Saskatchewan AgriARM Applied Research Management

Wheatland Conservation Area Inc.
Swift Current, SK.

Demonstrating Nitrogen Fertilizer Responses in Yellow and Brown Mustard

Project #20170402

Start Date: April 1, 2018
End Date: March 1, 2019

ADOPT 2018

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Final Report

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2018 Report

Abstract

In 2018 a trial took place in Swift Current Saskatchewan titled "Demonstrating Nitrogen Fertilizer Response to Yellow and Brown Mustard." This project consisted of a 4-replicate RCBD demonstration with increasing rates of nitrogen (0, 30, 50, 70, 90, 110 lbs of total N/ac) applied to Andante yellow mustard and a new Brown Hybrid Mustard variety (AAC Brown 18) to demonstrate optimum fertility management practices and dismiss the myth that mustard does not respond to inputs as well as other crops. Potential yields for the 2018 growing season were closely related to above average temperatures and low precipitation. Both yellow and the Brown Mustard Hybrid responded positively to increasing rates of nitrogen fertilizer, with brown outperforming and yielding a stronger response. Adequate nitrogen fertility is one of the most important agronomic practices for achieving high yields of mustard in Saskatchewan and developing a response curve over multiple years will be very useful for producers. This trial was brought to the attention of the group on the Annual Field Day on July 19, 2018 and was also promoted on a CKSW radio program called "Walk the Plots" which was broadcasted on a weekly basis throughout the summer. This project was also presented by Amber Wall from Wheatland Conservation Area at the Crop Production Show on January 17th, in Saskatoon in as a part of the Mustard Meetings, as well as by Chris Baan, a Wheatland Conservation Area Director at the Agri-ARM update.

Project Objectives

The objective of this project is to demonstrate to producers' optimum fertility management practices in yellow and brown mustard, by varying nitrogen fertilizer rates and to promote the findings of Dr. Ross McKenzie that dismiss the myth that mustard does not respond to inputs as well as other crops[1].

[1] Mustard fertilizer management. Grain News. Ross McKenzie. March 23, 2016. https://www.grainews.ca/2016/03/23/mustard-fertilizer-management/

Project Rationale

Fertilizer recommendations and other agronomic information for mustard production is predominantly based on mid-1970s data and area producers have traditionally thought of mustard as an inexpensive crop to grow, requiring fewer inputs such as nitrogen. However, more recently research scientist Ross McKenzie with Alberta Agriculture, Food and Rural Development (AAFRD) at Lethbridge has completed a four-year study to update the recommendations for mustard production. The results of his study in southern Alberta show a high response to nitrogen fertilizer and producers can benefit from higher yields by investing in crop inputs. Juncea mustards (brown and oriental) were somewhat more responsive than yellow mustards at most sites. McKenzie says that the optimum N fertilizer rate is a function of stored soil N, stored soil moisture (SSM) at seeding and expected growing season precipitation (GSP). This project is relevant to producers in numerous ways. By preventing both under application or over application of nutrients will benefit producers financially and environmentally. Since the traditional way of thinking suggests a mustard crop requires fewer inputs, there may be a tendency to under apply nutrients resulting in lower yields and less profits. By establishing a nitrogen response curve for mustard crops in SW Saskatchewan, similar to that recently established by Dr. McKenzie in Lethbridge, area producers can benefit by targeting optimal application rates.

Methods

This trial was direct seeded into durum stubble using a Fabro Cone Seeder with Atomjet openers and 9" row spacing. Helix Vibrance was applied as a pre-seed treatment. Treatments 2-6 and 7-12 received a blanket application of 30lb/ac 11-52-0 and 25lb/ac 21-0-0-24 to maximize mustard fertility. Having a previously dry year, spring soil tests revealed that a relatively high amount of nutrients (30lbs/ac N) already remained in the soil, therefore treatment 1 and 7 "using available soil nitrogen only" did not receive the blanket application of P and S like all other treatments. Therefore, Treatment 2 and 8, with "30lbs/ac of nitrogen" that did receive the blanket application became a check treatment and will be used as the control in this project. Treatment 1 and 7 received no additional fertilizer are simply a reference as to how mustard would look using soil nutrients only.

This project consisted of varying nitrogen treatments in both andante yellow mustard and hybrid brown mustard and included 4 reps to better demonstrate consistent fertility effects. Fertilizer N was added to the amount of stored soil N to achieve the following rates of total available N.

1) Stored soil N only- Yellow mustard
2) 30 lb/ac total N (Stored soil + Fertilizer N) - Yellow mustard
3) 50 lb/ac total N (Stored soil + Fertilizer N) - Yellow mustard
4) 70 lb/ac total N (Stored soil + Fertilizer N) - Yellow mustard
5) 90 lb/ac total N (Stored soil + Fertilizer N) - Yellow mustard
6) 110 lb/ac total N (Stored soil + Fertilizer N) - Yellow mustard
7) Stored soil N only- Brown mustard
8) 30 lb/ac total N (Stored soil + Fertilizer N) - Brown mustard
9) 50 lb/ac total N (Stored soil + Fertilizer N) - Brown mustard
10) 70 lb/ac total N (Stored soil + Fertilizer N) - Brown mustard
11) 90 lb/ac total N (Stored soil + Fertilizer N) - Brown mustard
12) 110 lb/ac total N (Stored soil + Fertilizer N) - Brown mustard

The following measurements were taken:

- Soil Sample to determine stored soil nitrogen
- Crop Establishment – plants/m^2
- Crop Height – cm
- Yield – bu/ac
- Pictures to capture visual differences for extension purposes

Other field notes were as follows:

02-May Spring Composite Soil Sample (0-6", 6-24") sent to Agvise Laboratories for analysis
15-May Pre-seed burnoff @ .67 l/ac of RT540
22-May Direct seeded with Fabro plot drill: atomjet knife openers; 9" row spacing

Variety: Mustard Trial
T1-T6 Andante Yellow Mustard @ 10lbs/ac
T7-T12 AAC Brown 18 @ 6lbs/ac

Mustard Demo
Andante Yellow Mustard @ 10lbs/ac
AAC Brown 18 @ 6lbs/ac
Carinata @130 seeds/m2

TKW: Yellow TKW=5.7g
AAC Brown 18 TKW=2.87g
Carinata TKW=4g (85% germ)

Fertility: Mustard Trial
Sidebanded all fertilizer
T1, T7 – Soil Nutrients Only
T2-T6, T8-T12 (30 lbs/ac **11-52-0** + 25 lbs/ac **21-0-0-24**)
T3, T9 **(46-0-0)** @ 26 lbs/ac
T4, T10 **(46-0-0)** @ 69.5 lbs/ac
T5, T11 **(46-0-0)** @113 lbs/ac
T6, T12 **(46-0-0)** @ 156.5 lbs/ac

Mustard Demo – 100#N (**30-15-0-6** @ 333lbs/ac)

13-Jun Irrigated 1" on Trial, ½" on Demo
26-Jun Irrigated ½" on Trial and Demo
11-Sep Combined mustard plots with Zurn Combine (7 rows)
22-Oct Combined Carinata (7 rows)

General Site Conditions

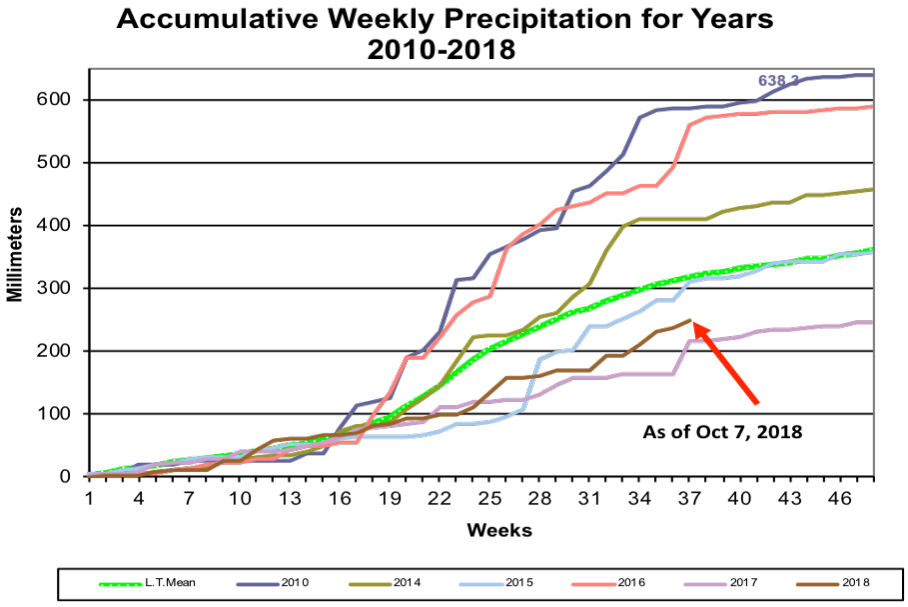

Figure 1. Accumulative weekly precipitation for years 2010-2018.

Similar to last growing season, accumulative precipitation was well below the mean and moisture deficient conditions caused major crop stress resulting in poor development and yield. Heat quickly advanced crop maturity over the summer and caused stress to the canopy. These adverse growing conditions made it difficult, in many cases, to show consistent treatment responses. Scattered rain showers were welcomed early in the season but preceded drought conditions as soil moisture quickly became depleted with a bout of extremely dry, hot days that continued throughout the next few months and into harvest (Figure 1). Dry field conditions were not ideal for germination, resulting in topsoil to quickly deteriorate giving patchy establishment. Uneven germination throughout the plots was present through the growing season, as a rainfall near the end of June caused a variety of growth stages to emerge at once. Extreme heat and strong winds throughout August continued to cause stress, rapid dry down, environmental damage and advanced crops quickly. A late rain mid-July helped to even out patchy emergence and to fill otherwise empty heads and pods, but by the second week of August, topsoil moisture on cropland was rated as 10% adequate, 40% short and 50% very short and continued to decline. Adverse growing conditions made it very difficult, in many cases, to show consistent treatment response. A temperature map in the Prairie Region of Canada of this year's growing season (Figure 2) shows above average temperatures indicated by the red areas[2]. Southwest Saskatchewan experienced more than 24 days above 30 degrees Celsius, leading to a significant reduction in mustard canopy and overall yield.

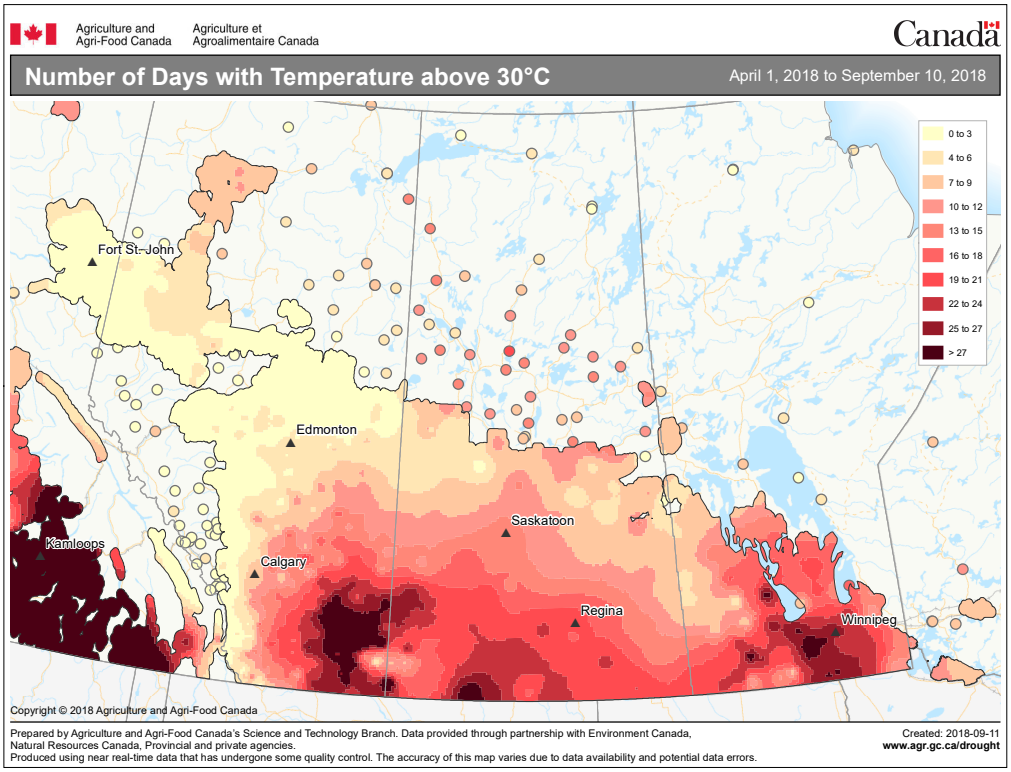

Figure 2. A temperature map of the prairie region of Canada, showing April 1, 2018 – September 10, 2018 provided by Agriculture and Agri-food Canada.

[2] http://www.agr.gc.ca/DW-GS/historical-historiques.jspx?jsEnabled=true

Results

The lack of moisture and hot temperatures negatively impacted crop production in 2018. According to the Crop Report, yields vary greatly throughout the province, depending on how early the crop was seeded and the amount of moisture received throughout the growing season[3]. With the continuation of warm temperatures and lack of precipitation, topsoil moisture conditions deteriorated and harvest quickly advanced in the southwest region. Yields in much of the south western region were greatly affected by the extended period of hot and dry conditions. Many crops did not fill properly as their source of moisture was depleted from the initial time of seeding through to harvest. Overall, emergence was delayed in many areas by the extremely dry field conditions. Area crops were patchy in growth and behind normal developmental stages throughout the growing season before quickly advancing through bouts of heat during important processes like flowering and pod fill. Majority of crop damage can be attributed to lack of moisture, strong winds, heat stress and hail damage.

Seedling emergence varied considerably due to mustard seeds requirement for a moist seed bed and the corresponding sensitivity to environmental and soil conditions. A dry seedbed likely reduced plant emergence and caused non-uniform plots, especially early in the growing season as the greatest amount of nitrogen would have been taken up in early stages to promote root, leaf and stem growth[4]. A denser crop stand would have also made the trial more competitive with weeds. Yellow mustard seed is larger and almost consistently showed higher plant emergence than brown with the exception of the soil nutrients only treatment, although was not statistically significant (data not shown).

Emergence did not necessarily correspond yield for a number reasons that could include lower emergence plots may have resulted in increased pod formation, more room to branch and lead to higher seed set on each plant. Both Andante yellow and the new Brown Mustard Hybrid (AAC Brown 18) responded positively to increasing applications of nitrogen fertilizer. In terms of overall yield, all six brown mustard treatments yielded higher compared to yellow mustard of the same nitrogen treatment. Compared to yellow mustard, hybrid brown showed a 45.8% increase at a rate of 110# of N (Figure 3).

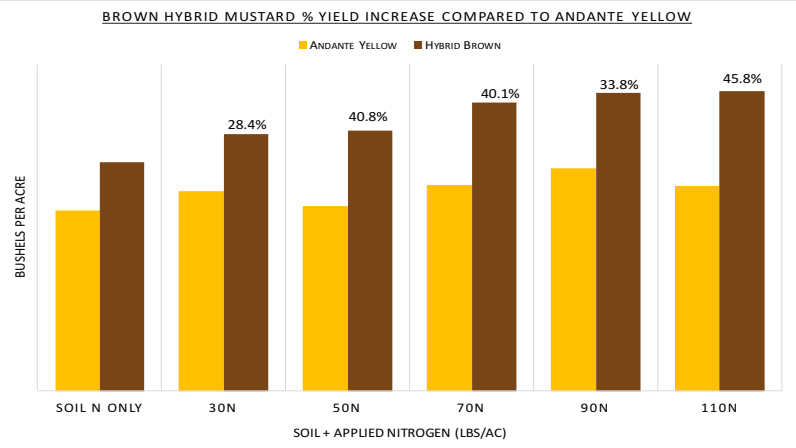

Figure 3. Brown Hybrid Mustard percent yield increase over Andante yellow mustard at increasing rates of nitrogen in lbs/ac.

[3] https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/market-and-trade-statistics/crops-statistics/crop-report
[4] https://saskmustard.com/production-manual/index.html

The highest yielding brown mustard treatment resulted from 110# of N, (25.7 bu/ac) but was not significantly higher than the next best yield (25.5 bu/ac) resulting from 90# of N (Figure 4). In terms of yield, the optimum nitrogen rate for hybrid brown was 90-110 #N. Yield positively increased with nitrogen rate, signifying an obvious response to fertilizer inputs. Optimum nitrogen rate is a function of available soil nitrogen, spring stored soil moisture and expected precipitation during the growing season. Although stored soil moisture was at an extreme low, 90-110# of total nitrogen yielded very good in terms of the new Hybrid Brown Mustard, 17% higher than the control (Table 1). According to the gradual increase in yield demonstrated here, if growing season precipitation was increased giving the plant higher capability of nitrogen uptake, 110# of N may have resulted in significantly higher yields than all other treatments.

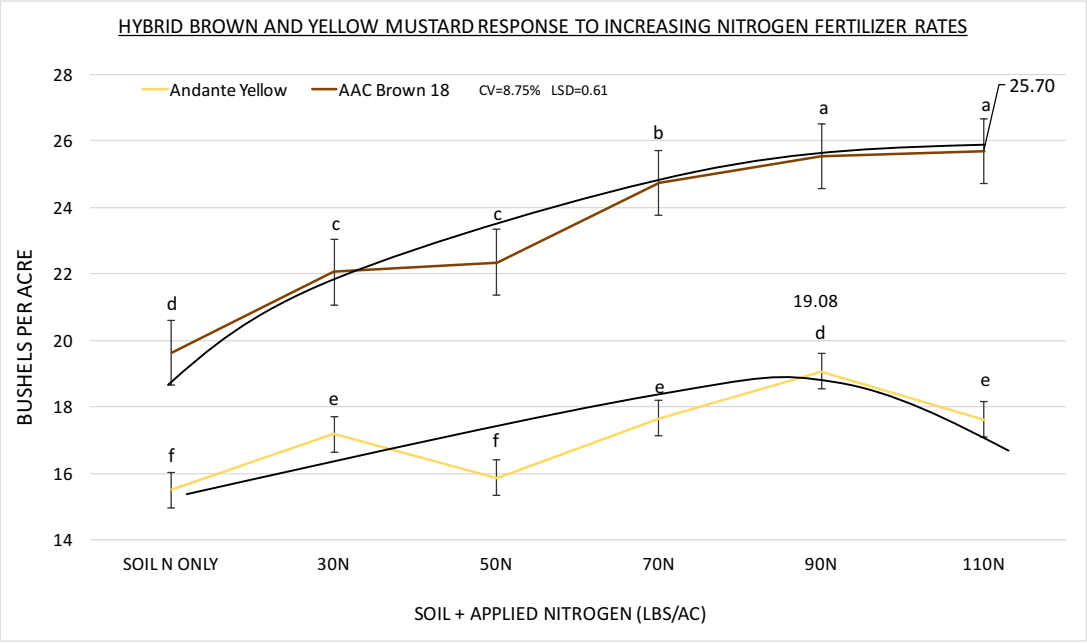

Figure 4. Brown Hybrid Mustard and Andante yellow mustard yield in bushels per acre in response to increasing rates of nitrogen fertilizer. (CV=8.75%, LSD=0.61, P<0.05)

The optimum treatment for yellow mustard in terms of yield was also 90# of N and yielded 19.08 bushels per acre (Figure 4). The highest nitrogen rate applied to yellow mustard may not have responded as strong due to extremely low stored soil moisture in the spring and relatively high amounts of nitrogen remaining in the soil from 2017. As moisture increases, the need for nitrogen fertilizer increases, therefore 90# N was adequate for yellow mustard this particular year. Similar to yellow mustard, if growing season precipitation had been increased 110# would likely have resulted in significantly higher yields than all other treatments. The nitrogen rate of 90# yielded 11% higher than the control treatment (Table 1). This reiterates the fact that mustard has a high response to nitrogen fertilizer inputs and producers can use the optimum rate to maximize yield increases that will benefit them financially and environmentally by avoiding under applying nutrients that leaves them with less yield and less profit.

Table 1. Percent yield relative to 30 # of Nitrogen.

Percent Yields relative to 30# N

	Andante Yellow Yield			Hybrid Brown Yield		
	% yield of 30 #N		bus/ac	% yield of 30 #N		bus/ac
SOIL N ONLY	N/A		15.50	N/A		19.63
30N	100%	a	17.18	100%	a	22.05
50N	92%	b	15.88	101%	a	22.35
70N	103%	a	17.65	112%	b	24.73
90N	111%	c	19.08	116%	c	25.53
110N	103%	a	17.63	117%	c	25.70

Another notable agronomic difference aside from yield was height. Again, all six nitrogen treatments on brown mustard grew significantly taller than all yellow mustard treatments (Figure 5). The tallest brown treatment was 110# N (106.4 cm) and was significantly different than all other nitrogen rates. The tallest treatment in the yellow mustard resulted from 30# N (75.1 cm), a difference of 31.2 cm. Yield, depicted by the orange line and corresponding to the right axis shows that nitrogen uptake up may have been allocated to plant biomass, but did not necessarily translate into higher yields. Perhaps shorter plants resulted in greater branching, therefore more pods and increased seed set compared to a taller plant with less pods. Plant heights within the brown are not highly variable, but did show differences in yield, as well as for yellow treatments the heights are not significantly different, but we did see a relatively positive slope in yield. Again, in term of height, Brown Hybrid Mustard appeared to respond better to nitrogen and would have been more significant if influenced by increased water availability.

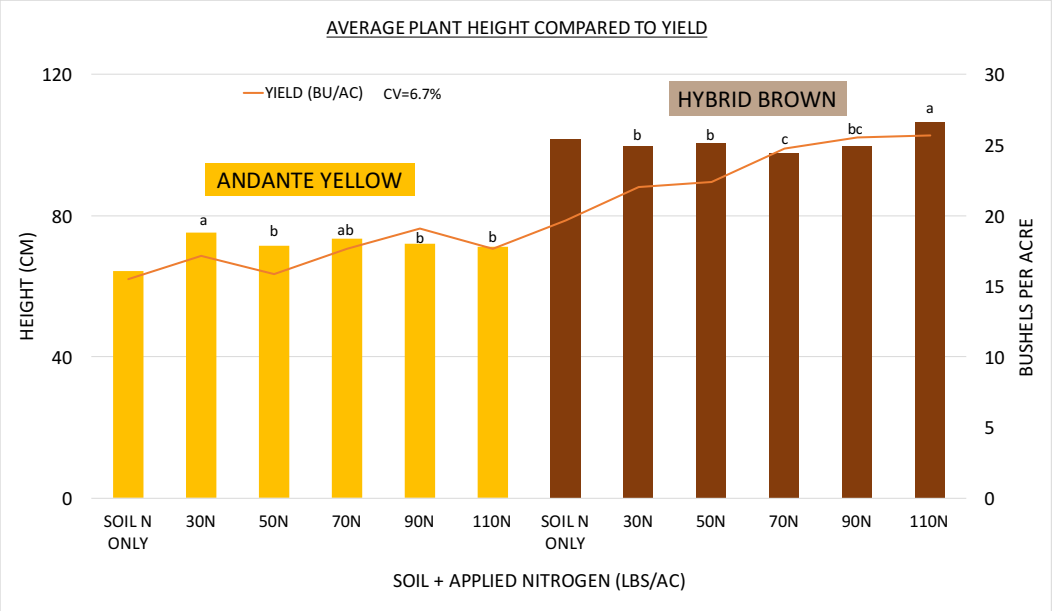

Figure 5. Brown Hybrid Mustard and Andante yellow mustard height in centimeters in response to increasing rates of nitrogen fertilizer. (CV= 6.7%, LSD=0.97, P<0.05)

A mustard demo was also established in 2018 to demonstrate side by side comparisons of carinata, centennial brown and the new brown hybrid. Carinata is another emerging bio-economy opportunity as industrial oil feedstock for the transportation industry and was included in the demo for visual and yield comparisons to conventional mustards used today[5]. All three crops were seeded at 6lbs/ac and all fertilizer side-banded at 100# N (333lbs/ac 30-15-0-6). Brown Hybrid Mustard yielded 22.97 bushels per acre compared to the Centennial brown check variety at 20.48 bushels per acre (Figure 7), but Brown Hybrid Mustard yield increases of up to 30% compared to the centennial brown have been seen in trials across Saskatchewan and Alberta[6]. Carinata yielded 13.93 bushels per acre, quite low compared to other trials conducted across Saskatchewan in previous years, likely due to poor germination.

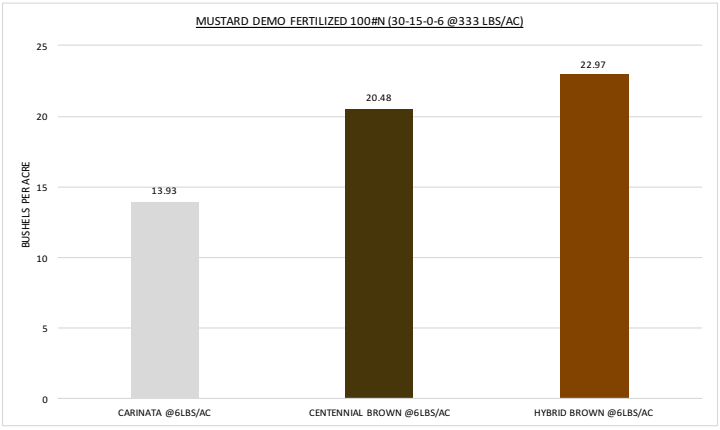

Figure 7. Yield shown in bushels per acre resulting from a mustard demo involving Carinata, Centennial brown, and AAC Brown 18.

This information compliments of the research of Bifang Cheng at AAFC in Saskatoon as the mustard hybrid technology can outperform conventional mustard varieties to stay competitive with domestic crops and global export[7]. AAC Brown 18 is the first Brown Hybrid Mustard that will be available, 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.

This trial was brought to the attention of the group on the Annual Field Day held July 19, 2018 (120 participants) by Matthew Bernard the provincial oilseed specialist and was also promoted on a CKSW radio program called "Walk the Plots" that was broadcasted on a weekly basis throughout the summer. Results of this trial were presented at winter meetings and workshops including Crop Production Week in Saskatoon on January 17th by Amber Wall of Wheatland Conservation Area at the Mustard Meetings[8], as well as Chris Baan, a Wheatland Conservation Area director at the Agri-ARM research update. Results will be also shared locally at Cropportunities 2019 on March 13th in Swift Current (200+ expected participants). A summary will also be posted on our website at www.wheatlandconservation.ca.

[5] https://agrisoma.com/wp-content/uploads/2018/10/2017_18_SE_Handbook.pdf
[6] https://saskmustard.com/wp-content/uploads/2019/01/2019-New-varieties-Bifang.pdf
[7] Condiment Mustard Breeding: Update. Bifang Cheng. Agriculture and Agri-Food Canada, Saskatoon Research Center. https://saskmustard.com/wp-content/uploads/2018/01/2018-New-Varieties-Bifang.pdf
[8] https://saskmustard.com/wp-content/uploads/2019/01/2019-Nitrogen-fertilizer-WCA-Wall-.pdf

Conclusions and Recommendations

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[9]. 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. In the past growers have traditionally thought of mustard as an inexpensive crop to grow, requiring fewer inputs resulting in lower yields. As AAC Brown 18 becomes available, it is important for growers to have a nitrogen response curve developed to avoid under, or over applying nutrients so as to maximize return and achieve the yield hybrid seed is capable of. The first developed condiment hybrid brown mustard is expected to launch commercially in 2020. 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 making a significant increase in yield a main strategic priority for Mustard 21[9].

This project demonstrated that mustard is highly responsive to fertilizer inputs, specifically nitrogen, which is the most influential agronomic factor controlling mustard yield and quality. For brown mustard, nitrogen was limiting on the low-end using available soil nutrients only and maximized on the high end of 110# of N in this particular year. For future demonstrations, rates should go above what was needed to find the optimum nitrogen rate. Nitrogen was also limiting for yellow mustard and yield only continued to increase with nitrogen until an optimal rate was reached at 90# of N. Overall, brown mustard yields were significantly greater than yellow mustard yields. As nitrogen uptake is directly correlated with stored soil nitrogen and moisture, nitrogen response may have appeared more effective in a greater precipitation year.

In recent years, producers may have been hesitant to grow mustard after the considerable fluctuations in price and production. Due to the drought experienced in 2017, mustard production was extremely low. Resulting high prices had a driving effect for seeded acres in 2018 being 31% more than the year before, therefore supplies are now expected to be comfortable, if not heavy[9]. Once again, prices are reflecting that and bids for all 3 mustard types are down, mainly in brown mustard. An increase in seeded acres was also seen in Canada's main customers in the US, as well as the European Union due to a large crop in Russia. This discouraging outlook for Canada may carry on for a few years, however if acreage significantly drops in 2019 again, a market recovery could follow. As other hybrid mustards such as oriental and synthetic yellow become available in the coming years other important traits like oil and protein content can be selected for to ensure Canada's place in mustard export for the future. More research should be done to develop a newly updated nitrogen response curve as well as an optimum seed rate to further demonstrate important differences between the Centennial brown check and the new Brown Hybrid Mustard (AAC Brown 18).

Acknowledgements

We thank the Ministry of Agriculture for all our ADOPT projects including plot signage and verbal acknowledgement at field days and on PowerPoint slides during presentations. This will continue at each venue where an extension activity occurs. We also thank Shannon Chant with the Saskatchewan Ministry of Agriculture for her help as well as the Saskatchewan Mustard Development Commission.

[9] https://saskmustard.com/wp-content/uploads/2018/12/SMDC_Mustard-Grower-Newsletter-Winter-2018.pdf

Appendix 1. Approved Budget

Project #2017402

	Year 1	Year 2	Total
Salaries and Benefits			
Students			
Postdoctoral / Research Associates			
Technical / Professional Assistants			
Consultant Fees & Contractual Services	$7,700		$7,700
Rental Costs			
Rentals			
Materials / Supplies			
Project Travel			
Field Work			
Collaborations/consultations			
Other			
Field Day	$300		$300
Administration	$400		$400
Miscellaneous			
Total	$8,400		$8,400