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Planting rate influence on yield and agronomic traits of hard red spring wheat in northeastern North Dakota

Bryan Hanson

North Dakota Agricultural Experiment Station

North Dakota State University

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Using the correct planting rate for hard red spring wheat (HRSW) (*Triticum aestivum*) is critical to establishing plant stands that ensure optimum yields.

Optimum planting rates for HRSW vary across North America spring wheat growing regions. In southeastern Saskatchewan, a planting rate of 18-36 pounds per acre was adequate where yields are less than 20 bushels per acre (Pelton, 1969), while in Alberta, where yield levels range from 38 to 51 bushels per acre, a planting rate of 90 pounds per acre gives optimum wheat yields (Guitard et al., 1961). Under irrigation in Utah, where yields ranged from 60 to 80 bushels per acre, a rate of 50 to 60 pounds per acre was adequate except when planted late (Woodard, 1956). In western North Dakota at Minot, Williston and Dickinson, HRSW wheat yields were optimized at a stand rate of 1 million plants per acre at yield levels of 30 to 35 bushels per acre (Riveland et al., 1979).

Many of the previous studies cited in literature were conducted a number of years ago with older varieties while much of the research on HRSW planting rates in North Dakota has been conducted in dryer environments. The objectives of this planting rate study conducted by the Langdon Research Extension Center were to i) evaluate planting rate effects on yield, yield components and other agronomic traits, and ii) study the relationship between established plant population and yield to determine the minimum number of plants per square foot needed to obtain optimum yields of HRSW in the high-yield environment (45-60 bushels per acre) of northeastern North Dakota.

Hanson is agronomist, Langdon Research Extension Center

Planting rate study

Grandin HRSW was planted at a total of 16 locations across northeastern North Dakota from 1991 to 1993. Precipitation totals for May through August were above normal at all locations in 1991 and 1993 and below normal in 1992 (Table 1). Small grain growing degree-days for May through August at Langdon were 177 degree-days above normal in 1991 and 500 and 397 degree-days below normal in 1992 and 1993, respectively. Four planting rates, adjusted for percent germination and seed size, of 0.5, 1.0, 1.5 and 2.0 million seeds per acre were used (Table 2). Trial design was a randomized complete block with four replications. Seed treatment was carboxin 17F + thiram 17 at 3 fluid ounces per hundred pounds of seed. Weed control was excellent throughout the study.

Stand counts were made in each plot after emergence to determine established plant populations and percent emergence. Seven 6-inch spaced rows 16 feet long were harvested for grain yield with a plot combine. Results were analyzed treating individual locations and years as separate environments.

Significant environment by planting rate interactions for yield, test weight, lodging, plant height and days to head were observed (Table 3). Upon inspection, it was determined that the significance was due to differences in magnitude of responses and not a change in rank due to planting rates, so the data are presented as averages across environments.

Yield, test weight, and protein

Yields across the 16 environments ranged from 27.0 bushels per acre at Devils Lake in 1993 to 75.7 bushels per acre at Cando in 1992, with an average yield of 51.7 bushels per acre. The 0.5

Table 1. Trial locations, planting and harvest dates, soil series, previous crop, yield goal and growing season rainfall for HRSW planting rate studies across northeast North Dakota, 1991-1993.

Trial Location	Planting Date	Harvest Date	Soil Series†	Previous Crop	Yield Goal	–Growing Season Rainfall (May-Aug)– 1991-93	Normal
					bu/acre	inches	inches
1991							
Langdon	25 April	21 Aug	Svea	Fallow	80	13.54	10.78
Cavalier	13 May	14 Aug	Overly	Wheat	50	12.89	11.14
Park River	26 April	13 Aug	Glyndon	Fallow	90	17.52	10.75
Tolna	23 April	6 Aug	Svea	Barley	70	12.57	10.98
Devils Lake	9 May	19 Aug	Overly	Wheat	85	17.39	10.21
Cando	9 May	19 Aug	Glyndon	Wheat	50	13.63	9.64
1992							
Langdon	26 April	1 Sep	Svea	Fallow	80	8.80	10.78
Cavalier	7 May	16 Sep	Overly	Wheat	65	10.16	11.14
Park River	23 April	20 Aug	Gardena	Fallow	80	9.83	10.75
Devils Lake	30 April	23 Aug	Bearden	Wheat	70	6.21	10.21
Cando	30 April	27 Aug	Glyndon	Fallow	60	6.98	9.64
1993							
Langdon	1 May	8 Sep	Svea	Fallow	80	22.18	10.78
Park River	30 April	4 Sep	Glyndon	Fallow	80	19.90	10.75
Petersburg	12 May	7 Sep	Hamerly	Sunflower	50	19.81	10.98
Devils Lake	8 May	28 Aug	Glyndon	Flax	80	20.80	10.21
Cando	12 May	17 Sep	Glyndon	Wheat	60	18.41	9.64

†Soil Classification. **Svea** – fine-loamy, mixed, Pachic Udic Haploborolls; **Overly** – fine-silty, mixed Pachic Udic Haploborolls; **Glyndon** – coarse-silty, frigid Aeric Calciaquolls; **Gardena** – coarse-silty, mixed Pachic Udic Haploborolls; **Bearden** – fine-silty, frigid Aeric Calciaquolls; **Hamerly** – fine-loamy, frigid Aeric Calciaquolls.

Table 2. Grandin HRSW planting rate for trials conducted in northeastern North Dakota, 1991-1993.

Planting Rate[1]			
Million seeds/acre	Seeds/ft²	lbs/bu	bu/acre
0.5	11	42	0.7
1.0	23	83	1.4
1.5	34	125	2.1
2.0	46	166	2.8

[1] Planting rate reported as pure live seeds. Adjusted for percent germination and seed size. Thousand kernel weight = 38 grams (11,950 seeds per pound).

Table 3. Analysis of variance for yield, yield components and other agronomic responses on Grandin HRSW.

	No. of Environments	Source: Planting Rate (PR)	Environment (E)	PR x E
Yield	16	**	**	**
Test weight	16	**	**	**
Protein	16	NS	**	NS
Plant height	16	NS	**	**
Lodging	6	**	**	**
Days to head	8	**	**	**
% Emergence	16	**	**	NS
Tillers/plant	16	**	**	NS
Heads/ft²	16	**	**	NS
Spikelets/head	16	**	**	NS
Kernels/spikelet	16	**	**	NS
1000 KWT	16	NS	**	NS

** Indicate significance at the 0.01 level of probability.
NS indicates non-significant.

million seeds per acre planting rate yielded an average of 6.3 bushels per acre less than all other planting rates and was the lowest yielding in 15 of the 16 environments. Yields from the 2.0 million seeds per acre planting rate were 1.9 bushels per acre higher than yields from the 1.0 million seeds per acre planting rate. There was not a significant yield difference between the 2.0 and 1.5 million seeds per acre planting rate (Table 4).

Test weights averaged 60.0 pounds per bushel in 1991 and 61.0 pounds per bushel in 1992, while the 1993 test weight averaged 58.4 pounds per bushel. Test weight averaged 1.0 pound per bushel lower for the 0.5 million seeds per acre planting rate compared to the higher planting rates and was the lowest in 13 of the 15 environments. Lower yields and test weights in 1993 resulted from fusarium head blight (*Fusarium graminearum*) infections.

Percent protein did not differ with planting rate.

Yield components

Yield components were determined from a 3-foot hand harvested row taken from each plot before harvest. Effects of planting rate on yield components are given in Table 5. Tillers per plant (which formed a head), spikelets per head, and kernels per spikelet were highest at the 0.5 million seeds per acre planting rate and

Table 4. Planting rate effect on yield, test weight and protein of Grandin HRSW across 16 environments in northeast North Dakota, 1991-1993.

Planting Rate	Yield	Test Weight	Protein
million seeds/acre	bu/acre	lbs/bu	%
0.5	46.9	58.3	14.8
1.0	52.2	59.1	14.8
1.5	53.2	59.3	14.8
2.0	54.1	59.5	14.9
LSD 5%	1.6	0.4	NS

Table 5. Planting rate effects on yield components of Grandin HRSW across 16 environments in northeast North Dakota, 1991-1993.

— Planting Rate —		Established					1000
Million Seeds	Plants	Plants	Heads	Tillers	Spikelets	Kernels	Kernel wt.
/acre	/ft²	/ft²	/ft²	/plant	/head	/spikelet	grams
0.5	11	10.7	49.0	4.6	12.5	2.0	34.9
1.0	23	18.7	56.6	3.1	12.0	1.9	35.0
1.5	34	24.8	57.1	2.4	11.6	1.8	35.0
2.0	46	30.8	60.1	2.1	11.3	1.8	35.4
LSD 5%		1.9	3.4	0.2	0.3	0.06	NS

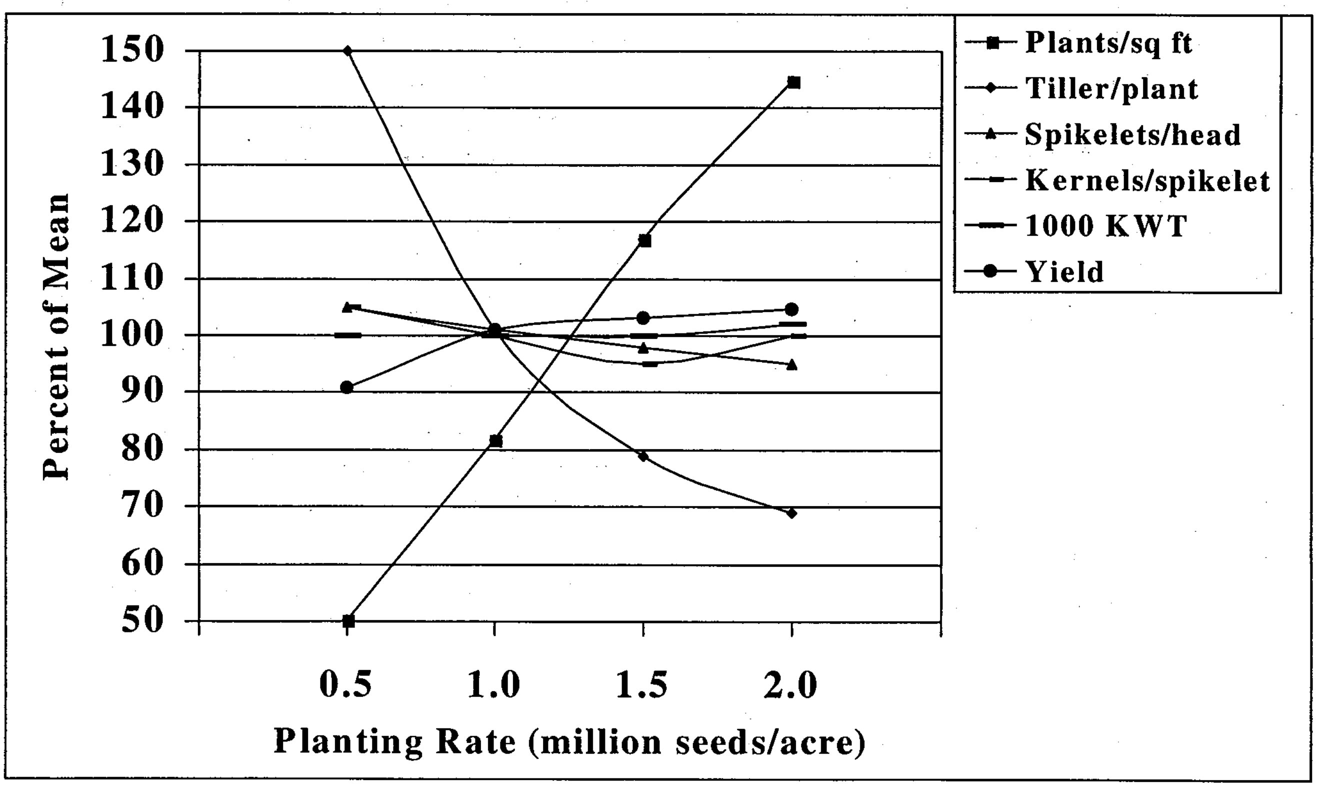

Figure 1. The influence of seeding rate on the yield and yield components of Grandin HRSW.

decreased as planting rate increased. Established plants and heads per square foot were highest at the 2.0 million seeds per acre planting rate and decreased as the planting rate decreased. Planting rate did not affect 1000 kernel weight. Similar yield component trends have been observed in other studies (Pelton, 1969; Guitard et al., 1961, Riveland et al., 1969).

The response of yield and yield components to planting rate as a percentage of the mean for each trait is shown in Figure 1. Plants per square foot had a strong positive response to planting rate while tillers per plant had a strong negative response.

Other agronomic traits

The effect of planting rate on plant height was non-significant. Lodging scores at the six environments where lodging occurred were the lowest at the 0.5 million seeds per acre rate and increased as planting rates increased. The number of days to heading from planting date was highest at the lowest planting rate and decreased as planting rates increased. Percent emergence was highest at the lowest planting rate (Table 6). Lower percent emergence at higher planting rates may have been due to increased seed competition within the row. This same effect as been seen in other small grain planting rate studies (Hanson and Lukach, 1992, 1993).

Table 6. Planting rate effect on agronomic traits of Grandin HRSW across several environments in northeast North Dakota.

Planting Rate	Plant Height (16)[1]	Lodging (6)	Days to Head (8)	Emergence (16)
million seeds /acre	inches	0-9[2]	from planting	%
0.5	36.5	0.1	57.3	94.8
1.0	36.6	0.4	56.5	88.0
1.5	36.7	1.2	56.0	85.3
2.0	36.5	1.9	55.8	84.9
LSD 5%	NS	0.9	0.5	4.4

[1] Number of environments observed.

[2] 0 = plants stand erect, 9 = plants flat on ground.

Established plant stands vs. yield

The relationship between established plant stand and yield was analyzed in this study to help determine the minimum number of plants per square foot needed to obtain optimum yields. The optimum yield in this study occurred at 34 plants per square foot (1.48 million plants per acre) with no significant difference in the range between 26 and 41 plants per acre) (Figure 2). This suggests that the minimum number of established plants to obtain optimum yields would be 26 plants per square foot. No significant yield benefits would be obtained with higher established plant stands.

A producer's goal, then, is to select a planting rate that establishes a plant stand of at least 26 plants per square foot. Percent emergence is unpredictable due to a variety of factors such as depth of planting, potential soil crusting, seedling diseases, dry seedbeds and herbicide injury. These factors can result in large differences in percent emergence that can occur from field to field, which makes selecting the best planting rate difficult.

In this study, the average percent emergence of the 1.0, 1.5 and 2.0 million seeds per acre planting rate at 16 environments was 86 percent. To obtain an established plant stand of 26 plants per square foot, a producer should use a planting rate between 1.25 and 1.40 million pure live seeds per acre assuming a 10-20 percent reduction in stand. Anticipated stand losses of greater than 10-20 percent would require further adjustments to planting rates.

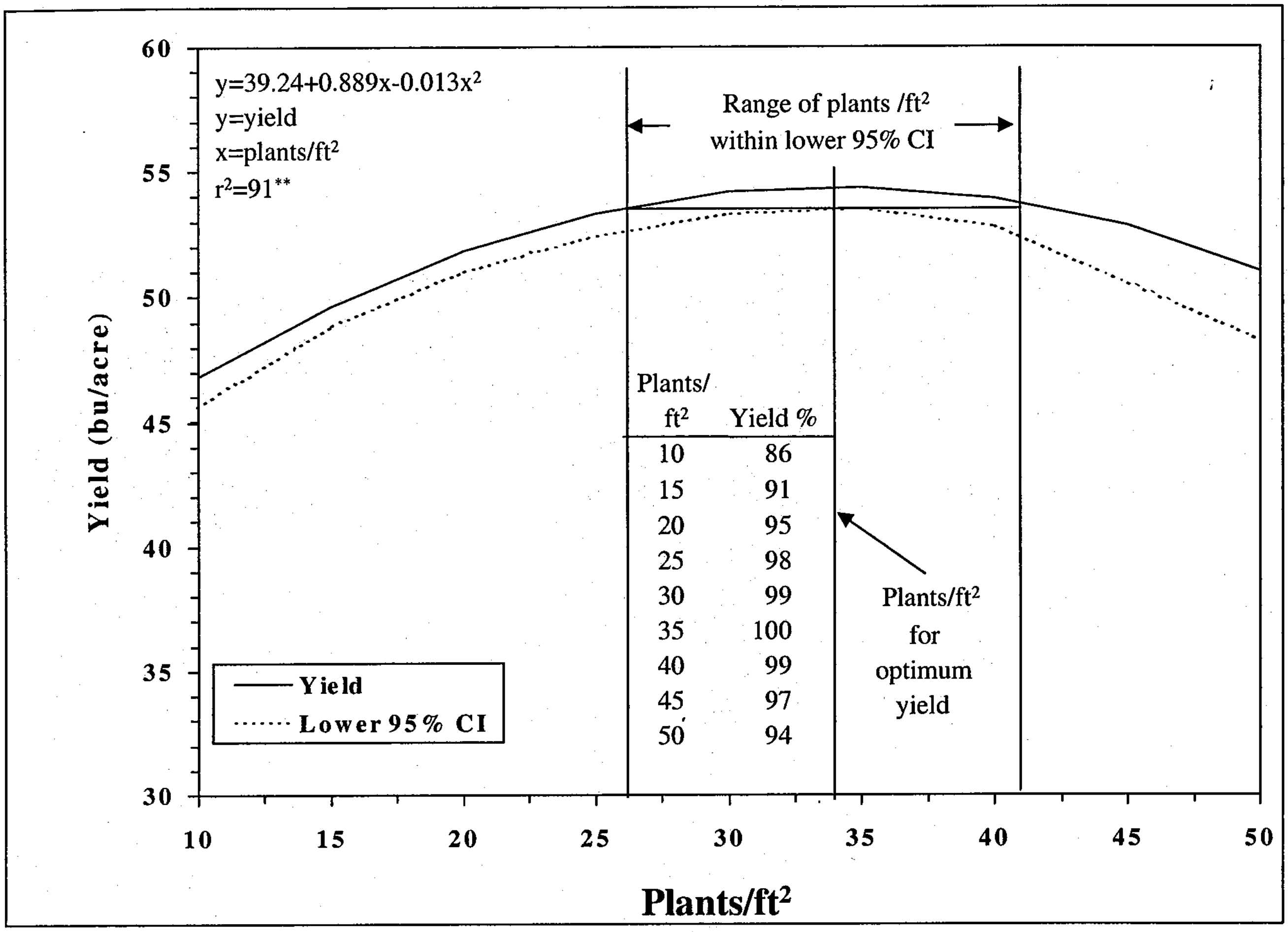

Figure 2. Relationship between plants/ft² and yield of Grandin HRSW averaged across 16 environments in northeast North Dakota, 1991-1993.

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