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Wheat Grain Yield Response to Seed Cleaning and Seed Treatment as Affected by Seeding Rate During the 2020–2021 Growing Season in Kansas

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Abstract

The objective of this project was to evaluate the winter wheat stand count and grain yield responses to seeding rate and its interaction with seed cleaning and seed treatment in Kansas during the 2020–2021 growing season. Experiments evaluating the response of the wheat variety SY Monument to three seeding rates (600,000, 900,000, and 1,200,000 seeds per acre), three seed cleaning intensities (none, air screen, and gravity table), and two seed treatments (none and insecticide + fungicide) were established in a split-split plot design conducted in a complete factorial experiment in ten Kansas locations. In-season measurements included stand count and grain yield. Despite a few location-specific results, the general trends were uniform to be generalized across locations as there were significant main effects of population and seed treatment for both stand and yield, but no significant seed cleaning effect or interactions among factors. Across locations, plant population increased with increases in seeding rate from 391,616 to 556,771 plants per acre from the lowest to the highest seeding rate, as expected. Seed treatment increased plant population from 467,778 to 492,211 plants/a. Grain yield increased from 68.8 to 72.5 bushels per acre as function of seeding rate, with higher yields associated with higher seeding rates. Grain yield increased from 69.8 bu/a in the untreated control to 71.8 bu/a when the seed was treated. This research is an initial step in evaluating the value of the seed certification process and does not compare certified seed versus bin-run seed. The seed used in this study was derived from a commercial seed production field (i.e., high quality seed) and not from commercial grain production fields.

Keywords

wheat, seed cleaning, seed treatment, seeding rate, seed size

Cover Page Footnote

The Kansas Crop Improvement Association funded this project. Polansky Seed provided the seed collected at the different timings within the seed cleaning process.

Authors

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Summary
The objective of this project was to evaluate the winter wheat stand count and grain yield responses to seeding rate and its interaction with seed cleaning and seed treatment in Kansas during the 2020–2021 growing season. Experiments evaluating the response of the wheat variety SY Monument to three seeding rates (600,000, 900,000, and 1,200,000 seeds per acre), three seed cleaning intensities (none, air screen, and gravity table), and two seed treatments (none and insecticide + fungicide) were established in a split-split plot design conducted in a complete factorial experiment in ten Kansas locations. In-season measurements included stand count and grain yield. Despite a few location-specific results, the general trends were uniform to be generalized across locations as there were significant main effects of population and seed treatment for both stand and yield, but no significant seed cleaning effect or interactions among factors. Across locations, plant population increased with increases in seeding rate from 391,616 to 556,771 plants per acre from the lowest to the highest seeding rate, as expected. Seed treatment increased plant population from 467,778 to 492,211 plants/a. Grain yield increased from 68.8 to 72.5 bushels per acre as function of seeding rate, with higher yields associated with higher seeding rates. Grain yield increased from 69.8 bu/a in the untreated control to 71.8 bu/a when the seed was treated. This research is an initial step in evaluating the value of the seed certification process and does not compare certified seed versus bin-run seed. The seed used in this study was derived from a commercial seed production field (i.e., high quality seed) and not from commercial grain production fields.

Introduction
Yield potential is defined as the yield of an adapted cultivar when only limited by weather conditions (i.e., temperature regime, solar radiation, and, in the case of rainfed crops, water availability) and in the absence of stresses caused by manageable factors. Using data from well-managed field experiments where the crop achieved levels close to its potential (i.e., Lollato and Edwards, 2015), Lollato et al. (2017) estimated that current wheat yields of commercial fields in Kansas are about 50% of their long-term water-limited potential, suggesting that appropriate management could economically improve wheat yields at the state level. This yield gap was further confirmed in several replicated field studies (de Oliveira Silva et al., 2020, 2021; Jaenisch et al., 2019, 2022)

and surveys of commercial fields (Jaenisch et al., 2021; Lollato et al., 2019). To ensure potential conditions can be attained, the first step after variety selection and sowing date (Munaro et al., 2020) is to ensure a good population establishment through high quality seed, appropriate seeding rate, and seed treatment. A recent review of winter wheat response to seeding rate suggested that the optimum seeding rate depended on yield environment (Bastos et al., 2020). Grain yield was independent of population in high-yielding environments such as high fertility fields sown at the appropriate time, when tillering is abundant. Higher seeding rates were required in lower-yielding environments where the crop does not have as much time to tiller. Similar results were reported by Fischer et al. (2019) and Lollato et al. (2019) suggesting an insensitivity of wheat to seeding rate in high-yielding environments; and by Jaenisch et al. (2019) suggesting that higher seeding rates were required in lower-yielding environments. More recently, Jaenisch et al. (2022) showed that reduced seeding rates could reduce light interception during grain filling and consequently grain yield.

Not all planted seeds become an emerged plant. In fact, Bastos et al. (2020) suggested that the ratio of achieved over target plant density ranged from 60 to 100% in nine Kansas experiments. Factors that might impact this ratio include seed quality and seed treatment (Pinto et al., 2019). While seed cleaning (e.g., air screening followed by gravity table) can affect seed size; and seed treatment can reduce the risk of disease transmission–thus both improving seed quality–the effects of seed cleaning and treatment on wheat grain yield have been inconsistent (Edwards and Krenzer, 2006). Thus, the objectives of this project were to assess winter wheat establishment and grain yield as affected by different combinations of seeding rate, seed cleaning, and seed treatment in several Kansas locations. This is the report of the third year of a three-year project. Data from the first two years was reported by Lollato et al., 2020a, 2021.

Procedures

Field experiments were conducted in ten locations during the 2020–2021 winter wheat growing season, including two fields with different soil textures near Ashland Bottoms, two fields with different previous crops (and consequent sowing dates) near Belleville, one field near Colby, two fields with early- or optimum-sowing dates near Hutchinson, and one field each near Manhattan, Mitchel, and Leoti. In Colby and Mitchell, plots were comprised of eight 10-in. spaced rows wide and 40-ft long, while at the remaining locations plots were seven 7.5-in. spaced rows wide by 30-ft long. A total of eighteen treatments resulting from the factorial combination of three seeding rates (600,000, 900,000, and 1,200,000 seeds/a), three seed cleaning intensities (none, air screen, and gravity table + color sorting), and two seed treatments (none and insecticide + fungicide) were established in a split-split plot design. The different seed treatments were established by collecting seed at three different intervals during the seed cleaning process: immediately after harvest, after air screening, and on the top of the gravity table. More details about the air screening and gravity table used were provided by Lollato et al. (2020). Seed treatment consisted of 5 oz/a of Cruiser Maxx and 0.75 oz/a Cruiser 5FS. The same wheat variety ('SY Monument') was evaluated at all locations. Harvest occurred using a Massey Ferguson XP8 small-plot, self-propelled combine.

Measurements and Statistical Analyses

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 three-way ANOVA in PROC GLIMMIX procedure in SAS v. 9.4. Because of the large number of locations included in the study, we treated location as a random factor, as well as replication nested within location. Random effects also included the ones to account for the statistical design of the experiment, including the seeding rate nested within replication, and the seeding rate by seed treatment nested within replication.

Results

Weather Conditions

The ten locations evaluated during the 2020–2021 winter wheat growing season provided contrasting environments for the evaluation of the different treatments (Table 1). Growing season precipitation ranged from 10.9 inches in Belleville to 18.6 inches in Manhattan, with corresponding grass reference evapotranspiration (ETo) ranging from 27.8 inches in Leoti to 35.9 inches in Colby. The corresponding water supply (WS) to water demand (WD) ratios ranged from 0.34 to 0.62. These relatively dry conditions are typical of the weather usually experienced by winter wheat in this region (Couedel et al., 2021; Lollato et al, 2020b; Sciarresi et al., 2019).

Stand Count

There were significant main effects of seeding rate and seed treatment for stand count, with no significant seed cleaning effect or interactions among any of the factors studied. Across locations, plant population increased with increases in seeding rate from 391,616 at the 600,000 seeds/a treatment, to 491,596 plants/a in the 900,000 seeds/a treatment, to 556,771 plants/a in the 1,200,000 seeds/a treatment. Seed treatment increased plant population from 467,778 plants/a in the untreated control to 492,211 plants/a when fungicide and insecticide seed treatment were provided.

Grain Yield

Similar to the results for stand count, there were main effects of seeding rate and seed treatment on grain yield, with no significant seed cleaning effect or interactions among any of the factors studied. Grain yield increased from 68.8 bu/a in the lowest population, to 70.9 bu/a at the 900,000 seeds/a treatment, to 72.5 bu/a in the highest seeding rate evaluated. Grain yield increased from 69.8 bu/a in the untreated control to 71.8 bu/a when the seed was treated with fungicide and insecticide seed treatment.

Preliminary Conclusions

Despite some location-specific responses due to different yield levels, our results showed a clear benefit from increases in seeding rate and from the presence of a fungicide plus insecticide seed treatment, in improving both stand establishment and grain yield of winter wheat. It is important to highlight that this research evaluates the value of the seed certification process; and does not compare certified seed versus bin-run seed. The most important difference here is that the seed used in this study was derived from commercial seed production fields (i.e., high quality seed) instead of commercial grain production fields. This was the third year of this research, and the results from the first and second years were published in Lollato et al. (2020, 2021). A comprehensive study including all three years of this research will soon be conducted.

Acknowledgments

The Kansas Crop Improvement Association funded this project. Polansky Seed provided the seed collected at the different timings within the seed cleaning process.

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Table 1. Average maximum (Tmax) and minimum (Tmin) temperatures, and cumulative precipitation, grass reference evapotranspiration (ETo) and the ratio of water supply (WS) to water demand (WD) during three portions of the growing season at the ten study locations during 2020–2021

Location*	Season	Tmax	Tmin	Precipitation	ETo	WS:WD
		°F	°F	inch	inch	
Ashland Bottoms	Fall	57.7	32.6	4.0	7.8	0.51
	Winter	47.1	25.0	4.5	6.9	0.65
	Spring	75.2	53.4	9.4	16.0	0.59
Belleville	Fall	56.1	30.0	1.1	8.0	0.14
	Winter	43.7	21.6	4.3	6.5	0.67
	Spring	74.9	50.4	5.5	17.2	0.32
Colby	Fall	56.8	27.2	0.9	9.9	0.09
	Winter	44.6	20.1	4.2	7.6	0.56
	Spring	73.0	46.9	7.5	18.4	0.41
Hutchinson	Fall	59.1	33.3	3.7	8.7	0.43
	Winter	48.2	25.2	6.2	7.3	0.85
	Spring	75.9	52.8	8.1	16.7	0.49
Manhattan	Fall	57.6	33.0	4.0	7.8	0.51
	Winter	46.5	25.0	4.6	6.8	0.68
	Spring	75.1	53.4	10.0	15.6	0.64
Mitchell	Fall	57.7	31.0	2.6	8.8	0.30
	Winter	44.6	20.1	4.7	7.2	0.65
	Spring	73.0	46.9	6.4	17.1	0.38
Leoti	Fall	61.2	29.4	0.1	10.8	0.01
	Winter	47.0	20.9	2.3	7.4	0.31
	Spring	74.8	47.5	8.7	9.6	0.90

*There were two fields near each of Ashland Bottoms, Belleville, and Colby.

Table 2. Effects of seeding rate, seed cleaning method and seed treatment on plant population and grain yield across 10 Kansas locations during the 2020–2021 winter wheat growing season

Factor	Description	Plant population	Grain yield
		(plants/a)	(bu/a)
Population	600,000 seeds/a	391,616 a	68.8 b
	900,000 seeds/a	491,596 b	70.9 ab
	1,200,000 seeds/a	556,771 c	72.5 a
Seed cleaning	None	480,467	69.9366
	Air	469,745	70.7739
	Table	489,772	71.6372
Seed treatment	None	467,778 b	69.8 b
	Treated	492,211 a	71.8 a
Test of fixed effects		Pr > |t|	Pr > |t|
	Seeding rate (R)	<.0001	0.0183
	Seed cleaning (C)	0.0873	0.108
	Seed treatment (T)	0.0004	0.0013
	R × C	0.3077	0.9665
	R × T	0.6755	0.6091
	C × T	0.5364	0.1896
	R × C × T	0.759	0.7919