



Wheatland Conservation Area Inc.

P.O. Box 2015, Swift Current, Saskatchewan. S9H 4M7

Ph. # (306) 773-4775

Strategic Field Program (SFP #20190405)

2022 Final Report

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



Principal Investigators: Bryan Nybo, Wheatland Conservation Area Inc., Chris Holzapfel, Indian Head Agricultural Research Foundation, Lana Shaw, South East Research Farm and Cory Jacob, Saskatchewan Ministry of Agriculture, Shannon Chant, Saskatchewan Ministry of Agriculture, Matthew Bernard, Saskatchewan Ministry of Agriculture

Site Report Prepared by: Amber Wall, Wheatland Conservation Area Inc.

Site Correspondence: wcawall@sasktel.net

1. **Project Title:** SFP #20190405 Establishing nitrogen and seeding rate recommendations for hybrid brown mustard production in SK (April 1, 2020 to February 1, 2023).
2. **Project Location:** Field trials were located near Swift Current (#137), Indian Head (#156), and Redvers (#61), Saskatchewan.
3. **Project contact person & details:**

Bryan Nybo, Manager
Wheatland Conservation Area Inc.
P.O. Box 2015, Swift Current, SK, S9H 2P4
Phone: 306-773-4775
Email: wcanybo@sasktel.net

Amber Wall, Research Technician
Wheatland Conservation Area Inc.
P.O. Box 2015, Swift Current, SK, S9H 2P4
Phone: 306-773-4775
Email: wcawall@sasktel.net

Cory Jacob, Provincial Specialist, Oilseed Crops
Saskatchewan Ministry of Agriculture
125 - 3085 Albert Street, Regina, SK, S4S 0B1
Phone: 306-570-1086
Email: cory.jacob@gov.sk.ca

Shannon Chant, Crops Extension Specialist
Saskatchewan Ministry of Agriculture
101-350 Cheadle St W
Swift Current, SK, S9H 4G3
Phone: 306-778-8291
Email: shannon.chant@gov.sk.ca

Collaborators:

Chris Holzapfel, Research Manager (Project Manager)
Indian Head Agricultural Research Foundation
PO Box 156, Indian Head, SK, S0G 2K0
Mobile: 306-695-7761
Office: 306-695-4200
Email: cholzapfel@iharf.ca

Lana Shaw, Research Manager
South East Research Farm
Box 129, Redvers SK, S0C 2H0
Phone: 306-452-7253
Email: lshaw.serf@gmail.com

4. Abstract

With AAC Brown 18 becoming commercially available to producers in recent years, recommended agronomic practices needed to be updated to ensure peak performance when growing the hybrid variety compared to the open pollinated varieties. The current recommended seeding rate for open pollinated varieties is to target a plant stand of 7 to 11 plants/ft² (70 to 110 plants/m²). It is expected that different

varieties of mustard may respond differently to agronomic inputs such as nitrogen and seed rate to maximize seed yields. To evaluate this, small-plot research trials were established in three different soil zones in Saskatchewan. The locations were Swift Current (WCA), Indian Head (IH) and Redvers (RD) in 2020 through to 2022. The project was comprised as two separate trials. Part one included both AAC Brown 18 and Centennial brown seeded at 22 seeds/ft² with increasing nitrogen rates of 0, 60, 80, 100, 120, 140 and 160 lbs/ac of total nitrogen (soil residual + nitrogen applied as urea). The first treatment (0N) ranged from 0-60 lbs of N, depending on the amount of residual nitrogen at the site. Part two included balanced NPKS with both AAC Brown 18 and Centennial brown seeded at increasing seed rates of 10, 14, 18, 22, and 26 seeds/ft². Data collection consisted of plant density, vigor ratings, height, lodging, days to maturity, and seed yield. AAC Brown 18 consistently yielded higher than Centennial brown when compared to the same seeding and/or nitrogen rate. Height, lodging and days to maturity varied by site, but did not have any impact on yield. As suggested by increased vigor ratings, other benefits of the hybrid may include increased biomass accumulation, quicker emergence and ground cover, which can help the crop to be competitive with weeds. AAC Brown displays strong nitrogen use efficiency as well as the ability to compensate with increased branching and ground cover when seeded at a lower target plant stand compared to the Centennial Brown. AAC Brown 18 has many desirable properties but producers should keep in mind that the seed cost of the hybrid is higher than open-pollinated varieties¹. AAC Brown 18 also has half of the erucic acid content of the open-pollinated check which is desired in European markets.

5. Extension Messages

- AAC Brown 18 consistently yielded higher than Centennial brown when the same seed and /or nitrogen rate was compared
- In the drier site years AAC Brown 18 yielded highest when seeded 10-18 seeds/ft² and a nitrogen rate of 100 lbs/ac. However, it is assumed if growing season precipitation was higher yield would increase further with increasing nitrogen. Generally assuming 50% emergence for mustard, this would target a plant stand of 5-9 plants/m² for AAC Brown 18. Centennial brown yielded highest when seeded a higher rate of 26 seeds/ft² and a nitrogen rate of 100-140 lbs/ac. This suggests a higher seeding rate and ultimately higher target plant stand is required for the open pollinated variety to meet a yield potential as large as AAC Brown 18.
- Visually, AAC Brown 18 was rated more vigorous suggesting increased biomass accumulation, as well as quicker emergence and ground cover, which can help the crop to be competitive with weeds.
- Height, lodging and days to maturity varied by site, but did not appear to have any impact on yield.

6. Introduction

Current mustard fertility recommendations are based on data from the 1970s to early 2000's. Hybrid mustard was not available during this period, and its increased vigour means that fertilizer rates needed to be revisited. Hybrid seed is typically associated with superior performance, including 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 support this demand while minimizing production inefficiencies detrimental to the environment. Previous ADOPT demonstrations have provided good proof-of-

¹ <https://saskmustard.com/production-manual/varieties/hybrid-brown.html>

concept, but more robust multi-site, multi-year data is necessary to perform meaningful statistical analyses and acceptable recommendation changes².

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 updated, especially for AAC Brown 18.

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.³ The control treatment for each variety is soil residual N only and all sites were seeded at 22 seeds/ft². Nitrogen was applied in the form of urea and all treatments were balanced in P, K and S (90-40-0-25; IH applied 100 lb N/ac, which was more appropriate as this is generally a wetter, high yielding site). In Redvers in 2020, residual soil nitrogen was at least 60 lbs/ac, therefore the 0N treatment, as well as the 60N treatment did not receive any urea. At Swift Current in 2020, residual N was 30lbs/ac, 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 6-30 lbs/ac.

Mustard seeding rate treatments were based on a target plant population of 7-11 plants/ft² (75-118 plants/m²). Using the thousand seed weight (TSW), 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.

7. Objectives

Understand nitrogen requirements of a hybrid mustard compared to Centennial brown and define upper and lower limits of Nitrogen (N) rates for hybrid brown mustard.	Completed. However, data is a result of 6 dry site years out of 9 and could be repeated.
Clarify if hybrid <i>B. juncea</i> nitrogen requirements are unique from hybrid <i>B. napus</i> (argentine canola). High performing canola hybrids require 2.9-3.5 lbs. of available N per bushel of seed yield increase; ⁴ how does this compare to hybrid <i>B. juncea</i> ?	Completed. Hybrid mustard is similar to canola for nitrogen use.
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.	Completed. However, data is a result of 6 dry site years out of 9 and could be repeated.
Update recommendations for Saskatchewan mustard producers (available via Sask Mustard’s mustard production manual).	Completed. Currently being updated.

8. Methodology

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

³ <https://www.canolacouncil.org/canola-watch/2020/12/16/how-much-fertilizer-does-canola-need-2/>

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

- This project was set up at three Agri-ARM sites in potential mustard growing regions of Saskatchewan. Soil samples were taken prior to trial establishment determine initial 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 and AAC Brown 18 mustard and included 4 replicates to better demonstrate consistent fertility effects. Nitrogen fertilizer was added to the residual soil N to achieve the specified rates of total available N.
- To ensure other nutrients were non-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 each Centennial brown mustard and AAC Brown 18 mustard and included 4 replicates to better demonstrate consistent seed rate effects.
- To ensure nutrients were non-limiting, all treatments at each site received a balanced application of N, P, K, and S, in the seed rate trial. For the nitrogen trial, the “0N” treatment varied in residual nitrogen and did not receive any additional fertilizer in order to not surpass overall N for any other treatments. For example, residual nitrogen at Swift Current in2020was 30lbs/ac, therefore the 60N treatment only received nitrogen from the applied phosphorus and sulfur products to total 60 lbs/ac nitrogen total for that treatment, and the rest of the treatments have nitrogen applied as urea and balanced P, K, S.
- Location and Variety were analysed separately on JMP and all data is included regardless of statistical significance.

Table 1. Operations and dates of each individual location

NOTE: SR=SEED RATE TRIAL. NR=NITROGEN RATE TRIAL

Location	Swift Current			Indian Head			Redvers		
Year	2020	2021	2022	2020	2021	2022	2020	2021	2022
Stubble	Durum	Durum	Durum	Oat	Canary seed	Oat	Cereal	Cereal	Cereal
Seed Date	15-May	13-May	12-May	16-May	14-May	28-May	21-May	17-May	May 22 (SR), Jun 4 (NR)
Row Spacing	8.25 inches			12 inches			12 inches		
Seed Rate	SR: 10-26 seeds/ft2, NR: 22seeds/ft2								
Residual N (0-6")	30 lbs/ac	11 lbs/ac	8 lbs/ac	14 lbs/ac	6 lbs/ac	3 lbs/ac	60 lbs/ac	31 lbs/ac	40 lbs/ac
Fertility	SR: Balanced NPKS, NR: Nitrogen range from 0-160 lbs/ac Nitrogen, balanced PKS								
Plant Density	08-Jun	12-Jun	22-Jun	11-Jun	17-Jun	09-Jun	02-Jun	17-Jun	13-Jun, 30-Jun
Early Vigor Rating	08-Jun	12-Jun	07-Jun	14-Jun	13-Jun	20-Jun	-	15-Jun	15-Jun
Herbicide	Muster/A ssure II	Centurion/ Amigo	Centurion/ Amigo	Centurion/ Amigo	Centurion/ Amigo	Centurion/ Amigo	Muster/A ssure II	Centurion/ Amigo	Centurion/Amigo
Herbicide	-	-	-	-	Muster/Ag ral 90	Muster/Ag ral 90	-	-	-
Insecticide	Voliam	-	Decis	Matador 120 EC	Malathion	Matador 120 EC	-	-	-
Fungicide	-	-	-	Lance AG	Lance AG	Lance WDG	-	-	-
Late Vigor Rating	22-Jun	22-Jun	22-Jun	24-Jun	21-Jul	29-Jun	25-Jun	21-Jul	06-Jul
Height (cm)	20-Aug	28-Jul	18-Aug	13-Jul	08-Jul	29-Jul	28-Aug	08-Jul	--
Lodging ratings	23-Jul	13-Aug	20-Aug	18-Aug	Jul 30	04-Aug	28-Aug	30-Jul	--
Desiccation	-	-	-	-	-	20-Aug	-	-	-

Days to Maturity	Aug	Aug	August	August	August	August	August	August	August
Note:	-	-	-	-	-	14-Aug (Hail)	-	-	-
Harvest Dates	26-Aug	17-Aug	15-Aug	28-Aug	13-Aug	30-Aug	28-Aug	13-Aug	01-Sep

Treatment List

Part 1: Nitrogen Trial	Residual + Applied Nitrogen (lb N/ac)	seeds/ft2
Variety		
Hybrid Brown	30	22
Hybrid Brown	60	22
Hybrid Brown	80	22
Hybrid Brown	100	22
Hybrid Brown	120	22
Hybrid Brown	140	22
Hybrid Brown	160	22
Centennial Brown	0	22
Centennial Brown	60	22
Centennial Brown	80	22
Centennial Brown	100	22
Centennial Brown	120	22
Centennial Brown	140	22
Centennial Brown	160	22

Part 2: Seed Rate Trial	Residual + Applied Nitrogen (lb N/ac)	seeds/ft2
Variety		
Hybrid Brown	90	10
Hybrid Brown	90	14
Hybrid Brown	90	18
Hybrid Brown	90	22
Hybrid Brown	90	26
Centennial Brown	90	10
Centennial Brown	90	14
Centennial Brown	90	18
Centennial Brown	90	22
Centennial Brown	90	26

Data Collection:

- **Soil Sample:** determine stored soil nitrogen
- **Crop Establishment:** plants/ft²
- **Visual Vigor:** 1-9 scale, where 9 is the most vigorous
- **Lodging:** 1-9 scale, where 1 is upright and 9 is flat
- **Crop Height:** cm
- **Yield:** kg/ha

9. Results and Discussion

Growing Conditions

Growing season temperatures and precipitation amounts for the 2020, 2021 and 2022 growing seasons (May-August) relative to the long-term averages are provided in Table 2. The mean monthly average temperatures were above the long-term averages with the exception of May in Redvers, which was cool each year. All 3 locations were considered relatively dry, with 6 out of the 9 site years reporting the total precipitation below their respective long-term averages, especially 2020. Swift Current was the hottest and driest location amongst all 3 locations, followed by Redvers and then Indian Head, SK. All 3 years at Swift Current received below the long-term average precipitation and were 0.8 to 1.4^oC warmer than the normal temperature. Redvers received above the long-term precipitation average in 2022 (311 mm higher) and Indian Head received above the long-term average precipitation in both 2021 (52 mm higher) and 2022 (43 mm higher). Sites that received very little precipitation early in the season had poor overall emergence, greatly affecting yield potential. Early on at Swift Current, crops were often behind normal stages of development as a result of limited to no rainfall, wind and very warm temperatures during flowering. Flea beetle pressure varied over the 9 site years. Overall soil moisture at Indian Head was adequate in 2021 and 2022, but rainfall events were not timely and in 2022 were sporadic. Indian Head had high flea beetle pressure in 2021 and also received hail before harvest in 2022, which undoubtedly affected yield. Crops at Redvers advanced quickly, but remained in relatively normal stages of development. Redvers received extreme amounts of precipitation in 2022 resulting in a late seeded crop. All site years, mustard was combined mid-end of August.

Table 2. Mean monthly temperatures and precipitation for the 2020, 2021, 2022 growing seasons at Saskatchewan trial locations and long-term (10-year) averages.

Location	Year	May	June	July	August	Avg. / Total
----- <i>Mean Temperature (°C)</i> -----						
Swift Current	2020	10.9	16.6	18.2	19.5	16.3
	2021	9.5	18.4	21.7	18	16.9
	2022	10.9	15.9	19.8	20.9	16.9
	Long-term	10.9	15.3	18.2	17.6	15.5
Redvers	2020	10.5	16.8	19.2	18.5	16.2
	2021	10.0	18.7	20.8	17.5	16.8
	2022	10.2	16.3	19.2	18.9	16.2
	Long-term	12.0	16.0	19.0	18.0	16.3
Indian Head	2020	10.7	15.6	18.4	17.9	15.7
	2021	9.0	17.7	20.3	17.1	16.0
	2022	10.9	16.1	18.1	18.3	15.8
	Long-term	10.8	15.8	18.2	17.4	15.6
----- <i>Precipitation (mm)</i> -----						
Swift Current	2020	36.3	80	62.5	6.5	185
	2021	35	29.6	38.9	55.8	159
	2022	51.2	37.7	90.4	7.5	187
	Long-term	51.2	77.1	60.1	47.4	236
Redvers	2020	22.9	59.7	47.8	36.1	166
	2021	42.2	107.3	58	57	265
	2022	135	92.4	303.3	73.1	604
	Long-term	60.0	91.0	78.0	64.0	293

Indian Head	2020	27.3	23.5	37.7	24.9	113
	2021	81.6	62.9	51.2	99.4	295
	2022	97.7	27.5	114.5	45.9	286
	Long-term	51.0	77.4	63.8	51.2	243

Part 1: Nitrogen Rate Trial

Nitrogen Rate Treatment Effects on Mustard Emergence

Centennial mustard had significantly greater establishment compared to AAC Brown 18 (Table 4). Plant density generally decreased with increasing nitrogen rate for both the hybrid and Centennial brown, but results were quite variable. This is likely due to ammonia injury associated with high rates of side-banded N in cases where either soil conditions were extremely dry or separation between the seed and fertilizer was inadequate due to poor seed-bed conditions. This varied across sites as the combined analysis of 9 site-years had a significant interaction between site-year and nitrogen rate indicating that the nitrogen response varied among locations. The lowest establishment rates coincided with the driest growing season precipitation recorded at Swift Current indicating that the poor soil moisture and lack of precipitation negatively influenced emergence. Emergence at Swift Current ranged from 30% to 35% and had a negative relationship with increasing nitrogen rate (Table 3). Indian Head had the highest emergence rates ranging from 70% to 80% and resulted in very little variation between nitrogen rates with Centennial brown emergence having a clearer negative relationship to increasing nitrogen rates. Emergence at Redvers was 43% to 61% , but similarly to Indian Head, there was very little variation in response to increasing nitrogen rates.

Table 3. AAC Brown 18 (HYB) and Centennial Brown (OP) mustard percent emergence in part 1 (increasing nitrogen rates) and part 2 (increasing seed rates) at each site.

Percent emergence in Seed rate trial (3 years)		
Location	HYB	OP
SC	32%	35%
IH	73%	80%
RD	43%	53%
Percent emergence in Nitrogen rate trial (3 years)		
Location	HYB	OP
SC	30%	33%
IH	70%	77%
RD	52%	61%

Nitrogen Rate Treatment Effects on Mustard Yield

Although AAC Brown 18 establishment rates were lower, average yields were statistically higher in 5/6 site years compared to Centennial brown yields. This demonstrates the vigorous elasticity of the hybrid and its ability to branch out and compensate for thin plant stands in order to produce greater yields. Despite poor establishment of the hybrid brown mustard, growing season rains likely promoted branching, flowering and pod development. As expected, yields were generally lower at Swift Current and Redvers at the Indian Head site due to below average growing season precipitation received. Yield was largely influenced by environmental conditions as moisture was a limiting factor for most of the site-years, in particular at Swift Current. The dry conditions that persisted over multiple growing seasons resulted in limited emergence and that ultimately had a negative impact on potential yield.

At Swift Current, AAC Brown 18 yield increased with nitrogen rates up to 100 lbs/ac (1312 kg/ha, Table 5). Centennial brown mustard yield increased yield up to 100-140 lbs/ac (1222 kg/ha). Although response to nitrogen was not very strong, we can conclude this was because this location was greatly limited by moisture all site years.

At Indian Head, both AAC Brown 18 and Centennial brown yields increased up to 160 lbs/ac resulting in 2360 kg/ha and 1936 kg/ha, respectively. Yields increased linearly with increasing nitrogen likely as a result of having received adequate precipitation at this site.

Redvers mustard yields also increased with nitrogen up to rates of 160 lbs/ac with AAC Brown 18 yielding 1440 kg/ha and Centennial brown yielding 1332 kg/ha.

Nitrogen Rate Treatment Effects on Vigor, Height, Lodging and Days to Maturity

In an attempt to document the increased vigor of AAC Brown 18, visual ratings were taken at two different times in the early growing stages (approximately 3 and 5 weeks after seeding). While not statistically analyzed, these observations are summarized below. Vigor ratings were based on how quickly plants emerged and developed on a 1-9 scale, where 9 is the most vigorous. The hybrid was more vigorous most site years and this vigor increased with nitrogen, despite the decrease in plant population. The hybrid does appear to have increased branching compared to the open pollinated variety throughout the season and most noticeably early on. Five weeks after seeding AAC Brown 18 vigor still rated higher than Centennial brown and there was a slightly stronger response to nitrogen (80-100 lbs/ac).

Height measurements greatly varied by year in Swift Current, but overall AAC Brown 18 was significantly taller than Centennial brown (Table 6). At Swift Current, height was only significantly different between nitrogen treatments when no nutrients were applied, resulting in a difference of 10-12 centimeters compared to the higher nitrogen rates. This was also true for AAC Brown 18 at Indian Head, but there were no significant differences in height between nitrogen rates for Centennial brown. At Redvers, height varied but generally increased with nitrogen rate increase up to the moderate rates. There was no variety effect on lodging, but it did increase fairly linearly with increasing nitrogen levels at Indian Head and Redvers. Overall lodging ratings were low and did not have an impact on yield. (Table 7). There was no variety effect on days to maturity at Swift Current and Redvers. However, days to maturity did increase with increasing nitrogen at Indian Head and Redvers (Table 8). 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. There were several differences in days to maturity when comparing years. This inconsistency is attributed to the difference in environmental conditions.

Part 2: Seed Rate Trial

Seeding Rate Treatment Effects on Mustard Emergence

Centennial mustard establishment was significantly higher compared to AAC Brown 18 when combined across seeding rates (Table 9). Plant density for the hybrid and Centennial brown varieties increased with seeding rate increases. Seeding rates were 10, 14, 18, 22 and 26 seeds/ft². However, percent survival decreased as seeding rate increased, meaning the lower seeding rates had a higher percentage of surviving plants. This is likely a result of the below average precipitation early in the growing season for most site years in addition to increased competition amongst seedlings at the higher seeded rates. The highest plant density for both varieties was at a seeding rate of 26 seeds/ft². Plant establishment for the hybrid mustard

was below the target window multiple site years and demonstrated the negative effects of the extremely dry soil moisture conditions. Although this greatly impacted yield potential at many sites, as shown in previous research, plant density does not necessarily equate to yield. Overall, Indian Head had the highest percent emergence, followed by Redvers, and lastly Swift Current (Table 3).

Plant density increased linearly with increasing seeding rate when averaged within each site. At Swift Current, overall emergence was extremely low due to a lack of soil moisture reserve and precipitation. Centennial brown mustard plant population averaged 67 plants/m² compared to the hybrid at 60 plants/m². Redvers had drought conditions in 2020, adequate precipitation in 2021 and very scattered, above average precipitation in 2022, which resulted in variable plant emergence at that site. Plant populations were above and below the target plant stand. On average, the variety Centennial brown had higher plant populations (104 plants/m²) compared to AAC Brown 18 (85 plants/m²). Indian Head received close to the long-term average rainfall in 2/3 site years, and emergence was higher at that site (Hybrid 130 plants/m² and Centennial 152 plants/m²) compared to the other sites.

Seeding Rate Treatment Effects on Mustard Yield

Although AAC Brown 18 establishment rates were lower, average yields were statistically higher in 5/6 site years compared to Centennial brown. This demonstrates the vigorous elasticity of the hybrid and its ability to branch out and compensate for thin plant stands to produce greater yields than the non-hybrid variety grown in the same conditions. Despite poor establishment of the hybrid brown mustard, growing season rains likely promoted branching, flowering and pod development. Overall, yields at Swift Current and Redvers were lower than at Indian Head due to timely precipitation. More site data with non-limiting moisture would allow for a more confident recommendation.

At Swift Current, AAC Brown 18 yield increased with seeding rates up to 18 seeds/ft² (1120 kg/ha), but was not significantly different than the yield at the lower seeding rates of 10 and 14 seeds/ft² (Table 10). Centennial brown mustard yield increased with seeding rates up to 26 seeds/ft² (1132 kg/ha).

At Indian Head, hybrid brown yields increased up to a seeding rate of 18 seeds/ft² (2278 kg/ha) and Centennial brown yields increased up to a rate of 18 seeds/ft² (1941 kg/ha), but was not significantly different than at 14 seeds/ft² (1907 kg/ha). A lot of variation in yield existed and similar to results in Swift Current, lower plant populations seem to out-perform higher populations when moisture was limited.

Results at Redvers resulted in little variation between seeding rate treatments due to poor environmental conditions in 2/3 years. Combined data at Redvers suggests there was no significant difference between seeding rates higher than 10 seeds/ft². However, when considering a more normal year rather than drought years, 2022 yields for AAC Brown 18 increased up to 22 seeds/ft² (1965 kg/ha) and Centennial brown mustard yields increased with seeding rates up to 18 seeds/ft² (1433 kg/ha).

Seeding Rate Treatment Effects on Vigor, Height, Lodging and Days to Maturity

In an attempt to document the increased vigor of AAC Brown 18, visual ratings were taken at two different times in the early growing stages (approximately 3 and 5 weeks after seeding). While not statistically analyzed, these observations are summarized below. Vigor ratings were based on how quickly plants emerged and developed on a 1-9 scale, where 9 is the most vigorous. The hybrid was more vigorous most site years and its vigor also increased with increasing seeding rate, despite the decreased percentage of survival. The hybrid does appear to have increased branching throughout the season, most noticeably early

on. Five weeks after seeding, the hybrid vigor still rated higher than the OP variety, but with less response from the increased seeding rate, likely due in part to the decline in survival at the higher rates.

Other data analyzed included height, lodging and days to maturity. At Swift Current, there was no variety, or seeding rate effect on any of these measurements, likely due to limited moisture. At the remaining sites, AAC Brown 18 was taller than Centennial and height decreased as seeding rate increased (Table 11). Although there was no difference between varieties, lodging did increase linearly with seeding rate. Overall lodging was highest at Indian Head (4.0 average), but did not have a noticeable impact on yield (Table 12). There was a seeding rate effect at Indian Head and Redvers with days to maturity being higher at lower seeding rates. At Indian Head alone, AAC Brown 18 matured 1-2 days earlier than Centennial (Table 13). Variation in days to maturity was generally small due to limited moisture and above average temperatures drying out plants naturally, making this a difficult visual rating at most sites.

10. Conclusions

After 9 site-years that included 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/ft² which caused variability in some of the results. With the below average moisture received for 6 of the site years, we saw emergence rates range from 30% to 73% for AAC Brown 18 and 33% to 80% for Centennial brown mustard. Generally, mustard emergence ranged from 50-80% when soil moisture was not limiting. Similar to previous research⁵, AAC Brown 18 appeared to better utilize nitrogen and appeared to promote branching, pod development, and higher yields at a lower seeding rate. When compared to Centennial brown at the same seed rate, or nitrogen rate, and on average AAC Brown 18 was higher yielding.

In the drier site years at Swift Current and Redvers, AAC Brown 18 yielded highest when the seeding rate was 10-18 seeds/ft² (1080-1120 kg/ha) and at a nitrogen rate of 100 lbs/ac (1312 kg/ha). Higher growing season precipitation would have likely resulted in yield increasing further with increasing nitrogen. Generally assuming 50% emergence, this would target a plant stand of 5-9 plants/ft² for AAC Brown 18. Centennial brown yielded highest when seeded at a higher rate of 26 seeds/ft² (1156 kg/ha) with a nitrogen rate of 100-140 lbs/ac (1277 kg/ha). This suggests a higher seeding rate and higher target plant stand may be required for the open pollinated variety compared to AAC Brown 18. These results also demonstrate the vigor and elasticity bred into the hybrid brown mustard given the higher yields at a lower seeding rate. At Redvers, AAC Brown 18 yielded highest when seeded at 18-22 seeds/ft² (1203-1291 kg/ha) and increased with increasing nitrogen rates up to 160 lbs/ac (1440 kg/ha). Centennial brown yield varied and yielded highest when seeded at a larger range of 14-26 seeds/ft² (1003 kg/ha to 1050 kg/ha) and a nitrogen rate of 140-160 lbs/ac (1310-1332 kg/ha). Results at Redvers were quite variable in 2020 and 2021 and yield likely would have increased more linearly with adequate growing conditions. Similarly, at Indian Head, AAC Brown 18 yielded highest when seeded at 18 seeds/ft² (2278 kg/ha) and increased with nitrogen rates up to 160 lbs/ac (2360 kg/ha). Centennial brown yield was slightly more variable and yield was highest when seeded at a larger range of 14-22 seeds/ft² (1907 kg/ha to 1941 kg/ha) and a nitrogen rate of 160 lbs/ac (1936 kg/ha).

Increases to average mustard yield will ensure that mustard is competitive with other crops grown in Canada, an economically viable crop rotation option for mustard growers and globally exported. As the first

⁵http://www.wheatlandconservation.ca/files/20180445_Optimum_Seeding_Rates_for_Hybrid_Brown_Mustard_Group.pdf

hybrid condiment brown mustard was developed and launched commercially in 2020, it remains important for growers to ensure they are optimizing both seeding and nitrogen rate in order 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 as well as micronutrients).

This information compliments the research done by Bifang Cheng at AAFC in Saskatoon, as the hybrid seed technology has been shown to outperform the open pollinated variety by double digit yield increases in optimal conditions. AAC Brown 18 was the first hybrid brown mustard commercially available, providing higher yields, greater weed competition and improved vigor. As superior yield is bred into future hybrid varieties, we can continue to select for lines with key traits like oil content, protein content and resistance to diseases such as blackleg and white rust.

11. Follow up work

- **Further project work**

Yield was largely influenced by environmental conditions as moisture was a limiting factor for most of the site-years, in particular at Swift Current. The dry conditions that persisted over multiple growing seasons resulted in limited emergence and that ultimately had a negative impact on potential yield.

- **Needs arising from this project**

Thousand seed weight varied by year for each variety, as seed source varied by year. Having a consistent seed weight for all site years would allow seed rate to also be presented in lbs/ac.

12. Patents/IP generated/commercialized products

- N/A

13. Technology transfer

- This project was featured on a radio program, “Walk the Plots” that airs weekly on CKSW throughout the summer from 2020-2022.
- At Swift Current the trial was featured on the Annual field day in years 2021-2022.
- At Indian Head the project was shown to more than 80 producers and industry representatives on a field day hosted by IHARF on July 20, 2021.
- Preliminary results were also presented by Cory Jacob at the Virtual Agronomy Research Update in 2021.
- Final results were presented by Cory Jacob and Amber at the Mustard Annual General Meeting, January 12, 2023.
- Results were also featured in a number of M21 Newsletters throughout the years.

14. Industry contributions or support received

- AAC Brown 18 seed provided in-kind by Mustard 21.
- Centennial Brown seed purchased from Sundwall Seed at Govan, SK.

15. Acknowledgements

We thank the Ministry of Agriculture for all the Strategic Field Program projects including verbal acknowledgement on field tours and on PowerPoint slides during presentations. This will continue at each venue where an extension activity occurs. We also thank Shannon Chant and Cory Jacob

with the Saskatchewan Ministry of Agriculture, as well as the Saskatchewan Mustard Development Commission.

16. Appendices

Table 4. Hybrid Brown and Centennial Brown mustard emergence at increasing nitrogen rates in Swift Current, Indian Head and Redvers (plants/m², 2020-2022). Means within a column followed by the same letter do not significantly differ.

Plant Density	Swift Current		Indian Head		Redvers	
Nitrogen Rate x AAC Brown 18	----- (plants/m²) -----					
0 lbs/ac	81	a	165	ab	125	a
60 lbs/ac	74	b	169	ab	125	a
80 lbs/ac	73	bc	162	ab	118	b
100 lbs/ac	73	bc	166	ab	128	a
120 lbs/ac	71	bc	170	a	121	b
140 lbs/ac	67	c	162	ab	130	a
160 lbs/ac	51	d	161	b	118	b
LSD	6.0		9.0		6.0	
CV(%)	20.8		13.0		13.0	
Nitrogen Rate x Centennial Brown						
0 lbs/ac	97	a	188	a	142	bc
60 lbs/ac	87	ab	184	ab	143	abc
80 lbs/ac	81	bc	190	a	147	ab
100 lbs/ac	79	bc	190	a	149	a
120 lbs/ac	78	bc	177	b	143	abc
140 lbs/ac	72	c	173	b	140	c
160 lbs/ac	60	d	174	b	143	abc
LSD	9.0		10.0		6.0	
CV(%)	30.5		13.8		10.0	
Nitrogen Rate						
0 lbs/ac	89	a	176	a	133	a
60 lbs/ac	80	ab	176	a	134	a
80 lbs/ac	76	b	176	a	133	a
100 lbs/ac	77	b	178	a	138	a
120 lbs/ac	73	b	174	a	132	a
140 lbs/ac	71	b	168	a	135	a
160 lbs/ac	55	c	167	a	131	a
LSD	10		11		7	
CV(%)	27.1		13.2		11.6	
Variety						
AAC Brown 18	70	b	165	b	123	b
Centennial Brown	79	a	182	a	144	a
LSD	3		3		2	
CV(%)	27.1		13.2		11.6	

Table 5. Hybrid Brown and Centennial Brown mustard yield at increasing nitrogen rates in Swift Current, Indian Head and Redvers (kg/ha, 2020-2022). Means within a column followed by the same letter do not significantly differ.

Mustard Yield	Swift Current		Indian Head		Redvers	
Nitrogen Rate x AAC Brown 18	----- (kg/ha) -----					
0 lbs/ac	933	c	922	g	952	f
60 lbs/ac	1184	b	1347	f	1113	e
80 lbs/ac	1234	b	1675	e	1232	d
100 lbs/ac	1312	a	1873	d	1282	cd
120 lbs/ac	1328	a	2080	c	1328	bc
140 lbs/ac	1323	a	2269	b	1366	b
160 lbs/ac	1329	a	2360	a	1440	a
LSD	70.0		45.0		60.0	
CV(%)	13.2		6.3		12.3	
Nitrogen Rate x Centennial Brown						
0 lbs/ac	878	d	813	g	901	f

	60 lbs/ac	1073	c	1176	f	978	e
	80 lbs/ac	1193	b	1492	e	1105	d
	100 lbs/ac	1222	ab	1679	d	1169	c
	120 lbs/ac	1231	ab	1766	c	1270	b
	140 lbs/ac	1277	a	1896	b	1310	ab
	160 lbs/ac	1195	b	1936	a	1332	a
	LSD	72.0		37.0		49.0	
	CV(%)	15.8		6.1		11.0	
Nitrogen Rate							
	0 lbs/ac	905	d	867	g	926	f
	60 lbs/ac	1129	c	1262	f	1046	e
	80 lbs/ac	1214	b	1583	e	1167	d
	100 lbs/ac	1267	a	1776	d	1225	cd
	120 lbs/ac	1279	a	1923	c	1299	bc
	140 lbs/ac	1301	a	2082	b	1338	ab
	160 lbs/ac	1262	ab	2148	a	1386	a
	LSD	50.0		50.0		75.0	
	CV(%)	15.1		6.2		12.7	
Variety							
	AAC Brown 18	1235	a	1789	a	1245	a
	Centennial Brown	1153	b	1537	b	1152	b
	LSD	27		15		23	
	CV(%)	15.1		6.2		12.7	

Table 6. Hybrid Brown and Centennial Brown mustard height at increasing nitrogen rates in Swift Current, Indian Head and Redvers (cm, 2020-2022). Means within a column followed by the same letter do not significantly differ.

Height	Swift Current		Indian Head		Redvers		
Nitrogen Rate x AAC Brown 18	------(cm)-----						
	0 lbs/ac	85	b	101	b	111	c
	60 lbs/ac	97	a	112	a	119	ab
	80 lbs/ac	97	a	112	a	121	ab
	100 lbs/ac	96	a	113	a	122	a
	120 lbs/ac	95	a	114	a	122	a
	140 lbs/ac	95	a	114	a	118	b
	160 lbs/ac	98	a	114	a	118	b
	LSD	3.0		2.0		3.0	
	CV(%)	9.1		4.0		5.8	
Nitrogen Rate x Centennial Brown							
	0 lbs/ac	88	b	110	a	107	c
	60 lbs/ac	98	a	103	a	113	b
	80 lbs/ac	100	a	107	a	116	a
	100 lbs/ac	97	a	106	a	117	a
	120 lbs/ac	100	a	106	a	117	a
	140 lbs/ac	97	a	108	a	118	a
	160 lbs/ac	97	a	108	a	116	a
	LSD	3.0		9.0		2.0	
	CV(%)	7.7		22.2		4.0	
Nitrogen Rate							
	0 lbs/ac	87	b	106	a	109	c
	60 lbs/ac	98	a	107	a	116	b
	80 lbs/ac	98	a	110	a	119	ab
	100 lbs/ac	97	a	110	a	120	a
	120 lbs/ac	98	a	110	a	119	ab
	140 lbs/ac	96	a	111	a	118	ab
	160 lbs/ac	97	a	111	a	117	ab
	LSD	4.0		8.0		3.0	
	CV(%)	8.4		15.6		5.1	
Variety							
	AAC Brown 18	95	b	111	a	119	a
	Centennial Brown	97	a	107	b	115	b
	LSD	1.0		3.0		1.0	
	CV(%)	8.4		15.6		5.1	

Table 7. Hybrid Brown and Centennial Brown mustard Lodging (1-9) at increasing nitrogen rates in Swift Current, Indian Head and Redvers (1=erect, 9=flat, 2020-2022). Means within a column followed by the same letter do not significantly differ.

Lodging (1-9) Nitrogen Rate x AAC Brown 18	Swift Current		Indian Head		Redvers	
	----- (lodging) -----					
0 lbs/ac	2	a	2	d	2	c
60 lbs/ac	2	a	2	d	3	b
80 lbs/ac	2	a	3	c	3	b
100 lbs/ac	2	a	4	b	3	b
120 lbs/ac	2	a	4	b	3	b
140 lbs/ac	2	a	5	a	4	a
160 lbs/ac	2	a	5	a	4	a
LSD	0.0		0.0		0.0	
CV(%)	33.6		11.0		31.4	
Nitrogen Rate x Centennial Brown						
0 lbs/ac	2	a	2	e	2	c
60 lbs/ac	2	a	3	d	2	c
80 lbs/ac	2	a	4	c	2	c
100 lbs/ac	2	a	4	c	3	b
120 lbs/ac	2	a	4	c	3	b
140 lbs/ac	2	a	5	b	4	a
160 lbs/ac	2	a	6	a	4	a
LSD	0.0		0.0		0.0	
CV(%)	40.0		13.2		27.0	
Nitrogen Rate						
0 lbs/ac	2	a	2	d	2	b
60 lbs/ac	2	a	2	d	2	b
80 lbs/ac	2	a	3	c	3	ab
100 lbs/ac	2	a	4	b	3	ab
120 lbs/ac	2	a	4	b	3	ab
140 lbs/ac	2	a	5	a	4	a
160 lbs/ac	2	a	5	a	4	a
LSD	0.0		0.0		1.0	
CV(%)	37.4		13.0		30.0	
Variety						
AAC Brown 18	2	a	4	a	3	a
Centennial Brown	2	a	4	a	3	a
LSD	0.0		0.0		0.0	
CV(%)	37.4		13.0		30.0	

Table 8. Hybrid Brown and Centennial Brown mustard days to maturity at increasing nitrogen rates in Swift Current, Indian Head and Redvers (Days, 2020-2022). Means within a column followed by the same letter do not significantly differ.

Days to Maturity Nitrogen Rate x AAC Brown 18	Swift Current		Indian Head		Redvers	
	----- (days) -----					
0 lbs/ac	86	a	79	d	77	d
60 lbs/ac	86	a	79	d	78	c
80 lbs/ac	86	a	80	c	78	c
100 lbs/ac	86	a	80	c	78	c
120 lbs/ac	86	a	81	b	79	b
140 lbs/ac	85	a	82	a	79	b
160 lbs/ac	86	a	82	a	80	a
LSD	0.0		0.0		0.0	
CV(%)	1.3		0.8		1.5	
Nitrogen Rate x Centennial Brown						
0 lbs/ac	86	a	80	d	79	c
60 lbs/ac	86	a	80	d	79	c
80 lbs/ac	86	a	81	c	80	b
100 lbs/ac	86	a	81	c	80	b
120 lbs/ac	86	a	82	b	80	b
140 lbs/ac	86	a	83	a	81	a
160 lbs/ac	87	a	83	a	81	a

	LSD	1.0	0.0	0.0
	CV(%)	1.6	0.6	4.0
Nitrogen Rate				
0 lbs/ac		86	a	79
60 lbs/ac		85	a	79
80 lbs/ac		85	a	80
100 lbs/ac		86	a	81
120 lbs/ac		86	a	82
140 lbs/ac		85	a	82
160 lbs/ac		86	a	83
LSD		1.0	0.0	1.0
CV(%)		1.5	0.7	1.5
Variety				
AAC Brown 18		86	a	80
Centennial Brown		86	a	81
LSD		0.0	0.0	0.0
CV(%)		1.5	0.7	1.5

Table 9. Hybrid Brown and Centennial Brown mustard plant density at increasing seeding rates in Swift Current, Indian Head and Redvers (plants/m², 2020-2022). Means within a column followed by the same letter do not significantly differ.

Plant Density	Swift Current		Indian Head		Redvers	
	Seed Rate x AAC Brown 18					
	plants/m ²					
10 seeds/ft ²	39	e	93	e	51	d
14 seeds/ft ²	53	d	118	d	67	c
18 seeds/ft ²	60	c	137	c	79	b
22 seeds/ft ²	70	b	161	b	104	a
26 seeds/ft ²	78	a	177	a	105	a
LSD	3.0		7.0		6.0	
CV(%)	17.5		12.6		18.0	
Seed Rate x Centennial Brown						
10 seeds/ft ²	39	e	94	d	63	e
14 seeds/ft ²	53	d	132	c	89	d
18 seeds/ft ²	67	c	137	c	97	c
22 seeds/ft ²	84	b	186	b	113	b
26 seeds/ft ²	92	a	209	a	135	a
LSD	5.0		7.0		7.0	
CV(%)	19.0		12.3		17.0	
Seed Rate						
10 seeds/ft ²	39	e	93	e	62	e
14 seeds/ft ²	53	d	125	d	82	d
18 seeds/ft ²	64	c	137	c	91	c
22 seeds/ft ²	77	b	174	b	113	b
26 seeds/ft ²	85	a	193	a	125	a
LSD	3.0		5.0		0.0	
CV(%)	17.9		12.4		18.0	
Variety						
AAC Brown 18	60	b	137	b	85	b
Centennial Brown	67	a	152	a	104	a
LSD	2.0		3.0		3.0	
CV(%)	17.9		12.4		18.0	

Table 10. Hybrid Brown and Centennial Brown mustard yield at increasing seeding rates in Swift Current, Indian Head and Redvers (kg/ha, 2020-2022). Means within a column followed by the same letter do not significantly differ.

Mustard Yield	Swift Current		Indian Head		Redvers	
	Seed Rate x AAC Brown 18					
	kg/ha					
10 seeds/ft ²	1080	b	2150	c	1203	b
14 seeds/ft ²	1065	b	2227	b	1225	b
18 seeds/ft ²	1120	ab	2278	a	1297	ab
22 seeds/ft ²	1175	a	2145	c	1347	a
26 seeds/ft ²	1156	a	2160	c	1236	ab
LSD	66.0		37.0		119.0	
CV(%)	14.9		4.2		23.7	

Seed Rate x Centennial Brown						
10 seeds/ft ²	947	c	1885	b	930	b
14 seeds/ft ²	961	c	1907	ab	1011	a
18 seeds/ft ²	1031	b	1941	a	1003	a
22 seeds/ft ²	1036	b	1938	a	1050	a
26 seeds/ft ²	1132	a	1880	b	1013	a
LSD	54.0		42.0		58.0	
CV(%)	13.0		5.5		1.5	
Seed Rate						
10 seeds/ft ²	1014	c	2018	bc	1067	a
14 seeds/ft ²	1013	c	2067	a	1118	a
18 seeds/ft ²	1075	b	2110	c	1150	a
22 seeds/ft ²	1105	ab	2041	ab	1199	a
26 seeds/ft ²	1144	a	2020	bc	1125	a
LSD	42.0		29.0		64.0	
CV(%)	14.1		5.0		20.0	
Variety						
AAC Brown 18	1119	a	2192	a	1262	a
Centennial Brown	1021	b	1898	b	1002	b
LSD	27.0		18.0		41.0	
CV(%)	14.1		5.0		20.0	

Table 11. Hybrid Brown and Centennial Brown mustard height at increasing seeding rates in Swift Current, Indian Head and Redvers (cm, 2020-2022). Means within a column followed by the same letter do not significantly differ.

Plant Height	Swift Current		Indian Head		Redvers	
	Seed Rate x AAC Brown 18					
	height (cm)					
10 seeds/ft ²	96	a	117	a	111	a
14 seeds/ft ²	96	a	116	ab	110	a
18 seeds/ft ²	97	a	114	bc	110	a
22 seeds/ft ²	99	a	114	bc	110	a
26 seeds/ft ²	96	a	113	c	107	b
LSD	3.0		2.0		2.0	
CV(%)	8.0		3.8		4.8	
Seed Rate x Centennial Brown						
10 seeds/ft ²	99	a	109	a	103	a
14 seeds/ft ²	99	a	109	a	103	a
18 seeds/ft ²	98	a	107	ab	104	a
22 seeds/ft ²	96	a	105	b	104	a
26 seeds/ft ²	97	a	106	b	100	b
LSD	3.0		2.0		2.0	
CV(%)	8.8		5.0		5.0	
Seed Rate						
10 seeds/ft ²	97	a	113	a	107	a
14 seeds/ft ²	97	a	112	ab	106	a
18 seeds/ft ²	97	a	111	bc	107	a
22 seeds/ft ²	95	a	109	d	107	a
26 seeds/ft ²	96	a	110	cd	104	b
LSD	2.0		1.0		1.0	
CV(%)	8.5		4.3		5.0	
Variety						
AAC Brown 18	96	a	115	a	109	a
Centennial Brown	97	a	107	b	103	b
LSD	1.0		1.0		1.0	
CV(%)	8.5		4.3		5.0	

Table 12. Hybrid Brown and Centennial Brown mustard lodging at increasing seeding rates in Swift Current, Indian Head and Redvers (1=erect, 9=flat, 2020-2022). Means within a column followed by the same letter do not significantly differ.

Lodging (1-9)	Swift Current		Indian Head		Redvers	
	Seed Rate x AAC Brown 18					
	lodging					
10 seeds/ft ²	2	a	3	c	2	b
14 seeds/ft ²	2	a	4	b	2	b

18 seeds/ft ²	2	a	4	b	2	b
22 seeds/ft ²	2	a	4	b	3	a
26 seeds/ft ²	2	a	5	a	3	a
LSD	3.0		0.0		0.0	
CV(%)	1.0		10.9		28.9	
Seed Rate x Centennial Brown						
10 seeds/ft ²	2	a	3	c	2	a
14 seeds/ft ²	2	a	4	b	2	a
18 seeds/ft ²	2	a	5	a	2	a
22 seeds/ft ²	2	a	5	a	2	a
26 seeds/ft ²	2	a	5	a	2	a
LSD			0.0		0.0	
CV(%)	50.0		13.9		32.0	
Seed Rate						
10 seeds/ft ²	2	a	3	c	2	a
14 seeds/ft ²	2	a	4	b	2	a
18 seeds/ft ²	2	a	4	b	2	a
22 seeds/ft ²	2	a	5	a	2	a
26 seeds/ft ²	2	a	5	a	2	a
LSD	0.0		0.0		0.0	
CV(%)	50.0		12.6		31.0	
Variety						
AAC Brown 18	2	a	4	a	2	a
Centennial Brown	2	a	4	a	2	a
LSD	0.0		0.0		0.0	
CV(%)	50.0		12.6		31.0	

Table 13. Hybrid Brown and Centennial Brown mustard days to maturity at increasing seeding rates in Swift Current, Indian Head and Redvers (Days, 2020-2022). Means within a column followed by the same letter do not significantly differ.

Days to Maturity	Swift Current		Indian Head		Redvers	
	-----days-----					
Seed Rate x AAC Brown 18						
10 seeds/ft ²	86	a	82	a	82	a
14 seeds/ft ²	86	a	82	a	82	a
18 seeds/ft ²	86	a	81	b	82	a
22 seeds/ft ²	86	a	81	b	82	a
26 seeds/ft ²	86	a	81	b	81	b
LSD	0.0		0.0		0.0	
CV(%)	1.5		0.6		1.4	
Seed Rate x Centennial Brown						
10 seeds/ft ²	86	a	84	a	83	a
14 seeds/ft ²	86	a	83	b	83	a
18 seeds/ft ²	85	a	83	b	82	b
22 seeds/ft ²	85	a	83	b	82	b
26 seeds/ft ²	85	a	82	c	81	c
LSD	1.0		0.0		0.0	
CV(%)	1.6		0.5		1.2	
Seed Rate						
10 seeds/ft ²	86	a	83	a	83	a
14 seeds/ft ²	86	a	83	a	83	a
18 seeds/ft ²	85	b	82	b	82	b
22 seeds/ft ²	85	b	82	b	82	b
26 seeds/ft ²	85	b	81	c	81	c
LSD	0.0		0.0		0.0	
CV(%)	1.5		0.5		1.0	
Variety						
AAC Brown 18	85	a	82	b	82	a
Centennial Brown	85	a	83	a	82	a
LSD	0.0		0.0		0.0	
CV(%)	1.5		0.5		1.0	