REACTION OF COTTON CULTIVARS AND BREEDING LINES TO AREOLATE MILDEW IN ALABAMA

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Abstract

At the Wiregrass Research and Extension Center (WGREC), 44 and 40 commercial and advanced breeding lines screened in the early and full season flex OVT trials, respectively, were evaluated for their reaction to areolate mildew. While target spot was the primary disease in the May planted full season flex OVT, areolate mildew was the primary disease observed in the early June planted early flex OVT. Areolate mildew defoliation noted in the full season OVT was higher for Deltapine 1646 B2XF (14%) than all cultivars and breeding except for Deltapine MON17R829 B3XF with little if any areolate mildew noted on many of the remaining cultivars and breeding lines. In contrast to the above study, considerable areolate mildew development was noted in the early June-planted early flex OVT trial with Americot NG 3729 B2XF suffering greater defoliation (64%) than all cultivars and breeding lines except for PhytoGen 340 W3FE, Deltapine 1646 B2XF, Stoneville 5020 GLT, PhytoGen 333 WRF, PhytoGen 330 W3FE, PhytoGen 300 W3FE, Croplan 9178 B3XF, and breeding lines Bayer BX1973GLTP and Bayer BX1975GLTP. Minimal defoliation ratings were recorded for five PhytoGen advanced breeding lines along with root knot resistant PhytoGen 320 W3FE (0.3%), PhytoGen 350 W3FE (6.7%), and PhytoGen 480 W3FE (2.3%). Modest target spot-incited defoliation was noted on a handful of cultivars and breeding lines in the early flex OVT. Yields and grades will be reported for the above cultivar × fungicide studies but those values for both the OVT trials at the WGREC were lost due to hurricane Michael. At the Field Crops Unit, areolate mildew-incited defoliation on the non-fungicide treated cotton was greater on PhytoGen 340 W3FE than all other cultivars except for Stoneville 5020 GLT and Stoneville 5471 GLTP, while similarly low disease related defoliation levels were noted for Deltapine 1747N B2XF and PhytoGen 490 W3FE. The fungicide umbrella program gave complete control of areolate mildew. In addition, yields differed significantly by cultivar and fungicide program.

Introduction

Areolate mildew, caused by the fungus *Ramularia gossipii*, typically causes little or no yield losses in U.S. cotton but requires an aggressive fungicide program to avoid significant damage in Brazilian cotton. The outbreak of areolate mildew observed in Southeast Georgia in 2017 expanded in 2018 into the remaining cotton production areas in Georgia and to a lesser extent in Alabama where significant disease-incited defoliation was observed in several widely planted cotton cultivars by early to mid-August. The objective of this study was to assess the reaction of cotton cultivars and advanced breeding lines to areolate mildew and identify disease resistant commercial cultivars.

Methods

At the Wiregrass Research and Extension Center (WGREC), 44 and 40 commercial cultivars and advanced breeding lines screened in the early and full season flex OVT trials, respectively, were evaluated for their reaction to areolate mildew. The experimental design was a randomized complete block with four replications. Individual experimental units were 3 feet wide by 20 feet in length. Recommended fertility, weed and insect control were followed for both WGREC OVT Trials. Areolate mildew intensity was assessed on 6 September using a 1 to 10 leaf spot scoring system where 1 = no disease, 2 = very few lesions in canopy, 3 = few lesions noticed in lower and upper canopy, 4 = some lesions seen and $\leq$ 10% defoliation, 5 = lesions noticeable and $\leq$ 25% defoliation, 6 = lesions numerous and $\leq$ 50% defoliation, 7 = lesions very numerous and $\leq$ 75% defoliation, 8 = numerous lesions on few remaining leaves and $\leq$ 90% defoliation, 9 = very few remaining leaves covered with lesions and $\leq$ 95% defoliation, and 10 = plants defoliated. Defoliation values were calculated using the formula [% Defoliation = 100/(1+e(-(leaf spot scoring system -6.0672)/0.7975)]. Yields and grades are not available for either of the above WGREC OVT trials due to damage caused by hurricane Michael. Means were separated using Fisher's protected least significant difference (LSD) test ($P \leq 0.05$).

At FCU and PBU, the experimental design was a factorial arranged in a split plot with the nine cotton cultivars as whole plots and a fungicide program as the split plot treatment. The fungicide program consisted of multiple broadcast applications of 8 fl oz/A Priaxor + 1.5 pt/A Bravo Ultrex or a non-fungicide treated control. Individual experimental units consisted of four 25-foot rows spaced 3 feet apart. Four replications of treatments were included. Fertility, weed, and insect control practices were according to the recommendations of the Alabama Cooperative Extension System. Plots were irrigated as needed. Fungicides were broadcast with a high clearance sprayer with AITTJ60-11002VP nozzles on 18 inch centers using 15 gal/A of spray volume at 40 psi. Areolate mildew intensity was assessed as described in the previous paragraph. Cotton was mechanically harvested at FCU and PBU on 15 October and 10 November, respectively. Significance of interactions was done using the PROC GLIMMIX procedure in SAS. Statistical analysis on target spot and areolate mildew defoliation were performed on rank transformations of data. Non-transformed data are presented. Means were separated using Fisher's protected least significant difference (LSD) test ($P \leq 0.05$).

Results

In the full season flex OVT planted in mid-May, areolate mildew defoliation was higher for Deltapine 1646 B2XF (14%) than all cultivars and breeding lines in the full season flex OVT except for Deltapine MON17R829 B3XF. While little if any areolate mildew was noted on many the remaining cultivars and breeding lines, the high levels of defoliation attributed to target spot observed across the full season flex OVT probably interfered with areolate mildew development and subsequent defoliation attributed to the latter disease (Table 1). In contrast to the above study, considerable areolate mildew development occurred in September in the early June planted early flex OVT trial with Americot NG 3729 B2XF suffering greater defoliation (64%) on 6 Oct than all cultivars and breeding lines except for PhytoGen 340 W3FE, Deltapine 1646 B2XF, Stoneville 5020 GLT, PhytoGen 333 WRF, PhytoGen 330 W3FE, PhytoGen 300 W3FE, Croplan 9178 B3XF, and breeding lines BX1973GLTP and Bayer BX1975GLTP. Minimal areolate mildew defoliation was recorded for five PhytoGen advanced breeding lines along with the commercial cultivars PhytoGen 320 W3FE (0.3%) and PhytoGen 350 W3FE (6.7%), and PhytoGen 480 W3FE (2.3%) (Table 2). Yields and grades are not available for either of the above WGREC OVT trials due to damage caused by hurricane Michael.

Table 1. Reaction of cotton cultivars and advanced breeding lines to areolate mildew, Full Season Flex OVT Trial, Wiregrass Research and Extension Center, 2018.

Cotton selection	Areolate Mildew %[z]	Cotton selection	Areolate Mildew %
Croplan 3527 B2XF	3.4 d-h[Y]	PhytoGen 3B07 W3FE	6.4 bcd
Croplan 9608 B3XF	6.3 cd	PhytoGen 3B09 W3FE	5.4 cde
Deltapine 1555 B2XF	0.7 gh	PhytoGen 3C06 W3FE	0.0 h
Deltapine 1646 B2XF	14.2 a	PhytoGen 4A64 W3FE	0.9 fgh
Deltapine 1747NR B2XF	1.9 e-h	PhytoGen 4A69 W3FE	0.4 gh
Deltapine 1835 B3XF	1.0 fgh	PhytoGen 5D28B W3FE	0.0 h
Deltapine 1840 B3XF	2.9 d-h	PhytoGen 5C09 W3FE	0.0 h
Deltapine 1851 B3XF	5.0 c-f	NexGen 5007 B2XF	4.3 c-g
Deltapine MON17R829 B3XF	10.5 ab	NexGen 5711 B3XF	2.9 d-h
PhytoGen 300 W3FE	3.8 d-h	Stoneville 4949 GLT	3.7 d-h
PhytoGen 320 W3FE	0.0 h	Stoneville 5020 GLT	1.9 e-h
PhytoGen 330 W3FE	8.3 bc	Stoneville 5122 GLT	0.3 gh
PhytoGen 333 WRF	0.9 fgh	Stoneville 5471 GLTP	4.0 d-h
PhytoGen 340 W3FE	5.7 cde	Stoneville 5517 GLTP	3.5 d-h
PhytoGen 350 W3FE	0.7 gh	Stoneville 5818 GLT	0.4 gh
PhytoGen 430 W3FE	0.2 h	Stoneville 6182 GLT	0.3 gh
PhytoGen 440 W3FE	0.0 h	Stoneville BX1973 GLTP	2.6 d-h
PhytoGen 444 WRF	0.9 fgh	Stoneville BX1974 GLTP	1.0 fgh
PhytoGen 480 W3FE	0.2 gh	Stoneville BX1975 GLTP	3.3 d-h
PhytoGen 530 W3FE	0.0 h	Stoneville BX1976 GLTP	1.6 e-h

[z] Areolate mildew intensity was assessed on 6 September on a 1 to 11 scale and converted to % defoliation values.
[y] Means followed by the same letter are not significantly different according to Fisher's protected least significant difference (LSD) test ($P \leq 0.05$).

Table 2. Reaction of cotton cultivars and advanced breeding lines to areolate mildew, Early OVT Trial, Wiregrass Research and Extension Center, 2018.

Cotton selection	Areolate mildew % defoliation [z]	Cotton selection	Areolate mildew % defoliation [z]
NexGen 3522 B2XF	21.4 h-n [Y]	PhytoGen 444 WRF	25.6 e-m
NexGen 3699 B2XF	32.8 d-l	PhytoGen 480 W3FE	2.3 tu
NexGen 3729 B2XF	64.2 a	PhytoGen 530 W3FE	15.9 m-t
NexGen 3780 B2XF	14.7 l-s	PhytoGen 3B07 W3FE	34.6 c-j
NexGen 4601 B2XF	24.8 g-n	PhytoGen 3B09 W3FE	39.4 c-k
NexGen 4689 B2XF	37.6 b-i	PhytoGen 3C06 W3FE	0.4 u
NexGen 4777 B2XF	23.4 f-m	PhytoGen 4A64 W3FE	7.2 o-u
NexGen AMX1801 B3XF	19.5 j-p	PhytoGen 4A69 W3FE	4.4 r-u
Croplan 9178 B3XF	43.5 a-e	PhytoGen 5D28B W3FE	2.3 stu
Deltapine 1518 B2XF	48.0 abc	PhytoGen 5C09 W3FE	7.1 q-u
Deltapine 1614 B2XF	41.3 a-g	Stoneville 4949 GLT	22.4 f-m
Deltapine 1646 B2XF	54.7 abc	Stoneville 5020 GLT	49.5 abc
Deltapine 1725 B2XF	36.5 a-h	Stoneville 5122 GLT	21.1 g-n
Deltapine 1820 B3XF	17.1 j-q	Stoneville 5471 GLTP	19.9 i-o
PhytoGen 300 W3FE	38.5 a-g	Stoneville 5517 GLTP	16.3 l-r
PhytoGen 320 W3FE	0.3 u	Stoneville 5818 GLT	16.7 k-q
PhytoGen 330 W3FE	53.3 a-d	Stoneville 6182 GLT	26.7 e-m
PhytoGen 333 WRF	49.6 a-d	Stoneville BX1973 GLTP	41.2 a-f
PhytoGen 340 W3FE	59.6 ab	Stoneville BX1974 GLTP	36.1 b-i
PhytoGen 350 W3FE	6.7 p-u	Stoneville BX1975 GLTP	40.6 a-g
PhytoGen 430 W3FE	7.3 p-u	Stoneville BX1976 GLTP	15.6 l-q
PhytoGen 440 W3FE	9.7 m-u	Winfield United 18XC9B3XF	33.4 b-i

[z] Areolate mildew intensity was assessed on 5 October on a 1 to 11 scale and converted to % defoliation values.
[y] Means followed by the same letter are not significantly different according to Fisher's protected least significant difference (LSD) test ($P \leq 0.05$).

Trials were also conducted at the Field Crop Unit (FCU) and Plant Breeding Unit (PBU) at the E. V. Smith Research Center to assess cotton cultivar reaction to areolate mildew as influenced by a fungicide program. The experimental design was a factorial arranged in a split plot with the nine cotton cultivars as whole plots and a fungicide program as the split plot treatment. The fungicide program consisted of multiple broadcast applications of 8 fl oz/A Priaxor + 1.5 pt/A Bravo Ultrex or a non-fungicide treated control. Individual experimental units consisted of four 25-ft rows spaced 3 ft apart. Four replications of treatments were included.

At FCU, the significant cultivar × fungicide program interaction for areolate mildew-incited defoliation and seed yield illustrated the differential response of cotton cultivars to the fungicide program. Across all cotton cultivars, the full-season Priaxor + Bravo WeatherStik program gave complete control of areolate mildew. With the non-fungicide program, areolate mildew-incited defoliation was greater on PhytoGen 340 W3FE (28.5%) than all other cultivars except for Stoneville 5020 GLT (17.4%) and Stoneville 5471 GLTP (11.9%), while similarly low defoliation levels were noted for Deltapine 1747NR B2XF (2.6%) and PhytoGen 490 W3FE (3.7%). With the full-season fungicide program, Stoneville 5471 GLTP had greater seed yields than all cultivars except for PhytoGen 450 W3FE and Deltapine 1538 B2XF, while significantly lower yields recorded for PhytoGen 340 W3FE and PhytoGen 490 W3FE were matched by Stoneville 5020 GLT and Stoneville 5818 GLT ($P \leq 0.10$). The non-fungicide Stoneville 5818 GLT had significantly higher seed yields compared with Deltapine 1747NR B2XF and PhytoGen 340W3FE, which had similarly low seed yields. In addition, PhytoGen 340 W3FE, which had the highest areolate mildew defoliation rating, also yielded significantly less than seven (7) non-fungicide treated cultivars. Finally, significant yield gains were obtained with the fungicide compared with the non-fungicide program with Stoneville 5471 GLTP, PhytoGen 450 W3FE, Deltapine 1538 B2XF, and Deltapine 1747NR B2XF.

Table 3. Defoliation from areolate mildew and target spot along with seed yield of selected cotton cultivars as influenced by fungicide program at Field Crops Unit in 2018.

Source of variation	Target spot[z]	Areolate mildew[z]		Seed yield[y]	
	- - - - - - - - - - - - - - - - *F*-values - - - - - - - - - - - - - - -				
Cultivar	2.60*	3.69**		3.05*	
Fungicide	25.30***	61.44***		11.51*	
Cultivar x fungicide	0.85	3.69***		2.12^	
	--------% Defoliation-------			----------lb/A----------	
Cultivar		Fungicide	No fungicide	Fungicide	No fungicide
PhytoGen 340 W3RF	5.1 ab	0.0 f	28.5 a	4834 ef	4384 f
PhytoGen 450 W3RF	9.0 a	0.0 f	8.7 bc	5652 ab	5089 de
PhytoGen 490 W3RF	6.1 ab	0.0 f	3.7 e	4673 ef	5011 de
Deltapine 1538 B2XF	2.2 c	0.0 f	7.9 bc	5605 abc	5027 de
Deltapine 1553 B2XF	3.1 bc	0.0 f	9.6 bc	5397 bcd	5170 b-e
Deltapine 1747N B2RF	3.3 bc	0.0 f	2.6 de	5354 bcd	4748 ef
Stoneville 5020 GLT	3.0 bc	0.0 f	17.4 ab	5128 cde	5056 de
Stoneville 5471 GLTP	1.7 c	0.0 f	11.9 abc	5997 a	5157 b-e
Stoneville 5818 GLT	8.9 a	0.0 f	8.0 cd	5175 b-e	5372 bcd
Fungicide program and rate/A					
Priaxor 4.17SC 8 fl oz + Bravo Weather Stik 6F 1 pt[v]	1.8 b	---		---	
No-fungicide treated control	7.6 a	---		---	

[z] Target spot and areolate mildew intensity was rated using a leaf spot scoring system (1 to 10 scale) on 10 September and converted to % defoliation values.
[y] Seed yield = weight of seed + lint.
[x] Significance of *F* values at the 0.10, 0.05, 0.01, and 0.001 levels is indicated by ^, *, **, or ***, respectively.
[w] Means in each column followed by the same letter are not significantly different according to Fisher's protected least significant difference (LSD) test ($P \leq 0.05$) unless otherwise indicated.
[v] Fungicide applications were scheduled at 1st, 3rd, 5th, and 7th week of bloom on 26 July, 8 August, 22 August, and 6 September.

For the early June-planted PBU cultivar × fungicide study, disease onset occurred between the 8 and 23 August rating dates with noticeable signs of areolate mildew observed on 29 August. By the 24 September rating date, greater premature defoliation levels were recorded for PhytoGen 450 W3FE (43.2%) compared with the remaining cultivars except for Deltapine 1538 B2XF (28.3%). With the exception of latter two cultivars and Stoneville 5122 GLT (20.4%) and PhytoGen 340 W3FE (16.3%), the low level of areolate mildew-incited defoliation observed on Deltapine 1553 B2XF (5.0%) was equaled by all remaining cultivars. As was noted above at FCU, the non-fungicide treated cotton (16.9%) had significantly greater areolate mildew defoliation ratings compared with the fungicide umbrella program, which provided complete control (0.0%) of areolate mildew. Similar seed yields, which were low, were noted across all cotton cultivars. Greater yield were recorded for the no fungicide than fungicide umbrella program.

Table 4. Seed yield and areolate mildew-incited defoliation on selected cotton cultivars as influenced by fungicide program at Plant Breeding Unit in 2018.

Source of variation	Areolate mildew [z]		Seed yield [y]
Cultivar	5.30*** [x]		0.89
Fungicide	85.84***		4.36*
Cultivar x fungicide	5.29***		1.21
Cultivar	Fungicide	No fungicide	
PhytoGen 340 W3RF	0.2 ef [w]	43.2 a	954 a
PhytoGen 450 W3RF	0.0 f	15.3 bc	1104 a
PhytoGen 490 W3RF	0.0 f	16.3 abc	757 a
Deltapine 1747 B2RF	0.0 f	5.0 e	713 a
Deltapine 1553 B2XF	0.0 f	10.8 cd	958 a
Deltapine 1646 B2XF	0.0 f	28.3 ab	812 a
Stoneville 4946 GLB2	0.0 f	5.7 de	784 a
Stoneville 5020 GLT	0.0 f	20.4 bc	963 a
Stoneville 6182 GLT	0.0 f	7.1 cd	844 a
Fungicide program and rate/A			
Priaxor 4.17SC 8 fl oz + Bravo Weather Stik 6F 1 pt [v]	---		836 b
No fungicide control	---		916 a

[z] Areolate mildew intensity was rated using a leaf spot scoring system (1 to 10 scale) on 24 September and converted to % defoliation values.
[y] Seed yield = weight of seed + lint.
[x] Significance of *F* values at the 0.10, 0.05, 0.01, and 0.001 levels is indicated by ^, *, **, or ***, respectively.
[w] Means in each column followed by the same letter are not significantly different according to Fisher's protected least significant difference (LSD) test ($P \leq 0.05$) unless otherwise indicated.

Summary

While factors such as location certainly influenced the development and intensity of areolate mildew, planting date appeared to have the greatest impact on overall level of disease activity in cotton. Defoliation levels were noticeably greater among cultivars in the June compared with May-planted cotton. In the later plantings, PhytoGen 340 W3FE along with Deltapine 1646 B2XF and Stoneville 5020 GLT proved highly susceptible to areolate mildew and could possibly suffer sizable yield loss under significant disease pressure. Other entries, such as the root knot resistant cultivar PhytoGen 320, PhytoGen 350, PhytoGen 440, and PhytoGen 480 demonstrated a high level of areolate mildew resistance as did a number of other cultivars and advanced breeding lines. The multi-application fungicide umbrella programs provided near complete areolate mildew control. The significant fungicide-related yield gains in the FCU study suggest that relatively low levels of defoliation attributed to areolate mildew along with target spot may result in significant yield loss. Additional data needs to be generated to provide a more complete picture of cultivar response to areolate mildew as well as assess the efficacy and yield response of disease susceptible and resistant cultivars to fungicide inputs.