Verticillium Wilt in Tennessee Valley Cotton

Tyson Raper, Cotton and Small Grains Specialist, Department of Plant Sciences
Brad Meyer, Director of Agronomy and Cooperative Services, AGRI-AFC
Kathy Lawrence, Plant Pathologist and Nematologist, Auburn University
Tyler Sandlin, Crops Specialist, Auburn University
Trey Cutts, Cotton Cropping Systems Agronomist, Auburn University
Nathan Silvey, Agronomist and Consultant, Madison Farmers Cooperative
Charles Burmester, Retired Crops Specialist, Auburn University
Taylor Dill, Agronomist, AGRI-AFC
Philip Shelby, Extension Agent III
Heather Kelly, Assistant Professor, Field Crops Plant Pathology, Department of Plant Sciences

Unbiased assessments of varietal tolerance to Verticillium wilt provide growers with information they need to select the most tolerant varieties and minimize impacts of the disease. This publication provides background on Verticillium wilt, summarizes recent variety trial results, and highlights other practices that can reduce the impact of the disease.

Introduction

Verticillium wilt of cotton has significantly reduced yields throughout the US Cotton Belt and across the world for decades; US loss estimates in 1961 equaled 580,000 bales; the Soviet Union's loss estimates in 1966 equaled 760,000; and Chinese losses reached 460,000 bales in 1982. As of 2016, US loss estimates caused by Verticillium wilt exceeded 185,000 bales.

According to the 2014, 2015 and 2016 Cotton Disease Loss Estimate Committee Reports, yield losses in Alabama and Tennessee exceeded 29,100 bales across those three seasons (Lawrence et al., 2014, 2015, 2016). The estimated $11.2 million dollar loss of income due to Verticillium wilt in these two states over three years is not evenly distributed; although rarely noted in West Tennessee and Central or South Alabama, the disease is very common in the Tennessee Valley regions of North Alabama and the cotton producing counties of Central Tennessee. Subsequently, yield losses within these regions are frequently substantial.

Identification

Visual Characteristics

Often, Verticillium wilt first appears as stunting of the infected plant relative to healthy adjacent plants. Should conditions supporting the disease persist, inconsistent mottling of leaf tissue typically develops (Figs. 1 and 3). Patterns on leaf blades are much more erratic than with nutrient deficiencies; quadrants of leaves, a partial leaf edge or complete leaf blade may begin to turn yellow or become chlorotic. Chlorotic regions may become necrotic (die) rather quickly after symptoms are first noted. Other regions of the leaves may continue to grow and maintain a dark green color or the infected leaves may abort and shed.

Figure 1: As the disease progresses, mottling of leaf tissue becomes evident. Patterns on leaf blades are erratic as edges, quadrants and/or entire leaf blades become chlorotic and die.

Incidence and severity typically vary within a row. Often, infected plants may be immediately adjacent to a plant that is not impacted by the disease (Fig. 2). These adjacent, healthy plants greatly contrast neighboring infected plants since infected plants commonly have far fewer fruiting positions and are notably shorter with less branching.

In order to isolate either Verticillium or Fusarium wilt as the cause of the stunting and leaf mottling, the stem of the infected plant should be sliced to inspect for staining (title image, Fig. 3). Brown or black staining within the pith (specifically the xylem) is indicative of Verticillium or Fusarium Wilt. In Verticillium-infected plants, this coloration is caused by the colonization of the causal agent *Verticillium dahliae* in the xylem tissue. Given the xylem's role in transporting water from the roots to the leaves, the fungal infection within the xylem tissue results in earlier onset of drought stress symptoms. As a result, infected plants often appear to have a "wilted" appearance. The blocked xylem and water stress cause earlier stomatal closure and a reduction in carbon dioxide available for photosynthesis. Reduced photosynthesis limits available resources and reduces yields. Leaf abortion from severe infestations further exacerbates the problem.

Figure 2: Incidence commonly varies through a row; infected plants may be immediately adjacent to healthy plants.

Conditions that Promote the Disease

Environment

Verticillium wilt spreads and proliferates quickly in cool, moist, heavy-textured soils. Due to evaporative cooling of water, higher disease pressure has been noted in irrigated acres. Recent work examining the response of Verticillium wilt to a variety of soil types and irrigation regimes noted trends of increasing incidence and severity with increasing clay and silt content and with the addition of irrigation (Land et al., 2017).

Genotype

Estimated yield reductions due to Verticillium wilt have declined over the past 60 years. Much of this decline is attributed to selection of varieties that are less susceptible to the disease. Still, commercially available cultivars vary greatly in tolerance to Verticillium wilt. One of the most practical and effective methods for minimizing the impact of Verticillium wilt is selecting a tolerant variety.

Management

Variety Selection

To minimize the potential negative impacts of Verticillium wilt, varieties that display low levels of infection, low visual severity ratings, and high yield potential should be placed on farms with a history of Verticillium wilt. These varietal characteristics are evaluated within the Tennessee Valley region each year. Brad Meyer, director of Agronomy and Cooperative Services with AGRI-AFC, and Nathan Silvey, agronomist and consultant with Madison Farmers Cooperative, established and maintained four variety trials in the Tennessee Valley and in Central Tennessee during 2015 and 2016. Trials were placed within fields with a history of Verticillium wilt pressure.

Figure 4: LEFT: Brad Meyer slices stems to check for staining. CENTER: Shawn Butler rates the severity of Verticillium wilt symptoms. RIGHT: A modified John Deere 9900 picker harvests strips to determine lint yield and fiber quality.

During mid-September, variety trials were assessed for percent infection by counting the number of plants with stained vascular tissue within a 10-foot section of row (Fig. 4), and the severity of Verticillium wilt symptoms was rated. Yield data were collected and samples were ginned at the UT

Cotton MicroGin to determine turnout, and fiber quality was assessed at the USDA Classing office in Memphis, TN (Figs. 4 and 5). Results from these assessments are summarized in Tables 1 and 2 below.

Table 1: Percent infection of evaluated plants within 10 row feet and severity of Verticillium wilt symptoms noted within each variety in four 2015 and 2016 Tennessee Valley locations. A severity rating of 5 indicates severe visual disease symptoms, whereas a rating of 1 indicates no visual symptoms. Means followed by the same letter are not significantly different (p = 0.05).

Infection Rank	Variety	Infection (%)	Severity Ratings
1	ST 4747 GLB2	28.8 a	1.82 A
2	ST 4848 GLT	36.9 ab	2.33 B
3	PHY 312 WRF	41.3 cb	2.86 Cdef
4	PHY 333 WRF	41.7 cb	2.96 Def
5	ST 5115 GLT	43.5 cb	2.53 Bcd
6	DP 1614 B2XF	47.0 dcb	2.89 Cdef
7	DP 1518 B2XF	49.1 edc	2.40 B
8	DP 1725 B2XF	49.9 edc	2.40 B
9	ST 4946 GLB2	50.0 edc	3.01 Ef
10	PHY 444 WRF	51.6 edc	2.73 Bcde
11	DP 1612 B2XF	56.8 ed	3.22 F
12	DP 1522 B2XF	58.7 e	2.96 Def
13	CP 3885 B2XF	74.4 f	3.11 Ef
Average		**48.4**	**2.71**

Figure 5: After harvesting, seedcotton was weighed and subsampled in preparation for ginning at the UT Cotton MicroGin.

Table 2: Yield and fiber quality properties averaged across the three strip locations harvested during the 2016 season. Means followed by the same letter are not significantly different (*p* = 0.05).

Yield Rank	Variety	Lint Yield (lb/ac)	Turnout (%)	Mic	Length (in.)	Strength (g/tex)	Unif. (%)	Leaf Grade
1	PHY 333 WRF	1422 a	41.4 abc	4.0 bcde	1.19 d-h	31.2 b-f	82.5 abcd	4 a
2	DP 1522 B2XF	1364 ab	38.6 def	4.3 ab	1.16 hij	31.3 b-f	82.2 a-f	3 abc
3	PHY 312 WRF	1360 ab	38.9 de	3.8 de	1.21 cd	31.8 bc	82.5 a-e	3 ab
4	PHY 339 WRF	1326 abc	39.0 de	3.9 bcde	1.19 d-h	30.8 cdef	82.2 a-f	3 ab
5	DP 1612 B2XF	1313 abc	36.3 fg	4.0 bcde	1.18 d-h	32.3 B	83.3 ab	3 abc
6	DP 1614 B2XF	1304 abc	42.2 ab	4.6 a	1.16 ghij	31.1 b-f	80.6 fg	3 a
7	PHY 444 WRF	1287 abcd	39.2 cde	3.3 f	1.26 a	31.7 bc	82.1 b-f	2 bc
8	DP 1725 B2XF	1278 abcd	42.4 ab	4.1 bcd	1.16 ghij	30.5 c-g	81.1 defg	2 c
9	ST 4946 GLB2	1275 abcd	38.6 de	4.3 abc	1.17 e-j	31.6 bcd	83.2 abc	4 a
10	DP 1518 B2XF	1264 abcd	38.4 def	3.7 ef	1.20 b-i	29.6 d-h	81.1 b-g	3 abc
11	PHY 243 WRF	1259 abcd	37.0 ef	3.7 ef	1.23 abc	28.9 H	79.6 g	3 a
12	ST 4747 GLB2	1246 a-e	38.4 def	3.9 bcde	1.20 def	30.6 c-g	80.9 efg	3 ab
13	CP 3527 B2XF	1226 bcde	41.4 abc	4.3 abc	1.20 cde	29.9 fgh	82.2 a-e	3 ab
14	ST 4949 GLT	1203 bcde	42.8 a	4.3 abc	1.14 j	30.0 fgh	81.6 cdef	3 abc
15	ST 4848 GLT	1166 cdef	40.2 bcd	4.2 abc	1.14 j	30.1 efgh	81.0 defg	3 abc
16	ST 5032 GLT	1107 defg	37.2 ef	3.7 ef	1.25 ab	31.5 bcde	82.5 abcd	3 ab
17	ST 5115 GLT	1102 defg	37.8 ef	4.0 bcde	1.16 hij	31.3 b-f	82.0 b-f	2 bc
18	PHY 223 WRF	1073 efg	34.6 g	3.7 ef	1.20 c-g	32.1 bc	81.8 b-f	3 ab
19	PHY 308 WRF	1061 efg	37.0 ef	3.9 cde	1.16 f-j	33.9 A	83.8 a	4 a
20	CP 3885 B2XF	1011 fg	39.0 de	4.0 bcde	1.14 ij	29.2 gh	81.5 def	2 c
21	ST 6182 GLT	931 g	38.6 de	3.9 cde	1.16 hij	29.9 fgh	80.9 defg	2 bc
	Average	**1218**	**39.0**	**4.0**	**1.18**	**30.9**	**81.8**	**3**

ST 4747 GLB2, ST 4848 GLT, PHY 312 WRF, PHY 333 WRF, ST 5115 GLT, DP 1518 B2XF and DP 1725 B2XF were characterized by low levels of infestation and low visual severity ratings. Generally, low levels of infestation corresponded to low visual severity ratings.

Lint yields were generally higher in varieties with less Verticillium wilt. The highest yields were noted from PHY 333 WRF, DP 1522 B2XF, PHY 312 WRF, PHY 339 WRF and DP 1612 B2XF. Of the five varieties characterized by the lowest levels of infection and lowest visual severity ratings, only ST 4848 GLT and ST 5115 GLT were not within the top-yielding “a” group.

Irrigation

Although irrigating cotton can increase the spread and incidence of the disease, irrigated cotton within the region consistently out yields dryland cotton. In order to reduce the impact of irrigation on the spread of Verticillium wilt, use Extension recommendations to properly initiate, time and terminate irrigation events through the season and only apply necessary amounts. Overirrigating can reduce yields by increasing disease incidence and severity.

Crop Rotation

Rotation is an effective method of reducing disease inoculum. Several grass species including barley, wheat, sorghum, perennial ryegrass and fescue can reduce disease inoculum. Legumes including several clovers (Hubam, sweet, white), alfalfa, lespedeza, peas and soybeans, as well as several mustard and rape species have also shown to decrease inoculum. However, several winter weeds can increase disease inoculum and should be controlled to minimize the impact of the disease if cotton is to be planted the following season.

Figure 6: Wheat in rotation has successfully reduced disease inoculum and is a good approach to mitigating the impacts of Verticillium wilt on cotton. Additionally, chopping stalks to speed organic matter breakdown can reduce disease incidence and severity.

Other Approaches

Practices that increase soil temperatures and/or increase soil drainage can also reduce the impact of the disease. Planting on raised beds and minimizing crop residues on the soil surface over winter by chopping stalks and/or tillage are effective ways of reducing disease inoculum. Although some high-value crops can support the use of soil fumigants to reduce inoculum, fumigation is currently not a practical approach to managing the disease in cotton. Additionally, seed treatments, in-furrow or foliar applications of fungicides curently are not effective for controlling Verticillium wilt.

Conclusions

Verticillium wilt is a major disease in many Tennessee Valley fields. Disease symptoms include stunting, erratic chlorosis and necrosis of portions of the leaf tissue, poor fruit retention, and staining of vascular tissue. Verticillium wilt severity tends to be worst in cool, irrigated, heavier textured soils planted to susceptible varieties. Increasing irrigation efficiency, increasing soil temperatures through tillage and bedding, and rotating to non-hosts can reduce disease inoculum and severity. However, one of the best management strategies is to select tolerant varieties. In fields with a history of Verticillium wilt, plant varieties that display low levels of infestation, low visual severity ratings and high yield potential.

References and Additional Resources

Kirkpatrick, T.L. and C.S. Rothrock. 2001. *Compendium of cotton diseases.* St. Paul, MN: American Phytopathological Society.

Land, C.J., K.S. Lawrence, and M. Newman. 2016. First report of *Verticillium dahliae* on cotton in Alabama. Plant Disease 100: 655.

Land, C., K. Lawrence, C. Burmester, and B. Meyer. 2017. Cultivar, irrigation, and soil contribution to the enhancement of Verticillium wilt disease in cotton. Crop Protection 96: 1-6.

Lawrence, K., A. Hagan, M. Olsen, T. Faske, R. Hutmacher, J. Mueller, D. Wright, R. Kemerait, C. Overstreet, P. Price, G. Lawrence, T. Allen, S. Atwell, S. Thomas, N. Goldberg, K. Edmisten, R. Bowman, H. Young, J. Woodward, and H. Mehl. 2017. Cotton disease loss estimate committee report, 2016. Proceedings of the 2017 Beltwide Cotton Conference, National Cotton Council of America, Memphis, TN.

Lawrence, K., A. Hagan, M. Olsen, T. Faske, R. Hutmacher, J. Mueller, D. Wright, R. Kemerait, C. Overstreet, P. Price, G. Lawrence, T. Allen, S. Atwell, S. Thomas, N. Goldberg, K. Edmisten, R. Bowman, H. Young, J. Woodward, and H. Mehl. 2016. Cotton disease loss estimate committee report, 2015. Proceedings of the 2016 Beltwide Cotton Conference, vol. 1, National Cotton Council of America, Memphis, TN.

Lawrence, K, A. Hagan, M. Olsen, T. Faske, R. Hutmacher, J. Mueller, D. Wright, R. Kemerait, C. Overstreet, P. Price, G. Lawrence, T. Allen, S. Atwell, S. Thomas, N. Goldberg, K. Edmisten, R. Bowman, H. Young, J. Woodward, and H. Mehl. 2015. Cotton disease loss estimate committee report, 2014. Proceedings of the 2015 Beltwide Cotton Conference, vol. 1, National Cotton Council of America, Memphis, TN.

AG.TENNESSEE.EDU

Real. Life. Solutions.™

W 403 02/17 17-0130 Programs in agriculture and natural resources, 4-H youth development, family and consumer sciences, and resource development. University of Tennessee Institute of Agriculture, U.S. Department of Agriculture and county governments cooperating. UT Extension provides equal opportunities in programs and employment.