IMPACT OF APPLICATION TIMING OF FUNGICIDES ON THE MANAGEMENT OF TARGET SPOT

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Abstract

Target spot, caused by the fungus *Corynespora cassiicola* (Berk. & M.A. Curtis) C.T. Wei, is a foliar disease of cotton of recent concern to growers across the southeastern United States. Previous research has documented the reduction in disease development and yield increases in response to fungicide applications. Field trials were conducted in 2012 at multiple locations in southwest Georgia and Virginia in order to determine appropriate fungicide timings for best disease suppression and optimal yields. Labeled fungicides included in this study were Twinline and Headline applied at different timings throughout the growing season. Results from these studies confirmed that disease suppression and yield increases are obtained with single or multiple applications of fungicide. Small plot trials in Georgia demonstrated that two applications of Twinline or Headline made during the first week of bloom and the third week of bloom provided the most consistent suppression of disease intensity. For fungicide applications at the first and third week of bloom yields were consistently numerically better with Headline than Twinline.

Introduction

Corynespora cassiicola (Berk. & M.A. Curtis) C.T. Wei is the causal agent of numerous target spot diseases throughout the world, and has the potential of causing significant yield losses in susceptible crops. This fungus has been reported to grow on more than 530 plant species from 380 different genera (Dixon, et. al, 2009). Notable diseases caused by *C. cassiicola* include brown spot of papaya (*Carica papaya*) and leaf fall disease of rubber (*Hevea brasiliensis*); however, in the Southeastern U.S., target spot of soybean (*Glycine max)*, cucumber (*Cucumis sativis*) and tomato (*Solanum lycopersicum*) have been the main crops of concern. (Vawdrey, et. al, 2008; Fernando, et. al, 2010; Vallad, et. al, 2011)

A leaf spot of cotton (*Gossypium hirsutum* L.) caused by *C. cassiicola* was first described in Mississippi by J.P. Jones in 1961. (Jones, 1961) Since the first discovery of this disease, target spot has not been perceived as an issue to cotton growers in the southeastern United States. However, in 2005, consultants and growers across southwestern Georgia began reporting the regular occurrence of a new leaf spot that differed from the common foliar diseases. Initial symptoms begin as brick-red spotting which then lead to the formation of irregular to circular shaped lesions with tan to light brown centers. As the disease progresses, lesions will become larger and reveal a target-like appearance that forms from concentric rings within the spot. Estimates of premature defoliation were reported as high as 70% and significant yield losses have been observed in Georgia. Koch's postulates were performed in 2011, and the pathogenicity of *C. cassiicola* on cotton was confirmed (Fulmer, et. al, 2012). In addition, target spot of

cotton was reported in Alabama, Georgia, Florida, North Carolina, South Carolina, and Virginia during the 2012 growing season (Kemerait, 2012).

Fungicides have been used to effectively suppress the epidemics caused by *C. cassiicola* in crops such as cucumber, papaya and tomato (Vawdrey, et. al, 2008; Vallad, et. al, 2011). Preliminary studies in Georgia have demonstrated that labeled fungicides reduced disease severity and have the potential to increase yield. The main objective of this study was to compare fungicide applications made at various growth stages throughout the season to determine the best application timing for disease management.

Materials and Methods

Locations

Three locations for small plot trials were selected within southwestern Georgia where the potential of target spot occurrence was known to be problematic. The first site was at Stripling Irrigation Research Park in Camilla, Georgia. The field at this location was planted in cotton the previous year in which heavy disease pressure was observed. The second location was in Attapulgus, Georgia where the previous crop was peanut. The final site was at the RDC Pivot located in Tifton, Georgia, which followed a soybean crop from the previous year. Data was also collected from separate field trials conducted outside the University of Georgia system. These included a large on-farm trial conducted by R. J. Byrne in Mitchel county Georgia, and a small plot trial conducted by Dr. Pat Phipps at the Tidewater Agricultural Research and Extension Center in Suffolk, Virginia.

Experimental Design and Treatments

Experiments in the three small plot trials in Georgia were designed in a randomized complete block containing 12 - 14 treatments and 4 replications. Plots were 25 feet in length and four rows wide (center two rows were treated and harvested). Fungicides in these trials included Headline (6 fl. oz. / A, pyraclastrobin) and Twinline (8.5 fl. Oz. / A, pyraclastrobin + metcanazole), and ranged from a single application to a total of seven applications. Applications were triggered based upon vegetative and reproductive growth stages, and included first square (FS), 14 days post first square (FS14), 1st week of bloom (B1), 3rd week of bloom (B3), 5th week of bloom (B5), and 7th week of bloom (B7). At the Stripling and Attapulgus sites, there were 14 treatments that consisted of single or combined timings of Twinline applied at FS, B1, B3, B5, FS + FS14, B1 + B3, B3 +B 5, B5 + B7, or seven applications sprayed every 14 days starting at FS. Similarly, Headline was also applied at B1, B5, B1 + B3, or B5 + B7. There were 12 treatments at RDC Pivot that consisted of single or combined timings of Twinline applied at FS, B1, B3, B5, FS + FS14, B1 + B3, B3 + B5, B5 + B7, and seven applications sprayed every 14 days starting at FS. Headline was also applied at this location at B1 and B1 + B3. Fungicides were applied using a self-propelled Lee Spider research sprayer with a 6 ft. boom equipped with four 8002 Teejet flat-fan nozzles spaced 18 in. apart. At Stripling and RDC Pivot, plots were sprayed at a pressure of 42 psi was used to achieve a volume of 20 gal / A. Attapulgus was sprayed at a pressure of 40 psi to achieve a volume of 15 gal / A.

The on farm trial in Mitchell County was arranged in a split plot design with nine different cotton varieties (See Table 4). Each variety was replicated in the field four times and the rows were approximately 1,000 feet in length. A single application of Twinline (8.5 fl. oz. / A) was made during the sixth week of bloom to half of the cotton within each variety. The small plot trial in Virginia was designed in a randomized complete block. Similar to the small plot trials in Georgia, this trial was treated with both Headline and Twinline throughout the season; however, Headline AMP (pyraclastrobin + metconazole) and Priaxor (pyraclastrobin + fluxapyroxad) were also added and applied later in the season. The treatments at this location included: Headline B3, Twinline B3, Twinline B1 + B3 + B5, Headline AMP B3, Priaxor B3, Priaxor B4 + Headline AMP B6 or Priaxor B4 + Headline B6.

Disease Assessment

In the small plot trials in Georgia, disease severity ratings were taken based on a scale from 1 to 6 in which a rating of 1 = few lesions on lower canopy, 2 = many lesions on lower canopy, 3 = few lesions on mid-canopy, 4 = many lesions on mid-canopy, 5 = few lesions on upper canopy, and 6 = many lesions on upper canopy. Severity ratings were conducted from mid to late season and included at least one assessment per location. In all locations, a visual defoliation assessment was conducted on each plot. Defoliation ratings were based on a scale from 0 to 100% with 0 = no defoliation and 100 = completely defoliated. Yield data was also recorded at the end of the season for each location. Plots were harvested and weight individually, then combined and averaged by treatment. Severity and yield data were analyzed for each location using ARM (Gylling Data Management, Inc.). Analysis of variance

(ANOVA) was used to determine significant differences in the treatments, and Fisher's protected least significant different (LSD) was used for mean separations where $\alpha = 0.05$ or 0.10.

Results

Stripling Irrigation Research Park

Target spot was confirmed on June 20th, which was two weeks before first bloom. On August 1st, near the fourth week of bloom, disease severity was significantly lower in all treatments when an application was made during B3. Twinline applied every 14 days and at B1 were also significantly lower than the untreated check (Table 1). On the same rating date, defoliation was significantly lower in all plots that had been treated with the exception of Twinline applied at B3. On August 16th, all treatments applied at B3 and the treatment sprayed every 14 days showed significant decreases in defoliation. At the final defoliation rating on September 10th, the B3 and B7 applications were significantly lower than the untreated check. Yields across treatments were not statistically higher than the untreated check. Although not statistically significant at this location, a numeric yield increase of 200 lb. of lint was obtained with two applications of Headline at B1 and B3. Yields in this study could have been compromised by damage to plots during crop maintenance.

Table 1. Target spot severity, defoliation, and yield for treatments in the fungicide application timing experiment at Stripling Irrigation Research Park in 2012

		Severity[A]		Defoliation[B]		Yield
Treatment, Rate/A	Application Timing	8/01/2012	8/01/2012	8/16/2012	9/10/2012	Lb. /Acre
Twinline (8.5 oz.)	First Square	5.0 abc	20.5 b-e	38.8 a-e	62.5 a	1093.80 a
Twinline (8.5 oz.)	First Square + 14D	5.0 abc	12.5 c-f	40.0 a-d	55.0 ab	1018.91 a
Twinline (8.5 oz.)	First Square + Every 14 Days	4.5 bcd	9.0 def	33.8 cde	33.8 a-f	1007.46 a
Twinline (8.5 oz.)	1st Week of Bloom	4.5 bcd	8.0 def	42.5 a-d	45.0 a-e	978.84 a
Headline (6 oz.)	1st Week of Bloom	5.5 ab	17.5 b-f	46.3 a-d	48.8 a-d	984.57 a
Twinline (8.5 oz.)	1st Week of Bloom 3rd Week of Bloom	3.0 ef	4.3 ef	15.0 ef	15.0 ef	933.05 a
Headline (6 oz.)	1st Week of Bloom 3rd Week of Bloom	3.0 ef	1.8 f	8.8 f	22.5 c-f	1190.64 a
Twinline (8.5 oz.)	3rd Week of Bloom	4.0 cde	21.3 a-d	33.8 cde	25.0 b-f	1064.71 a
Twinline (8.5 oz.)	3rd Week of Bloom 5th Week of Bloom	3.8 def	11.0 c-f	22.5 def	7.5 f	976.93 a
Twinline (8.5 oz.)	5th Week of Bloom	5.0 abc	20.0 b-e	47.5 abc	50.0 abc	1092.64 a
Headline (6 oz.)	5th Week of Bloom	5.5 ab	33.8 ab	58.8 ab	37.5 a-f	815.70 a
Twinline (8.5 oz.)	5th Week of Bloom 7th Week of Bloom	5.0 abc	26.3 abc	38.8 a-e	23.8 c-f	870.08 a
Headline (6 oz.)	5th Week of Bloom 7th Week of Bloom	5.8 a	37.5 a	56.3 abc	18.8 def	930.53 a
Untreated		5.8 a	30.0 ab	52.5 abc	47.5 a-d	984.57 a
LSD (P<0.05)		1.15	16.9	23.9	30.7	312.63

[A] Severity was based on a 1 to 6 scale where 1 = few lesions on lower canopy and 6 = many lesions on upper canopy
[B] Defoliation was based on a scale from 0 to 100% with 0 = no defoliation and 100 = completely defoliated

Attapulgus, Georgia

Target spot was confirmed on August 24th which corresponds with the fourth week of bloom. Stemphyllium leaf spot was also present in the field. The severity of target spot was likely lower in this trial due to the open canopy and abundant air flow within the field. On all three rating dates, defoliation within the field was not statistically lower in any treatment when compared to the untreated check (Table 2). Yields across treatments were not statistically higher than the untreated check. Although not statistically significant at this location, a numeric yield increase was experienced in 11 out of 13 treated plots when compared to the untreated check.

Table 2. Defoliation primarily due to target spot and yield for treatments in the fungicide application timing experiment in Attapulgus, Georgia in 2012

		Defoliation[A]			Yield
Treatment, Rate/A	Application Timing	8/29/2012	9/11/2012	9/24/2012	Lb. /Acre
Twinline (8.5 oz.)	First Square	20.3 a	25.8 a-d	24.5 a	1281.92 a
Twinline (8.5 oz.)	First Square + 14D	13.5 a	28.3 abc	30.8 a	1174.76 a
Twinline (8.5 oz.)	First Square + Every 14 Days	9.0 a	5.8 e	9.2 a	1301.77 a
Twinline (8.5 oz.)	1st Week of Bloom	5.7 a	9.5 de	17.5 a	1226.36 a
Headline (6 oz.)	1st Week of Bloom	12.5 a	17.8 a-e	14.8 a	1287.88 a
Twinline (8.5 oz.)	1st Week of Bloom 3rd Week of Bloom	8.2 a	11.2 cde	12.0 a	1139.05 a
Headline (6 oz.)	1st Week of Bloom 3rd Week of Bloom	13.7 a	11.7 b-e	9.2 a	1373.20 a
Twinline (8.5 oz.)	3rd Week of Bloom	16.8 a	14.2 b-e	17.8 a	1285.89 a
Twinline (8.5 oz.)	3rd Week of Bloom 5th Week of Bloom	10.3 a	13.2 b-e	11.5 a	1210.89 a
Twinline (8.5 oz.)	5th Week of Bloom	19.2 a	17.5 a-e	10.3 a	1329.55 a
Headline (6 oz.)	5th Week of Bloom	28.7 a	28.3 abc	17.0 a	1289.86 a
Twinline (8.5 oz.)	5th Week of Bloom 7th Week of Bloom	25.0 a	33.3 a	16.7 a	1325.58 a
Headline (6 oz.)	5th Week of Bloom 7th Week of Bloom	23.2 a	15.3 a-e	20.8 a	1236.28 a
Untreated		11.3 a	13.2 b-e	16.7 a	1180.72 a
LSD (P<0.05)		16.2	18.7	16.6	255.54

[A] Defoliation was based on a scale from 0 to 100% with 0 = no defoliation and 100 = completely defoliated

RDC Pivot

Target spot was confirmed on September 5th, which corresponds with the eighth week of bloom. Stemphyllium leaf spot was also present at this location. On September 18th, disease severity was significantly lower in the treatment sprayed every 14 days as well as the treatment that was sprayed twice with Twinline at B5 and B7 (Table 3). On the same rating date, defoliation was significantly lower in all plots sprayed with Twinline every 14 days, B1 + B3, B3, B5, and B5 + B7. Yields across treatments were not statistically higher than the untreated check. Although not statistically significant at this location, a numeric yield increase was experienced in 8 out of 11 treated plots when compared to the untreated check.

Table 3. Severity and defoliation primarily due to target spot and yield for treatments in the fungicide application timing experiment at the RDC Pivot in 2012

		Severity[A]	Defoliation[B]	Yield
Treatment, Rate/A	Application Timing	9/18/2012	9/18/2012	Lb. /Acre
Twinline (8.5 oz.)	First Square	5.3 a	45.0 a	993.94 a
Twinline (8.5 oz.)	First Square + 14D	4.8 ab	28.8 a-d	903.15 a
Twinline (8.5 oz.)	First Square + Every 14 Days	4.0 bc	8.3 de	1113.00 a
Twinline (8.5 oz.)	1st Week of Bloom	5.3 a	32.5 abc	901.66 a
Headline (6 oz.)	1st Week of Bloom	5.0 a	27.5 a-e	1040.32 a
Twinline (8.5 oz.)	1st Week of Bloom 3rd Week of Bloom	4.5 abc	19.3 b-e	1045.53 a
Headline (6 oz.)	1st Week of Bloom 3rd Week of Bloom	4.7 ab	27.8 a-e	1100.84 a
Twinline (8.5 oz.)	3rd Week of Bloom	4.8 ab	10.5 cde	969.13 a
Twinline (8.5 oz.)	3rd Week of Bloom 5th Week of Bloom	5.0 a	33.0 abc	1017.99 a
Twinline (8.5 oz.)	5th Week of Bloom	5.0 a	16.8 cde	944.33 a
Twinline (8.5 oz.)	5th Week of Bloom 7th Week of Bloom	3.8 c	5.0 e	1049.75 a
Untreated		5.0 a	41.3 ab	953.26 a
LSD (P<0.10)		0.77	22.9	187.60

[A] Severity was based on a 1 to 6 scale where 1 = few lesions on lower canopy and 6 = many lesions on upper canopy

[B] Defoliation was based on a scale from 0 to 100% with 0 = no defoliation and 100 = completely defoliated

On Farm Trial Mitchell County, Georgia

The data from this trial demonstrates how different cotton varieties are affected by target spot and the response of these varieties to a single application of fungicide late in the season (Table 4). Yield data at the end of the season showed a numeric yield increase in six of the nine tested varieties. PHY 367, FM 1944 and PHY 375 provided significant yield increases of 137 lb. /A, 222 lb. /A and 171 lb. /A, respectively.

Table 4. Target spot yield data from on farm variety trial in Mitchell County, Georgia in 2012

Variety	Treatment	Yield Lb. /Acre
DPL 1050	Treated	1378.33 b-e
	Untreated	1433.80 b-e
DPL 1137	Treated	1544.86 a
	Untreated	1549.84 a
FM 1740	Treated	1344.72 cde
	Untreated	1273.58 efg
PHY 367	Treated	1154.71 ij
	Untreated	1017.47 k
FM 1944	Treated	1390.70 b-e
	Untreated	1168.83 hij
PHY 375	Treated	1289.32 d-g
	Untreated	1118.61 jk
ST 5458	Treated	1246.86 f-i
	Untreated	1271.10 e-h
PHY 499	Treated	1287.68 d-g
	Untreated	1199.43 g-j
DPL 1252	Treated	1454.53 ab
	Untreated	1404.04 bc

Tidewater AREC

Initial outbreaks of Target spot was confirmed on August 27 at this location which corresponded to the sixth week of bloom. Two defoliation ratings as well as yield ratings were taken near the end of the season (Table 5). Ratings taken on the 12th of September showed significant decreases in defoliation across all treatments, except Headline B3. Ratings on the 12th of October showed similar results across treated plots, except Twinline B3, which showed a significant decrease in defoliation. All treated plots showed a numerical increase in yield compared to the untreated check; however, only one treatment, Priaxor B4 + Headline B6, showed a significant increase.

Table 5. Target spot defoliation and yield for treatments in the fungicide application timing experiment at the Tidewater AREC in 2012

Treatment, Rate/A	Application Timing	Defoliation		Yield
		9/12/2012	10/12/2012	Lb. /Acre
Headline (6 oz.)	3rd Week of Bloom	16.0 ab	45.0 c	2050 b
Twinline (8.5 oz.)	3rd Week of Bloom	13.6 bc	52.0 ab	2050 b
Twinline (8.5 oz.)	1st Week of Bloom 3rd Week of Bloom 5th Week of Bloom	9.6 cd	38.0 d	2115 ab
Headline AMP (10 oz.)	3rd Week of Bloom	14.0 bc	47.0 bc	2140 ab
Priaxor (4 oz.)	3rd Week of Bloom	8.2 cd	47.0 bc	2140 ab
Priaxor (4 oz.) Headline AMP (10 oz.)	4th Week of Bloom 6th Week of Bloom	6.0 d	41.0 cd	2115 ab
Priaxor (4 oz.) Headline (6 oz.)	4th Week of Bloom 6th Week of Bloom	11.0 b-d	46.0 bc	2225 a
Untreated		21.0 a	54.0 a	2025 b

Conclusion

In this study where target spot was the major disease, judicious applications of fungicides resulted in reduced disease severity. The optimal timing of fungicide applications appeared to be the first week of bloom or the first and third week of bloom. However, applications made as late as the sixth of week of bloom in the large plot trial in Mitchell County showed significant decreases in disease severity as well as increased yields among some varieties. Yields from small plot studies conducted in 2012 were not statistically different from the untreated control. However, there was a strong trend for numeric yield increase across fungicide treatments versus the untreated control. The largest yield increases tended to be when fungicides were applied at the first and third week of bloom, and plots treated with Headline tended to out-yield plots treated with Twinline. Based upon results from Georgia and Virginia, it is evident that target spot of cotton can be controlled with fungicides and the potential for protected yield is approximately 200 pounds of lint per acre. These studies will continue in 2013 to refine recommendations for fungicide application timings and to better determine the impact of these applications on yield.

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