2006 Beltwide Cotton Conferences, San Antonio, Texas - January 3 - 6, 2006

CULTIVAR SUSCEPTIBILITY TO VERTICILLIUM WILT ON THE HIGH PLAINS OF TEXAS

Terry A. Wheeler
Greta L. Schuster
West Texas A&M University
Canyon, TX

Abstract

Small plot variety trials were conducted at five sites (Olton, Muleshoe, Lubbock, Lamesa, and Colorado City, TX) to test for incidence of wilt and yield for varieties in fields infested with *Verticillium dahliae*. Varieties that were tested at a minimum of two sites were ranked by both relative wilt ratings and relative yield in an effort to determine the best recommendation. The top 20% by this method were: FiberMax (FM) 960BR, FM 989B2R, FM 989BR, Deltapine (DP) 455BR, FM 960RR, Paymaster (PM) 2379RR, DP 5690RR, FM 960B2R, and PM 2167RR. The poorest 20% of varieties tested at a minimum of two sites to recommend for Verticillium wilt fields were: All-Tex Magnum RR, Beltwide Cotton Genetics (BCG) 30R, BCG 50R, Americot 821R, DP 5415RR, BCG 28R, DP 432RR, All-Tex Warrior RR, and Stoneville 5599BR. Varieties at one site were tested with Temik 15G at 0 and 5 lbs/acre. Yields increased slightly with the use of Temik 15G, but when cost was factored in, there was no advantage of using Temik 15G in the Verticillium wilt field.

Introduction

Verticillium dahliae which is the causal agent of Verticillium wilt of cotton was a yield limiting disease in both 2004 and 2005. This pathogen had caused little yield losses from 1998 – 2003 because of hot, dry conditions in July and August. The varieties planted in the High Plains of Texas underwent a dramatic change from 1998 – 2005. There was insufficient information on the new varieties to make recommendations for Verticillium wilt fields. Variety selection is the most important control measure for this disease in cotton.

Materials and Methods

Variety Tests. Five sites were selected based on symptom expression in 2004 and soil assays for microsclerotia of *V. dahliae* (Wheeler and Rowe, 1995). One site was lost to hail soon after planting. The plots were 35.5 ft. long, 2-rows wide with 40-inch centers. The surviving sites were near Lamesa (planted May 11), Muleshoe (planted May 12), Lubbock (planted May 16), and Colorado City (planted May 20), TX. At each site, between 28 and 36 varieties were planted, with four seed planted/ foot of row in four replications, with varieties arranged in a randomized complete block design. Stand counts were taken at one month after planting. Plants that displayed symptoms of Verticillium wilt were counted from both rows of each plot starting in the last week of July, and continuing at approximately 2-week intervals until the end of August. The exception was the Lamesa site where sufficient wilt had developed by 8 August to determine differences between varieties. No ratings were made at that site after 8 August. In most of the sites, substantial levels of wilt did not develop until the end of August. At all sites in 2005, *V. dahliae* was consistently isolated from plants outside of the test area, but within the same field. The plots were harvested with a two-row plot stripper, weighed with load cells, and a subsample taken to determine percent lint, seed, and HVI testing. The Colorado City, Lamesa, Lubbock, and Muleshoe tests were harvested on October 25, November 3, November 5, and November 28, respectively.

Statistical analysis for each site was conducted by analysis of variance. If the F-test was significant at $P \leq 0.05$, then a Waller-Duncan k-ratio t-test was used to separate variety means at $P = 0.05$.

Variety x Temik test. At a site located near Olton, TX where *V. dahliae* and root-knot nematode were confirmed with soil sampling, a variety test was conducted with 16 varieties (main plots), and Temik 15G (0 vs 5 lbs/acre) as the subplot. The main plots were arranged as a randomized complete block design with four replications. The subplots were fixed in position due to constraints with the turning mechanism of the insecticide boxes. The test area was 8-rows wide (40-inch centers), where the outside two rows (4 total) did not have Temik 15G applied, and the middle four rows did. There were always four consecutive rows with the same variety, so each four-row variety plot had two rows with Temik 15G and two rows without. The test was planted on May 11. The plots were rated similarly to what was described in the previous section for Verticillium wilt. The test was harvested as two row plots on October 26. The analysis was a split-plot using PROC GLM in SAS, where the error term for the Temik

factor was specifically written in the program. The Waller-Duncan k-ratio t-test was used to separate variety differences at $P = 0.05$.

Overall Variety Recommendation. For each of the five Verticillium wilt sites tested, a relative wilt rating was achieved by dividing the mean wilt rating for that variety by the highest average wilt rating for that site. Varieties that were only planted at one site (one site was loss, so not all varieties were at two locations), were not included. Yield, which is a measure of tolerance to Verticillium wilt, as well as adaptability to other site-specific factors was also described as relative yield. The average yield of each variety at each site was divided by the highest average yield at that site to determine relative yield. The averages of both relative wilt and relative yield were calculated. In an attempt to describe the best overall varieties to plant at Verticillium wilt sites, the average relative wilt was subtracted from 1, and added to the average relative yield. The higher the combined sum, the better the variety was to plant in a Verticillium wilt field.

Results

Variety Tests. Air temperature in late July and August was conducive for development of Verticillium wilt. The maximum air temperature of Halfway represents the more northern sites tested (Olton and Muleshoe), Lubbock is in the middle of the High Plains, and Lamesa, and Colorado City are in the southern High Plains. At all of these sites, most days were well under 95 F in late July and August (Fig. 1).

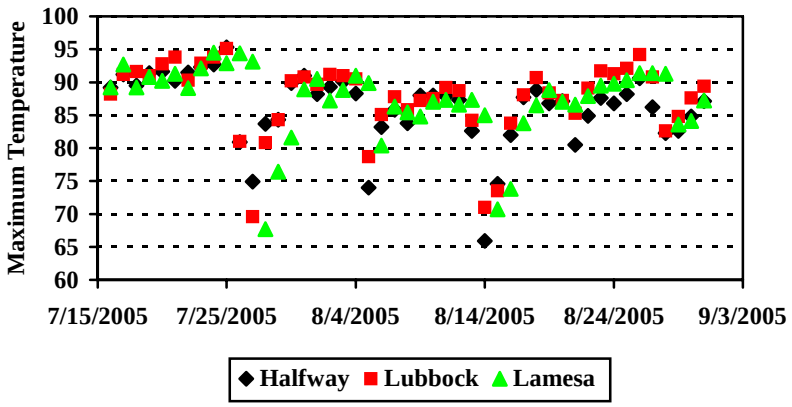

Figure 1. The maximum air temperature (F) recorded daily at weather stations located in Halfway, Lubbock, and Lamesa, TX.

At the Colorado City site, which was the most southern one tested, there were no significant differences between varieties with respect to Verticillium wilt incidence at any of the times rated. Average wilt ranged from 25 to 50% of the plants in the plot, across varieties and average yields ranged from 419 to 1,028 lbs of lint/acre. There was also some development of Phymatotrichum root rot at this site. The length of row killed *P. omnivorum* was measured, and yields were adjusted accordingly. The varieties with the best yields and loan values x yields were: FM 991RR, Phytogen 480WR, DP 455BR, FM 989BR, FM 960B2R, FM 960RR, FM 991BR, Phytogen 470WR, DP 449BR, DP 5690RR, FM 960BR, FM 989B2R, ST 6636BR, and DP 444 BR (Table 1).

The Lamesa site developed wilt earlier than the other sites, however, yields were the highest overall at this site (Table 2). Incidence of wilt in each plot was significantly different by variety on 8 August. Average wilt ranged from a low of 13% (FM 960RR) to a high of 48% (Stoneville [ST] 4575BR). Other varieties with low wilt incidence included FM 960BR, and FM 989B2R. Other varieties with high incidences of wilt included Americot 821R, DP 449BR, and DP 488BR (Table 2). Yield ranged from a low of 742 lbs of lint/acre to a high of 1,863 lbs of lint/acre. The highest yielding varieties included FM 989B2R, Paymaster (PM) 2379RR, FM 960BR, FM 960RR, FM 960B2R, FM 989RR, and PM 2266RR (Table 2).

The Lubbock site had lower incidence of Verticillium wilt than the other sites. The average wilt incidence ranged from a low of 4% (ST 3664R) to a high of 30% for Americot 8120. Yield ranged from a low of 565 lbs of lint/acre (DP 5415RR) to a high of 1,264 lbs of lint/acre (FM 960BR) (Table 3).

The Muleshoe site had some hail damage which may have lowered yields overall, compared with the other sites. The incidence of wilt ranged from a low of 18% for Paymaster 2326RR to a high of 56% for Stoneville 4793RR. Yield ranged from a low of 270 lbs of lint/acre for All-Tex Xpress RR to a high of 917 lbs of lint/acre for FiberMax 960BR (Table 4).

Variety x Temik test. Wilt symptoms were substantial by the end of August. There was no difference between varieties with respect to incidence of wilt. Wilt ranged from a low of 34% to a high of 48%, which is a smaller range than was found at other locations. Yield ranged from a low of 687 lbs of lint/acre for Phytogen 310R to a high of 1,102 lb of lint/acre for FM 960B2R. Variety significantly impacted yield and value/acre (yield x loan value) – cost of Temik 15G. Temik 15G significantly reduced incidence of wilt (41% in the absence of Temik 15G and 38% in the presence of Temik 15G), and improved yield (866 lbs in the absence of Temik 15G and 901 lbs of lint/acre in the presence of Temik 15G). However, the improvement in yield was not sufficient to offset the cost of product, so that in calculating value/acre, the Temik factor was not significant. The improvement in yield with Temik 15G in a Verticillium wilt trial was modest compared to the improvement seen with Fusarium wilt.

Table 1. Affect of variety on Verticillium wilt incidence, yield, and loan value in Colorado City.

Variety	lbs of lint/acre	Loan value ($)	Loan value x yield ($)	% Wilt on Aug. 30
FiberMax 991RR	928 a-e[a]	0.563	522.52 a	28
Phytogen 480WR	1,028 a	0.507	520.57 ab	35
DeltaPine 455BR	986 ab	0.528	520.26 ab	30
FiberMax 989BR	950 abc	0.525	498.87 ab	25
FiberMax 960B2R	934 a-d	0.523	488.16 abc	36
FiberMax 960RR	912 a-e	0.532	485.04 abc	27
FiberMax 991BR	929 a-e	0.522	484.89 abc	30
Phytogen 470WR	947 abc	0.51	482.71 a-d	37
DeltaPine 449BR	867 a-f	0.555	480.83 a-d	30
DeltaPine 5690RR	888 a-e	0.533	473.63 a-d	25
FiberMax 960BR	890 a-e	0.531	471.94 a-d	25
FiberMax 989B2R	913 a-e	0.516	470.68 a-e	30
Stoneville 6636 BR	875 a-f	0.533	465.79 a-e	38
DeltaPine 444BR	880 a-f	0.522	458.83 a-e	30
Stoneville 5242BR	850 b-g	0.518	440.15 a-f	38
FiberMax 989 RR	834 b-h	0.519	432.79 a-f	29
Stoneville 5303R	846 b-h	0.509	430.09 b-g	29
Stoneville 4575BR	809 c-i	0.503	406.73 c-h	29
NexGen 2448R	755 e-k	.0527	397.95 c-h	31
All-Tex Patriot RR	763 d-k	0.514	392.14 d-i	27
NexGen 3969R	773 c-j	0.487	376.22 e-j	38
Americot 821R	705 f-m	0.521	367.01 f-j	37
FiberMax 991B2R	711 f-l	0.510	362.10 f-j	38
DeltaPine 555BR	684 g-n	0.519	354.96 f-k	39
Americot 262R	666 h-n	0.512	341.30 h-k	33
Stoneville 5599BR	643 i-n	0.530	340.93 g-k	35
Stoneville 4686R	625 j-n	0.533	332.96 h-k	30
DeltaPine 434RR	637 i-n	0.500	315.50 ijk	30
DeltaPine 494RR	632 i-n	0.494	312.35 ijk	47
Beltwide Cotton Genetics 28R	531 m-o	0.561	297.76 jk	41
Phytogen 410R	574 l-o	0.507	291.09 jk	30
Beltwide Cotton Genetics 30R	563 l-o	0.517	290.84 jk	39
DeltaPine 424B2R	587 k-o	0.457	268.08 kl	35
All-Tex Warrior RR	511 lm	0.501	265.76 kl	35
All-Tex Magnum RR	507 no	0.524	265.15 kl	50
Beltwide Cotton Genetics 24R	419 o	0.475	199.07 l	44

[a]Values with a different letter are significantly (P = 0.05) different.

Table 2. Affect of variety on Verticillium wilt incidence and yield at Lamesa.

Variety	Lbs of lint/a	% Wilt on 8 August
FiberMax 989B2R	1,863 a[a]	15.3 c-e
Paymaster 2379RR	1,747 ab	16.6 b-e
FiberMax 960BR	1,744 ab	14.1 de
FiberMax 960RR	1,607 bc	13.0 e
FiberMax 960B2R	1,578 bcd	16.0 b-e
FiberMax 989RR	1,556 b-e	17.9 b-e
Paymaster 2266RR	1,528 b-e	19.6 b-e
DeltaPine 5690RR	1,515 c-f	30.4 a-e
DeltaPine 455BR	1,490 c-g	27.5 a-e
DeltaPine 555BR	1,457 c-g	32.2 a-e
NexGen2448R	1,454 c-g	30.8 a-e
All-Tex Atlas RR	1,449 c-g	19.9 b-e
FiberMax 989BR	1,439 c-g	21.9 b-e
Stoneville 5242BR	1,421 c-h	23.3 b-e
Stoneville 5303R	1,420 c-h	33.7 a-e
Americot 262R	1,380 d-i	35.3 a-e
Phytogen 470WR	1,372 d-i	20.8 b-e
DeltaPine 5415RR	1,372 d-i	35.9 a-d
Stoneville 4575BR	1,338 e-j	48.0 a
DeltaPine 444BR	1,307 f-j	25.5 a-e
DeltaPine 494 RR	1,303 f-j	28.3 a-e
DeltaPine 488BR	1,295 f-j	38.7 ab
Beltwide Cotton Genetics 28R	1,283 g-j	34.7 a-e
DeltaPine 449BR	1,278 g-j	38.2 ab
Phytogen 410R	1,221 h-k	26.0 a-e
DeltaPine 424B2R	1,186 i-l	29.8 a-e
Associated Farmers Delinting 3602R	1,172 i-l	35.9 a-d
Stoneville 4686R	1,170 i-l	28.5 a-e
Stoneville 6636BR	1,147 j-l	28.2 a-e
Stoneville 5599BR	1,049 kl	33.3 a-e
NexGen 3969R	1,032 lm	21.9 b-e
DeltaPine 455BR	998 lm	36.6 a-d
Beltwide Cotton Genetics 30R	988 lm	37.2 abc
DeltaPine 434RR	883 mn	32.5 a-e
Americot 821R	864 mn	38.5 ab
Beltwide Cotton Genetics 50R	742 n	27.7 a-e

[a]Values with a different letter are significantly (P = 0.05) different.

Table 3. Affect of variety on wilt incidence and yield in Lubbock county.

Variety	lbs of Lint/acre	%Wilt on 24 August
FiberMax 960BR	1,264 a[a]	6 hi
FiberMax 989BR	1,239 a	7 hi
DeltaPine 455BR	1,223 a	11 e-i
FIberMax 5045BR	1,171 ab	12 d-i
FiberMax 958	1,112 abc	16 b-i
FiberMax 960RR	1,073 a-d	7 hi
Associated Farmers Delinting 3602R	993 b-e	8 ghi
FiberMax 958LL	990 b-e	16 b-h
DeltaPine 424B2R	980 b-e	12 d-i
FiberMax 966LL	968 b-e	12 d-i
Associated Farmers Delinting 3511R	950 cde	12 d-i
Beltwide Cotton Genetics 28R	937 cde	12 d-i
Americot 1621	934 cde	12 d-i
FiberMax 981LL	932 cde	17 b-h
DeltaPine 493	929 cde	15 b-i
All-Tex Patriot RR	904 c-f	8 ghi
DeltaPine 445BR	900 c-f	19 a-g
NexGen 2448R	892 d-g	5 i
FiberMax 5035LL	877 d-g	15 b-i
Beltwide Cotton Genetics 295	868 d-h	20 a-f
DeltaPine 434RR	867 d-h	6 hi
DeltaPine 393	859 d-h	12 d-i
Phytogen 310R	847 e-h	10 e-i
Stoneville 3664R	833 e-h	4 i
All-Tex Xpress	815 e-h	12 d-i
All-Tex Warrior RR	777 e-i	21 a-e
Americot 8120	697 f-i	30 a
Americot 262R	696 f-i	15 c-i
DeltaPine 491	689 f-i	17 b-h
Beltwide Cotton Genetics 245	681 ghi	26 ab
All-Tex Magnum RR	655 hi	25 abc
DeltaPine 5415RR	565 i	22 a-d

[a]Values with a different letter are significantly (P = 0.05) different.

Table 4. Affect of variety of incidence of Verticillium wilt and yield at Muleshoe.

Variety	lbs of Lint/acre	% Wilt on 25 August
FiberMax 960BR	917 a[a]	24 efg
Paymaster 2167RR	909 ab	33 c-g
FiberMax 989B2R	861 abc	25 efg
NexGen 2448R	814 a-d	32 c-g
Paymaster 2326RR	803 a-d	18 g
NexGen 1553R	788 bcd	28 d-g
FiberMax 989BR	774 cde	33 c-g
FiberMax 960B2R	771 c-f	40 a-e
Paymaster 2280BR	704 d-g	25 e-g
Paymaster 2145RR	687 d-g	35 b-f
Paymaster 2266RR	656 efg	34 b-f
FiberMax 989RR	654 efg	39 b-f
All-Tex Atlas RR	643 fg	32 c-g
FiberMax 960RR	609 gh	37 b-f
FiberMax 5045BR	608 gh	36 b-f
Paymaster 2379RR	593 gh	24 fg
DeltaPine 444BR	579 ghi	25 efg
All-Tex Excess RR	511 hij	39 b-f
Stoneville 4793R	498 h-k	56 a
DeltaPine 432RR	493 h-k	40 a-f
All-Tex Patriot RR	454 i-l	44 abc
Associated Farmers Delinting 3511R	435 jkl	39 b-f
Beltwide Cotton Genetics 50R	391 j-m	39 b-f
Americot 262R	388 j-m	42 a-d
DeltaPine 434RR	376 klm	34 b-g
Phytogen 310R	347 lm	42 a-d
Beltwide Cotton Genetics 28R	277 m	50 ab
All-Tex Xpress RR	270 m	42 a-d

[a]Values with a different letter are significantly (P = 0.05) different.

Table 5. Affect of variety on incidence of Verticillium wilt, yield, and value per acre of varieties.

Variety	lbs of lint/acre	Loan value ($)	(Loan value x yield) – Temik 15G cost[b] ($)	% Wilt on August 31
FiberMax 960B2R	1,102 a[a]	0.523	567.81 a	37
FiberMax 989RR	1,072 ab	0.510	538.60 ab	42
Paymaster 2167RR	1,010 abc	0.486	482.94 cd	38
Paymaster 2379RR	980 bc	0.513	494.92 bc	40
Paymaster 2280BR	951 cd	0.485	453.14 cde	38
DeltaPine 444BR	949 cd	0.494	460.71 cde	34
FiberMax 960RR	915 cde	0.481	432.67 def	35
NexGen 1553R	859 def	0.505	425.75 efg	39
NexGen 2448R	837 ef	0.509	417.95 e-h	40
Paymaster 2266RR	830 ef	0.521	424.14 efg	37
Paymaster 2145RR	812 ef	0.457	363.19 ij	39
DeltaPine 432RR	803 f	0.470	369.39 hij	40
Deltapine 434RR	770 fg	0.490	389.52 f-i	42
NexGen 3969R	768 fg	0.505	379.52 ghi	44
FiberMax 5045BR	754 fg	0.480	354.28 ij	48
Phytogen 310R	687 g	0.479	320.90 j	40

[a]Values with a different letter are significantly (P = 0.05) different.

[b]Temik 15G was applied at 5 lbs/acre in the furrow at planting, and was estimated at a cost of $3.15/ lb of product.

Overall Variety Recommendation. Of those varieties at two locations or more (46 varieties), the ones with the worse symptoms were All-Tex Magnum RR, ST 4575BR, BCG 30R, DP 432RR, Americot 821R, DP 494RR, DP 5415RR, DP 555BR, and PM 2145RR. The best varieties with respect to having lower wilt ratings at two sites or more were: FM 960BR, FM 989BR, FM 989B2R, FM 960RR, All-Tex Atlas RR, AFD 3602R, and DP 455BR (Table 6). The overall top 20% of the varieties, based on a combination of wilt incidence and yield and tested at a minimum of two sites: FM 960BR, FM 989B2R, FM 989BR, DP 455BR, FM 960RR, PM 2379RR, DP 5690RR, FM 960B2R, and PM 2167RR. The 20% of the varieties which performed the worse overall in terms of wilt incidence and yield were: All-Tex Magnum RR, BCG 30R, BCG 50R, Americot 821R, DP 5415RR, BCG 28R, DP 432RR, All-Tex Warrior RR, and ST 5599BR.

References

Wheeler, T. A. and R. C. Rowe. 1995. Influence of soil characteristics and assay techniques on quantification of *Verticillium dahliae* in Ohio soils. Plant Dis. 79:29-34.

Acknowledgements

We thank the seed companies that donated seed: All-Tex Seed, American Cotton Breeders Inc. (Americot varieties), Associated Farmers Delinting (now part of Bayer Crop Sciences), Bayer Crop Sciences (FiberMax varieties), Beltwide Cotton Genetics, Delta and Pine Land (Deltapine and Paymaster varieties), Phytogen Seed Company (now part of Dow AgroSciences), Stoneville Texas (Stoneville and NexGen varieties, now part of Monsanto). We also thank Bayer Crop Sciences for providing Temik 15G for the study.

We thank the producers that provided land to conduct these tests: Scott Robertson (Olton), Marty McGuire (Muleshoe), AFD nursery (Lubbock), John Sentel (Lamesa), and Mark Wright (Colorado City).

We thank the county and IPM agents who assisted in these trials: Emilio Nino, Monti Vandiver, Mark Brown, Tommy Doederlein, and John Senter.

Table 6. Relative wilt ratings for varieties planted at a minimum of two Verticillium wilt sites.

Variety	Average Relative Wilt[a]	Average Relative Yield[b]	Best guess to plant in wilt field[c]	Number of sites tested
FiberMax 960BR	0.36	0.95	1.59	4
FiberMax 989B2R	0.46	0.94	1.48	3
FiberMax 989BR	0.44	0.88	1.44	4
DeltaPine 455BR	0.51	0.91	1.40	3
FiberMax 960RR	0.49	0.82	1.33	5
Paymaster 2379RR	0.54	0.82	1.28	3
DeltaPine 5690RR	0.57	0.84	1.27	2
FiberMax 960B2R	0.63	0.90	1.27	4
Paymaster 2167RR	0.69	0.95	1.26	2
All-Tex Atlas RR	0.49	0.74	1.25	2
Phytogen 470WR	0.59	0.83	1.24	2
NexGen 2448R	0.57	0.77	1.20	5
Paymaster 2280BR	0.62	0.82	1.20	2
FiberMax 989RR	0.63	0.83	1.20	4
Associated Farmers Delinting 3602R	0.51	0.70	1.19	2
DeltaPine 444BR	0.57	0.76	1.19	4
Stoneville 5242BR	0.62	0.79	1.17	2
Paymaster 2266RR	0.60	0.76	1.16	3
NexGen 1553R	0.66	0.82	1.16	2
Stoneville 5303R	0.64	0.79	1.15	2
All-Tex Patriot RR	0.53	0.65	1.12	3
DeltaPine 424B2R	0.57	0.66	1.09	3
FiberMax 5045BR	0.68	0.76	1.08	3
Associated Farmers Delinting 3511R	0.55	0.61	1.06	2
Stoneville 6636BR	0.67	0.73	1.06	2
Deltapine 449BR	0.70	0.76	1.06	2
Phytogen 410R	0.57	0.61	1.04	2
Stoneville 4686R	0.60	0.62	1.02	2
Paymaster 2145RR	0.72	0.74	1.02	2
DeltaPine 434RR	0.59	0.58	0.99	5
DeltaPine 555BR	0.73	0.72	0.99	2
NexGen 3969R	0.71	0.67	0.96	3
Stoneville 4575BR	0.79	0.75	0.96	2
Americot 262R	0.66	0.59	0.93	4
Phytogen 310R	0.64	0.56	0.92	3
DeltaPine 445BR	0.70	0.62	0.92	2
DeltaPine 494RR	0.76	0.66	0.90	2
Stoneville 5599BR	0.70	0.59	0.89	2
All-Tex Warrior RR	0.70	0.56	0.86	2
Deltapine 432RR	0.77	0.63	0.86	2
Beltwide Cotton Genetics 28R	0.71	0.56	0.85	4
DeltaPine 5415RR	0.74	0.59	0.85	2
Americot 821R	0.77	0.57	0.80	2
Beltwide Cotton Genetics 50R	0.64	0.41	0.77	2
Beltwide Cotton Genetics 30R	0.78	0.54	0.76	2
All-Tex Magnum RR	0.92	0.51	0.59	2

[a]The % average wilt for each variety at each site was divided by the highest average wilt for a variety at that site.
[b]The yield for each variety at each site was divided by the highest average yield for a variety at that site.
[c]The average relative wilt was subtracted from 1, and that value added to the average relative yield. This provides a measure of both symptom development and tolerance to base variety recommendations on.