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# Wheat Grain Yield Response to Seed Cleaning and Seed Treatment as Affected by Seeding Rate During the 2018–2019 Growing Season in Kansas

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## Abstract

The objective of this project was to evaluate winter wheat stand count and grain yield responses to the interactions among seeding rate, seed cleaning, and seed treatment in the state of Kansas during the 2018–2019 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 at seven Kansas locations. In-season measurements included stand count, grain yield, grain test weight, and grain protein concentration, though this report only shows stand count and grain yield. Stand count increased with increases in seeding rate at all locations, with improvements in seed cleaning in five locations, and by seed treatment in one location. Grain yield increased with increases in seeding rate in five locations, with improvements in seed cleaning in four locations, and with seed treatment in one location. Significant interactions on grain yield occurred between seeding rate and seed cleaning (one location) and seeding rate and seed treatment (two locations), usually suggesting an advantage for seed cleaning or seed treatment at low seeding rates. The combined analysis across locations suggested that seeding rate and seed cleaning improved stand count (~140,000 and ~35,000 more plants established for each level of seeding rate and seed cleaning improvement) and grain yield (about 5 and 2 more bushels per acre for each improvement in seeding rate and seed cleaning, respectively). This research is an initial step in evaluating the value of the seed certification process; it does not compare certified seed versus bin-run seed. The seed used in this study derived from commercial seed production fields (i.e., high quality seed) and not from commercial grain production fields, which usually provide bin-run seed.



## Keywords

wheat, seed cleaning, seed treatment, seeding rate





## Cover Page Footnote

The Kansas Crop Improvement Association funded this project. We also acknowledge Polansky Seed for providing us with the seed collected at the different timings within the seed cleaning process.



## Authors

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# Wheat Grain Yield Response to Seed Cleaning and Seed Treatment as Affected by Seeding Rate During the 2018–2019 Growing Season in Kansas

*R.P. Lollato, K. Mark, B.R. Jaenisch, and L. Haag*

## Summary
The objective of this project was to evaluate winter wheat stand count and grain yield responses to the interactions among seeding rate, seed cleaning, and seed treatment in the state of Kansas during the 2018–2019 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 at seven Kansas locations. In-season measurements included stand count, grain yield, grain test weight, and grain protein concentration, though this report only shows stand count and grain yield. Stand count increased with increases in seeding rate at all locations, with improvements in seed cleaning in five locations, and by seed treatment in one location. Grain yield increased with increases in seeding rate in five locations, with improvements in seed cleaning in four locations, and with seed treatment in one location. Significant interactions on grain yield occurred between seeding rate and seed cleaning (one location) and seeding rate and seed treatment (two locations), usually suggesting an advantage for seed cleaning or seed treatment at low seeding rates. The combined analysis across locations suggested that seeding rate and seed cleaning improved stand count (~140,000 and ~35,000 more plants established for each level of seeding rate and seed cleaning improvement) and grain yield (about 5 and 2 more bushels per acre for each improvement in seeding rate and seed cleaning, respectively). This research is an initial step in evaluating the value of the seed certification process; it does not compare certified seed versus bin-run seed. The seed used in this study was derived from commercial seed production fields (i.e., high quality seed) and not from commercial grain production fields, which usually provide 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 (Evans and Fischer, 1999). This study used data from well-managed field experiments where the crop achieved levels close to its potential (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. To ensure potential conditions can be attained, the first step after variety selection is to ensure a good population establishment through quality seed, appropriate seeding rate, and seed treatment (though these practices might not always be economical).

Seeding rate is important within the context of attaining potential yields because it defines the first yield component: plant population. 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 (e.g., high fertility sown at the appropriate time, where tillering is abundant); and higher seeding rates were required in lower-yielding environments (e.g., where the crop does not have as much time to tiller) to improve grain yield (Bastos et al., 2020). 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.

Not all seeded 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 (Peske et al., 2012); and seed treatment can reduce the risk of disease transmission (Khanzada et al., 2002) —thus both improving seed quality—the effects of seed cleaning and treatment on wheat grain yield have been inconsistent (Edwards and Krenzer, 2006; Kashyap et al., 1994; 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 to start developing a more probabilistic response of yield gain and breakeven.

## Procedures

Field experiments were conducted during the 2018–2019 winter wheat growing season in seven locations across Kansas: Ashland Bottoms, Belleville, Beloit, Colby, Hutchinson, Leoti, and Manhattan (Table 1). In Colby and Beloit, 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 per acre), 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 time 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. 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. Plot ends were trimmed at harvest time to avoid border effect.

### *Measurements and Statistical Analyses*

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. Nitrogen (N) rates were adjusted for a 75 bushel per acre yield goal using a 2.4 conversion factor and accounting for soil profile N, organic matter, and other N credits. In-season measurements included stand count (measured about 20–30 days after sowing, except for one location that did not emerge in the fall, Table 1) and grain yield at harvest maturity (corrected for 13% moisture content). Statistical analysis of the data collected in this experiment was performed using as 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 included those to account for the statistical design of the experiment (i.e., replication, replication × seeding rate, and replication × seeding rate × seed cleaning).

## Results

### *Weather Conditions*

The weather data for the studied locations during the 2018–2019 winter wheat growing season are shown in Table 2. Overall, the weather was characterized by below average temperatures and above average precipitation. The fall had anywhere from 5.0 to 17.3 inches of precipitation, which coupled with cool temperatures, slowed down crop development. In many cases, such as in Beloit, the wheat only emerged in the spring. The studied locations received anywhere from 7.7 to 24.9 inches of precipitation during the spring.

### *Overall Treatment Significance on the Measured Variables*

Table 3 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 and test weight at all locations, and grain yield in five locations. Seed cleaning affected stand count in five locations, and grain yield in four locations. Seed treatment affected stand count in one location and grain yield in one location.

### *Stand Count*

Across all treatments and locations, stand count ranged from 357,154 to 895,900 plants per acre (Table 4). At all locations, the achieved population was considerably lower than the target, ranging from 51 to 85%. The locations with the lowest stand count were Beloit and Belleville (360,000 –630,000 plants per acre) and the location with the highest stand count was Hutchinson (504,000–896,000 plants per acre). In Colby, the total number of tillers was counted instead of actual population, resulting in much greater values (Table 4). At all locations, established population increased consistently with increases in seeding rate and with improvements in seed cleaning (the latter, except for Belleville and Manhattan). In Beloit, the only location in which seed treatment was a significant effect, application of seed treatment increased stand establishment from 477,754 to 507,406 plants per acre (data not shown).

### *Grain Yield*

Treatment effects on grain yield depended on location. The grain yield data are shown in Table 5, for the analysis in which only the main effects were significant (Belleville, Mitchel, Colby, and in the combined analysis). At these locations and in the combined analysis, a target seeding rate of 1,200,000 seeds per acre always out-yielded a target seeding rate of 600,000 seeds per acre (77.6–89.6 bushels per acre versus 70.1–79.9 bushels per acre); whereas seeding at 900,000 seeds per acre resulted in intermediate yields (72.9–84.8 bushels per acre). Regarding seed cleaning, gravity table always out-yielded no seed cleaning (75.6–86.5 bushels per acre versus 71.3–83.0 bushels per acre), whereas air screen was intermediate (73.7–84.9 bushels per acre).

There were also some significant interactions between treatments on wheat grain yield. Specifically, there were significant seed treatment by seeding rate interactions in Colby and in Hutchinson, and a significant seeding rate by seed cleaning interaction in Manhattan (Table 3). In Colby, the presence of seed treatment increased grain yield at seeding rates of 600,000 and 900,000 but not at 1,200,000 (Figure 1). In Hutchinson, there was a similar trend at the 600,000 seeds per acre seeding rate (a trend for a yield benefit of seed treatment), but an opposite trend at the 900,000 seeds per acre (Figure 1). In Manhattan (where the significant interaction was between seeding rate and seed cleaning), grain yield increased linearly in response to increases in seeding rate when the seed was air screened or received no cleaning. These relationships showed a crossover interaction where air screen tended to yield more at 600,000 seeds per acre and 'None' tended to yield more at 1,200,000 seeds per acre (Figure 2). Meanwhile, gravity table yielded similarly to both treatments at the low seeding rate and out-yielded them at the 900,000 seeds per acre rate, following a quadratic shape with diminishing yield increases beyond this point.

### *Preliminary Conclusions*

Winter wheat population establishment and grain yield responses to seeding rate, seed cleaning, seed treatment, and their interactions are dependent on environmental conditions. Usually, increasing seeding rate and improving seed cleaning resulted in more plants emerged per unit area, but only translated into increased grain yield in about half of the times. The other times, grain yield was affected by the interaction among these factors, which suggested a greater benefit of seed cleaning or of seed treatment at lower seeding rates. 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 first year of this research, which will continue for two more years to establish probabilities of yield gain and breakeven on seeding rate, seed cleaning and seed treatment.

## Acknowledgments

The Kansas Crop Improvement Association funded this project. We also acknowledge Polansky Seed for providing us with the seed collected at the different timings within the seed cleaning process.

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**Table 1. Dates of major field activities at the seven locations where the seed rate by seed cleaning by seed treatment trial was established during the 2018–2019 growing season**

| Location | Sowing date | Stand count | N fertilization | Fungicide | Harvest |
|---|---|---|---|---|---|
| Ashland Bottoms | 11/1/2018 | 1/9/2019 | 3/22/2019 | 5/31/2019 | 7/1/2019 |
| Belleville | 10/3/2018 | 11/7/2019 | 4/2/2019 | 5/16/2019 | 7/15/2019 |
| Beloit | 11/4/2018 | 3/10/2019 | 4/1/2019 | --- | 7/8/2019 |
| Colby | 10/3/2018 | 11/7/2019 | 4/2/2019 | --- | 7/23/2019 |
| Hutchinson | 10/22/2018 | 11/14/2019 | 3/18/2019 | 5/15/2019 | 6/26/2019 |
| Leoti | 9/27/2018 | 11/5/2019 | 3/21/2019 | 5/16/2019 | 7/2/2019 |
| Manhattan | 10/23/2018 | 12/10/2019 | 3/22/2019 | 5/20/2019 | 7/1/2019 |

**Table 2. Average maximum (Tmax) and minimum (Tmin) temperatures, and cumulative precipitation and evapotranspiration (ETo) during the fall (September 1- December 31), winter (January 1-March 31), and spring (April 1-July 15) at the study locations during the 2018–2019 growing season**

| Location | Season | Tmax | Tmin | Precipitation | ETo |
|---|---|---|---|---|---|
| Ashland Bottoms | Fall | 59.2 | 37.9 | 14.1 | 9.2 |
| | Winter | 41.1 | 23.1 | 5.0 | 5.0 |
| | Spring | 77.2 | 55.0 | 22.3 | 20.4 |
| Belleville | Fall | 56.7 | 35.7 | 13.6 | 9.6 |
| | Winter | 37.6 | 21.2 | 2.2 | 4.5 |
| | Spring | 75.0 | 51.7 | 17.9 | 18.8 |
| Beloit | Fall | 58.8 | 36.2 | 14.0 | 10.2 |
| | Winter | 40.1 | 21.1 | 2.9 | 5.2 |
| | Spring | 77.7 | 52.5 | 14.2 | 21.0 |
| Colby | Fall | 58.3 | 33.5 | 5.4 | 12.6 |
| | Winter | 40.7 | 20.0 | 2.8 | 5.4 |
| | Spring | 74.4 | 47.4 | 10.4 | 21.3 |
| Hutchinson | Fall | 59.7 | 34.4 | 5.2 | 14.6 |
| | Winter | 41.7 | 21.3 | 1.9 | 6.3 |
| | Spring | 76.0 | 48.2 | 7.7 | 21.5 |
| Leoti | Fall | 58.8 | 37.9 | 17.2 | 10.6 |
| | Winter | 44.5 | 24.5 | 3.3 | 6.0 |
| | Spring | 78.0 | 54.4 | 19.0 | 19.5 |
| Manhattan | Fall | 60.0 | 39.0 | 17.3 | 9.4 |
| | Winter | 42.0 | 23.9 | 5.0 | 4.9 |
| | Spring | 77.8 | 55.6 | 24.9 | 19.0 |

**Table 3. Significance of seeding rate, seed cleaning, seed treatment and their interactions on stand count and grain yield at seven Kansas locations where the trial was conducted, as well as the analysis combined across sites, during the 2018–2019 growing season**

| Factor | Ashland Bottoms | Belleville | Beloit | Colby | Hutchinson | Leoti | Manhattan | Combined |
|---|---|---|---|---|---|---|---|---|
| Stand count | | | | | | | | |
| Rate (R) | 0.0003 | 0.0003 | <.0001 | 0.03 | <.0001 | 0.002 | 0.001 | <.0001 |
| Cleaning (C) | 0.05 | 0.17 | 0.005 | 0.04 | 0.0094 | 0.001 | 0.45 | 0.0002 |
| Treatment (T) | 0.76 | 0.61 | 0.05 | 0.89 | 0.2342 | 0.29 | 0.82 | 0.88 |
| R × C | 0.23 | 0.39 | 0.44 | 0.52 | 0.9861 | 0.07 | 0.96 | 0.12 |
| R × T | 0.48 | 0.49 | 0.97 | 0.83 | 0.6475 | 0.79 | 0.26 | 0.62 |
| C × T | 0.59 | 0.83 | 0.44 | 0.24 | 0.4926 | 0.11 | 1.00 | 0.66 |
| R × C × T | 1.00 | 0.36 | 0.10 | 0.56 | 0.9309 | 0.12 | 0.57 | 1.00 |
| Yield | | | | | | | | |
| Rate (R) | 0.19 | 0.01 | 0.01 | 0.0009 | 0.06 | 0.68 | 0.0001 | 0.0002 |
| Cleaning (C) | 0.29 | 0.03 | 0.03 | 0.02 | 0.45 | 0.89 | 0.005 | 0.01 |
| Treatment (T) | 0.58 | 0.25 | 0.91 | 0.04 | 0.16 | 0.51 | 0.56 | 0.58 |
| R × C | 0.44 | 0.73 | 0.22 | 0.13 | 0.47 | 0.80 | 0.05 | 0.25 |
| R × T | 0.37 | 0.55 | 0.80 | 0.03 | 0.03 | 0.62 | 0.75 | 0.52 |
| C × T | 0.52 | 0.36 | 0.11 | 0.31 | 0.72 | 0.49 | 0.11 | 0.99 |
| R × C × T | 0.17 | 0.79 | 0.37 | 0.72 | 0.54 | 0.97 | 0.72 | 0.30 |

**Table 4. Wheat population (stand establishment) as affected by seeding rate and seed cleaning at seven experiments conducted in Kansas during the winter wheat season of 2018–2019, as well as the combined analysis across experiments**

| | Seeding rate | | | Seed cleaning | | |
|---|---|---|---|---|---|---|
| Location | 600000 | 900000 | 1200000 | None | Air screen | Gravity table |
| | Plants per acre | | | | | |
| Ashland Bottoms | 425985 c | 560881 b | 742368 a | 524938 b | 593717 a | 610579 a |
| Belleville | 363419 c | 476127 b | 614129 a | 457490 | 485446 | 510739 |
| Beloit | 357154 c | 484614 b | 635973 a | 466026 b | 479303 b | 532412 a |
| Colby | 1710093 b | 1992870 ab | 2166021 a | 1814637 b | 2000493 a | 2053854 a |
| Hutchinson | 504526 c | 716188 b | 895900 a | 673589 b | 686901 b | 756124 a |
| Leoti | 418886 b | 533369 a | 578186 a | 460153 b | 517838 a | 552450 a |
| Manhattan | 456603 c | 565318 b | 689120 a | 575524 | 547569 | 587948 |
| Combined | 433884 c | 570377 b | 703941 a | 538339 c | 566294 b | 603568 a |

The effect of seed treatment was only significant at one location so data are shown in text. Means within the same location and variable (either seeding rate or seed cleaning) followed by the same letter indicate no statistical difference at the 0.05 probability level.

**Table 5. Wheat grain yield as affected by seeding rate and seed cleaning (significant main effects) at two experiments conducted in Kansas during the winter wheat season of 2018–2019, as well as the combined analysis across experiments**

| | Seeding rate | | | Seed cleaning | | |
|---|---|---|---|---|---|---|
| Location | 600,000 | 900,000 | 1,200,000 | None | Air screen | Gravity table |
| | Bushels per acre | | | | | |
| Belleville | 74.7 b | 82.9 a | 89.4 a | 79.2 b | 82.3 ab | 85.4 a |
| Beloit | 70.1 b | 72.9 ab | 77.6 a | 71.3 b | 73.7 ab | 75.6 a |
| Colby | --- | --- | --- | 79.6 b | 81.7 a | 83.2 a |
| Combined | 79.9 c | 84.8 b | 89.6 a | 83.0 b | 84.9 ab | 86.5 a |

Means within the same location and variable (either seeding rate or seed cleaning) followed by the same letter indicate no statistical difference at the 0.05 probability level.

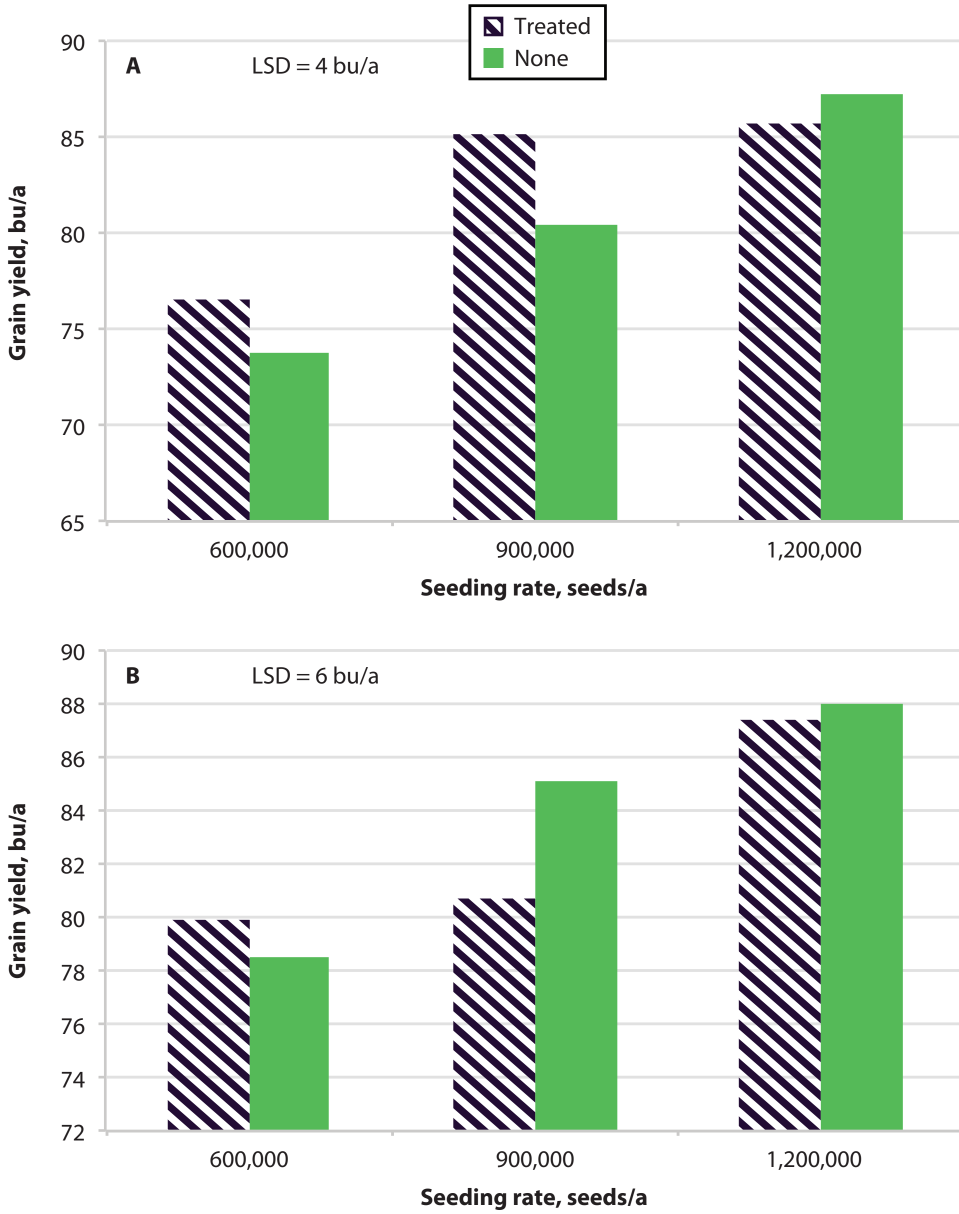


**Figure 1. Winter wheat grain yield as affected by the interaction between seeding rate and seed treatment at (A) Colby and (B) Hutchinson in experiments conducted during the 2018–2019 growing season. The least significant difference (LSD) is shown.**

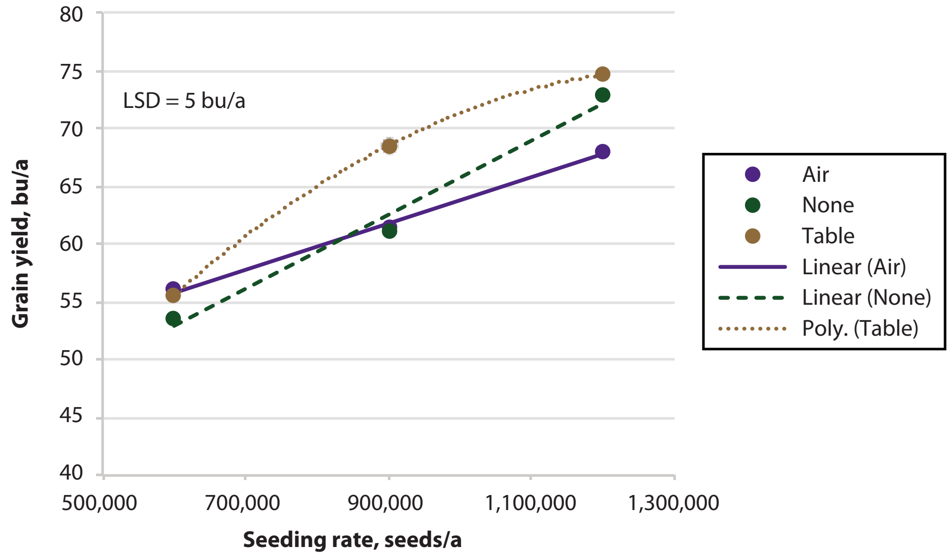


**Figure 2. Winter wheat grain yield as affected by the interaction between seeding rate and seed cleaning at Manhattan in experiments conducted during the 2018–2019 growing season. The least significant difference (LSD) is shown. Linear and polynomial (Poly.) trends are shown.**