11. Effect of spring cereal seeding rate on its yield potential

Project duration

- 2017-2021

Collaborators

- Anne Kirk, Manitoba Agriculture
- Manitoba Agriculture Diversification centers

Objectives:

- Determine if target plant stand recommendations should be adjusted for spring wheat, oats, and barley.
- Determine if optimum plant stands differ for individual varieties.
- Assist producers with determining target plant stand and seeding rate for newer spring cereal varieties.

Results

Stand establishment increased as seeding rate increased at most site years. There was no significant difference in plant stand between seeding rate treatments for wheat at Roblin, results will not be shown for this site as a range of plant populations were not established. At many locations plant stands were lower than the target. The exception was Arborg where plant stands ranged from 18-57, 12-47, and 25-35 plants /ft^2 in the barley, oats, and wheat plots, respectively (Table 11.1).

Cereals can compensate for lower plant populations by increasing tillering. Research in which spring wheat plants were given ample room found that stems per plant ranged from 19 to 44 depending on the variety (Wiersma 2014). While cereal cultivars differs in their abilities to tiller, there was no difference in heads per plant between cultivars at the majority of sites (Table 11.2). The actual number of spikes or panicles present at maturity depends on the number of tillers produced and the number that survive to maturity. The effect of drought stress on yield components depends on the timing of drought stress, and early season drought stress reduces yield potential through tiller death (Duggan et al. 2000). This is evident in the results from the Arborg location, where heads per plant were low across all crop types and treatments.

Heads per plant decreased as seeding rate increased, which demonstrates the ability of cereal crops to compensate for reduced plant populations by increasing tillering (Table 11.2). There was no significant difference in heads per plant at target plant populations ranging from 21-39 plants /ft^2 at five out of the eight sites where there were significant differences in heads per plant.

Wheat

There were significant yield differences between wheat varieties at the three locations where yields are reported, with AAC Brandon yielding significantly higher than Faller at two sites (Table 11.3). Yields were generally low at Arborg and Carberry due to drought conditions, with Carberry yields being further reduced as a result of hail.

When averaged across cultivars, there were no differences in wheat yield across plant densities at Melita. At Carberry, yields increased as plant stand increased, with the highest

yields being reported at target plant densities of 27 to 39 plants /ft^2 (Table 11.3 and Fig. 11.2). At Arborg, the 9 plants/ft^2 treatment had the lowest yield overall, with 33 plants/ft^2 yielding the highest (Table 11.3 and Fig. 11.2). Actual plant populations ranged from 9 to 30 plants /ft^2 at Carberry, 6 to 19 plants /ft^2 at Melita, and 25-35 plants /ft^2 at Arborg.

Table 11.1. Plant stand (plants /ft^2) for barley, oats, and wheat at the Arborg (Arb), Carberry (Car), Melita (Mel), and Roblin (Rob). Barley varieties are CDC Austenson (A) and AAC Connect (B), oat varieties are CS Camden (A) and Summit (B), and wheat varieties are AAC Brandon (A) and Faller (B).

	Barley				Oats			Wheat			
	Arb	Car	Mel	Rob	Arb	Mel	Rob	Arb	Car	Mel	Rob
	plants/ft^2										
Variety											
A	40	15	16.3b	18	33	17a	12	29	19	14	11
B	43	14	17.8a	18	29	13b	10	31	21	14	13
LSD‡	-	-	1.3	-	-	2	-	-	-	-	-
	Target Plant Population (pl/ft^2)										
9	18e	6d	7f	8c	12e	6f	6f	25d	9e	6d	11
15	36d	10cd	12e	14b	23d	10e	9ef	27cd	15d	10c	12
21	40cd	13bc	15d	17b	29cd	14d	10de	30bc	20c	13b	11
27	47bc	14b	19c	21a	34bc	16c	12cd	33ab	23bc	16b	17
33	53ab	19ab	23b	23a	40b	21b	14bc	33ab	26b	19a	11
39	57a	24a	28a	23a	47a	24a	16a	35a	30a	19a	9
LSD‡	9	5	2	3	7	3	3	5	3	3	-

‡Least significant difference (LSD) values are shown for sites where there is a significant difference (Pr<0.05) between treatments. At sites with significant differences between treatments, means within the same site year followed by the same letter within a column are not significantly different.

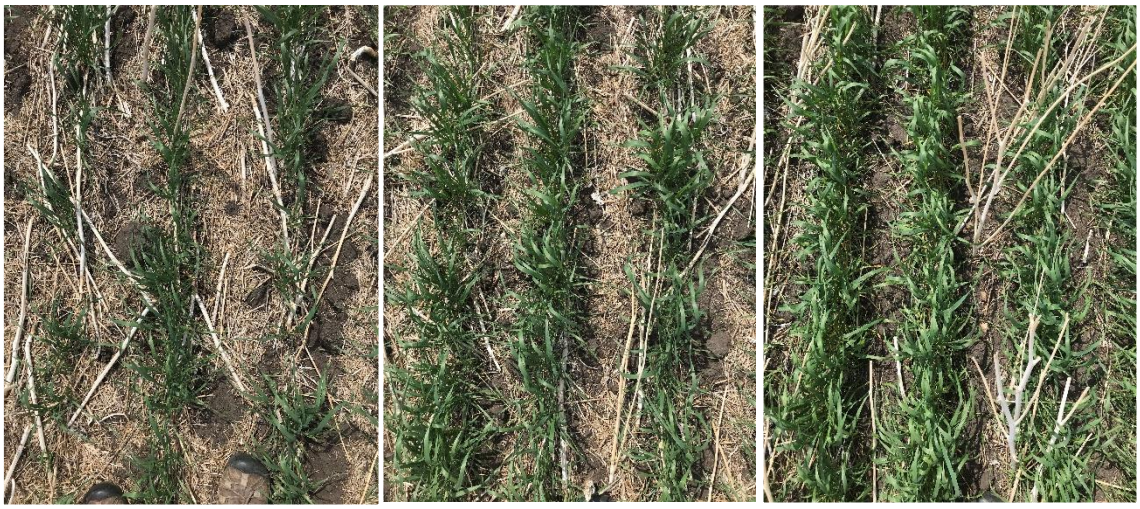

Fig. 11.1. AAC Brandon wheat planted at target plant stands of 9, 21, and 33 plants /ft^2 at Melita in 2021.

Table 11.2. Heads per plant for barley, oats, and wheat at the Arborg, Carberry, Melita, and Roblin. Barley varieties are CDC Austenson (A) and AAC Connect (B), oats varieties are CS Camden (A) and Summit (B), and wheat varieties are AAC Brandon (A) and Faller (B).

	Barley			Oats			Wheat		
	Arborg	Carberry	Roblin	Arborg	Melita	Roblin	Arborg	Carberry	Melita
	---------- Heads/plant ----------								
Variety									
A	0.8	6.0	6.8	0.77	1.7b	6.03	1.1	5.8	2.7
B	0.8	5.7	6.7	0.89	2.2a	6.74	1.2	5.9	2.8
LSD	-	-	-	-	0.2	-	-	-	-
	Target Plant Population (pl /ft^2)								
9	1.5a	6.5ab	10.2a	1.2a	3.2a	7.8	1.8a	6.7a	4.3a
15	0.9b	6.8a	7.9b	0.7b	2.2b	6.7	1.3b	5.9b	3.1b
21	0.7c	5.1c	7.2b	0.8b	1.8bc	6.9	1.2b	5.8b	2.6bc
27	0.6c	5.5c	5.7c	0.9b	1.7cd	6.0	0.9c	5.6b	2.3c
33	0.6c	5.7bc	4.5c	0.8b	1.4d	5.8	0.9c	5.5b	2.0c
39	0.5c	5.3c	4.9c	0.7b	1.4d	5.1	0.8c	5.8b	2.2c
LSD‡	0.2	0.9	1.4	0.3	0.4	-	0.3	0.8	0.7

‡Least significant difference (LSD) values are shown for sites where there is a significant difference (Pr<0.05) between treatments. At sites with significant differences between treatments, means within the same site year followed by the same letter within a column are not significantly different. Roblin wheat data is not shown due to high coefficients of variation.

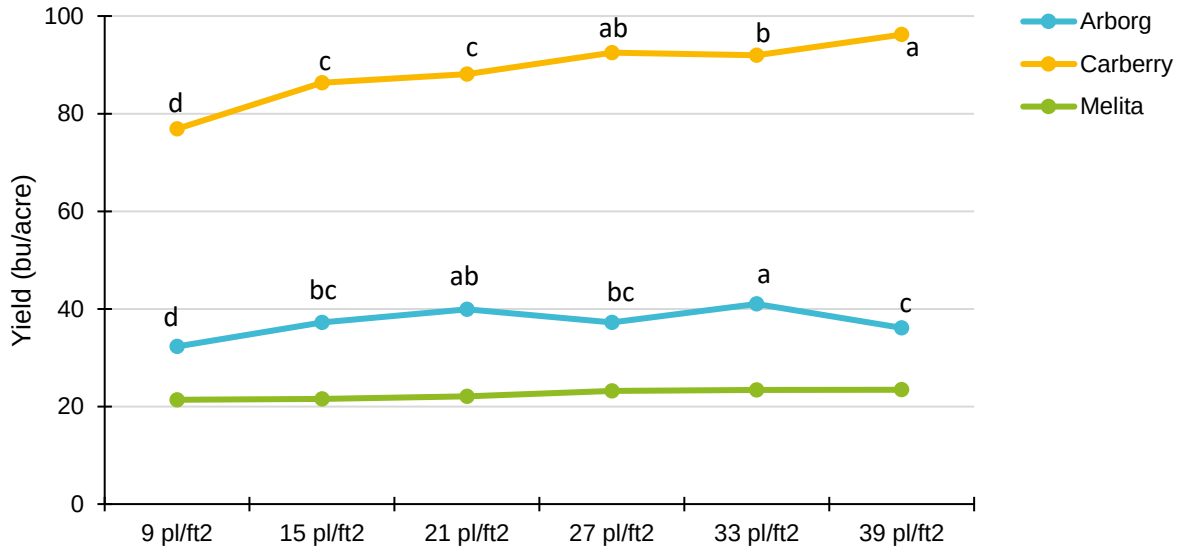

Fig. 11.2. Wheat yield (bu/acre) at six target plant densities at Arborg, Carberry and Melita. Statistically significant differences are shown by letters above the line. Treatments within the same site with the same letter are not significantly different (P<0.05).

Fig. 11.3 shows yield plotted against plant stand, giving context to the results. There was no interaction between seeding rate and cultivar, both cultivars responded similarly to increased seeding rates (data not shown).

Barley

There were no significant yield differences between barley varieties at three of four locations. At Arborg, CDC Austenson yielded significantly higher than AAC Connect (Table 11.3). When averaged across cultivars, there were no significant yield differences between target plant stands at three of the four locations. There were only significant yield differences between target plant densities at Arborg, with the 9 plants /ft^2 treatment yielding significantly lower than the higher target plant densities (Table 11.3 and Fig. 11.4). Actual plant populations ranged from 6 to 28 plants /ft^2 at Carberry, Melita, and Roblin, and 18 to 57 plants/ft^2 at Arborg (Table 11.1 and Fig. 11.5). Fig. 11.5 shows yield plotted against plant stand, giving context to the results and highlighting the higher plant populations at Arborg. There was no interaction between plant density and cultivar, both cultivars responded similarly to increased seeding rates (data not sown).

Oats

There was a significant yield difference between the two oats varieties at two of the three locations, with CS Camden yielding higher than Summit in both cases (Table 11.3). Averaged across cultivars, there was no difference in oats yield across the range of target plant densities at two of the three locations. There were significant yield differences across target plant densities at the Arborg location, but no consistent trend (Fig. 11.6). Oats yield plotted against plant stand is shown in Fig. 11.7. There was no interaction between plant density and cultivar, both cultivars responded similarly to increased seeding rates (data not sown).

This study is a continuation of a research project that took place at Arborg, Carberry, Melita, and Roblin in 2017 and 2018. The oats and barley sites in 2017 and 2018 showed similar yields across a range of plant stands, indicating that the current recommended target plant populations for barley and oats are sufficient. In the wheat trials of 2017 and 2018, there was a general trend of higher yields with increased plant stands, but no significant difference in yields between target plant stands of 21 to 39 plants /ft^2 at four of the five sites.

The 2021 results are similar, in that there were no significant yield differences across the range of plant densities at most sites. There was a general trend of higher yields with higher plant stands at the wheat, barley, and one of the oats sites, although the data indicates that these trends should be taken with caution. There was no significant difference in yields between target plant stands of 21 to 39 plants /ft^2 at nine out of the 10 sites. At all sites, both varieties tested responded similarly to each target plant stand, indicating that similar seeding rate recommendations could be made for both varieties of each crop type studied.

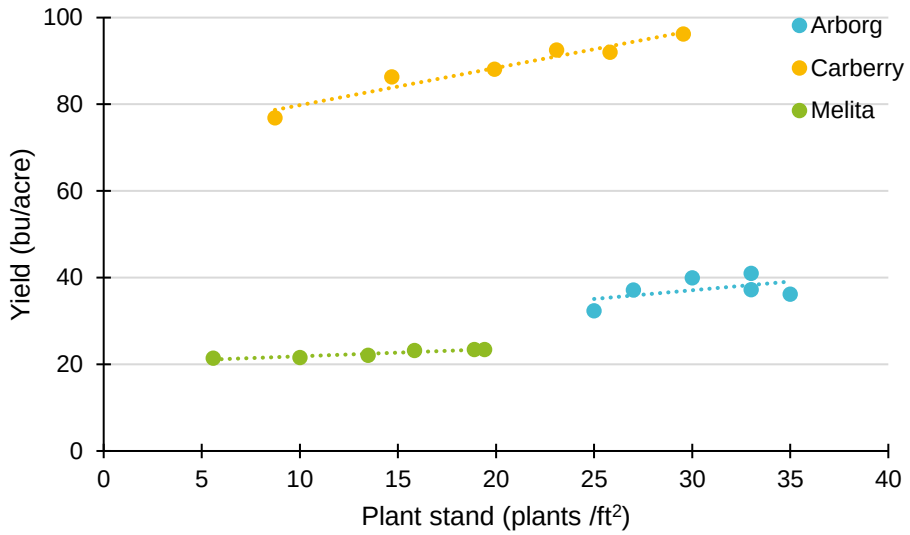

Fig. 11.3. Wheat yield (bu/acre) plotted against actual plant density (plants /ft^2) at Arborg, Carberry and Melita.

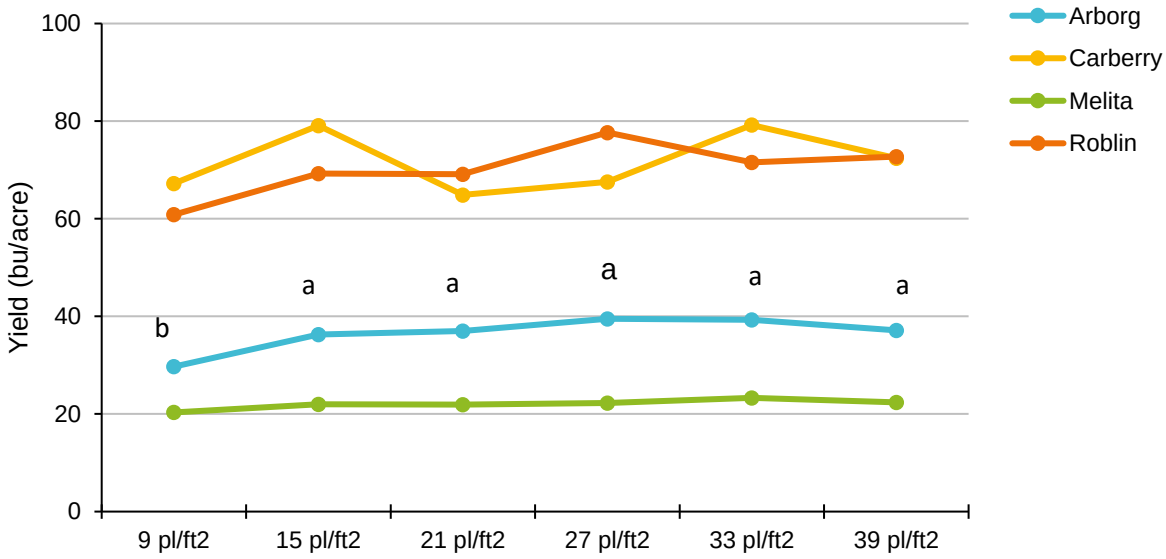

Fig. 11.4. Barley yield (bu /acre) at six target plant densities at Arborg, Carberry, Melita, and Roblin. Statistically significant differences are shown by letters above the line. Treatments within the same site with the same letter are not significantly different (P<0.05).

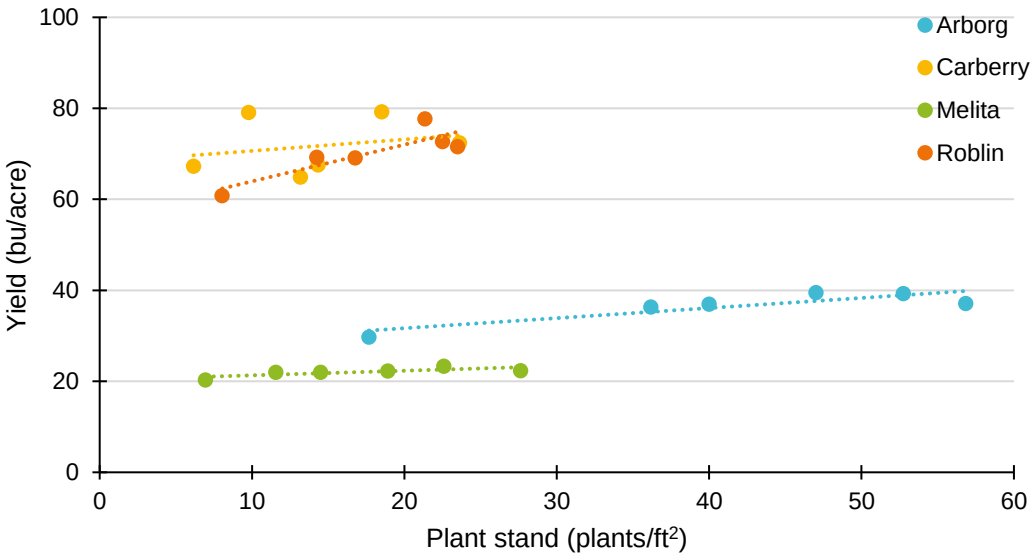

Fig. 11.5. Barley yield (bu /acre) plotted against actual plant density (plants /ft^2) at Arborg, Carberry Melita, and Roblin.

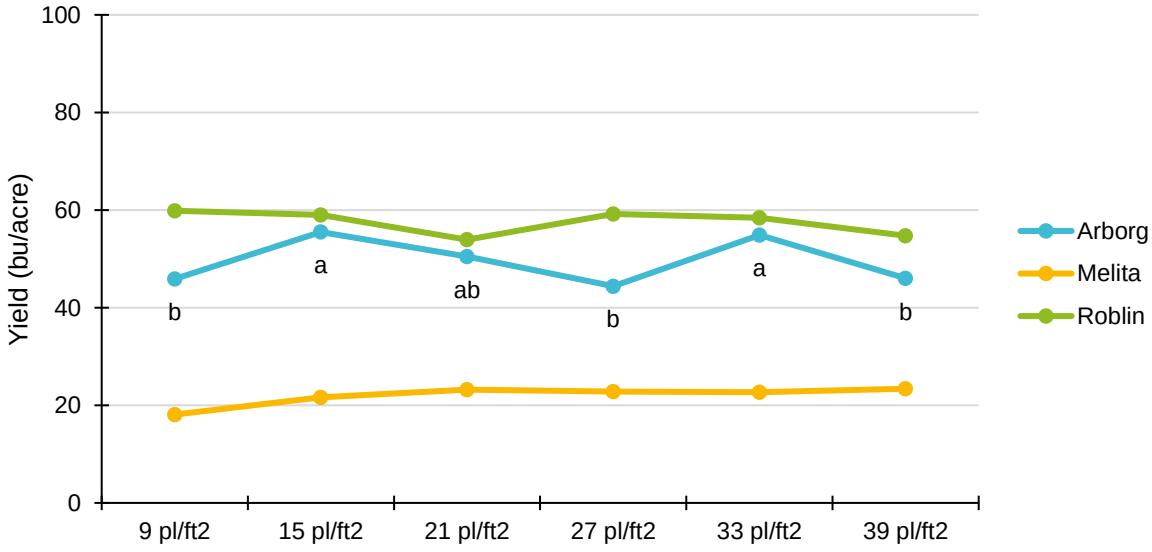

Fig. 11.6. Oats yield (bu /acre) at six target plant densities at Arborg, Melita, and Roblin. Statistically significant differences are shown by letters below the line. Treatments within the same site with the same letter are not significantly different (P<0.05).

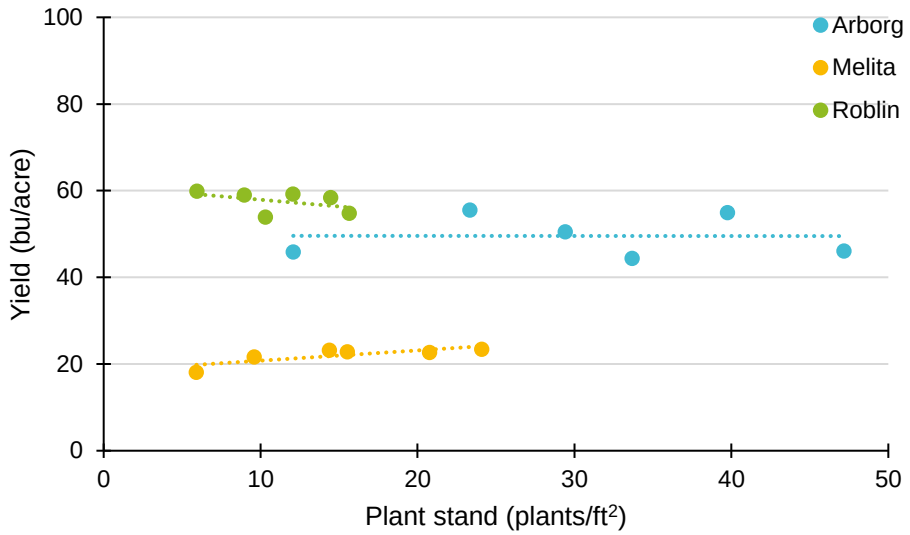

Fig. 11.7. Oats yield (bu /acre) plotted against actual plant density (plants /ft^2) at Arborg, Melita, and Roblin.

Table 11.3. Yield (bushels/acre) for barley, oats, and wheat at the Arborg, Carberry, Melita, and Roblin. Barley varieties are CDC Austenson (A) and AAC Connect (B), oats varieties are CS Camden (A) and Summit (B), and wheat varieties are AAC Brandon (A) and Faller (B).

	Barley				Oats			Wheat		
	Arborg	Carberry	Melita	Roblin	Arborg	Melita	Roblin	Arborg	Carberry	Melita
	---------- Yield (bu/acre) ----------									
Variety										
A	38.5a	73.9	22.0	70.9	53.8a	21.1	86.9a	38.3a	84.9b	23.6a
B	34.4b	69.5	22.1	69.5	45.3b	22.8	28.1b	36.3b	92.4a	21.4b
LSD‡	2.3	-	-	-	4.1	-	4	2.0	2.7	0.9
	Target Plant Population (pl /ft^2)									
9	29.7b	67.2	20.3	60.8	45.9b	18.1	59.9	32.3d	76.9d	21.4
15	36.3a	79.1	22.0	69.2	55.5a	21.6	59.0	37.2bc	86.3c	21.6
21	37.0a	64.9	21.9	69.1	50.5ab	23.2	53.9	39.9ab	88.1bc	22.1
27	39.5a	67.5	22.3	77.7	44.4b	22.8	59.2	37.2bc	92.5ab	23.2
33	39.3a	79.2	23.3	71.5	54.9a	22.7	58.4	41.0a	92.0b	23.4
39	37.1a	72.4	22.4	72.7	46.0b	23.4	54.8	36.1c	96.2a	23.4
LSD‡	4	-	-	-	7	-	-	3.5	4.7	-

‡Least significant difference (LSD) values are shown for sites where there is a significant difference (Pr<0.05) between treatments. At sites with significant differences between treatments, means within the same site year followed by the same letter within a column are not significantly different.

Background

Yield of spring cereals is impacted by many agronomic practices, but starts with variety selection, seeding date, target plant stand, and the seeding rate needed to achieve those plant stands. Optimum plant population is determined by factors including crop management practices and growing conditions. Manitoba Agriculture currently recommends target plant stands of 23-28 plants /ft^2 for spring wheat, 18-23 plants /ft^2 for oats, and 22-25 plants /ft^2 for barley. With the introduction of semi-dwarf and higher yielding cultivars, target plant stands may need to be adjusted to maximize profitability. Pervious research has shown that optimum plant populations can differ by both crop type and variety. In a North Dakota study, Mehring et al. (2016) found that optimum seeding rates for spring wheat ranged from 14 to 46 plants /ft^2 depending on the characteristics of the variety.

References

Crop Production. 2020. Manitoba Agriculture. Available online: https://www.gov.mb.ca/agriculture/crops/production/index.html

Duggan, B.L., Domitruk, D.R., and Fowler, D.B. 2000. Yield component variation in winter wheat grown under drought stress. Can. J. Plant Sci. 80: 739-745.

Mehring, G., Wiersma, J., and Ransom, J. 2016. What do the results from the recent seeding rate studies suggest for new spring wheat varieties? NSDU Crop and Pest Report. Available online: https://www.ag.ndsu.edu/cpr/plant-science/what-do-the-results-from-recent-seeding-rate-studies-suggest-for-new-spring-wheat-varieties-05-05-16

Wiersma, J. 2014. Optimum seeding rates for diverse HRSW varieties. 2014 Research Report. Northwest Research and Outreach Centre, NDSU, Crookston. Available online: https://smallgrains.org/wp-content/uploads/formidable/46/2014OptimumSeedingRateHRSWWiersma.pdf

Materials and methods

Sites: Arborg, Carberry, Melita, and Roblin (Table 11.4)

Experimental design: Randomized complete block design with factorial treatments and replicated three times

Treatments: Two cultivars of spring wheat, oats, and barley planted at six seeding rates. Target plant populations were 9, 15, 21, 27, 33, and 39 plants /ft^2 (

Table 11.5).

Experiments were separated by crop type. Seeding rates were calculated based on thousand kernel weight and assumed 15% seedling mortality. Carberry oats plots had poor emergence and were terminated.

Data Collection

Plant stand, mortality, heads per plant, and yield.

All sites have lower than normal precipitation over the entire growing season (Table 11.6). Arborg had very low precipitation throughout May, June, and July, which resulted in short plants, few tillers, and low yields overall. Low precipitation was especially evident at all sites in July, where Arborg and Carberry had 20 and 17% or normal precipitation, respectively, and Melita and Roblin has 51 and 52% of normal precipitation, respectively. July was warmer than normal at all locations, and the warm and dry conditions affected plant growth and development. Melita had hail on July 17. It is estimated that the hail resulted in 20% yield loss in the wheat, and 30% yield loss in the barley and oats.

Table 11.4. Site information and agronomic management of wheat, oats and barley experiments at all locations.

Crop		Site			
		Arborg	Carberry	Melita	Roblin
	Soil series	Peguis Clay	Wellwood Loam	Waskada Loam	Erickson Loamy Clay
Wheat					
	Seeding date	07-May	3-May	4-May	6-May
	Harvest date	17-Aug	13-Aug	4-Aug	31-Aug
	Fertility (lb/ac)				
	Residual	93 N, 44 P	12 N, 4 P, 158 ppm K, 12 S	10 N, 14 P, 364 K, 90 S	93 N, 46 ppm P, 709 ppm K
	Applied	60 N, 20 P	78 N, 34 P, 15 K	105 N, 28 P, 20 K, 12 S	96 N, 15 P
Oats					
	Seeding date	10-May	-	6-May	4-May
	Harvest date	18-Aug	-	6-Aug	15-Sep
	Fertility (lb/ac)				
	Residual	93 N, 44 P	-	10 N, 14 P, 364 K, 90 S	162 N, 41 ppm P, 703 ppm K
	Applied	60 N, 20 P	-	112 N, 28 P, 20 K, 12 S	10 N, 15 P
Barley					
	Seeding date	10-May	30-Apr	4-May	6-May
	Harvest date	18-Aug	13-Aug	4-Aug	8-Sep
	Fertility (lb/ac)				
	Residual	93 N, 44 P	12 N, 4 P, 158 ppm K, 12 S	10 N, 14 P, 364 K, 90 S	93 N, 46 ppm P, 709 ppm K
	Applied	60 N, 20 P	78 N, 34 P, 15 K	105 N, 28 P, 20 K, 12 S	31 N, 15 P

Table 11.5. Crop types, varieties, and target plant stands studied.

Crop type	Variety	Target plant stand (pl /ft^2)
Wheat	AAC Brandon	9, 15, 21, 27, 33, 39
	Faller	9, 15, 21, 27, 33, 39
Oats	CS Camden	9, 15, 21, 27, 33, 39
	Summit	9, 15, 21, 27, 33, 39
Barley	AAC Connect	9, 15, 21, 27, 33, 39
	CDC Austenson	9, 15, 21, 27, 33, 39

Table 11.6. Monthly and growing season (May 1 - September 30) summaries. Data from Manitoba Agriculture Growing Season Report web43.gov.mb.ca/climate/SeasonalReport.aspx

Weather variables	Month					
	May	June	July	August	September	Total growing season
				Arborg		
Precipitation (mm)	19	39	11	116	34	221
% of Normal precipitation[1]	36	51	20	147	71	69
Growing degree days (GDD)	163	412	502	397	291	1767
% of Normal GDD[1]	80	122	116	103	153	114
				Carberry		
Precipitation (mm)	36	74	12	111	8	243
Normal precipitation[1]	75	106	17	158	16	79
Growing degree days (GDD)	156	419	496	389	308	1770
Normal GDD[1]	85	125	117	100	161	116
				Melita		
Precipitation (mm)	28	87	35	125	13	289
Normal precipitation[1]	52	86	51	160	38	86
Growing degree days (GDD)	108	426	522	426	323	1878
Normal GDD[1]	88	121	115	103	153	115
				Roblin		
Precipitation (mm)	50	62	37	82	16	249
Normal precipitation[1]	111	84	52	148	31	83
Growing degree days (GDD)	148	380	467	360	266	1623
Normal GDD[1]	86	121	119	102	163	116

[1]Based on 30-year averages