Kansas Agricultural Experiment Station Research Reports

Volume 5
Issue 6 *Kansas Field Research*

Article 14

2019

Integrated Wheat Management for Improved Wheat Yield and Protein in Kansas

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Recommended Citation

Jaenisch, B. R. and Lollato, R. P. (2019) "Integrated Wheat Management for Improved Wheat Yield and Protein in Kansas," *Kansas Agricultural Experiment Station Research Reports*: Vol. 5: Iss. 6. https://doi.org/10.4148/2378-5977.7786

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Abstract

In Kansas, seven to nine million acres of winter wheat are sown annually with grain yields averaging about 40 bu/a. Variety selection and management strategies are critical decisions to maximize wheat yield. Thus, the main objective of this experiment was to evaluate four wheat varieties and their response to six management strategies at three locations in Kansas. These strategies included a farmer practice, enhanced fertility, economical intensification, increased foliar protection, water-limited yield, and increased plant productivity. Locations were pooled based on tillage practice and environment within Kansas; conventional till in central (Hutchinson and Belleville), and no-till in western (Leoti). In the conventional till analysis, enhanced fertility increased grain yield from 63 bu/a in the farmer practice to 72 bu/a and no other management strategy further increased yields. Thus, WB4303, WB4458, and WB-Grainfield produced a similar grain yield of 72 bu/a; however, Zenda yield was less (68 bu/a). The water-limited yield treatment increased protein concentration from 11.7% in the farmer practice to 14.1%. Protein concentration was 13.1% and 13.6% for WB-Grainfield and WB4303, respectively. In the no-till analysis, the farmer practice and increased plant productivity yielded 51 bu/a and the enhanced fertility increased yields to 64 bu/a. Joe yielded 61 bu/a, which was significantly greater than WB4458 and Byrd (~57 bu/a). In the conventional till, farmer practice measured a protein concentration of 11.2%, which was increased to 12.8% and 13.2% by enhanced fertility and increased plant productivity, respectively. The wheat varieties WB-Grainfield, Joe, and Byrd all had a protein concentration of 12.4%, and WB4458 increased protein concentration to 13.3%. The grain yield and protein concentration of different varieties responded to increases in management input intensity depending on tillage practices and environments. Improved agronomic management based on variety-specific characteristics can help increase wheat productivity in Kansas.

Keywords

wheat, intensive management, fungicide, nitrogen, micronutrients, plant population

Cover Page Footnote

We thank Andrew Esser, Keith Thompson, and Horton Seed Services 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 experiment. We also acknowledge the Kansas State University Winter Wheat Production Program staff for their hard work and assistance in the project.

Integrated Wheat Management for Improved Wheat Yield and Protein in Kansas

B.R. Jaenisch and R.P. Lollato

Summary
In Kansas, seven to nine million acres of winter wheat are sown annually with grain yields averaging about 40 bu/a. Variety selection and management strategies are critical decisions to maximize wheat yield. Thus, the main objective of this experiment was to evaluate four wheat varieties and their response to six management strategies at three locations in Kansas. These strategies included a farmer practice, enhanced fertility, economical intensification, increased foliar protection, water-limited yield, and increased plant productivity. Locations were pooled based on tillage practice and environment within Kansas; conventional till in central (Hutchinson and Belleville), and no-till in western (Leoti). In the conventional till analysis, enhanced fertility increased grain yield from 63 bu/a in the farmer practice to 72 bu/a and no other management strategy further increased yields. Thus, WB4303, WB4458, and WB-Grainfield produced a similar grain yield of 72 bu/a; however, Zenda yield was less (68 bu/a). The water-limited yield treatment increased protein concentration from 11.7% in the farmer practice to 14.1%. Protein concentration was 13.1% and 13.6% for WB-Grainfield and WB4303, respectively. In the no-till analysis, the farmer practice and increased plant productivity yielded 51 bu/a and the enhanced fertility increased yields to 64 bu/a. Joe yielded 61 bu/a, which was significantly greater than WB4458 and Byrd (~57 bu/a). In the conventional till, farmer practice measured a protein concentration of 11.2%, which was increased to 12.8% and 13.2% by enhanced fertility and increased plant productivity, respectively. The wheat varieties WB-Grainfield, Joe, and Byrd all had a protein concentration of 12.4%, and WB4458 increased protein concentration to 13.3%. The grain yield and protein concentration of different varieties responded to increases in management input intensity depending on tillage practices and environments. Improved agronomic management based on variety-specific characteristics can help increase wheat productivity in Kansas.

Introduction
In Kansas, seven to nine million acres of winter wheat are sown annually with an average grain yield of about 40 bu/a. Variety selection and management strategies are critical decisions to maximize wheat yield and protein concentration. First, a variety has to be adapted to the specific environment (good yield record) and have other desirable agronomic traits such as high yield potential, strong straw strength, disease resistance, acid soil tolerance, or heat or drought stress tolerance. However, with many

wheat varieties currently on the market, detailed information about how individual varieties respond to management is not available. Likewise, most of the wheat research conducted in Kansas and in the Great Plains has been performed under standard management levels and average yield conditions, with very few efforts to characterize how intensifying wheat management might improve crop yields. For instance, Jaenisch et al. (2019) reported that foliar fungicides were effective tools to improve wheat yield and profitability under disease-conducive environments, and higher seeding rates in no-till, lower yielding environments. Meanwhile, Lollato et al. (2019) suggested that wheat yield response to seeding rate was null in high yielding environments, with extremely low populations allowing for achievement of high yields. These gaps warrant further research to evaluate variety-specific performance in a range of environments and their response to different management strategies.

Materials and Methods

Field experiments were conducted in a split-plot design with four replications for the growing season of 2018. Treatments were arranged in complete factorial structure with whole plot as management and sub-plot as winter wheat variety. Locations included North Central Experiment Field in Belleville (moderately well-drained Crete silt loam, 0–1% slopes,), South Central Experiment Field in Hutchinson (well-drained Ost loam, 0–1% slopes), and Horton Seed Services in Leoti (well-drained Richfield silt loam, 0–1% slopes). All locations were grown under rainfed conditions and were chosen to help capture the variability in the environment throughout central and western Kansas and its role on maximizing winter wheat yields.

Wheat was sown into fallow conditions (no crop in the past 10–14 months) with a Great Plains 506 no-till drill (7 rows spaced at 7.5 inches) with plot dimensions of 4.375-ft wide × 30-ft long at all locations. Seed was treated with 5 oz Sativa IMF Max across the whole study so fungicide or insecticide was not a limiting factor. Conventional till sites included Belleville and Hutchinson (field cultivated multiple times prior to sowing), and conversely, Leoti was no-till following fallow after a grain sorghum crop.

In the fall of 2017, soil samples were taken at sowing at each location for soil nutrient analysis. Samples were taken by a hand push probe at two depths, 0–6 in. and 6–24 in., and a total of 15 cores were pulled per depth and combined to represent a composed sample at each location. Weeds were controlled to ensure they were not limiting factors by a pre- and post-emergence herbicide application. Insect pressure was not experienced in 2018.

Treatment combinations were designed to represent an integrated systems approach that a producer may perform during the growing season. Thus, four winter wheat varieties were sown at each location and these varieties were evaluated for their response to six management strategies. Wheat varieties were selected based on their adaptability to dryland cropping systems and response to management. In conventional till, varieties seeded were WB4303, WB4458, WB-Grainfield, and Zenda. No-till varieties seeded included Byrd, WB4458, WB-Grainfield, and Joe. Management strategies included a farmer practice (FP), enhanced fertility (EF), economical intensification (EI), increased foliar protection (IFP), water limited yield potential (Y_w), and increased plant productivity (IPP). The FP consisted of a seeding rate of 1.1 million seeds/a and nitrogen (N) application for a yield goal of the ten-year county wheat grain yield average. Enhanced fertility consisted of 100 lb of MESZ/a placed with the seed and additional N for a 100 bu/a yield goal applied at Feekes 3. Economical intensification consisted of EH plus one fungicide application at Feekes 10.5. Increased foliar protection consisted of EH plus two fungicide applications at Feekes 6 and 10.5. Water-limited yield potential consisted of IPP plus a micronutrient (sulfur, zinc, manganese, boron) application at Feekes 6. Increased plant productivity consisted of Y_w; however, the seeding rate was reduced to 430,000 seeds/a. A detailed description of treatments is in Table 1.

A pressurized CO_2 backpack sprayer with a three-nozzle boom was used to apply the N, fungicide, and micronutrients. Thus, N was applied with a streamer nozzle (SJ3-03-VP), and the rate varied between locations due to the N carryover from the previous growing season. Likewise, the backpack sprayer was used with a flat fan (XR11002) to apply a single or dual fungicide and micronutrient applications. Single fungicide was applied at 7 oz/a, dual fungicide at 13 oz/a, and micronutrient at 2 gal/a, respectively with a constant volume of 15 gallons of water/a.

Results

Weather

The 2017–18 wheat growing season had a cold and dry winter and early spring, and a hot and dry late spring/early summer. The drought and cool temperatures kept the wheat crop dormant until late April and the reduced rainfall in the spring reduced spring tillering and incorporation of fertilizer in the root zone, thus decreasing spikes per foot. Belleville and Hutchinson received 60% and 55%, respectively, of their annual rainfall during the growing season. Likewise, Leoti received 75% of its annual rainfall for the season, but two inches of rainfall were received a week before harvest when the crop was already mature. Not considering this rainfall, the total was 41% for the growing season. Temperatures were above normal for May and June, thus crop development was accelerated in the later part of the cycle, which decreased yield potential as grain filling was reduced. This experiment was sown into fallow to measure the genetic potential of these varieties, and the yields were above normal. . Wheat yields ranged from 63–75 bu/a in Belleville and Hutchinson and 51–64 bu/a in Leoti.

Wheat Grain Yield

A significant treatment effect for grain yield occurred for both variety and management but not the interaction, at all locations. In the conventional till, EF increased grain yield from 63 bu/a for the FP to 72 bu/a and no other management strategy further increased yields (Table 2). Interestingly, decreasing plant population to 430,000 seeds/a as compared to 1.1 million seeds per acre did not reduce wheat yield. This was likely due to a combination of high fertility and pesticide inputs and planting in the early side of the optimum sowing date (see comparison between 'Water limited yield' and 'Increased plant productivity' in Table 2). The varieties WB4303, WB4458, and WB-Grainfield all had statistically similar yields of approximately 72 bu/a; however, Zenda resulted in a lower yield of 68 bu/a.

In the no-till, management strategies responded differently than the conventional till. The FP and IPP both had the lowest yield of 51 bu/a, suggesting that reducing plant population in this location was detrimental to yields. This was likely because the location was planted in the later portion of the optimum planting date due to above average rainfall in the early portion. The EH and EI increased yields to 64 and 62 bu/a, respectively. However, the Y_w produced yields of 60 bu/a which was lower than EH, EI and IFP. The variety Joe yielded 61 bu/a, which was significantly higher than WB4458 and Byrd that produced yields of 58 and 57 bu/a, respectively. WB-Grainfield produced the lowest yield of 55 bu/a in the no-till.

Grain Protein Concentration

A significant treatment effect for grain protein concentration was measured for both main effects of variety and management but not for the interaction. In the conventional till, the Y_w increased grain protein concentration from 11.7% in the FP to 14.1%, and the EH, IFP, and IPP produced a similar protein concentration. WB-Grainfield and WB4303 measured the lowest (13.1%) and highest (13.6%) protein concentrations across all wheat varieties, respectively. WB4458 produced a similar protein to WB4303 and Zenda produced similar protein to WB-Grainfield. In the no-till, grain protein concentration was 11.2% for the FP and increased to 12.8% by the EH, EI, IFP, and Y_w, then further increased to 13.2% by the IPP. The wheat varieties WB-Grainfield, Joe, and Byrd all produced a similar protein concentration of 12.4%, however, WB4458 had greater protein concentration (13.3%).

Preliminary Conclusions

These preliminary results suggested that seeding rates can be reduced when high inputs are provided, but for this system to work, sowing needs to occur in the early portion of the optimal season. Also, moisture is required to ensure tillering and spike number. Different varieties responded similarly to input levels, but had different yield potentials; thus, careful evaluation of long-term and several locations of variety performance data are needed to justify variety selection. Protein concentration increased mainly due to the greater fertilizer amount in the EF treatment. Varieties differed in protein concentration; thus, if a producer has the opportunity to receive a premium for high protein wheat, variety selection for this trait should also be considered. This experiment reinforced the use of integrated management strategies, and sheds new information on the production of tillering/spike capacity and protein concentration of these varieties.

Acknowledgments

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Table 1. Treatment description of six management strategies studied for possible options to increase wheat yield.

	Management strategy					
Treatments	FP	EF	EI	IFP	Y_w	IPP
Nitrogen application for yield goal, bu/a	40	100	100	100	100	100
Seeding rate, million seeds/a	1.1	1.1	1.1	1.1	1.1	0.43
In-furrow starter fertilizer	No	Yes	Yes	Yes	Yes	Yes
Fungicide	No	No	1x	2x	2x	2x
Micronutrients	No	No	No	No	1x	1x

FP = farmer practice. EF = enhanced fertility. EI = economical intensification. IFP = increased foliar protection. Y_w = water-limited yield potential. IPP = increased plant productivity.

Table 2. Average winter wheat grain yield (bu/a) and wheat grain protein concentration (%) as affected by management strategy and winter wheat varieties for the conventional till (Belleville and Hutchinson), and no-till (Leoti) for the 2017–18 Kansas growing season

	2017–18			
Treatment	No-till	Conventional till	No-till	Conventional till
	---------------- bu/a ----------------		----------------- % -----------------	
Management strategy				
Farmer practice	51±2†c‡	63±3b	11.2±0.2c	11.7±0.3c
Enhanced fertility	64±2a	72±3a	12.8±0.2b	13.6±0.3ab
Economical intensification	62±2ab	74±3a	12.8±0.2b	13.4±0.3b
Increased foliar protection	60±2ab	72±3a	12.9±0.2ab	13.8±0.3ab
Water limited yield potential	60±2b	75±3a	12.9±0.2ab	14.1±0.3a
Increased plant productivity	51±2c	74±3a	13.2±0.2a	13.6±0.3ab
Winter wheat varieties				
Zenda	NA	68±2b	NA	13.3±0.2bc
WB4303	NA	72±2a	NA	13.6±0.2a
WB-Grainfield	55±1c	72±2a	12.4±0.1b	13.1±0.2c
WB4458	58±1b	73±2a	13.3±0.1a	13.5±0.2ab
Joe	61±1a	NA	12.4±0.1b	NA
Byrd	57±1b	NA	12.4±0.1b	NA

†Standard error of the difference.

‡Letter differences indicate that treatment was significantly different at $P < 0.05$ from the other treatments within the same column under each respective treatment of either management strategy or winter wheat variety.

Winter wheat varieties sown were KSU Zenda, WB 4303, WB Grainfield, and WB 4458 in conventional till, and WB Grainfield, WB 4458, CSU Byrd, and KSU Joe in no-till. Management strategies evaluated were farmer practice, enhanced fertility, economical intensification, increased foliar protection, water-limited yield potential, and increased plant productivity.