

# Plant Population and Fungicide Treatment Reduce Winter Wheat Yield Gap in Kansas

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## Abstract

Despite the large winter wheat yield gap in Kansas, limited research is available on integrated agronomic practices to increase grain yield. Our objective was to quantify the contribution of individual and combined management practices to reduce wheat yield gap. An incomplete factorial treatment structure established in a randomized complete block design was conducted in three locations in Kansas during 2016–2017 to evaluate the impacts of 14 treatments on yield and grain protein concentration of the modern wheat variety ‘Everest.’ We individually added six treatments to a low-input standard control or removed from a high-input intensive control, which received all treatments. Treatments were: additional nitrogen, sulfur or chloride, increased plant population, foliar fungicide, and plant growth regulator. In Manhattan, the intensive control increased grain yield by 6 bu/a as compared to the standard control, mostly led by additional nitrogen, sulfur, increased population, and fungicide (3–6 bu/a). In Belleville and Hutchinson, foliar fungicide increased grain yield on average by 19 bu/a. Additional nitrogen was the only treatment that increased grain protein concentration across all locations. Our results suggest that integrated pest management should be preferred over an intensive program with prophylactic pesticide application.

## Introduction

The last two winter wheat growing seasons in Kansas were characterized by above average yields, with 57 and 47 bu/a in 2015–16 and 2016–2017, respectively. However, these yields are below the long-term yield potential of 75 bu/a. Thus, further research is needed to determine which management strategies will help narrow this yield gap. Our hypothesis is that improved management can largely contribute to closing wheat yield gaps in Kansas. Our objectives were to quantify the partial contribution of different management strategies, including fertilization, plant population density, fungicide, and growth regulator applications, all individually or in combination to close the wheat yield gap in central Kansas.

## Procedures

Field studies were conducted as a randomized complete block design with an incomplete factorial treatment structure and six replications at three locations during the growing season of 2016–2017. Locations included the North Central Kansas Experiment Field in Belleville, the South Central Experiment Field in Hutchinson, and the North Agronomy Farm in Manhattan, KS. The trial was conducted under rainfed conditions at all locations and sown to the wheat variety Everest. Seed was treated with

5 oz. Sativa IMF Max across the entire study so fungicide or insecticide seed treatment was not a limiting factor. Soil samples were taken for soil nutrient analysis at sowing at each location for the 0–6 and 6–24-in. soil depths, and analyzed by the Kansas State University Soil Testing Laboratory.

The treatment combinations were set up with two control treatments: a standard “farmer practice” and an intensive “kitchen sink” management approach. Yield goals in these treatments were 70 and 120 bu/a, respectively. Agronomic management strategies that were modified from the standard to the intensive treatment and also evaluated individually consisted of high vs. low seeding rate (110 vs. 75 lb/a), nitrogen at planting and top-dressed (Feekes 3-4) vs. additional 100 lb N/a nitrogen applied early spring (Feekes 5-6), sulfur or chloride applied during Feekes 5-6, two foliar fungicide applications (Feekes 6-7, 10.5), and growth regulator (Feekes 6-7). The standard control consisted of: low seeding rate and N applied at planting and top-dressed for a yield goal of 70 bu/a. Next, treatments were added individually to the standard control totaling six low-input treatments plus a control (Table 1). The intensive control consisted of: nitrogen applied at planting and top-dressed similarly to the standard treatment, an additional 100 lb of nitrogen/a at Feekes 6, high seeding rate, sulfur, chloride, two applications of fungicide, and growth regulator. Conversely, treatments were removed individually from the intensive approach for a total of an additional six high-input treatments plus a control (Table 1). A total of 14 treatment combinations was evaluated in this study. Plants were harvested using a small plot combine, and grain moisture was corrected for 13.5% moisture content. Protein content was measured using near-infrared spectrometry. In this report, we discuss the effects of the treatments on wheat grain yield and protein content.

## Results

In 2016–2017, all locations received more than 16 inches precipitation during the growing season, which is considered greater than the minimum necessary to maximize wheat yields. In addition, below average temperature during grain fill (May and early June) resulted in grain yields as high as 97, 101, and 84 bu/a at Belleville, Hutchinson, and Manhattan, respectively. Likewise, split nitrogen significantly affected grain protein concentration across all three locations.

### *Grain Yield*

Across all locations, treatment applications resulted in significant differences for grain yield (Table 2). Due to the cool and moist conditions in April and May, stripe rust had high levels of infestation in central Kansas. Thus, foliar fungicide increased grain yield by an average of 19 bu/a in Belleville and Hutchinson. Likewise, the removal of nitrogen from the intensive control resulted in a yield decrease of 11 bu/a. In Belleville, no other treatments significantly increased or decreased yields from their respective control. However, additional nitrogen, sulfur, and plant population significantly affected yields in Manhattan, where the trial was conducted under no-till and had less severe disease pressure.

In Belleville, grain yield for the standard control consisted of 77 bu/a and addition of individual treatments resulted in no significant differences in grain yield. However, the removal of fungicide from the intensive control decreased yield from 90 bu/a

to 70 bu/a. Following a similar trend, the standard control yielded 74 bu/a and the addition of fungicide increased yields to 90 bu/a in Hutchinson. The removal of split nitrogen and fungicide from the intensive control decreased yields from 100 bu/a to 90 and 71 bu/a, respectively. Grain yield in Manhattan did not follow the same trend as Belleville and Hutchinson. Increased plant population increased grain yield to 79 bu/a from 73 bu/a for the standard control. However, the removal of additional nitrogen, sulfur, and increased plant population decreased yields from 84 bu/a for the intensive control to 74, 74, 77 bu/a, respectively.

### ***Grain Protein Concentration***

Across all locations, additional 100 lb of N/a applied as split nitrogen during Feekes GS 6 was the only treatment that consistently affected grain protein (Table 3). In Belleville, additional nitrogen and fungicide increased grain protein from the standard control of 11.0 to 11.8% and 11.5%, respectively. Likewise, the removal of additional nitrogen and fungicide decreased grain protein to approximately 12.0% as compared to 13.0% for the intensive control. Grain protein concentration in Hutchinson and Manhattan followed a similar trend to those measured in Belleville. Grain protein increased from 9.3 to 11.9% and 9.6% from additional nitrogen and plant growth regulator, respectively in Hutchinson. However, only the removal of additional nitrogen decreased grain protein from 12.3% for the intensive control to 9.3%. Split nitrogen increased grain protein for the standard control from 11.9 to 12.7%, and the removal of additional nitrogen decreased grain protein to 12.2% as compared to 13.1% for the intensive control in Manhattan.

### ***Conclusions***

Due to severe stripe rust infestations, foliar fungicide increased grain yield by an average of 19 bu/a at Belleville and Hutchinson. In Manhattan, the no-till conditions resulted in a yield increase resulting from additional nitrogen, sulfur, and increased plant population. Additional nitrogen consistently increased grain protein at all locations. Wheat grain yield was increased by an intensive approach; however, this was not economical. This demonstrates that an integrated approach should be adopted by producers.

### ***Acknowledgments***

We acknowledge and appreciate Andrew Esser, Gary Cramer, and Dustin Ridder for helping us with project establishment, production, and harvest at the experiment fields. We also appreciate the Kansas Wheat Commission for the funding to allow us to conduct this research, DuPont for partial funds to support research and for providing the fungicide products Aproach and Aproach Prima used in this study. We also acknowledge Syngenta for providing the Palisade growth regulator used in this study.

**Table 1. Standard and intensive treatments were the low and high input controls, respectively**

Treatment	Description	Rate
1-Standard	75 lb/a, top-dress N at Feekes GS 3	Yield goal: 70 bu/a
2	+ Split nitrogen at Feekes GS 5	+ 120 lb N/a
3	+ Sulfur at Feekes GS 5	+ 40 lb S/a
4	+ Chloride at Feekes GS 5	+ 40 lb Cl/a
5	+ Plant population	110 lb/a
6	+ Fungicide at Feekes GS 6 and 10.5	+ 2 applications
7	+ Growth regulator at Feekes GS 6	+ 1 application
8- Intensive	All treatments 2-7 combined	Yield goal: 120 bu/a
9	- Split nitrogen	- 120 lb N/a
10	- Sulfur	- 40 lb S/a
11	- Chloride	- 40 lb Cl/a
12	- Plant population	110 lb/a
13	- Fungicide	- 2 applications
14	- Growth regulator	- 1 application

Description of the individual treatment strategy for each addition (+) or removal (-) of an input from the respective control.

**Table 2. Average winter wheat grain yield as affected by management strategy and by addition or removal of individual treatments from the standard and intensive controls, respectively, for the 2016–2017 growing seasons in Belleville, Hutchinson, and Manhattan, KS**

Treatment		2016–2017		
Management strategy	Exception	Belleville	Hutchinson	Manhattan
		----- bu/a -----		
Standard	None	77	74	73
Standard	+ Split nitrogen	72	75	72
Standard	+ Sulfur	75	78	74
Standard	+ Chloride	77	78	73
Standard	+ Plant population	82	68	79*
Standard	+ Fungicide	86	90*	73
Standard	+ Plant growth regulator	73	70	68
Intensive	None	90	101	84
Intensive	- Split nitrogen	93	90*	74*
Intensive	- Sulfur	95	102	74*
Intensive	- Chloride	89	99	81
Intensive	- Plant population	83	100	77*
Intensive	- Fungicide	70*	71*	79
Intensive	- Plant growth regulator	97	100	83

\*Indicates significance at the 0.05 probability as compared to the respective control ('Standard' or 'Intensive').

**Table 3. Average winter wheat grain protein concentration as affected by management strategy and by addition or removal of individual treatments from the standard and intensive, respectively, for the 2016–2017 growing seasons in Belleville, Hutchinson, and Manhattan, KS**

Treatment		2016–2017		
Management strategy	Exception	Belleville	Hutchinson	Manhattan
		----- % -----		
Standard	None	11.0	9.3	11.9
Standard	+ Split nitrogen	11.8*	11.9*	12.7*
Standard	+ Sulfur	11.2	9.3	11.5
Standard	+ Chloride	11.1	9.3	11.7
Standard	+ Plant population	10.9	9.3	11.6
Standard	+ Fungicide	11.5*	9.3	11.9
Standard	+ Plant growth regulator	11.7	9.6*	11.7
Intensive	None	13.0	12.3	13.1
Intensive	- Split nitrogen	12.0*	9.3*	12.2*
Intensive	- Sulfur	13.1	12.3	13.0
Intensive	- Chloride	13.0	12.4	12.8
Intensive	- Plant population	13.1	12.3	13.2
Intensive	- Fungicide	12.3*	12.0	13.1
Intensive	- Plant growth regulator	12.7	12.2	13.0

\*Indicates significance at the 0.05 probability as compared to the respective control ('standard' or 'intensive').