.0 (Fig. 3). Combining the two locations, the number of plants with vascular staining due to Verticillium wilt was most severe in DP 1725 B2XF (59%) with NG 3930 B3XF and ST 5471 GLTP having the lowest level of infection (34 and 32% respectively).

Yields indicated significant differences between cultivars when challenged with Verticillium wilt (Table 1). Seed cotton yields varied by 2561 & 1429 lb./A in TN and AL respectively, with TN supporting lower yields with more Verticillium wilt than the AL location in 2019. Lint cotton yields varied by 974 and 668 lb./A in TN and AL respectively. Ranking the cultivars by lint yield indicates DP 2012 B3XF, CP 9178 B3XF, DP 2038 B3XF, PHY 400 W3XF, and DP 1646 B2XF were the top five yielding cultivars in Alabama while PHY 360 W3XF, PHY 400 W3XF,

DP1646 B2XF, DP 2012 B3XF, and ST 4550 GLTP ranked highest in Tennessee. In both locations under these disease conditions, these cultivar yields were 33 % greater than the lowest yielding cultivars.
Comparing the data between disease incidence and severity indicated a significant positive correlation (R^2 =0.76954; $P < 0.000$) between visual symptoms and the signs of the disease in the vascular system. A correlation between Verticillium wilt incidence and lint cotton yield did indicate a negative relationship (R^2 = - 0.77509; $P < 0.0001$). The correlation between Verticillium wilt severity and lint cotton yield (R^2 = - 0.63693; $P < 0.0001$). Verticillium wilt contributed to a 70% reduction of the cotton yield in 2019.

Conclusions

Cotton cultivar selection is very important in a Verticillium wilt infested field. The lowest yielding cultivars appeared most susceptible to Verticillium wilt in 2019. Level of incidence, severity of symptoms, and yield all need to be considered when selecting a cultivar for a Verticillium wilt field.

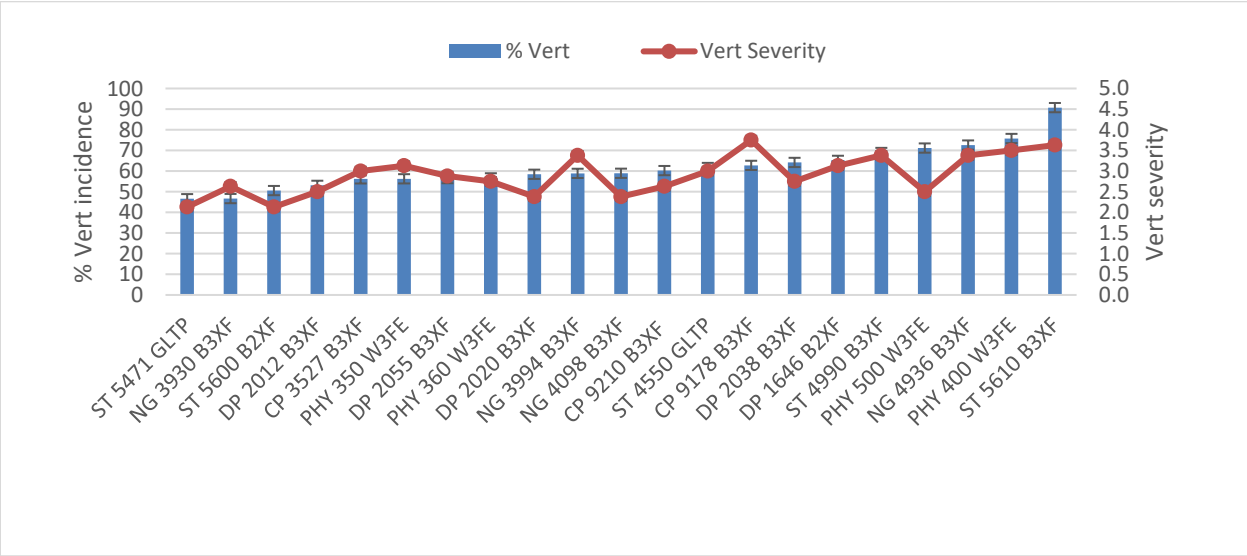

Figure 2. Verticillium wilt incidence and severity within cotton cultivars, 2019 TN.

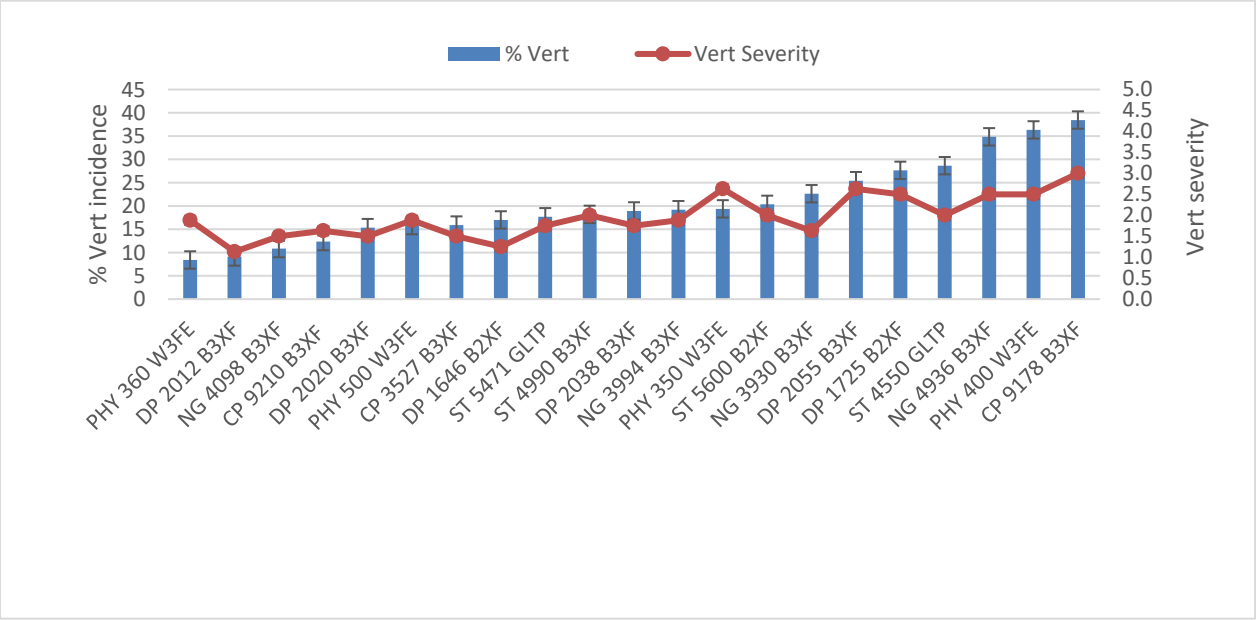

Figure 3. Verticillium wilt incidence and severity within cotton cultivars, 2019 AL.

Table 1. Cotton cultivar seed and lint cotton yields with percent turnout by state, 2019.

	Alabama				Tennessee		
Cultivar	**Seed cotton lb./A**	**Lint cotton lb./A**	**Turnout %**	**Cultivar**	**Seed cotton lb./A**	**Lint cotton lb./A**	**Turnout %**
NG 4098 B3XF	4031	1432	36	NG 4098 B3XF	3393	1168	34
Croplan 9210 B3XF	4757	1866	39	Croplan 9210 B3XF	2654	997	38
CROPLAN 3527 B2XF	4461	1859	42	CROPLAN 3527 B2XF	3107	1272	41
CROPLAN 9178 B3XF	5036	2064	41	CROPLAN 9178 B3XF	2285	887	39
DP 1646 B2XF	4722	1896	40	DP 1646 B2XF	3386	1300	38
DP 1725 B2XF	3990	1586	40	DP 2012 B3XF	3465	1300	38
DP 2012 B3XF	5254	2097	40	DP 2020 B3XF	3627	1296	36
DP 2020 B3XF	4858	1794	37	DP 2038 B3XF	3024	1239	41
DP 2038 B3XF	4434	1943	44	DP 2055 B3XF	2433	951	39
DP 2055 B3XF	4208	1648	39	NG 3930 B3XF	3047	1082	35
NG 3930 B3XF	4373	1671	38	NG 3994 B3XF	1360	525	39
NG 3994 B3XF	4380	1769	40	NG 4936 B3XF	3729	1261	34
NG 4936 B3XF	5165	1814	35	PHY 350 W3FE	3064	1127	37
PHY 350 W3FE	4164	1500	36	PHY 400 W3FE	3692	1455	39
PHY 400 W3FE	4830	1921	40	PHY 360 W3FE	3921	1499	38
PHY 360 W3FE	4075	1560	38	PHY 500 W3FE	1821	670	37
PHY 500 W3FE	3825	1539	40	ST 4550 GLTP	3241	1300	40
ST 4550 GLTP	4556	1880	41	ST 4990 B3XF	3606	1270	35
ST 4990 B3XF	4704	1650	35	ST 5471 GLTP	2675	993	37
ST 5471 GLTP	4521	1680	37	ST 5600 B2XF	3061	1152	38
ST 5600 B2XF	4417	1634	37	ST 5610 B3XF	1869	739	40

Figure 4. Verticillium wilt crew: from left to right top row: Alex Mayfield, Ty Smith, Shelly Pate, Nathan Silvey, Cheyanne, WinDi Sanchez, Cheyanne Williams, Matt Davis, David Dyer, Marina Rondon, Bisho Lawaju, Will Groover, Rachel Guyer, and Brad Meyer.

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