Final report for the Grain Millers Canada Corporation

Project Title: Oat Varietal Response to Seed Date

Project Location: Northeast Agriculture Research Foundation, Melfort, SK

Project Duration: February 24, 2021 to December 31, 2022

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Objective/Rationale:
The objective of this project was to evaluate the response of different oat milling varieties to two seeding dates in northeast Saskatchewan

Methodology:
The small-plot research trial was conducted as a split-plot design with 4 replicates. Each plot was 2-meters wide by 7-meters long with borders on the ends of each replicate. The main-plot factor of the split-plot was seeding date and the sub-plot factor was oat variety. Two separate seed dates were used. The first seed date was intended to target the earliest possible seeding date, and the second seed date was to target a typical seeding date for the respective region. Within each seeding date six different oat milling varieties were randomized throughout (Table 1).

Table 1. Treatments used in Oat Varietal Response to Seed Date in Melfort, SK 2021 and 2022.

Treatment #	Seeding Date[z]	Variety
1	Early May	CDC Arborg
2		CS Camden
3		CDC Ruffian
4		Summit
5		CDC Endure
6		Ore3542M
7	Mid-Late May	CDC Arborg
8		CS Camden
9		CDC Ruffian
10		Summit
11		CDC Endure
12		ORe3542M

[z]Early May will target the earliest possible seeding time and will be dependent on seasonal conditions; Mid-Late May will target typical seeding time for northeast Saskatchewan

Prior to seeding the trial in both years, the site was soil sampled to determine residual nutrient levels (Table 2). The results of the soil test were used to determine the recommended fertility at seeding for a 150 bu/ac oat crop. Based on the recommendation's 64lbs/ac of nitrogen, 40lbs/ac of phosphorus, 10 lbs/ac of potassium, and 7lbs/ac of sulphur was applied at seeding in 2021,

and 46lbs/ac of nitrogen, 44lbs/ac of phosphorus, and 10lbs/ac of potassium was applied at seeding in 2022. Nitrogen was applied as 46-0-0 and was midrow-banded. Phosphorus was applied as 11-52-0, potassium as 0-0-60, and sulphur as 21-0-0-24. Phosphorus, potassium, and sulphur were all applied as a fertilizer blend in the side-band at the time of seeding.

Table 2. Residual Soil Levels in Oat Varietal Response to Seed Date in Melfort, SK 2021 and 2022.

Date	Depth (inches)	N (lbs/ac)	P (ppm)	K (ppm)	S (lbs/ac)	OM (%)	pH	Salts (mmho/cm)
April 30, 2021	0 to 6	35	7	502	14	9.2	5.8	0.47
	6 to 12	22			10		6.5	0.42
	0 to 12	57			24			
May 6, 2022	0 to 6	39	13	453	32	9.5	5.8	0.35
	6 to 12	30			44		6.1	0.38
	0 to 12	69			76			

For the early seed date all varieties were seeded as early as possible based on spring field conditions. The late seed date was to target a minimum of 14-days after the first date, which was intended to be more representative of a typical seeding date in the region. Dates of operation in both years are included in Table 3. Each variety was seeded at 350 seeds/m^2, and was corrected for % germination and thousand kernel weights. No seed treatment was applied prior to seeding, and seeding was completed using a 6-row Fabro plot seeder on 12-inch row spacing. The trial was direct seeded into canola stubble that had been lightly harrowed prior to seeding. The seed was placed at a 1-1.5-inch soil depth.

The trial area received crop protection products as needed throughout the season. In 2021, no pre-emergent herbicide, insecticide, fungicide, or desiccants were used. A post-emergent herbicide application was the only crop protection product applied in 2021. In 2022, a pre-emergent and post-emergent herbicide application were used for crop protection, while insecticides, fungicide, and desiccants were not used. Both seed dates in both years of the trial were harvested when the majority of plants in all plots were considered ripe. All plots were harvested with a Wintersteiger plot combine, in which 5 crop rows were collected.

In 2021 and 2022, data collection consisted of plant density, weed control ratings, lodging, maturity, yield, thousand kernels weights, and test weights. Subsamples of each treatment were also sent to the Grain Millers for further quality analysis. Plant density was determined by counting the seedlings along 2 1-meter crop rows 2 weeks after crop emergence. Weed control was determined by rating the % weed control in every plot prior to maturity using a 0-100% scale, where 100% equated to complete weed control. Lodging was rated using the Belgian lodging scale to rate every plot prior to harvest in 2021; however, in 2022 a scale of 0 to 9 was used to rate lodging where 0 equated to no lodging and 9 equated to the whole plot laying flat. Maturity was noted by determining the day that the majority of plants in every plot reached the hard dough stage (Zadoks 87). Yield was accounted for by cleaning and weighing all harvested

plot samples while correcting to 13.5% storage moisture. Thousand kernel weights were determined by counting a minimum of 500 seeds per plot, and test weights were determined by weighing the grams of seed in a 0.5-litre. Lastly, statistics were completed to analyze all data collected using split-plot analysis in Statistix 10.

Table 3. Dates of operation for Oat varietal response to seed date at Melfort, SK in 2021 and 2022.

	2021	**2022**
Pre-emergent herbicide	None	Glyphosate 540 at 0.67L/ac May 21 (late date only)
Seeding date		
Early seed	April 30	May 9
Late seed	May 19	May 25
Plant counts		
Early seed	May 26	June 3
Late seed	June 9	June 17
Post-emergent herbicide	Prestige XC (0.17L/ac of A and 0.8L/ac of B) June 18	Prestige XC (0.166L/ac of A and 0.809L/ac of B) June 28
Weed control rating	July 8	July 11
Lodging		
Early seed	August 16	August 19
Late Seed	August 16	September 6
Maturity	July 28- August 13	August 19-30
Harvest		
Early Seed	August 16	August 29
Late Seed	August 16	September 6

Results:

In 2021, average growing season temperatures were much warmer than the long-term average by 1.5 ^{o}C, and cumulative precipitation was reduced by 119mm from the long-term average (Table 4). May was the only month where average temperatures fell below the long-term average by 1.1 ^{o}C. All other growing season months experienced above average temperatures ranging from 0.1 ^{o}C-3.2 ^{o}C above the long-term climate average. August was the only month with above average precipitation with a 16.9mm increase from the long-term average, whereas all other month's experienced below average precipitation. Most notably, July experienced a significant reduction in rainfall where only 0.2mm of precipitation was received. This reduction in precipitation along with an increase in average temperatures of 2.5 ^{o}C resulted in limited soil moisture and stressful crop conditions during flowering and grain filling. The warm and dry conditions in July and August also lead to earlier maturation of many annual grain crops, including oats.

In 2022, average growing season temperature was warmer than the long-term average (+0.8°C), while cumulative precipitation was very similar to the long-term average (+4.9mm)(Table 4).

During seeding temperatures were near normal, with above average precipitation (+47.9mm), which resulted in rapid and even crop emergence. June was also near normal in average temperature, with above average precipitation (+23.8mm). The summer months of July through September brought about above average temperatures with lower-than-average precipitation (Table 4). July was warmer and drier than the long-term average, however July conditions in 2022 were cooler with more precipitation as compared to 2021. This resulted in better crop conditions during the later oat growth stages in 2022 as compared to 2021. Lastly, August was 1.9°C warmer than the long-term average with 15.9mm less rainfall, which resulted in rapid crop maturation and timely harvesting of both seed dates in 2022.

Table 4. Mean temperatures and precipitation collected from the Government of Canada weather station at Melfort, SK., from May to September of 2021 and 2022.

	May	**June**	**July**	**August**	**September**	**AVG/Total**
			Temperature (°C)			
2021	9.6	18.2	20.1	16.9	14.0	15.8
2022	9.9	15.2	18.2	18.7	13.7	15.1
Long-Term[z]	10.7	15.9	17.5	16.8	10.8	14.3
			Precipitation (mm)			
2021	31.4	37.6	0.2	69.3	7.5	146.0 (55%)
2022	90.8	78.1	34.9	36.5	29.6	269.9 (102%)
Long-Term[z]	42.9	54.3	76.7	52.4	38.7	265.0

[z]Long-term data is from 1981 to 2010 from Environment Canada Records

Although, stressful environmental crop conditions persisted throughout the 2021 season at Melfort, significant differences were found amongst the data collected between the different seeding dates and the different oat milling varieties (Table 5). In 2021, data was significantly impacted by seeding date for plant density, maturity, and yield, whereas, variety significantly impacted maturity, yield, thousand kernel weight, and test weights (Table 5). In 2021, there were no significant interactions between seeding date and variety for any of the data collected. In 2022, seeding date significantly impacted plant density, maturity, yield, thousand kernel weight and test weights, and variety significantly impacted maturity, lodging, thousand kernel weight, and test weight (Table 5). In 2022, there were significant interactions between seeding date and variety for plant density, maturity, and test weight.

Table 5. Statistical summary for Oat Varietal Response to Seed Date at Melfort, SK 2021 and 2022

Year	Source	Plant Density (PPMS)[z]	Days to Maturity[z]	Lodging[y,z]	Yield (KG/HA)[z]	Yield (Bu/ac)[z]	TKW (g/100seeds)[z]	Test Weight (g/0.5L)[z]
2021	Date	0.0152*	0.0009**	NS	0.0449*	0.0449*	NS	NS
	Variety	NS	0.0061*	NS	<0.0001***	<0.0001***	<0.0001***	<0.0001***
	Date*Variety	NS	NS	NS	NS	NS	NS	NS
	Grand Mean	198.3	87.8	0.2	3474.4	91.1	36.99	247.98
	CV	11.56	0.99	--	6.94	6.94	4.12	2.57
2022	Date	0.0056*	<0.0001***	NS	0.0004**	0.0004**	0.0492*	0.0092*
	Variety	NS	0.0023*	<0.0001***	NS	NS	<0.0001***	0.0024*
	Date*Var	0.0305*	0.0494*	NS	NS	NS	NS	0.0011*
	Grand Mean	233.7	100.3	1.1	7046.2	187.7	40.54	260.12
	CV	13.31	1.02	115.1	8.35	8.35	2.52	1.24

[y]Belgian Scale used in 2021, and scale of 0-9 used in 2022

[z] *** p<0.0001; ** p<0.001; * p<0.05; NS – Not significant

Plant density was significantly impacted by seeding date, but not by oat variety in both years of the trial (Table 5). Plant density was significantly increased at the later seeding date by an average of 41 plants/m^2 as compared to the early seeding date in 2021(Table 6); however, the opposite occurred in 2022, where plant density was increased by 50 plants/m^2 for the early date as compared to the late seeding date (Table 7). Cooler soil temperatures at the time of the early seed date as well as freezing temperatures near the end of may after the emergence of this treatment, may have contributed to the initial reduced plant density in 2021. Furthermore, drier spring conditions in 2021 (198 plants/m^2 avg) resulted in lower plant emergence overall as compared to 2022 (234 plants/m^2 avg). Lastly, variety had no significant effect on plant emergence, however in 2022 the variety Ore3542M did have significantly reduced plant stands at the late seeding date (173 plants/m^2) as compared to the early seeding date (270 plants/m^2), while all other varieties were considered statistically comparable for the date by variety interaction.

Weed control was not significantly different between dates or varieties in both years of the trial (Table 5). When comparing years weed control was greater in 2021 (98% avg) as compared to 2022 (73% avg). The difference in overall weed control between the two seasons is likely due to different environmental conditions as well as trial location.

Days to maturity was significantly impacted by seeding date and variety in both years; however, there was only a date by variety interaction for days to maturity in 2022 (Table 5). In 2021, the early seed date demonstrated a significantly increased days to maturity by 5 days as compared to the late seed date (Table 6). When comparing varieties, CDC Ruffian had a significantly increased days to maturity as compared to CDC Endure and CS Camden. Although significant, the average difference was 1.4 and 1.8 days, which is of very little agronomic importance. Summit also had a significantly increased days to maturity as compared to CS Camden by 1.6 days. All other varieties were not considered statistically different from one another, and average differences ranged from 0.2-1.8 days, which has very little practical importance. In 2022, the average days to maturity was significantly increased for the early seed date by 8 days as compared to the late seed date (Table 7). Although, the days to maturity was longer for the early date, the average calendar date for maturity was earlier for the early seed date (August 29) as compared to the late seed date (September 6). When comparing varieties, Ore3542M, CDC Ruffian, and Summit all had significantly higher days to maturity as compared to CS Camden (Table 7). Similar to 2021, the differences in days to maturity between these varieties was only 1.6 to 2.1 days, which is of very little agronomic importance. Lastly, for the date by variety interaction CS Camden had significantly reduced days to maturity for the early seed date as compared to CDC Arborg, CDC Ruffian, Ore3542M, and Summit; however, all varieties were statistically similar for maturity at the late seed date (Table 7).

Lodging was not significant for date or variety in 2021 as there was no crop lodging throughout the trial area prior to harvest (Table 5); however, there were significant varietal differences in lodging in 2022. The varietal significance in lodging was such that Summit (5.3) had significantly increased lodging as compared to all other varieties (0-0.8) (Table 7). This is not surprising as Summit has a lower varietal resistance to lodging as compared to all other varieties.

Yield was significantly impacted by both seeding date and oat variety in 2021 (Table 5). Of the varieties, CDC Endure (100.3bu/ac), CDC Ruffian (99.0bu/ac), CS Camden (97.0bu/ac), and CDC Arborg (95.5bu/ac) all had significantly increased average yields as compared to ORe3542M (72.3bu/ac) and Summit (82.5bu/ac) (Table 6). When referring to the Saskatchewan Seed Guide, ORe3542M and Summit are the lowest yielding varieties as compared to all other varieties, therefore it is not surprising that they demonstrated the lowest average yields. Furthermore, CDC Ruffian is rated as having moderate yields as compared to the other varieties, however it had the second highest average yield at 99.0 bu/ac. Overall, most varieties demonstrated comparable yields as to what would have been expected based on their yield ratings in the Saskatchewan Seed Guide for the respective growing region. Lastly, at the earlier seeding date yields (94.5bu/ac) were significantly increased as compared to the later seeding date (87.7bu/ac) (Table 6). In 2022, seed yields were only significantly impacted by seeding date (Table 5). The early seeding date (195.5bu/ac) had significantly increased yields as compared to the late seeding date (174.0bu/ac) (Table 7). Overall, oat yields were much higher in 2022 (187.8bu/ac avg) as compared to 2021 (91.1bu/ac avg). There were no significant effects of variety on grain yield in 2022.

For grain quality, both thousand kernel weights (TKW) and test weights were not significantly different between seeding dates, but were significantly different between varieties in 2021(Table 5). ORe3542M (39.7g) had the greatest thousand kernel weight, which is likely due to its high percentage of plump kernels as compared to other varieties. ORe3542M's thousand kernel weight was significantly greater than CDC Arborg (36.4g) and CDC Ruffian (35.8g). All other varieties were considered statistically similar in comparison (Table 5). Furthermore, although not significant it is important to note that both thousand kernel weight and test weight averages were greater for the early seed date. For varietal comparisons, test weight was significantly greater for Summit (265.8g) as compared to all other varieties (Table 6). All other varieties were considered statistically similar in comparison to one another. All other varieties fell within a 0.87-10.44g difference of one another, whereas Summit had a significantly increased test weight of 16.10g-26.54g as compared to all other varieties. Lastly, of the varieties Summit, ORe3542M, and CDC Endure all had average test weights above 245g/0.5L, which is above the cut-off for potential discounts in oats. CDC Arborg, CDC Ruffian, and CS Camden all fell below 245g/0.5L, which is below the cut-off for discounts, but above the rejection test weight of 230g/0.5L. In 2022, TKW and test weight were both significantly effected by variety and seeding date; however, there was only a significant two-way interaction between variety and seeding date for test weights (Table 5). The early seeding date (41.4g) had a significantly greater TKW as compared to the later seeding date (39.7g); however, the early seeding date (256.5g/0.5L) had a significantly reduced test weight as compared to the late seeding date (263.8g/0.5L) (Table 7). ORe2542M (43.2g) had a greater TKW as compared to all varieties, with the exception of CDC Endure (42.3g). Summit (37.5g) had significantly reduced TKW as compared to all other varieties. In contrast, Summit (265.0g/0.5L) had the greatest test weight, which was significantly greater than all other varieties except for CDC Arborg (260.7g/0.5L). All other varieties had statistically comparable test weights ranging from 258.4-259.0g/0.5L (Table 7). In contrast to 2021, all treatments in 2022 regardless of seeding date or variety were above the 245g/0.5L test weight discount in oats.

Table 6. Treatment means for Oat Varietal Response to Seed Date at Melfort, SK 2021.

Year	Source	Plant Density (PPMS)[z]	Days to Maturity[z]	Lodging (Belgian Scale)	Weed control (%)	Yield (KG/HA)[z]	Yield (Bu/ac)[z]	TKW[z]	Test Weight (g/0.5L)[z]
	Date								
	Early	177.8b	90.3a	0.2a	98.0a	3603.0a	94.5a	37.7a	249.8a
	Late	218.8a	85.3b	0.2a	98.0a	3345.7b	87.7b	36.4a	246.2a
	Variety								
2021	CDC Arborg	183.2a	87.8abc	0.2a	98.0a	3643.4a	95.5a	36.4b	243.8b
	CS Camden	209.7a	86.9c	0.2a	98.0a	3700.8a	97.0a	37.0ab	239.2b
	Summit	186.0a	88.5ab	0.2a	98.0a	3146.7b	82.5b	36.6ab	265.8a
	CDC Ruffian	208.3a	88.7a	0.2a	98.0a	3775.3a	99.0a	35.8b	244.3b
	CDC Endure	195.3a	87.3bc	0.2a	98.0a	3824.2a	100.3a	36.8ab	245.1b
	ORe3542M	207.2a	87.8abc	0.2a	98.0a	2755.7b	72.3b	39.7a	249.7b

[z] Letters indicate groupings that are significantly different at $p<0.05$ using Tukey's HSD

Table 7. Treatment means for Oat Varietal Response to Seed Date at Melfort, SK 2022.

Year	Source	Plant Density (PPMS)[z]	Days to Maturity[z]	Lodging (0-9)	Weed control (%)	Yield (KG/HA)[z]	Yield (Bu/ac)[z]	TKW[z]	Test Weight (g/0.5L)[z]
	Date								
	Early	258.8a	104.4a	0.7a	77.9a	7456.5a	195.5a	41.4a	256.5b
	Late	208.6b	96.3b	1.5a	68.5a	6636.0b	174.0b	39.7b	263.8a
	Variety								
	CDC Arborg	254.9a	100.5ab	0.3b	74.4a	7208.5a	189.0a	39.7cd	260.7ab
	CS Camden	244.9a	99.0b	0.3b	71.3a	6691.0a	175.4a	41.1bc	258.7b
	Summit	230.7a	100.9a	5.3a	69.4a	6830.2a	179.1a	37.5e	265.0a
	CDC Ruffian	229.9a	100.6a	0.8b	66.9a	7116.4a	186.6a	39.5d	258.4b
	CDC Endure	221.6a	99.8ab	0.1b	76.9a	7313.7a	191.8a	42.3ab	259.0b
	Ore3542M	220.4a	101.1a	0.0b	80.6a	7117.5a	186.6a	43.2a	259.0b
	*Date*Variety*								
2022	Early Arborg	294.5a	105.0a	0.0c	85.0a	7551.5ab	198.0ab	40.7	257.6
	Early Camden	278.9ab	102.0b	0.0c	75.0a	7073.1abc	185.4abc	42.2	256.6
	Early Endure	237.5abc	104.3ab	0.3c	88.8a	7807.5a	205.7a	42.7	254.9
	Early Ore3542M	269.9ab	105.0a	0.0c	88.8a	7575.2ab	198.6ab	44.2	251.2
	Early Ruffian	228.0abc	105.0a	0.0c	55.0a	7193.8abc	188.6abc	41.0	258.6
	Early Summit	244.4abc	105.0a	3.8ab	75.0a	7537.6ab	197.6ab	37.7	260.1
	Late Arborg	215.4abc	96.0c	0.5bc	63.8a	6865.6abc	180.0abc	38.7	263.9
	Late Camden	211.0bc	96.0c	0.5bc	67.5a	6308.9bc	165.4bc	40.0	260.9
	Late Endure	203.3bc	95.3c	0.0c	65.0a	6819.9abc	178.8abc	42.0	263.2
	Late Ore3542M	173.3c	97.3c	0.0c	72.5a	6659.8abc	174.6abc	42.2	266.7
	Late Ruffian	231.7abc	96.3c	1.5bc	78.8a	7038.9abc	184.5abc	38.1	258.2
	Late Summit	217.0abc	96.8c	6.8a	63.8a	6122.7c	160.5c	37.4	269.8

[z] Letters indicate groupings that are significantly different at $p<0.05$ using Tukey's HSD

Summary and Conclusion:

Due to the different environmental conditions of 2021 as compared to 2022 at Melfort, the oat varietal response to seed date was not always consistent across the two seasons of this trial. Plant stands were not affected by variety in either season, however in 2021 plant stands were reduced at the early seed date, and in 2022 they were reduced at the late seed date. Although, the effects to plant density varied by season the yield effects of seeding date remained the same under both conditions, where yield was significantly increased when oats were seeded early. Differences in days to maturity were similar in both years, where the late seeding date demonstrated decreased days to maturity, however the early date always matured at an earlier calendar date than the late date. Any differences in days to maturity for varieties were of very little agronomic importance in both years, with average differences being a day or two. In 2021, there was no lodging, and in 2022 the only significant effect to lodging was variety, where Summit had significantly increased lodging as compared to all other varieties. Variety had no significant effect on seed yields in 2022, however in 2021 varieties with higher yields (SK variety guide) tended to yield higher (Arborg, Camden, Endure, and Ruffian) as compared to lower yielding varieties (Ore3542M and Summit). In 2021, quality was only significantly impacted by variety, where Summit had the greatest test weight and Ore3542M has the greatest thousand kernel weight. In 2022, Summit also had the greatest test weight and Ore3542M had the greatest TKW, however there were also significant effects of seeding date, where test weight was greatest at the late seed date, and thousand kernel weight was greatest at the early seeding date. There was also a significant seeding date by variety interaction for test weight where CDC Ruffian's test weight remained the same regardless of seeding date. Overall, there were many significant findings from this oat variety by seed date comparison, that suggest seeding oats as early as possible in the spring in northeast Saskatchewan results in higher seed yields, with the potential for reduced test weights, higher seed weights, and longer days to maturity.