Winter Wheat Variety Response to Flag Leaf Foliar Fungicide Application in 2019–2020

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Summary

Foliar fungicide can be an important tool in improving wheat yields, but its effectiveness is season- and variety-dependent. To evaluate the yield, test weight, and protein responses of different commercial winter wheat varieties to one foliar fungicide application around heading, we conducted a trial combining four winter wheat varieties and two fungicide management treatments in Manhattan during 2019–2020. The control treatment consisted of no fungicide application, and the alternative treatment consisted of 5 oz/a Absolute Maxx + NIS applied at heading. Varieties evaluated were Bob Dole, Larry, WB4269, and Zenda. The study was conducted under no-tillage practices following a previous soybean crop. Grain yield across varieties averaged 47.8 bushels per acre in the control and 51.3 bu/a in the fungicide treatment. Zenda was the highest yielding variety (51.3 bu/a), followed by Larry (48.9 bu/a), and WB4269 and Bob Dole (~45.5 bu/a). The statistical analysis suggested that all varieties responded similarly to the fungicide application, but we hypothesize that this was because we did not have enough observations to build statistical power. Grain test weight and protein concentration were only impacted by variety and showed no fungicide effect (both were usually greater in Bob Dole and Larry as compared to Zenda or WB4269). These results suggest that the yield increase due to fungicide application did not result in protein dilution, likely due to an extended period for nitrogen (N) uptake and remobilization into the grain. Further research is needed to statistically detect significant differences among varieties in their response to foliar fungicide.

Introduction

Fungal foliar diseases often reduce wheat yield in Kansas, with losses as large as 22% (Hollandbeck et al., 2019) and foliar fungicide has been associated with increased wheat yields in long-term variety performance trials (Munaro et al., 2020). The benefits of foliar fungicides to susceptible varieties are well documented and could account for as much as 15–20 bu/a in seasons with high disease incidence (Jaenisch et al., 2019; Sassenrath et al., 2019). However, this benefit might be insignificant in dry seasons with low disease pressure (Cruppe et al., 2017). Because of the variability in growing conditions and disease pressure in Kansas, the breakeven probability of foliar fungicides is highly variable. Thus, genetic resistance has been the main strategy used in the region to mitigate yield losses resulting from diseases in historical time scales (Kelley, 2001).

Recent evidence suggests that even resistant varieties might benefit from foliar fungicides in seasons when disease pressure is high (de Oliveira Silva et al., 2020a). In fact, a

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recent evaluation of intensively managed wheat fields suggested that foliar fungicides were among the most important factors contributing to the increased wheat yields in Kansas (Lollato et al., 2019a), and are often used in intensified wheat management systems (Lollato and Edwards, 2015).

Given the importance of foliar fungicide management to maximizing wheat yields, and its dependence on variety, the objective of this study was to evaluate how different wheat varieties responded in terms of grain yield and grain test weight to one foliar fungicide application around heading time in Kansas.

Procedures

One field experiment was conducted in Manhattan, KS, during the 2019–2020 winter wheat growing season. The experiment was sown using a Great Plains NT606 drill and was conducted under no-tillage practices after soybeans in a complete two-way factorial treatment structure arranged in a split-plot design and six replications. Fungicide applied at heading was the whole plot (either presence or absence), and four commercial winter wheat varieties with contrasting genetic resistance to the different predominant diseases were the sub-plot. Fungicide management consisted of 5 oz/a of Absolute Maxx + NIS applied at heading. The winter wheat varieties included in this study were: Bob Dole, Larry, WB4269, and Zenda. A Massey Ferguson XP8 small-plot, self-propelled combine was used for harvesting. Plot ends were trimmed at harvest time to avoid border effect. Measurements included grain yield (corrected for 13% moisture content), grain test weight, and grain protein concentration at harvest maturity (corrected for 13% moisture content).

Statistical analysis was performed using a two-way ANOVA in PROC GLIMMIX procedure in SAS v. 9.4 (SAS Inst. Inc., Cary, NC) where variety, fungicide, and their interactions were considered fixed effects, and replication was treated as a random effect in the analysis of variance.

Results

Weather Conditions

The study location received 18.4 inches of precipitation during the growing season (Table 1), which is enough to suggest that there was no water limitation to grain yields (Patrignani et al., 2014; Lollato et al., 2017). Precipitation was well distributed according to the different water needs depending on the crop's stage of development, with ~3.4 inches in the fall, ~4.0 inches in the winter, and ~11 inches in the spring. These moisture levels, combined with relatively cool spring temperatures, led to the development of stripe rust and later, leaf rust (visual observations only).

Grain Yield

Grain yield was affected by fungicide and by variety individually ($P < 0.01$), but the evidence for variety-specific response to fungicide was weak ($P = 0.15$) (Table 2). In the treatments receiving foliar fungicide, grain yield averaged 51.3 bu/a as compared to 47.8 bu/a in the treatments not receiving fungicides. Zenda was the highest yielding variety (58.1 bu/a) and was followed by Larry (48.9 bu/a), which yielded more than Bob Dole and WB4269 (average 45.5 bu/a). This trial was planted beside an early-planted wheat trial, which increased the incidence of barley yellow dwarf virus in the study. This can help explain the much greater yield in Zenda as compared to the other varieties. While there was no variety × fungicide interaction, we note that there was a range in the differences in treated versus untreated depending on variety, with Bob Dole showing no yield gain from fungicide, while the other three varieties evaluated gained 4–6 bu/a. The lack of significance in this study might be because it was conducted in one location and therefore, had only a few observations. Perhaps more observations could have improved the power of this analysis and detected these differences among varieties in their response to fungicide – if a difference truly existed.

Grain Test Weight

Grain test weight differed among varieties but was not impacted by fungicide management or by the interaction between fungicide and variety (Table 2). Bob Dole and Larry had the greatest test weights, whereas Zenda and WB4269 had the lowest.

Grain Protein Concentration

Similarly to test weight, grain protein concentration differed among varieties but was not affected by fungicide or its interaction with variety (Table 2). All varieties differed from each other ($P < 0.01$), with Bob Dole having greater protein than Larry, which had greater protein than WB4269, which had greater protein than Zenda. It was interesting to note that the increase in grain yield resulting from fungicide application did not decrease grain protein concentration, as expected due to a dilution effect associated with greater yields. This might have occurred due to the extended green leaf area resulting from fungicide treatment (Jaenisch et al., 2019), possibly extending the duration of N uptake and translocation into the grain, which determines protein (de Oliveira Silva 2020b; Lollato et al., 2019b; 2021).

Preliminary Conclusions

Results suggest that both fungicide and variety impacted grain yield, but varieties responded similarly to fungicide management. Nonetheless, we hypothesize that with a single site year, there were not enough observations to build statistical power and detect these differences. Our results also showed that grain yield increases due to fungicide did not dilute grain protein concentration, similar to results by Kelley (2001). We hypothesize that the extended green leaf area resulting from the fungicide (Jaenisch et al., 2019) increases the duration of N uptake and translocation to the grain, compensating for increased yield levels.

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Table 1. Average maximum (Tmax) and minimum (Tmin) temperatures, and cumulative precipitation and grass evapotranspiration (ETo) during the fall (October 1 – December 31), winter (January 1 – March 31), and spring (April 1 – June 30) at the study location during the 2019–2020 growing season. The ratio of water supply (WS) over water demand (WD) is also shown.

Season	Tmax	Tmin	Precip.	Eto	WS:WD
	------- °F -------		------- in. -------		
Fall	54.0	31.5	3.4	6.5	0.52
Winter	48.2	28.0	4.0	6.4	0.63
Spring	75.6	53.3	11.0	17.0	0.65
Total	59.3	37.6	18.4	29.9	0.62

Table 2. Mean grain yield, grain test weight, and grain protein concentration as affected by fungicide, variety, and fungicide × variety for the trial conducted in Manhattan, KS, during the 2019–2020 winter wheat growing season. F-test probabilities are also shown. Values less than 0.05 indicate statistical significance.

	Grain yield (bu/a)			Grain test weight (lb/bu)			Grain protein concentration (%)		
Variety	Control	Fungicide	Mean	Control	Fungicide	Mean	Control	Fungicide	Mean
Bob Dole	45.4	45.3	45.3 c	57.7	57.3	57.5 a	12.1	12.2	12.2 a
Larry	46.0	51.7	48.9 b	57.4	57.4	57.4 ab	11.7	11.8	11.8 b
WB4269	43.8	47.9	45.9 c	57.0	57.1	57.1 bc	11.5	11.5	11.5 c
Zenda	56.0	60.3	58.1 a	56.8	56.9	56.8 c	10.7	10.7	10.7 d
Mean	47.8 b	51.3 a		57.2	57.2		11.5	11.6	
Fixed effects					------- Pr > F -------				
Fungicide (F)		<0.01			0.83			0.25	
Variety (V)		<0.01			<0.01			<0.01	
F × V		0.15			0.46			0.96	