Effect of Foliar Fungicides on Late-season Anthracnose Stem Blight on Soybean

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ABSTRACT

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Anthracnose stem blight, caused by *Colletotrichum truncatum*, is responsible for soybean (*Glycine max*) yield losses in subtropical and tropical growing regions. There are inadequate data regarding the effect of anthracnose stem blight on yield in Iowa, and it is unknown if fungicide application can manage this disease. Field studies were conducted from 2008 to 2010 to determine the effect of fungicide application timing on late-season development of this disease. We also

investigated the effect of anthracnose stem blight on yield and specific yield components. Fungicides reduced late-season symptom development when compared to the untreated control; however, there were no differences in yield and yield components. While foliar fungicides can reduce late-season disease development, anthracnose stem blight typically should not affect crop management decisions involving use of foliar fungicides on soybean in Iowa.

INTRODUCTION

Anthracnose stem blight (ASB) is an important disease of soybean (*Glycine max* (L.) Merr.) in commercial growing regions throughout the world and in the United States (12,17). In Iowa, the disease is primarily caused by *Colletotrichum truncatum* (Schwein), but the disease can also be caused by other *Colletotrichum* species (7,9). Soybean yield loss caused by this disease has been documented in tropical or subtropical environments (1,2,9,17). While yield losses as high as 25% have been reported in the southern United States (2), the disease has not historically impacted soybean yield in the north central United States.

In Iowa, disease symptoms and signs typically only occur as the soybean crop begins to senesce. Most often irregular black lesions are observed on the main stem and pods. Lesions often coalesce and can cover a large portion of the stem. Lesions on soybean pods may lead to seed infection that can result in plant infection the following year. Fungal fruiting structures, called acervuli, form in lesions and look like small, dark spots. Under magnification these spots appear spiny. Anthracnose stem blight symptoms on soybean also may occur during early reproductive growth stages as reddening of leaf veins at the top of the plant followed by necrosis of the leaf lamina. This results in a characteristic “shepherd’s crook,” which is a downward turning of necrotic leaves and petioles at the top of the plant. These symptoms are less common in Iowa than elsewhere.

Colletotrichum truncatum can overwinter in infected seed or infested plant residue, and some isolates can survive as microsclerotia in soil for up to four years (11). Cultural control measures for ASB include crop rotation and tillage, although crop rotation has limitations because of the broad host range of *Colletotrichum* spp. This host range includes several weeds

common in soybean fields that can serve as alternative hosts (7). Tillage may not be a viable management option for all farmers, especially those who practice soil conservation tillage practices. The use of fungicides can be effective (1,2), and various classes of fungicides, including strobilurins (quinone outside inhibitors) and triazoles (demethylation inhibitors), are labeled in the United States for managing this disease.

Foliar fungicides have increasingly been applied to commercial soybeans (4). Initially this increase in foliar fungicide use was related to the introduction of *Phakopsora pachyrhizi* Syd and P. Syd., which causes soybean rust (6,10,13,14). Today, in Iowa and other Midwestern states, fungicides are used to control numerous endemic diseases. High soybean grain prices have also contributed to increased fungicide use. As grain prices increase, the return on investment of a fungicide application increases, thus even small increases in yield may be cost effective. Consequently, fungicide applications have become a more common input in crop management than in previous years. Farmers and agronomists in Iowa have reported fewer ASB symptoms at harvest on soybean crops that have been sprayed with foliar fungicides. Consequently, there have been questions regarding the effect of foliar fungicide applications on ASB and grain yield. The objectives of this research were to evaluate: (i) the effect of foliar fungicides applied at different growth stages on ASB severity, and (ii) the impact of late-season ASB development on soybean grain yield.

MANAGEMENT OF ANTHRACNOSE STEM BLIGHT WITH FOLIAR FUNGICIDES

Experiments were conducted at Iowa State University research farms. Field trials were conducted at a total of 11 locations in 2008, 2009, and 2010. Locations, soybean variety, and field activities are summarized in Table 1. A randomized complete block design was used with five or six replications and plots were 35 to 50 ft long and 4 to 6 rows wide (30-inch row spacing) depending on the location. Headline (pyraclostrobin, 6 oz/acre;

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TABLE 1
Experimental details for soybean research plots used in this study.

Year	County	Variety	Planting date	R1 app. ^x	R3 app.	Harvest date
2008						
	Cass	DSR ^y 3155RR	12 May	2 Jul	30 Jul	20 Oct
	Floyd	Asgrow 2107	17 May	13 Jul	4 Aug	19 Oct
	O'Brien	Asgrow 2107	13 May	9 Jul	31 Jul	30 Sep
	Washington	DSR 3155RR	22 May	7 Jul	5 Aug	3 Oct
2009						
	Adair	Cherokee 1029RR2Y	19 May	15 Jul	31 Jul	3 Nov
	Floyd	Navaho 720RR	20 May	16 Jul	29 Jul	2 Nov
	Story	Navaho 720RR	22 May	15 Jul	27 Jul	13 Oct
	Washington	Cherokee 1029RR2Y	21 May	17 Jul	30 Jul	28 Oct
2010						
	Floyd	Asgrow 2430	19 May	6 Jul	28 Jul	6 Oct
	O'Brien	Asgrow 2430	17 May	6 Jul	28 Jul	6 Oct
	Story	Asgrow 2430	19 May	7 Jul	21 Jul	13 Oct

^x R1 and R3 applications were based on the growth stage of soybean. Growth stage R1 is the beginning of flowering and growth stage R3 is the beginning of pod set (5).

^y DSR = Dairyland Seed Research

BASF, Research Triangle Park, NC) and Stratego YLD (trifloxystrobin + prothioconazole, 6 oz/acre; Bayer CropScience, Research Triangle Park, NC) were applied using a CO₂-powered backpack sprayer system (R&D Sprayers, Opelousas, LA) calibrated to spray 20 gal/ acre either at growth stage R1 (beginning flowering) or R3 (beginning pod set) (5). Anthracnose stem blight severity was determined by estimating the percentage of the main stem and pods covered by lesions at full maturity (R8) (5) on 20 consecutive plants in one of the middle two rows of each plot. The starting point for these 20 plants was arbitrarily selected. Plot combines were used to harvest the middle two rows of each plot, and yield data were standardized to 13% moisture for comparison. Standard herbicide practices were used at each location as needed.

Mean anthracnose severity and yield were calculated and analyzed using the mixed model procedure in SAS (SAS Institute Inc., Cary, NC). Data were analyzed separately for each fungicide since Headline was evaluated at seven locations and Stratego YLD was evaluated at all 11 locations. Locations were combined for analysis, although the location × treatment interaction was significant for ASB for both fungicides (Headline, $P = 0.003$ and Stratego YLD, $P < 0.001$). However, for each fungicide there was only one location that created this significant interaction. Headline treatments and the untreated control were not significantly different ($P = 0.661$) at the Nashua location in 2009, and the Stratego YLD treatments and untreated control were not significantly different ($P = 0.322$) in Nashua in 2010. The other 6 locations for Headline and 10 locations for Stratego YLD showed significant differences between the untreated control and both fungicide timings. In each case, disease severity on untreated plants was greater than plants with the R1 application, and the disease severity on plants with the R1 application had more disease than plants with the R3 application. There was not a significant location × treatment interaction for yield (Headline, $P = 0.834$ and Stratego YLD, $P = 0.696$).

Applications of fungicides were effective in controlling disease in all years, despite mean severity fluctuating greatly year-to-year. Across all years and locations Headline applications at R1 reduced ASB 41.5% when compared to the untreated control (Table 2). Headline applied at R3 reduced disease 62.4%. Stratego YLD reduced ASB severity 46.3 and 60.8% when applied at R1 or R3, respectively (Table 2).

There were significant ($P < 0.001$) increases in yield with both R1 and R3 applications of Headline compared to the untreated control (Table 2). Also, there was a significant ($P < 0.001$) increase in yield following an R3 application of Stratego YLD, but not with an R1 application, when either were compared to the untreated control (Table 2). There was very little foliar disease at most site years (*data not shown*). However, two site years, Story County (2009) and Story County (2010), had enough foliar disease to affect yield. While fungicide applications generally decreased ASB and increased yield, there was not a significant relationship between disease severity and yield at any location ($P > 0.05$), except at Story County in 2010 ($P = 0.007$).

TABLE 2
Mean percent anthracnose stem blight severity and yield of soybean treated with Headline and Stratego YLD in Iowa during 2008, 2009, and 2010.

Headline (7 locations)		
Timing ^w	ASB severity ^x	Yield ^y
R1	15.9 b ^z	59.9 a
R3	10.2 c	61.6 a
Untreated control	27.2 a	57.5 b
P value	<0.001	<0.001
Stratego YLD (11 locations)		
Timing ^w	ASB severity ^x	Yield ^y
R1	11.2 b	57.2 b
R3	8.2 c	58.7 a
Untreated control	20.9 a	55.6 bc
P value	<0.001	<0.001

^w Fungicide applications were based on the growth stage of soybean. Growth stage R1 is the beginning of flowering and growth stage R3 is the beginning of pod set (5).

^x Mean percent anthracnose stem blight severity visually estimated on 20 consecutive soybean stems per plot.

^y Yield in bushels per acre standardized at 13% moisture.

^z Treatments with the same letter are not considered significantly different according to an LSD test ($P > 0.05$).

ANTHRACNOSE STEM BLIGHT AND YIELD LOSS

From each field location in each year, 50 to 100 plants in untreated plots were hand harvested. Plants were chosen to give an even gradient from low to high ASB severity. These plants were not representative of the overall disease severity and were not chosen at random. Each plant was assessed for ASB severity as a percentage of lesions covering the stem and pods. The number of pods per plant, seeds per pod, and seed weight were determined for each plant. There was no significant interaction between the yield components, fungicides, and locations so data were combined across all sites. The relationship between yield components and anthracnose stem blight severity was calculated using the correlation procedure in SAS.

While soybean plants were purposely selected to represent a range of ASB severity in each field, mean severity still varied between locations. For example, mean severity was 56 and 9.9% in 2009 in Floyd and Adair counties, respectively (Table 3). A summary of average severity and yield components collected for each year and location can be found in Table 3. Late-season anthracnose stem blight did not have a significant ($P > 0.05$) correlation with any of the yield component data.

CONCLUSIONS

Fungicide applications generally decreased ASB and increased yield; however, a significant relationship was found between ASB severity and yield at only one of the 11 site years. Our results are consistent with a report (16) from Indiana in which a reduction in late-season stem symptoms did not result in a yield response. Our results differ from those of Backman et al. (1,2) who discovered that anthracnose stem blight did reduce soybean yields; however, Backman's study was done in the southern United States, where infection was estimated to occur during early reproductive stages. There has been limited research on the effect of anthracnose stem blight on yield, and apart from the report from Indiana, there are no other reports of late-season symptomology and its effect on yield. Early season symptoms of anthracnose stem blight are not common in Iowa, and the rare occurrence of early season anthracnose stem blight symptoms in Iowa has not been explored. It is possible that early season environmental conditions are not

conducive for infection and/or early disease development. Disease development is favored by periods of frequent rain and temperatures above 77°F (3,8).

Since we observed no relationship between disease severity and yield response in the fungicide studies, we assume in some cases where there was a yield response to the application of fungicides that other diseases, such as frogeye leaf spot (*Cercopsora sojae* Hara) were influencing yield response. This was the situation in Story County in 2010. There was no relationship between disease severity and any yield component.

Reduction of ASB during very late reproductive stages did not affect yield. Soybean yield is mostly determined between growth stages R1 (beginning flowering) and R6 (full seed), and consequently stressors have the most impact when they occur during those stages, especially between R3 (beginning pod set) and R6 when seed fill is occurring (15). In our study, ASB symptoms did not appear until after growth stages R6 or R7 when the soybeans were approaching maturity and had no effect on yield even when fungicides controlled the disease. Since applications of a fungicide at R3 reduced disease we suggest anthracnose infection occurred at R3 to R4.

From this study, Iowa farmers should not have to consider late-season ASB when developing a crop management strategy. The application of fungicides should only be considered when trying to manage diseases that reduce yield potential. In Iowa and other north central states, such diseases may include Septoria brown spot (*Septoria glycines* Hemmi) and frogeye leaf spot, and both have the potential to reduce soybean yields in the Midwest (4,17). Consequently, an application of fungicide may be necessary in some years to protect yield from fungal foliar diseases. Although we found late-season development of anthracnose stem blight did not impact yield in this study in Iowa, given the proper environmental conditions for disease development, this disease can possibly reduce soybean yield elsewhere (1,2,12,17).

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TABLE 3
Mean pods per plant, seeds per pod, 100 seed weight (g), and percent anthracnose stem blight severity of soybean at various locations in Iowa in 2008, 2009, and 2010.

Year County	Mean percent anthracnose stem blight severity (range) ^x	Average pods per plant	Average seeds per pod	Average 100 seed weight (g) ^y
2008				
Cass	18.3 (5-60)	33.0	2.5	12.4
Floyd	20.3 (0-85)	30.5	2.3	14.7
Washington	33.5 (5-90)	45.3	2.5	11.2
2009				
Adair	9.9 (1-74)	30.9	2.4	—
Floyd	56.0 (3-95)	28.3	2.4	—
O'Brien	23.3 (2-90)	34.5	2.4	—
Story	15.3 (1-80)	22.9	2.5	—
Washington	55.9 (5-95)	31.1	2.4	—
2010				
Floyd	10.5 (1-55)	39.7	2.1	12.2
O'Brien	28.0 (2-60)	41.5	2.0	12.7
Story	43.1 (10-80)	53.9	1.8	14.8

^x Regression analysis between mean percent anthracnose stem blight severity and yield components yielded either no significant relationship and/or slopes were nearly zero.

^y Average 100 seed weight data in 2009 was not measured prior to eliminating seed.

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