Optimum Seeding Rates for Diverse HRSW Varieties

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Research Questions

Yield of HRSW is affected by many agronomic practices starting with choice of the cultivar, the planting date, and seeding rate. Previous research has shown that optimum seeding rates differ for individual cultivars (Wiersma, 2004). This research project specifically explores the relationship between a set of genetic traits, including semi-dwarf stature and day length sensitivity, of individual cultivars, planting dates, and seeding rates, and to develop regression models that supersede individual cultivars and looks to explain how a group of genetically similar varieties respond to seeding rate.

Results

In both 2013 and 2014 the environment was atypical in that the accumulated growing degree days was behind the historical 30 year average, evidence of a cooler than normal growing season that proves hard red spring wheat response to seeding rate is not always as pronounced as what is expected (Figure 3). At the Kennedy North Dakota Agricultural Weather Network (NDAWN) station, which is just nine miles from the Hallock, MN field trial, there is evidence that the summer was cooler overall, especially at periods of grain fill. Table 2 has results of the seeding rate factor at all environments from 2014. Of the nine environments, four had a range in grain yield of less than 4 bu/ac across the five seeding rates. The other five locations had yield ranges of 5-8 bu/ac across five seeding rates. Within and across locations there were no significant variety by seeding rate interactions in 2014 and therefor no variety specific seeding rate response regressions can be developed. However, the single seed hill plots proved that cultivars have varying propensity to tiller. At Prosper, ND, averaged over all four planting dates as no significant interaction existed, the cultivar 'Sabin' had significantly higher stems per plant than any other cultivar (Table 3). Results from Prosper reiterate the importance of tillering when choosing a seeding rate for a specific cultivar. Contrary to Prosper, ND, results from Crookston, MN, show that with each successive planting date later into the season, the number of stems per plant decreased (Table 4). Two cultivars, 'Marshall' and 'Rollag' increased total number of stems at the second planting date compared to the first, but followed the general trend at the last two planting dates. Results confirm that as HRSW is planted later, a higher seeding rate should be considered as less tillers can be expected. Varieties and their genetic make-up, including semi-dwarf stature and day length sensitivity, influence this response. Results from stand counts and head counts leading to a total stems per plant calculation within the solid seeded trials showed a far smaller spread than in the hill plots, as expected, though six of nine environments had significant differences between cultivars (Table 5). Yield results from the planting date effect from the past two years with cooler than normal periods indicate that increasing seeding rate at later than optimal planting dates will not significantly increase or decrease yield (Table 6). Thus, the unpredictability of growing conditions, especially during critical growth periods, indicate the importance of erring on the side of increased seeding rate. Figures 1 and 2 begin to show the results that were intended from the hypothesis of this research. In 2013, at Crookston, MN, presence of the *Rht2* gene at the early planting date did not result in a yield decrease as seeding rate increased, while cultivars that did not have the Rht2 gene had a pronounced yield decrease at increased seeding rates above the optimum. In contrast to that result, when the Rht2 gene was present in a cultivar and the planting date was three weeks later than optimum, the yield curve broke into a large yield decrease after the 1.4 million seeding rate, mirroring the curve of cultivars without *Rht2*. Results begin to show that knowledge of the genetic makeup of a plant with respect to certain qualitative traits could impact seeding rate decisions.

Application/Use

Evidence from 2013 was that for many cultivars, increasing seeding rate up to the highest rate lead to significantly greater yield. Yields in the late planting date at the three locations highlighted in table 5 and 6 show varying results when increasing seeding rate. Evidence from the Crookston location in 2014 is that the highest seeding rate yielded greater than the four lower seeding rates in the late planting date while this trend was not seen in the early planting date. After two years of research the results do not allow us to recommend seeding rates through any genetic analysis of cultivars, however there is promise that this objective can be met.

Material and Methods

Six field locations were established in 2014 at Hallock, Crookston, Perley, Kimball, and Lamberton, MN and Prosper, ND. Locations were chosen to pair locations latitudinal, with Hallock and Crookston, Perley and Prosper, and Kimball and Lamberton being paired. Four field locations were established in 2013 at Hallock, Crookston, and Perley, MN and Prosper, ND. Locations were chosen to run down latitude lines with Hallock being the validation site for Crookston and Perley being the validation site for Prosper. Crookston (2013 and 2014), Prosper (2014), and Lamberton (2014) used a randomized complete block design (RCBD) with a split-split plot restriction with planting date as whole plot, HRSW cultivar as the split plot, and seeding rate as the split-split plot. Hallock (2013 and 2014), Perley (2013 and 2014), Prosper (2013), and Kimball (2014) were RCBD with a split plot restriction with HRSW cultivar as the whole plot and seeding rate the split plot. When planting date was a factor the first planting date would be as close to optimal as possible, and the second planting date three weeks later. The HRSW cultivar factor was twelve cultivars split into six groups of two from known genetic associations for *Rht1, Rht2*, and day length sensitivity (Table 1). The seeding rate factor had five levels at 600,000, 1,000,000, 1,400,000, 1,800,000, and 2,200,000 live seeds/acre planted. The data collected were stand count at Feekes 1-2, head count at Feekes 11, height, lodging, and grain yield components. Stand counts and head counts were measured from a 3 ft length in two adjacent rows, and used to verify seeding rates and determine the number of stems per plant. An additional trial with single seed hill plots was done at Crookston, MN and Prosper, ND in 2014. The trial was designed as a RCBD with a split plot with planting date as the whole plot and cultivar as the split plot. The same twelve cultivars from Table 1 were used, and there were four planting dates at each location, separated by approximately one week. Single seeds were space planted on a one foot spaced grid. Number of stems were counted at Feekes 11.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

Table 7 shows the yield trend at all five seeding rates at Hallock in 2013. Though there was an interaction of cultivar during 2013, this data is averaged over cultivar to show the impact of seeding rate. The optimum seeding rate for maximum bet income with yield from Hallock, 2013, and seed costs taken into account, is the 1.4 million seeds per acre rate. The second most economical seeding rate was 1.0 million seeds per acre, while 0.6 million seeds per acre would net the lowest. If a farmer were to plant 500 acres with the math from table 7 holding true, planting at the optimum seeding rate of 1.4 million seeds per acre would net $8,618 more than the most uneconomical seeding rate of 0.6 million seeds per acre.

Recommended Future Research

From two years of research into the effect of planting date, seeding rate, and diverse HRSW cultivars it is evident that a third year of research will be needed to fully test the objectives of the research. The atypical growing conditions encountered in either year, especially 2014, limit our ability to meat the objectives of the research. Although some of the data, in particular Figure 1 and 2, strongly suggest that the genetic make-up of contrasting groups of cultivars influences their response to seeding rate and that this response therefor should be able to be predicted. In 2013 we had a spring wheat average yield at Crookston optimum planting date on May 10, 2013 of 91 bu/ac, while at the planting date almost three weeks later on May 28, 2013 averaged a higher yield at 95 bu/ac. In 2014 the seeding rate by cultivar interaction was not as expected, due to cooler than average temperature during grain fill which allowed wheat tillers to even out yield between seeding rates. While the seeding rate response curve in 2013 is more like what we would expect, we simply do not have a large enough data set to draw robust conclusions and develop the regression models. We will submit a proposal for continuation of this research for the 2015 season, where after, if funded, we will draw final conclusions on the potential of the ideas proposed in this research for choosing a seeding rate based on genetic components of the HRSW cultivar.

Table 1. The HRSW cultivars included in research and presence of day length sensitivity, Rht1, and Rht2 genes

Group	Cultivar	Day length Sensitivity	Rht1	Rht2
1	Albany	+	+	-
	Faller	+	+	-
2	Knudson	-	+	-
	Samson	-	+	-
3	Briggs	+	-	-
	Vantage	+	-	-
4	Sabin	-	-	-
	Oklee	-	-	-
5	Kelby	-	-	+
	Kuntz	-	-	+
6	Marshall	+	-	+
	Rollag	+	-	+

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Table 2. Effect of seeding rate on yield a 6 study locations, with 2 planting dates at 3 locations, 2014.

	Location								
Rate	**Hallock**	**Crookston PD 1**	**Crookston PD 2**	**Perley**	**Prosper PD 1**	**Prosper PD 2**	**Kimball**	**Lamberton PD 1**	**Lamberton PD 2**
Million seeds/ac	-------------------------------bu/ac-------------------------------								
0.6	76.9	71.3	64.5	88.1	64.8	44.2	83.8	71.6	58.4
1.0	81.8	75.2	67.2	89.8	65.9	49.1	83.5	75.2	61.5
1.4	81.8	73.2	67.9	90.7	66.4	48.9	82.6	78.1	63.7
1.8	82.0	74.2	67.9	88.8	66.5	49.8	80.7	78.0	65.7
2.2	82.3	73.9	70.5	88.7	65.7	49.0	81.2	79.5	63.8
Mean	80.9	73.5	67.6	89.2	65.9	48.2	82.4	76.5	62.6
Min	76.9	71.3	64.5	88.1	64.8	44.2	80.7	71.6	58.4
Max	82.3	75.2	70.5	90.7	66.5	49.8	83.8	79.5	65.7
Range	5.4	3.9	6.0	2.5	1.7	5.6	3.1	7.9	7.3
LSD (0.5)	1.5	NS	2.6	NS	NS	1.9	NS	2.2	3.3

Table 3. Effect of cultivar on total stems per plant, Prosper, ND, 2014.

Cultivar	Stems/plant
Sabin	43.9
Marshall	36.1
Albany	36.0
Knudson	33.9
Faller	31.7
Oklee	28.4
Kuntz	26.7
Vantage	25.8
Rollag	25.0
Briggs	24.2
Kelby	20.4
Samson	18.7
LSD (0.5)	6.2

Table 4. Effect of cultivar by planting date interaction on total stems per plant, Crookston, ND, 2014

Cultivar	23-May	30-May	6-Jun	23-Jun
	----------------stems/plant----------------			
Albany	34.3	25.8	8.5	3.7
Briggs	19.3	15.4	14.2	5.5
Faller	29.6	26.2	16.3	16.4
Kelby	14.3	13.2	11.5	6.5
Knudson	24.7	21.5	14.3	8.1
Kuntz	16.3	17.7	9.5	5.6
Marshall	14.7	24.2	13.5	7.9
Oklee	16.1	16.8	12.9	6.0
Rollag	11.1	19.8	13.9	5.4
Sabin	24.7	24.3	22.8	13.1
Samson	18.2	13.8	14.2	7.2
Vantage	20.8	20.0	10.6	4.4
Mean	20.4	19.9	13.5	7.5
LSD (0.05)	6.2	5.1	5.1	5.1

Table 5. Effect of cultivar on stems per plant at 6 study locations, with 2 planting dates at 3 locations, 2014.

Cultivar	Location								
	Hallock	Crookston PD 1	Crookston PD 2	Perley	Prosper PD 1	Prosper PD 2	Kimball	Lamberton PD 1	Lamberton PD 2
	stems/plant								
Albany	2.35	1.98	1.51	2.08	2.70	4.24	2.37	3.04	3.26
Briggs	2.35	2.04	1.66	2.40	2.93	3.56	2.46	2.78	3.39
Faller	2.47	2.02	1.45	1.99	2.53	2.73	2.43	3.03	3.60
Kelby	2.05	1.78	1.43	1.78	2.37	3.00	2.19	2.63	3.47
Knudson	2.45	2.04	1.82	2.24	2.66	3.20	2.45	3.33	4.19
Kuntz	1.71	1.65	1.54	1.70	2.37	3.77	2.12	2.52	3.04
Marshall	2.21	1.97	1.60	2.32	2.91	4.16	2.30	3.13	3.60
Oklee	2.28	1.69	1.46	1.75	2.18	2.49	2.12	2.80	3.12
Rollag	2.75	1.97	1.60	2.02	2.58	4.05	2.43	2.77	3.22
Sabin	1.93	1.74	1.25	1.92	2.30	2.58	1.96	2.77	2.52
Samson	1.96	1.94	1.44	1.83	2.01	3.13	2.61	2.58	2.85
Vantage	1.89	1.60	1.59	2.03	2.46	2.72	2.30	2.22	2.27
Mean	2.20	1.87	1.53	2.01	2.50	3.30	2.31	2.80	3.21
LSD (0.05)	0.33	0.26	0.23	0.30	0.73	0.68	NS	NS	NS

Table 6. Effect of planting date by seeding rate interaction averaged over HRSW cultivar on yield at Lamberton and Crookston, MN, 2014

Planting Date	Lamberton, MN 2014					
	600,000	1,000,000	1,400,000	1,800,000	2,200,000	LSD
	bu/ac					
Early	71.7	75.2	78.1	78.0	79.5	2.8
Late	58.4	61.5	63.7	65.7	63.8	4.0
	Crookston, MN 2013					
Early	88.6	92.6	92.9	91.3	90.8	NS
Late	91.0	94.8	97.0	95.5	96.2	NS
	Crookston, MN 2014					
Early	71.3	75.2	73.2	74.2	73.9	NS
Late	64.5	67.2	67.9	67.9	70.5	NS

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Figure 1. Effect of Rht2 gene on yield response to seeding rate in the early (optimal) planting date of May 10, Crookston, MN, 2013.

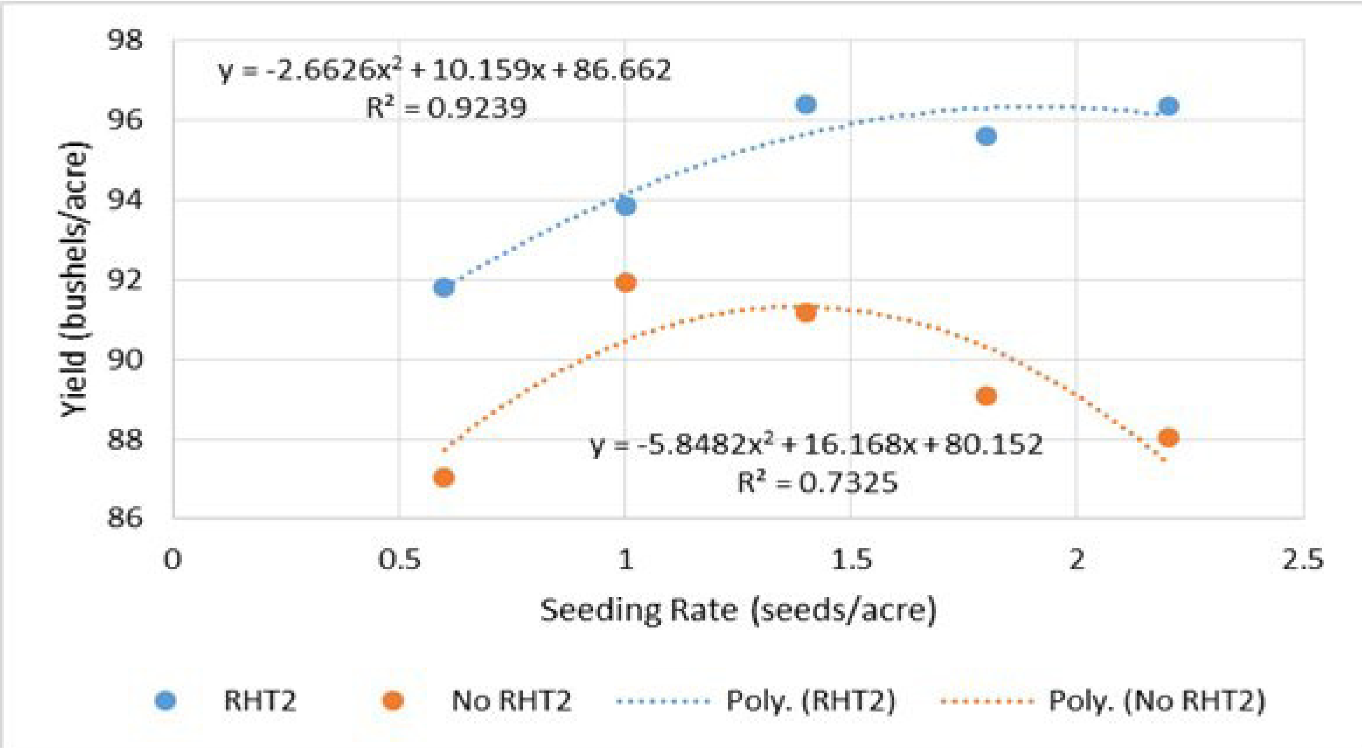

Figure 2. Effect of Rht2 gene on yield response to seeding rate in the late planting date of May 28, Crookston, MN, 2013

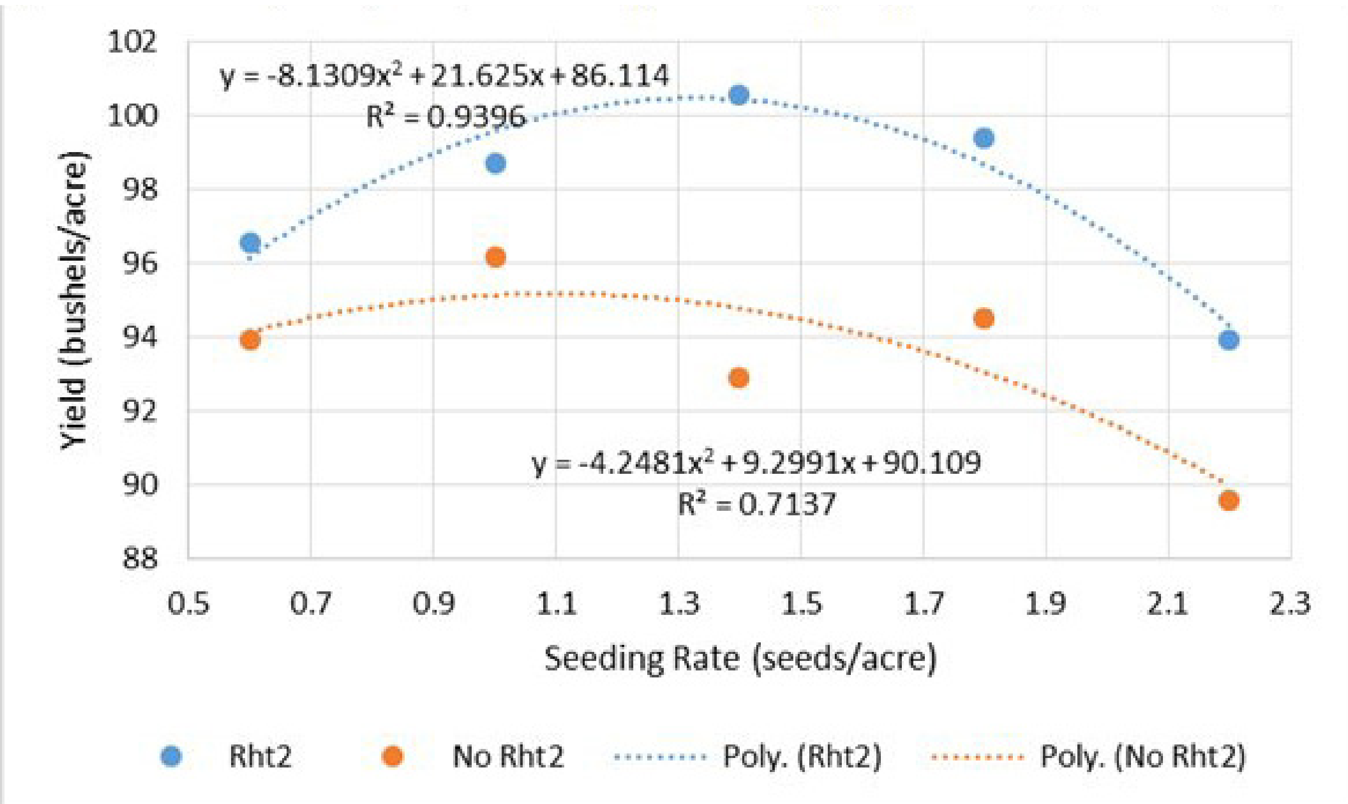

Figure 3. Accumulated growing degree days at the Kennedy, MN, North Dakota Agricultural Weather Network (NDAWN) for the 2014 dates growing season of the Hallock, MN trial and the 30 year average at Kennedy site.

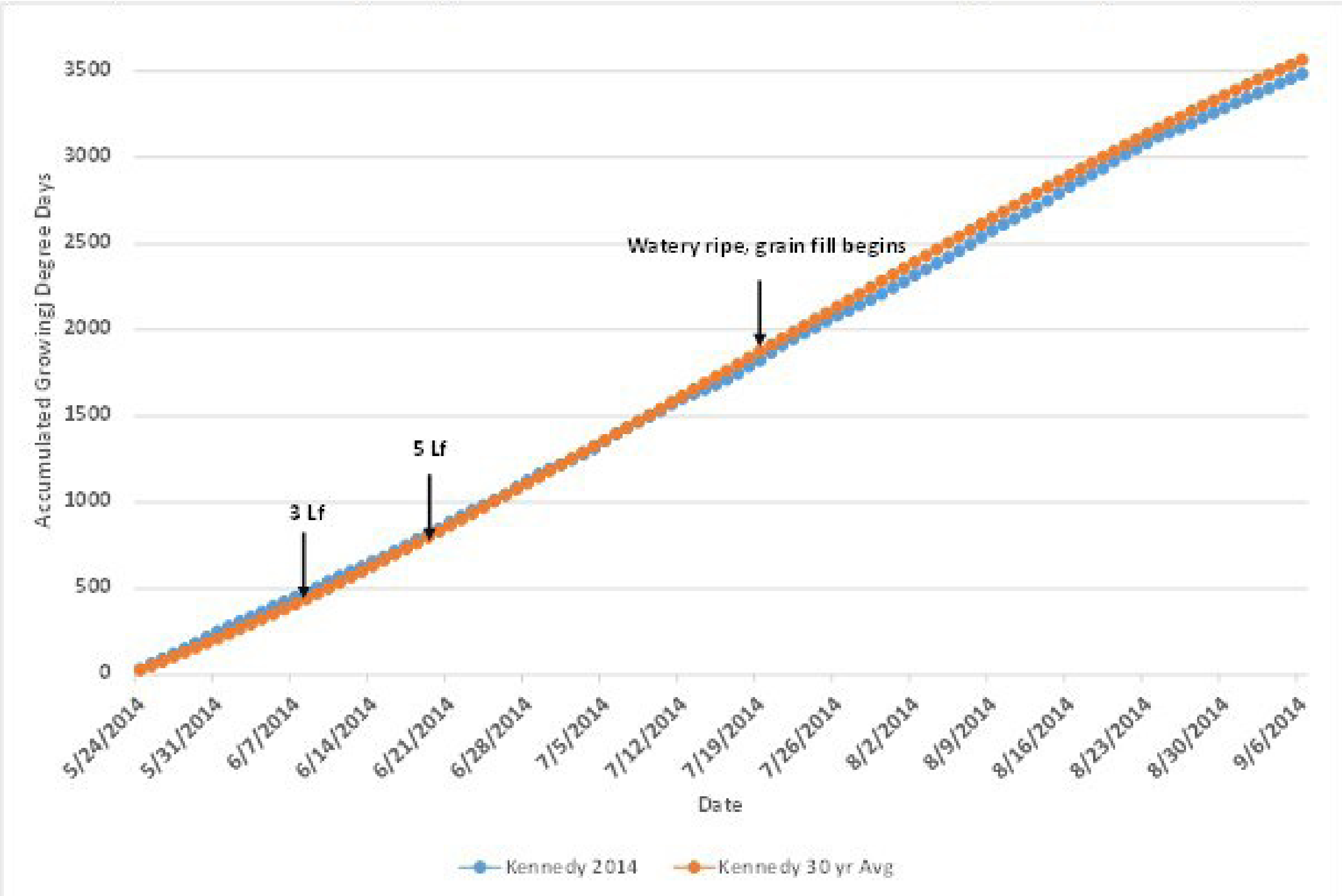

Table 7. Costs and benefits associated with seeding rate with yields from Hallock, MN, 2013

Seeding Rate	Seeding Rate	Seed cost [1]	Yield	Gross Income [2]	Net Income
Seeds/ac	-Bushels/ac-	--$/acre--	-Bushels/ac-	----$/ac----	----$/ac----
600,000	0.9	13.7	64.8	355.8	342.1
1,000,000	1.5	22.8	68.8	377.4	354.6
1,400,000	2.1	32.0	71.3	391.3	359.3
1,800,000	2.6	41.1	71.4	391.7	350.6
2,200,000	3.2	50.2	72.4	397.7	347.5

[1] Seed cost of $15.50 per bushel of HRSW.
[2] December wheat price of $5.49

References

Wiersma, J.J. 2002. Determining an optimum seeding rate for spring wheat in Northwest Minnesota. Online. Crop Management doi:10.1094/CM-2002-0510-01-RS.