



## **Wheatland Conservation Area Inc.**

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### **Strategic Field Program (SFP #20190405)**

2021 Progress Report

**Project Title:** Establishing nitrogen and seeding rate recommendations for hybrid brown mustard production in Saskatchewan



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### **Project Identification**

**1. Project Title:** Establishing nitrogen and seeding rate recommendations for hybrid brown mustard production in SK.

**2. Project Number:** SFP #2019045

**3. Contractor Undertaking the Project:** Wheatland Conservation Area Inc.

**4. Project Location:** Swift Current, SK, Indian Head, SK, Redvers, SK.

**5. Project start and end dates (month & year):** April 1, 2020 to December, 2022

**6. Project contact person & contact details:**

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### **Objectives and Rationale**

#### **7. Project Objectives**

- Understand nitrogen requirements of a hybrid mustard compared to Centennial brown and define upper and lower limits of N for hybrid brown mustard.
- Clarify if hybrid *B. juncea* nitrogen requirements are unique from hybrid *B. napus* (argentine canola). High performing canola hybrids require 2.9-3.5 lbs. of available N per bushel of seed yield increase;<sup>1</sup> how does this compare to hybrid *B. juncea*.
- Maximize production by optimizing seeding rates based on seeds per square foot rather than lbs/ac, for both the hybrid and open pollinated brown mustard, due to the difference in seed size and establishment.
- Update recommendations for Saskatchewan mustard producers (available via Sask Mustard's mustard production manual).

#### **8. Project Rationale**

- Current mustard fertility recommendations are based on data generated from the 1970s to early 2000's. Hybrid mustard was not available during this period, and its increased vigor has changed the context. Hybrid seed is typically associated with superior performance such as increased yields. The sooner the performance of this hybrid can be understood, the sooner producers can begin to optimize its production. There is increasing interest in plant protein uses, as well as value-added uses of fractionated mustard seed; thus, increased demand is anticipated in the near future. Maximizing productivity on an area of land will supply this demand while minimizing production inefficiencies detrimental to the environment. Previous ADOPT demonstrations have provided good proof-of-concept, but more robust multi-site, multi-year data is necessary to perform meaningful statistical analyses and acceptable recommendation changes<sup>2</sup>.
- Establishing an optimum seed rate for new varieties is important. The traditional, standard seeding rate for Centennial brown mustard was 6 lbs/ac, however this is based on outdated research that needs to be refined.

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<sup>1</sup> <https://www.canolacouncil.org/canola-watch/2020/12/16/how-much-fertilizer-does-canola-need-2/>

<sup>2</sup> <http://www.wheatlandconservation.ca/research.html>

**Methodology and Results**

**9. Methodology**

- This demonstration was set up at three Agri-ARM sites in potential mustard growing regions of Saskatchewan. Preliminary soil samples were taken to determine residual nutrients (Table 1).
- Helix Vibrance was applied as a pre-seed treatment.
- Part one consisted of 7 nitrogen rates applied to both Centennial brown mustard and hybrid brown mustard and included 4 replicates to better demonstrate consistent fertility effects. Nitrogen fertilizer was added to the amount of residual soil N to achieve the specified rates of total available N.
- To insure other nutrients were none limiting, all treatments at each site received a balanced side banded application of P, K, and S.
- Part two consisted of 5 seeding rates of both Centennial brown mustard and hybrid brown mustard and included 4 replicates to better demonstrate consistent seed rate effects.
- To insure nutrients were none limiting, all treatments at each site received a balanced application of N, P, K, and S, with the exception of the increasing nitrogen treatments in the N rate trial. For this trial, Redvers (2020), residual soil nitrogen was 60N, therefore the 0N treatment, as well as the 60N treatment did not receive any additional fertilizer in order to not surpass overall N for any other treatments. Swift Current (2020) residual was 30N, therefore the 60N treatment only received nitrogen from the applied phosphorus and sulfur products to total 60N, and the rest of the treatments have nitrogen applied as Urea and balanced P, K, S. Residual nitrogen ranged from 6N-30N (lbs/ac) in 2021.
- Data collection was included whether statistically significant, or not and this study will greatly benefit from another year of research (2020-2022).
- Each trial, as well as Hybrid and Centennial varieties were analysed separately on JMP and all data is included regardless of statistical significance.

**Table 1. Operations and dates of each individual location**

Location	Swift Current			Indian Head			Redvers		
	2020	2021	2022	2020	2021	2022	2020	2021	2022
Stubble	Durum	Durum	--	Oat	Canary seed	--	Cereal	Cereal	--
Seed Date	May 15	May 13	--	May 16	May 14	--	May 21	May 17	--
Row Spacing	8.25 inches			12 inches			12 inches		
Seed Rates	SR: 10-26 seeds/ft2, NR: 22seeds/ft2								
Residual N (0-6")	30#N	11#N	--	14#N	6#N	--	60#N	31#N	--
Fertility	SR: Balanced NPKS, NR: Nitrogen range from 0-160 lbs/ac Nitrogen, balanced PKS								
Plant Density	Jun 8	Jun 12	--	Jun 11	Jun 17	--	Jun 2	Jun 17	--
Early Vigor Rating	Jun 8	Jun 12	--	Jun 14	Jun 13	--	missed	Jun 15	--
Herbicide	Muster/Assure II	Centurion/Amigo	--	N/A	Centurion/Amigo	--	Muster/Assure II	Centurion/Amigo	--
Insecticide	Voliam	N/A	--	Matador 120 EC	Malathion	--	N/A	N/A	--
Fungicide	N/A	N/A	--	Lance/Headline 250 EC	N/A	--	N/A	N/A	--
Late Vigor Rating	Jun 22	Jun 22	--	Jun 24	Jul 21	--	Jun 25	Jul 21	--
Height (cm)	Aug 20	Jul 28	--	Jul 13	Jul 8	--	Aug 28	Jul 8	--
Lodging ratings	Jul 23	Aug 13	--	Aug 18	Jul 30	--	Aug 28	Jul 30	--
Days to Maturity	Aug	Aug	--	Aug	Aug	--	Aug	Aug	--
Harvest Dates	Aug 26	Aug 17	--	Aug 28	Aug 13	--	Aug 28	Aug 13	--

**Treatment List**

Part 1: Nitrogen Trial		Total Nitrogen	seeds/ft2
TRT #	Variety		

1	Hybrid Brown	30	22
2	Hybrid Brown	60	22
3	Hybrid Brown	80	22
4	Hybrid Brown	100	22
5	Hybrid Brown	120	22
6	Hybrid Brown	140	22
7	Hybrid Brown	160	22
8	Centennial Brown	0	22
9	Centennial Brown	60	22
10	Centennial Brown	80	22
11	Centennial Brown	100	22
12	Centennial Brown	120	22
13	Centennial Brown	140	22
14	Centennial Brown	160	22

Part 2: Seed Rate Trial		Total Nitrogen	seeds/ft2
TRT #	Variety		
1	Hybrid Brown	90	10
2	Hybrid Brown	90	14
3	Hybrid Brown	90	18
4	Hybrid Brown	90	22
5	Hybrid Brown	90	24
6	Centennial Brown	90	10
7	Centennial Brown	90	14
8	Centennial Brown	90	18
9	Centennial Brown	90	22
10	Centennial Brown	90	24

#### Data Collection:

- **Soil Sample:** determine stored soil nitrogen
- **Crop Establishment:** plants/ft<sup>2</sup>
- **Lodging:** 1-9 scale where 1 is upright and 9 is flat
- **Crop Height:** cm
- **Yield:** kg/ha

#### Field Results

##### 10. General Site Conditions (Table 2)

Table 2. Mean monthly temperatures and precipitation and long-term (10-year) averages for the 2020/2021 growing seasons at Saskatchewan trial locations.

Location	Year	May	June	July	August	Avg. / Total
-----Mean Temperature (°C)-----						
Swift Current	2020	10.9	16.6	18.2	19.5	16.3
	2021	9.5	18.4	21.7	18	16.9
	<b>Long-term</b>	<b>10.9</b>	<b>15.3</b>	<b>18.2</b>	<b>17.6</b>	<b>15.5</b>
Redvers	2020	10.5	16.8	19.2	18.5	16.2
	2021	10.0	18.7	20.8	17.5	16.8
	<b>Long-term</b>	<b>12.0</b>	<b>16.0</b>	<b>19.0</b>	<b>18.0</b>	<b>16.3</b>
Indian Head	2020	10.7	15.6	18.4	17.9	15.7
	2021	9.0	17.7	20.3	17.1	16.0

	<b>Long-term</b>	<b>10.8</b>	<b>15.8</b>	<b>18.2</b>	<b>17.4</b>	<b>15.6</b>
----- <i>Precipitation (mm)</i> -----						
Swift Current	2020	36.3	80	62.5	6.5	185
	2021	35	29.6	38.9	55.8	159
	<b>Long-term</b>	<b>51.2</b>	<b>77.1</b>	<b>60.1</b>	<b>47.4</b>	<b>236</b>
Redvers	2020	22.9	59.7	47.8	36.1	166
	2021	42.2	107.3	58	57	265
	<b>Long-term</b>	<b>60.0</b>	<b>91.0</b>	<b>78.0</b>	<b>64.0</b>	<b>293</b>
Indian Head	2020	27.3	23.5	37.7	24.9	113
	2021	81.6	62.9	51.2	99.4	295
	<b>Long-term</b>	<b>51.0</b>	<b>77.4</b>	<b>63.8</b>	<b>51.2</b>	<b>243</b>

According to the Saskatchewan Crop Report, most regions in Saskatchewan went into spring seeding with below adequate moisture levels in 2021.<sup>3</sup> All sites received scattered rain showers throughout seeding followed by cool conditions, therefore emergence was delayed and soil moisture diminished very quickly. Swift Current and Redvers in particular received very little precipitation at seeding and resulted in poor emergence, but timely rainfall throughout May and June at Indian Head resulted in good emergence and a drastic improvement in plant population compared to 2020.

Crop development was behind normal at Swift Current when limited to no rainfall, wind and warm temperatures really began to slow growth. By the middle of June, soil conditions at Swift Current had completely deteriorated, far worse than 2020. Swift Current also experienced higher than average temperatures, dry and windy weather for the remainder of June causing crops to rapidly advance, resulting in accelerated maturity and below average yields. Meanwhile, Redvers received heavy rainfall events throughout June and continued to develop normally to slightly behind normal. Soil moisture at Indian Head was adequate and crops remained in good condition, but also experienced wind and above average temperatures.

Into the first week of July, mustard plots at Swift Current experienced irreparable damage. Crops at Redvers and Indian Head began to advance quickly in the heat, as soil moisture began to deteriorate. At this time last year, crops remained in relatively normal stages of development, but were also affected by heat and drought in most locations. 2021 brought an earlier than normal harvest and the plots were harvested by mid-August at each location.

## 11. Part 1: Nitrogen Rate Trial

Nitrogen (N) rates for this trial were chosen to be on the lower and upper extreme of what might be required to reach optimum yields. If the current recommendation for hybrid canola (3.5 lbs. N/bu of seed yield) applies to mustard, having a high amount of available N (160lbs/ac) would target a top yield of about 45 bu/ac and the low end of available N (60 lbs/ac) would target 17 bu/ac.<sup>4</sup> The control treatment for each variety is soil residual N only and all sites were seeded at 22 seeds/ft<sup>2</sup>. Nitrogen was applied in the form of Urea and all treatments were balanced in P, K and S. In the case of Redvers (2020), residual soil nitrogen was at least 60 lbs. of N, therefore the 0N treatment, as well as the 60N treatment did not receive any urea. Swift Current (2020) residual N was 30N, therefore the 60N treatment only received nitrogen from the applied phosphorus and sulfur forms; the rest of the treatments have nitrogen applied as Urea and balanced P, K, S. Residual nitrogen ranged from 6N-30N (lbs/ac) in 2021.

<sup>3</sup> <https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/market-and-trade-statistics/crops-statistics/crop-report/previous-crop-reports>

<sup>4</sup> <https://www.canolacouncil.org/canola-watch/2020/12/16/how-much-fertilizer-does-canola-need-2/>

### Plant Density (plants/ft<sup>2</sup>, Table 3)

When averaged over 6-site years, Centennial mustard had higher plant establishment than the hybrid. AAC Brown 18 averaged 10.2 plants/ft<sup>2</sup> (46% emergence) and Centennial brown averaged 12.3 plants/ft<sup>2</sup> (56% emergence). Emergence had a negative relationship with increasing nitrogen rate, and the lowest plant stands resulted from 160N.

At Swift Current, Centennial brown mustard resulted in higher plant densities than hybrid brown in 2020, but not in 2021. Hybrid brown mustard emergence remained fairly consistent both years, but in 2021 the Centennial brown resulted in a much lower density compared to 2020, likely due to a lack of soil moisture reserve and precipitation early in the growing season. Plant density tended to decrease with increased nitrogen for both varieties and emergence was limited by precipitation in both years. However, as in previous research, plant density does not necessarily equate to yield on a drought year. Indian Head having received higher precipitation in 2021, similar to an average year, resulted in higher emergence compared to 2020. Centennial brown had higher emergence than the hybrid both years. Centennial emergence tended to max out at 100N before levelling off, while hybrid plant stand increased to 120N before showing a slight decrease. At Redvers having received adequate precipitation in 2021, plant emergence was up compared to 2020. In year one hybrid plant stands were much lower than Centennial, but this was the reverse in 2021. However, there was not a lot of variation between treatments and both varieties resulted in a low plant density when applying 160N.

**Table 3. Hybrid Brown and Centennial Brown mustard plant establishment at increasing nitrogen rates in Swift Current, Indian Head and Redvers (plants/ft<sup>2</sup>, 2020-2021).**

Location		Swift Current		Indian Head		Redvers		6-site years
Year		2020	2021	2020	2021	2020	2021	
-----Plant Density (plants/ft <sup>2</sup> )-----								
<b><u>Treatment</u></b>								
LSD		0.8	0.5	0.5	0.7	0.7	0.9	0.5
Grand Mean		6.7	6.8	7.7	15.7	7.7	16.7	10.2
CV		0.3	16.1	13.9	9	18.2	11.8	25.6
Hybrid (AAC Brown 18)	0N	8.0	8.1	7.9	14.6	7.5	17.1	10.5a
	60N	7.5	7.1	7.6	15.8	8.5	16.7	10.5a
	80N	7.8	7.0	7.7	15.5	6.5	16.4	10.1a
	100N	7.8	6.0	7.9	15.6	8.9	16.2	10.4a
	120N	5.5	7.0	8.8	16.4	7.5	16.6	10.2a
	140N	5.8	6.9	7.0	16.3	8.0	17.8	10.4a
	160N	4.8	5.3	7.3	15.9	7.1	15.8	9.3b
LSD		1.6	0.6	0.7	0.8	0.7	0.5	0.5
Grand Mean		8.2	5.0	13.6	17.5	13.9	14.8	12.3
CV		40	26	15.6	9.8	11.2	6.6	22
OP Brown (Centennial)	0N	13.5	5.5	14.9	15.8	14.4	14.4	13.0a
	60N	11.5	5.0	14.9	16.2	13.9	15.1	12.8a
	80N	9.5	5.4	14.4	18.4	14.2	14.6	12.6a
	100N	9.0	5.1	14.9	18.3	13.4	16.3	12.9a
	120N	7.8	5.4	12.7	17.5	12.8	14.3	11.8b
	140N	6.0	4.8	12.5	16.1	14.4	14.3	11.6b
	160N	5.3	4.6	12.3	18.6	14.4	14.0	11.5b

### Mustard Yield (Fig.1, Table 4)

In 2020, yield results from the nitrogen trial were above the provincial average (923 kg/ha), but yields in 2021 were significantly lower and varied by region due to growing season conditions. When averaged over 6-site years in this trial, hybrid mustard yield increased with nitrogen up to 160N (1602 kg/ha), while Centennial mustard yield increased up to 140N (1402.3 kg/ha) before levelling off, as illustrated in figure 1.

According to the SMDC Mustard Production Manual, recommended rates of N are 50 to 80 lbs/acre of actual N (applied) where N is deficient, but increasing N levels does not always lead to further increased yields and the highest response to added N occurs when moisture is not limiting. In dry years, N rates near the low range of the recommendation will be adequate since realistic target yields will be lower than when moisture is not a limiting factor.<sup>5</sup> These results show that mustard does respond to increased nitrogen rates, but yields are limited by soil moisture and a third year of data will help to make any recommendations.

Mustard yields did vary by year and site. Generally, in Swift Current hybrid brown yields increased with nitrogen up to 120N before leveling off and Centennial brown yield increased up to 140N before leveling off. At Indian Head the hybrid brown mustard yield increased up to 140N before leveling off, while Centennial brown yield increased up to 160N. At Redvers hybrid mustard yield increased up to 160N, and Centennial brown up to 140N before leveling off.

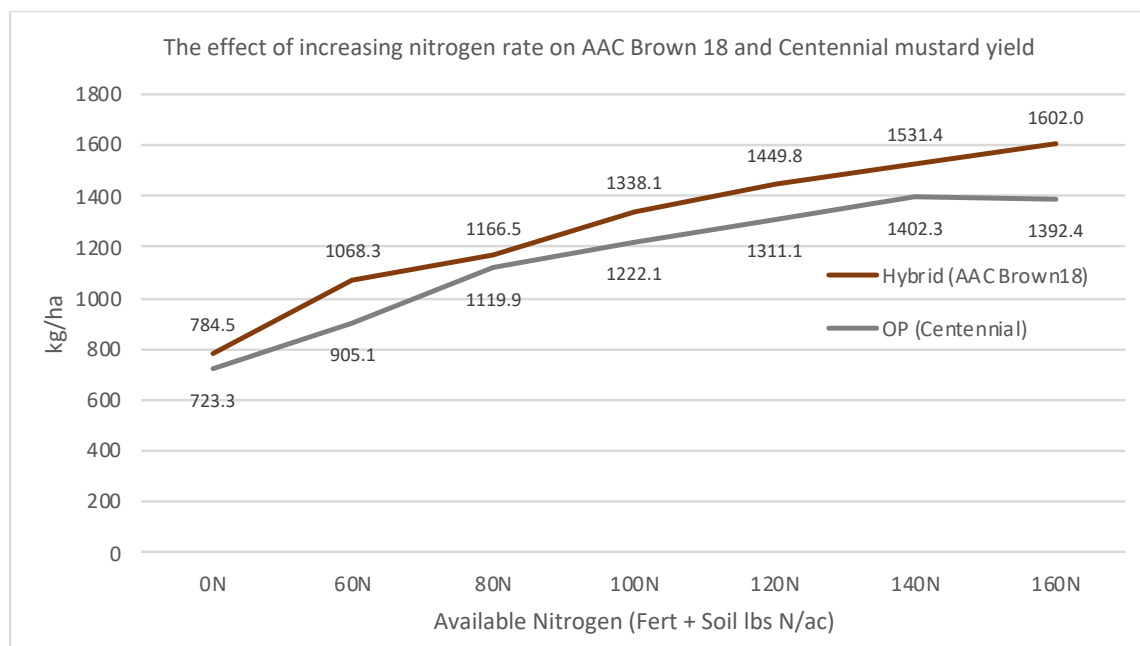


Figure 1. Overall 6-site year average of hybrid brown and Centennial brown mustard yields at increasing nitrogen rates (Swift Current, Indian Head, Redvers, 2020-2021).

Table 4. Hybrid Brown and Centennial Brown mustard yield at increasing nitrogen rates in Swift Current, Indian Head and Redvers (kg/ha, 2020-2021).

Location	Swift Current		Indian Head		Redvers		6-site years	
	2020	2021	2020	2021	2020	2021		
-----Yield (kg/ha)-----								
<b>Treatment</b>								
LSD	113.7	18	56.4	26.8	59.2	62.6	31.2	
Grand Mean	1500.7	486.0	2183.3	1329.9	1431.8	759.4	1277.2	
CV	16.7	7.9	5.6	4.3	8.9	17.8	13.7	
Hybrid (AAC Brown 18)	ON	1000	407	1241	512	1067	479.5	784.5g
	60N	1579	407	1673	942	1160	649.1	1068.3f
	80N	1315	445	1965	1210	1342	722.2	1166.5e
	100N	1605	451	2265	1427	1401	880.1	1338.1d
	120N	1807	563	2535	1584	1593	827.5	1449.8c
	140N	1567	514	2812	1792	1541	947.4	1531.4b
	160N	1633	616	2793	1843	1918	809.9	1602a
LSD	104.3	22.1	45.9	26.5	52.5	49.1	26.4	

<sup>5</sup> <https://saskmustard.com/production-manual/fertility/nitrogen/index.html>

<b>Grand Mean</b>		1296.2	642.3	1972.5	1313.6	1335.5	792.9	1153.8
<b>CV</b>		17.9	7.8	5.4	4.8	8.8	14.2	12.7
<b>OP Brown (Centennial)</b>	<b>0N</b>	717	429	1059	408	953	502.9	723.3f
	<b>60N</b>	1019	625	1380	805	976	625.7	905.1e
	<b>80N</b>	1225	733	1807	1094	1180	681.3	1119.9d
	<b>100N</b>	1276	636	2033	1290	1313	783.6	1222.1c
	<b>120N</b>	1415	608	2066	1466	1452	859.6	1311.1b
	<b>140N</b>	1493	639	2208	1584	1580	909.4	1402.3a
	<b>160N</b>	1350	613	2341	1642	1511	897.7	1392.4a

In terms of other data collected, when all locations were averaged together, hybrid mustard was generally taller than Centennial, and the height of both varieties increased with nitrogen rate, but did not result in much variation between treatments for N rates exceeding 60N (Table 5). Lodging increased linearly with nitrogen, but was overall low and not statistically significant (Table 6). Days to maturity also increased with applied nitrogen, but only varied by 2 days (Table 7). In 2021, variation between treatments was small due to limited moisture and above average temperatures that naturally dried out plants making this a difficult visual rating at most sites, but generally Centennial matured 1-2 days later.

**Table 5. Hybrid Brown and Centennial Brown mustard height at increasing nitrogen rates in Swift Current, Indian Head and Redvers (cm, 2020-2021).**

Location		Swift Current		Indian Head		Redvers		6-site years
Year		2020	2021	2020	2021	2020	2021	
-----Plant Height (cm)-----								
<b>Treatment</b>								
<b>LSD</b>		3.9	3.4	1.7	2.4	2.8	2.8	2.2
<b>Grand Mean</b>		118.2	74.2	115.9	111.1	123.3	108.9	108.5
<b>CV</b>		7.1	9.7	3.1	4.6	4.9	5.6	11.3
<b>Hybrid (AAC Brown 18)</b>	<b>0N</b>	105	61	114	91	118	100	97.5d
	<b>60N</b>	124	75	116	109	126	113	110.5cd
	<b>80N</b>	123	75	114	113	127	110	110.4c
	<b>100N</b>	124	72	116	116	128	111	111.1cd
	<b>120N</b>	118	76	116	116	125	112	110.3b
	<b>140N</b>	118	74	117	118	117	115	109.9b
	<b>160N</b>	115	86	118	115	123	102	109.7a
<b>LSD</b>		3.3	4.4	1.3	2	2.9	2.1	3.4
<b>Grand Mean</b>		117.2	84.9	107.3	106.4	116.4	106.6	105.7
<b>CV</b>		6.2	11.4	2.6	4.1	4.7	4.4	18
<b>OP Brown (Centennial)</b>	<b>0N</b>	103	71	99	81	111	92	101.4b
	<b>60N</b>	119	85	105	100	117	102	104.7ab
	<b>80N</b>	120	89	108	105	117	109	107.8a
	<b>100N</b>	114	84	105	108	116	107	105.6a
	<b>120N</b>	122	83	108	107	116	108	107.5a
	<b>140N</b>	114	84	108	109	118	107	106.6a
	<b>160N</b>	115	84	110	108	115	108	106.6a

**Table 6. Hybrid Brown and Centennial Brown mustard Lodging (1-9) at increasing nitrogen rates in Swift Current, Indian Head and Redvers (1=erect, 9=flat, 2020-2021).**

Location		Swift Current		Indian Head		Redvers		6-site years
Year		2020	2021	2020	2021	2020	2021	
-----Lodging-----								
<b>Treatment</b>								
<b>LSD</b>		1.2	0.3	0.2	0.2	0.2	0.5	0.2
<b>Grand Mean</b>		2.8	2.3	3.0	4.5	2.4	2.8	3.0
<b>CV</b>		29	26.3	12.6	10.9	17.4	38	32.2
<b>Hybrid (AAC Brown 18)</b>	<b>0N</b>	2.5	4.0	1.63	2.0	1.50	1.8	2.3e
	<b>60N</b>	2.5	1.5	2.25	2.5	1.88	2.1	2.2e
	<b>80N</b>	2.8	2.0	2.88	3.1	2.25	2.6	2.6d
	<b>100N</b>	3.3	1.8	3.00	4.5	2.50	3.3	3.0c



	<b>120N</b>	3.3	1.9	3.38	5.4	2.88	2.9	3.3b
	<b>140N</b>	2.3	2.2	3.50	6.8	2.88	3.4	3.5b
	<b>160N</b>	3.3	3.0	4.25	7.0	3.13	3.3	4.0a
<b>LSD</b>		0.5	0.3	0.3	0.2	0.2	0.4	0.2
<b>Grand Mean</b>		3.3	2.3	3.9	4.4	2.5	2.4	2.9
<b>CV</b>		33	31.9	15.5	13.4	17.6	36.3	29.1
<b>OP Brown (Centennial)</b>	<b>0N</b>	3.0	2.8	1.63	1.5	1.88	1.0	1.9f
	<b>60N</b>	3.5	2.0	2.75	2.1	2.00	1.3	2.2e
	<b>80N</b>	3.5	3.0	3.25	3.1	1.75	1.4	2.7d
	<b>100N</b>	3.5	2.3	3.88	4.6	2.25	2.4	3.1c
	<b>120N</b>	3.5	2.0	4.13	4.4	2.63	2.6	3.2c
	<b>140N</b>	2.8	2.0	4.25	5.9	2.88	3.3	3.5b
	<b>160N</b>	3.3	2.3	5.00	6.3	3.38	3.4	3.9a

**Table 7. Hybrid Brown and Centennial Brown mustard days to maturity at increasing nitrogen rates in Swift Current, Indian Head and Redvers (Days, 2020-2021).**

Location		Swift Current		Indian Head		Redvers		6-site years
Year		2020	2021	2020	2021	2020	2021	
-----Days to Maturity-----								
<b><i>Treatment</i></b>								
<b>LSD</b>		0.6	0.3	0.3	0.3	0.3	0.8	0.5
<b>Grand Mean</b>		82.8	88.2	82.8	77.8	77.3	72.6	80.2
<b>CV</b>		1.5	0.7	0.7	0.7	1.3	2.3	3.6
<b>Hybrid (AAC Brown 18)</b>	<b>0N</b>	82	89	80	78	77	70	79.2d
	<b>60N</b>	83	88	82	76	78	72	79.7cd
	<b>80N</b>	83	88	82	77	77	73	79.8c
	<b>100N</b>	82	88	83	77	77	72	79.7cd
	<b>120N</b>	83	88	84	79	78	73	80.7b
	<b>140N</b>	83	88	85	79	77	75	80.9b
	<b>160N</b>	85	88	85	80	79	74	81.6a
<b>LSD</b>		0.6	0.2	0.2	0.2	0.7	0.7	0.4
<b>Grand Mean</b>		83.8	88.3	83.8	79.7	78.3	76.5	81.5
<b>CV</b>		1.7	0.6	0.5	0.4	0.3	2.1	2.9
<b>OP Brown (Centennial)</b>	<b>0N</b>	83	89	81	79	77	75	80.4c
	<b>60N</b>	83	89	81	79	78	75	80.6c
	<b>80N</b>	83	89	83	79	78	78	81.4b
	<b>100N</b>	84	88	84	79	78	76	81.4b
	<b>120N</b>	83	89	84	80	78	77	81.8b
	<b>140N</b>	85	88	85	81	79	77	82.3a
	<b>160N</b>	86	89	86	81	79	77	82.9a

## 12. Part 2: Seed Rate Trial

Mustard seeding rate treatments were based on a target plant population of 7-11 plants/ft<sup>2</sup> (75-118 plants/m<sup>2</sup>). Using the thousand kernel weight (TKW), germination and estimating 50% seed emergence, rates calculated also account for survival in order to achieve a range above and below the current recommended plant stand density. When averaged over 6-site years, plant establishment for the seed rate trial ranged from 5.4 to 13.2 plants/ft<sup>2</sup> (Table 8).

### Plant Density (plants/ft<sup>2</sup>, Table 8)

When averaged by variety over 6-site years, Centennial mustard generally had greater establishment (9.9 plants/ft<sup>2</sup>) compared to the hybrid (8.2 plants/ft<sup>2</sup>). Although plant density increased with seeding rate for both the hybrid and Centennial brown, percent survival decreased as seeding rate increased, meaning the lower seeding rates had a higher percentage of surviving plants. This can be explained by the below average precipitation early in the growing season at most sites in addition to increased competition amongst seedlings at the higher rates. The highest plant density resulted when Centennial mustard was seeded at 26

seeds/ft<sup>2</sup> (13.2 plants/ft<sup>2</sup>), but the highest hybrid mustard density resulted when seeded 22-26 seeds/ft<sup>2</sup> (10-10.7 plants/ft<sup>2</sup>). Plant establishment for the hybrid mustard was below the target window for multiple site years and demonstrated the negative effects of the extreme dry soil moisture conditions. However, as shown in previous research, plant density does not necessarily equate to yield.

At Swift Current, Centennial brown mustard resulted in higher plant densities than the hybrid in 2020, but not 2021, which was similar to the N rate trial. Overall emergence was extremely low in 2021 due to a lack of soil moisture reserve and precipitation, but plant density did increase with increased seeding rate, similarly to 2020. Indian head having received much more precipitation in 2021; close to the long-term average, resulted in higher emergence compared to 2020. Centennial brown had much higher emergence than the hybrid in 2020, but there was little variation between varieties in 2021. Centennial mustard emergence continued to increase until 26 seeds/ft<sup>2</sup>, while hybrid mustard density tended to increase up to 22 seeds/ft<sup>2</sup> before leveling off. At Redvers, having received adequate precipitation in 2021 plant emergence was higher for the hybrid brown, but lower for Centennial compared to 2020. Both varieties tended to level off in plant stand at 22 seeds/ft<sup>2</sup>.

**Table 8. Hybrid Brown and Centennial Brown mustard plant density at increasing seeding rates in Swift Current, Indian Head and Redvers (plants/ft<sup>2</sup>, 2020-2021).**

Location		Swift Current		Indian Head		Redvers		6-site years
Year		2020	2021	2020	2021	2020	2021	
-----Plant Density (plants/ft <sup>2</sup> )-----								
<b><i>Treatment</i></b>								
LSD		0.5	0.6	0.3	1.1	1.7	0.8	0.8
Grand Mean		7.1	4.9	6.5	14.7	7.1	8.9	8.2
CV		12.2	20.1	8.8	13.5	17.7	15.1	41.5
Hybrid (AAC Brown 18)	10	5.1	3.2	4.0	9.9	3.7	6.4	5.4d
	14	6.5	3.9	4.4	13.0	5.0	7.6	6.7c
	18	6.1	5.5	7.0	14.0	7.1	8.9	8.1b
	22	9.0	5.4	7.2	18.0	9.8	10.4	10.0a
	26	8.9	6.6	9.7	18.7	9.6	11.0	10.7a
LSD		0.5	0.6	0.8	0.9	1.1	0.7	0.6
Grand Mean		9.0	4.1	10.7	14.5	12.9	8.8	9.9
CV		10.6	27	14	11.2	14.7	14.1	28.3
OP Brown (Centennial)	10	5.3	2.3	6.5	10.2	9.0	5.8	6.5d
	14	6.8	3.7	8.9	12.9	11.6	7.1	8.5c
	18	8.7	3.7	8.2	13.9	12.2	9.1	9.0c
	22	12.2	5.3	14.6	15.7	14.5	11.0	12.1b
	26	11.9	5.6	15.1	19.5	17.3	10.7	13.2a

### Mustard Yield (Table 9)

When yield was averaged over all seeding rates per variety, although establishment rates with the hybrid were much lower, average yields were higher (1260 kg/ha) compared to Centennial (1065.4 kg/ha). Hybrid mustard yields were higher than Centennial 5 of 6 site years, even though establishment rates for the hybrid brown were much lower. This demonstrates the vigorous elasticity of the hybrid and its ability to branch out and compensate for thin plant stands to produce yield once moisture conditions improve. Despite poor establishment of the hybrid brown mustard, growing season rains likely promoted branching, flowering and pod development producing higher yields than Centennial brown mustard at each seeding rate treatment. The hybrid brown was shown to result in the highest yields when seeded around 10-18 seeds/ft<sup>2</sup>, whereas the Centennial yielded best when seeded at a higher rate of about 14-22 seeds/ft<sup>2</sup>. More site data with non-limiting moisture will allow for a more confident recommendation.

Mustard yields did vary by year and site. Generally, in Swift Current hybrid and Centennial brown yields increased with seeding rate, but the hybrid was able to yield higher at lower seeding rates compared to higher on drought years. At Indian Head, hybrid brown yields tend to increase up to 18 seeds/ft<sup>2</sup> and Centennial brown yields up to 22 seeds/ft<sup>2</sup>, but a lot of variation existed and similarly to Swift Current, lower plant populations seem to out-perform higher populations when moisture is limited. Redvers resulted in little variation between treatments with the highest hybrid yields resulting from 14-18 seeds/ft<sup>2</sup> and a slight downward trend for the effect of increasing seeding rate. Centennial brown mustard followed a similar trend with highest yields resulting from 14-22 seeds/ft<sup>2</sup>. Each variety seeded at 26 seeds/ft<sup>2</sup> resulted in the lowest yields each year at Redvers. Although there was not a lot of variation between treatments, yield was limited by moisture.

**Table 9. Hybrid Brown and Centennial Brown mustard yield at increasing seeding rates in Swift Current, Indian Head and Redvers (kg/ha, 2020-2021).**

Location	Swift Current		Indian Head		Redvers		6-site years	
Year	2020	2021	2020	2021	2020	2021		
-----Yield (kg/ha)-----								
<b><i>Treatment</i></b>								
LSD	54.3	32.8	53.4	27.4	205.9	58.3	67.8	
Grand Mean	1021.1	544.9	2658.1	1695.2	1148.8	959.9	1260.0	
CV	9.7	10.2	3.7	3	32.6	10.8	24.9	
Hybrid (AAC Brown 18)	10	1047	606	2543	1750	1185	961	1259.9ab
	14	899	542	2602	1723	1185	951	1246.1b
	18	987	535	2912	1694	1224	1009	1315.9a
	22	1081	489	2525	1672	1101	977	1236b
	26	1092	553	2709	1636	1050	902	1243.6b
LSD	77.2	47.4	90.5	24.1	76.3	34.3	41.3	
Grand Mean	788.8	650.7	2390.6	1534.3	926.4	702.5	1065.4	
CV	17.7	12.9	6.9	2.8	14.6	8.6	18.1	
OP Brown (Centennial)	10	727	574	2328	1576	948	647	1049.5b
	14	731	600	2451	1534	1025	721	1093a
	18	819	645	2376	1531	875	702	1035.5b
	22	793	675	2411	1547	956	760	1091.3a
	26	875	759	2387	1483	827	682	1057.8ab

In terms of other data collected, when all locations were averaged together, hybrid mustard was generally taller than Centennial, and both varieties tend to be shorter at higher seeding rates, but not a lot of variation exists between treatments (Table 10). Lodging increased linearly with seeding rate for both varieties, but was overall low (Table 11). When lodging was averaged across treatments the hybrid (3.0 lodging) and Centennial (2.9 lodging) were similar and not statistically significant. Days to maturity decreased with higher seeding rates for both varieties (Table 12). Variation between treatments was generally small due to limited moisture and above average temperatures drying out plants making this a difficult visual rating at most sites, but Centennial mustard generally matured 1-2 days later.

**Table 10. Hybrid Brown and Centennial Brown mustard height at increasing seeding rates in Swift Current, Indian Head and Redvers (cm, 2020-2021).**

Location	Swift Current		Indian Head		Redvers		6-site years	
Year	2020	2021	2020	2021	2020	2021		
-----Height (cm)-----								
<b><i>Treatment</i></b>								
LSD	1.9	12.9	2.9	1.8	3.3	3	3.8	
Grand Mean	121.9	76.0	113.9	120.8	114.3	110.4	109.5	
CV	2.9	8	4.6	2.7	5.2	4	16.3	
Hybrid (AAC Brown 18)	10	122	74	114	125	118	114	111.1

	14	118	78	110	124	114	114	109.6
	18	123	76	112	122	112	111	109.1
	22	125	75	117	119	116	109	110.1
	26	121	77	116	115	112	104	107.8
LSD		2.9	6.5	3.6	2.1	3.1	2.9	2.8
Grand Mean		119.1	79.2	105.3	109.0	105.7	101.2	103.2
CV		4.4	14.8	6.2	3.4	5.2	5.1	12.5
OP Brown (Centennial)	10	125	80	109	109	106	101	105.1
	14	122	81	107	111	105	102	104.7
	18	114	87	105	109	106	102	103.8
	22	117	68	99	110	107	102	100.4
	26	117	80	107	106	104	99	102.1

Table 11. Hybrid Brown and Centennial Brown mustard lodging at increasing seeding rates in Swift Current, Indian Head and Redvers (1=erect, 9=flat, 2020-2021).

Location		Swift Current		Indian Head		Redvers		6-site years
Year		2020	2021	2020	2021	2020	2021	
-----Lodging (1-9)-----								
<b><i>Treatment</i></b>								
LSD		0.3	0.6	8.9	0.3	0.4	0.4	0.2
Grand Mean		2.1	3.1	3.4	5.0	1.9	2.9	3.0
CV		27.7	32.8	0.2	9.1	34.4	24.3	34
Hybrid (AAC Brown 18)	10	2.3	3.3	3.1	3.3	1.5	2.6	2.7c
	14	1.8	4.0	3.4	4.3	2.3	3.1	3.1ab
	18	1.5	3.0	3.3	5.5	1.5	2.4	2.9bc
	22	2.5	3.3	3.1	5.5	2.1	3.5	3.3a
	26	2.5	2.0	4.0	6.5	2.0	3.0	3.3a
LSD		0.3	0.6	0.4	0.2	0.4	0.3	0.2
Grand Mean		2.3	2.3	4.1	4.6	2.3	1.8	2.9
CV		26.5	46.1	18.8	6.1	29.7	34	29
OP Brown (Centennial)	10	2.5	1.4	3.8	3.3	1.5	1.6	2.4c
	14	2.5	2.8	3.6	3.9	2.3	1.3	2.6c
	18	2.5	2.5	4.0	4.8	2.0	1.8	2.9c
	22	1.8	2.5	4.6	5.1	2.5	2.4	3.1ab
	26	2.0	2.2	4.5	5.9	3.0	2.1	3.3a

Table 12. Hybrid Brown and Centennial Brown mustard days to maturity at increasing seeding rates in Swift Current, Indian Head and Redvers (Days, 2020-2021).

Location		Swift Current		Indian Head		Redvers		6-site years
Year		2020	2021	2020	2021	2020	2021	
-----Days to Maturity-----								
<b><i>Treatment</i></b>								
LSD		0.4	0.3	0.3	0.3	0.4	0.5	1
Grand Mean		82.1	88.5	85.4	77.9	73.1	79.0	81.0
CV		0.9	0.7	0.6	0.6	1.1	1.1	5.8
Hybrid (AAC Brown 18)	10	83	89.0	86	79	74	79	81.7a
	14	82	88.3	86	79	74	80	81.4ab
	18	81	88.3	85	78	72	79	80.6bc
	22	82	88.8	85	78	74	79	80.9abc
	26	82	88.0	85	77	72	78	80.2c
LSD		0.3	0.3	0.3	0.2	0.4	0.3	0.7
Grand Mean		82.7	88.5	86.1	80.5	73.5	80.4	81.9
CV		0.7	0.6	0.5	0.4	0.9	0.8	3.8
OP Brown (Centennial)	10	83	88.5	87	81	74	81	82.4a
	14	83	88.8	86	81	74	81	82.1ab
	18	82	88.0	86	81	74	80	81.8ab
	22	83	88.5	86	80	73	80	81.7ab
	26	83	88.5	85	80	73	80	81.5b

## **Conclusions and Recommendations**

### **13. Conclusions**

After two years of this study and multiple drought years, more robust data is essential to perform meaningful statistical analyses and acceptable recommendations for the optimum seeding rate and nitrogen fertilizer requirements of hybrid brown mustard. Crop establishment rates were often below the target plant stand of 7-11 plants/ft<sup>2</sup> and resulted in a wide range of results. Emergence rates for mustard generally range from 50-80% when soil moisture is not limiting. With the below average moisture received for 5-site years, we saw emergence rates range from 41% to 54% for hybrid brown mustard and 50% to 60% for Centennial brown mustard. Similar to previous research, the vigorous nature of the hybrids appeared to better utilize higher rates of nitrogen to promote branching, pod development, and higher yields, as hybrid plant stands were thin compared to the Centennial brown mustard<sup>6</sup>. Even with the low emergence rates and available nitrogen dependent on precipitation, preliminary results reveal the highest yielding hybrid to result from 160N (1602 kg/ha) and the highest yielding Centennial treatment to result from 140N (1402.3 kg/ha) with no significantly different increase with nitrogen available up to 160N. The hybrid brown also appears to result in the highest yields when seeded around 10-18 seeds/ft<sup>2</sup>, whereas the Centennial yielded best when seeded 14-22 seeds/ft<sup>2</sup>. After two of three years, this trial does demonstrate the vigor and the impressive elasticity bred into the hybrid brown mustard given the negative correlation between plant establishment and yield throughout both the nitrogen and seed rate trials, but given the poor conditions, data is variable.

Many growers in the province are opting out of growing mustard acres as it has not kept up with technological advances driving the competitiveness of other Canadian crops, particularly canola. Double digit increases to yield can keep mustard competitive with domestic crops and global export by remaining a valuable business option as a rotational crop for our mustard growers. Since the first hybrid condiment brown mustard was developed and launched commercially in 2020, going forward it is important for growers to optimize both seed and nitrogen rates to maximize yield potential. In the coming years, further research is required to develop optimal fertilizer rates for other nutrients (i.e., P, K, and S) and will help to further explore the vigor and elasticity of hybrid mustards and their ability to compensate for a reduced plant stand to produce yield. Mustard has not kept up technologically in previous years compared to other Canadian crops due to the huge financial commitment of research and development for such a small acreage crop; therefore, increasing yields and optimizing production for this crop is a main strategic priority for Mustard 21.

This information compliments the research done by Bifang Cheng at AAFC in Saskatoon, as the mustard hybrid technology can outperform the Centennial brown by double digit yield increases to stay competitive with domestic crops and global export over the next decade. AAC Brown 18 is the first Brown Hybrid Mustard commercially available (2020), providing higher yields, greater weed competition and a higher quality of seed in comparison to the Centennial brown check. After breeding superior yield into hybrid seed technology is accomplished, we can begin to select for other lines with key traits like oil content, protein content and resistance to diseases such as blackleg and white rust.

### **13. Acknowledgements**

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<sup>6</sup>[http://www.wheatlandconservation.ca/files/20180445\\_Optimum\\_Seeding\\_Rates\\_for\\_Hybrid\\_Brown\\_Mustard\\_Group.pdf](http://www.wheatlandconservation.ca/files/20180445_Optimum_Seeding_Rates_for_Hybrid_Brown_Mustard_Group.pdf)

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14

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