Integrated Management of Verticillium Wilt in Cotton

Jason E. Woodward, Extension Plant Pathologist, Texas *Agri*LIFE Extension Service

Terry A. Wheeler, Research Plant Pathologist Texas *Agri*LIFE Research

Texas *Agri*LIFE Research and Extension Center
1102 E. FM 1294
Lubbock, TX 79403
(806) 746-4053

Verticillium wilt, caused by the soilborne fungus *Verticillium dahliae*, is an increasingly important disease of cotton on the Southern High Plains. The pathogen has a broad host range of more than 400 plant species, and can survive extremely long periods of time in the soil as microsclerotia. Several factors, including variety selection, plant density, pathogen aggressiveness, inoculum density (microsclerotia per gram of soil), and environmental conditions influence Verticillium wilt development. Initial infections occur early in the growing season, following the germination of microsclerotia. The fungus infects through the roots, invades the vascular system resulting in a systemic infection. Prolific growth in the xylem vessels disrupts the plants ability to transport water and nutrients.

Symptoms of Verticillium wilt may be observed on relatively young plants; however, expression is greatest after flowering. Foliar symptoms consist of interveinal chlorosis or necrosis (Fig. 1). As the disease progresses, severe stunting and premature defoliation can occur (Fig. 2). Discoloration of the vascular system (Fig. 3) can be observed on infected plants. Younger bolls may abscise or become malformed. Symptoms of Verticillium wilt can be confused with Fusarium wilt, and may require laboratory diagnosis.

Figure 1. Intervenial chlorosis and necrosis of a leaf from a plant infected with Verticillium wilt

Verticillium wilt is not new to cotton producing areas on the Southern High Plains. The disease was responsible for significant losses throughout the 1970's and 1980's. The widespread, long-term use of partially resistant varieties, such as Paymaster HS-26, in the 1990's is believed to have disrupted soil populations of *V. dahliae*; however, the introduction and rapid adoption of picker-type varieties resulted in a resurgence of the disease. To date, Verticillium wilt has become the most economically important disease in the region. Substantial yield losses and reductions in fiber quality (primarily micronaire, length, strength, and uniformity) can result from severe infections. Such conditions, can lead to reductions in net returns greater than $400 per acre.

Figure 2. Stunting, premature defoliation and reduced square retention of a plant infected with Verticillium wilt (right), compared to a healthy plant (left).

Figure 3. Dark brown streaks in the stem of a plant exhibiting symptoms of Verticillium wilt.

Management of Verticillium wilt requires the integration of multiple tactics. While utilizing a partially resistant or tolerant variety is the primary management strategy, the manipulation of cultural practices such as seeding rate, irrigation level, or crop rotation are also known to impact disease development. The purposes of this bulletin are to inform producers of the potential for Verticillium wilt on a field by field basis, as well as discuss potential management options that are available to minimize losses associated with the disease.

Determining Verticillium wilt risk levels: Laboratory assays are available to determine inoculum densities of *V. dahliae*. This is critical as disease severity increases with increasing soil populations of the fungus. Soil sampling can be conducted any time of the year; however, field conditions should be considered prior to sampling. Avoid sampling fields that are saturated or below field capacity. Adequate soil moisture will result in consistent sampling. Use a shovel or an auger to collect soil from a depth of 10 to 12 inches (Fig. 4). A minimum of 4 samples (representing no more than ½ acre each) should be taken to accurately estimate soil populations of *V. dahliae*. At each location, collect a total of 10 to 12 soil cores, combine in a bucket, and mix thoroughly. Transfer ~100 grams (5 oz) of the soil to a plastic bag, and label with the appropriate contact and sample identification information. Keep samples cool and out of direct sunlight. Samples should be processed as soon as possible. Send samples to the Texas AgriLife Research & Extension Center, c/o Extension Plant Pathology Lab, 1102 East FM 1294 Lubbock, TX 79403. If monitoring fields over several seasons, samples should be collected at roughly the same time of year and location within the field. Allow 3-4 weeks for samples to be processed. Laboratory results will be reported as the number of ms/cc soil, allowing for the designation of a risk level on a field by field basis (Table 1).

Figure 4. Soil sampling for *Verticillium daliae.* Note the sample is being taken from the top of the bed at a depth of 10-12 inches

Table 1. Assessment of Verticillium wilt risk based on inoculum density of *Verticillium dahliae* in soil†

Verticillium dahliae **inoculum density (microsclerotia/cc soil)**	**Risk level**
<2	None
2 – 5	Low
6 – 12	Moderate
> 12	High

† The risk level designation is based on field observation over the past 4 years. The definition of risk levels will change as more data becomes available.

Variety selection: To date, there are more than 100 cotton varieties commercially available on the Southern High Plains. An extensive screening program was initiated in 2005; however, it is impossible to properly characterize the performance of each variety. To further complicate matter, the short-lived nature of cotton varieties leads to new material entering the marketplace on a regular basis. The current focus of the screening program is to identify varieties that exhibit partial resistance or tolerance to Verticillium wilt; however, the varieties that are evaluated need to fit a specific geographic region(s). Field trials are conducted throughout the High Plains in order to achieve this goal. Results from annual variety trials can be found at the Texas AgriLife Research & Extension website (www.lubbock.tamu.edu). Annotated lists of varieties recommended for areas south and north of Lubbock are listed in Table 2.

Table 2. Cotton variety recommendations for areas south and north of Lubbock, Texas†

Lubbock South	**Lubbock North**
Deltapine 1032B2RF	Fibermax 9160B2F
Fibermax 9160B2F	Fibermax 9058F
Fibermax 9170B2F	NexGen 3348B2RF
Fibermax 9180B2F	NexGen 3410RF
Fibermax 9058F	Stoneville 4288B2F
Fibermax 1740B2F	NexGen 2549B2RF
Deltapine 1034B2RF	Fibermax 9180B2F
Deltapine 164B2RF	
Deltapine 174RF	

† Varieties from either of these lists may fit for Lubbock and adjacent counties

Seeding rate: Producers are continually looking for ways to reduce input costs without sacrificing yield. One approach that would accomplish this would be to lower seeding rates. Manipulating seeding rates can easily be done by producers at planting. According to Texas AgriLife Extension Service, the optimum plant density on conventional 40-in centers is 2 to 4 plants per foot of row. Several studies have shown that decreased plant populations exhibit higher levels of Verticillium wilt. Recent studies on the Southern High Plains found that Verticillium wilt incidence decreased with increasing seeding rates for three varieties (Table 3). While the optimum seeding rate to be recommended for Verticillium wilt is currently unknown, these results indicate that substantial losses can be experienced when reducing seeding rates below 4 seed per foot.

Table 3. Effect of seeding rate on Verticillium wilt incidence for three cotton varieties

	Verticillium wilt incidence (%)			
Seeding rate (seed/ft)	**AFD 5065B2F†**	**Fibermax 9063B2F†**	**Americot 1532B2RF†**	**Mean‡**
2	21.4	29.2	33.2	27.9 a
4	11.9	18.2	17.0	15.7 b
7	8.6	11.3	13.2	11.0 b

† Values within each cell are the means of 16 observations from 4 trials over a two year period.

‡ Means within a column followed by the same letter are not statistically different according to Fisher's protected LSD Test ($P \leq 0.05$).

Crop rotation: Crop rotation with non-host crops (i.e. grain crops) may help reduce Verticillium wilt incidence, when compared to the continued plantings of susceptible hosts. Care must be taken when selecting rotation crops as *V. dahliae* has a wide host range. Crops such as peanut, sesame, safflower and chili pepper should not be used as they are susceptible to infection by *V. dahliae.* While incorporating non-host crops into a rotation may limit the build-up of inoculum, it is unlikely that rotation alone will provide satisfactory results. This is due in part to the wide host range of the pathogen and the ability of the fungus to persist in soil in the absence of a host (as microsclerotia). Crop rotation should be viewed as a preventative rather than curative management option.

Preliminary data on the Southern High Plains indicate that crop rotation can aid in suppressing disease development and negatively impact *V. dahliae* inoculum density under low to moderate conditions (Table 4). While variation in *V. dahliae* populations can occur when sampling over time, data collected from producer fields have shown that continuous cotton consistently results in higher soil populations. Benefits of rotation have been observed in grower fields (data not shown). Rotation with sorghum for one year can lower your risk level for subsequent cotton crops; however, growing cotton behind two to three years of sorghum resulted in substantial reductions in soil populations. These results agree with previous studies, suggesting that the greatest benefit from rotation would be observed when the rotation is initiated early, before inoculum builds up to high levels in the soil.

Table 4. Effect of rotation schemes including sorghum on Verticillium wilt incidence in cotton and *Verticillium dahliae* microsclerotia in soil over 3 years

Year, rotation scheme	Verticillium wilt incidence (%)†	*Verticillium dahliae* inoculum density (microsclerotia/cc soil)
2008		
Cotton-Cotton-Cotton	15.0 a‡	2.7 a‡
Sorghum-Cotton-Cotton	4.1 b	0.2 b
Cotton-Sorghum-Cotton	1.9 b	0.8 b
Cotton-Cotton-Sorghum	n/a	0.2 b
2009		
Cotton-Cotton-Cotton	23.3 a	25.6 a
Sorghum-Cotton-Cotton	6.7 b	1.1 b
Cotton-Sorghum-Cotton	3.3 b	2.1 b
Cotton-Cotton-Sorghum	n/a	1.3 b
2010		
Cotton-Cotton-Cotton	- -	50.7 a
Sorghum-Cotton-Cotton	- -	3.6 c
Cotton-Sorghum-Cotton	- -	1.6 c
Cotton-Cotton-Sorghum	- -	9.1 b

† Disease incidence represents the % of plants exhibiting foliar symptoms of Verticillium wilt. n/a = not applicable. - - = observations are not currently available.
‡ Means within a column followed by the same letter are not different according to Fisher's protected LSD ($P \leq 0.05$).

Irrigation: Cotton is considered a relatively drought tolerant plant. The amount if water used by cotton will vary by the amount available in the soil, rainfall, and other growing conditions. While cotton yields generally increase with rainfall or the addition of irrigation, excessive irrigation will lower soil temperature. Since growth and development of *V. dahliae* is favored by cool conditions, overwatering will lead to an increase in Verticillium wilt incidence (Table 5). Reducing irrigation during flowering (late July and early August) will decrease Verticillium wilt severity; however, drought stress imposed during this time may also have a detrimental effect on yield. It is important to closely monitor moisture needs during this timeframe in order to maximize yields and minimize Verticillium wilt severity. Raised plant beds will help to improved drainage and increase soil temperature, where poor drainage exists.

Table 5. Effect of irrigation level on Verticillium wilt incidence at the Helms Farm (2008 and 2009)

	Verticillium wilt incidence (%)†	
Irrigation level	**2008**	**2009**
50% ET	0.9 c‡	4.0 c‡
100% ET	9.2 b	9.6 b
150% ET	14.5 a	19.3 a

† Disease incidence represents the % of plants exhibiting foliar symptoms of Verticillium wilt.

‡ Means within a column followed by the same letter are not statistically different according to Fisher's protected LSD Test ($P \leq 0.05$).

Nitrogen fertilization: Over fertilization with nitrogen compounds has been shown to incite Verticillium wilt in other crops such as potato and strawberry. Increasing irrigation levels have been shown to incite Verticillium wilt (described above); however, these effects have been exacerbated in the presence of excessive nitrogen. The percentage of plants infected with *V. dahliae* has been shown to increase with higher rates of nitrogen fertilizers. While this relationship is poorly understood at this time, studies are currently underway to better define the impact of increasing nitrogen fertilizer rates on Verticillium wilt.

Chemical management options: The use of the soil fumigant metam sodium (Vapam) has been effective at reducing Verticillium wilt incidence in potato when applied at rates of 50 to 75 gallons per acre. These use rates are cost prohibitive for cotton production on the Southern High Plains. Experimental use of Vapam (7-20 gallons per acre) in the region has proved inefficient at reducing Verticillium wilt severity, or increasing yields. There are several fungicides registered for use in cotton (Headline, Quadris, and Topsin-M). These products are labeled for use against foliar and boll rot diseases, but not Verticillium wilt. Several trials, evaluating Headline and Quadris to improve '*Plant Health*', were conducted in fields infested with *V. dahliae*, and the use of these products did not affect Verticillium wilt. To date, there are no chemical management options commercially available for Verticillium wilt in cotton.

Summary: No single management option is effective at controlling Verticillium wilt in cotton. Furthermore, the lack of economically viable chemical control options for Verticillium wilt necessitates the need to incorporate cultural practices into disease management programs. The selection of partially resistant or tolerant varieties that possess the required agronomic characteristics and are properly adapted to specific growing region is the cornerstone of any management program. However, the integration of other tactics can be used to further reduce losses related to the disease. Information presented in this bulletin indicates that practices such as irrigation, seeding rate, and crop rotation can impact disease incidence and/or soil populations of *V. dahliae*. Various aspects of the aforementioned practices will remain the focus of future research on the Southern High Plains.

AgriLIFE EXTENSION
Texas A&M System