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R. P. Lollato
Kansas State University, lollato@ksu.edu

B. R. Jaenisch
Kansas State University, bjaenisch5@ksu.edu

L. Haag
Kansas State University, lhaag@ksu.edu

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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.

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R.P. Lollato, B.R. Jaenisch, and L. Haag

Summary

The objective of this project was to evaluate winter wheat stand count and grain yield responses to seeding rate and its interaction with seed cleaning and seed treatment in Kansas during the 2019–2020 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 enough to be generalized across locations. The average plant population across treatments ranged from ~285,000 to 620,000 plants per acre, with the low populations occurring either in sites where severe freeze damage caused winterkill or in sites where sowing was followed by extremely dry periods. Grain yield across treatments ranged from 25 to 75 bushels per acre. Across locations, both stand count and grain yield increased with increases in seeding rate, with improvements in seed cleaning, and with the presence of a fungicide plus insecticide seed treatment across locations. 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 was study derived from commercial seed production fields (i.e., high quality seed) and not from commercial grain production fields, which are usually the case for bin-run seed.

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 approximately 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 with a field study evaluating improved management practices (de Oliveira Silva et al., 2020). 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 the population in high-yielding environments such as high fertility fields sown at the appropriate timing, where tillering is abundant. Meanwhile, higher seeding rates were required in lower-yielding environments where the crop did not have as much time to tiller (Bastos et al., 2020). Similar results were reported by 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.

Not all planted seeds become emerged plants. 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; Pinto et al., 2019). 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 second year of a three-year project. The first year of data was reported by Lollato et al., 2020.

Procedures

Field experiments were conducted in ten locations during the 2019–2020 winter wheat growing season: Ashland Bottoms, Beloit, Belleville, Colby, Conway Springs, Great Bend, Hutchinson (optimum sowing time, conventional till after canola), Hutchinson (late sowing, no-till after soybeans), Leoti, and Manhattan (Table 1). 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 (hereafter referred to as 'None'), after air screening, and on the top of the gravity table. 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. A Massey Ferguson XP8 small-plot, self-propelled combine was used for harvesting.

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 (SAS Inst. Inc., Cary, NC). Replication was treated as a random effect in the analysis for individual locations, while location and replication nested within location were random effects in the analysis across locations.

Random effects also accounted for the statistical design of the experiment (i.e., seeding rate nested within replication, and seed cleaning nested within seeding rate nested within replication).

Results

Weather Conditions

The ten locations evaluated during the 2019–2020 winter wheat growing season provided very contrasting environments for the evaluation of the different treatments (Table 1). Growing season mean maximum temperatures ranged from 57.7°F in Belleville to 61.9°F in Conway Springs and mean minimum temperatures ranged from 31.5°F in Colby to 39.4°F in Conway Springs. Growing season precipitation ranged from 6.7 inches in Leoti to 24.4 inches in Ashland Bottoms, with corresponding grass reference evapotranspiration (ETo) ranging from 29.9 inches in Manhattan to 41.7 inches in Leoti. The corresponding water supply (WS) to water demand (WD) ratios ranged from 0.16 in Leoti to 0.80 in Ashland Bottoms.

Overall Treatment Significance on the Measured Variables

Table 2 shows the results from the analysis of variance for each location individually, as well as for the combined analysis across locations. At the 0.05 probability level, seeding rate affected stand count in nine locations and in the combined analysis; seed cleaning affected stand count in seven locations and in the combined analysis; and seed treatment impacted stand count in two locations and in the combined analysis. Grain yield was affected by seeding rate in seven locations plus the combined analysis; by seed cleaning in six locations and in the combined analysis; and by seed treatment in four locations plus in the combined analysis.

Stand Count

Across all treatments, stand count ranged from ~285,000 plants/a in Colby and Great Bend, to ~620,000 plants/a in Hutchinson (optimal sowing) (Table 3). The very low average population in Colby was a result from the harsh April freeze that increased winterkill, and in Great Bend it was due to extremely dry conditions for several months following the sowing of the wheat crop. Despite some small differences in response to the treatments among locations (Table 2), these responses were uniform enough to be discussed across locations. Across locations, increasing seeding rates increased plant population linearly, as the 600,000 seeds/a rate averaged 362,009 plants/a; the 900,000 seeds/a rate averaged 489,480 plants/a; and the 1,200,000 seeds/a rate averaged 574,350 plants/a rate. Seed cleaning also had a significant impact on final population, with a special advantage resulting from the gravity table in comparison to the other treatments: the average population for the unclean seed was 438,812 plants/a, which is statistically the same as that resulting from air screen (452,914 plants/a). Gravity table, however, increased the final plant population to 534,113 plants/a. Likewise, there was a significant effect of seed treatment on plant population, as the treated seed averaged 490,046 plants/a as compared to 460,514 plants/a in the untreated seed.

Grain Yield

The ten locations was this experiment were conducted during the 2019–2020 growing season provided a large range in yielding conditions. Average grain yield across all treatments ranged from 25 bu/a in Colby to 75 bu/a in Hutchinson (optimal planting).

Similar to the plant population, grain yield across locations was affected by the main effects of seeding rate, cleaning, and treatment, individually (Table 3). Each increase of 300,000 seeds/a in the seeding rate increased grain yield by ~3 bu/a, for average grain yields of 46.6, 50.9, and 53.5 bu/a for the three seeding rates evaluated. Likewise, there were significant yield increases resulting from the seed cleaning process, with the unclean seed treatment averaging 48.7 bu/a; the air screen treatment averaging 50.5 bu/a; and the gravity table treatment averaging 51.9 bu/a. Finally, the fungicide plus insecticide seed treatment increased grain yield by 0.5 bu/a (from 49.6 bu/a in the untreated control to 51.1 bu/a with seed treatment).

Preliminary Conclusions

Winter wheat population establishment and grain yield responses to seeding rate, seed cleaning, seed treatment, and their interactions were dependent on environmental conditions. Despite some location-specific responses due to different yield levels, our results showed a clear benefit from increases in seeding rate, improvements in seed cleaning, and 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, which are usually the case for bin-run seed. This was the second year of this research, and the results from the first year are published in Lollato et al., 2020. This research will continue for one more growing season so that we can establish probabilities of yield gain and breakeven on seeding rate, seed cleaning, and seed treatment.

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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 the growing season at the ten study locations during 2019–2020

Location	Tmax	Tmin	Precip.	ETo	WS:WD
	------------- °F	-------------	---------- inches	----------	
Ashland Bottoms	59.3	37.0	24.2	30.3	0.80
Beloit	59.5	34.9	17.0	33.5	0.51
Belleville	57.7	33.7	12.5	31.0	0.40
Colby	60.1	31.5	7.9	38.4	0.20
Conway Springs	61.9	39.4	16.4	35.9	0.46
Great Bend	60.9	36.0	16.3	36.3	0.45
Hutchinson (optimum)	61.7	37.2	16.8	34.5	0.49
Hutchinson (late)	59.4	34.6	13.6	30.8	0.44
Leoti	61.6	32.7	6.7	41.7	0.16
Manhattan	59.3	37.6	18.4	29.9	0.62
Average	60.1	35.5	15.0	34.2	0.45
Max	61.9	39.4	24.2	41.7	0.80
Min	57.7	31.5	6.7	29.9	0.16

Table 2. Significance of seeding rate (R), seed cleaning (C), seed treatment (T) and their interactions on stand count and grain yield at ten Kansas locations where the trial was conducted, as well as the analysis combined across sites, during the 2019–2020 growing season

Effect	Ashland Bottoms	Beloit	Belleville	Colby	Conway Springs	Great Bend	Hutch. (optimum)	Hutch. (late)	Leoti	Manhattan	Combined
	Stand count										
R	0.15	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
C	0.11	0.16	< 0.01	< 0.01	< 0.01	0.34	< 0.01	< 0.01	0.03	0.02	< 0.01
T	0.17	0.03	0.45	< 0.01	0.25	0.61	0.74	0.36	0.09	0.77	< 0.01
R × C	0.61	0.54	0.44	0.95	0.52	0.48	0.93	0.05	0.85	0.94	0.51
R × T	0.18	0.57	0.77	0.99	0.04	0.65	0.42	0.64	0.38	0.71	0.17
C × T	0.41	0.85	0.97	0.46	0.81	0.43	0.49	0.91	0.09	0.14	0.86
R × C × T	0.49	0.92	0.82	0.09	0.76	0.19	0.83	0.01	0.04	0.63	0.03
	Grain yield										
R	0.02	< 0.01	< 0.01	< 0.01	0.36	0.02	0.16	< 0.01	0.21	< 0.01	< 0.01
C	0.35	< 0.01	< 0.01	0.02	0.08	0.02	0.39	< 0.01	0.59	0.01	< 0.01
T	0.91	< 0.01	< 0.01	< 0.01	0.09	0.05	0.11	0.17	0.28	0.39	< 0.01
R × C	0.69	0.87	0.43	0.39	0.37	0.62	0.79	0.88	0.07	0.27	0.28
R × T	0.76	0.18	0.17	0.14	0.96	0.36	0.15	0.14	0.29	0.83	0.76
C × T	0.28	0.31	0.61	0.72	0.15	0.09	0.34	0.68	0.65	0.23	0.44
R × C × T	0.22	0.15	0.47	0.96	0.34	0.44	0.34	0.87	0.23	0.84	0.68

Table 3. Effects of seeding rate, seed cleaning method, and seed treatment on plant population and grain yield across 10 Kansas locations during the 2019–2020 winter wheat growing season

Effect		Plant population		Grain yield	
		------ plants/a ------		----- bu/a -----	
Seeding rate (seeds/a)	600,000	362,009	c	46.6	b
	900,000	489,480	b	50.9	ab
	1,200,000	574,350	a	53.4	a
Seed cleaning	None	438,812	b	48.7	c
	Air screen	452,914	b	50.4	b
	Gravity table	534,113	a	51.8	a
Seed treatment	None	460,514	b	49.5	b
	Treated	490,046	a	51.1	a

Means followed by a common letter are not significantly different by the Tukey test at the 5% level of significance.