# Wheat Yield Response to Nitrogen Rate Depends on Foliar Fungicide Application

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## Summary

Nitrogen (N) and fungicide are among the most important factors impacting wheat yields in Kansas. However, there is limited information on whether foliar fungicides interact with N rates in wheat yield determination. Thus, our objectives were to evaluate wheat yield as impacted by different N rates with or without the use of foliar fungicide. One field experiment was established using a factorial structure of five N rates (0, 30, 60, 90, and 120 pounds of N per acre) by two fungicide management practices (either absent or 13 fluid ounces per acre of Nexicor) in a split-plot design near Hutchinson, KS, during the 2020–2021 wheat growing season. The variety Larry was planted at 90 pounds of seed per acre, N was the whole plot and fungicide was the subplot. There was a significant interaction between N and fungicide on winter wheat grain yield, where the benefit of fungicide was greater with higher N rates. In the absence of fungicide, wheat yields ranged from 51.1 bushels per acre in the zero N rate, to 68.5 bu/a in the highest N rate. Meanwhile, grain yield ranged from 57.3 bu/a when no N was applied, to 83.8 bu/a in the highest N rate. Despite higher yields when fungicides were applied, grain yield within fungicide treatment plateaued at the 90 pounds of N per acre rate. This experiment provided initial empirical evidence for the interaction between N management and fungicide. More field experiments are expected to validate this in future years.

## Introduction

A recent survey of management practices adopted in ~700 commercial fields in Kansas suggested that nitrogen (N) management and foliar fungicide applications were among the largest drivers of wheat yield (Jaenisch et al., 2021). This information was well aligned with a previous survey of practices adopted by wheat growers who entered their crop into the Kansas Wheat Yield Contest (Lollato et al., 2019a), reinforcing the importance of both variables for wheat yields in the state. Considering the large yield gap of winter wheat in this region (Lollato et al., 2017), further research is warranted on agronomic practices to increase yields.

Crop N requirement is linked to yield potential (de Oliveira Silva et al., 2020a, b); thus, higher yielding environments require greater N rates to optimize yield (Lollato et al., 2019b, 2021). Meanwhile, foliar fungicides protect the crop canopy, increasing solar radiation interception and grain yield (Jaenisch et al., 2019, 2022). Data-rich experiments suggested that, depending on environmental conditions during the growing

season and on cultivar susceptibility, winter wheat yield gain from fungicides in the US central Great Plains can range from -27 to +97% (Cruppe et al., 2017, 2021).

Reasons justifying potential interactions between N and fungicide include (1) that higher N rates can create a lusher canopy that decreases wind flow and creates a more favorable environment for disease development, and (2) that the crop receiving foliar fungicide may have a greater yield potential, thus increasing N requirements (Salgado et al., 2017). Therefore, our objectives were to explore the potential interaction between these two important yield-determining management factors for wheat in Kansas.

## Procedures

A two-way factorial experiment was conducted in a split-plot design near Hutchinson, KS, during the 2020–2021 winter wheat growing season. Whole plot treatments included five N rates (0, 30, 60, 90, and 120 pounds of N per acre) and sub-plots were either the presence or absence of a foliar fungicide application at heading. The foliar fungicide product used was Nexicor applied at 13 fluid ounces per acre.

The winter wheat variety Larry was sown at 90 pounds of seed per acre on October 8, 2020, in combination with 50 pounds of diammonium phosphate as starter fertilizer. The previous crop was soybeans and the field was established under no-tillage practices. The field was maintained weed-free using commercially available herbicides. No insect pressure was observed during the experiment. Nitrogen fertilizer treatments were established on March 10, 2021, at the spring tillering stage, and fungicide was applied on April 30, 2021, at the heading stage. Plots were harvested on June 22, 2021, using a Massey Ferguson 8 XP small plot combine.

One composite soil sample, consisting of 15 individual soil cores, was retrieved from each of the 0–6 and 6–24 inch depths at sowing. For each depth, the sample was analyzed for soil fertility and texture. Grain yield and grain moisture were measured at harvest maturity and yield was corrected to 13% moisture for statistical analysis. Data were analyzed using a two-way analysis of variance considering N rate, fungicide, and their interactions as fixed effects, and replication and N rate nested within replication as random effects.

## Results

### *Soil and Weather Conditions*

Although winter wheat in Kansas is often subjected to drought and heat stresses during important yield-determining portions of the season (Couedel et al., 2021; Lollato et al., 2020; Sciarresi et al., 2019), the 2020–2021 growing season in Hutchinson was favorable for good yielding conditions. Overall, 3.7 inches of fall precipitation ensured good crop establishment and average fall temperatures of 45.1°F promoted crop tillering (Table 1). A total of 12.2 inches of precipitation in the winter and spring helped with N incorporation into the soil profile and reduced potential impacts of drought stress. Mild temperatures (51.3 to 74.5°F) during the spring and early summer decreased the incidence of heat stress. Total $NO_3$-N in the soil profile at sowing was 57 pounds of N per acre (Table 2). We also note that the soil pH in the 0- to 6-inch depth was 4.7 in the study site (Table 2), which could have limited wheat yields in the study even for a tolerant variety (Lollato et al., 2019c).

### *Grain Yield*

Grain yield ranged from 51.1 to 83.8 bushels per acre across the different N rates and foliar fungicide treatments (Figure 1). Statistical analysis suggested a significant interaction between N rate and foliar fungicide (Table 3). Here, the benefit of fungicide was greater with higher N rates. In the absence of fungicide, wheat yields increased from 51.1 bu/a in the zero N rate to 65.9–68.5 bu/a in the 90 and 120 pounds of N per acre rates, respectively, with no statistical differences between the two highest rates. When fungicide was applied, grain yield increased from 57.3 bu/a when no N was applied, to 81.7–83.8 bu/a in the two highest N rates, which again did not differ statistically from each other. Interestingly, though not biologically meaningful, wheat grain yield with 30 pounds of N per acre and foliar fungicide (69.3 bu/a) was statistically the same as that receiving 90 or 120 pounds of N per acre in the absence of foliar fungicide.

### *Conclusions*

This experiment only reports on one site-year of data, so conclusions are preliminary. Nonetheless, we collected empirical evidence to support the hypothesis that nitrogen rates interact with foliar fungicide management. Further research will be performed to quantify the probability of these responses in a large number of Kansas environments.

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**Table 1. Weather data for the 2020–2021 winter wheat growing season at Hutchinson, KS**

| Season | Tmax (°F) | Tmin (°F) | Precip. (in.) | ETo (in.) |
|---|---|---|---|---|
| Fall* | 57.5 | 32.7 | 3.7 | 7.6 |
| Winter | 48.2 | 25.2 | 6.2 | 7.3 |
| Spring | 74.5 | 51.3 | 5.9 | 15.2 |

*Fall: Sowing to December 31. Winter: January 1 - March 31. Spring: April 1 to harvest date.

**Table 2. Soil pH, nitrate nitrogen ($NO_3$-N), Mehlich phosphorus (P), potassium (K), sulfur (S), organic matter (OM), and texture (percent sand, silt, and clay) for two different depths at the experimental site near Hutchinson, KS, during the 2020–2021 winter wheat growing season**

| Depth (in.) | pH | $NO_3$-N ppm | P-M ppm | K ppm | S ppm | OM % | Sand % | Silt % | Clay % |
|---|---|---|---|---|---|---|---|---|---|
| 0–6 | 4.7 | 8.9 | 71.2 | 212.6 | 11.3 | 2.1 | 36.00 | 42.00 | 22.00 |
| 6–24 | 5.7 | 4.4 | 21.2 | 189.3 | 11.0 | 2.0 | 34.00 | 40.00 | 26.00 |

**Table 3. Analysis of variance for winter wheat grain yield as affected by nitrogen rate, foliar fungicide management, and their interaction for a field experiment conducted during the 2020–2021 growing season near Hutchinson, KS**

| Effect | Num. DF | Den. DF | F Value | Pr > F |
|---|---|---|---|---|
| N rate | 4 | 24 | 118.26 | <.0001 |
| Fungicide | 1 | 3 | 49.39 | 0.0059 |
| N rate × Fungicide | 4 | 24 | 8.98 | 0.0001 |

DF = degrees of freedom. Num. = numerator. Den. = denominator.

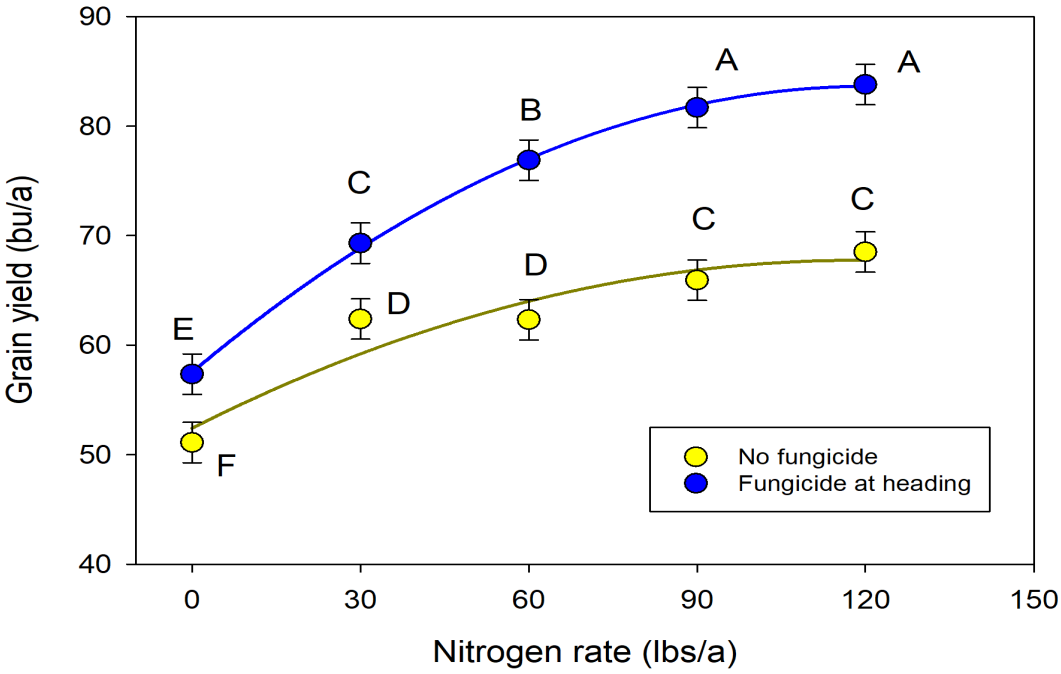


**Figure 1. Winter wheat grain yield as function of nitrogen rate and foliar fungicide application during the 2020–2021 growing season near Hutchinson, KS. Means followed by the same letter are not statistically different at $P < 0.05$.**