Wheat Yield Response to Fungicide Application and Nitrogen Management in Kansas during 2023-2024

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Summary

Nitrogen (N) and fungicide are among the more important management tools to increase wheat (*Triticum aestivum* L.) grain yield in Kansas. However, there is limited information on whether hard red winter wheat grain yield is impacted by the interaction of nitrogen rates and foliar fungicide application. Thus, our objective was to evaluate the effects of different N rates with or without a fungicide application at Feekes 10.5 on grain yield of two winter wheat genotypes with contrasting disease resistances to leaf and stripe rust. Seven field experiments were established in Kansas using a factorial structure of two fungicide management (either absence of fungicide or 13 oz of Nexicor per acre), five N rates (0, 30, 60, 90, and 120 pounds of N per acre), and two genotypes (Larry and Zenda) in a split-split plot design during the 2023-2024 growing season. Depending on the environment, grain yield varied from less than 18 bushels per acre to more than 88 bushels per acre, likely due to differences in initial soil NO_3-N levels and in-season precipitation. A significant interaction was observed between fungicide application and location, with mean yields ranging from 14.0 bushels per acre in Hoisington (with fungicide) to 87.9 bushels per acre in Leoti (without fungicide). Fungicide had a significant effect in half of the locations, with the greatest yield response observed in Ashland Bottoms (8.6 bushels per acre), which also received the highest precipitation during the growing season. Nitrogen rate increased the yield of variety Zenda from 55.1 bushels per acre at the zero nitrogen rate, to 62.5 bushels per acre at the highest rate, and of the wheat variety Larry from 51 to 54 bushels per acre. Results suggested that the management of nitrogen and fungicide were variety- and environment-specific, respectively, supporting the notion of adaptive management based on seasonal conditions.

Introduction

There is a large yield gap for winter wheat in Kansas, where the current farmer yields are considerably lower than their attainable potential (Couedel et al., 2025; Patrignani et al., 2014; Lollato et al, 2017). Within this context, in-season management decisions can largely improve grain yields, narrowing the yield gap (Jaenisch et al., 2019, 2022; de Oliveira Silva et al., 2020, 2021). Among the many practices that growers can manage, nitrogen management and foliar fungicide applications seem to be the largest drivers of wheat yield in this region (Cruppe et al., 2017, 2021; Jaenisch et al., 2021; Lollato et al.,

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2019a; Munaro et al., 2020). Thus, more research is needed on agronomic management of nitrogen, fungicide, and potentially of their interaction to increase winter wheat yield in the region.

Some evidence suggested an interaction between N management and foliar fungicide application in other regions and for other wheat classes (Brinkman et al., 2014). Nitrogen can increase disease pressure by promoting lush growth, which creates a moist microclimate within the canopy and keeps leaves green longer. (Salgado et al., 2017). Likewise, with applications of foliar fungicide, the crop may have higher yield potential, and N requirements are linked to the crop's yield potential (Salgado et al., 2017; Lollato et al., 2019b, 2021). Further, different wheat varieties may have different yield potentials (Lollato et al., 2020; Raj et al., 2023), also affecting nitrogen requirements – especially in high-yield environments where N is not limiting (Giordano et al., 2024). Although information on N × fungicide interactions is available in other regions, there is limited information on whether hard red winter wheat yield is impacted by this interaction in Kansas. Therefore, our objectives were to evaluate the effects of different N rates with or without a foliar fungicide application at heading on the grain yield of two winter wheat varieties with contrasting disease resistances to leaf and stripe rust.

Procedures

This study was conducted at seven rainfed locations across the state of Kansas during the 2023-2024 winter wheat growing season (Ashland Bottoms, Hays, Hoisington, Hutchinson, McPherson, Leoti, and Phillipsburg). Initial soil fertility conditions for these locations are provided in Table 1.

The field experiment was established using a factorial structure arranged in a split-split plot design, where the fungicide application constituted the whole plot, N rates the sub-plot, and the genotype constituted the sub-sub-plot. The fungicide management was either no fungicide or 13 oz of Nexicor per acre at heading; the five nitrogen rates were 0, 30, 60, 90, and 120 pounds of N per acre; and the two winter wheat varieties used across locations were Larry (susceptible to leaf rust) and Zenda (susceptible to stripe rust).

Winter wheat varieties were sown at 90 pounds of seeds per acre, in combination with 50 pounds of diammonium phosphate applied in-furrow at sowing. Nitrogen was applied as urea (46-0-0) by hand broadcast at spring green-up (Feekes 3-4), and foliar fungicide was applied using flat fan nozzles mounted on a CO_2 backpack sprayer at Feekes 10.5. The fields had adequate weed control using commercially available herbicides to ensure weeds were not a limiting factor. Plots were harvested using a Massey Ferguson 8 XP small plot combine.

Soil samples were collected from 0 to 6 inches and from 6 to 18 inches depth at each location before sowing (Table 1). For each depth, soil fertility and texture were analyzed. Plots were 6 × 30 ft, and yield was measured by combine harvesting the entire experimental unit at maturity. Four-way ANOVA evaluated the main effects of N rate, fungicide, genotype, and environment, as well as their interactions.

Results

This report does not include the grain yield data from Hays due to the low emergence and poor stand establishment caused by the dry conditions at the time of seeding.

Grain yield showed a significant variability as function of environment, likely due to the different initial soil NO_3-N contents (Table 1) and the amount of precipitation during the growing season (Figure 1). Precipitation from planting to the harvest ranged from 10.9 to 25.3 inches, with low precipitation amounts recorded in Hoisington, Hutchinson, and Leoti; particularly at the end of the winter and the beginning of the spring. On average, grain yield ranged from 14 to 83.1 bushels per acre, with the highest yields recorded in Leoti and Phillipsburg while the lowest yields were recorded in Hoisington (Figure 2).

There was a significant interaction between fungicide application and the environment with a positive effect on grain yield for the variety Larry in McPherson, Ashland Bottoms, and Phillipsburg. At these locations, fungicides increased the grain yield of wheat by 5.0, 10.3, and 4.4 bushels per acre, respectively. No differences were found between plots receiving fungicide or not for the variety Larry in Hoisington and Hutchinson, while there was a reduction of 9.2 (bushels per acre) in Leoti (Figure 3). Yield reductions due to fungicides in dry environments are not uncommon and can relate to increased crop water usage due to a prolonged green canopy (Cruppe et al., 2021). For the variety Zenda, foliar fungicide applications increased grain yield in Phillipsburg and Ashland Bottoms (Figure 3).

Across sources of variation, grain yield of the variety Larry increased slightly but significantly, from 51 bushels per acre at 30 pounds of N per acre to 54.2 bushels per acre at 120 pounds of nitrogen per acre. Yield gains of the variety Zenda due to nitrogen were also small but significant, with yields ranging from 55.1 bushels per acre at the zero nitrogen rate to 62.5 bushels per acre with the highest N rate (Figure 4).

Conclusions

The grain yield responses to fungicide and to nitrogen were variety- and environment-specific, likely attributed to the different amounts and timing of precipitation, as well as the varying initial soil NO_3-N contents. The genotype Larry responded to fungicide application in four environments while Zenda significantly increased grain yield when fungicide was applied in two environments. Both varieties showed small but positive responses to increased nitrogen rates across environments. Fungicide had a significant effect in half of the locations, with greater yield responses in environments with higher precipitation, which are conditions that favor the incidence of diseases such as stripe and leaf rust (DeWolf et al., 2023).

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Table 1. Initial soil fertility, for winter wheat sowing during the 2023-2024 growing season for seven environments in Kansas

Location	Depth	OM	pH	NO_3-N	P-M	K	Sand	Silt	Clay
	in.	%		------------ ppm	------------		-------------- %	-------------	
Ashland Bottoms (AB)	0 to 6	1.7	6.1	24.4	65	198	35	53	12
	6 to 24	1.4	7.7	5.4	34	154	35	53	12
Hays	0 to 6	2.4	5.2	53.2	39	441	9	70	21
	6 to 24	2.1	6.6	33.5	17	298	16	67	17
Hoisington (HOI)	0 to 6	2.1	7.2	43	28	177	31	46	23
	6 to 24	1.9	8	31	17	147	32	40	28
Hutchinson (HUT.O)	0 to 6	2.1	6.6	1.9	34	510	17	50	33
	6 to 24	1.9	7	1.7	39	469	17	47	36
Leoti (LEO)	0 to 6	1.9	7.1	14.1	87	623	24	52	24
	6 to 24	2	7.8	14.5	59	577	22	50	28
McPherson (MCP)	0 to 6	2.9	6.5	9.4	36	330	16	49	35
	6 to 18	2.4	6.8	10.7	19	319	15	45	40
Phillipsburg (PHB)	0 to 6	2.5	6.1	40.6	97	651	20	56	24
	6 to 24	2	6.9	31.4	110.0	702.0	18	53	29

Abbreviations: OM, organic matter; pH, soil pH; NO_3-N, soil nitrate nitrogen; P, phosphorus; K, potassium; CEC, cation exchange capacity, Cl, chloride.

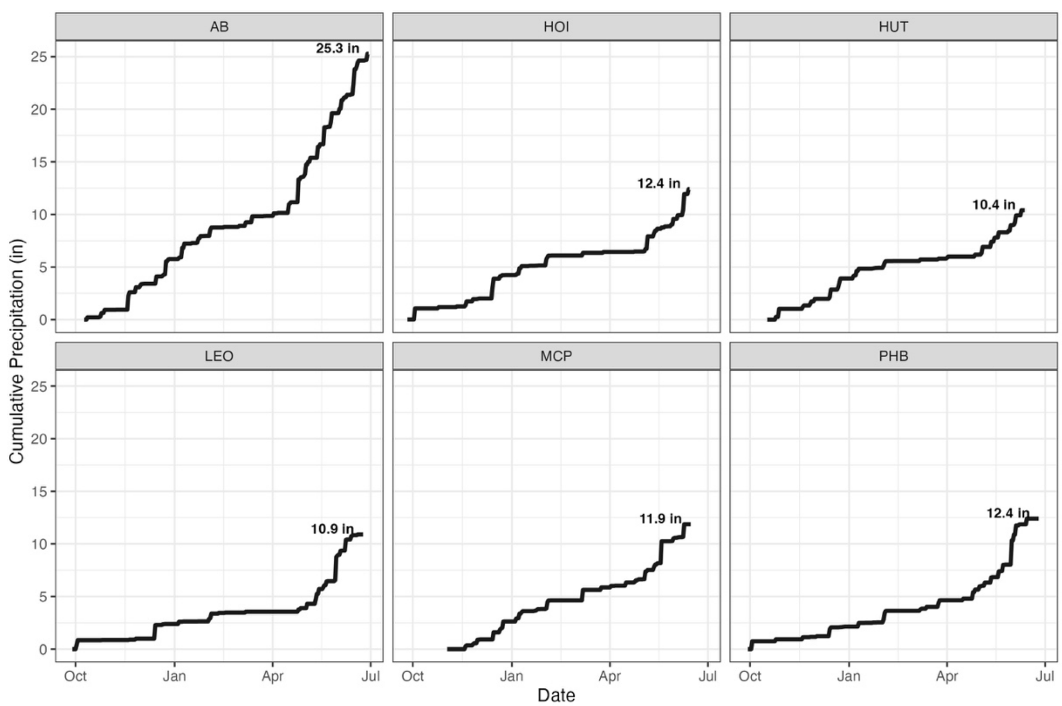

Figure 1. Cumulative precipitation from planting to harvest in the 6 locations during the 2023-2024 growing seasons in Kansas.

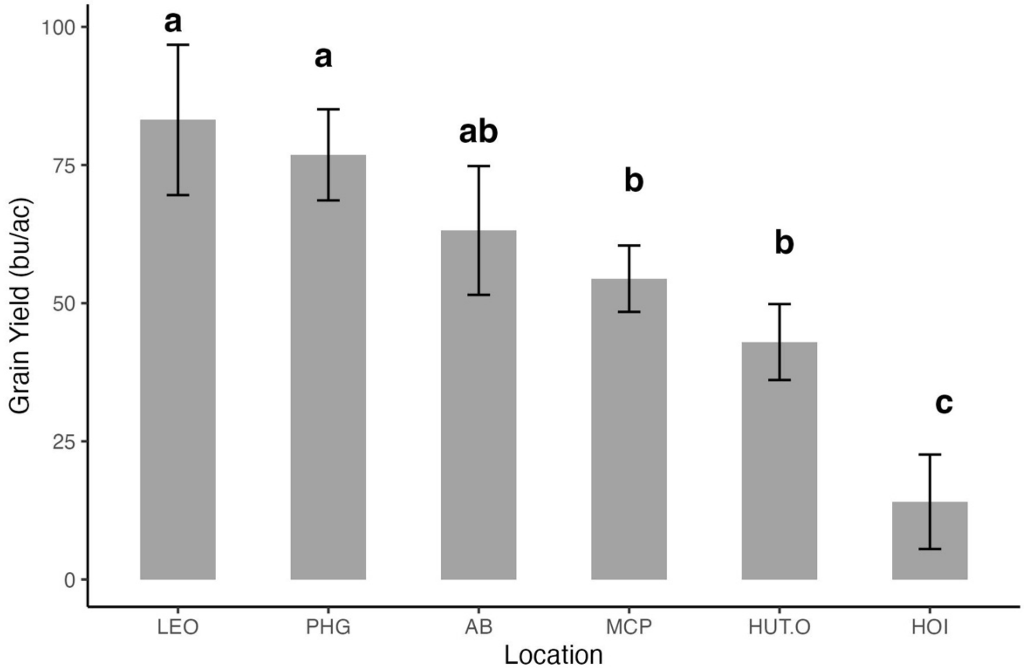

Figure 2. Wheat grain yield at 6 locations during the 2023-2024 wheat growing seasons in Kansas. Letters indicate significant differences with p-value < 0.05.

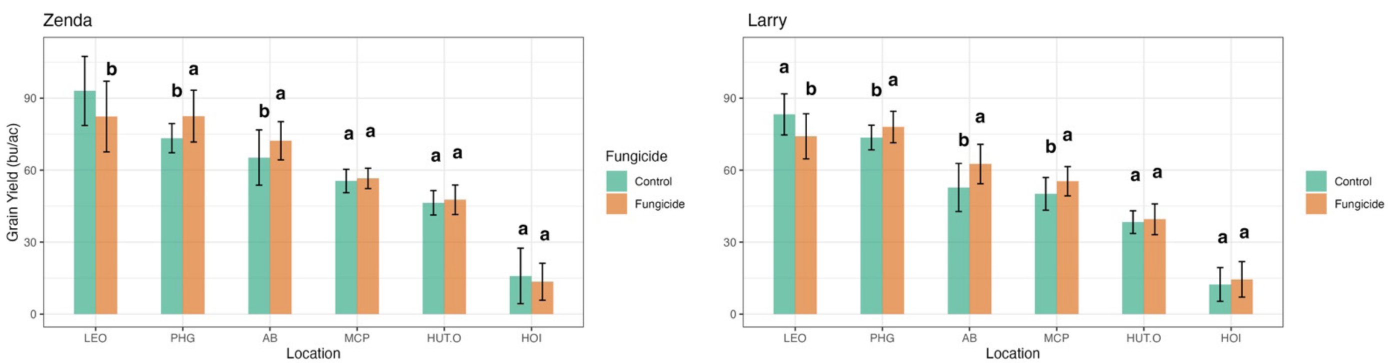

Figure 3. Winter wheat grain yield response to foliar fungicide application at heading in six locations for the varieties Zenda (left panel) and Larry (right panel) during the 2023-2024 growing season in Kansas.

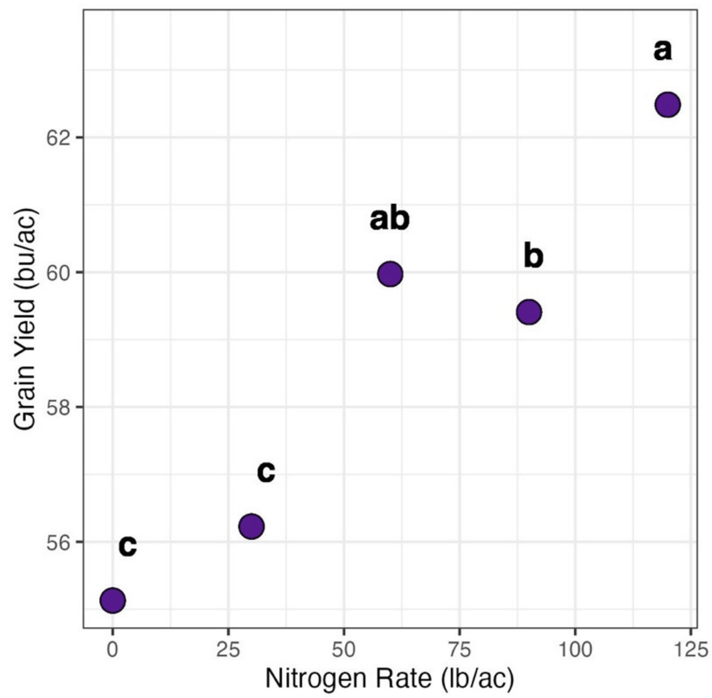

Figure 4. Wheat grain yield of the variety Zenda in response to five nitrogen rates across six locations during the 2023-2024 wheat growing season in Kansas.

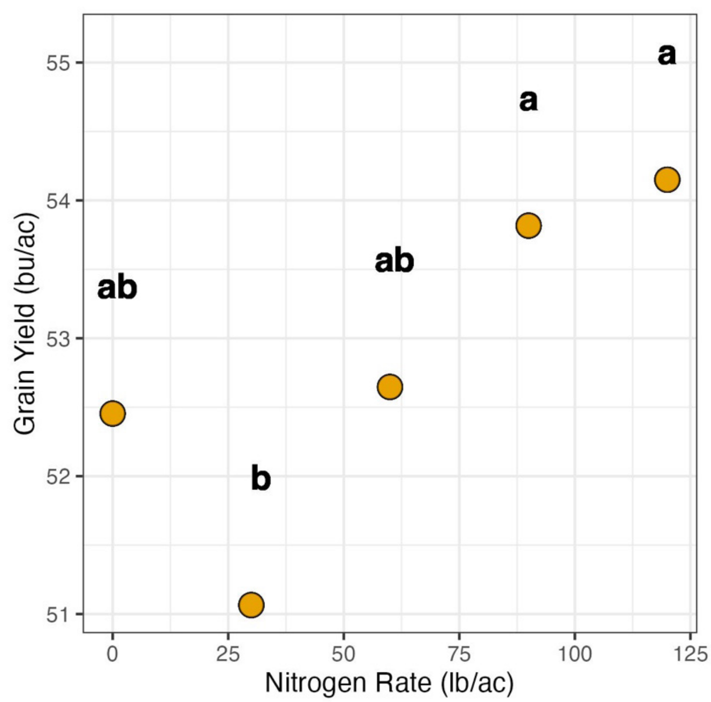

Figure 5. Wheat grain yield of the variety Larry in response to five nitrogen rates across six locations during the 2023-2024 wheat growing season in Kansas.