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## Cover Page Footnote

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

# Intensive Management Strategies to Close Wheat Yield Gaps in Central Kansas

*B.R. Jaenisch and R.P. Lollato*

## Introduction

Winter wheat is the most widely sown crop in Kansas, and yields had not surpassed 50 bushels per acre until 2015-16, when average state wheat yield was 57 bushels per acre. However, recent estimates of the long-term winter wheat yield potential in central Kansas indicate that it lies around 75 bushels per acre. A particular crop's yield gap in a given region is determined by the difference between potential and actual yields. The long-term yield gap in Kansas is approximately 45 bushels per acre, which corresponds to more than 50% of the yield potential. Yield gaps have the potential to be economically reduced to approximately 30%. The two possible ways to reduce yield gaps are through improved agronomic management or increasing yield potential through improved genetics. Our hypothesis is that improved management can largely contribute to closing wheat yield gaps in central Kansas. Our objectives were to quantify the partial contribution of different management strategies toward closing the wheat yield gap in central Kansas, including fertilization, plant population density, fungicide, and growth regulator applications, all individually or in combination.

## 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 2015-16. 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 the wheat variety Everest was sown. 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 6-18 inch 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 bushels per acre, 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 pounds per acre), nitrogen (N) at sowing and top-dressed (Feekes 3-4) vs. additional 100 pounds N per acre 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 sowing and top-dressed for a yield goal of 70 bushels per acre. 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 sowing and top-dressed similarly to the standard treatment, an additional 100 pounds of nitrogen per acre 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 were 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

The weather at all three locations had a warm and moist fall, followed by a mild and dry winter, and a cool and moist spring. A total of 20 inches of precipitation occurred in Hutchinson, 18.2 inches in Belleville, and 23.4 inches in Manhattan during the growing season. Late winter (late February/early March) drought hindered some of the yield potential as dry fertilizers were not dissolved into the soil profile and root zone in a timely manner and spring tillering was delayed. However, the cool and moist spring observed from mid-April until physiological maturity provided excellent grain filling conditions for the wheat crop.

## *Grain Yield*

Significant differences in grain yield occurred among the locations during the 2015-16 growing season, and significant treatment effect occurred at all locations. Belleville averaged the highest yield among the three locations, averaging 86 bushels per acre. Hutchinson and Manhattan followed Belleville, averaging 59 and 57 bushels per acre, respectively. The main reason for the reduced yields in Hutchinson was the delayed sowing of October 29, 2015, which is considered late for that area. Late sowing dates reduce the amount of fall-produced tillers, which may directly affect the number of heads per plant.

Belleville and Hutchinson both experienced yield increases resulting from the application of foliar fungicide due to significant amount of spring precipitation, which promoted a severe incidence of stripe rust. Foliar fungicide protected the canopy from injury and significantly improved grain yield increase. On the other hand, split-nitrogen application and increased plant population resulted in a significant improvement in grain yield increase in Manhattan. The increased grain yield resulting from both of these management practices can be partially attributed to the no-till farming system adopted in this location, which increased the surface residue and inhibited the achievement of a good seed to soil contact, warranting increased plant population. Additionally, the high N immobilization rates typically experienced from broadcast N into heavy residue, as well as by soil microbes, can partially explain the yield gain from increasing N rate. Additionally, minimal rainfall occurred after the fertilizer application, allowing for some of the urea to be lost by volatization.

In Belleville, the standard low-input control had a grain yield of 52 bushels per acre, which was similar to all six treatments with individual additions to the standard control, except the addition of two fungicide applications, which significantly increased grain yield to 78.4 bushels per acre (Figure 1). The intensive treatment had a grain yield of 84 bushels per acre, which was statistically the same to the standard treatment plus fungicide. This yield was greater than the removal of fungicide from the intensive treatment, which significantly decreased the yield to 55 bushels per acre. Grain yield response to treatments in Hutchinson followed the same trend as Belleville, where fungicide was the only significant factor. The standard treatment resulted in a yield of 37.8 bushels per acre, and the addition of fungicide significantly increased grain yield to 49.8 bushels per acre. The intensive treatment had a grain yield of 51.2 bushels per acre and was statistically similar to all treatment removals from the intensive, except the removal of fungicide which significantly reduced the yield to 32.5 bushels per acre. In Manhattan, the standard treatment had a yield of 47.6 bushels per acre with no significant differences within the standard treatment additions. However, the intensive treatment had a yield of 49.9 bushels per acre, and the removal of split-nitrogen, sulfur, plant population, or fungicide significantly reduced yields to 42.6, 46.1, 45.4, and 46.1 bushels per acre, respectively.

### *Grain Protein Concentration*

In Belleville, wheat protein concentration for the standard treatment averaged 11.6% and was statistically the same as to all other standard treatments, except for the spilt-nitrogen and the growth regulator additions, which significantly increased protein concentration at 12.1 and 12% (Figure 1). Wheat protein concentration averaged 12.3% for the intensive treatment; however, removing the split-nitrogen significantly lowered the protein concentration to 11.6%. The standard treatment for Hutchinson resulted in an average of 12.4% wheat protein concentration, and the fungicide application significantly increased the protein concentration by 1%. Likewise, the intensive treatment had an average wheat protein concentration of 13.8%, with no significant differences recorded among the other intensive management treatments. In Manhattan, average protein concentration was 11% in the standard treatment and was statistically the same as all other standard management strategies, except when the split-nitrogen was added, which significantly increased the protein concentration to 11.9%. The intensive treatment resulted in protein concentration of 12.1%, removal of split-nitrogen application was the only factor that significantly decreased the protein concentration, resulting in 11.1%.

### *Preliminary Conclusions*

With the high year-to-year environmental variability, three site-years are not enough to make definite recommendations based on an intensive vs. standard management strategy. However, some tendencies can be identified across the studied locations. For instance, fungicide significantly increased yields in heavy-disease years, and nitrogen and plant population were more important factors in no-till conditions. For two studied locations, Belleville and Hutchinson, fungicide increased yield and test weight. Because of a severe outbreak in stripe rust for the growing season, fungicide application resulted in more than 25 bushel per acre yield gain in Belleville and over 15 bushel per acre in Hutchinson. The no-till conditions experienced in Manhattan resulted in a yield gain from the split-nitrogen application and the increased plant population. Regarding

wheat protein concentration, additional N seems to be the leading factor, as the application of 100 pounds of N per acre raised the protein concentration for all three studied locations.

## Acknowledgments

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**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 bushels/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 bushels/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.
N = nitrogen.
GS = growth stage.
S = sulfur.
Cl = chloride.

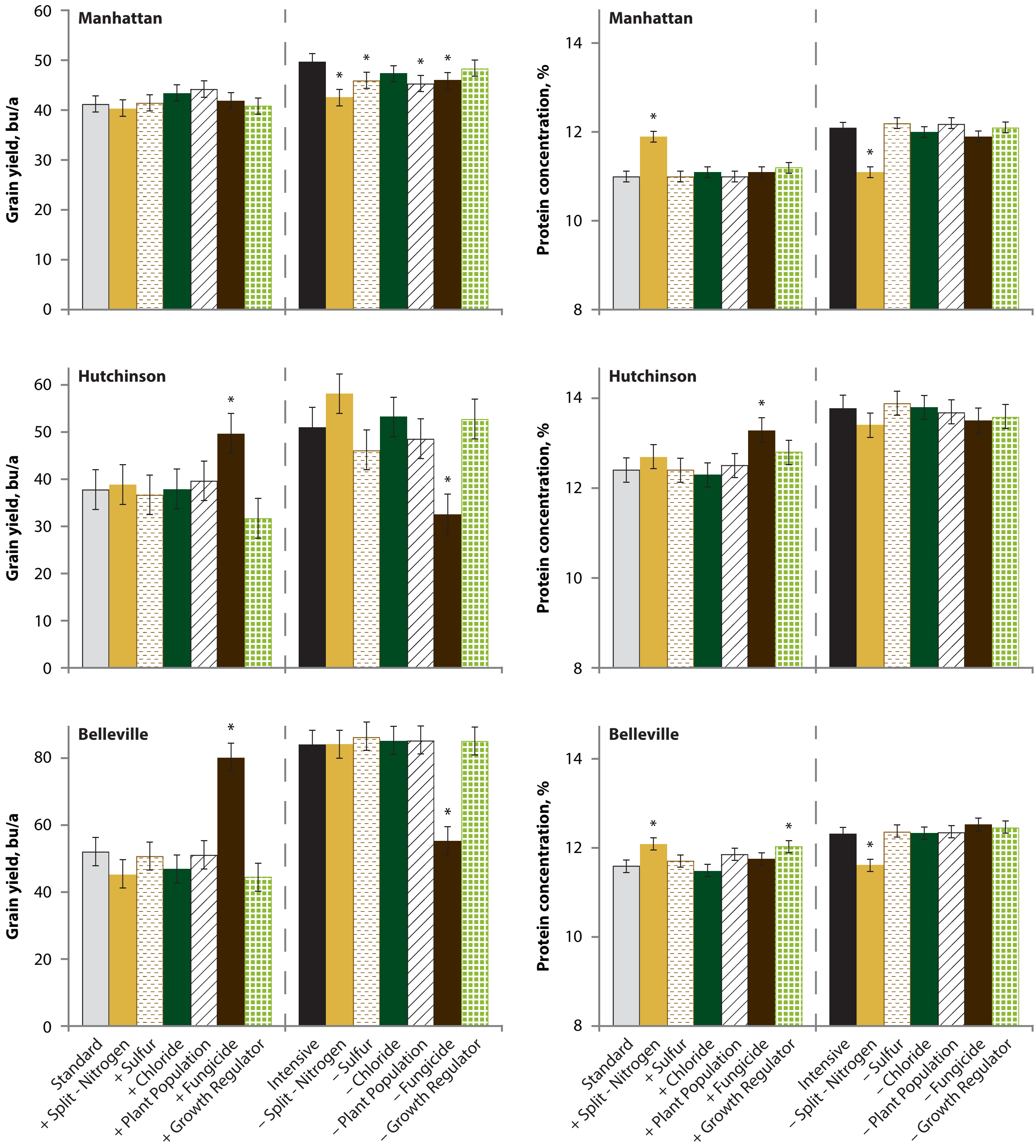


**Figure 1. Winter wheat grain yield (left panels) and grain protein concentration (right panels) as affected by management strategies in Manhattan, Hutchinson, and Belleville, KS, during the 2015-16 growing season. Dashed lines separate the two treatment controls (standard and intensive), which were analyzed separately; asterisk (*) indicates significance at $P < 0.05$ from the respective control.**