A Comparison of Recommended High Seeding Rates and Zero-Fungicide with Recommended Fungicide Treatments (Approved July 2012)

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Objectives:
The objectives of this study are to determine if (1) seeding rate, (2) fungicide applications, and/or (3) their interactions affects spring wheat yields.

Justification:
Currently, the SDSU Extension Service has two seeding rate recommendations for spring wheat in South Dakota. Planting 1.2 million pure-live-seeds (PLS)/ac or about 28 PLS/ft^2 was the standard recommended plant rate for many years. Many agri-business agronomists have suggested that a seeding rate of 2.4 million PL/ac or 56 PLS/ft^2 is more realistic for producers using intensive management practices. Past research by Hall et al. at SDSU has indicated there were no significant yield advantages to raising the recommended seeding rate of 28 PLS (1X), to rates of 42 PLS (1.5X), and to 56 PLS (2X)/ft^2. These seeding rates are equal to 1.22, 1.83, and 2.44 million PLS/ac, respectively. Hall et al. also determined the 1X, 1.5X, and 2X seeding rates resulted in 1.8, 1.4, and 1.1 harvested heads for each seed planted in the spring. The 1X rate produced one main and 0.8 secondary heads/plant, while the 2X rate resulted in one main and only 0.1 secondary heads/plant, or essentially one main head per plant.

In 2007, the SDSU Extension Service, as the result of testimonials from individual growers and agribusinesses, compromised and recommended that growers using intensive management practices plant 1.83 million PLS/ac or 42 PLS/ft^2. Many field agronomists felt, that although higher seeding rates did not increase yields, it did produce more main but fewer secondary heads. This was important to them because, main heads flower first, followed by any secondary and tertiary heads. Thus, the flowering period would be more uniform and shorter because nearly all of the plants would be main heads with few later-flowering secondary heads. Consequently, many field agronomist and spring wheat producers speculated they would gain more benefit from fungicide treatments applied at flowering, because the more uniform and shorter flowering period would afford better coverage and protection of the heads during the grain-filling period.

Although, SDSU currently has two spring wheat seeding rate recommendations, the 1.22 million rate (standard) and a higher 1.83 million PLS/ac rate (intensive management), there are still questions regarding the seeding rate issue for South Dakota. Questions include (1) is the intensive management seeding rate of 1.83 million sufficient or should it be raised to 2.44 million PLS/ ac? and (2) does either the 1.83 or 2.44 million PLS/ac really result in more uniform flowering, a shorter flowering duration, and better fungicide coverage and/or higher yields compared to the standard seeding rate of 1.22 million PLS/ac? In addition, with the emphasis on delivering crop biotechnology to the farm via seed, the potential for higher priced seed is real. Thus, a resolution to the seeding rate recommendations for spring wheat in South Dakota may be a very significant factor in determining production input costs in the future.

Materials and Methods:
This study will be conducted at two locations (Table 1). The South Shore study will be located on or near the NE Research Farm and the Brown Co. study will be located on the Roger Locken Farm of Bath, SD. Varieties will include Brick, Select, and Howard. Seeding rates will include a recommended 1X rate of 28 PLS, a 1.5X rate of 42 PLS, and a high 2X rate of 56 PLS/ft^2.

Plots will measure 5 feet wide by 20 feet long and will be seeded with a small plot cone-drill. The experimental design at all locations will be a stratified split-plot design. The design factors included variety, seeding rate, and fungicide treatment. There will 72 total plots per location (3 varieties x 3 seeding rates x 2 fungicide treatments x

4 blocks). Soil samples will be collected and tested prior to planting to determine how much fertilizer (soil test-N + applied-N) is needed to attain a 100 bu/ac yield goal at each location. Following crop emergence, two 2-foot sections of row will be randomly selected and flagged for the later collection of plant sub-samples prior to harvest.

A ‘moderately intensive fungicide’ program will be compared to ‘no fungicide’ for all variety*seeding rate combinations. This program will include Headline, applied at 6 oz./ac at flag leaf emergence (Feekes 8-9) followed by Prosaro applied at 5.7oz/ac when most main tillers are in flowering stage (Feekes 10.51). Prior to and following fungicide treatments, disease incidence will be determined as percent leaf area affected for each plot. Weed control will be applied as necessary.

Table 1. Summary of materials or soil tests required for spring wheat seeding rate study.

Materials	Location					
	South Shore			Brown Co.		
Variety- maturity, days	Brick-0	Briggs-2	Howard-5	Brick-0	Briggs-2	Howard-5
Pure-live-seed rate/ft^2:	1X 28/ft^2	1.5X 42/ft^2	2X 56/ft^2	1X 28/ft^2	1.5X 42/ft^2	2X 56/ft^2
Soil fertility levels:						
Pre-plant soil test levels	N *lb.*	P *ppm*	K *ppm*	N *lb.*	P *ppm*	K *ppm*
Nutrients for 100 bu/ac yield goal:	N *lb.*	P *ppm*	K *ppm*	N *lb.*	P *ppm*	K *ppm*
Test recommendations	TBD[1]	TBD	TBD	TBD	TBD	TBD
Nutrients applied	TBD	TBD	TBD	TBD	TBD	TBD
Total requirements	TBD	TBD	TBD	TBD	TBD	TBD
Fungicide treatments:	0-Check[2]	FL+H[3]		0-Check	FL+H	
FL=flag leaf application		Headline, 6 oz./ac, Feekes 9.0			Headline, 6 oz./ac, Feekes 9.0	
H= head scab timing		Prosaro, 5.7 oz./ac, Feekes 10.51			Prosaro, 5.7 oz./ac, Feekes 10.51	
Herbicide(s) if needed Bronate, 1.0 pt./ac	2-leaf to early boot stage			2-leaf to early boot stage		

[1] TBD – to be determined. [2] 0-check or untreated. [3] Fungicide application.

Plots will be harvested with a Massey Ferguson 8XP small plot combine. Prior to harvest, whole-plants within each flagged section of row for sub-sample collection will be hand-pulled and bagged. These sub-samples will be used to determine what effects variety, seeding rate, and fungicide treatment have on the density variables spikes (heads)/ft^2, seeds/spike, seeds/lb., and spikes/seed kernel. The first three density variables will indicate if the treatments influence yield by affecting spikes/ft^2, seeds/spike, and seeds/lb. (seed size). The last variable spikes/seed kernel will determine if the treatments affected the number of spikes produced/seed kernel planted. The number of spikes and seeds (seed counter) in each sample will be counted. Spikes/ft^2, spikes/seed kernel, seeds/spike and seeds/lb. (seed size) will then be calculated. A sub-sample of grain from each bagged subsample will be ground and submitted for vomitoxin (deoxynivalenol) testing. The harvested plot yield will be combined with the yield of the two sub-samples to obtain the final plot yield. Significant treatment effects and interactions (.05 level of probability) will be identified using the Statistical Analysis System (SAS) data analysis procedures.

The analysis of variance (ANOVA) model and plot layout this research trial is shown below.

Analysis of Variance (ANOVA) Table	
No. & Source	Degrees of freedom – *d.f.*
2—Spray–SP	1
4—Block–B	3
Error (a)–V x B	3
Total (a)	*(7)*
3—Variety–V	2
V x SP	2
Error (b)–(V x B) + (V x SP x B)	
Error (b)–6 + 6	12
Total (b)	*(16)*
3—Seeding rate–SR	2
SR x SP	2
SR x V	4
SR x B	4
SR x SP x V	6
Error (c)–(SR x SP x B) + (SR x V x B) +(SR x SP x V x B)	
Error (c)–6 + 12 +12	30
Total (c)	*(48)*
Total	71

Block-4

Variety	Seeding rate			Variety	Seeding rate		
Brick	V1SR1	V1SR2	V1SR3	Brick	V1SR1	V1SR2	V1SR3
Briggs	V2SR2	V2SR3	V2SR1	Briggs	V2SR3	V2SR1	V2SR2
Howard	V3SR3	V3SR1	V3SR2	Howard	V3SR2	V3SR3	V3SR1

Block-3

Variety	Seeding rate			Variety	Seeding rate		
Howard	V3SR2	V3SR3	V3SR1	Briggs	V2SR3	V2SR1	V2SR2
Brick	V1SR3	V1SR1	V1SR2	Howard	V3SR2	V3SR3	V3SR1
Briggs	V2SR1	V2SR2	V2SR3	Brick	V1SR1	V1SR2	V1SR3

Block-2

Variety	Seeding rate			Variety	Seeding rate		
Howard	V3SR3	V3SR1	V3SR2	Howard	V3SR2	V3SR3	V3SR1
Briggs	V2SR1	V2SR2	V2SR3	Briggs	V2SR1	V2SR2	V2SR3
Brick	V1SR2	V1SR3	V1SR1	Brick	V1SR3	V1SR1	V1SR2

Block-1

Variety	Seeding rate			Variety	Seeding rate		
Briggs	V2SR1	V2SR2	V2SR3	Brick	V1SR3	V1SR2	V1SR1
Howard	V3SR3	V3SR1	V3SR2	Briggs	V2SR1	V2SR3	V2SR2
Brick	V1SR2	V1SR3	V1SR1	Howard	V3SR2	V3SR1	V3SR3
	0-Check, untreated				Fungicide applied		

Spring Wheat Planting Rate Study Progress Report – 2011

Weather conditions at test locations in 2011 were as follows: Brown County (Aberdeen airport 9 miles north of test site) – This study was abandoned when it was determined that due to unknown causes the entire field exhibited poor emergence and individual plants exhibited spindly growth. South Shore –Monthly rainfall varied from 0.8” below average in April to 4.8” above average in July. Average daily temperatures were 5 and 3° F below average in April and May; but 3° F higher than average in July. The higher than normal rainfall and average daily temperatures in July appeared to set the crop back in 2011.

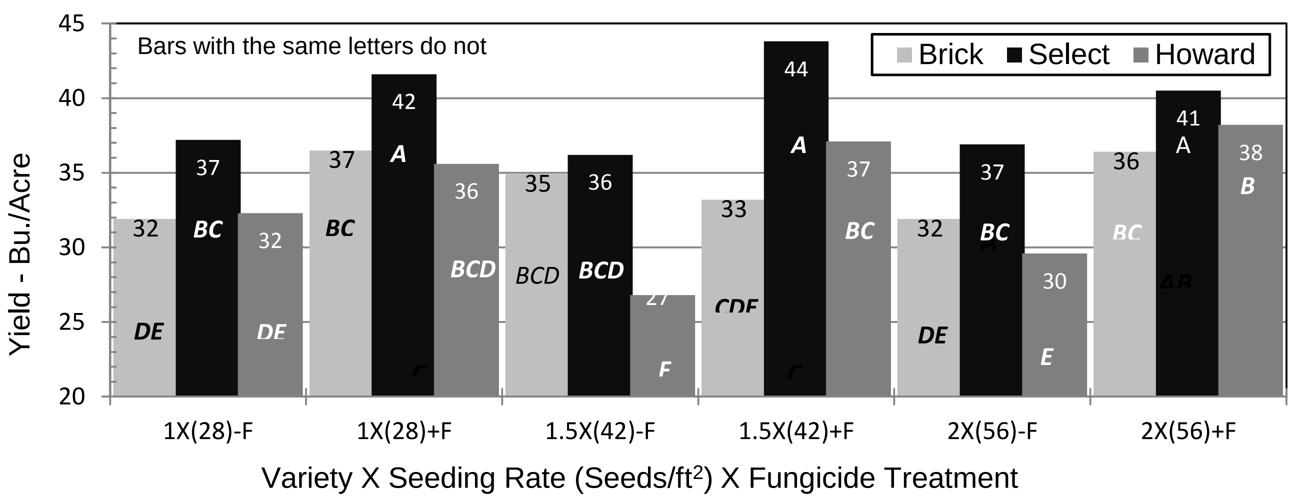
Significance of agronomic variable effects:
The yield, bushel weight, protein content, plant height, and lodging score response of spring wheat to the main effects for variety, seeding rate, fungicide application and their interactions at South Shore and Warner, SD are indicated in table 1.

Main effects & Interactions	South Shore - Northeast Research Farm				
	Yield (bu/a)	Bushel Wt. (lbs.)	Grain Protein. (%)	Height (inch)	Lodging Score (1-5)
Variety - V	**	*	*	**	ns
Seed Rate- SR	ns	ns	ns	ns	ns
V*SR	ns	ns	ns	ns	ns
Fungicide- F	**	ns	ns	*	ns
V*F	*	**	ns	ns	ns
SR*F	ns	ns	ns	ns	ns
V*SR*F	*	ns	ns	ns	ns

** Differences are highly significant at the 0.01 level of probability.
* Differences are significant at the 0.05 level of probability.
ns – Differences are nonsignificant at the 0.05 level of probability.

Yield– the yield response to variety was highly significant (Table 1). The highest yielding variety was Select at 39.4 followed by the lower yielding Brick at 34.1 and Howard at 33.3 bu/a, both of which were similar in yield. The significant response to fungicide indicated the zero-fungicide treatment yielded 33.0 while fungicide treated plots yielded 38.1 bu/a, a differences of 5 bu/a (14 percent). More importantly there were two significant yield response interactions. Although there was a significant variety x fungicide two-way interaction, there was an even more important variety x seeding rate x fungicide three-way interaction that affected yield in 2011 (Figure 1.). The variety Select was always the highest in yield regardless of seeding rate and fungicide treatment. Generally, with the varieties Brick and Howard, the use of a fungicide increased yield compared to the zero-fungicide treatment when seeded at any seeding rate. Regardless of variety and fungicide treatment there was no significant advantage to increasing the seeding rate in order to improve yield.

Figure 1. The yield response of spring wheat to the variety x seeding rate x fungicide interaction using three varieties, seeding rates of 1X, 1.5X, and 2X; along with a zero-fungicide (-F) and an applied fungicide



Test weight– the test weight of wheat responded to the variety main effect; but more importantly to the variety x fungicide two-way interaction (Table 1). The variety Select was highest in weight (54.2 lbs./bu.) while Brick at 52.6 and Howard at 52.3 lbs/bu were similar but significantly lower in weight. The variety x fungicide two-way interaction (Fig. 2.) showed the 2 oz. Folicur/acre treatment and Select variety combination resulted in the highest weight of 55.6 lbs/bu. All the zero-fungicide treatments along with the two other varieties treated with fungicide tested signficanly lower in weight compared to the variety Select treated with fungicide. Thus, only the variety Select responded to the fungicide treatment that in turn increased test weight.

Grain protein– the variety main effect was the only main effect that influenced the protein response of spring wheat (Table 1 and Fig. 3.). The highest protein content was in the variety Brick (15.9%), followed by Howard (15.7%) and Select (15.5%). The protein content of Brick vs. Howard was similar and Howard vs. Select was similar; while the protein content of Brick was significantly higher than for Select.

Figure 2. The test weight response of spring wheat to the variety x fungicide treatment interaction using three varieties and two fungicide

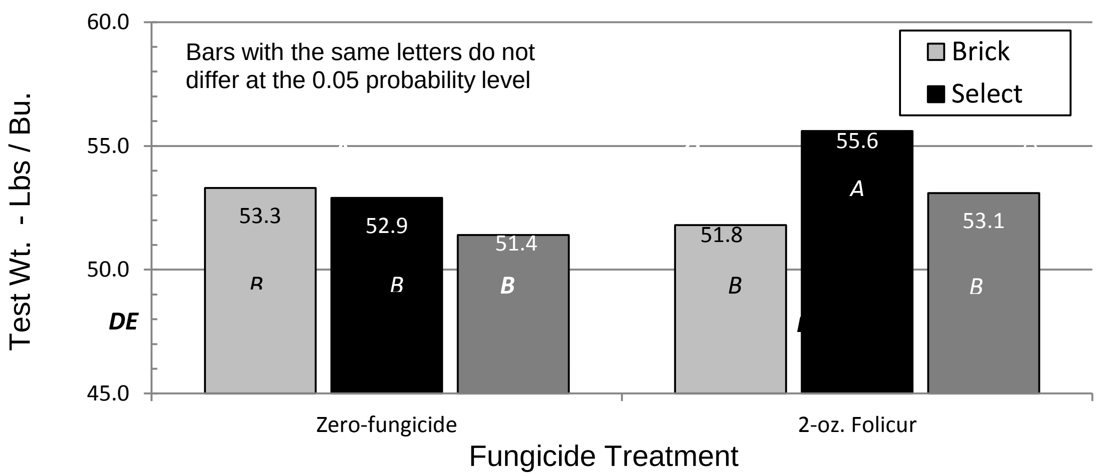
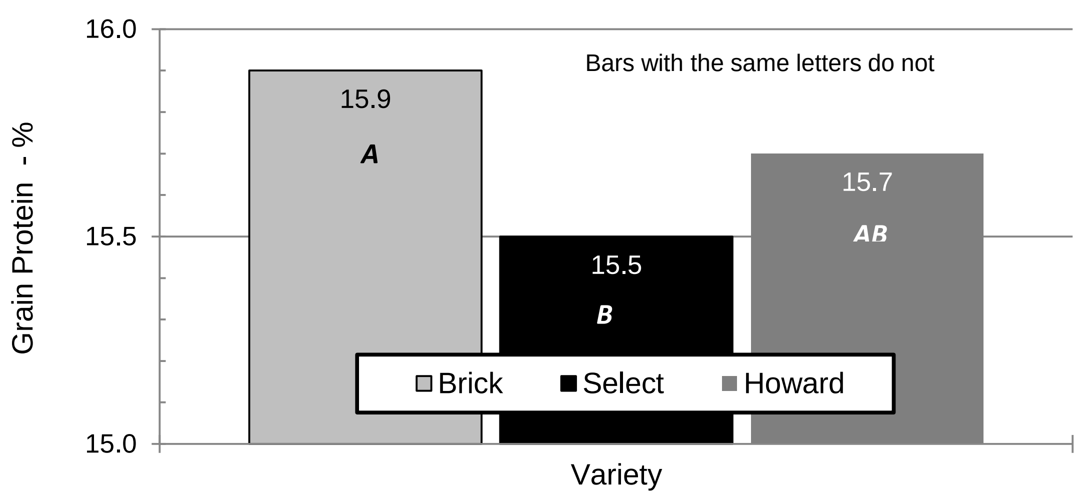


Figure 3. The grain protein response of three spring wheat varieties at South



Plant height– the plant height response to the variety main effect was highly significant and to the fungicide main effect the high response was significant (Table 1). The variety Howard was the tallest at 30.2 inches, followed by both Brick and Select at 28.8 inches in height. Howard was significantly taller than Brick and Select which were equal in height. The application of fungicide increased plant height from 28.9 to 29.6 inches, an increase of 0.7 inches.

Lodging score– Although the spring wheat plant height responded to the main effects of variety and fungicide none of the main effects for variety, seeding rate, or fungicide influenced the lodging scores at South Shroe in 2011. In addition, there was no two-way or three-way interactions of the main effects that affected the lodging scores in 2011.

Summary of Agronomic Performance Variable Responses:

The yield of spring wheat was significantly affected by a variety x seeding rate x fungicide three-way interaction . The variety Select was always the highest in yield regardless of seeding rate and fungicide treatment. Generally, varieties sprayed with fungicide produced higher yields compared to the zero-fungicide treatment when seeded at any seeding rate. Regardless of variety and fungicide treatment there was no significant advantage to increasing the seeding rate in order to improve yield.

The test weight of wheat responded most importantly to a variety x fungicide two-way interaction . This interaction showed the 2 oz. Folicur/acre treatment and Select variety combination resulted in the highest weight of 55.6 lbs/bu. compared to any other variety and fungicide combination. Thus, only the variety Select responded to the Folicure fungicide that in turn increased test weight.

Variety was the only effect (main or interaction) that influenced the protein response of spring wheat. The variety Brick was highest in protein, Howard was intermediate, and Select was lowest.

The plant height response to the main effects for variety and fungicide was highly significant and significant, respectively. The variety Howard was the tallest while both Brick and Select were shorter but similar in height. The Folicur application increased plant height 0.7 inches.

Lodging score– Although the spring wheat plant height responded to the main effects of variety and fungicide none of the main effects for variety, seeding rate, or fungicide influenced the lodging scores at South Shroe in 2011. In addition, there were no interactions between variety, seeding rate, and fungicide that affected the lodging scores in 2011.

The responses for the number of heads/seed planted, heads/ft^2, seeds/head, seeds/ft^2, and seeds/lb., to the main effects for variety, seeding rate, fungicide application and their interactions at South Shore, SD are indicated in table 2.

Table 2. Significance of main effects and interactions of variety, seeding rate, and fungicide treatment on the yield component variables in at South Shore SD, in 2011.

Main effects & Interactions	Yield component variable measured				
	Heads per seed planted	Heads per ft^2	Seeds per head.	Seeds per ft^2	Seeds per lb.
Variety - V	ns	*	ns	*	**
Seed Rate- SR	**	ns	ns	ns	ns
V*SR	ns	ns	ns	ns	ns
Fungicide- F	*	*	ns	*	**
V*F	ns	ns	ns	ns	ns
SR*F	*	**	ns	ns	ns
V*SR*F	ns	ns	ns	ns	ns

** Differences are highly significant at the 0.01 level of probability.

* Differences are significant at the 0.05 level of probability.

ns – Differences are nonsignificant at the 0.05 level of probability.

Harvested heads per seed planted– the number of heads per seed planted response to both the variety and seeding rate main effects were significant (Table 2). The seeding rate effect was highly significant and ranged from 1.7 at the 1X rate, 1.1 at the 1.5X rate, to 0.9 heads/seed planteded at the 2X seeding rate. This resulted in decrease in harvested heads/seed planted of about 35% at the 1.5X rate and about 47% at the 2X seeding rate. Likewise, the fungicide treatment effect was significant where the treated plots produced 1.3 compared to 1.2 heads per seed planted. More importantly, however, there was a highly significant seeding rate x fungicide treatment interaction (Table 2 and Fig. 4). This interaction indicated changes in the number of heads produced per seed planted depended on the seeding rate and the fungicide treatment imposed. Generally, as the seeding rate increased from 1X to 2X the number of heads harvested for each seed planted decreased. At each seeding rate (1X, 1.5X, or 2X) the number of heads produced per seed planted did not differ between the fungicide treatments. The zero-fungicide treatments seeded at the 1.5X rate produced a similar number of heads per seed planted when compared to the 2X seeding rate with either fungicide treatment.

Head density– the head density (heads/ft2) response to the variety planted was significant (Table 2 and Fig. 5). The variety Select produced density of 52 heads/ft2, compared to signifcantly lower but similar densities of 47 for Brick and 46 heads/ft2 for Howard. The head density respone to the effect of fungicide treatment was significant. The fungicide treatment resulted in 50 heads compared to 46 heads/ft2 or a drop of 8% for the zero-fungicide treatment. More importantly, the head density response to the seeding rate x fungicide interaction was highly significant. At the 1X and 2X seeding rates there were no differences between the zero-fungicide and fungicide treated plots. At the intermediate 1.5X seeding rate the zero-fungicide plots produced fewer heads/ft2 compared to the fungicide treated plots. Thus, the fungicide treatment only improved the head density at the 1.5X seeding rate, but not at the other seeding rates.

Figure 4. The heads/seed planted density response of spring wheat to the seeding rate x fungicide interaction using seeding rates of 1X , 1.5X, and 2X; along with a zero-fungicide and a fungicide treatment at South Shore , SD in 2011.

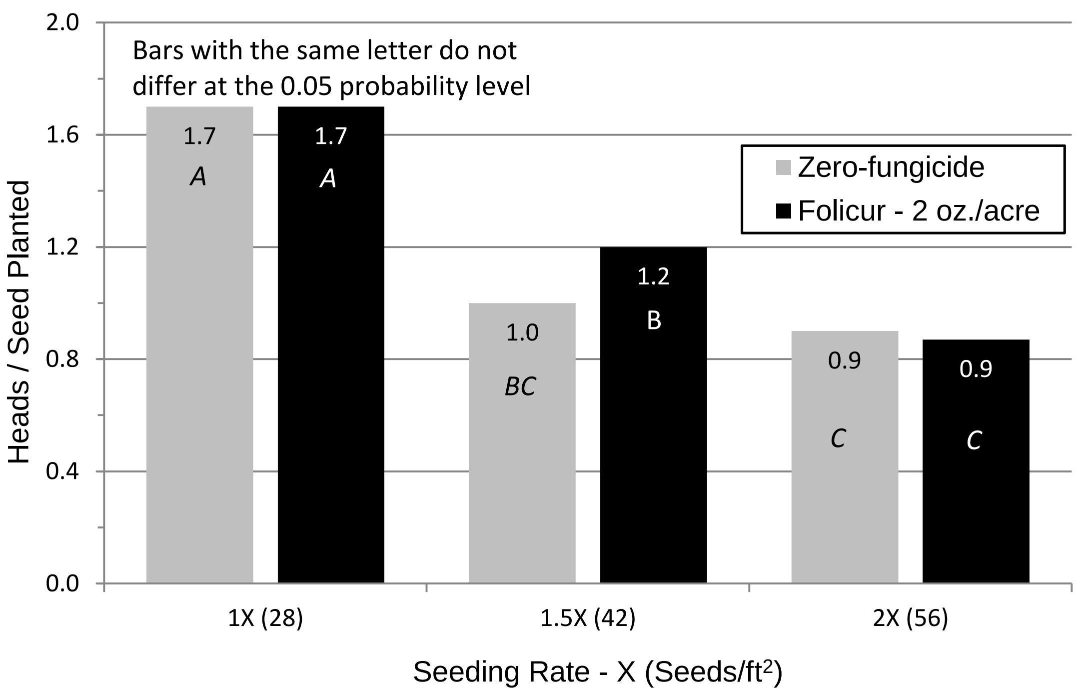
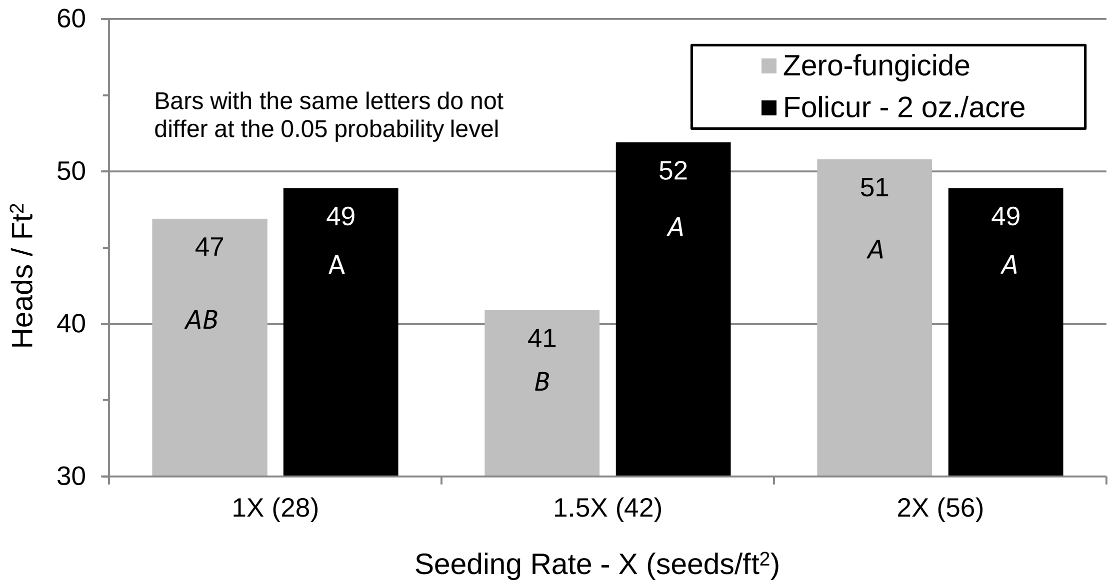


Figure 5. The heads/ft² density response of spring wheat to the seeding rate x fungicide interaction using seeding rates of 1X , 1.5X, and 2X; along with a zero-fungicide and a fungicide reatment at South Shore , SD in 2011.



Seeds per head– the seeds per head density responses to the variety, seeding rate, and fungicide treatment main effects were not significant (Table 2). The seeds/head density did not respond significantly to any othe the main effects for variety, seeding rate, fungcide treatment or their interactions. The seed density/head for the 1X, 1.5X, and 2X seeding rates were 11, 11, 9 seeds/head, respectively; compared to higher densities of 17, 16, and 15 seeds/head in 2010. Although the actual density differed between years the trends tended to be similar.

Seed density– the seeds/ft^2 density responses to the main effects for variety and fungicide treatment were significant (Table 2). The variety with the highest seed density was Select at 527 followed by Brick at 489, and Howard at 456 seeds/ft^2. The seed densities for Select and Brick were similarly high and the densities for Brick and Howard were similarly low; while the high density for Select was significantly higher than the low density for Howard. There was a significant seed density response to the fungicide treatment. The fungicide applied treatment produced 516 compared to 465 seeds/ft^2 for the zero check fungicide treatment or a difference of about 10 percent.

Seed Size (No./lb)– the seed size (seeds/lb) responses to main effects for variety and fungicide treatment were highly significant (Table 2). The number of seeds/lb. is a measure of seed size because seeds/lb. is inversely related to seed size. This means as the number of seeds/lb. increase the size of the individual seeds decreases. The variety Select at the lowest seed density of 18.3 thousand seeds/lb, was the largest seed; followed a higher but similar seed density of 19.0 thousand seeds/lb for Howard, followed in turn by the highest seed density of 20.2 thousand seeds/lb for Brick. Thus, the seed of Select and Howard were larger than for the variey Brick. The fungicide applied treatment produced significantly larger seed at 14.4 thousand seeds compared to a smaller seed size of 15.5 thousand seeds/ft^2 for the zero-check fungicide treatment, a difference of 8 percent.

The number of heads harvested/seed planted was highly and significantly affected by a seeding rate x fungicide treatment interaction. This interaction indicated changes in the number of heads produced per seed planted depended on the seeding rate and the fungicide treatment imposed. Generally, as the seeding rate increased from 1X to 2X the number of heads harvested for each seed planted decreased. This was the same trend that was shown in 2010 (data not shown). At each seeding rate the number of heads produced per seed planted did not differ between the fungicide treatments. The zero-fungicide treatments seeded at the 1.5X rate produced a similar number of heads per seed planted compared to the 2X seeding rate with either fungicide treatment. Thus, increasing the seeding rate above 1.5X did not improve the number of harvestable heads/seed planted. In turn, neither the 1.5X or 2X seeding rate increased the number of harvestable heads/seed planted.

The density of heads/ft^2 was influenced by variety and by fungicide treatment but not by seeding rate. In 2011, the head density was considerably lower (46 to 50 heads/ft^2) compared to 2010 (60 to 75 heads/ft^2), a decrease of about 33%. This reduction was likely the result of limited early season moisture along with exceptionally cooler than normal temperature in April and May that limited early plant development.

The yield component variables seeds/head, seeds/ft^2, and seed size (seeds/lb.) were generally affected by variety and fungicide treatment; but not by seeding rate. The range in average seed size in 2010 (14.6 to 15.5) compared to 2011 (18.3 to 20.2) indicates the seeds were smaller in 2011, most likely the result of a less than ideal growing season limited by early season growth and development and/or a short mid-season grain filling period.

Conclusions for 2011 research results:

The results for 2011 tended to show more main effects responses to variety, seeding rate, and fungicide treatment and few responses to their interactions compared to 2010. This was likely influenced by the cooler and drier than average early spring in 2011. With a much less than ideal growing season it would not be surprising that there were few interactions. The three significant interactions that occurred in 2011 was the variety x fungicide treatment that influenced yield and test weight; the variety x seeding rate x fungicide treatment interaction that affected yield; and the seeding rate x fungicide interaction that affected the number of heads/seed planted and the number of heads/ft^2.

In 2011 as was the case in 2010, increases in seeding rate did not improve agronomic variables like yield, test weight, or protein. Increasing seeding rates did result in significantly fewer heads/seed planted. Consequently, increases in seeding rates were offset by decreases in heads/seed planted which in turn resulted in no significant yield improvement by increasing the seeding rate.