REACTION OF COTTON CULTIVARS AND BREEDLING LINES TO TARGET SPOT IN ALABAMA

A. K. Hagan
K. Burch
Department of Entomology and Plant Pathology, Auburn University
Auburn, AL
H. B. Miller
Brewton Agricultural Research Unit
Brewton, AL
D. Moore
Prattville Agricultural Research Unit
Prattville, AL

Abstract

Trials were conducted at the Brewton Agricultural Research Unit (BARU) and Prattville Agricultural Research Unit (PARU) to assess the reaction of cotton cultivars as influenced by an umbrella fungicide program to target spot. The experimental design was a factorial arranged in a split plot with the nine cotton cultivars as whole plots and a Priaxor+ Bravo Ultrex umbrella fungicide program as the split plot treatment. At BARU, final defoliation ratings differed by cultivar and fungicide program. Stoneville 6182 GLT suffered greater defoliation than all cultivars except PhytoGen 580 W3FE and Deltapine 1851 B3XF. In contrast, lowest defoliation noted for Deltapine 1646 B2XF was equaled by the remaining cultivars. Final target spot intensity was significantly lower for the fungicide than non-fungicide treated cotton. Open boll counts, which were greater also greater for Deltapine 1646 B2XF than all Stoneville but not the remaining Deltapine and PhytoGen cultivars, were similar for the fungicide and non-fungicide cotton. As indicated by a significant cultivar × fungicide program interaction, seed cotton yield differed by cultivar and fungicide program. For the fungicide-treated cotton, Deltapine 1840 B3XF had significantly greater yield than all cultivars except Deltapine 1646 B2XF, Deltapine 1851 B3XF, and PhytoGen 350 W3FE. With the non-fungicide cotton, the former cultivar produced greater seed cotton yield than all cultivars except Deltapine 1646 B2XF and Stoneville 5818 GLT. Except for Stoneville 5600 GLT, seed yield for the fungicide and non-fungicide control were similar for all remaining cultivars. For the PARU location, defoliation differed by cotton cultivar. Stoneville 5471 GLT suffered less defoliation compared with all cultivars except for PhytoGen 440 WRF, PhytoGen 480 W3FE, Deltapine 1840 B3XF, and Deltapine 1851 B3XF. Differences in open, unopened, hardlocked, and rotted boll counts were noted between cultivars. Deltapine 1646 B2XF produced greater seed yields than all cultivars except Deltapine 1840 B3XF and Deltapine 1851 B3XF. Results from the Irrigated Early Flex OVT and Irrigated Full Season Flex OVT trials at PARU are also presented.

Introduction

Target spot, which is caused by the fungus *Corynespora cassiicola* Berk. & M.A. Curtis) C.T. Wei, is linked with significant yield losses in cotton (Bowen et al, 2018; Hagan et al, 2015; Hagan et al, 2018). Mehl et al. (2019) has also reported a negative correlation between target spot-incited defoliation and yield. Disease distribution in the U.S. includes all cotton producing states except for Arizona and California (Butler et al. 2016; Conner et al. 2013; Donahue 2012; Edmisten 2012; Fulmer et al. 2012; Price et al. 2015a, Damicone, personal communication; Woodruff, personal communication). Target spot outbreaks have also been reported in Brazil (Galbieri et al. 2014) and China (Wei et al. 2014).

Strong-growing cotton with early canopy closure and a yield potential of 1500 lb./acre is most vulnerable to target spot, particularly when irrigated and/or close proximity to the Gulf Coast where frequent afternoon summer showers favor early disease onset and development (Hagan 2014). As was previously demonstrated in 2017, absence of a closed canopy after first bloom minimizes target spot development, regardless of rainfall or irrigation patterns (Hagan, personal observation).

Plant resistance is often the most efficient and cost effective method of managing field crop diseases as compared with fungicides, which provide target spot control but inconsistent yield gains (Mehl et al, 2019). Previously, sizable differences in target spot-incited defoliation have been noted among cotton cultivars (Hagan et al, 2013; Hagan et al, 2016). Hagan et al (2018) reported that PhytoGen 499WRF suffered greater premature defoliation compared with other commercial cultivars, all of which had similarly lower levels of premature defoliation. More recently, Deltapine

1646 B2XF has often had significantly lower levels of defoliation compared with many other commercial cultivars in combination with excellent yield potential (Bowen et al, 2019).

The study objective is to identify commercial cultivars and breeding lines with tolerance or partial resistance to target spot as well as determine the yield response of susceptible and partially resistant commercial cultivars to fungicide inputs.

Methods

For the cotton cultivar × fungicide studies at BARU and PARU, the experimental design was a factorial arranged in a split plot with cultivars as the whole plots and fungicide program as subplots. Individual subplots consisted of four 25 foot rows spaced 3 feet apart arranged in four replications. Recommendations of the Alabama Cooperative Extension System for fertility along with insect and weed control, canopy management, and harvest preparation were followed. Both study sites were irrigated as needed with a lateral irrigation system. Cultivars were hill dropped at BARU and PARU at 3 seed/foot of row on 7 and 3 May, respectively. Broadcast applications of Priaxor at 8 fl oz/A + Bravo WeatherStik 6F at 1.0 pt./A were made with a 'high-boy' sprayer at two-week intervals beginning the 1st or 3rd week of bloom and ending the 7th week of bloom. A non-fungicide treated control was also included.

The Irrigated Early Flex and Full Season Flex OVT trials, which were sown in mid- and early May, respectively, were conducted at PARU. Recommendations of the Alabama Cooperative Extension System for soil fertility along with insect and weed control, canopy management and harvest preparation were followed. Both study sites were irrigated as needed with a lateral irrigation system. Studies were picked in early November.

Target spot intensity was assessed at cut-out 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 (Chiteka et al, 1988). Defoliation values were calculated using the formula [% Defoliation = 100/(1+e(-(leaf spot scoring system -6.0672)/0.7975)] (Li et al, 2012). Cotton was mechanically harvested and samples collected for grading. Significance of cultivar × fungicide interactions were determined using PROC GLIMMIX in SAS. Statistical analyses were done on rank transformations for non-normal values. Non-transformed data are reported. Means were separated using Fisher's protected least significant difference (LSD) test ($P \leq 0.05$).

Results

While temperatures at PARU were near to above normal, monthly rainfall totals for July and August were above to well above the 30-yr average but below average for May, June, and September. As indicated by a significant cultivar × fungicide interaction, lint yield levels for target spot differed by cotton cultivar and fungicide program (Table 1). Interactions between the above variables on target spot-incited defoliation and lint turn out are not significant. For all cultivars, final % defoliation values were lower for the fungicide- than the non-fungicide-treated cotton. Stoneville 6182 GLT had significantly greater target spot-incited defoliation than all cultivars except PhytoGen 580 W3FE and Deltapine 1851 B3XF with the latter cultivars also having the highest rate of disease development. In contrast, low defoliation recorded for Deltapine 1646 B2XF was equaled by Deltapine 1840 B3XF, Stoneville 5600 B2XF, Stoneville 5818 GLT, PhytoGen 480 W3FE and PhytoGen 350 W3FE. For the fungicide-treated cotton, Deltapine 1646 B2XF produced significantly greater lint yields than all cultivars except Deltapine 1840 B3XF and Deltapine 1851 B3XF, while Stoneville 5818 GLT had significantly lower lint yield than all cultivars except for PhytoGen 480 W3FE and Stoneville 6182 GLT. With the non-fungicide cotton, greater yields were recorded for Deltapine 1646 B2XF than any other cultivar except Deltapine 1840 B3XF, while the low yield for Stoneville 5600 B2XF was matched by Stoneville 6182 GLT. Except for Stoneville 5600 B2XF, similar lint yield was noted for the remaining cultivars for fungicide and no fungicide programs.

Table 1. Target spot defoliation along with lint turn out and yield as influenced by cotton cultivar selection and fungicide inputs at BARU in 2019.

Source of Variation	Target spot [z]	Turn out	Lint yield [y]	
	------*F*-values------			
Cultivar	3.76**	23.99***	4.98***	
Fungicide	83.35***	4.92*	0.01	
Cultivar × Fungicide	0.92	2.17	2.58*	
Cultivar	% final defoliation	lint content	lb./A	
			Fungicide	No Fungicide
PhytoGen 350 W3FE	30.0 bc	0.411 d	1474 bcd	1435 cde
PhytoGen 480 W3FE	24.2 c	0.430 c	1361 def	1486 bcd
PhytoGen 580 W3FE	38.9 ab	0.446 ab	1446 b-e	1465 bcd
Deltapine 1646 B2XF	19.3 c	0.441 b	1648 a	1645 a
Deltapine 1840 B3XF	25.2 bc	0.414 d	1557 abc	1586 ab
Deltapine 1851 B3XF	31.5 bc	0.425 c	1540 abc	1467 bcd
Stoneville 5600 B2XF	20.6 c	0.426 c	1451 b-e	1267 f
Stoneville 5818 GLT	26.4 bc	0.393 e	1309 ef	1414 cde
Stoneville 6182 GLT	49.7 a	0.453 a	1375 def	1412 c-f
Fungicide and Rate/A [v]				
Priaxor 4.17F 8 fl oz + Bravo Weather Stik 6F 1 pt	14.4 b	0.428 a	---	
No-fungicide control	44.6 a	0.425 b	---	

[z] Target spot intensity was rated using a leaf spot scoring system (1 to 10 scale) on 11 September and converted to % defoliation values.
[y] Lint yield = Total weight - weight of seed.
[x] Significance of *F* values at the 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 3rd, 5th and 7th week of bloom on 9 July, 23 July, and 12 August.

While temperatures during the study period at PARU were near to above normal, monthly rainfall totals for Jun and Aug were above the 30-yr average but below average for May, Jul, and Sep. As indicated by a significant cultivar × fungicide interaction, defoliation levels attributed to target spot varied by cotton cultivar and fungicide program (Table 2). Across all cultivars, final % defoliation was significantly lower for the fungicide positive than the no fungicide control. For the no-fungicide program, the high defoliation level noted for Stoneville 4550 GLTP was equaled by PhytoGen 350 W3FE, Deltapine 1851 B3XF, Deltapine 1646 B2XF, and Stoneville 5818 GLT, while Stoneville 5471 GLTP suffered the least premature defoliation. With the exception of Stoneville 4550 GLTP and Stoneville 5818 GLT, the defoliation ratings for all cultivars matched the low level of damage noted on Stoneville 5471 GLTP. While significant differences in yield were noted between cultivars, similar yields were recorded both the fungicide umbrella program and no fungicide control despite significant levels of premature defoliation associated with the latter program. Delayed disease development in early to mid-August due to dry July weather patterns is likely the reason for the absence of a yield response to the fungicide umbrella program. Overall, greater seed yield was obtained with Deltapine 1646 B2XF than all cultivars except for Deltapine 1840 B3XF and Deltapine 1851 B3XF.

Table 2. Target spot defoliation along with lint turn out and yield as influenced by cotton cultivar selection and fungicide inputs at PARU in 2019.

Source of Variation	Target spot [z]		Seed yield
	------*F*-values------		
Cultivar	8.37***[y]		3.84**
Fungicide	207.62***		1.86
Cultivar × Fungicide	8.62***		0.66
	% defoliation		
Cultivar	Fungicide	No Fungicide	lb./A
PhytoGen 350 W3FE	4.6 gh	20.1 b-e	3144 d
PhytoGen 440 W3FE	3.3 gh	12.4 de	3192 cd
PhytoGen 480 W3FE	3.2 gh	45.7 ab	3425 bcd
Deltapine 1646 B2XF	5.0 fg	20.4 cde	3801 a
Deltapine 1840 B3XF	2.9 gh	33.2 abc	3610 ab
Deltapine 1851 B3XF	3.5 gh	27.0 bcd	3509 abc
Stoneville 4550 GLTP	9.2 ef	63.1 a	3179 d
Stoneville 5471 GLTP	0.8 h	7.0 fg	3283 bcd
Stoneville 5818 GLT	4.8 fg	32.7 a-d	3419 bcd
Fungicide Program and Rate/A			
Priaxor 4.17SC 8 fl oz + Bravo WeatherStik 6F 1 pt [w]	---		3443 a
No fungicide control	---		3348 a

[z] Target spot intensity was rated using a leaf spot scoring system (1 to 10 scale) on 4 September and converted to % defoliation values.

[y] Significance of *F* values at the 0.05, 0.01, and 0.001 levels is indicated by *, **, or ***, respectively.

[x] 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.

[w] Fungicide applications were scheduled at 1st, 3rd, 5th, and 7th week of bloom on 1 July, 15 July, 29 July, and 13 August.

While temperatures during the study period were near to above normal, monthly rainfall totals for June and August were above the 30-yr average, but below average for May, July, and September 2019. While significant differences in target spot incited defoliation were noted between cotton cultivars and advanced breeding lines, overall disease intensity was relatively low except for NexGen 4936 B3XF along with a handful of other entries and was unlikely to negatively impact lint yield, which were exceptionally high for the majority of entries, particularly for PhytoGen PX3B07 W3FE (Table 3). Other entries that matched the lint yield of PhytoGen PX3B07 W3FE included PhytoGen 480 W3FE, BASF Stoneville 5471 GLTP, BASF BX2076 GLTP, PhytoGen PX3C06 W3FE, and Croplan 3527 B2XF. Also, the high lint content levels recorded for the majority of entries were likely elevated due to the ideal dry weather patterns at harvest.

Table 3. Target spot defoliation, lint content and yield of cotton cultivars and breeding lines in 2019 Irrigated Early Flex OVT trial at PARU.

Cotton Cultivar or Breeding Line	Target Spot % defoliation [z]	Turn out lint content	Lint yield lb./A
Americot NexGen 3729 B2XF	2.1 g-j [y]	0.421 h-l	1985 b-g
Americot NexGen 5007 B2XF	9.5 a-f	0.425 g-k	1932 b-h
BASF Stoneville 4550 GLTP	22.0 a-d	0.465 a	2069 abc
BASF Stoneville 5471 GLTP	3.4 c-j	0.417 i-n	2141 ab
BASF BX2076 GLTP	6.0 a-i	0.446 bcd	2106 abc
Croplan 3527 B2XF	6.6 a-i	0.444 b-f	2022 a-e
Croplan 9178 B3XF	1.7 j	0.436 d-h	1916 b-i
Croplan 9608 B3XF	7.1 a-h	0.450 bcd	1771 c-i
Deltapine 1518 B2XF	20.3 b-i	0.413 k-n	1639 g-j
Deltapine 1614 B2XF	0.5 ij	0.419 i-n	1676 e-j
Deltapine 1646 B2XF	8.2 d-j	0.445 b-e	1943 b-h
Deltapine 1725 B2XF	9.2 a-i	0.450 a-d	1981 b-g
Deltapine 1823 NR B2XF	3.1 e-j	0.436 d-h	1660 f-j
Deltapine 1916 B3XF	22.0 a-f	0.457 ab	1925 b-h
Deltapine 18R628 NR B3XF	11.6 a-e	0.440 c-g	1770 c-i
Dyna-Gro 3317 B3XF	2.1 ij	0.425 g-l	1824 c-i
Dyna-Gro 3385 B2XF	21.0 a	0.431 e-i	1945 b-h
Dyna-Gro 3520 B3XF	3.8 c-j	0.404 n	1668 f-j
Dyna-Gro 3570 B3XF	9.6 a-h	0.429 f-j	1937 b-h
NexGen 3930 B3XF	7.8 a-i	0.414 j-n	1822 c-i
NexGen 3994 B3XF	1.1 hij	0.451 a-d	1990 b-f
NexGen 4936 B3XF	36.1 a	0.406 mn	1924 b-h
NexGen AMX1816 B3XF	8.9 a-f	0.366 o	1394 j
NexGen AMX1818 B3XF	6.3 a-h	0.414 j-n	1616 hij
NexGen AMX1828 B3XF	3.2 f-j	0.423 h-l	1812 b-i
PhytoGen 340 W3FE	5.8 a-h	0.452 abc	1939 b-i
PhytoGen 350 W3FE	8.1 b-i	0.418 i-n	1566 ij
PhytoGen 480 W3FE	8.0 a-h	0.421 i-m	2136 ab
PhytoGen PX3B07 W3FE	7.4 a-g	0.449 bcd	2365 a
PhytoGen PX3C06 W3FE	12.5 abc	0.444 b-f	2031 a-d
PhytoGen PX3D32 W3FE	16.8 a-h	0.415 j-n	1881 b-i
PhytoGen PX3D43 W3FE	4.7 b-i	0.410 lmn	1716 d-i

[z] Target spot was rated using the Florida 1 to 10 leaf spot rating scale on 17 September and converted to % defoliation values.

[y] Means in each column followed by the same letter are not significantly different according Fisher's least significant difference (LSD) test ($P \leq 0.05$).

While temperatures during the study period were near to above normal, monthly rainfall totals for June and August were above the 30-yr average, but below average for May, July, and September 2019. Significant differences in target spot-related defoliation were noted between cotton cultivars and breeding lines with Bayer ST 4550 GLTP suffering greater defoliation than 17 cotton selections, while the numerically lowest defoliation level was recorded for Dyna-Gro 3605 B2XF. Lint turn out also differed significantly among the cultivars and advanced breeding lines. The high turnout value for PhytoGen PX5C05 W3FE was equaled by six other cultivars and breeding lines. PhytoGen PX3B07 W3FE produced greater lint yields than all but six cultivars including the popular Deltapine 1646 B2XF. Overall yields ranged from an impressive 3.6 to 5.2 bales per acre.

Table 4. Target spot defoliation, lint content and yield of cotton cultivars and breeding lines in 2019 Irrigated Full Season Flex OVT trial at PARU.

Cotton Cultivar or Breeding Line	Target Spot % defoliation [z]	Turnout lint content	Lint yield lb./A
Americot NexGen 4936 B3XF	45.3 a-g [y]	0.405 r	2135 e-k
Americot NexGen 5007 B2XF	27.4 f-j	0.433 mno	2087 g-l
Americot NexGen 5711 B3XF	19.4 g-j	0.428 n-q	2126 e-l
BASF Stoneville 4550 GLTP	69.7 a	0.464 c-f	2287 b-g
BASF Stoneville 5471 GLTP	18.3 g-j	0.428 npo	2286 c-g
BASF Stoneville 5600 B2XF	29.0 e-j	0.442 lm	1980 j-l
BASF Stoneville 5707 B2XF	54.9 a-e	0.402 r	1871 kl
BASF Stoneville 5818 GLT	16.6 hij	0.417 qr	2088 g-l
BASF Stoneville 6182 GLT	62.5 ab	0.468 a-d	2167 d-j
BASF BX2076 GLTP	12.0 ij	0.443 klm	2119 e-l
Deltapine 1555 B2RF	36.2 c-j	0.449 jkl	2194 c-j
Deltapine 1646 B2XF	18.3 g-j	0.453 h-k	2334 a-g
Deltapine 1835 B3XF	55.8 abc	0.452 ijk	2160 d-j
Deltapine 1840 B3XF	50.7 a-f	0.431 pqr	2186 c-j
Deltapine 1851 B3XF	43.7 b-h	0.438 mn	1931 jkl
Deltapine 18R445 B3XF	43.5 b-h	0.461 d-g	2316 b-g
Dyna-Gro 3605 B2XF	11.6 j	0.452 ijk	2303 b-g
Dyna-Gro 3615 B3XF	46.2 a-g	0.464 c-f	2566 ab
Dyna-Gro 3753 B3XF	35.8 c-j	0.452 h-k	2000 h-l
PhytoGen 340 W3FE	42.1 b-h	0.469 abc	2290 b-g
PhytoGen 350 W3FE	42.0 b-h	0.427 opq	1854 l
PhytoGen 480 W3FE	40.5 b-i	0.454 g-j	2387 a-e
PhytoGen 580 W3FE	46.1 a-g	0.453 hij	2371 a-f
PhytoGen PX3B07 W3FE	19.1 g-j	0.469 abc	2608 a
PhytoGen PX3C06 W3FE	31.6 d-j	0.456 f-i	2449 abc
PhytoGen PX5D28 W3FE	45.8 a-g	0.477 ab	2427 a-d
PhytoGen PX3D32 W3FE	60.7 abc	0.458 e-h	2244 c-i
PhytoGen PX3D43 W3FE	49.8 a-f	0.450 i-l	2243 c-i
PhytoGen PX5C05 W3FE	60.5 abc	0.474 a	2255 c-i
PhytoGen PX5C45 W3FE	46.3 a-g	0.469 a-d	2268 c-h
PhytoGen PX5E28 W3FE	57.5 a-d	0.421 n-q	2092 f-l
PhytoGen PX5E34 W3FE	55.3 a-e	0.421 pqr	2147 d-k
Winfield United 19XG9B3XF	60.2 abc	0.467 b-e	2191 c-j

[z] Target spot was rated using the Florida 1 to 10 leaf spot rating scale on 17 September and converted to % defoliation values.

[y] Means in each column followed by the same letter are not significantly different according Fisher's least significant difference (LSD) test ($P \leq 0.05$).

Summary

As was noted at both study locations, partial resistance is an effective tool for reducing defoliation levels attributed to target spot in cotton. While the fungicide positive control consistently reduced target spot-incited defoliation, associated yield gains from the fungicide program were limited to one cultivar at the BARU location. A non-significant cultivar × fungicide program for the study at PARU demonstrated that similar yields were recorded across all cotton cultivars. Previously, significant yield gains were linked to a reduction of defoliation on target spot susceptible but not partially resistant cotton cultivars (Hagan et al, 2018). In addition, considerable differences in target spot-incited defoliation were recorded among mid- to late-maturing and to a lesser extent early maturing cotton cultivars and advanced breeding lines in the PARU OVT trials. Overall, Deltapine 1646 B2XF has often suffered among the least defoliation and produced greater lint yields than the majority of cultivars screened at multiple sites across Alabama.

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