COTTON CULTIVAR EVALUATIONS FOR RESISTANCE TO FUSARIUM WILT AND ROOT-KNOT NEMATODE DISEASE COMPLEX IN ALABAMA

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Abstract

Fusarium oxysporum f. sp. *vasinfectum* (FOV) is the causal agent of the fungal disease Fusarium wilt in cotton. Objectives of this study are to 1) Observe commercial variety responses to Fusarium wilt and root-knot nematodes (*Meloidogyne incognita*) and compare to yield and 2) Identify races of FOV present at the site of the Commercial Fusarium Wilt Trial. The projected outcome of these experiments is to be able to more effectively control the Fusarium wilt root-knot nematode disease complex in the southeastern United States with resistant varieties being the main control measures. Results showed three varieties having statistically higher yields than the susceptible check Rowden: FiberMax 1944 GLB2, Phytogen 339 WRF, and Phytogen 499 WRF. Ten of the twelve varieties tested had statistically lower wilt percentages than the susceptible check Rowden: Croplan Genetics 3787 B2RF, Deltapine 1137 B2RF, Deltapine 12R242B2R2, Deltapine 1321 B2RF, FiberMax1944 GLB2, Phytogen 339 WRF, Phytogen 375 WRF, Phytogen 499 WRF, Stoneville 4946 GLB2, and Stoneville 6448 GLB2. Two varieties had similar root-knot reproduction factors as the resistant check M-315: Deltapine 12R242B2R2 and FiberMax 1944 GLB2.

Introduction

The intensity of Fusarium wilt disease pressure is increased by the presence of the Southern root-knot nematode, *Meloidogyne incognita*. There are currently no curatives for this disease, and prevention methods available are minimal at best. This creates a dire need for research to discover cultivars that are resistant to both of these pathogens to help control disease severity and crop losses.

Fusarium oxysporum f. sp. *vasinfectum* (FOV) caused the loss of over $1.7 million and 4,000 bales of cotton for 2011 in Alabama (National Cotton Council, 2013). Fusarium wilt and the root knot nematode (RKN) are two pathogens that put great pressure on cotton crops throughout the Southeast. There are currently no commercial cotton cultivars that are resistant to this disease complex. The only available option for control is to fumigate soils to reduce nematode populations; two downfalls to this control method are 1) the lack of economic feasibility for row crop farming to use these nematicides on a large scale and 2) the discontinuation of most effective fumigants due to environmental concerns. It is crucial to find other means of controlling and preventing this disease complex in order to decrease yield losses and economic losses for present day and future farmers.

FOV was first documented in an Alabama cotton field by Atkinson in 1892 (Atkinson, 1892). Symptoms and signs (Figure 1) that are present within affected cotton plants include chlorotic and necrotic leaves, abscission of affected leaves, wilting, reduced yield, and death. A relationship between the *Fusarium* pathogen and nematodes was noticed early on (Atkinson, 1892). The fungal hyphae induce vascular discoloration and xylem blockage causing the plant to wilt.

The Commercial Wilt Trial has been utilized since 2003. Its purpose is to evaluate commercially available cotton cultivars for Fusarium wilt and root-knot resistance. Cultivars are provided by plant breeders and various companies for evaluation. Factors considered during evaluation are Fusarium incidence and severity, root-knot reproduction factors, and yield performance.

Figure 1a. Figure 1b. Figure 1c. Figure 1d.

Figure 1a: Fusarium wilt foliar symptoms. Figure 1b: Interveinal chlorosis and necrosis. Figure 1c: Vascular discoloration of hypocotyl. Figure 1d: Galling associated with root-knot nematode damage.

Methods

The Commercial Fusarium Wilt Trial was located at the Plant Breeding Unit of the E. V. Smith Research Center near Tallassee, Alabama. Commercial varieties that are commonly grown in Alabama and the Southeast are tested with this trial and compared to resistant (M-315) and susceptible (Rowden) checks. The trial was organized in a randomized complete block design with four replications. Replications were set up as 10 ft. one-row plots with 36-inch row spacing, with 6 ft. alleys separating blocks. The trial was planted May 23, 2013 and maintained throughout the growing season using standard practices for pesticide and fertilizer applications as recommended by the Alabama Cooperative Extension System. Initial stand counts were taken June 18 and final stand counts were taken September 5 to determine plant survival rates by plot. Four wilt disease evaluations were taken throughout the season: July 2 and 18, and August 7 and 22. Infected plants were counted and collected and the fungus was re-isolated onto half-strength APDA (Acidified Potato Dextrose Agar) 100mm plates to confirm infection. FOV cultures will be identified to race using six primers to sequence identification of pathogenic races of FOV according to Kim (2009): two EF-1α primers (EF1 and EF2), two Beta-tubulin primers (BT3 and BT5), and two phosphate permease primers (PHO1 and PHO6). Three root systems per plot were sampled on July 23 and root-knot eggs were extracted by shaking in 0.6% NaCl for four minutes and collecting eggs on a 25µm sieve and counted at 40X using an inverted Nikon TSX microscope. Data were statistically analyzed using Generalized Linear Mixed Models with SAS® PROC GLIMMIX with a negative binomial distribution function for count variables. Seed cotton yield was analyzed using a normal distribution function. Dunnett's *P*-values were calculated to compare entries to resistant and susceptible checks.

Results

Fusarium wilt incidence was low in 2013. Monthly average maximum temperatures from planting in April through harvest in October were 74.7, 79.4, 87.1, 85.4, 86.5, 85.9, and 76.5°F with average minimum temperatures of 50.6, 56.1, 67.9, 68.9, 68.3, 63.1, and 52.0°F, respectively. Rainfall accumulation for each month was 3.80, 2.02, 7.10, 6.44, 5.16, 1.79, and 0.48 in with a total of 26.79 inches over the entire season. Some possible causes of low Fusarium wilt incidence could be differing weather patterns. Rainfall amounts for June and July of 2013 were more than doubled the amounts for 2012. Soil temperatures were much cooler in 2013 with a 10°F higher temperature in July 2012 (94.7°F) than in July 2013 (84.2°F). Air temperatures were also cooler in 2013.

The susceptible check Rowden had an average of 11.8% wilt, with the lowest amount of disease being 7.5% and the most disease observed was 18.1%. Ten cultivars displayed fewer Fusarium wilt symptoms than Rowden, including Croplan Genetics 3787 B2RF, Deltapine 1137 B2RF, Deltapine 12R242B2R2, Deltapine 1321 B2RF, FiberMax1944 GLB2, Phytogen 339 WRF, Phytogen 375 WRF, Phytogen 499 WRF, Stoneville 4946 GLB2, and Stoneville 6448 GLB2. Seven cultivars had statistically similar wilt percentages to the resistant check M-315. The lowest wilt percentages observed were FiberMax 1944 GLB, Phytogen 339 WRF, Stoneville 4946 GLB2, Phytogen 499 WRF, and Stoneville 6448 GLB2 with 0.3%, 0.3%, 0.8%, 0.9%, 0.9%, and 0.9% percent wilt, respectively.

The identification of races of FOV using DNA primers is currently in progress. Preliminary results indicate a diverse group of FOV present.

Table 1. Fusarium wilt percentage incidence as observed by variety.

Cultivar	Avg	Lower	Upper	Rowden**	M-315**
CG 3787 B2RF*	2.5	1.1	5.7	**0.004**	0.186
DP 1050 B2RF	5.8	3.3	10.1	0.123	0.032
DP 1137 B2RF	3.7	1.8	7.2	**0.012**	0.281
DP 1252 B2RF	7.4	4.3	12.2	0.485	0.001
DP 12R242B2R2	4.3	2.3	7.8	**0.013**	0.01
DP 1321 B2RF	1.0	0.3	3.2	**0.001**	1.000
FM 1944 GLB2	0.3	0.0	2.6	**0.01**	0.998
PHY 339 WRF	0.3	0.0	2.3	**0.007**	0.891
PHY 375 WRF	1.1	0.4	3.5	**0.001**	0.999
PHY 499 WRF	0.9	0.2	3.0	**0.001**	1.000
ST 4946 GLB2	0.8	0.2	3.0	**0.001**	1.000
ST 6448 GLB2	0.9	0.2	3.1	**0.002**	1.000
M-315	0.9	0.3	2.6	<0.001	
Rowden	11.8	7.5	18.1		0.000

*Varieties that are bolded showed significantly lower wilt percentages than the susceptible check Rowden.
**Dunnett's *P*-values vs. checks.

The susceptible check Rowden had an average of 510 root-knot nematode eggs per gram of root fresh weight (eggs/g RFW), with a range of 256 to 1016 eggs/g RFW. The resistant check M-315 had an average of 86 eggs/g RFW, and supported a range of only 43 to 170 eggs/g RFW. Two varieties were supported more root knot nematodes than the resistant check M-315: Phytogen 339 WRF and Phytogen 375 WRF, with averages of 681 and 602 eggs/g RFW, respectively. No varieties were statistically lower than the susceptible check Rowden, but two varieties supported only 111 eggs/g RFW: Deltapine 12R242B2R2 and FiberMax 1944 GLB2.

Table 2. Root-knot eggs per gram of root fresh weight from each cotton variety.

Variety	Avg	Lower	Upper	Rowden**	M-315**
CG 3787 B2RF	169	73	390	0.332	0.869
DP 1050 B2RF	141	61	325	0.176	0.982
DP 1137 B2RF	409	178	943	1.000	0.055
DP 1252 B2RF	252	109	580	0.841	0.362
DP 12R242B2R2*	111	48	255	**0.064**	1.000
DP 1321 B2RF	409	177	942	1.000	0.055
FM 1944 GLB2	111	48	257	**0.066**	1.000
PHY 339 WRF	681	295	1569	1.000	0.004
PHY 375 WRF	602	261	1389	1.000	0.008
PHY 499 WRF	183	79	422	0.424	0.778
ST 4946 GLB2	264	115	609	0.891	0.308
ST 6448 GLB2	999	434	2304	0.877	<0.001
M-315	86	43	170	0.006	
Rowden	510	256	1016		0.006

*Varieties that are bolded showed similar reproduction factors to the resistant check M-315.
**Dunnett's *P*-values vs. checks.

The susceptible cultivar Rowden yielded an average of 1963 lbs of seed cotton per acre, with a range of 759 to 3167 lbs per acre. At .85¢ per pound (the average price of cotton lint in December 2013) the average profit per acre would be $667. The resistant check M-315 yielded an average of 2994 lbs of seed cotton per acre, with a range of 1789 to 4198 lbs per acre. The average profit per acre for M-315 would be $1018. Three varieties were statistically higher yielding than the susceptible check Rowden: FiberMax 1944 GLB2, Phytogen 339 WRF, and Phytogen 499 WRF with 5300, 4712, and 4806 lb. averages per acre of seed cotton yield. FiberMax 1944 GLB2 profited $1802 per acre, Phytogen 339 WRF $1602 per acre, and Phytogen 499 WRF $1634 per acre. The highest yielding cultivar – FiberMax 1944 GLB2 – produced an average of $1135 more in profits than the susceptible check Rowden. This represents how imperative it is to be selective of the cultivar grown.

Table 3. Seed cotton yield in pounds per acre.

Variety	Avg	Lower	Upper	Rowden**	M-315**
CG 3787 B2RF	3303	1855	4751	0.748	1.000
DP 1050 B2RF	2781	1332	4229	0.987	1.000
DP 1137 B2RF	2904	1456	4352	0.963	1.000
DP 1252 B2RF	1902	454	3350	1.000	0.923
DP 12R242B2R2	3801	2352	5249	0.365	0.999
DP 1321 B2RF	2483	1035	3931	1.000	1.000
FM 1944 GLB2*	5300	3852	6748	**0.008**	0.164
PHY 339 WRF	4712	3264	6160	**0.045**	0.35
PHY 375 WRF	4211	2763	5659	0.157	0.791
PHY 499 WRF	4806	3358	6254	**0.034**	0.511
ST 4946 GLB2	4530	3082	5978	0.072	0.481
ST 6448 GLB2	2418	969	3866	1.000	1.000
M-315	2994	1789	4198	0.873	
Rowden	1963	759	3167		0.826

* Varieties that are bolded showed significantly higher yield than the susceptible check Rowden.
**Dunnett's *P*-values vs. checks.

Summary

The highest yielding variety was FiberMax 1944 GLB2, with an average of 5300 lbs per acre of seed cotton yield. This variety also had the lowest Fusarium wilt percentage among all varieties. FiberMax 1944 GLB2 averaged 111 root-knot nematode eggs per gram of root fresh weight; this was higher than the resistant check M-315 (averaging 86 eggs/g RFW), and equal to Deltapine 12R242B2R2 and lower than all of the other cultivars tested in the trial. The next highest yielding variety was Phytogen 499 WRF with an average of 4806 lbs per acre of seed cotton yield. This variety had a moderate average of 183 root-knot nematode eggs/g RFW. Average wilt percentage for Phytogen 499 WRF was 0.9%, which was statistically lower than the susceptible check Rowden. Phytogen 339 WRF yielded an average 4712 lbs seed cotton yield per acre. This variety had the second highest root-knot egg population per gram of fresh root weight with 681 eggs/g RFW. Average wilt percentage was 0.3%. This indicates a tolerance to the root-knot nematode, and potentially resistance to Fusarium wilt disease with Phytogen 339 WRF. Two other varieties yielded 4000+ lbs per acre of seed cotton: Stoneville 4946 with 4530 lbs per acre and Phytogen 375 with 4211 lbs per acre. Further testing will need to be done to confirm or deny resistance to FOV. Variety selection can be very important economically to the producer when concerning the Fusarium wilt Root-knot nematode disease complex.

References

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