EFFICACY OF REGISTERED AND CANDIDATE FUNGICIDES AGAINST TARGET SPOT (CORYNESPORA LEAF SPOT) COMPARED

Austin Hagan
Department of Entomology and Plant Pathology, Auburn University
Auburn, AL
Malcomb Pegues
Jarrod Jones
Gulf Coast Research and Extension Center
Fairhope, AL

Abstract

In 2012, studies were conducted at the Gulf Coast Research and Extension Center in Fairhope, AL on a site cropped the previous two years to cotton to assess the efficacy of registered and candidate fungicides for the control of target spot caused by *Corynespora crassiicola* on cotton. In study 1, the registered fungicides Twinline at 7 and 8.5 fl oz/A, Headline 2.09SC at 6 and 9 fl oz/A, and Quadris 2.08E at 6 and 9 fl oz/A were applied at first bloom and 14-days later to the cotton varieties Phytogen 499 and Deltapine 1050. For study 2, registered fungicides Twinline at 7 and 8.5 fl oz/A, Headline 2.09SC at 6 fl oz/A, and Quadris 2.08E along with the candidate fungicides Headline AMP at 9 fl oz/A, Quilt EXCEL at 14 fl oz/A, Muscle 3.6E at 7.2 fl oz/A, Bravo Weather Stik at 1.5 pt/A, and Stratego YLD at 5 fl oz/A were applied on demand after symptoms first appeared on July 26 (3rd week of bloom) and 14 days later to Phytogen 499. Target spot intensity was rated on September 13 using the Florida 1 to 10 peanut leaf spot rating scale. In study 1, Phytogen 499 suffered heavier leaf spotting and defoliation than Deltapine 1050. While defoliation was reduced with Twinline, Headline 2.09SC and Quadris 2.08E, none provided a high level of protection from target spot on either variety. Also, disease control did not improve at the higher rates of the above fungicides. For study 2, reductions in defoliation levels were obtained with the recommended fungicides Twinline, Headline 2.09SC, and Headline AMP when compared with the non-treated control which suffered 80% defoliation. Least efficacious fungicides were Bravo Weather Stik, Muscle 3.6E (generic tebuconazole), and Stratego YLD.

Introduction

Target spot (Corynespora leaf spot), which is caused by the fungus *Corynespora cassiicola*, has emerged as a significant disease of cotton in the South. While target spot was first seen in 2003 in irrigated cotton in southwest Georgia (Kemeriat *et al*. 2011), this disease has appeared in recent years in dryland and irrigated cotton in Alabama (Campbell *et al.* 2012), Florida (Donahue, 2012), North Carolina (Edmisten, 2012), South Carolina (Hagan, personal communication), and Virginia (Phipps, personal communication). Yield loss in heavily defoliated cotton in Georgia have been estimated at 200+ lb/A of lint cotton (Fulmer *et al.* 2012). In a 2011 study, Hagan *et al*. (2012) noted the highest level of leaf spotting and premature defoliation on Phytogen 499 with less defoliation on Phytogen 375 and Phytogen 565, while Stoneville 5288 and Deltapine 1050, which had among the lowest target spot ratings, suffered some leaf spotting and little if any leaf loss. Kemeriat *et al.* (2011) also reported significant differences in target spot severity among selected Deltapine commercial varieties and experimental lines.

Headline 2.09SC, Quadris 2.08E, and Twinline may be applied preventatively at first bloom or on-demand when target spot first appears followed by a second application14 to 21 days later (Hagan, 2012). As specified by FRAC guidelines for strobilurin fungicides, no more than two consecutive applications of any combination of the above fungicides may be scheduled, so the total number of fungicide applications that can be made per year is two (2). Kemeriat *et al.* (2011) noted that Headline 2.09SC significantly reduced defoliation and sometimes increased yield. Quadris 2.08E and Headline provided excellent control of target spot on tomato (Pernezny *et al.* 2002, Schlub *et al.* 2009). Unfortunately, catastrophic declines in the efficacy of these strobilurin, and the newly released carboxamide (SDHI) fungicides boscalid and penthiopyrad, against *C. cassiicola*-incited diseases on cucumber (Miyamoto et al., 2009) and tomato (Adkison *et al.* 2012) have recently been reported. As a result, the specter of strobilurin resistance may limit the long-term viability of the above fungicides for the control of target spot in cotton. The broad spectrum fungicide chlorothalonil, which has proven effective in controlling target spot on tomato (Pernezny *et al.* 2002), is not registered on cotton.

The objective of this study was to assess the efficacy of a preventative fungicidal program with two rates of Headline 2.09SC, Quadris 2.08E, and Twinline fungicides as well as an on demand program with registered and candidate fungicides for the control of target spot and potential seed cotton yield gains.

Material and Methods

For both the preventative and on-demand fungicide studies, a wheat cover crop, which was drilled at a rate of 2.5 bu seed/A, was killed with 22 fl oz/A of Roundup Weather Max. On March 19, 200 lb/A of 10-21-21 fertilizer with 10 lb/A sulfur, 3 lb/A zinc was broadcast. A layby application of 23 gal/a 28-0-0-5S (70-0-0) liquid fertilizer was made on June 18. Cotton was hill dropped behind a KMC strip till unit at a rate of 3 seed/1.1 row ft in a Malbis fine sandy loam (OM <1%) at the Gulf Coast Research and Extension Center in Fairhope, AL. While Phytogen 499 WRF and Deltapine 1050 B2RF were used for the preventative study, only the former variety was sown for the on-demand fungicide study. Thrips control was provided by an at-plant application of 5 lb/A Temik 15G, while seed in the hopper was treated with Prevail for seed rot and seedling disease control. Weed control was obtained with a pre-plant application of 2 pt/A Prowl H_2O followed by 2 pt/A Cotoran at-planting. An application of the plant growth regulator Mepichlor at 6 fl oz/A + Induce at 1 pt/50 gal on June 18 was followed by three additional applications of 8 fl oz Mepichlor + 1 pt/50 gal Induce + 4 fl oz Bidrin + 1 gal/A of 5-0-20 liquid fertilizer on July 5, July 16, and July 30. Cotton was prepared for harvest with an application of Diuron at 1 oz/A + Dropp 50W at 2 oz/A + Ethephon at 21 fl oz /A on September 22 and September 27. Plots were mechanically harvested on October 11. Plots consisted of four 30–ft rows spaced 3.2 ft apart arranged in a randomized complete block with four replications. Yields are reported as lb/A seed cotton. Fungicides were applied with a Spider sprayer with 11002 tips mounted on a four row boom in 15 gal/A of spray volume at 40 psi. For the on-demand study, the first applications were made on July 26 after symptoms were first noted in the canopy and again on August 7 as compared with the preventative study where application was scheduled on July 5 at first bloom and on July 23.

Target spot was rated in both studies on September 13 using a leaf spot rating scale 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). For the preventative study, significance of interactions was done using the PROC MIXED procedure in SAS. Statistical analysis on non-normal data was done on rank transformations, which were then back transformed for presentation. Means were separated using Fisher's protected least significant difference (LSD) test (P<0.05).

Results

At the Gulf Coast Research and Extension Center in 2012, rainfall totals for the months of May, June, July, and August exceeded the 30 year average but was below average in September.

On-Demand Recommended and Candidate Fungicide Comparison

Significant differences in target spot intensity were noted among the fungicide treatments, which were first applied when leaf spotting was observed. While the least leaf spotting and premature defoliation attributed to target spot was noted with the Headline 2.09SC and 8.5 fl oz rate of Twinline, similarly low disease ratings were also recorded for 7 fl oz /A rate of Twinline, Headline AMP, and Quilt XCEL. When compared with the non-treated control, target spot intensity was equally high on the Stratego YLD, Bravo WeatherStik and Muscle-treated cotton. Yields for all fungicide treatments and the non-treated control did not significantly differ. Higher yields were noted for the Headline AMP- than Stratego YLD-treated cotton.

Table 1. Yield and target spot intensity on Phytogen 499 cotton as influence by registered and candidate fungicides applied on-demand.

Fungicide and rate/A	Target spot intensity[z]	Seed cotton yield (lb/A)[y]
Twinline 7 fl oz.	6.0 de[x]	3383 ab
Twinline 8.5 fl oz	5.9 e	3302 ab
Headline 2.09SC 6 fl oz	5.9 e	3336 ab
Headline AMP 9 fl oz	6.1 de	3428 a
Quadris 2.08E 6 fl oz	6.5 bcd	3279 ab
Quilt EXCL 14 fl oz	6.3 cde	3222 ab
Muscle 3.6F 7.2 fl oz	6.9 abc	3199 ab
Bravo Weather Stik 6F 1.5 pt	7.4 a	3096 ab
Stratego YLD 5 fl oz	7.1 ab	3015 b
Non-treated control	7.3 a	3142 ab

[z]Target spot intensity was assessed on September 13 using a 1 to 10 leaf spot scoring system.
[y]Seed cotton yield = total weight of seed + lint.
[x]Means in each column followed by the same letter are not significantly different according to Fisher's protected least significant difference (LSD) test ($P \leq 0.05$).
[w]Disease intensity data in columns are calculated means, but letters differentiating means were calculated using rank transformations.

Recommended Fungicides compared on Preventative Schedule

Initial applications of Headline 2.09SC at 6 and 9 fl oz/A, Quadris 2.08E at 6 and 9 fl oz/A, and Twinline at 7.5 and 9 fl oz/A were made at first bloom before target spot symptoms were noted. Since the cotton variety x fungicide interaction was not significant, data presented for each variable were pooled by variety and fungicide treatment. While the target spot intensity was higher on Phytogen 499 than Deltapine 1050, seed cotton yield was similar. All fungicide treatments were equally effective in reducing the level of leaf spotting and premature defoliation attributed to target spot when compared to the non-treated control. With the exception of Headline 2.09SC at 9 fl oz/A, yields for the remaining fungicide treatments and the non-treated control did not significantly differ. Yields were also higher for Headline 2.09SC at 9 fl oz/A as compared with both rates of Twinline and Quadris 2.08E at 6 fl oz/A. Target spot control and yield response to Headline 2.09SC, Quadris 2.08E, and Twinline was not impacted by application rate.

Table 2. Yield and target spot intensity as influenced by cotton variety and recommended fungicides applied on a preventative treatment schedule.

Split plot analysis (F value)	Target spot intensity[z]	Seed cotton yield lb/A[y]
Cotton variety	300.06***[x]	1.13
Fungicide	8.59***	2.32*
Cotton variety x fungicide	1.20	1.27
Cotton variety means		
Deltapine 1050	5.1 b[wv]	3321 a
Phytogen 499	6.7 a	3238 a
Fungicide means		
Twinline 7.0 fl oz	5.7 b	3256 b
Twinline 8.5 fl oz	5.7 b	3216 b
Headline 2.09 SC 6 fl oz	5.7 b	3400 ab
Headline 2.09SC 9 fl oz	5.7 b	3474 a
Quadris 2.08E 6 fl oz	5.8 b	3205 b
Quadris 2.08E 9 fl oz	5.8 b	3377 ab
Non-treated control	6.5 a	3156 b

[z]Target spot intensity was rated using a 1 to 10 leaf spot scoring system on September 13.
[y]Seed cotton yield = total weight of seed + lint.
[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 ($P \leq 0.05$).
[v]Disease intensity data in columns are calculated means, but letters differentiating means were calculated using rank transformations.

Discussion

With defoliation level ranging from just below 50% to above 60% as indicated by disease ratings of 5.7 to 6.5, respectively, none of the registered fungicides in the on-demand and preventative trials gave highly effective target spot control on cotton. However, significant reductions in target spot intensity were obtained with preventative or on-demand treatments of Headline 2.09SC, Quadris 2.08E, and Twinline when compared with the non-treated control. In the on-demand study, Headline 2.09E and 8.5 fl oz/A rate of Twinline gave better target spot control than 6 fl oz/A rate of Quadris 2.08E, while both rate of the above fungicides gave the same level of disease control when applied on preventative schedule. Previously, Kemeriat *et al*. 2011 obtained better target spot control with a single Headline 2.09SC application in a Thomas Co., GA study than were obtained here in either with the on-demand or preventative trials. Application rate did not greatly impact target spot control with Headline 2.09SC, Quadris 2.08E, or Twinline.

Among the candidate fungicides, only Quilt EXCL and Headline AMP gave the same level of target spot control as Headline 2.09SC and the 8.5 fl oz/A rate of Twinline. Bravo Weather Stik 6F, which is among the fungicide standards for target spot control on tomato (Schlub *et al.* 2009) but does not have a cotton label, proved surprisingly ineffective against this disease. This result is unfortunate because a broad spectrum fungicide partner is needed to minimize the risk of resistance-related control failures with the strobilurin fungicides now used on cotton. The systemic acquired resistance activator Actigard 50W, which greatly reduced target spot-induced defoliation on tomato (Pernezny *et al*. 2002), should be evaluated for target spot control on cotton.

As previously noted by Kemeriat *et al.* (2011), significant reductions in target spot intensity did not necessarily translate into higher yields. In the on-demand trial, yields for the non-treated control were similar to those recorded for the registered and candidate fungicides, while the cotton treated twice with 9 fl oz/A Headline 2.09SC yielded higher than the non-treated control in the preventative schedule trial.

Overall, those fungicides that were screened failed to provide a high level of target spot control and did not consistently increase yield of cotton. Relatively poor fungicide performance could be traced in part to the

susceptibility of Phytogen 499, the difficulty in obtaining thorough leaf coverage throughout a dense cotton canopy, an insufficient numbers of fungicide applications to provide effective disease control through boll maturation, or less likely, tolerance or resistance to strobilurin fungicides in established *C. cassiicola* populations. Additional studies need to focus on identifying more efficacious fungicides, early onset or lengthened treatment regimes, and sprayer modifications to improve canopy coverage.

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