Determining Optimum Target Plant Stands for Spring Cereal Crops in Manitoba

Project duration: May 2019 – August 2021
Objectives: 1) Determine if target plant stand recommendations should be adjusted for spring wheat, oat, and barley
2) Determine if optimum plant stands differ for individual varieties
3) Assist producers with determining target plant stand and seeding rate for newer spring cereal varieties
Collaborators: Anne Kirk, Manitoba Agriculture; Manitoba Agriculture Diversification Centres

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/ft2 for spring wheat, 18-23 plants/ft2 for oat, and 22-25 plants/ft2 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/ft2 depending on the characteristics of the variety.

Results
Plant Stand
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, oat, and wheat plots, respectively (Table 4).

Table 4. Plant stand (plants/ft^2) for barley, oat, and wheat at the Arborg (Arb), Carberry (Car), Melita (Mel), and Roblin (Rob) locations. 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). 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.

	Barley				**Oat**			**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*	-

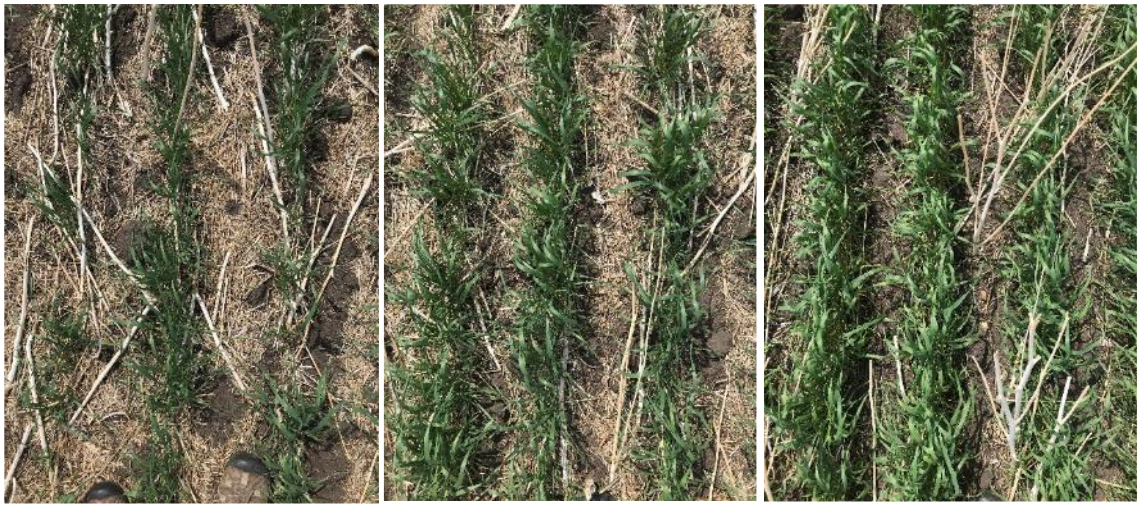

Figure 1. AAC Brandon wheat planted at target plant stands of 9, 21, and 33 plants/ft^2 at Melita in 2021.

Heading

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 have differing abilities to tiller, at the majority of sites there was no difference in heads per plant between cultivars (Table 5). 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 5). 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.

Table 5. Heads per plant for barley, oat, and wheat at the Arborg, Carberry, Melita, and Roblin locations. 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). 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.

	Barley			**Oat**			**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*

Yield

Wheat

There were significant yield differences between the wheat varieties at the three locations where yields are reported, with AAC Brandon yielding significantly higher than Faller at two sites (Table 6). 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 the Carberry location yields increased as plant stand increased, with the highest yields being reported at target plant densities of 27 to 39 plants/ft^2 (Table 6, Figure 2). At Arborg, the 9 plants/ft^2 treatment had the lowest yield overall, with 33 plants/ft^2 yielding the highest (Table 6, Figure 2). Actual plant populations ranged from 9 to 30 plants/ft2 at Carberry, 6 to 19 plants/ft2 at Melita, and 25-35 plants/ft2 at Arborg. Figure 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 higher seeding rates (data not shown).

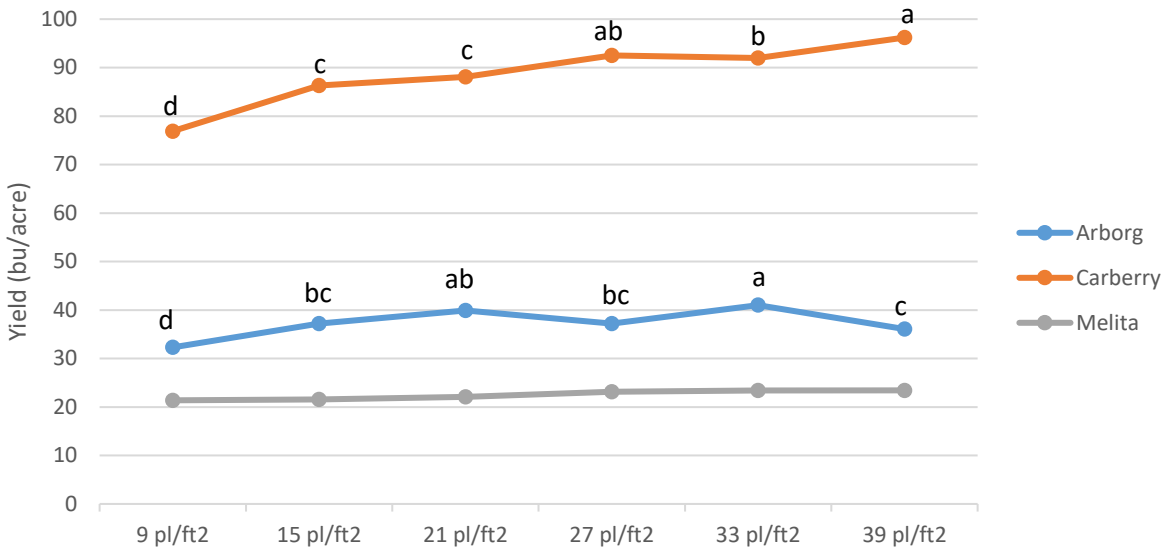

Figure 2. Wheat yield (bu/acre) at six target plant densities at Arborg, Carberry and Melita. Statistically significant differences are shown by letters above the line. Treatments within the same site with the same letter are not significantly different (P<0.05).

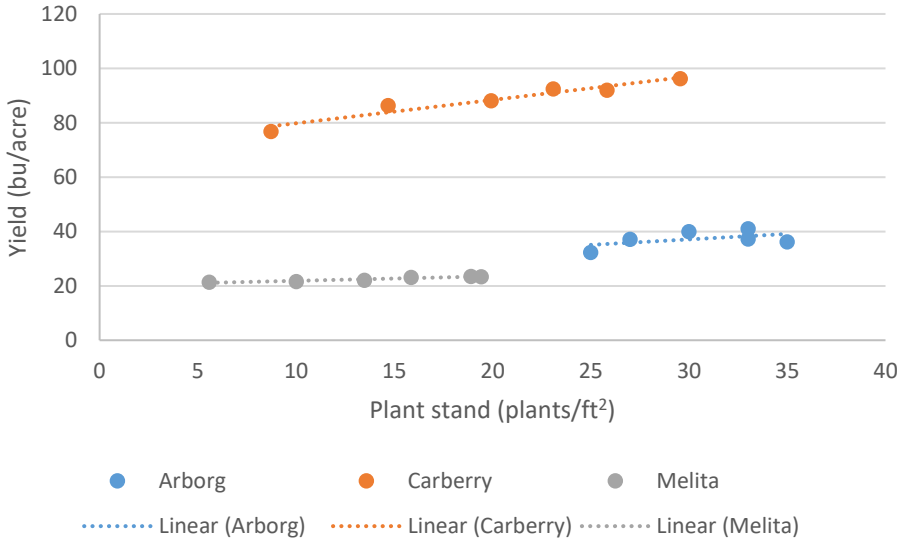

Figure 3. Wheat yield (bu/acre) plotted against actual plant density (plants/ft^2) at Arborg, Carberry and Melita. Statistically significant differences for plant stand and yield can be found in Tables 4 and 6, respectively.

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 6). 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 (Figure 4 and Table 6). 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 4). Figure 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 higher seeding rates (data not shown).

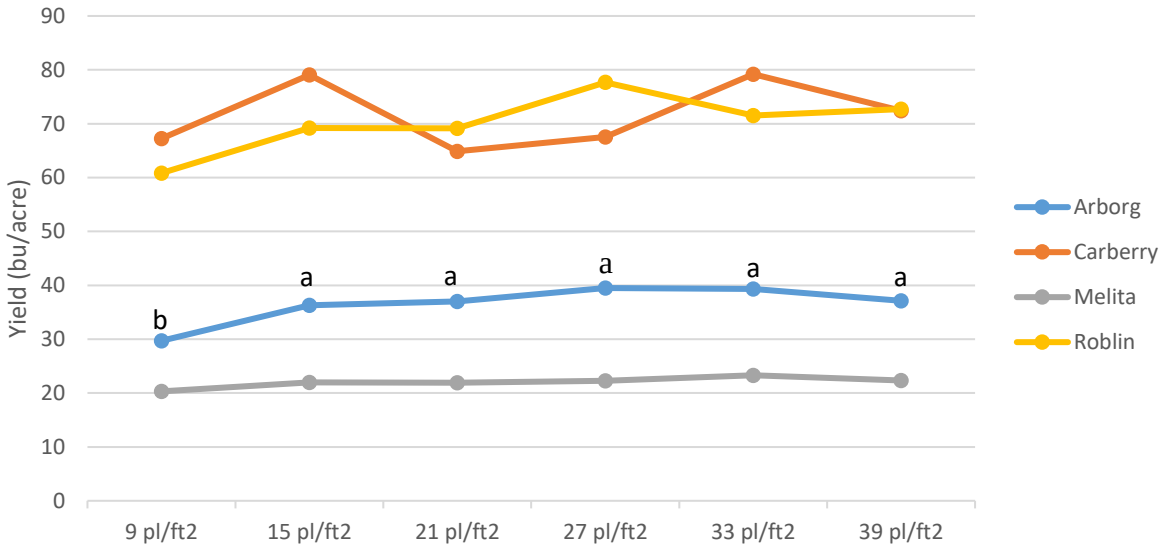

Figure 4. Barley yield (bu/acre) at six target plant densities at Arborg, Carberry, Melita, and Roblin. Statistically significant differences are shown by letters above the line. Treatments within the same site with the same letter are not significantly different (P<0.05).

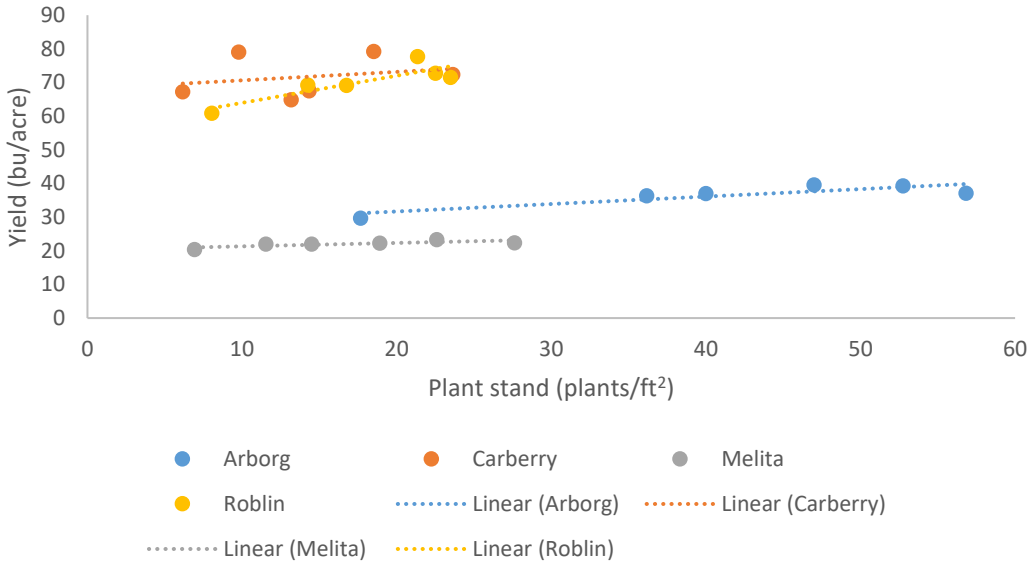

Figure 5. Barley yield (bu/acre) plotted against actual plant density (plants/ft^2) at Arborg, Carberry Melita, and Roblin. Statistically significant differences for plant stand and yield can be found in Tables 4 and 6, respectively.

Oat

There was a significant yield difference between the two oat varieties at two of the three locations, with CS Camden yielding higher than Summit in both cases (Table 6). Averaged across cultivars, there was no difference in oat 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 (Figure 6). Oat yield plotted against plant stand is shown in Figure 7. There was no interaction between plant density and cultivar, both cultivars responded similarly to higher seeding rates (data not shown).

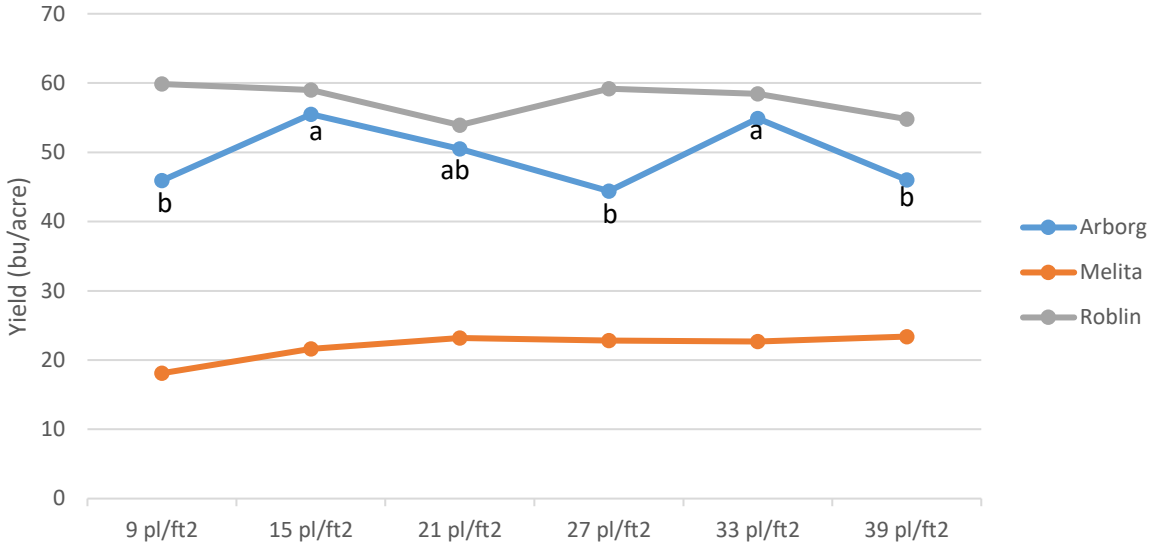

Figure 6. Oat yield (bu/acre) at six target plant densities at Arborg, Melita, and Roblin. Statistically significant differences are shown by letters below the line. Treatments within the same site with the same letter are not significantly different (P<0.05).

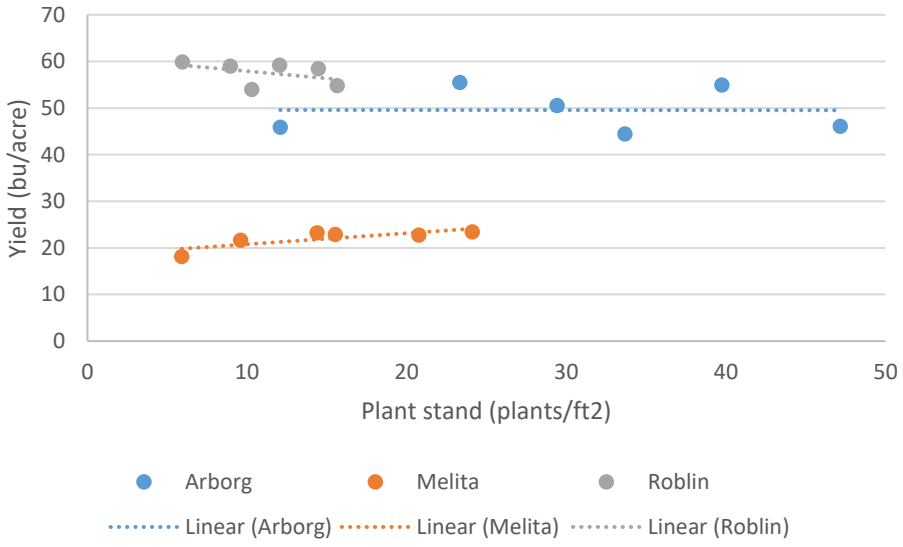

Figure 7. Oat yield (bu/acre) plotted against actual plant density (plants/ft^2) at Arborg, Melita, and Roblin. Statistically significant differences for plant stand and yield can be found in Tables 4 and 6, respectively.

Table 6. Yield (bushels/acre) for barley, oat, and wheat at the Arborg, Carberry, Melita, and Roblin locations. 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). 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.

	Barley				Oat			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*	-

This study is a continuation of a research project that took place at Arborg, Carberry, Melita, and Roblin in 2017 and 2018. The oat 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 oat are sufficient. At the wheat sites in 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 oat sites, although the data indicates that these trends should be taken with caution. There were 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.

Materials and methods

- Locations: Arborg, Carberry, Melita, and Roblin
- Year: 2021
- Experimental Design: Randomized complete block design with factorial treatments and replicated three times

- Treatments: Two cultivars of spring wheat, oat, and barley planted at six seeding rates. Target plant populations were 9, 15, 21, 27, 33, and 39 plants/ft^2. See Table 1 for a complete treatment list.
    - Experiments were separated by crop type
    - Seeding rates were calculated based on thousand kernel weight and assumed 15% seedling mortality
- Data Collection: Plant stand, mortality, heads per plant, and yield.
    - Carberry oat plots had poor emergence and were terminated.
    - 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 1. Crop types, varieties, and target plant stands studied.

Crop Type	Variety	Target Plant Stand (pl/ft^2)
Spring Wheat	AAC Brandon	9, 15, 21, 27, 33, 39
	Faller	9, 15, 21, 27, 33, 39
Oat	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 2. Agronomic information

	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
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
Harvest Date	17-Aug	13-Aug	4-Aug	31-Aug
Oat				
Seeding Date	10-May	-	6-May	4-May
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
Harvest Date	18-Aug	-	6-Aug	15-Sep
Barley				
Seeding Date	10-May	30-Apr	4-May	6-May
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
Harvest Date	18-Aug	13-Aug	4-Aug	8-Sep

Table 3. Monthly and growing season (May 1 - September 30) summaries. (Data from Manitoba Agriculture Growing Season Report web43.gov.mb.ca/climate/SeasonalReport.aspx)

Arborg						
	May	June	July	August	September	Growing Season
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						
	May	June	July	August	September	Growing Season
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						
	May	June	July	August	September	Growing Season
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						
	May	June	July	August	September	Growing Season
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

All sites has lower than normal precipitation over the entire growing season. 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.

References

Crop Production. 2020. Manitoba Agriculture. Available online.

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.

Wiersma, J. 2014. Optimum seeding rates for diverse HRSW varieties. 2014 Research Report. Northwest Research and Outreach Centre, NDSU, Crookston. Available online.