

Wheat Variety-Specific Response to Seeding Rate Under Intensive Management Conditions in Western Kansas in 2019–2020

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Summary

Wheat response to seeding rate is variable and depends on resource availability during the growing season (e.g., fertility, moisture, and temperature). Our objective was to evaluate winter wheat population and grain yield responses to seeding rate and its interaction with variety in a highly-managed production system where manageable stresses were limited. One experiment evaluating the response of the wheat varieties Joe, WB-Grainfield, Langin, and LCS Revere to seeding rates ranging from 200,000 to 1,000,000 seeds per acre was established in a field managed by growers that consistently win state and national wheat yield contests near Leoti, KS. The trials were established on September 25, 2019, after a long fallow. The growing season was extremely dry, with only 6.3 inches of cumulative precipitation (corresponding only to 15% of atmospheric water demand). Stand count increased with increases in seeding rate but final population was closer to the target under low populations. Varieties differed statistically in grain yield but all varieties responded similarly to seeding rate. The lowest yield was recorded across varieties in the treatment with 200,000 seeds/a, with the treatments ranging from 400,000 to 1,000,000 seeds/a all resulting in the same yield level. The variety WB-Grainfield underperformed the other varieties, likely due to more damage from a spring freeze occurring in April 2020. These results suggest that wheat grain yield responses to seeding rate were not dependent on variety, with optimum seeding rates as low as 400,000 seeds/a. We note that increasing seeding rates past this point led to numerical, but not statistical, increases in yield.

Introduction

Wheat responses to seeding rate are inconsistent, ranging from quadratic (Holliday, 1960) to positive linear, quadratic-plateau, plateau-negative linear, and even inexistent (Whaley et al., 2000; Lloveras et al., 2004; Jaenisch et al., 2019; Fischer et al., 2019; Lollato et al., 2019). The quadratic response suggests that there is an optimum population below which the crop is limited by less than optimum plants (Whaley et al., 2000) and above which it is limited by disease pressure, insects, lodging, or insufficient resources such as fertility (Lloveras et al., 2004). Recently, some Kansas evidence suggested that wheat responses to seeding rate were dependent on the level of resource availability of the environment (Bastos et al., 2020). In high-yielding environments (above 90 bushels per acre) where the crop is not limited by resources (these including fertility levels but also temperature and moisture for tillering), crop yield was unresponsive to plant population. Similar results were derived from the Kansas Wheat

Yield Contest (Lollato et al., 2019) and from studies with intensively managed wheat in Kansas (Jaenisch et al., 2019) and in Mexico (Fischer et al., 2019). Meanwhile, in average- (65 bu/a average) and low- (45 bu/a average) yielding environments, wheat responded to increases in plant population up until about 25 to 31 plants/ft² (approximately 1.1 to 1.35 million plants/a), leveling out at greater populations (Bastos et al., 2020). The optimum plant population might also depend on the variety's tillering potential (Bastos et al., 2020), as varieties with greater tillering potential might require less population to maximize yields when compared to varieties with lower tillering potential.

The majority of the studies evaluating wheat yield response to seeding rate were performed under standard management conditions i.e., not excessively high fertility levels or other management factors (e.g., Whaley et al., 2000; Lloveras et al., 2004; Bastos et al., 2020). Thus, in this study we aimed at understanding wheat response to seeding rate in a high resource availability scenario. This is relevant in a context in which increases in food production are needed to feed an increasing global population, especially in regions characterized by actual yields well below the potential yield such as in Kansas and neighboring states (Lollato and Edwards, 2015; Lollato et al., 2017; 2019; Patrignani et al., 2014). Considering that resource availability and variety-specific tillering capacity seem to govern wheat yield response to plant population, our objective was to evaluate the grain yield response of different winter wheat varieties to seeding rate, including extremely low seeding rates, in a highly managed commercial field in western Kansas.

Procedures

A field experiment was conducted during the 2019–2020 winter wheat growing season in a commercial wheat field near Leoti, KS. The research plots comprised of seven 7.5 in.-spaced rows wide and were 30-ft long. A two-way factorial treatment structure was established in a completely randomized block design and included four commercial wheat varieties (i.e., Joe, Byrd, WB-Grainfield, and LCS Revere) and five seeding rates (200,000, 400,000, 600,000, 800,000, and 1,000,000 seeds/a). All seeds were treated with insecticide and fungicide seed treatment to avoid potential stand losses due to pests (Pinto et al., 2019). The experiments were planted on September 25, 2019, after a long summer fallow in sorghum residue, and were the second crop after manure application (5 tons per acre, providing about 150 pounds of N and phosphorus). Management of the field consisted of 80 pounds of nitrogen (N) per acre plus 13 lb of sulfur per acre in December, 3.5 ounces per acre Rave herbicide in February, and 13.7 oz/a of Miravis Ace once the flag leaf was fully emerged. Combined with the soil fertility available at sowing, all the manageable stresses were likely reduced. A Massey Ferguson XP8 small-plot, self-propelled combine was used for harvesting.

A total of 15 individual soil cores (0–24 in. depth) were collected from each location and divided into 0–6 in. and 6–24 in. increments for initial fertility analysis. The individual cores were mixed to form one composite sample, which was later analyzed for base fertility levels (Table 1). In-season measurements included stand count (measured about 20–30 days after sowing) and grain yield at harvest maturity (corrected for 13% moisture content). Statistical analysis of the data collected in this experiment was performed using a two-way ANOVA in PROC GLIMMIX procedure in SAS v. 9.4 (SAS Inst. Inc., Cary, NC). Linear and non-linear regression analyses were used to test

the grain yield response to plant population. Replication was treated as a random effect in the analysis of individual locations.

Results

Weather Conditions

The 2019–2020 growing season was extremely dry in Leoti. Total precipitation during the growing season was 6.3 inches, which compared to 41 inches of crop water demand (Table 2), meaning that water supply only accounted for 15% of water demand. Despite very dry growing season conditions, sowing was followed by ~0.6 inches of precipitation, which allowed for good emergence and tiller production during the fall.

Seeding Rate and Variety Effects on Stand Establishment and Grain Yield

There was a significant seeding rate effect on final stand establishment (Table 3). Overall, increases in seeding rate resulted in greater stand count, as expected. However, we note that final populations were closer to the target population at lower seeding rates as compared to higher seeding rates. For instance, the target population of 200,000 plants per acre resulted in 197,684 plants/a; while the target of 1,000,000 plants/a resulted in 642,306 plants/a. This is usually observed in seeding rate studies (Bastos et al., 2020). As expected, there was no variety effect on final stand establishment.

Grain yield was affected by seeding rate and by variety independently, but there was no variety × seeding rate interaction, suggesting that varieties responded similarly to seeding rate (Table 3). Overall, there was a linear-plateau grain yield response to seeding rate, increasing from 41.4 bu/a in the 200,000 plants/a seeding rate, to anywhere from 47.6 to 51.3 bu/a in the seeding rates ranging from 400,000 to 1,000,000 seeds/a, with no significant statistical differences among the latter seeding rates. The variety WB-Grainfield had the lowest grain yield (40.5 bu/a) as compared to the remaining varieties, which ranged from 49.1 to 52.2 bu/a (with no significant yield differences among Joe, LCS Revere, or Langin). The lower grain yield measured in WB-Grainfield was likely due to its early release from winter dormancy, being well advanced in maturity when a harsh spring freeze occurred in April, causing severe burn-back and tiller loss particularly in this variety.

Preliminary Conclusions

This trial provided information on wheat response to seeding rate within a highly-managed scenario, during a dry growing season. At yield levels ranging between 32.7 and 57.3 bu/a, wheat response to seeding rate was independent of variety and yield, maximized at 400,000 seeds/a. Yield increases reported for seeding rates beyond 400,000 seeds/a, while numerically present (~10%), were not statistically significant.

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Table 1. Initial soil fertility measured at wheat sowing during the 2019–2020 growing season for the trial conducted near Leoti, KS

Depth	OM	pH	CECS	NO ₃ -N	NH ₄ -N	P	K	Ca	Mg	Mn	Na	Cu	Zn	Fe	S	Cl	Sand	Silt	Clay
in.	%		meq/100 g	----- ppm -----										----- % -----					
0 to 6	2.9	6.6	18.3	30.9	3.7	155.0	864.0	2,433.9	460.3	13.6	19.2	1.4	19.4	27.4	4.9	9.4	16.0	58.0	26.0
6 to 14	1.9	7.6	31.1	15.6	7.8	67.2	747.4	4,845.7	582.2	6.7	21.9	1.1	4.4	15.6	3.8	8.7	14.0	52.0	34.0

Table 2. Weather conditions including average maximum (Tmax) and minimum (Tmin) air temperatures, and cumulative precipitation and reference evapotranspiration (ETo) near Leoti, KS, during the 2019–2020 growing season. The water supply (WS) to water deficit (WD) ratio is also shown.

Season	Tmax	Tmin	Precip.	Eto	WS:WD
	°F		in.		
Fall	57.8	28.8	0.7	10.3	0.07
Winter	50.1	23.9	1.9	8.4	0.23
Spring	76.4	45.3	3.6	22.5	0.16
Total	61.4	32.6	6.3	41.0	0.15

Table 3. Stand count and grain yield of four winter wheat varieties (WB-Grainfield, Joe, LCS Revere, and Langin) as affected by seeding rate ranging from 200,000 to 1,000,000 seeds per acre. The significance of fixed effects resulting from the ANOVA is also shown.

Seed rate	Variety					Variety				
	WB-Grainfield	Joe	LCS Revere	Langin	Mean	WB-Grainfield	Joe	LCS Revere	Langin	Mean
	----- Stand count (plants/a) -----					----- Grain yield (bu/a) -----				
200,000	167732	191693	239617	191693	197684	32.7	41.7	47.5	43.8	41.4 b
					e					
400,000	346113	330139	394036	306177	344116	44.3	50.0	50.8	45.4	47.6 a
					d					
600,000	362087	484558	505857	391374	435969	38.4	49.7	52.1	57.3	49.4 a
					c					
800,000	585730	535144	569755	521832	553115	42.6	51.1	57.0	54.5	51.3 a
					b					
1000000	788073	657615	537806	585730	642306	44.7	53.3	53.5	52.3	51.0 a
					a					
Mean	449947	439830	449414	399361		40.5 b	49.2 a	52.2 a	50.7 a	
Fixed effects	----- Pr > F -----									
Seeding rate (R)			< 0.01					< 0.01		
Variety (V)			0.36					< 0.01		
R × V			0.11					0.41		