FOLIAR FERTILIZATION AND FUNGICIDE APPLICATION FOR SOYBEAN

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Introduction

Concerns over fungal diseases in soybean have renewed interest in applying pesticides for disease control with the goal of increasing grain yield. Interest has especially been sparked by discussions of the possibility of Asian Soybean Rust (*Phakopsora pachyrhizi*) spreading north to the North Central region. Because of increasing prices of soybean grain and traditional fertilizers, many Midwest growers are considering mixing fluid fertilizers and fungicides for foliar application to soybean. Extensive research in Iowa and in other non-irrigated areas of several North Central states during the last decade has shown only a small probability of soybean yield response to foliar fertilization with macro- or micro-nutrients. Moreover, Iowa research has shown that it is difficult to predict situations where foliar fertilization may be profitable (Haq and Mallarino, 1998, 2000, 2005; Mallarino et al., 2001; Mallarino and Haq, 2005; Mallarino et al., 2005). Current research in Iowa and other states has been addressing potential soybean response to fungicide application, which as expected has shown little or no yield response when there was no disease pressure. However, no recent research has focused on studying possible interactions between foliar fertilization and fungicide application at controlling diseases and increasing soybean yield. Therefore, this study evaluated effects of foliar fertilization, fungicide application, and their interaction on soybean grain yield and incidence of leaf/stem diseases.

Materials and Methods

Field trials were conducted at five fields in Iowa during 2005 and 2006. In 2005, the trials were located in Boone (central Iowa) and Washington (southeast Iowa) counties. In 2006 the trials were located in Boone, Washington, and Pottawattamie (southwest Iowa) counties. Adapted glyphosate-resistant soybean varieties were used at all trials. Soybean was planted using narrow rows (7.5 inches) at the sites in Boone and Pottawattamie counties and in rows spaced 30 inches at the sites in Washington County. Eight treatments were replicated three times at each site using conventional small plots and a completely-randomized plot design. Foliar fertilization treatments consisted of a control, a single application of 3 gal/acre of 3-18-18 fluid fertilizer at the V5-V6 and R2-R3 growth stages, 3-18-18 applied at both V5-V6 and R2-R3 stages, and 3.3 gal/acre of 28% urea-ammonium nitrate (UAN) solution (10 lb N/acre) applied at the R2-R3 stage. The fungicide *Pyraclostrobin* [Headline® (BASF)] was sprayed at 12 oz/acre at the R2-R3 growth stage alone and in combination with 3-18-18 and UAN fertilizers. All solutions sprayed at the R2-R3 stage were mixed with a 90% non-ionic surfactant at a rate of 0.1 quart/10 gallons. Solutions turned a slight milky-white color when fertilizers and fungicide were mixed but no precipitation or material settling was observed. Treatments were sprayed with a CO_2 powered sprayer calibrated to apply 30 gal of liquid/acre at 25 psi based on product recommendations. Spraying was done in early morning or evening to lessen the risk of leaf burning. There was no rainfall 24 hours before and after treatment application.

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Soil samples taken before planting soybean were analyzed for soil pH, organic matter, P, and K (Table 1). The test results indicated that soil P was Optimum or Very High and soil K was Low to Very High. Soil pH was slightly acid to slightly alkaline (due to calcium carbonate) and in two sites was below values recommended for soybean production in Iowa. No P or K fertilizer was applied to soil, and lime was not applied. Visual ratings to estimate leaf burning from treatment application were taken two days after spraying the treatments applied at the R2-R3 growth stage. The plots were scouted for disease incidence and severity by an experienced plant pathologist prior to and 3 weeks following application of treatments at the R2-R3 growth stage. Diseases identified included Brown Spot (*Septoria glycines*), Bacterial Blight (*Pseudomonas syringae*), Downy Mildew (*Peronospora manshurica*), Frog Eye Leaf Spot (*Cercospora sojina*), and Cercospora Leaf Spot (*Cercospora kukuchii*). All plots were evaluated for leaf greenness and remaining leaf area late in the season. Grain yield was adjusted to 13% moisture content. Treatment differences were compared by the Tukey multiple range test when the main treatment effect or an orthogonal comparison between the control and the average of all other treatment was significant at $P \leq 0.05$.

Results and Discussion

Application of UAN fertilizer caused moderate leaf burning and application of 3-18-18 fertilizer caused minor or no burning (Table 2). Other research has shown that N application at this rate and higher rates often produce leaf burn. Temperature and relative humidity differences at the time of application could not explain the higher leaf burning with UAN at Sites 3, 4, and 5. Fungicide application significantly delayed leaf senescence and increased green leaf area late in the season at four sites (Table 2). These results were not observed at Site 2 probably due to a too early evaluation that could not be repeated later on. The addition of fluid fertilizers with the fungicide did reduce the effect of the fungicide on delaying maturity. In most cases there were no differences between the control and plots receiving the 3-18-18 or UAN fluid fertilizers applied alone. At Site 5, however, the remaining leaf area for the two treatments receiving 3-18-18 fertilizer or UAN at the R2-R3 growth stage was slightly lower than for the untreated control suggesting that maturity was advanced.

Brown Spot and Bacterial Blight were the most prevalent diseases across sites (Table 3). There was no consistent pattern of disease control by the fungicide across sites. The fungicide reduced incidence and/or severity of Brown Spot at Sites 1, 3, and 5; and all treatments reduced incidence of Cercospora at Site 5. Unexpectedly, the fungicide application reduced incidence or severity of Bacterial Blight at four sites but especially at Site 4, which was a result we cannot fully explain. Foliar fertilization did not affect disease incidence or the fungicide effect on disease control except for Site 1 and the mentioned effect at Site 5. At Site 1, the incidence of Bacterial Blight was lowest with application of UAN mixed with the fungicide, and both incidence and severity of Brown Spot were lowest when either 3-18-18 or UAN were sprayed in mixture with the fungicide.

One or more treatments influenced soybean grain yield ($P \leq 0.05$) at four sites (Fig. 1). The Headline fungicide applied alone increased yield significantly at all sites except Site 1. The yield increases were largest at the two trials conducted in 2005 and 2006 in southeast Iowa (Sites 2

and 4). However, the grain yield response was clearly explained by disease control only at Sites 3 and 5. Foliar fertilization with 3-18-18 or UAN had inconsistent effects on yield. At Site 1, small apparent yield increases due to spraying 3-18-18 at the R2-R3 growth stage and a small yield decrease due to spraying UAN did not reach statistical significance. The 3-18-18 fertilizer applied without fungicide increased yield slightly at Site 2 and at Site 5 only when it was sprayed at the V5-V6 growth stage. Fertilization with UAN without fungicide did not affect yield at Sites 1 and 4, increased it slightly at Site 2, and decreased it at Sites 3 and 5. Mixing foliar fertilizers with the fungicide did not influence the effect of each product applied separately. Average treatment effects on grain yield across the five sites showed no effect of 3-18-18 fertilizer applied alone, a yield decrease from UAN fertilizer applied alone, and a yield increase from the fungicide applied alone or in mixture with 3-18-18.

Conclusions

The results confirmed results of previous research including more numerous Iowa fields in showing a small probability of soybean grain yield response to foliar fertilization, and that application of UAN at rates used in this study or higher often will decrease yield. Fungicide application can potentially increase soybean yield in some Iowa fields, however. The results showed that mixing 3-18-18 foliar fertilizer with the fungicide used in this study may not increase yield further than the fungicide alone, but will not reduce yield either.

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Table 1. Fields, selected soil properties, and spraying dates.

			Soil Test Values †				Spraying Date	
Year	County	Site	P	K	pH	OM	V5-V6	R2-R3
			---- ppm ----			- % -		
2005	Boone	1	17	122	5.8	4.5	30 Jun.	14 Jul.
	Washington	2	47	173	6.2	5.7	27 Jun.	11 Jul.
2006	Boone	3	21	184	6.6	4.1	28 Jun.	14 Jul.
	Washington	4	28	160	5.6	5.3	29 Jun.	13 Jul.
	Pottawattamie	5	25	343	7.6	4.2	26 Jun.	15 Jul.

† Mehlich-3 P and K. OM, organic matter.

Table 2. Effects of foliar fertilization and fungicide application on soybean leaf burn after spraying and green leaf area at maturity.

	Leaf Burn					Remaining Green Leaf Area				
Treatment	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
	---------- % ----------					---------- % ----------				
Control	0	0	0	0	0	6	88	4	4	13
Fungicide at R2-R3	0	0	0	0	0	37	78	37	25	32
3-18-18 at V5-V6	0	0	0	0	0	6	83	5	4	12
3-18-18 at R2-R3	1	0	4	4	3	7	83	6	4	6
3-18-18 at V5-V6 & R2-R3	1	0	3	5	2	13	67	7	4	4
3-18-18 at R2 + Fung.	2	0	5	9	2	23	89	28	20	22
UAN at R2-R3	10	10	27	17	22	8	79	8	3	5
UAN at R2-R3 + Fung.	18	3	28	23	22	33	79	40	25	18

Table 3. Effects of foliar fertilization and fungicide application on soybean diseases.

Site	Treatment	Brown Spot		Bacterial Blight		Downy Mildew		Frog Eye Spot	
		Incid*	Sev*	Incid	Sev	Incid	Sev	Incid	Sev
		%		%		%		%	
S1	Control	100	2.3	60	1.0	1.7	0.3	1.7	0.3
	Fungicide at R2-R3	85	1.7	43	0.8	<0.1	<0.1	1.7	0.2
	3-18-18 at V5-V6	100	1.7	90	0.8	<0.1	<0.1	6.7	0.2
	3-18-18 at R2-R3	95	1.3	43	0.7	0.3	0.3	3.5	0.5
	3-18-18 at V5-V6 & R2-R3	100	1.7	83	1.0	<0.1	<0.1	2.3	0.3
	3-18-18 at R2-R3 + Fungicide	20	1.0	78	1.0	<0.1	<0.1	0.3	0.2
	UAN at R2-R3	100	2.3	60	1.0	1.7	0.3	9.0	0.3
	UAN at R2-R3 + Fungicide	18	1.0	13	0.8	<0.1	<0.1	1.7	0.2
S2	Control	100	3.0	0.3	0.7	67	1.7	0.3	0.2
	Fungicide at R2-R3	63	0.7	2.0	0.7	20	1.0	1.0	0.8
	3-18-18 at V5-V6	100	3.0	0.0	0.0	80	2.3	3.7	1.3
	3-18-18 at R2-R3	100	2.7	0.7	0.7	87	2.3	0.7	0.7
	3-18-18 at V5-V6 & R2-R3	100	2.7	3.3	0.5	87	2.3	0.7	0.7
	3-18-18 at R2-R3 + Fungicide	100	1.7	0.3	0.3	20	1.5	2.0	0.7
	UAN at R2-R3	100	2.0	0.7	0.7	40	1.3	0.3	0.3
	UAN at R2-R3 + Fungicide	100	1.5	0.7	0.7	50	1.3	1.0	1.0
						Cercospora		Frog Eye Spot	
S3	Control	100	2.5	80	2.0	1	0.2	7	0.2
	Fungicide at R2-R3	60	1.5	80	2.0	0	0.0	0	0.0
	3-18-18 at V5-V6	100	3.0	80	2.0	0	0.0	0	0.0
	3-18-18 at R2-R3	100	2.7	80	2.0	1	0.2	1	0.2
	3-18-18 at V5-V6 & R2-R3	93	2.3	80	2.0	0	0.0	1	0.2
	3-18-18 at R2-R3 + Fungicide	63	1.3	80	2.0	0	0.0	0	0.0
	UAN at R2-R3	100	2.8	80	2.0	0	0.0	0	0.0
	UAN at R2-R3 + Fungicide	50	1.0	80	2.0	0	0.0	1	0.2
S4	Control	100	3.0	100	2.0	2	0.5	5	0.5
	Fungicide at R2-R3	100	1.0	60	1.0	3	0.5	5	0.5
	3-18-18 at V5-V6	100	3.0	100	2.2	0	0.0	5	0.5
	3-18-18 at R2-R3	100	3.0	100	2.2	1	0.2	5	0.5
	3-18-18 at V5-V6 & R2-R3	100	3.0	100	2.0	0	0.0	5	0.5
	3-18-18 at R2-R3 + Fungicide	100	1.8	75	1.1	2	0.6	5	0.5
	UAN at R2-R3	100	3.0	100	2.0	1	0.5	5	0.5
	UAN at R2-R3 + Fungicide	100	1.0	87	1.0	1	0.3	5	0.5
S5	Control	93	1.7	72	1.0	18	0.5	3	0.7
	Fungicide at R2-R3	55	1.0	20	0.7	4	0.5	0	0.2
	3-18-18 at V5-V6	90	2.0	90	1.0	4	0.3	4	0.7
	3-18-18 at R2-R3	97	2.0	87	1.0	3	0.8	12	0.8
	3-18-18 at V5-V6 & R2-R3	97	2.0	97	0.8	7	0.3	1	0.3
	3-18-18 at R2-R3 + Fungicide	77	1.0	33	0.5	4	0.5	5	0.2
	UAN at R2-R3	100	1.7	89	0.8	4	0.5	2	0.2
	UAN at R2-R3 + Fungicide	87	1.0	33	0.5	8	0.5	2	0.5

Incid = disease incidence; Sev = severity on a scale from 0 (no symptom) to 5 (> 60% chlorotic or necrotic).

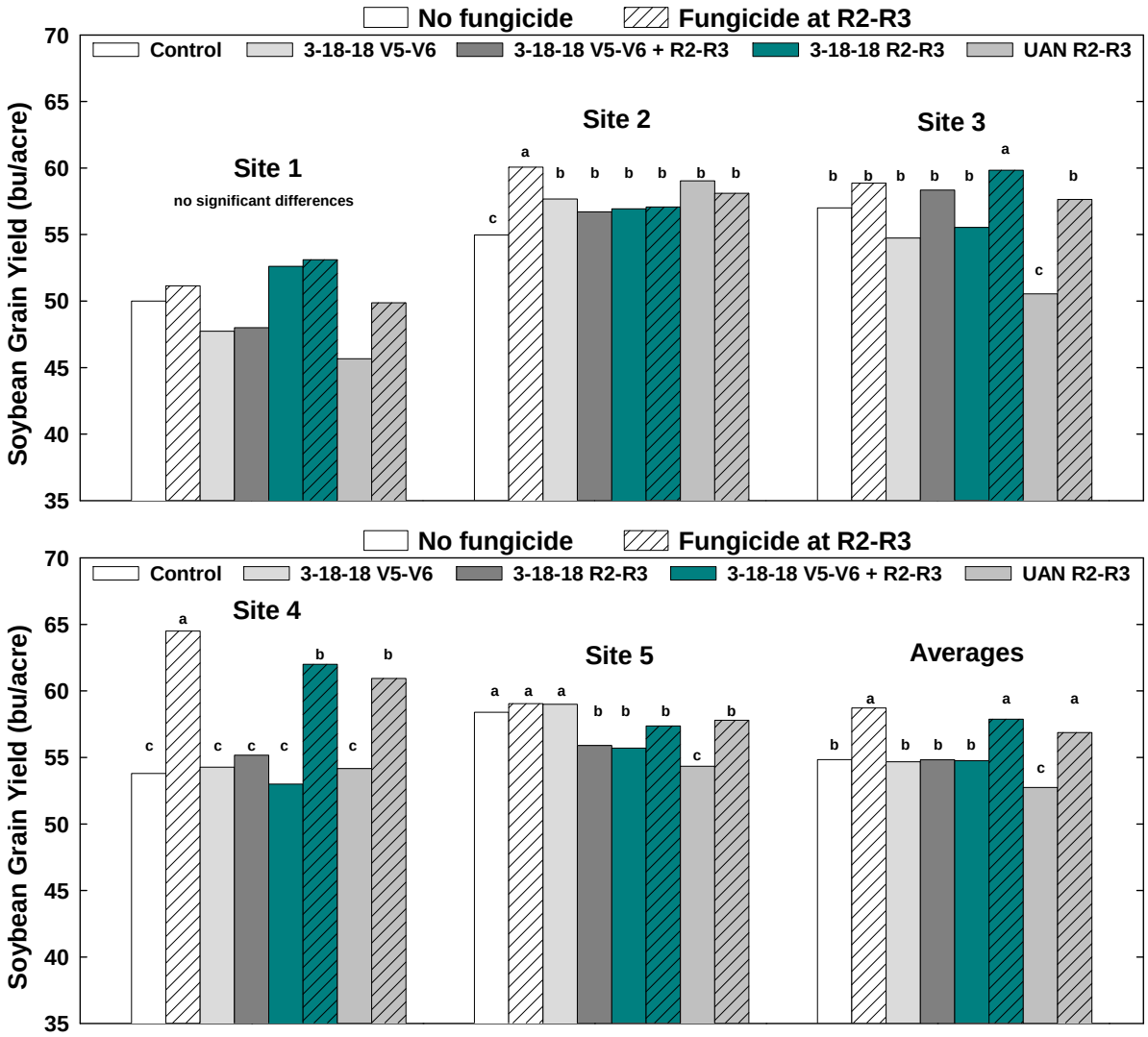

Fig. 1. Soybean grain yield as affected by foliar fertilization and fungicide application at five fields and the average across fields. Different letters on top of the bars indicate significant differences.

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