Determining Optimum Target Plant Stands for Spring Cereal Crops in Manitoba

Anne Kirk, Rejean Picard, and Earl Bargen, Manitoba Agriculture and Resource Development
James Frey, Scott Chalmers, Nirmal Hari, Haider Abbas, and Craig Linde, 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 and Resource Development currently recommends target plant stands of 23-28 plants/ft^2 for spring wheat, 18-23 plants/ft^2 for oat, 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.

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

Materials and Methods

- Locations: Arborg, Carberry, Melita, and Roblin
- Years: 2017, 2018
- Experimental Design: Randomized complete block design with factorial treatments and replicated three times
- Treatments: Two cultivars of spring wheat, oat, and barley planted at five seeding rates. Target plant populations were 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/plant, and yield.
    - Heads/plant was not collected at Carberry in 2017
    - A late season hail storm damaged wheat and oat plots in Arborg 2017. Yield data from Arborg wheat and oats 2017 is not included in this report

Table 1. Crop types, varieties, and target plant stands studied.

Crop Type	Variety	Target Plant Stand (pl/ft^2)
Spring Wheat	AAC Brandon	15, 21, 27, 33, 39
	Prosper	15, 21, 27, 33, 39
Oat	CS Camden	15, 21, 27, 33, 39
	Summit	15, 21, 27, 33, 39
Barley	AAC Synergy	15, 21, 27, 33, 39
	CDC Austenson	15, 21, 27, 33, 39

Table 2. Agronomic information for trial locations.

	Arborg		Carberry		Melita		Roblin	
	2017	2018	2017	2018	2017	2018	2017	2018
Soil Series	Peguis Clay		Wellwood Loam		Waskada Loam		Erickson Loamy Clay	
Wheat								
Seeding Date	19-May	11-May	05-May	09-May	10-May	04-May	17-May	15-May
Fertility (lb/ac)								
Residual	107 N, 34 P	77 N, 30 P	41 N		10 N, 18 P	24 N, 20 P	86 N, 20 P	54 N, 26 P
Applied	75 N, 25 P	75 N, 25 P	100 N, 17 P		126 N, 35 P	115 N, 35 P	130 N, 10 P	96 N, 10 P
Harvest Date	31-Aug	20-Aug	22-Aug	21-Aug	28-Aug	13-Aug	01-Sep	23-Aug
Oat								
Seeding Date	19-May	11-May	12-May	09-May	10-May	09-May	18-May	15-May
Fertility (lb/ac)								
Residual	107 N, 34 P	77 N, 30 P	41 N		13 N, 15 P	24N, 20 P	86 N, 20 P	54 N, 26 P
Applied	75 N, 25 P	75 N, 25 P	30 N, 17 P		116 N, 35 P	115 N, 35 P	15 N, 10 P	96 N, 15 P
Harvest Date	07-Sep	23-Aug	22-Aug	21-Aug	23-Aug	20-Aug	04-Sep	24-Aug
Barley								
Seeding Date	18-May	11-May	12-May	14-May	09-May	04-May	18-May	16-May
Fertility (lb/ac)								
Residual	107 N, 34 P	77 N, 30 P	54 N, 24 P		13 N, 15 P	24 N, 20 P	86 N, 20 P	54 N, 26 P
Applied	75 N, 25 P	75 N, 25 P	70 N, 17 P		80 N, 35 P	115 N, 35 P	38 N, 10 P	96 N, 10 P
Harvest Date	29-Aug	20-Aug	22-Aug	15-Aug	14-Aug	07-Aug	01-Sep	23-Aug

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

	Arborg		Melita		Roblin		Carberry	
	2017	2018	2017	2018	2017	2018	2017	2018
Precipitation (mm)	266	249	206	243	182	416	226	300
Normal precipitation[1]	320	320	338	336	300	298	307	307
Growing degree days (GDD)	1525	1668	1765	1780	1333	1459	1568	1747
Normal GDD[1]	1554	1554	1637	1635	1396	1395	1524	1524

[1]Based on 30-year averages

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 and oat at Roblin 2017, at the Arborg 2018 wheat site, and Carberry 2018 and Roblin 2018 barley sites. Results will not be shown for the site years where a range of plant populations were not established.

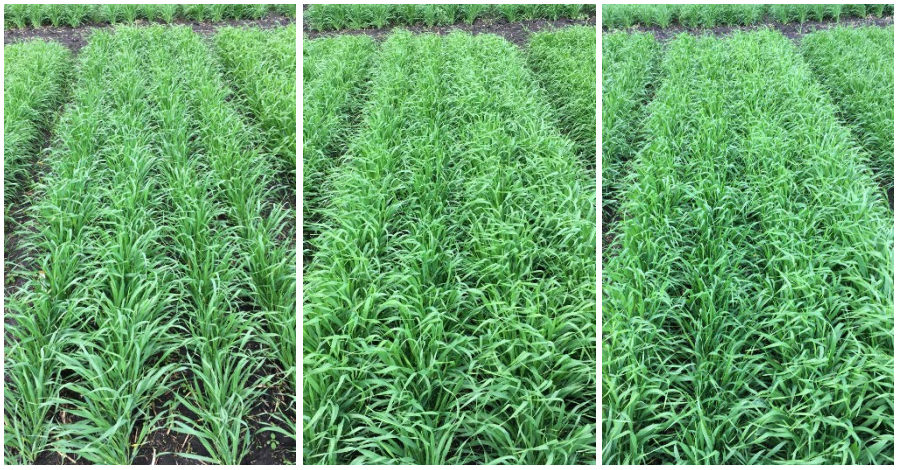

Figure 1. AAC Synergy barley planted at target plant stands of 15, 27, and 39 plants/ft^2 at Carberry 2017.

Heading

Cereal cultivars have differing abilities to tiller, but in both years of this study there were no significant differences in heads/ft^2 between the two wheat and oat cultivars at any site year. There were significant differences between the barley cultivars at Melita 2017 and Arborg 2018. In both cases, CDC Austenson had significantly more heads than AAC Synergy (Table 4).

Cereals typically compensate for lower plant populations by increasing tillering. Previous research in which spring wheat plants were given ample room found that stems/plant ranged from 19 to 44 depending on the variety (Wiersma 2014). There was no significant difference in heads/ft^2 between seeding rates at two of four wheat sites, four of five barley sites, and two of five oat sites (Table 4),

which demonstrates the ability of cereal crops to compensate for reduced plant populations by increasing tillering. At the sites where there were significant differences in heads/ft^2 between plant populations, heads/ft^2 increased as plant stand increased. The one exception was the barley at Arborg 2018 where there were more heads at the lowest seeding rates (Table 4). At the remaining sites, the increase in heads/ft^2 between the highest and lowest seeding rates ranged from 10 to 23 heads/ft^2 (Table 4).

Yield

Wheat

There were significant yield differences between the wheat varieties at two locations, with AAC Brandon yielding significantly higher than Proper in both cases (Table 5). When averaged across cultivars, there were no differences in wheat yield across target plant densities at Carberry in both years, but yields increased as plant stand increased at Melita (Table 5, Figure 2). There was no interaction between seeding rate and cultivar, both cultivars responded similarly to increased seeding rates (data not shown).

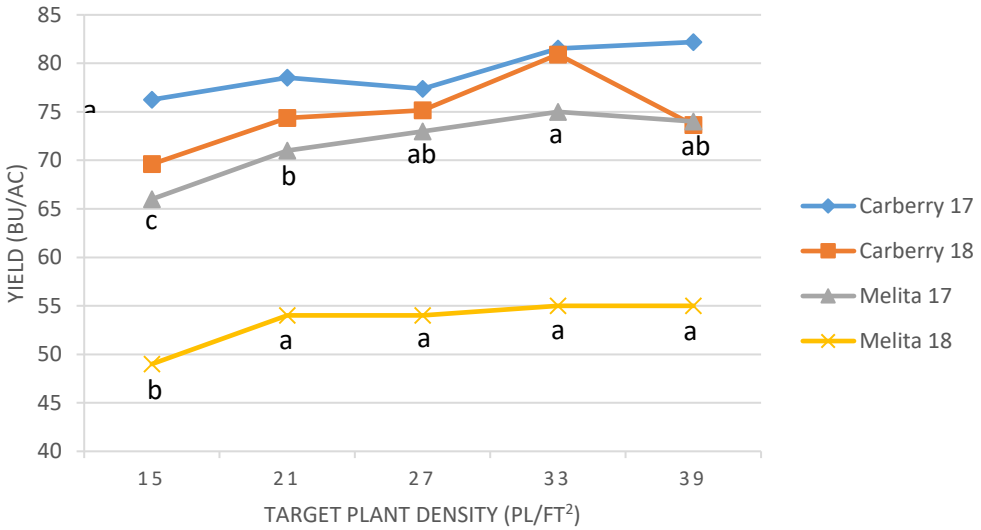

Figure 2. Wheat yield (bu/acre) at five target plant densities at Carberry and Melita. Statistically significant differences are shown by letters below the line. Treatments within the same site with the same letter are not significantly different (P<0.05).

Barley

There were no significant yield differences between barley varieties at three of five locations, but at Arborg 2017 and Melita 2018 CDC Austenson yielded significantly higher than AAC Synergy (Table 5). When averaged across cultivars, there were no significant yield differences between target plant densities at three of five locations (Table 5, Figure 3). At Roblin 2017, there were no significant yield differences between the first four seeding rates, but yield was significantly reduced at the higher plant density. There were significant yield differences between target plant densities at Arborg 2017, but the range in yield was only 4 bu/acre and there was no yield trend (Figure 3). There was no interaction between seeding rate and cultivar, both cultivars responded similarly to increased seeding rates (data not shown).

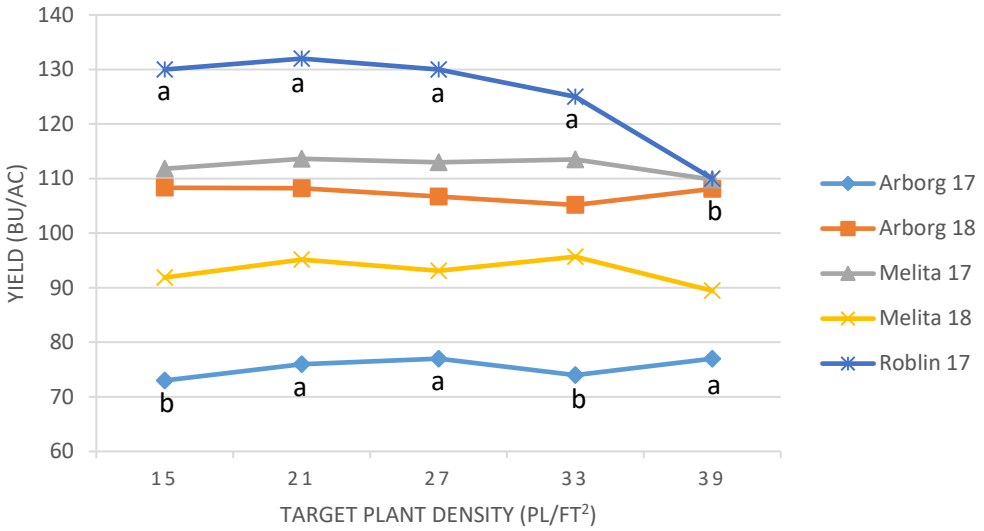

Figure 3. Barley yield (bu/acre) at five target plant densities at Arborg, Melita, and Roblin. Statistically significant differences are shown by letters below the line. Treatments within the same site with the same letter are not significantly different (P<0.05).

Oat

There was a significant yield difference between the two oat varieties at Carberry 2018 only, with CS Camden yielding significantly higher than Summit (Table 5). Averaged across cultivars, there were no differences in oat yield across target plant densities at any location (Table 5, Figure 4). Roblin 2018 was the only location where there was a significant interaction between variety and seeding rate (data not shown). At a target plant stand of 15 pl/ft2 Summit yielded significantly more than CS Camden, and at a target plant stand of 33 pl/ft2 CS Camden yielded significantly more than Summit (data not shown).

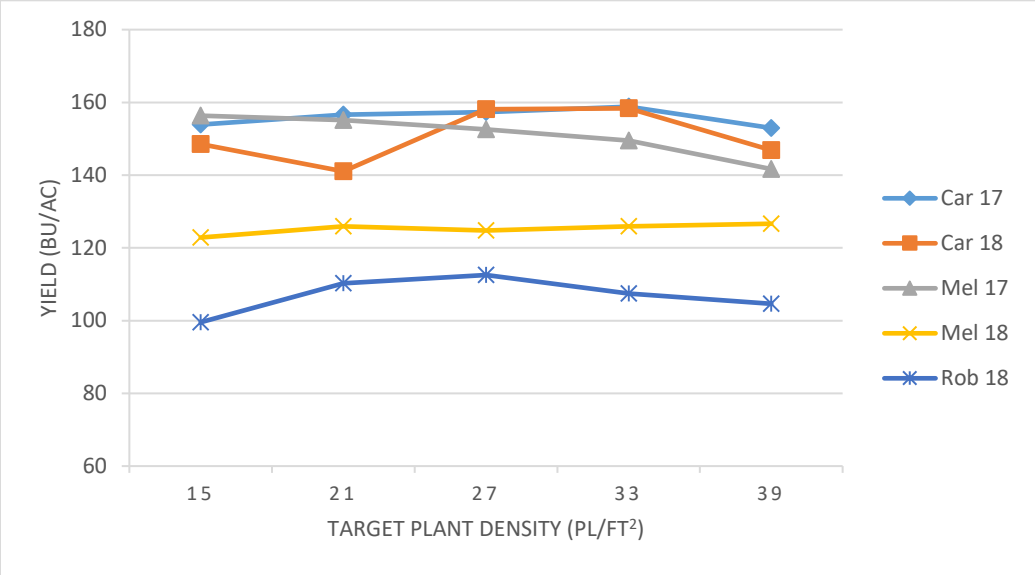

Figure 4. Oat yield (bu/acre) at five target plant densities at Carberry, Melita, and Roblin. There were no statistically significant yield differences (P>0.05) between plant *densities.*

The results from this study suggest that the current recommended target plant populations for wheat, barley, and oat are sufficient. The oat and barley sites showed similar yields across a range of plant stands (Figures 3 and 4), the one exception being barley at Roblin 2017, where the highest seeding rate had a significantly lower yield (Figure 3). At the wheat sites, there was a general trend of higher yields with increased plant stand (Figure 2); however, there were no significant difference in yields between target plant stands of 21-39 plants/ft^2 at four of the five sites. At the fourth site, the target plant stand of 33 plants/ft^2 yielded significantly higher than 21 plants/f^{t2}, but there were no significant differences in yield between the highest three target plant stands (Figure 2). At the majority of 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.

Table 4. Heads/ft^2 for wheat, barley, and oat at the Arborg (Arg), Carberry (Car), Melita (Mel), and Roblin (Rob) locations. Wheat varieties are AAC Brandon (A) and Prosper (B), barley varieties are AAC Synergy (A) and CDC Austenson (B), and oat varieties are Summit (A) and CS Camden (B). Significant P values (Pr<0.05) are indicated by an asterisk. 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.

	Wheat				**Barley**					**Oat**				
	Arb 17	Car 18	Mel 17	Mel 18	Arb 17	Arb 18	Mel 17	Mel 18	Rob 17	Arb 17	Arb 18	Car 18	Mel 17	Mel 18
	---------- Heads/ft^2 ----------													
Variety														
A	48	34	34	44	56	47b	36b	58	65	39	39	25	24	40
B	51	33	31	44	54	53a	44a	58	68	42	39	26	22	40
Pr>F	*ns*	*ns*	*ns*	*ns*	*ns*	*	*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
LSD	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*2.5*	*5*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
Target Plant Population (pl/ft^2)														
15	48	29	23b	37c	55	53a	34	58	67	37b	26c	19e	21	38
21	46	32	33a	38c	57	53a	40	60	69	37b	34b	22d	21	41
27	48	33	30ab	46b	51	52a	38	57	60	40b	40b	25c	18	42
33	54	38	38a	51a	55	47b	42	59	64	41b	46a	29b	28	41
39	52	35	39a	47a	57	45b	46	55	72	47a	49a	34a	26	40
Pr>F	*ns*	*ns*	*	*	*ns*	*	*ns*	*ns*	*ns*	*	*	*	*ns*	*ns*
LSD	*n/a*	*n/a*	*9.5*	*4.5*	*n/a*	*4.0*	*n/a*	*n/a*	*n/a*	*6.4*	*4.1*	*2.4*	*n/a*	*n/a*

Table 5. Yield (bushels/acre) for wheat, barley, and oat at the Arborg (Arg), Carberry (Car), Melita (Mel), and Roblin (Rob) locations. Wheat varieties (Var) are AAC Brandon (A) and Prosper (B), barley varieties are AAC Synergy (A) and CDC Austenson (B), and oat varieties are Summit (A) and CS Camden (B). Significant P values (Pr<0.05) are indicated by an asterisk. 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.

	Wheat				**Barley**					**Oat**				
	Car 17	Car 18	Mel 17	Mel 18	Arb 17	Arb 18	Mel 17	Mel 18	Rob 17	Car 17	Car 18	Mel 17	Mel 18	Rob 18
	---------- Yield (bu/ac) ----------													
Variety														
A	82a	75	76a	53	70b	105	113	91	123	154	140	153	124	109
B	76b	75	68b	54	81a	109	112	96	128	158	161	150	126	105
Pr>F	*	*ns*	*	*ns*	*	*ns*	*ns*	*	*ns*	*ns*	*	*ns*	*ns*	*ns*
LSD	*4*	*n/a*	*2*	*n/a*	*1.2*	*n/a*	*n/a*	*4*	*n/a*	*n/a*	10	*n/a*	*n/a*	*n/a*
Target Plant Population (pl/ft^2)														
15	76	70	66c	49b	73b	108	112	92	130a	154	149	156	123	100
21	79	74	71b	54a	76a	108	114	95	132a	157	141	155	126	110
27	77	75	73ab	54a	77a	107	113	93	130a	157	158	153	125	113
33	82	81	75a	55a	74b	105	114	96	125a	159	158	149	126	107
39	82	74	74ab	55a	77a	108	110	89	110b	153	147	142	127	105
Pr>F	*ns*	*ns*	*	*	*	*ns*	*ns*	*ns*	*	*ns*	*ns*	*ns*	*ns*	*ns*
LSD	*n/a*	*n/a*	*3*	*3*	*2*	*n/a*	*n/a*	*n/a*	*9*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*

References

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

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