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AGRONOMY AND SOILS

Evaluation of Foliar Applications of Strobilurin Fungicides in Cotton across the Southern United States

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ABSTRACT

With the registration of pyraclostrobin (Headline) and azoxystrobin (Quadris) in the United States for protection of cotton (*Gossypium hirsutum*) foliage and bolls against fungal diseases, there has been increased interest in efficacy of the fungicides on mid- to late-season diseases and whether there are non-fungicidal plant health benefits. A total of 15 field trials were conducted throughout cotton growing regions of the United States between the 2008 and 2010 growing seasons. Applications of azoxystrobin and pyraclostrobin were made at the following rates and timings: 0.22 kg ai ha^{-1} at first bloom (FB); 0.11 kg ai ha^{-1} at FB with a sequential application being made 14-21 days later; and 0.11 kg ai ha^{-1} at FB with a second application (0.22 kg ai ha^{-1}) 14-21 days later. Cotton height, total nodes, lint yield, and fiber quality parameters were used to compare treatments, which included a non-treated control. There were no significant treatment differences with respect to most parameters, including yield. Overall, disease pressure was low, but foliar symptoms, caused by *Alternaria macrospora* (3 tests in Jackson, TN), and *Stemphylium solani* + *Cercospora gossypina* (1 site in Statesboro, GA), were observed, as well as hardlock and boll rot in selected trials in Mississippi and Tennessee. It is concluded that application of fungicides in cotton should be based on disease risk and the potential of environmental conditions conducive for foliar disease development during the growing season.

Recently, foliar applications of strobilurin fungicides have been promoted for use in many crops (see Wise and Mueller, 2011). In 2008, the United States Environmental Protection Agency (EPA) granted BASF Corp. a supplemental label registration for the fungicide Headline (pyraclostrobin) for plant disease management and plant health in registered crops, including cotton (Anonymous, 2008). Subsequently, Syngenta Crop Protection renewed the label for the fungicide Quadris (azoxystrobin) at which time they included use in cotton for a number of foliar diseases. Several factors are responsible for increased fungicide usage with the most obvious being purported potential cotton yield increases in the absence of yield-limiting foliar disease, a situation more often referred to as "plant health". Given the proliferation of purported cotton yield increases following foliar fungicide applications throughout the grower community, many questions have arisen regarding the utility of foliar fungicides in cotton production systems.

Strobilurin fungicides, or the quinone outside inhibitors (QoI), are believed to affect a number of physiological properties in plants, particularly in the absence of foliar disease. Nason et al. (2007) reported that azoxystrobin decreased stomatal conductance, which led to an increase in water use efficiency in wheat (*Triticum aestivum*). Strobilurin fungicides have been reported to block the production of ethylene

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by inhibiting the synthesis of 1-aminocyclopropane-1-carboxylic acid synthase (Grossman and Retzlaff, 1997). Furthermore, because ethylene is a phytohormone involved in leaf senescence, decreasing ethylene production may result in a delay in senescence. Studies have been published reporting a delay in the maturity of both dicotyledonous and monocotyledonous plants resulting from a fungicide-induced "greening effect", whereby plants remain greener for an extended period of time (Bryson et al., 2000; Fernández-Ortuño et al., 2008; Kyveryga et al., 2013). Wu and von Tiedemann (2002) reported that strobilurin fungicides increased concentrations of nitrate reductase in wheat, an enzyme that reduces nitrate to ammonia (Beevers and Hageman, 1969). Similar effects were observed in spinach (*Spinacia oleracea*) where nitrate reductase activity increased in response to application of strobilurin fungicides (Glaab and Kaiser, 1999). In addition, some researchers have reported that strobilurin fungicides increase grain yield in the absence of disease (Bartlett et al., 2002; Grossman and Retzlaff, 1997); however, the majority of studies evaluating the "plant health" aspects of strobilurin fungicides in the absence of disease have been in cereals or soybean (*Glycine max*).

Fungicides are used extensively in cotton production as seed treatments to reduce the severity of seedling disease and optimize stand establishment (Rothrock et al., 2012); however, information on the efficacy of topical applications of strobilurins is limited. While several fungal pathogens including *Alternaria macrospora*, *Cercospora gossypina*, *Corynespora cassiicola*, *Puccinia cacabata*, and *Stemphylium solani* are capable of causing foliar diseases in cotton (Hillocks, 1992), topical applications of fungicides are seldom warranted for their management. In previous studies, fungicide applications made during the bloom period in conjunction with insecticides were useful in the management of Fusarium hardlock, caused by *Fusarium verticillioides* (Leite et al., 2007). In other studies on hardlock bolls, fungicide use did not increase yields (Padgett et al., 2007; Woodward et al., 2009). The objective of this research was to evaluate the response of cotton to strobilurin fungicides at various rates and different application timings across the Cotton Belt.

MATERIALS AND METHODS

Experiments were conducted at 15 locations in seven states from 2008 to 2010 (Table 1) to evaluate the effect of the strobilurin fungicides azoxystrobin (Quadris, Syngenta Crop Protection, Greensboro, NC) and pyraclostrobin (Headline, BASF Corporation, Research Triangle Park, NC) on cotton growth, development, lint yield, and fiber quality. Applications of azoxystrobin or pyraclostrobin were made at the following rates and timings: 0.22 kg a.i. ha^{-1} at early bloom; 0.11 kg a.i. ha^{-1} early bloom followed by 0.11 kg a.i. ha^{-1} two to three weeks later, and 0.11 kg a.i. ha^{-1} at early bloom followed by 0.22 kg a.i. ha^{-1} two to three weeks later. A non-treated control was included for comparison purposes in all trials. All agronomic and pest management practices other than fungicide applications were conducted according to each respective state's Extension recommendations.

Plots consisted of four 76-102 cm rows that were 14 to 19 m in length depending on location (Table 2). Experiments were conducted using a randomized complete block with four replications. Fungicides were applied with either a CO_2-pressurized backpack sprayer or a tractor-mounted compressed air sprayer calibrated to deliver 94 to 140 L ha^{-1}. Cotton height, total nodes, and nodes above white flower (NAWF) were determined prior to, two weeks after, and four weeks after each fungicide application. Plots were monitored for foliar disease during the growing season and percent hard lock and boll rot were determined approximately 2 weeks prior to harvest. Plots were harvested with a picker or stripper modified for small plot research. Seed cotton samples were collected from each plot and were ginned using a 10-saw laboratory gin to determine lint percentage. Lint yields were determined by multiplying seed cotton weights by lint turnouts. Sub-samples of lint were subjected to high volume instrumentation (HVI) for fiber quality analysis (Sasser, 1981).

Data were subjected to analysis of variance using the PROC MIXED procedure in SAS (SAS, 2011). Each year-location combination was considered an environment. Replications were considered a random effect. No fungicide treatment by environment interactions were observed; therefore, data were pooled across environments. Pooling across environments permits inferences about the treatments to be made over a range of environments (Carmer et al., 1989). A similar statistical approach utilizing a randomized complete block design has been used by several researchers (Jenkins et al., 1990) as well as those utilizing a factorial arrangement of treatments in a randomized complete block design (Bond et al., 2008). Treatment means were separated using Fisher's Protected LSD test at the 0.05 significance level.

Table 1. Agronomic information for evaluation of foliar fungicides on cotton growth, development, and yield

Location	Year	Cultivar	Planting date	Seeding rate[z]	Harvest date	Date of 1st application[y]	Date of 2nd application[x]	Foliar disease	Causal agent
Altus, OK	2010	FM 9170 B2F	12 May	128,000	19 November	20 July	03 August	No	--
Jackson, TN	2008	FM 1740 B2F	04 May	135,000	05 October	10 July	26 July	Yes	*Alternaria macrospora*
Jackson, TN	2009	FM 1740 B2F	05 May	135,000	14 October	08 July	28 July	Yes	Alternaria macrospora
Jackson, TN	2010	PHY 375 WRF	01 May	135,000	28 September	06 July	24 July	Yes	*Alternaria macrospora*
Lamesa, TX	2008	AM 1532 B2RF	02 May	128,000	01 November	07 July	21 July	No	--
Lamesa, TX	2009	ST 5458 B2F	06 May	128,000	15 October	08 July	22 July	No	--
Lamesa, TX	2010	DP 0935 B2RF	05 May	128,000	05 November	14 July	28 July	No	--
Marianna, AR	2008	ST 5458 B2F	19 May	118,560	27 October	16 July	30 July	No	--
Marianna, AR	2010	ST 5288 B2F	06 May	118,560	14 September	01 July	22 July	No	--
Duplin Co., NC	2009	AM 1550 B2RF	15 May	126,000	04 November	22 July	08 August	No	--
Starkville, MS	2008	DP 164 B2RF	07 May	128,000	30 November	20 July	05 August	No	--
Starkville, MS	2009	ST 5458 B2F	22 May	128,000	23 November	23 July	07 August	No	--
Starkville, MS	2010	ST 5458 B2F	11 May	128,000	28 September	08 July	21 July	No	--
Statesboro, GA	2009	DP 0949 B2RF	01 June	107,000	01 December	08 July	17 July	Yes	*Stemphylium solani/ Cercospora gossypina*
Verona, MS	2009	PHY 375 WRF	29 April	135,000	04 November	07 July	21 July	No	--

[z] Values within the column represent the number of seeds per hectare.

[y] First application was made at first bloom.

[x] Second application was made two to three weeks after first bloom application.

Table 2. Agronomic and fungicide application information for evaluation of foliar fungicides on cotton growth, development and yield

Location	Year	Soil texture	Irrigation	Row spacing	Plot dimensions	Application pressure	Spray tip	Application volume	Speed
				- cm -	# rows * length (m)	---- kPa ----		--- L ha^{-1} ---	Km hr^{-1}
Altus, OK	2010	Silty Clay Loam	Yes	102	4 * 12.2	200	Flat Fan	94	6.4
Jackson, TN	2008	Silt Loam	No	97	4 * 9.1	207	Flat Fan	114	6.4
Jackson, TN	2009	Silt Loam	No	97	4 * 9.1	207	Flat Fan	114	6.4
Jackson, TN	2010	Silt Loam	No	97	4 * 9.1	207	Flat Fan	114	6.4
Lamesa, TX	2008	Fine Sandy Loam	Yes	102	4 * 15.2	207	Flat Fan	140	5.6
Lamesa, TX	2009	Fine Sandy Loam	Yes	102	4 * 15.2	207	Flat Fan	140	5.6
Lamesa, TX	2010	Fine Sandy Loam	Yes	102	4 * 15.2	207	Flat Fan	140	5.6
Marianna, AR	2008	Silt Loam	Yes	97	4 * 15.2	283	Flat Fan	140	5.6
Marianna, AR	2010	Silt Loam	Yes	97	4 * 15.2	283	Flat Fan	140	5.6
Duplin Co., NC	2009	Loamy Sand	No	91	4 * 12.2	207	Flat Fan	140	4.8
Starkville, MS	2008	Silty Clay Loam	No	97	4 * 12.2	180	Flat Fan	140	4.8
Starkville, MS	2009	Sandy Loam	No	97	4 * 12.2	180	Flat Fan	140	4.8
Starkville, MS	2010	Silty Clay Loam	No	97	4 * 12.2	207	Flat Fan	140	4.8
Statesboro, GA	2009	Sandy Loam	Yes	91	4 * 9.1	165	Flat Fan	140	4.8
Verona, MS	2009	Silt Loam	No	97	4 * 15.2	255	Flat Fan	140	6.0

RESULTS AND DISCUSSION

Cotton growth and developmental parameters for all treatments were uniform across trials prior to the initiation of fungicide applications (Table 3). There were no differences among treatments with respect to plant height, the number of total nodes, internode length, or nodes above white flower (NAWF) before applications were initiated. No differences in plant height were observed among treatments prior to application of fungicides; however, differences in height as great as 6% were observed between the non-treated control and two of the three fungicide programs where pyraclostrobin was applied at first bloom (Table 4). Plant heights increased throughout the duration of each trial; however, no other significant differences in height were observed among treatments even though plant height was increased by between 1 and 4% depending on the specific treatment applied (Tables 5 and 6). Total nodes, internode length and NAWF were not significantly different among treatments. Developmental parameters were not affected by fungicide application two and four weeks after subsequent applications (Tables 5 and 6). An exception was that azoxystrobin applied at a rate of 0.22 kg a.i. ha^{-1} at first bloom or following an initial application at 0.11 kg a.i. ha^{-1} resulted in fewer nodes than the non-treated control or treatments containing pyraclostrobin (Table 6).

Overall, incidence of foliar disease was low at the end of the growing season; however, leaf spot symptoms were observed in the middle to upper canopy in four of the 15 trials. *Alternaria macrospora* was identified in each of the three trials conducted in Tennessee, whereas, *Cercospora gossypina* and *Stemphylium solani* were isolated from infected tissues in the 2009 Georgia trial (Table 1). Applications of azoxystrobin and pyraclostrobin tended to reduce the number of lesions in these trials with no disease occurring in plots receiving two applications; however, it is unlikely that yield or quality were affected by such low levels of foliar disease (data not presented). Dorman et al. (2009) demonstrated the efficacy of azoxystrobin towards foliar blight diseases of carrot (*Daucus carota*) caused by *Alternaria dauci* and *Cercospora carotae*. Azoxystrobin and pyracostrobin are both labeled for use against *C. arachodicola* in peanut (*Arachis hypogaea*) with the latter being more efficacious than other commercially available fungicides (Culbreath et al., 2002). Symptoms of boll rot and/or hard lock were observed in a majority of trials conducted in the Mid-south and Southeast, whereas, little if any such symptoms were observed in trials conducted in the southwest. No fungicide treatment effects were observed when averaged across locations with boll rot and hard lock severity ranging from 12 to 14% (Table 7).

The application of fungicides had no effect on lint percentage (data not presented), and yields were not significantly different among treatments (Table 7). Bryson et al. (2000) reported yield increases resulting from fungicide applications made in the absence of disease in grass crops such as wheat and barley (*Hordeum vulgare*)*;* however, such increases were inconsistent. A summary of wheat trials conducted from 1994 to 2010 where no appreciable levels of disease were observed, revealed a profitable response only 7% of the time, whereas, yield increased in 50 of the 100 comparisons met the predicted break-even value when fungal diseases were present (Weisz et al., 2011).

Likewise, yield benefits from use of strobilurin fungicides in soybean are inconsistent and do not always result in a measurable yield increase, especially when applied as a growth stage timed application in the absence of disease. No yield increases were achieved when pyraclostrobin was applied to soybean at the R1, R3, or R5 growth stages in Iowa (Swoboda and Pederson, 2009). In Ohio, Dorrance et al (2010) found that the application of azoxystrobin at R3 resulted in an increased soybean yield in only one of four trials where no diseases were observed. Henry et al. (2011) reported that seed yield of two cultivars was increased by 99 kg ha^{-1} when pyraclostrobin was applied at R4. The use of pyraclostrobin to increase plant yield was attributed to yield increases above calculated break-even values in approximately 55% of 282 on-farm field trials conducted in Iowa between 2005 and 2009 (Kyveryga et al., 2013). Throughout the duration of their study, greater yield responses were observed when above average rainfall was received, which may have increased the potential for foliar diseases.

In addition to yield enhancement, other benefits beyond disease management in crops, such as improvements in quality parameters, have been suggested, but not necessarily detected. Sugar beet (*Beta vulgaris*) quality (sucrose concentration (%) and recoverable sucrose (ton/ha)) from a multiyear study evaluating various fungicides was unaffected by applications of pyraclostrobin or any of the other fungicides tested (Khan et al., 2009). No differences in protein or oil content of soybean were detected with applications of pyraclostrobin or tebuconazole (Swoboda and Pederson, 2009). In the current study, the fiber quality parameters (micronaire, length, strength and uniformity) were unaffected by the application of fungicides even though the fiber characteristics varied by variety and location (Table 7). As a result, lint percent was similar among treatments (data not presented).

Table 3. Cotton growth and development parameters prior to fungicide application

Fungicide	Application rate	Application timing	Height[Z]	Nodes[Z]	Internode length[Z, Y]	NAWF[Z, X]
	kg ai ha^{-1}		-- cm --	--- # ---	-------- cm --------	----- # -----
Azoxystrobin	0.22	1st Bloom	78	15	7.2	6.3
Azoxystrobin	0.11	1st Bloom	78	14	6.7	6.3
	0.11	+ 14 – 21 Days				
Azoxystrobin	0.11	1st Bloom	78	14	6.9	6.4
	0.22	+ 14 – 21 Days				
Pyraclostrobin	0.22	1st Bloom	79	14	6.8	6.4
Pyraclostrobin	0.11	1st Bloom	78	14	6.7	6.4
	0.11	+ 14 – 21 Days				
Pyraclostrobin	0.11	1st Bloom	79	14	6.9	6.6
	0.22	+ 14 – 21 Days				
Non-treated control	--	--	77	14	6.8	6.1
	LSD		NS	NS	NS	NS
	P > F		0.59	0.26	0.09	0.49
	df		6, 210	6, 186	6, 186	6, 209
	F		0.78	1.31	1.89	0.91

[Z] Data were obtained from the following locations: Altus, OK – 2010; Jackson, TN – 2010; Lamesa, TX – 2010; Starkville, MS – 2008, 2009, 2010; Statesboro, GA – 2009; Verona, MS – 2009.

[Y] Internode lengths were taken between the fourth and fifth nodes down from the apical meristem.

[X] NAWF = nodes above white flower.

Table 4. Cotton growth and development parameters two weeks after the first bloom fungicide application

Fungicide	Application rate	Application timing	Height[Z]	Nodes[Z]	Internode length[Z, Y]	NAWF[Z, X]
	kg ai ha^{-1}		-- cm --	--- # ---	-------- cm --------	----- # -----
Azoxystrobin	0.22	1st Bloom	91	16	6.1	3.8
Azoxystrobin	0.11	1st Bloom	91	16	6.0	3.6
	0.11	+ 14 – 21 Days				
Azoxystrobin	0.11	1st Bloom	90	16	6.2	4.0
	0.22	+ 14 – 21 Days				
Pyraclostrobin	0.22	1st Bloom	93	16	6.1	4.0
Pyraclostrobin	0.11	1st Bloom	91	16	6.2	3.6
	0.11	+ 14 – 21 Days				
Pyraclostrobin	0.11	1st Bloom	94	16	6.3	3.7
	0.22	+ 14 – 21 Days				
Non-treated control	--	--	89	16	6.0	3.9
	LSD		3	NS	NS	NS
	P > F		0.01	0.29	0.49	0.25
	df		6, 189	6, 186	6, 186	6, 186
	F		2.74	1.23	0.91	1.31

[Z] Data were obtained from the following locations: Altus, OK – 2010; Jackson, TN – 2010; Lamesa, TX – 2010; Starkville, MS – 2008, 2009, 2010; Statesboro, GA – 2009; Verona, MS – 2009.

[Y] Internode lengths were taken between the fourth and fifth nodes down from the apical meristem.

[X] NAWF = nodes above white flower.

Table 5. Cotton growth and development parameters two weeks (four to five weeks after bloom app.) after the second fungicide application

Fungicide	Application rate	Application timing	Height[Z]	Nodes[Z]	Internode length[Z, Y]	NAWF[Z, X]
	kg ai ha^{-1}		-- cm --	--- # ---	-------- cm --------	----- # -----
Azoxystrobin	0.22	1st Bloom	100	17	5.4	1.9
Azoxystrobin	0.11	1st Bloom	96	17	5.2	1.6
	0.11	+ 14 – 21 Days				
Azoxystrobin	0.11	1st Bloom	99	17	5.3	1.9
	0.22	+ 14 – 21 Days				
Pyraclostrobin	0.22	1st Bloom	100	17	5.2	2.0
Pyraclostrobin	0.11	1st Bloom	99	17	5.4	1.6
	0.11	+ 14 – 21 Days				
Pyraclostrobin	0.11	1st Bloom	100	17	5.4	2.0
	0.22	+ 14 – 21 Days				
Non-treated control	--	--	96	17	5.1	1.9
	LSD		NS	NS	NS	NS
	P > F		0.11	0.63	0.43	0.07
	df		6, 231	6, 231	6, 231	6, 222
	F		1.75	0.73	0.99	1.95

[Z] Data were obtained from the following locations: Altus, OK – 2010; Jackson, TN – 2010; Lamesa, TX – 2010; Marianna, AR – 2010; Duplin County, NC – 2009; Starkville, MS – 2008, 2009, 2010; Statesboro, GA – 2009; Verona, MS – 2009.

[Y] Internode lengths were taken between the fourth and fifth nodes down from the apical meristem.

[X] NAWF = nodes above white flower.

Table 6. Cotton growth and development parameters four weeks (four to five weeks after bloom app.) after the second fungicide application

Fungicide	Application rate	Application timing	Height[Z]	Nodes[Z]	Internode length[Z, Y]	NAWF[Z, X]
	kg ai ha^{-1}		-- cm --	--- # ---	-------- cm --------	----- # -----
Azoxystrobin	0.22	1st Bloom	100	17	4.6	0.1
Azoxystrobin	0.11	1st Bloom	98	18	4.6	0.3
	0.11	+ 14 – 21 Days				
Azoxystrobin	0.11	1st Bloom	99	17	4.8	0.1
	0.22	+ 14 – 21 Days				
Pyraclostrobin	0.22	1st Bloom	100	18	4.7	0.2
Pyraclostrobin	0.11	1st Bloom	100	18	4.9	0.3
	0.11	+ 14 – 21 Days				
Pyraclostrobin	0.11	1st Bloom	100	18	4.8	0.1
	0.22	+ 14 – 21 Days				
Non-treated control	--	--	99	18	4.7	0.3
	LSD		NS	1	NS	NS
	P > F		0.79	0.04	0.25	0.43
	df		6, 210	6, 210	6, 186	6, 186
	F		0.52	2.23	1.32	0.99

[Z] Data were obtained from the following locations: Altus, OK – 2010; Lamesa, TX – 2010; Marianna, AR – 2010; Duplin County, NC – 2009; Starkville, MS – 2008, 2009, 2010; Statesboro, GA – 2009; Verona, MS – 2009.

[Y] Internode lengths were taken between the fourth and fifth nodes down from the apical meristem.

[X] NAWF = nodes above white flower.

Table 7. Effect of fungicide application on incidence of hardlock/boll rot and cotton yield and fiber quality

Fungicide	Application rate	Application timing	Hardlock/ Boll rot	Lint yield[Y]	Micronaire[Y]	Fiber length[Y]	Fiber strength[Y]	Fiber uniformity[Y]
	kg ai ha^{-1}		---- % ----	-- kg ha^{-1} --		- inches -	--- g/tex ---	----- % -----
Azoxystrobin	0.22	1st Bloom	14	1442	4.4	1.14	29.8	82.1
Azoxystrobin	0.11	1st Bloom	13	1466	4.4	1.15	29.7	82.3
	0.11	+ 14 – 21 Days						
Azoxystrobin	0.11	1st Bloom	12	1463	4.4	1.14	29.8	82.4
	0.22	+ 14 – 21 Days						
Pyraclostrobin	0.22	1st Bloom	12	1470	4.4	1.14	29.5	82.2
Pyraclostrobin	0.11	1st Bloom	14	1459	4.4	1.14	29.7	82.2
	0.11	+ 14 – 21 Days						
Pyraclostrobin	0.11	1st Bloom	12	1497	4.4	1.14	29.7	82.3
	0.22	+ 14 – 21 Days						
Non-treated control	--	--	13	1431	4.4	1.14	29.7	82.3
	LSD		NS	NS	NS	NS	NS	NS
	P > F		0.43	0.20	0.88	0.87	0.68	0.88
	df		6, 247	6, 327	6, 331	6, 331	6, 331	6, 331
	F		0.43	1.45	0.40	0.42	0.66	0.40

[Z] Data were obtained from the following locations: Altus, OK – 2010; Jackson, TN 2009; Lamesa, TX – 2008, 2009, 2010; Duplin County, NC – 2009; Starkville, MS – 2008, 2009, 2010; Statesboro, GA – 2009; Verona, MS – 2009.

[Y] Data were obtained from the following locations: Altus, OK – 2010; Jackson, TN 2008, 2009, 2010; Lamesa, TX – 2008, 2009, 2010; Marianna, AR – 2008, 2010; Duplin County, NC – 2009; Starkville, MS – 2008, 2009, 2010; Statesboro, GA – 2009.

The use of foliar applied fungicides in row crops has increased over the past 15 years; however, little information on the overall agronomic or physiological response of cotton to strobilurin fungicides exists. The application of foliar fungicides represents additional production costs. A lack of any appreciable yield response in this study brings into question the utility of such applications in a profitable production system. Furthermore, strobilurin fungicides are classified by the Fungicide Resistance Action Committee (FRAC) as having a high-risk for the development of resistance (Anonymous, 2001). Resistance to strobilurin fungicides is an increasingly important topic in other row-crop production systems in the U.S. In soybean, over the past several years, *C. kikuchii*, *C. sojina*, and *S. glycines*, have all been reported to be resistant to the strobilurin class of fungicides in either a limited geography or widespread in a single state as a result of repeated applications in situations where sound crop rotation practices have not been followed (Price et al., 2015; Standish et al., 2015; Wise et al. 2009; Zeng et al., 2015). In cotton, strobilurin fungicides are extensively used to manage Rhizoctonia seedling disease, caused by *Rhizoctonia solani*. Recently, strobilurin-resistant isolates of *R. solani* were identified in rice (*Oryza sativa*) and soybean, where the frequency of resistant isolates from the initially reported field, ranged from 7 to 100% with resistant isolates being recovered from areas as far apart as 40 km from one another (Olaya et al., 2013).

Corynespora cassiicola, the causal organism of target spot, is increasing in importance throughout cotton production areas in the U.S., China and Brazil (Fulmer et al., 2012; Galbieri et al., 2014; Wei et al., 2014). Significant levels of defoliation can occur shortly after the disease is detected with considerable yield losses having been reported (Hagan et al. 2012; Mehta et al., 2005). Strobilurin fungicides have been used in management of target spot. Wide-spread use of strobilurin fungicides in cotton is of concern as the potential for fungicide resistance in populations of *C. cassiicola* appears to be high. Takeuchi et al. (2006) recovered strobilurin resistant populations of *C. cassiicola* from cucumber (*Cucumis sativus*) in Japan. Populations of the fungus exhibiting cross-resistance to boscalid, a succinate dehydrogenase inhibitor (SDHI), were later identified in other areas of the country (Miyamoto et al., 2009). In addition to cotton, *C. cassiicola* can infect several other crops including soybean, tomato (*Solanum lycopersicum*), sweet potato (*Ipomoea batatas*), and pepper (*Capsicum* spp.) (Farr and Rossman, 2015). Strobilurin fungicides are commonly used in these crops and over usage in other crops such as cotton may increase selection pressure for resistance development. Due to the lack of a consistent increase in yield or quality, fungicides should not be applied to cotton to promote "plant health." Rather, fungicide use should be reserved for management of important, potentially yield reducing fungal diseases in years where disease pressure warrants application.

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