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Optimum Seeding Rate for Different Wheat Varieties in Kansas

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Abstract

Seeding rate is an important management practice affecting wheat yield. Wheat varieties differ in their tillering capacity and therefore in their yield response to seeding rate. Our objectives were to evaluate the tillering and yield response of different modern wheat varieties to seeding rate. The study was conducted in Hutchinson and Manhattan, KS, during the 2015-16 growing season. Seven wheat varieties (Everest, KanMark, 1863, Joe, Tatanka, Larry, and Zenda) were sown at five different seeding rates (0.6, 0.95, 1.3, 1.65, and 2 million seeds per acre). Tiller number and grain yield were measured in the spring. Increasing plant population decreased the number of spring tillers sustained by the different varieties from more than eight tillers per plant at 600,000 seeds per acre to fewer than four tillers per plant at 2 million seeds per acre. There were varietal differences in tillers per plant, with the variety Joe standing out as a high-tillering variety. At both locations, wheat grain yield increased with increased seeding rates and was maximized at approximately 0.8-0.95 million emerged plants per acre. Further increases in seeding rate did not affect grain yield.

Keywords

Wheat, seeding rate, variety

Cover Page Footnote

The authors wish to acknowledge the Kansas Wheat Alliance for funding and providing the seed necessary to perform this research.

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Summary

Seeding rate is an important management practice affecting wheat yield. Wheat varieties differ in their tillering capacity and therefore in their yield response to seeding rate. Our objectives were to evaluate the tillering and yield response of different modern wheat varieties to seeding rate. The study was conducted in Hutchinson and Manhattan, KS, during the 2015-16 growing season. Seven wheat varieties (Everest, KanMark, 1863, Joe, Tatanka, Larry, and Zenda) were sown at five different seeding rates (0.6, 0.95, 1.3, 1.65, and 2 million seeds per acre). Tiller number and grain yield were measured in the spring. Increasing plant population decreased the number of spring tillers sustained by the different varieties from more than eight tillers per plant at 600,000 seeds per acre to fewer than four tillers per plant at 2 million seeds per acre. There were varietal differences in tillers per plant, with the variety Joe standing out as a high-tillering variety. At both locations, wheat grain yield increased with increased seeding rates and was maximized at approximately 0.8-0.95 million emerged plants per acre. Further increases in seeding rate did not affect grain yield.

Introduction

Plant population density is among the major factors determining the crop's ability to capture resources such as water, nutrients, and solar radiation. The response of wheat to plant density is largely determined by competition for resources with neighboring plants, and increased competition can result in reduced survival, dry matter production, and grain yield of individual wheat plants. Wheat plants subjected to high density generally have fewer tillers and grains than widely spaced plants; on the other hand, too widely spaced plants can result in few plants per unit area and consequently fewer grains per unit area, explaining the typical parabolic response of grain yield to plant density. Consequently, appropriate management of population density may allow maximum yields per unit area to be achieved. Given the difference in wheat lines regarding their ability to tiller as well as their response to intra-canopy competition for resources, it is possible that different varieties require different seeding densities to maximize yield. Thus, the main objective of this project was to better understand the response of different wheat lines and varieties to seeding density and ultimately to provide better recommendations to producers about seeding rate per variety.

Procedures

One experiment was conducted at two locations in Kansas: the South Central Kansas experiment field near Hutchinson, and the Agronomy North Farm in Manhattan.

Trials were established in a randomized complete block design with four replications. Seven varieties (Everest, KanMark, 1863, Larry, Zenda, Tatanka, and Joe) and five seeding rates (0.6, 0.95, 1.3, 1.65, and 2 million seeds per acre) were tested, for a total of 35 treatments. Plots were 7 rows wide in Manhattan, at a 7.5-inch row spacing, and 6 rows wide in Hutchinson, at a 10 inch row spacing. Plots were approximately 20-ft long at both locations. Management practices adopted at both locations are described in Table 1. Nitrogen (N) fertilization at both locations was performed with a yield goal of approximately 70 bushels per acre, considering 2.4 lb of N needed for each bushel of yield goal. Weeds and foliar diseases were controlled at both locations so these were not confounding factors in the study.

Stand count was conducted at approximately 3-4 weeks after sowing, which was used to calculate plants per acre. All remaining analyses were performed using plants per acre rather than seeding rate. Tiller counts occurred during the spring, and a 1-meter row subsample was clipped from each plot at harvest time for biomass, harvest index, head count, average grain weight and head size. Plots were harvested using a small plot combine at both locations. Moisture and test weight were automatically measured by the combine in Hutchinson, and manually measured from the plots in Manhattan. Grain yield was adjusted for 13.5% moisture content. Statistical analysis included analysis of variance and regression, depending on the variable being evaluated.

Results

Growing Season Weather

The weather at both locations was characterized by a warm and moist fall, followed by a dry and mild winter and a cool and moist spring. Growing-season precipitation total was 20.5 inches in Hutchinson and 24.4 inches in Manhattan, mostly concentrated during the fall (approximately 1/3 of total precipitation) and spring (approximately 2/3 of total precipitation). The high yield potential led by abundant precipitation during the spring may have affected the results of grain yield.

Tillers Per Plant

Tillers were counted from a 1-meter row from all plots during late March/early April at both locations. Number of tillers per plant was significantly affected by both variety and plant population in Hutchinson, and by plant population in Manhattan (Table 2). In Manhattan, there was a trend ($P < 0.1$) for tillers per plant to be affected by variety, although this was not significant at $P < 0.05$. At the plant population of approximately 1 million plants per acre, each plant had approximately 3.8 tillers in Hutchinson. Decreasing plant population significantly increased the number of tillers per plant so that a population of about 700,000 plants per acre had 4.8 tillers per plant; and a further decrease to 400,000 plants per acre significantly increased tillers per plant to 8.2. Likewise, increasing the plant population to 1.2 million plants per acre significantly decreased the number of tillers each plant produced and maintained, but further increase in sowing density to 1.4 million plants per acre did not decrease tillers per plant. Varieties also differed in their ability to tiller. In Hutchinson, Everest, KanMark, and Zenda resulted in lower numbers of tillers per plant (3.7, 3.7, and 3.9, respectively) than did Joe (5.3). The varieties 1863, Larry, and Tatanka (4.2, 4.2, and 4.1, respectively), were statistically similar to both Joe and the lowest tillering group. Results obtained in Manhattan were similar to those obtained in Hutchinson. Joe and Larry produced numerically greater number of tillers (4.9 and 4.8, respectively) than did Tatanka, Zenda, 1863, and KanMark (4.5, 4.3, 4.2, and 4.4, respectively), and Everest had the lowest number of tillers per plant (4.0). Again, this was only a trend as these differences were not statistically significant at $P < 0.05$. The effects of plant population on the number of tillers per plant in Manhattan were similar to those measured in Hutchinson. A plant population of approximately 450,000 plants per acre resulted in 7.4 tillers per plant, and increasing plant population to 700,000 and 900,000 plants per acre significantly decreased the number of tillers per plant to 4.9 and 4.8, respectively, which are statistically equal. A further increase in plant population to 1.1 and 1.3 million plants per acre significantly decreased number of tillers per plant to 3.5 and 3.3, respectively, which are statistically the same.

Tillers Per Acre

Similarly to tillers per plant, tillers per acre were significantly affected by variety and plant population density in Hutchinson, and by plant population density in Manhattan (Table 2). In Hutchinson, the number of tillers per acre was only greater at the highest plant population of 1.3 million plants per acre. The 1.3 million plants per acre plant population had a total of 4.4 million tillers per acre, which is statistically greater than the number of tillers per acre for the plant populations of 400,000 plants per acre (3.8 million tillers per acre), 700,000 plants per acre (3.6 million tillers per acre), and 1 million plants per acre (3.8 million tillers per acre). The 1.2 million plants per acre rate resulted in 4 million tillers per acre, which is not statistically different from the numbers resulting from the higher and the lower plant populations. There was a significant effect of variety on the number of tillers per acre in Hutchinson. The variety 1863 had the highest number of tillers per acre (4.3 million tillers per acre). Zenda, Tatanka, and Joe had an intermediate number of tillers per acre (4.0, 4.1, and 3.9 million, respectively), and Larry, Everest, and KanMark resulted in the lowest readings (3.7, 3.6 and 3.7 million tillers per acre, respectively). In Manhattan, the number of tillers per acre was only greater at the highest plant population of about 1.3 million plants per acre, which is similar to the response measured in Hutchinson. The 1.3 million plants per acre resulted in a greater number of tillers per acre than that measured in the 500,000 and 800,000 plants per acre populations (4.5 versus 3.7 and 3.7 million tillers per acre, respectively). Meanwhile, the 1.1 and 1.3 million plants per acre populations resulted in similar numbers of tillers per acre (4.2 and 4.1 million tillers per acre, respectively) to those of the lower rates and the higher rate. There was no significant effect of variety in number of tillers produced per acre in Manhattan, although Joe and Larry had numerically more tillers per acre than the other varieties.

These results illustrate the capacity of the different varieties to compensate for a thin stand. Despite significantly fewer plants per acre at the lowest plant populations, these plants produced many more tillers per plant, so that the final number of tillers per acre was not as much affected as the final population. Joe stood out in its tillering capacity at both Manhattan and Hutchinson, as did Larry in Manhattan.

Grain Yield

There was a great difference in yield potential between both study locations. Across all varieties and plant population densities, the trial in Manhattan averaged 44 bushels per acre while the trial in Hutchinson averaged 78 bushels per acre. At both Hutchinson and Manhattan, grain yield was significantly affected by variety and population density, but there was no significant interaction (Table 2). In other words, there were differences between varieties, differences between population densities, but all varieties responded similarly to the change in population density, precluding the need for an analysis by variety.

In Hutchinson, plant populations of 700,000, 1 million, 1.2 million, or 1.4 million plants per acre resulted in statistically similar yields (Figure 1). The lowest population density, 400,000 plants per acre, resulted in a lower grain yield than the remaining population densities. As far as varieties, Tatanka yielded statistically more than Everest and Zenda. KanMark, 1863, Larry, and Joe were placed in the middle group and yielded similarly to Everest, Zenda, and Tatanka.

In Manhattan, a similar trend to that measured in Hutchinson occurred, with the exception that both 500,000 and 800,000 plants per acre yielded fewer than 1.4 million plants per acre (Figure 2). The fact that 800,000 plants per acre resulted in a lower grain yield than the highest plant population density as opposed to the results in Hutchinson can be a function of the no-tillage system, which generally requires increased seeding rate to compensate for the lack of seedbed preparation, cooler soils promoting less tillering, and increased disease incidence from pathogens. The intermediate plant population rates of 900,000 and 1.1 million plants per acre resulted in statistically similar yields to both the lowest and the highest yielding groups. Joe resulted in greater yield than did all the other varieties, while KanMark was the lowest yielding variety. Everest, 1863, Larry, Zenda, and Tatanka were classified in the intermediate yielding group.

Individual Variety Response to Seeding Rate

Although the analysis of variance did not call for analysis of the interaction of variety by plant population, we unfolded the interaction effects to better understand each individual variety's response to density. Each variety's yield response to plant population density was first modeled as an exponential rise to the maximum, following the trend measured in the main factor plant population at both locations and considering that there was no variety by plant population density interaction. Linear and quadratic response models were tested afterward to determine if the latter resulted in a better fit to the data.

In Hutchinson, the grain yield of Everest, KanMark, Zenda, and Larry was well modeled by an exponential rise to maximum model in the plant population range from 400,000 to 1.4 million plants per acre (Figure 3). These results indicate that, for these varieties, the best plant population for the studied growing season was in between the populations of 1.0 and 1.4 million plants per acre, both with no clear definition of a specific value. These results were most likely influenced by the above-average spring precipitation, which ensured enough moisture for tiller survival and grain yield under high population densities. KanMark and Larry seemed to maximize yields towards higher plant populations (1.1 - 1.3 million plants per acre), whereas Zenda seemed to maximize around 1 million plants per acre. The varieties 1863 and Tatanka did not show yield decrease at low population densities, meaning that their yields were the same regardless of plant population ranging from 400,000 to 1.4 million plants per acre. Joe showed a quadratic response of grain yield as affected by population. Although Joe's yield in the 700,000, 1.0, and 1.3 million plants per acre population was not statistically different, solving the quadratic equation indicates that the optimum population for Joe to maximize yields was about 980,000 plants per acre.

In Manhattan, all varieties except Everest showed an exponential rise to the maximum response (Figure 4). Everest had a linear grain yield response to plant population, indicating that if the maximum yield was achieved in the study, it was achieved at 1.3 million plants per acre and possibly could show even greater yield increase in response to population. The varieties Joe, Tatanka, Zenda, and 1863, seemed to have reached their maximum in between plant population densities of 0.9 and 1.3 million plants per acre as these did not differ among each other. KanMark and Larry, on the other hand, seemed to maximize yields towards higher plant populations (1.3 million plants per acre).

Acknowledgments

The authors wish to acknowledge the Kansas Wheat Alliance for funding and providing the seed necessary to perform this research.

Table 1. Location (latitude, longitude, and elevation) and management practices adopted at both study locations during the 2015-16 growing season

	Hutchinson	Manhattan
Latitude	37.9313° N	39.2181° N
Longitude	98.0246° W	96.5907° W
Elevation	1535 ft	1020 ft
Soil type	Ost loam	Kahola silt loam
Tillage	Conventional till	No-tillage
Previous crop	Wheat	Corn
Sowing date	10/07/2016	10/08/2016
Row spacing	10 inches	7.5 inches
Topdress N rate	107 lb N/a	99 lb N/a
Topdress N date	2/19/2016	02/28/2016
Herbicide rate	Powerflex – 2 oz/a MCPE – 1 pt/a AMS – 2.8 lb / 100 gal mix	Harmony Extra – 0.7 oz/a MCPA Ester – 16 oz/a NCIS – 16 oz / 100 gal mix
Herbicide date	2/19/2016	03/10/2016
Fungicide rate	Quilt Xcel – 12 fl. oz/a	Quilt Xcel – 14 fl. oz/a
Fungicide date	4/25/2016	04/22/2016
Harvest date	6/16/2016	06/24/2016

N = Nitrogen.

Table 2. Significance of the source of variation on the number of tillers counted per plant in Hutchinson and Manhattan, KS, during the 2015-16 growing season

Response	Effect	Hutchinson	Manhattan
Tiller per plant	Variety	***	$P = 0.07$
	Plant population	***	***
	Variety × plant population	ns	ns
Tiller per acre	Variety	*	ns
	Plant population	***	***
	Variety × plant population	ns	ns
Grain yield	Variety	***	***
	Plant population	*	***
	Variety × plant population	ns	ns

Ns = not significant.
* - significant at $P < 0.05$
*** - significant at $P < 0.001$

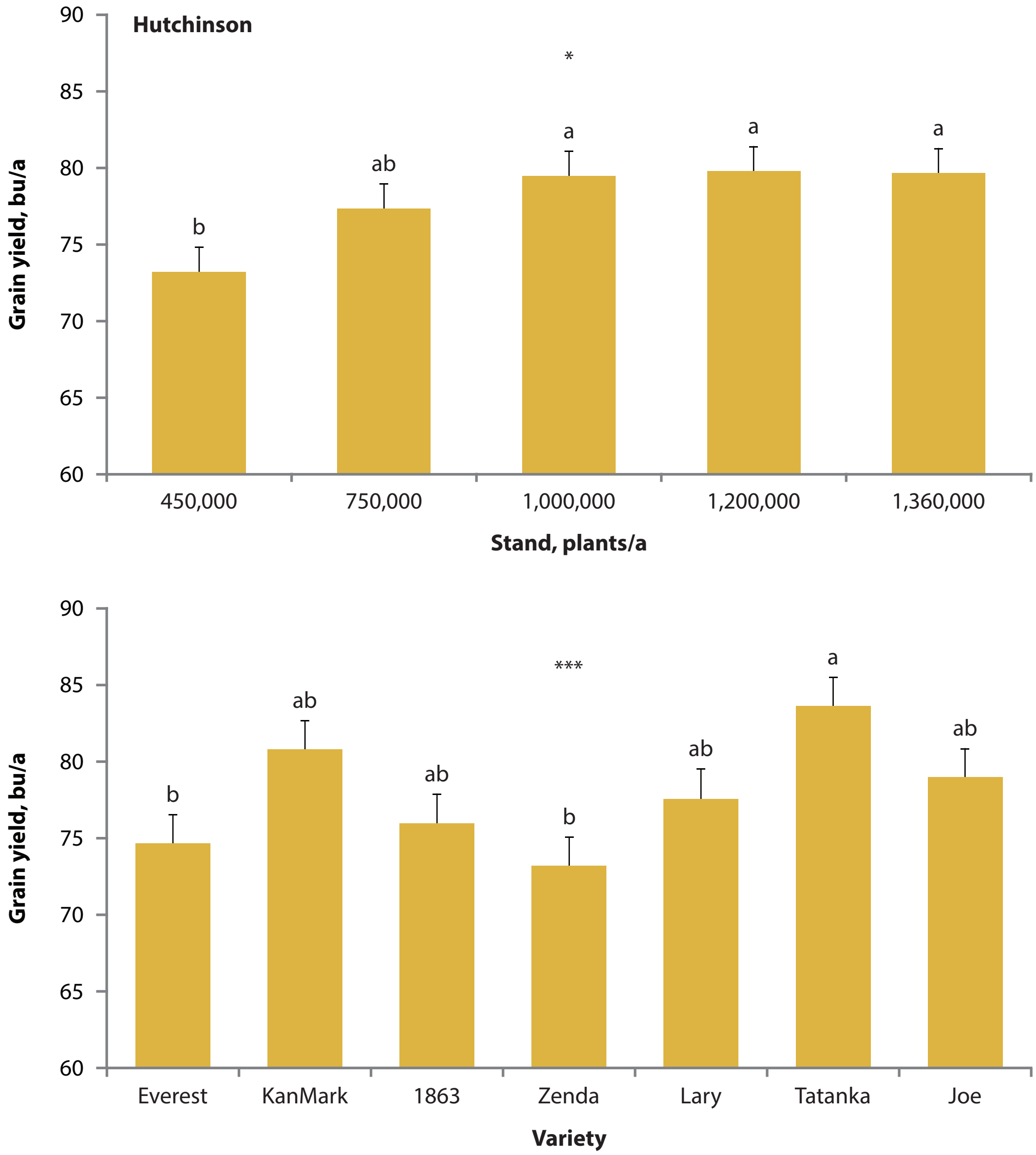

Figure 1. Wheat grain yield as affected by seeding rate and variety during the 2015-16 growing season in Hutchinson, Kansas. The *, * indicates that the main effect plant population was statistically significant at *P* < 0.05, and the main effect variety (lower chart) was statistically significant at *P* < 0.001.**

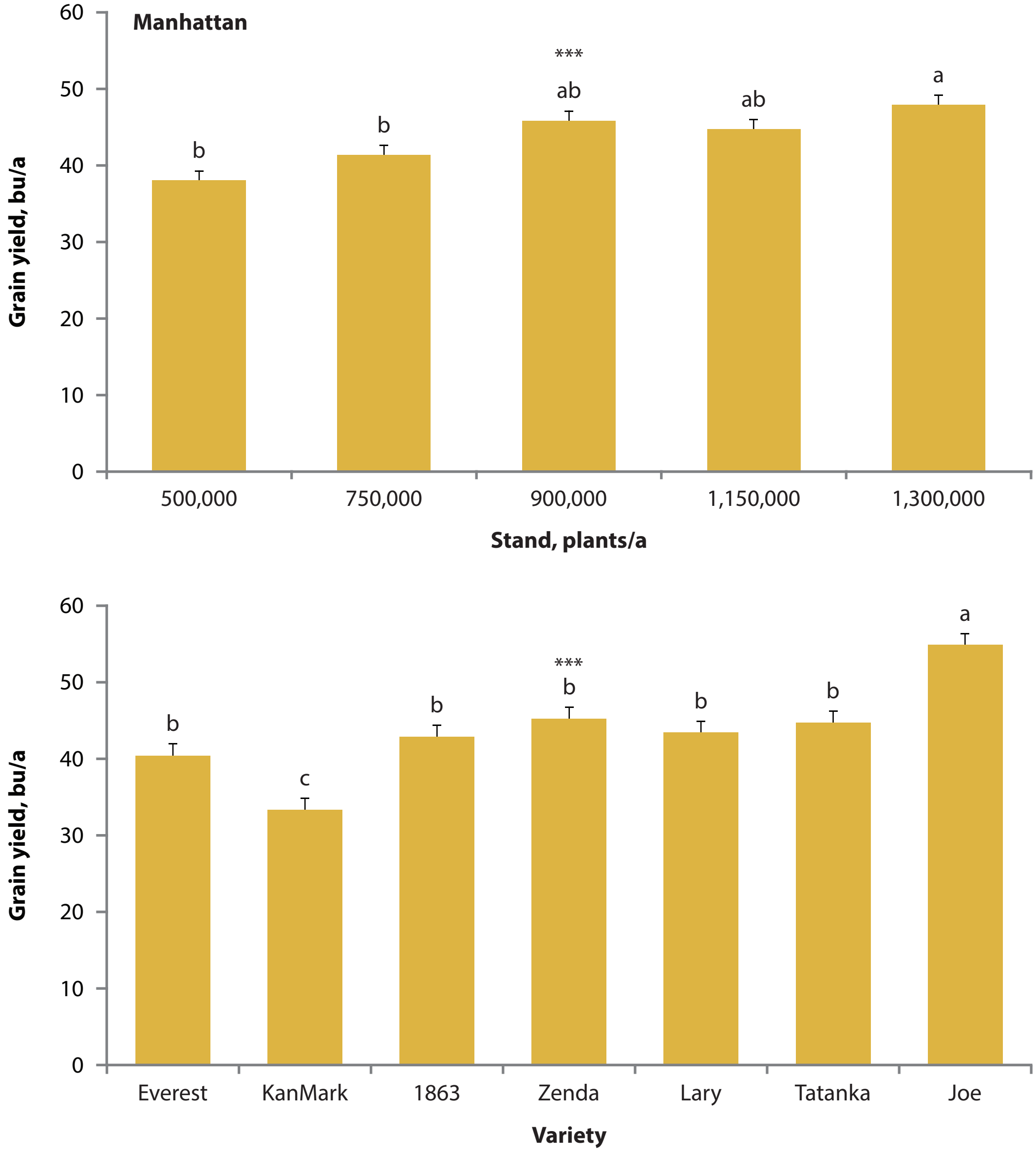

Figure 2. Wheat grain yield as affected by seeding rate and variety during the 2015-16 growing season in Manhattan, Kansas. The * indicates that the main effects plant population (upper chart) and variety (lower chart) were statistically significant at $P < 0.001$.**

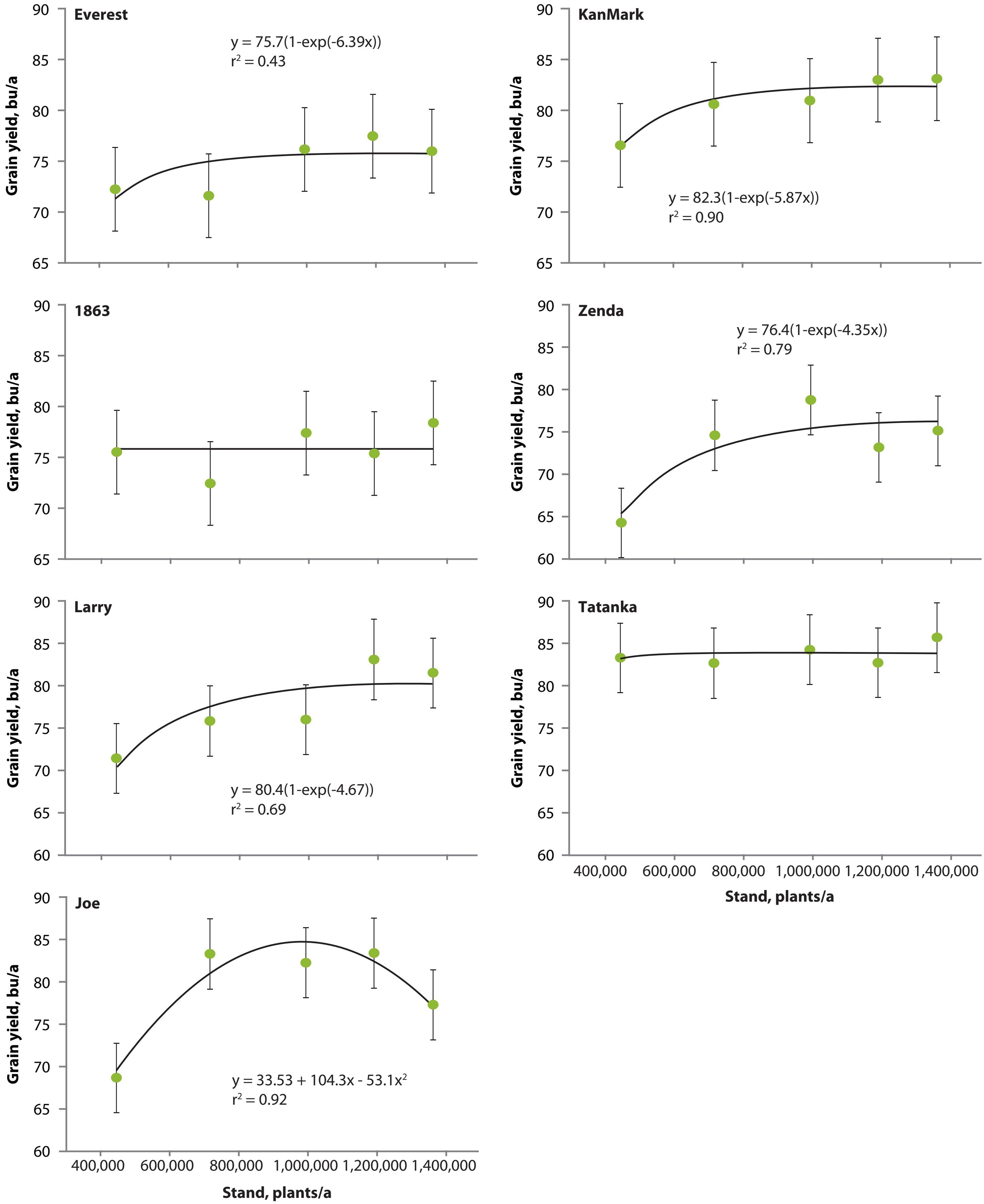

Figure 3. Grain yield response to plant stand of each individual variety at Hutchinson, KS, during the 2015-16 growing season.

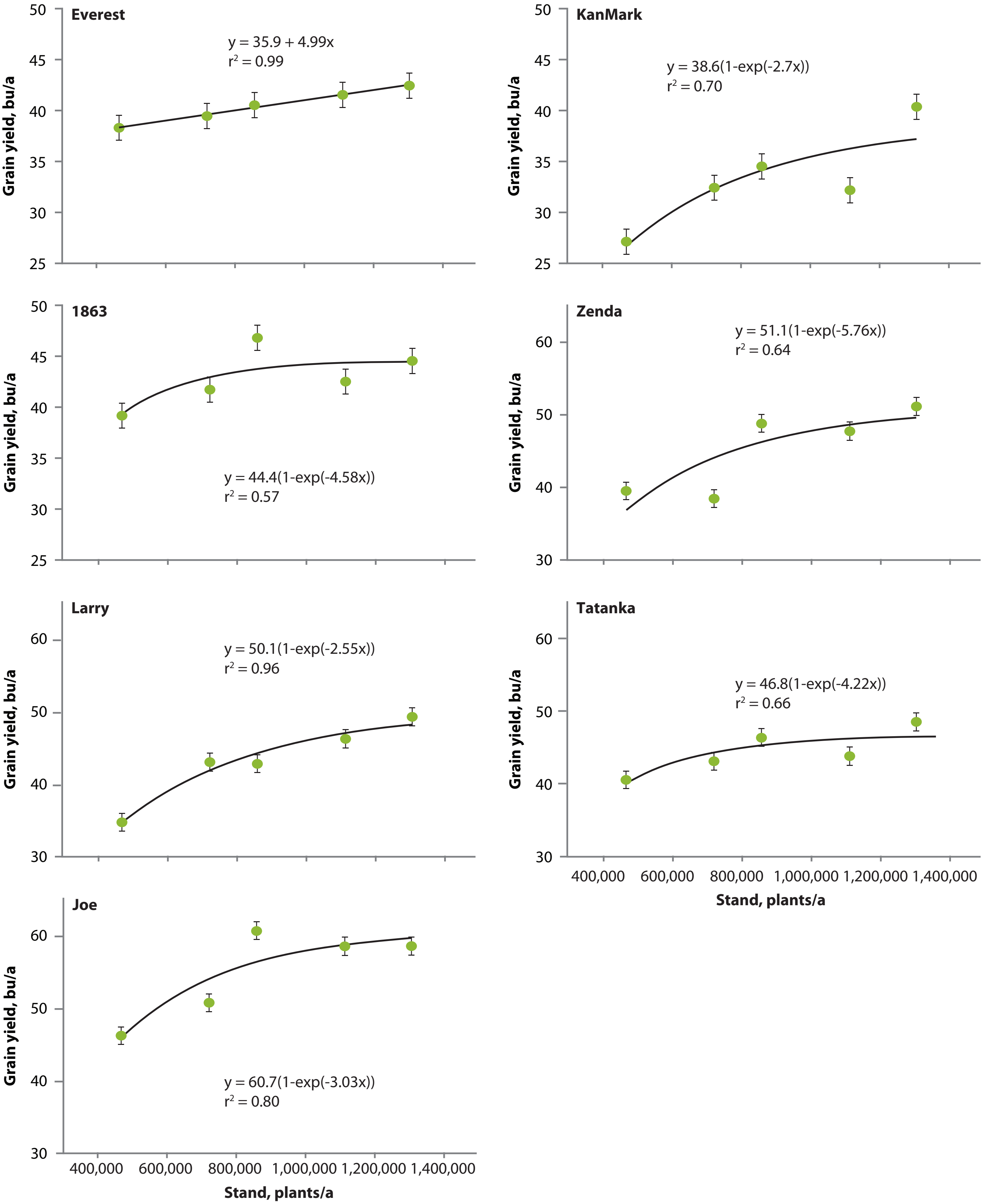

Figure 4. Grain yield response to plant stand of each individual variety at Manhattan, KS, during the 2015-16 growing season. Notice the difference in scale between Everest, KanMark, and 1863, compared to the other varieties.