2017 Annual Report for the Agriculture Demonstration of Practices and Technologies (ADOPT) Program

Project Title: EVALUATING YIELD POTENTIALS THROUGH SEEDING DATES IN YELLOW AND ORIENTAL MUSTARD

Project Number: 20160379

Producer Group Sponsoring the Project: Western Applied Research Corporation

Project Location(s):

- Scott Saskatchewan, R.M. #380 Legal land description: NE 17-39-20 W3

Project start and end dates (month & year): May 2017 and completed January 2018

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Objectives and Rationale

Project objectives:

The objective of this project is to demonstrate the advantages and disadvantages to various seeding dates for mustard production.

Project Rationale:

Precipitation and high summer temperatures are two of the main limiting factors in the Canadian Prairies. Mustard is considered to be a crop that is more tolerant to heat stress than other oilseeds, but there is still a yield loss when temperatures are too high during critical points in the plants life (flowering). Often, mustard is grown and seeded later within the season, but it is now known that planting earlier may result in yield benefits. Many studies have been conducted to show that mustard is more frost tolerant than other seeds, and can germinate in soils that are 4°C. It is therefore a good candidate to be seeded early in the spring. Mustard has also been shown to thrive with the early spring moisture, as well as the earlier the flowering the less chance there is heat stress.

This project looked at various seeding dates to determine which timing will result in the greatest yield benefits. We are looking at getting a better, more exact, recommendation for growers in the West Central area. The varieties chosen will be a yellow mustard, and an oriental mustard, as they are most commonly grown in West Central Saskatchewan.

Methodology and Results

Methodology:

The demonstration was arranged as a randomized complete block design with four replicates at Scott 2017. The treatments consisted of two varieties (yellow and oriental mustard) and six seeding dates, spaced approximately 10 days apart beginning from end of April to mid-June. Actual seeding dates started early May rather than late April due to late frost, snowfall and excessive moisture. The plots were direct-seeded into wheat stubble using an R-Tech plot drill on ten-inch row spacing. Weeds and diseases where be controlled using registered herbicide and foliar fungicide applications (Appendix A1). Soil temperature and soil moisture were collected at time of seeding (Appendix A2).

Table 1: Treatment list representing treatment numbers, variety and seeding date.

Treatment #	Variety	Seeding Date	Actual Seeding Date
1	Yellow: AC Pennant	End of April	May 4th
2	AC Pennant	Begin of May	May 12th
3	AC Pennant	Mid- May	May 24th
4	AC Pennant	End of May	June 2nd
5	AC Pennant	Begin of June	June 12th
6	AC Pennant	Mid- June	June 23rd
7	Oriental: Cutlass	End of April	May 4th
8	Cutlass	Begin of May	May 12th
9	Cutlass	Mid- May	May 24th
10	Cutlass	End of May	June 2nd
11	Cutlass	Begin of June	June 12th
12	Cutlass	Mid- June	June 23rd

Data Collection:

Soil temperature and moisture were collected at time of seeding. Plant densities were determined by counting numbers of emerged plants on 2 x 1 meter row lengths per plot approximately two weeks after emergence. Yields were determined from cleaned harvested grain samples and corrected to 10% moisture content. Seed quality analyses were done to determine thousand kernel weights. Weather data was recorded from the online database of Environment Canada weather station.

Growing Conditions:

The 2017 growing season started with great soil moisture in April and May with 30.9 mm and 69 mm of precipitation, respectively. Midseason growing conditions in June and July were very dry with 51% and 68% less precipitation compared to the long-term average. Throughout the growing season, the temperature was very similar to the long-term average. Frost occurred on several occasions with a nightly low of -0.02 ^{o}C, -1.6 ^{o}C, -2.7 ^{o}C on May 15th, 16th and 18th, respectively. Growing degree days were higher than the long-term average for the months of May and July, and lower for the remaining months (Table 2).

Table 2. Mean monthly temperature, precipitation and growing degree day accumulated from April to September in 2016 and 2017 at Scott, SK.

Year	April	May	June	July	August	Sept.	Average /Total
---*Temperature (°C)* -------------------------------------							
2016	5.9	12.4	15.8	17.8	16.2	10.9	13.2
2017	3.0	11.5	15.1	18.3	16.6	11.5	12.7
Long-term[z]	3.8	10.8	14.8	17.3	16.3	11.2	12.4
---*Precipitation (mm)*------------------------------------							
2016	1.9	64.8	20.8	88.1	98.2	22.2	296
2017	30.9	69.0	34.3	22.4	53	18.9	228.5
Long-term[z]	24.4	38.9	69.7	69.4	48.7	26.5	277.6
--*Growing Degree Days*---------------------------------							
2016	58.9	224.9	303	398.7	343.8	176.2	1505.5
2017	16.6	202.7	283.3	399.1	348.4	194.8	1444.9
Long-term[z]	44	170.6	294.5	380.7	350.3	192.3	1432.4

[z]Long-term average (1985 - 2014)

Analysis:

The data was analysed using PROC MIXED in SAS 9.4. The residuals were tested for normality and equal variance to meet the assumptions of ANOVA. The means were separated using a Tukey's Honestly Significant Difference (HSD) test with level of significance at 0.05. Replications were treated as random effect factor whiles treatments were fixed effect factors. Seeding date was assessed using PROC GLM for a regression analysis for plant density, yield and thousand kernel weights. A significant interaction occurred between variety and seeding date for plant density, yield, and seed size. Yellow and oriental mustard were separated to determine the effect of seeding date on the individual mustard classes for plant density, yield and seed size.

Results & Discussion:

Early seeding is recommended for all mustard classes and can be critical to obtaining full yield potential (Saskatchewan Mustard Development Commission, 2017). Early planting may increase the likelihood of utilizing early spring moisture, however, decreased plant stands typically occur due to strained environmental conditions. Timing of seeding played a crucial role in oriental mustard (TKW 2.8 g) emergence (P=<0.0001) (Table 3). Early, mid, and late seeding in May resulted in a 51%, 19%, and 26% stand reduction of oriental mustard compared to plant densities seeded in June, respectively (Figure 1). On average, plant densities of oriental mustard increased linearly by 32% with delayed seeding into June.

Plant densities of yellow mustard (AC Pennant) at both seeding date intervals (May vs. June) exhibited a trend relating to seeding date, however, a significant linear increase was not detected (Table 3). Plant densities tended to remain consistent after the earliest May seeding date with an average plant density increase of 21% (Figure 1).

Table 3. The P values were generated using a Two-way Analysis of Variance ($P < 0.05$) to determine the effect of variety and seeding date on plant density (plants m^{-2}), yield (bu ac^{-1}) and thousand kernel weights (g 1000 $seeds^{-1}$) at Scott, 2017. Treatment means were generated and separated using Tukey's HSD.

	Plant Density	**Yield**	**Thousand Kernel Weights**
	(plant m^{-2})	bu ac^{-1}	g 1000 $seeds^{-1}$
Variety (Vr)	0.0396	0.2377	<0.0001
Seeding Date (SD)	<0.0001	<0.0001	0.0041
Vr x SD	0.0013	0.0162	0.0247
Oriental (Cutlass) x Seeding Date	<0.0001	0.0004	0.0093
Yellow (AC Pennant) x Seeding Date	0.0148	0.0019	0.0219

Early seeding resulted in a decreased stand establishment for yellow and oriental mustard. The lowest plant densities were recorded when seeding occurred in early May. This is likely attributed to the frost that occurred after emergence, as well as the high incidence of flea beetles noted at mid-May. Plant density of oriental mustard was more severely affected by timing of seeding compared to yellow mustard. This could be attributed to the difference in seed size, as the oriental mustard was a smaller seed variety (>3 g per 1000s) that resulted in lower plant densities throughout all of May. In contrast, yellow mustard had a lower plant density for early May but tended to remain consistent throughout the remaining seeding dates. This could be attributed to seed size, as yellow mustard has a larger seed size and has a slightly higher emergence percentage compared to other mustards (Alberta Agriculture and Forestry, 2016). Overall, plant densities tended to increase for both mustard varieties throughout mid-May until end of June. This is likely attributed to warmer temperatures, timely rains and lower flea beetle population at the end of May that coincided with emergence of mid-May to late June seeding dates.

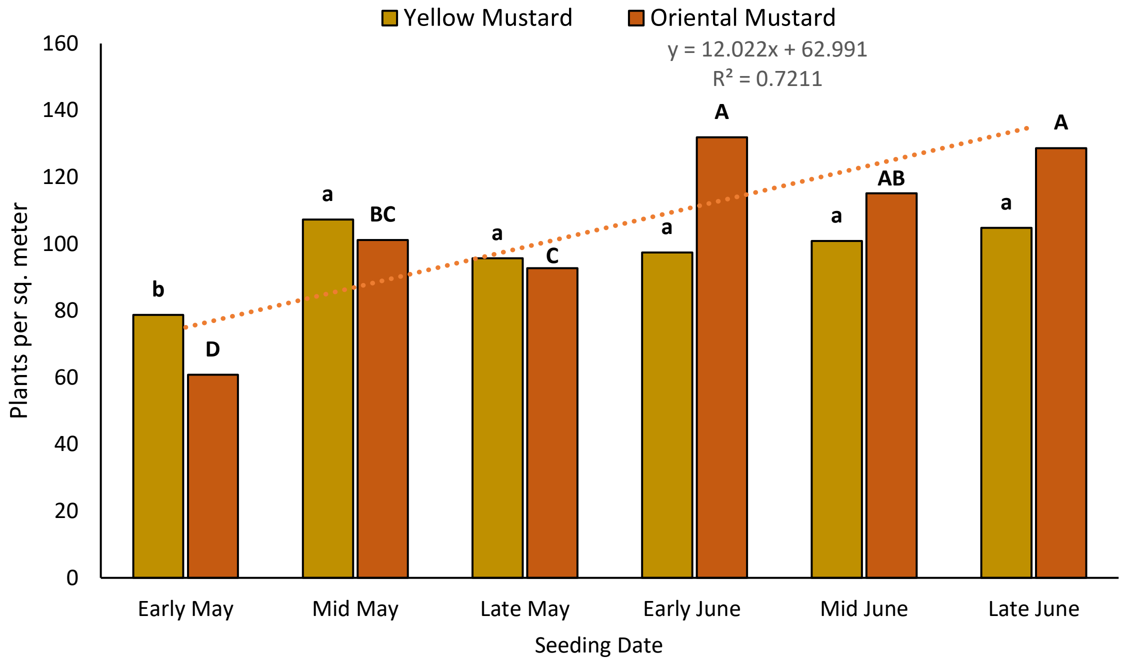

Figure 1. Seeding from early, mid, late- May to early, mid, late- June of oriental mustard (Cutlass) resulted in a significant linear (P=0.0353) increase in plant density at Scott, 2017. Timing of seeding did significantly (P=0.0162) improved plant density of yellow mustard (AC Pennant) when seeded after early may at Scott, 2017. Different letters indicate a significant difference (P < 0.05).

Early seeding in May resulted in a substantial yield reduction of 9 bu per acre in yellow mustard (Figure 3). Yield reductions are likely not attributed to poor stand establishment, regardless that the targeted vs achieved plant densities were significantly different (10 lbs. per acre vs. 7 lbs. per acre). Yellow mustard has a very large capacity to compensate for low plant density by producing more branches and pods per plant (Brandt 1992). Brandt (1992) reported that yield fully compensated when stand establishments were ≥ 7 lbs. per acre, indicating yield losses are likely not attributed to plant densities.

Based on the capacity of yellow mustard to compensate for a low stand establishment, yield reductions are likely associated with shatter losses. The trial randomization altered yellow and oriental mustard of the same seeding date between replicates, resulting in the yellow mustard being located between two oriental mustard plots (Figure 2). The oriental mustard matured much slower compared to the yellow mustard. Access to the fast-maturing yellow mustard was not feasible. Harvest was delayed until the oriental mustard reached maturity and thus allowed for over-ripening and shatter of the yellow mustard pods.

Figure 2. The study randomization for yellow and oriental mustard seeding date with yellow mustard seeding in replicates one and three and oriental mustard seeding in replicates two and four.

Yield losses due to shattering resulted in a skewed quadratic response to seeding date, indicating that mid- May would result in maximized yield (Figure 3). The demonstration results would likely coincide with current recommendations if shatter losses had not occurred. Current recommendations suggest that seeding in early May will result in a yield increase, as early emerged plants can better utilize spring soil moisture. Early seeding also ensures that plant maturity occurs prior to high temperatures, reducing the occurrence of heat-stress related bud abortion. In a 2006-08 study in Saskatoon, Saskatchewan, yields of yellow mustard increased on average by 1.4 to 2.2 bu per acre when the crop was seeded in early to mid-May versus late May to early June. Brandt (1992) also reported that seeding between May 1st and May 26th had a small impact on yield in most years. Brandt (1992) noted yield reduction from 13% up to 31% were recorded when seeding was delayed from early to late June. Similarly, delayed seeding into June had a detrimental effect on yellow mustard yield resulting in a 29% yield loss. Delayed seeding resulted in a nine-day shorter maturity period compared to mustard seeded in May. A shorter day to maturity period reduces the length of time in which plants can produce and develop seeds, resulting in fewer and smaller seeds as seeding is delayed. Although the later seeded mustard reached physiological maturity quicker, earlier seeded mustard was ready to harvest up to 14 days earlier. Overall, yellow mustard should be seeded in early May to mid-May in order to maximize yield production and seed size.

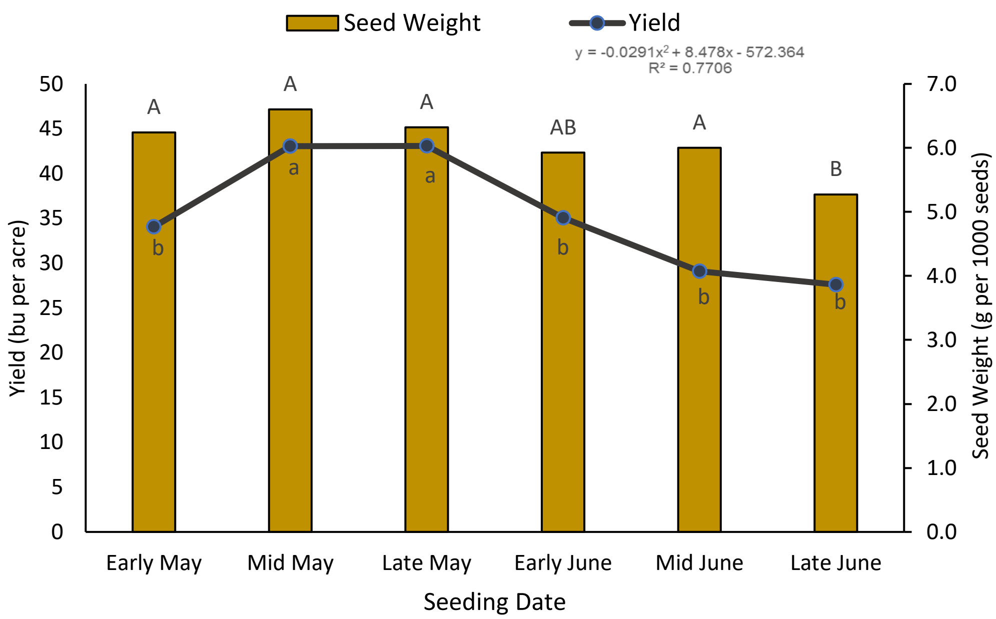

Figure 3. Seeding date had a significant linear and quadratic effect (P= 0.035; <0.0001) on yield (bu per acre) and a significant effect (P= 0.0219) on seed size (g per 1000 seeds) of yellow mustard (AC Pennant). Different letters indicate a significant difference (P < 0.05).

Timing of seeding played a significant (P= 0.004) role in oriental mustard yield production (Table 3). Seeding date (early May, mid-May and early June) resulted in a 13 bu per acre yield reduction compared to late May and early June timings (Figure 4). Yield reductions in May are attributed to poor stand establishment as targeted vs achieved plant densities varied greatly for early May (6 lbs. per acre vs. 2 lbs. per acre) and mid-May (6 lbs. per acre vs 3 lbs. per acre). Brandt reported that a substantial yield occurred when plant densities dropped below 3.5 lbs. per acre. Thus, stand establishment for early and mid-May fell below the acceptable threshold resulting in a yield penalty. The quadratic response of oriental mustard to seeding date indicated that late May seeding date would result in the highest yields of 48 bu per acre (Figure 4).

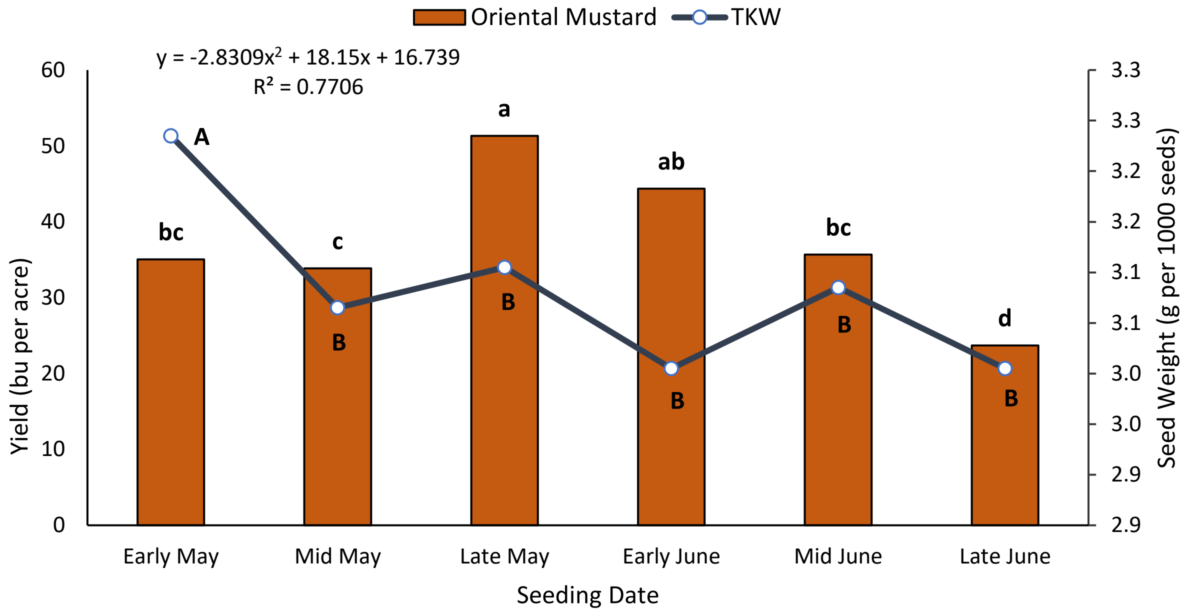

Figure 4. Seeding date had a significant linear and quadratic effect (P= <0.0001; <0.0001) on yield (bu per acre) and a significant effect (P= 0.0093) on seed size (g per 1000 seeds) of oriental mustard (Cutlass). Different letters indicate a significant difference (P < 0.05).

These results contrast the current recommendations that oriental mustard should be seeded early to mid-May in order to maximize yield production. SaskMustard (2017) reported a 2.8 bu per acre yield increase when seeded early to mid- May versus mid-May to early June. Variation between studies are likely attributed to the harsh environmental conditions that occurred in early to mid- May. Environmental conditions play a very large role in stand establishment and consequentially, yield production (Brandt 1992). A late frost combined with a high incidence of flea beetles resulted in a diminished plant stand, resulting in detrimentally low plant stand establishment.

Mustard seeded in late June resulted in a 50% yield reduction compared to May seeded mustard. Yield reductions are likely attributed to 1) the occurrence of high temperatures during flowering which resulted in bud abortion and 2) shortened days to maturity (-15 DTM) allowing less time for seed production (Figure 4). Timing of seeding also had a significant (P= 0.0093) effect on seed size. Although the difference in overall size is minor, an inverse linear trend for seed size indicated that delayed seeding resulted in declined from 3.25 to 3 g per 1000 seeds. These results indicate that when seeding is delayed until mid to late June, yield production is severely compromised as well as seed size is negatively influenced.

Conclusions and Recommendations:

The results of this study have provided insights to seeding date recommendations for yellow and oriental mustard by demonstrating the effect of timing of seeding on mustard yield and seed size. For both mustard classes, seeding in May was beneficial as it allowed for utilization of soil moisture and avoidance of flowering during high temperatures. Yellow mustard was less affected by early seeding compared to oriental mustard, however, both exhibited a severe yield decline when seeding was delayed until June. The implications of this study coincide with current recommendations in which mustard should be seeded in early to mid-May in order to maximize yields, regardless of reduced plant populations. Delayed seeding resulted in both yellow and oriental mustard in shorter days to maturity (DTM) by 9 and 15 days, respectively. A shortened DTM reduced the days required for greater seed production and seed size. Although DTM was shortened, the length of time to reach harvest maturity declined, resulting a greater risk of frost of delayed seeded mustard. Overall, this demonstration indicates to producers that seeding dates plays a very large role in yield and should be considered when planting.

Supporting Information

Acknowledgements

We would like to thank the Ministry of Agriculture for the funding support on this project. We would like to acknowledge Herb Schell and our summer staff for their technical assistance with project development and implementation for the 2017 growing season. This report will be distributed through WARC's website and included in WARC's and Agri-ARM annual reports.

Appendices A

Table A1: In-crop herbicide applications for weed control in yellow and oriental mustard.

Application	Rate	Date	Treatment Number
Glyphosate	1 L/ ac	4-May	All
Clethodim	75 ml/ac	29-May 7-June	1 & 7 1 & 7
Clethodim	150 ml/ac	7-June 15-June 27-June 4-July 13-July	2 & 8 3 & 9 4 & 10 5 & 11 6 & 12

Table A2: Soil moisture and soil moisture at time of seeding and oriental mustard at Scott, 2017.

Variety	**Class**	Julian Seeding Date	Soil Moisture %	Soil Temperature °C	Growing Degree Days
AC Pennant	Yellow	124	23	14	1651
AC Pennant	Yellow	132	18	10	1556
AC Pennant	Yellow	144	15	14	1574
AC Pennant	Yellow	153	16	13	1508
AC Pennant	Yellow	163	14	14	1472
AC Pennant	Yellow	174	16	12	1491
Cutlass	Oriental	124	23	14	1694
Cutlass	Oriental	132	18	10	1704
Cutlass	Oriental	144	15	14	1594
Cutlass	Oriental	153	16	13	1450
Cutlass	Oriental	163	14	14	1512
Cutlass	Oriental	174	16	12	1482

Abstract

Mustard is grown common oilseed crop that is typically seeded later within the growing season. However, current recommendations indicate that yield benefits could be derived from earlier seeding dates. This study was developed to demonstrated the effect of seeding dates (early vs. late) on mustard production. The demonstration was arranged as a randomized complete block design with four replicates at Scott 2017. The treatments consisted of two varieties (yellow and oriental mustard) and six seeding dates, spaced approximately 10 days apart beginning from early April to late June. The results of this study coincided with the current seeding date recommendations for yellow and oriental mustard in which early May seeding results in the greatest yield and highest seed size. Yellow mustard was less affected by early seeding compared to oriental mustard, however, both exhibited a severe yield decline when seeding was delayed until June. Delayed seeding resulted in both yellow and oriental mustard in shorter days to maturity (DTM) by 9 and 15 days, respectively. Although DTM was shortened, the length of time to reach harvest maturity declined, resulting in delayed harvest and a greater risk of frost. Overall, this demonstration indicates to producers that seeding dates plays a very large role in yield and should be considered when planting.

Extension Activities

The results of this trial were highlighted at the Scott Field Day with approx. 140 people in attendance and will be shared at the annual Crop Opportunity event hosted in March with approximately 150 people in attendance. A fact sheet will be generated and distributed on the WARC website, as well as all Agri-ARM and WARC events to ensure the information will be transferred to producers.

References

Alberta Agriculture and Forestry. 2016. Mustard Production for Alberta. [Accessed December 14th, 2017]
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex12947

Brandt SA. Depths, rates and dates of seeding and yield of yellow mustard (*Sinapis alba* L.) in west-central Saskatchewan. Canadian Journal of Plant Science. 1992 Apr 1;72(2):351-9.

Saskatchewan Mustard Development Commission. 2017. Mustard Production Manual: Time of Seeding. [Accessed December 14th, 2017] https://saskmustard.com/production-manual/seeding/time-of-seeding/index.html