

Strategic Field Program (SFP)

Project Progress Report

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Project Title: Establishing nitrogen and seeding rate recommendations for composite yellow mustard production in Saskatchewan

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Abstract *(no more than 250 words)*

Describe in lay language the progress towards the project objectives over the last reporting period. Include any key findings and any interim conclusions. Include any deviations from the original methodology.

The project was initiated to define upper limits of nitrogen fertilizer and specify an optimal seeding rate to maximize yield for a composite yellow mustard (AAC Yellow 80). The current recommended seeding rate for open pollinated varieties is a target plant stand of 7 to 11 plants/ft² (70 to 110 plants/m²). It is expected that optimal seed and nitrogen rate for composite mustard may be different. To evaluate this, small-plot research trials were established in three different soil zones in Saskatchewan. Locations were Swift Current (WCA), Indian Head (IHARF) and Redvers (SERF). The project was comprised as two separate trials that included both varieties AAC Yellow 80 and Andante yellow mustard. The first trial evaluates both varieties at increasing nitrogen rates of 0, 60, 80, 100, 120, 140 and 160 lbs/ac of total nitrogen (soil residual + nitrogen applied as urea). The second trial includes both varieties and balanced NPKS at increasing seed rates of 108, 150, 194, 237, and 280 seeds/m² (conversion to lbs/ac can be seen in Table 10). Data collection consists of plant density, vigor ratings, height, lodging, days to maturity, and seed yield. In the first year, AAC Yellow 80 has indicated strong nitrogen use efficiency and the ability to compensate with increased branching at a lower target plant stand compared to Andante. The field trials will be repeated for the next two growing seasons; therefore, the project will be completed after the 2025 growing season.

Introduction *(maximum 1,500 words)*

Provide a brief project background and rationale.

Current mustard fertility recommendations are based on data generated from the 1970s to early 2000s. Composite mustard (AAC Yellow 80) was not available during those studies and heterosis (hybrid vigor) introduced with hybridity has resulted in a need to revisit these recommendations. Heterosis is typically associated with superior performance such as increased yields and vigor. In the case of composite mustard, it is produced under a breeding system that uses a mixture of female and male plants in seed production and harvests both the seed from the male and female plants. In composite varieties, at least 70% of the progeny result from crossing of the parent lines.

There is increasing interest in plant protein uses, as well as value-added uses of fractionated mustard seed. Increased demand is anticipated in the near future for mustard. This research would help to maximize productivity on land and mitigate inefficient use of crop inputs such as seed, or nitrogen fertilizer.

There is also anticipated uptake of composite mustard in the near future due to the threat of increased mustard production in regions outside of Canada (our competitors) by re-using the harvested seed from currently-registered AAFC mustard seed (i.e., bin-running). Composite seed reduces this threat, but does not eliminate it.

AAC Yellow 80 is the first commercially-available composite mustard (registered in 2020). Typically, mustard growers do not include canola in their rotation and as such are less familiar with the fertility and seeding rate requirements for crops with hybrid vigor or partial hybrid vigor in the case of composite mustard.

Yellow mustard production is approximately 50-60% of all mustard production in Saskatchewan and optimizing mustard productivity will directly contribute to Saskatchewan's 2020-2030 growth plan. Particularly in growing exports (greater output per area of land) by 50%, growing agri-food exports to \$20 billion, increasing crop production to 45 million metric tonnes, engaging internationally to secure access and expand international markets (shifting to hybrid and

composite varieties will combat bin running open-pollinated seed outside of Canada), and supporting the transformation of the economy through innovation and technology.

In 2021, Saskatchewan exported \$75,001,729 (70,323 metric tonnes) of mustard seed to the world and Saskatchewan is the leading Canadian exporter of mustard seed, accounting for 71% of total Canadian mustard seed exports.

Objectives and Progress *(add additional lines as needed)*

Please list the original objectives and/or revised objectives if ministry-approved revisions have been made to original objectives. A justification is needed for any deviation from original objectives.

Objective	Progress <i>(i.e., completed/in progress)</i>
To establish nitrogen and seeding rate recommendations for composite yellow mustard in Saskatchewan.	In progress
To understand nitrogen requirements for composite yellow mustard compared to Andante (open-pollinated) yellow mustard.	In progress
To define upper limits of nitrogen fertilizer for composite yellow mustard.	In progress
To specify the required seeding rate the producers can use to maximize yield, keeping seed costs in mind.	In progress
To update the recommendation for Saskatchewan mustard producers (available via Sask Mustard's mustard production manual).	In progress

Project Changes *(400 words or less)*

Briefly explain any new challenges faced during the reporting period and the impact on the work plan or the budget.

No Changes.

Methodology *(maximum of five pages)*

Specify project activities undertaken during this reporting period. Include approaches, experimental design, tests, materials, sites, etc. Please note that any significant changes from the original work plan will require written approval from the ministry.

Specific site operations are listed in Table 3 (appendices).

Fertilizer was side-banded with the exception of Indian Head, where part of the P requirements (35 kg monoammonium phosphate/ha) were placed in-furrow.

Experimental design: Set up as two separate trials (nitrogen rates and seeding rates) each an RCBD with 4 replicates

Locations: Swift Current (dry Brown), Indian Head (thin-Black), & Redvers (black-long season)

Treatments: Part 1: (2 yellow mustard varieties x 7 Nitrogen Rates x 4 reps = 56 plots) and

Part 2: (2 yellow mustard varieties x 5 Seeding Rates x 4 reps = 40 plots)

Part 1		
Mustard Variety	Seed Rate	Residual + Applied Nitrogen (lb N/ac)
AAC Yellow 80	237 seeds/m ²	Soil N ²

AAC Yellow 80	237 seeds/m ²	60
AAC Yellow 80	237 seeds/m ²	80
AAC Yellow 80	237 seeds/m ²	100
AAC Yellow 80	237 seeds/m ²	120
AAC Yellow 80	237 seeds/m ²	140
AAC Yellow 80	237 seeds/m ²	160
Andante	237 seeds/m ²	Soil N ^z
Andante	237 seeds/m ²	60
Andante	237 seeds/m ²	80
Andante	237 seeds/m ²	100
Andante	237 seeds/m ²	120
Andante	237 seeds/m ²	140
Andante	237 seeds/m ²	160
Part 2		
Mustard Variety	Seed Rate	Residual + Applied Nitrogen (lb N/ac) ^y
AAC Yellow 80	108 seeds/m ²	100
AAC Yellow 80	150 seeds/m ²	100
AAC Yellow 80	194 seeds/m ²	100
AAC Yellow 80	237 seeds/m ²	100
AAC Yellow 80	280 seeds/m ²	100
Andante	108 seeds/m ²	100
Andante	150 seeds/m ²	100
Andante	194 seeds/m ²	100
Andante	237 seeds/m ²	100
Andante	280 seeds/m ²	100

^z soil nitrogen varied at each site (Table 2).

^y varied according to location (Table 3).

Data Collection:

- Composite soil samples (0-6", 6-24") submitted for residual nutrients and basic quality analyses (NO₃-N, Olsen – P, K, S, micronutrients, OM, pH and CEC).
- Plant counts – Record the number of plants in a minimum of 2 x 1 m sections of crop row approximately 2-3 weeks after emergence is first noted.
- Vigor ratings (completed at both the 3-4 leaf stage and again at budding)
- Lodging – Completed prior to harvest, rated on a scale of 1-9 where 1 is upright and 9 is flat.
- Maturity – Approximately 60% of the seeds have turned color from green to brownish/red or yellow, depending on the mustard type.
- Yield – Corrected for dockage and to uniform moisture content of 9.5%.

Results (maximum of 20 pages (not including figures or tables))

Describe project accomplishments during the reporting period under relevant objectives listed under “Objectives and Progress” section. Please accompany written description of results with tables, graphs and/or other illustrations. Provide discussion necessary to the full understanding of the results. Where applicable, results should be discussed in the context of existing knowledge and relevant literature. Detail any major concerns or project setbacks.

General Conditions

Growing season temperatures and precipitation amounts for the 2023 growing season (May-August) relative to the long-term averages are provided in Table 1. All locations were above the long-term average temperature (Redvers: 108%, Swift Current: 109%, Indian Head: 109%) and below the long-term average precipitation (Redvers: 60%, Swift Current: 97%, Indian Head: 49%). Yield potential was very limited due to extreme drought conditions and Swift Current experienced a hail storm on July 22, 2023 that resulted in both yield loss due to pod shatter (estimated 20% yield loss). Overall weed and insect pressure was low. At Indian Head, supplemental hand-weeding was completed prior to flowering; however, the vast majority of weeds were eliminated by the pre-seed burn-down and in-crop herbicide applications.

Table 1. Mean monthly temperature and precipitation for the 2023 growing season (May-August) at Saskatchewan trial locations and long-term (10-year) averages.

Location	Year	May	June	July	August	Avg. / Total
-----Mean Temperature (°C)-----						
Redvers	2023	14.5	19.7	17.6	17.9	17.4
	Long-term	11.1	16.2	18.7	18.0	16.0
Swift Current	2023	14.8	17.8	18.5	17.8	17.2
	Long-term	10.9	15.4	18.7	17.7	15.7
Indian Head	2023	14.0	19.4	16.7	17.7	17.0
	Long-term	10.8	15.8	18.2	17.4	15.6
-----Precipitation (mm)-----						
Redvers	2023	70	25	11	49	155
	Long-term	60	85	66	47	257
Swift Current	2023	49	34	77	48	207
	Long-term	44	74	52	43	214
Indian Head	2023	13	50	16	41	119
	Long-term	52	77	64	51	244

Selected soil test results for each site are provided in Table 2 below. All sites had a similar pH. Organic matter varied and was lowest at Swift Current (2.6%) followed by Redvers (4.0%) and highest at Indian Head (6.1%). Residual P was considered medium at Swift Current and very low at Indian Head and Redvers. Residual Sulphur was medium at Swift Current, high at Indian Head and very high at Redvers. Overall residual Nitrogen was low at Swift Current and Indian Head and High at Redvers.

Table 2. Soil residual nutrients (0-6", 6-24") and basic quality analyses (NO3-N, Olsen – P, K, S, micronutrients, OM, pH and CEC).

Depth	pH	OM%	CEC (meq/100 g)	N (lbs/ac)	P (ppm)	K (ppm)	S (lbs/ac)	Cl (lbs/ac)	B (ppm)	Zn (ppm)	Cu (ppm)
-----Swift Current 2023-----											
0-6"	7.0	2.6	16	6	11	239	8	16	0.3	0.52	0.56
6-24"	7.9	-	-	12	-	-	24		-	-	-
-----Indian Head 2023-----											
0-6"	7.6	6.1	44.2	9	7	611	20	32	1.3	0.82	2.2
6-24"	8.0	-	-	13	-	-	40		-	-	-
-----Redvers 2023-----											

0-6"	7.6	4.0	33	16	7	254	120	-	-	1.62	-
6-24"	8.1	-	-	36	-	-	360	-	-	-	-

Plant Densities & Establishment

Mustard variety and nitrogen rate effects on establishment were similar at each location. Andante yellow mustard resulted in a higher plant stand than AAC Yellow 80 at each site with nitrogen rate having little to no effect on population (Tables 4-6). Mean mustard emergence was the lowest at Swift Current (43%) with establishment ranging from 74-98 plants/m², Table 4), followed by Redvers, which ranged from 147-172 plants/m² (69%, Table 6) and Indian Head, which ranged from 174-195 plants/m² (88%, Table 5). Early in the season plots were rated equally as vigorous and there was no difference between variety, or nitrogen rate (data not shown). However, by mid-June vigor ratings increased with increasing nitrogen at Redvers and Indian Head.

Mustard variety and seed rate effects on mustard establishment were also similar at each location. Andante yellow mustard resulted in higher plant stands compared to AAC Yellow 80 at each site, with the exception of Swift Current not being significantly different (Table 7). Andante was also rated as more vigorous at Swift Current and Redvers (data not shown). Plant stand and vigor increased with seed rate at all sites (Tables 7-9). However, seed mortality increased as seeding rate increased, meaning the lower seeding rates had a higher percentage of surviving plants. This is likely a result of increased competition amongst seedlings at the higher seeded rates. Again, emergence rates were the lowest at the Swift Current site (43%) with establishment ranging from 53-91 plants/m², Table 7), followed by Redvers ranging from 83-184 plants/m² (78%, Table 8) and Indian Head ranging from 83-179 plants/m² (82%, Table 9).

Height

Mustard variety and nitrogen rate effects on plant height were similar at each location. The composite mustard, AAC Yellow 80 resulted in taller plants than Andante at Indian Head and Redvers (Tables 5-6). However, variability was high. Height varied at Redvers as well, but generally increased with nitrogen up to the moderate rates. At the Swift Current, height was only significantly different between nitrogen treatments less than or equal to 60N (Table 4).

Seeding rate had no effect on mustard height (only measured at Indian Head and Swift Current, Tables 7-8), but AAC Yellow 80 (112 cm) was significantly taller than Andante (95cm) at Indian Head.

Lodging

There was no variety or nitrogen effect on lodging at Swift Current, or Redvers (Table 4, Table 6). At Indian Head, AAC Yellow 80 was more prone to lodging (2.1) compared to Andante (1.3) and lodging increased with nitrogen rates from 1.2 to 2.2, on a scale of 1-9 (Table 5).

Seeding rate had no effect on lodging (only measured at Indian Head and Swift Current). However, there was a slight trend at Indian Head for lodging to increase with seed rate and ranged from 1.6 to 2.1 (Table 8).

Days to Maturity

Maturity ratings were largely affected by drought and high temperatures at each site with the plots maturing early (70 to 80 days) compared to the expected 84 days.¹ There was no variety or nitrogen effects on maturity at Swift Current, or Redvers (Table 4, Table 6). At Indian Head, AAC Yellow 80 matured an average of 2 days later than Andante yellow mustard and an application of 120N, or higher delayed maturity by 2 days (Table 5).

Seeding rate did affect days to maturity (only measured at Indian Head and Swift Current). At Swift Current varieties were not significantly different, but increasing seeding rate delayed maturity by 6-7 days (Table 7). This is the opposite of what was expected and is likely due to the hail damage and this becoming a difficult measurement to capture. At Indian Head, Andante was earlier maturing than AAC Yellow 80 by an average of 2 days and the lowest seeding rates caused a 2-day delay in maturity compared to the highest seeding rate (Table 8).

Seed Yield

Yield potential was negatively affected by limited moisture and above average temperatures at all sites. Despite AAC Yellow 80 establishment rates being significantly lower than Andante, average yields of AAC Yellow 80 were statistically higher compared to Andante at Swift Current and Indian Head for both the nitrogen and seed rate trials. This demonstrates the vigorous nature and improved genetics of AAC Yellow 80 composite mustard and its ability to compensate for thin plant stands in order to produce greater yields.

Both Andante and AAC Yellow 80 yields generally increased with nitrogen. At Redvers, where varieties did not yield significantly different from one another, 160N resulted in the highest yielding treatment averaging a yield of 1480 lb/ac, significantly higher than all other nitrogen rates (Table 6). Optimal seeding rate at Redvers varied. For the composite variety, AAC Yellow 80, the highest yielding seeding rate resulted from 194 seeds/m² (1677 lb/ac). The highest yielding Andante mustard treatments resulted from a range of seeding rates from 108-194 seeds/m² (1612-1661 lb/ac). Optimal seeding rate was unclear and more robust data is required to make a conclusion.

Indian Head was the highest yielding site, despite the extreme drought and challenging growing conditions. AAC Yellow 80 was significantly higher yielding compared to Andante and increased with increasing nitrogen (Table 5). Both varieties saw increased yields up to 160N applied, with Andante yielding 1863 lb/ac and AAC Yellow 80 yielding 2015 lb/ac. However, AAC Yellow 80 yield was significantly different than when 140N was applied (2022 lb/ac). Mustard yields at Indian Head decreased as seeding rate increased (Table 8). This is likely a result of increased competition for moisture. This trend was unexpected at Indian Head and is more common at dry sites, such as Swift Current; however, the growing season at Indian Head was unusually dry and it was actually the driest location in 2023. Highest yields resulted from AAC Yellow 80 seeded at 108-150 seeds/m² (1817 lb/ac and 1777 lb/ac).

¹ <https://saskseed.ca/interactive-seed-guide/>

Swift Current was the lowest yielding site in 2023. AAC Yellow 80 was significantly higher yielding compared to Andante and increased with increasing nitrogen (Table 5). Contributing factors to the low yield were differences in soil (low organic matter compared to other sites), low residual soil moisture and precipitation, and the hail storm in July (estimated 20% yield loss). Yields increased with nitrogen up to 160N for each variety. Composite mustard, AAC Yellow 80, highest yields resulted from 120-160N (1200-1225 lb/ac) and Andante mustard highest yields ranged from 100-160N (947-1010 lb/ac). The highest yielding seeding rate at Swift Current for each variety was 108 seeds/m² and decreased with increasing seeding rate, especially from 237-80 seeds/m². AAC Yellow 80 yielded 1033 lb/ac significantly higher than Andante, which yielded 760 lb/ac.

Interim Conclusions

Describe the interim conclusions.

This project is intended to provide novel seeding rate and fertility recommendations on a composite mustard (first in the industry). Therefore, the project will be repeated at the three sites over three years (i.e., two more growing seasons). More robust data is essential to perform meaningful statistical analyses and acceptable recommendations for the optimum seeding rate and nitrogen fertilizer requirements of AAC Yellow 80 composite mustard.

At Swift Current, seed mortality was high, therefore plant establishment was low compared to the other sites. The highest yielding treatments resulted from the lowest seeding rate of 108 seeds/m² for both varieties at this site. However, the hail may have had more of a negative effect on higher seeding rates that may have been more mature at that time, compared to lower seeding rates. Upper nitrogen limits were not clearly defined, but results indicate applying 120N to 160N at Swift Current resulted in the highest yielding treatments for both varieties. Yields were expected to increase with seeding and nitrogen rate. However, with the hot and dry conditions and increased competition for moisture, the low to middle range of seeding rates resulted in the highest yields at both Redvers and Indian Head and upper limits for nitrogen were not always clear. Redvers mustard yields increased up to 160N for both varieties. At Indian Head, mustard yields increased up to 160N, but were not significantly different than 140N.

Knowledge Transfer Activities

List any knowledge transfer activities undertaken in relation to this project. Include presentations, talks, papers published in science journals or other magazines etc.

- Amber Wall, "Walk the Plots" Radio Show with Glenda Lee Allan on CKSW (570) on June 20, 2023 (South West Saskatchewan).
- Chris Holzapfel, IHARF Research Manager and Cory Jacob, Provincial Oilseed Specialist, at the Annual Indian Head Agricultural Research Foundation field day (160 attendees) on July 18, 2023.
- Rick Mitzel, Executive Director of Sask Mustard and Cory Jacob, Provincial Oilseed Extension Specialist at the Annual Wheatland Conservation Area field day (80 attendees) on July 20, 2023.
- Lana Shaw, SERF Research Manager at the Annual South East Research Farm field day (50 attendees) on July 27, 2023.
- The final results from this project will be included in the mustard production manual and will be presented on where possible for future crop research updates such as the Agronomy Research Update and the Sask Mustard AGM in Saskatoon.

Contributions and Support

Identify any changes expected to industry contributions, in-kind support, collaborations or other resources.

Funded by the Government of Canada under the Sustainable Canadian Agricultural Partnership, a federal-provincial-territorial initiative.

- Cory Jacob, Provincial Specialist, Oilseed Crops, Saskatchewan Ministry of Agriculture.
- Shannon Chant, Crops Extension Specialist, Saskatchewan Ministry of Agriculture.

Seed provided in kind by Saskatchewan Mustard Development Commission and Mustard 21.

- Rick Mitzel, Executive Director, Saskatchewan Mustard Development Commission.

Appendices

Identify any changes expected to industry contributions, in-kind support, collaborations or other resources.

No changes.

Table 3. 2023 operations at each location.

Location	Swift Current	Indian Head	Redvers
Year	-----2023-----		
Stubble	Durum	Canary Seed	Barley
Seed Date	15-May	24-May	31-May
Seeded plot size	17.25m ²	22m ²	20m ²
Row Spacing	8.25 inches	12 inches	12 inches
Seed	AC Yellow 80 (5.5 g/1000 seeds, 99% germ), and Andante (6.3 g/1000 seeds, 99% germ)		
Seed rate trial	100N - 62P - 0K - 49S	120N - 36P - 10K - 10S	110N - 20P - 0K - 10S
	Seed rate varied by treatment		
Nitrogen rate trial	62P - 0K - 49S	36P - 10K - 10S	38P - 10K - 15S
	Nitrogen rate varied by treatment. All plots seeded at 237 seeds/m ²		
Plant Density	08-Jun	09-Jun	30-Jun
Herbicide	Centurion/Amigo	Contender II/1% IPCO MSO	Arrow All In
Insecticide	Decis	Decis	-
Fungicide	-	Lance WDG	-
Lodging	21-Aug	10-Aug	-
Height	01-Aug	10-Aug	12-Aug
Desiccation	-	Roundup Weathermax	-
Harvest Dates	24-Aug	16-Aug	01-Sep

Table 4. Individual site means for variety, nitrogen and variety x nitrogen effects at Swift Current (2023). Means within a column followed by the same letter do not significantly differ.

Swift Current 2023												
Variety	emergence		height	days to maturity	lodging		yield					
	plants/m ²	%	(cm)	(days)	(1-9, 9=flat)		(lb/ac)					
AAC Yellow 80	84	b	41	74	a	78	a	1102	a			
Andante	90	a	44	72	a	78	a	1.0	a	870	b	
	5		1	1	1	0	54					
<u>Nitrogen Rate</u>												
Soil N	86	a	42	64	c	79	a	1.0	a	705	d	
60N	89	a	44	71	b	77	a	1.1	a	902	c	
80N	89	a	44	75	a	77	a	1.0	a	973	bc	
100N	91	a	45	75	a	77	a	1.0	a	1024	ab	
120N	89	a	43	76	a	79	a	1.0	a	1084	a	
140N	84	a	41	75	a	79	a	1.0	a	1095	a	
160N	83	a	40	76	a	78	a	1.1	a	1117	a	
	9		2	1	1	0.1	101					
<u>Variety x Nitrogen Rate</u>												
AAC Yellow 80	Soil N	88	de	43	66	h	80	a	1.0	b	822	f
AAC Yellow 80	60N	90	cd	44	72	f	77	c	1.0	b	1035	c
AAC Yellow 80	80N	84	f	41	75	cd	78	bc	1.0	b	1116	b
AAC Yellow 80	100N	84	f	41	76	bc	77	c	1.0	b	1101	b
AAC Yellow 80	120N	92	bc	45	76	bc	78	bc	1.0	b	1200	a
AAC Yellow 80	140N	80	g	39	76	bc	79	ab	1.0	b	1214	a
AAC Yellow 80	160N	74	h	36	79	a	78	bc	1.0	b	1225	a
Andante	Soil N	86	ef	42	62	i	78	bc	1.0	b	589	h
Andante	60N	88	de	43	70	g	77	c	1.0	b	770	g
Andante	80N	95	ab	46	75	cd	77	c	1.0	b	830	f
Andante	100N	98	a	48	74	de	78	bc	1.0	b	947	e
Andante	120N	86	ef	42	76	bc	79	ab	1.0	b	969	e
Andante	140N	88	de	43	74	de	79	ab	1.0	b	975	de
Andante	160N	91	cd	45	74	de	78	bc	1.3	a	1010	cd
	LSD	3		1	1	1	0.1	38				
	CV%	12.6		5.3	2.9	17.5	12.7					

Table 5. Individual site means for variety, nitrogen rate and variety x nitrogen rate effects at Indian Head (2023). Means within a column followed by the same letter do not significantly differ.

Indian Head 2023										
	emergence		height	days to maturity	lodging	yield				
<u>Variety</u>	plants/m ²	%	(cm)	(days)	(1-9, 9=flat)	(lb/ac)				
AAC Yellow 80	171	b	84	112	77	a	1.3	1616	a	
Andante	189	a	92	95	75	b	2.1	1539	b	
	5		13	0	0.1	40				
<u>Nitrogen Rate</u>										
Soil N	181	a	89	83	75	c	1.2	838	e	
60N	182	a	89	98	76	b	1.4	1336	d	
80N	179	a	87	100	76	b	1.4	1489	c	
100N	185	a	90	129	76	b	1.8	1732	b	
120N	178	a	87	103	77	a	1.8	1789	b	
140N	174	a	85	105	77	a	1.9	1922	a	
160N	176	a	86	106	77	a	2.2	1938	a	
	14		25	0	0.3	75				
<u>Variety x Nitrogen Rate</u>										
AAC Yellow 80	Soil N	176	d	86	86	76	c	1.0	784	k
AAC Yellow 80	60N	177	d	87	103	77	b	1.0	1413	h
AAC Yellow 80	80N	174	d	85	106	77	b	1.3	1588	g
AAC Yellow 80	100N	175	d	86	161	77	b	1.4	1715	f
AAC Yellow 80	120N	165	ef	81	108	77	b	1.4	1776	de
AAC Yellow 80	140N	162	f	79	109	78	a	1.5	2022	a
AAC Yellow 80	160N	168	e	82	112	78	a	1.8	2015	a
Andante	Soil N	186	c	91	79	75	d	1.4	891	j
Andante	60N	186	c	91	94	75	d	1.9	1259	i
Andante	80N	184	c	90	94	75	d	1.6	1389	h
Andante	100N	195	a	95	98	76	c	2.3	1749	e
Andante	120N	192	ab	94	99	76	c	2.5	1803	cd
Andante	140N	187	bc	91	101	76	c	2.5	1821	c
Andante	160N	183	c	90	99	76	c	2.6	1862	b
	LSD	5		9	0	0.1	28			
	CV%	9.5		29.5	1.0	24.5	5.9			

Table 6. Individual site means for variety, nitrogen rate and variety x nitrogen rate effects at Redvers (2023). Means within a column followed by the same letter do not significantly differ.

Redvers 2023											
Variety	emergence		height	days to maturity		lodging	yield				
	plants/m ²	%	(cm)	(days)		(1-9, 9=flat)	(lb/ac)				
AAC Yellow 80	128	b	63	127	a	70	a	1.2	1189	a	
Andante	154	a	75	121	b	70	a	1.1	1159	a	
	9		2	0		0.1	56				
<u>Nitrogen Rate</u>											
Soil N	154	a	75	113	d	70	a	1.0	862	f	
60N	143	ab	70	120	c	70	a	1.1	996	e	
80N	138	ab	68	127	ab	70	a	1.1	1098	d	
100N	141	ab	69	125	bc	70	a	1.3	1151	c	
120N	143	ab	70	125	bc	70	a	1.3	1302	b	
140N	139	ab	68	128	ab	71	a	1.3	1332	b	
160N	131	b	64	132	a	71	a	1.4	1480	a	
	16		6	1		0.2	106				
<u>Variety x Nitrogen Rate</u>											
AAC Yellow 80	Soil N	147	c	72	114	g	70	b	1.0	856	g
AAC Yellow 80	60N	125	ef	61	121	ef	70	b	1.3	1071	e
AAC Yellow 80	80N	121	f	59	127	cd	70	b	1.3	1093	e
AAC Yellow 80	100N	110	g	54	129	bc	70	b	1.3	1213	d
AAC Yellow 80	120N	136	d	66	130	b	70	b	1.3	1272	c
AAC Yellow 80	140N	131	de	64	131	b	71	a	1.3	1337	b
AAC Yellow 80	160N	130	de	64	140	a	71	a	1.3	1484	a
Andante	Soil N	161	b	79	111	h	70	b	1.0	868	g
Andante	60N	161	b	79	120	f	70	b	1.0	921	f
Andante	80N	156	b	76	127	cd	70	b	1.0	1102	e
Andante	100N	172	a	84	121	ef	70	b	1.3	1089	e
Andante	120N	149	c	73	120	f	70	b	1.3	1332	b
Andante	140N	147	c	72	126	d	70	b	1.3	1328	b
Andante	160N	131	de	64	123	e	71	a	1.5	1475	a
	LSD	9		2	0		0.1	40			
	CV%	14.1		6.4	1.0		23.3	11.1			

Table 7. Individual site means for variety, seed rate and variety x seed rate effects at Swift Current (2023). Means within a column followed by the same letter do not significantly differ.

Swift Current 2023												
Variety		emergence		height	days to maturity	lodging	yield					
		plants/m ²	%	(cm)	(days)	(1-9, 9=flat)	(lb/ac)					
AAC Yellow 80		70	a	42%	78	a	74	a	1.1	a	910	a
Andante		73	a	44%	77	a	74	a	1.1	a	677	b
		6			3		4		0.1		53	
Seed Rate												
108 seeds/m ²		56	c	61%	78	a	70	b	1.1	a	896	a
150 seeds/m ²		60	c	46%	80	a	70	b	1.0	a	811	b
194 seeds/m ²		71	b	42%	77	a	76	ab	1.1	a	806	bc
237 seeds/m ²		81	ab	40%	78	a	77	a	1.1	a	732	bc
280 seeds/m ²		89	a	37%	75	a	77	a	1.0	a	723	c
		10			5		6		0.2		84	
Variety x Seed Rate												
AAC Yellow 80	108 seeds/m ²	59	e	64%	78	b	70	b	1.0	a	1033	a
AAC Yellow 80	150 seeds/m ²	58	ef	44%	83	a	70	b	1.0	a	908	b
AAC Yellow 80	194 seeds/m ²	65	d	39%	77	b	76	a	1.0	a	923	b
AAC Yellow 80	237 seeds/m ²	82	bc	40%	78	b	77	a	1.0	a	828	c
AAC Yellow 80	280 seeds/m ²	87	ab	36%	75	c	76	a	1.0	a	862	c
Andante	108 seeds/m ²	53	f	57%	77	b	69	b	1.0	a	760	d
Andante	150 seeds/m ²	62	de	47%	77	b	68	b	1.0	a	717	e
Andante	194 seeds/m ²	77	c	46%	77	b	76	a	1.0	a	689	e
Andante	237 seeds/m ²	81	c	40%	78	b	78	a	1.0	a	618	f
Andante	280 seeds/m ²	91	a	38%	75	c	77	a	1.0	a	602	f
LSD		5			2		3		0.1		38	
CV%		16.8			6.9		8.9		22.5		12.5	

Table 8. Individual site means for variety, seed rate and variety x seed rate effects at Indian Head (2023). Means within a column followed by the same letter do not significantly differ.

Indian Head 2023											
Variety		emergence		height	days to maturity		lodging		yield		
		plants/m ²	%	(cm)	(days)		(1-9, 9=flat)		(lb/ac)		
AAC Yellow 80		129	b	77%	113	a	78	a	1.5	1736	a
Andante		146	a	87%	102	b	76	b	2.0	1680	b
.		7			2		0		0.2	62	
Seed Rate											
108 seeds/m ²		89	d	96%	111	a	78	a	1.6	1765	a
150 seeds/m ²		120	c	92%	107	a	77	b	1.6	1734	ab
194 seeds/m ²		142	b	85%	107	a	77	b	1.6	1672	ab
237 seeds/m ²		168	a	82%	107	a	77	b	1.9	1714	ab
280 seeds/m ²		169	a	70%	107	a	76	c	2.1	1654	b
.		11			4		0		0.4	98	
Variety x Seed Rate											
AAC Yellow 80	108 seeds/m ²	83	h	89%	117	a	78	a	1.4	1817	a
AAC Yellow 80	150 seeds/m ²	109	f	84%	110	b	78	a	1.4	1777	ab
AAC Yellow 80	194 seeds/m ²	136	d	82%	112	b	77	b	1.4	1696	de
AAC Yellow 80	237 seeds/m ²	156	b	77%	112	b	77	b	1.8	1743	bc
AAC Yellow 80	280 seeds/m ²	161	b	67%	115	a	77	b	1.8	1648	f
Andante	108 seeds/m ²	96	g	103%	104	c	77	b	1.9	1713	cd
Andante	150 seeds/m ²	130	e	100%	105	c	77	b	1.9	1692	def
Andante	194 seeds/m ²	148	c	89%	101	d	76	c	1.9	1648	f
Andante	237 seeds/m ²	179	a	88%	101	d	76	c	2.1	1685	ef
Andante	280 seeds/m ²	177	a	73%	99	d	76	c	2.4	1660	ef
LSD		5			2		0		0.2	44	
CV%		9.8			4.2		0.5		24.2	6.8	

Table 9. Individual site means for variety, seed rate and variety x seed rate effects at Redvers (2023). Means within a column followed by the same letter do not significantly differ.

Redvers 2023								
Variety	emergence			height	days to maturity	lodging	yield	
	plants/m ²		%	(cm)	(days)	(1-9, 9=flat)	(lb/ac)	
AAC Yellow 80	123	b	74%	-	-	-	1576 a	
Andante	135	a	81%	-	-	-	1594 a	
.	8						92	
Seed Rate								
108 seeds/m ²	83	e	90%	-	-	-	1576 a	
150 seeds/m ²	102	d	78%	-	-	-	1610 a	
194 seeds/m ²	129	c	77%	-	-	-	1644 a	
237 seeds/m ²	158	b	77%	-	-	-	1557 a	
280 seeds/m ²	172	a	71%	-	-	-	1537 a	
	13						146	
Variety x Seed Rate								
AAC Yellow 80	108 seeds/m ²	83	i	90%	-	-	-	1527 c
AAC Yellow 80	150 seeds/m ²	98	h	76%	-	-	-	1558 bc
AAC Yellow 80	194 seeds/m ²	125	f	75%	-	-	-	1677 a
AAC Yellow 80	237 seeds/m ²	148	d	72%	-	-	-	1557 bc
AAC Yellow 80	280 seeds/m ²	161	c	67%	-	-	-	1558 bc
Andante	108 seeds/m ²	83	i	90%	-	-	-	1625 a
Andante	150 seeds/m ²	106	g	81%	-	-	-	1661 a
Andante	194 seeds/m ²	134	e	80%	-	-	-	1612 ab
Andante	237 seeds/m ²	168	b	82%	-	-	-	1557 bc
Andante	280 seeds/m ²	184	a	76%	-	-	-	1516 c
	LSD	6						65
	CV%	11.5						10.9

Table 10. Seed rate conversion from seeds/m2 to lbs/ac. The same seed lot was used at each site.

Variety	AAC Yellow 80	Andante
TKW	5.5 g	6.3 g
Seeds/m2	lb/ac	lb/ac
108	5	6
150	7	9
194	10	11
237	12	13
280	14	16