Project Identification

Project Title: Oat varietal response to Plant Growth Regulators

Project Number: ADOPT 20200533

Producer Group Sponsoring the Project: Northeast Agriculture Research Foundation

Project Location(s): RM of Star City no. 428 SE 31-44-18 W2

Project start and end dates (month & year): April 2021 to February 2022

Project contact person & contact details:

Brianne McInnes AAg
Operations Manager
Northeast Agriculture Research Foundation
Box 1240
Melfort, SK
S0E 1A0
email: neag.agro@gmail.com

David MacTaggart AAg
Associate Research Manager
Northeast Agriculture Research Foundation
Box 1240
Melfort, SK
S0E 1A0
email: research.narf@gmail.com

Objectives and Rationale:

Project objectives: To demonstrate the response of different commonly grown milling oat varieties to registered plant growth regulators. To demonstrate the response oats have to plant growth regulators applied at different timings.

Project Rationale:
Oat is one of the major cereal grains grown in Western Canada with 2.6 million acres produced in 2021 (Statistics Canada 2021). It is known for its ability to compete with weeds and relatively low nitrogen requirements (Barker 1999). However, lodging is a significant risk in oat, and has the potential to reduce yields by 10-40% (King 2020). In the northeast growing region of Saskatchewan, oat crops are typically tall and yield well due to high moisture conditions. Because lodging in oats has the potential to reduce seed yields, and thus profitability, exploring management options for reducing lodging is important to oat producers. Plant growth regulators (PGRs) applied at the correct time may be a strategy to improve the performance of oat by reducing plant height, which in turn may reduce crop lodging. Two PGRs are currently registered for use in cereal crops, which are Manipulator® and Moddus®. Both work by similar mechanisms, whereas they reduce plant internode length by inhibiting production of the plant growth hormone gibberellin. Work done by Alberta Agriculture has evaluated both PGR's in different cereal crops, and concluded that Wheat is more responsive to Manipulator® applications, whereas Barley has often been more responsive to height reductions with Moddus® applications (Strydhorst et. al. 2014). In barley, PGRs demonstrated a consistent ability to reduce plant height but did not have a significant effect on lodging when applied during stem elongation or early booting (Tidemann et al. 2020). Furthermore, Manipulator® applications in wheat have demonstrated more consistent responses than barley to crop height reductions, however responses in wheat have varied by variety (Strydhorst 2020). While most previous research has focused on PGR applications in barley and wheat, some preliminary results in oat suggest that height reductions vary based on varietal selection as well as by product (Strydhorst et al. 2014). Understanding the effects of PGR on different oat varieties will help farmers make sound economic decisions regarding the use of these products on their operations.

Methodology and Results

Methodology:
This small plot demonstration was conducted at SE 31-44-18 W2 in the RM of Star City near Melfort, SK. The demonstration was set up in a 3 X 5 factorial experiment arranged in a randomized complete block design with 4 replicates. Variety was the first factor and plant growth regulator regimen was the second factor. There were 15 treatments (Table 1) that varied based on three different oat varieties and two different plant growth regulator products applied in a single or dual application as compared to no PGR.

Table 1. Treatments used in Oat varietal response to Plant Growth Regulators in Melfort, SK 2021.

Treatment #	Variety	PGR+Rate	N rate
1	CDC Arborg	--	1X
2		Manipulator single	1.5X
3		Manipulator Dual	1.5X
4		Moddus single	1.5X
5		Moddus Dual	1.5X
6	CDC Ruffian	--	1X
7		Manipulator Single	1.5X
8		Manipulator Dual	1.5X
9		Moddus Single	1.5X
10		Moddus Dual	1.5X
11	CS Camden	--	1X
12		Manipulator Single	1.5X
13		Manipulator Dual	1.5X
14		Moddus Single	1.5X
15		Moddus Dual	1.5X

Manipulator: Single App= GS 31 @2.3L/ha; Split App= GS 14 @1.15L/ha + GS 32 @ 1.15L/ha
Moddus: Single App= GS 30-32 @ 0.83L/ha; Split App= GS 21-24 @ 0.41L/ha + GS 37-39 @0.41L/ha

At Melfort, plots were 2-m wide by 7-m long. Prior to seeding, the test site was soil sampled for residual nutrient levels (Table 2). On May 11th, 2021 all plots were seeded at a 1.5-inch depth into canola stubble. Seeding was completed using a 6-row Fabro plot seeder on 30.5cm row spacing. The target oat population was 350 plants/m^2. Nitrogen was side banded as 46-0-0 to meet the 1X rate (64 lbs actual N/acre) or the 1.5X rate (96 lbs actual N/acre). A 1.5X recommended nitrogen rate was applied to all PGR treatments as a means to increase the risk of crop lodging. All treatments received 11-52-0 (40 lbs P_2O_5/acre), 0-0-60 (10 lbs K_2O/acre), and 21-0-0-24 (7 lbs SO_4/acre) in the side band at seeding time.

Table 2. Residual soil nutrient levels found in Oat varietal response to Plant Growth Regulators in Melfort, SK 2021. Residual nitrogen and sulfur was from 0-30cm while phosphorus and potassium was from 0-15cm.

Residual Soil Levels			
Nitrogen (lb/ac)	*Phosphorus (ppm)*	*Potassium (ppm)*	*Sulphur (lb/ac)*
57	7	502	24

A pre-emergent herbicide mix of Glyphosate 540 (0.67L/ac) and Heat LQ (0.059 L/ac) was applied on May 14th. A post-emergent herbicide was applied on June 18th (Prestige XC 0.17L/ac of A & 0.8L/ac of B). No foliar fungicide or insecticide was required. Treatments that received a single application of Moddus (0.336 L/ac) were treated at Zadoks 30-32 (Youngest leaf sheath visible-2nd node detectable). Split applications of Moddus (0.166 L/ac per application) were applied at Zadoks 21-24 (1st tiller-4th tiller) and then again at Zadoks 37-39 (Flag leaf just visible-flag leaf ligule just visible). Single applications of Manipulator (0.931 L/ac) were applied at Zadoks 31 (1st node detectable). Split applications of Manipulator (0.466 L/ac per application) were applied at Zadoks 14 (4th tiller visible) and 32 (2nd node

detectable). All plots were harvested on August 23rd with a plot combine, in which 5 full crop rows were collected.

To assess treatment differences, data collection consisted of plant density, plant height, lodging, maturity, seed yield, test weight, and thousand kernel weight. Methodology for this data collection is described below. The single site year of data was analyzed using Factorial design in Statistix 10.

Results

Environmental Conditions:
The environmental conditions of 2021 were marked by being warmer and dryer than the long-term average for several months of the growing season. The monthly mean temperature was greater than the long-term average from June-September (**Table 3**). The deviation from the long-term mean temperature was most pronounced in September and July when the temperature was 3.2°C and 2.6°C greater than the mean, respectively. May was the only month that was cooler than average with a monthly mean of 9.6°C relative to the long-term mean of 10.7°C (**Table 3**). From May to September, Melfort received 55% of normal precipitation with all months except August (16.9mm above normal) that received below average precipitation. This deficit was most pronounced in July and September which received 76.5mm and 31.2mm of precipitation less than the long-term average.

Table 3: Mean temperatures and precipitation collect from the Environment Canada Weather Station at Melfort SK., from May to September 2021.

	May	June	July	August	September	Average/Total
			--- Mean Temperature (°C) ---			
2021	9.6	18.2	20.1	16.9	14.0	15.8
Long-Term[x]	10.7	15.9	17.5	16.8	10.8	14.3
			--- Total Precipitation (mm) ---			
2021	31.4	37.6	0.2	69.3	7.5	146.0
Long-Term[x]	42.9	54.3	76.7	52.4	38.7	265.0

[x] Long-term climate normal from Environment Canada Weather Station located at Melfort SK., from 1981-2010

Plant Density:
Plant density was assessed on June 3rd, 2021 by counting the number of emerged seedlings along two 1-meter sections of crop row per plot. The analysis of variance (ANOVA) indicated that there was a significant difference in plant density based on the variety (p=0.017) while there was no difference in plant density based on plant growth regulator or the interaction between oat variety and PGR (Table 1). In comparing varieties, CDC Arborg (185.2 plants/m^2) had a significantly lower plant density than CDC Ruffian (216.9 plants/m^2) and CS Camden (216.2 plants/m^2). This may be a result of different varietal responses to inter-plant competition.

Plant Height:
Plant height was assessed on July 27th, 2021 by measuring the average plant height in cm at 2 areas in the plot. The ANOVA identified both significant differences in plant heigh based on variety (p=0.0009) and PGR treatments (p=0.0013). CDC Arborg (72.1 cm) was significantly taller than CDC Ruffian (60.9 cm) and CS Camden (60.6 cm). This corresponds with the description in the Saskatchewan Varieties of Grain Crops Guide where CDC Arborg is listed to be approximately 10cm taller than both CDC Ruffian and CS

Camden (Saskatchewan Ministry of Agriculture, 2022). There was no significant difference in plant height between the control and treatments receiving Manipulator. However, treatments receiving Moddus were significantly shorter than the control, but comparable in height to the Manipulator treatments.

Crop Maturity:

Crop maturity was assessed by recording the date when the majority plants in a plot reached Zadoks growth stage 87 (Hard dough stage). The ANOVA identified that there were significant differences in maturity based on oat variety ($p<0.0001$***) and the plant growth regulator ($p=0.0072$**), but not the interaction between the two factors (Table 4). Pairwise comparison identified that CDC Ruffian (91.3 days to maturity) and CDC Arborg (88.4 days to maturity) matured significantly later than CS Camden (83.5 days to maturity). This is slightly different than the variety testing information which indicates that CDC Arborg has a middle maturity date while CDC Ruffian and CS Camden have late maturity dates (Saskatchewan Ministry of Agriculture, 2022). Furthermore, treatments receiving Moddus applications demonstrated a significant increase in days to maturity as compared to the control. In contrast, Manipulator treatments were comparable to both the control and Moddus treatments for days to maturity.

Lodging:

Lodging was assessed on August 23rd, 2021 using the Belgian lodging scale. No lodging occurred in any plots, therefore lodging was not included in the statistical analysis.

Seed Yield:

Seed yield was assessed by cleaning and weighing every harvested plot sample. Plot weights were converted to kg/ha and bu/ac equivalents while correcting to 13% seed moisture. The ANOVA indicated that there were no significant differences in yield based on variety, PGR treatment, or the interaction between the two factors (**Table *4***). Average yields did increase slightly for both Manipulator applications and the dual application of Moddus as compared to the control, however these yield differences may also be a factor of the increased nitrogen supply of these treatments.

Test weight:

After grain was cleaned and dried to a consistent moisture, test weight was measured by recording the mass of grain in grams with a volume of 0.5L. The ANOVA identified that there were no significant differences in test weight based on variety, or a variety by PGR interaction, however PGR application alone did significantly impact oat test weight (**Table *4***). Numerically, all PGR applications demonstrated average decreases in test weight as compared to the control, however the single application of Moddus was the only application that significantly reduced test weight as compared to the control. When comparing the two products of PGR both Moddus and Manipulator demonstrated comparable oat test weights regardless of application type.

Thousand Kernel Weight:

After the grain was cleaned and dried to a consistent moisture, thousand kernel weight was determined by counting and weighting 500 seeds per plot to determine g/1000 seeds. By the ANOVA, no significant differences in thousand kernel weight were observed based on variety or the variety by PGR interaction,

however PGR application did significantly affect TKW. Numerically, average test weight was reduced for all PGR applications as compared to the control, with the exception of the dual application of Moddus. Additionally, all PGR applications were statistically similar to the control except for the dual application of Manipulator.

Table 4: Statistical analyses and treatment means for Oat varietal response to Plant Growth Regulators in Melfort, SK 2021.

	Plant Density (plants/m^2)^z		Height (cm)^z		Maturity (Days to)^z		Yield (bu/ac)^z		Test Weight (g/0.5L)^z		TKW (g/1000seeds)^z	
Variety	0.0001**		<0.0001***		<0.0001***		NS		0.9127		0.2049	
PGR	NS		0.0059**		0.0072*		NS		0.0422*		0.0137*	
Variety*PGR	NS		NS		NS		NS		0.7889		0.7814	
Grand Mean	206.1		64.6		87.7		112.0		247.21		37.79	
CV	11.26		6.85		4.44		8.26		2.58		4.50	
Variety												
CDC Arborg	185.2	b	72.1	a	88.4	a	111.3	a	247.5	a	38.2	a
CDC Ruffian	216.9	a	60.9	b	91.3	a	115.4	a	247.5	a	37.3	a
CS Camden	216.2	a	60.6	b	83.5	b	109.0	a	246.7	a	37.9	a
PGR												
Control	216.4	a	67.7	a	83.8	b	109.9	a	250.7	a	38.5	a
Manipulator Single	205.9	a	64.2	ab	87.8	ab	114.5	a	248.6	ab	38.0	ab
Manipulator Dual	202.1	a	66.8	ab	88.3	ab	112.6	a	245.3	ab	36.5	b
Moddus Single	208.0	a	62.4	b	89.7	a	109.9	a	243.0	b	37.3	ab
Moddus Dual	198.2	a	61.8	b	88.8	a	112.9	a	248.5	ab	38.7	a

* significant p<.05; **significant p<0.01; *** significant p<0.001, NS=Not significant

^{z}Letter separate treatment means that are significantly different using Tukey's HSD at p <0.05

Conclusions and Recommendations

The use of plant growth regulators (PGRs) in oat production could be of use to reduce crop height to minimize lodging risk. For farmers to best use PGRs, accurate information must be available regarding the available products, application timing, and the effect of different oat varieties. The objective of this project was to demonstrate the response of different commonly grown milling oat varieties to registered plant growth regulators, and to demonstrate the response of oat to plant growth regulators applied at different timings. These objectives were addressed with a single year small plot experiment in the RM of Star City in 2021. Applying both PGR products as either single or split applications did not have a significant effect on the parameters measured (Data not shown). Plant density was significantly influenced by variety, with reduced plant emergence for CDC Arborg as compared to CDC Ruffian and CS Camden. Plant height and stand maturity were significantly impacted by oat variety and the application of a PGR, however these two factors did not have significant interactions. Moddus was the only PGR to significantly reduce plant height relative to the control. Application of a PGR did delay maturity. The differences in height and maturity among varieties and PGR treatments did not result in significant differences in yield. Lastly, PGR applications did significantly impact oat quality as a single application of Moddus significantly reduced test weight and a dual application of Manipulator significantly reduced TKW. Although, test weights were reduced with PGR application, all average treatment test weights were above the value at which oats are discounted at 245g/0.5L.Overall, the 2021 season was very dry and hot, which minimized crop growth and lodging risk, which may have impacted PGR responses. These results may differ in a year with more precipitation that could increase the incidence of lodging or with a shorter harvest window when delayed maturity could be of concern.

Extension Activities

The experiment was described in the 2021 Northeast Agriculture Research Foundation virtual field day. Results will be posted on neag.ca

Supporting Information

Acknowledgements
The Northeast Agriculture Research Foundation would like to express our gratitude to the Saskatchewan Ministry of Agriculture's ADOPT program for funding this demonstration and for providing signage. We would like to thank Jessica Slowski (formerly of NARF), Brianne McInnes, and David MacTaggart of NARF for coordinating the project protocol, data analysis and report writing for this project. Finally, NARF would like to thank Gayelene Dagenais, Caitlyn Hartman, and Carter Fettes for their hard work and dedication in completing this project.

Works Cited

Barker, B. 1999. Fertilizing oats for yield and quality. Top Crop Manager. [Online]. Available: https://www.topcropmanager.com/fertilizing-oats-for-yield-and-quality-10554/ [February 10, 2022].

King, C. 2020. Limiting lodging in oat. Top Crop Manager. [Online]. Available: https://www.topcropmanager.com/limiting-lodging-in-oat/ [February 10, 2022].

Saskatchewan Ministry of Agriculture. 2022. Oat: Main Characteristics of Varieties. Varieties of Grain Crops 2022.

Statistics Canada. 2022. Estimated areas, yield, production, average farm price and total farm value of principal field crops, in metric and imperial units. [Online]. Available: https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=3210035901 [February 10, 2022].

Strydhorst, S. 2020. "Investigating PGRs." TopCrop Manager. Investigating PGRs - Top Crop ManagerTop Crop Manager

Strydhorst, S., Aidoo, J., Hall, L. December 4, 2014. "Optimizing Oat Yield, Quality and Standability in Central Alberta." Prairie Oat Growers Association 17th Annual Conference. Banff, AB. http://poga.ca/images/pdf/agm2014/Optimizing_Oat_Yield_Quality_and_Standability_in_Centra_Alberta.pdf

Tidemann, B.D., O'Donovan, J.T., Izydorczyk, M., Turkington, T.K., Oatway, K., Beres, B., Mohr, R., May, W.E., Harker., K.N., Johnson, E.N., de Goojier, H. 2020. Effects of plant growth regulator applications on malting barley in western Canada. Can. J. Plant Sci. **6** (100): 653-665.

Abstract

Abstract/Summary

Oat can be a desirable option for farmers in crop rotations because of its ability to compete with weeds and efficiently scavenge nitrogen from the soil. However, issues like lodging can severely reduce the yield of oat crops. Plant growth regulators (PGRs) may have the potential to reduce lodging in oats by reducing plant height. The objective of this project was to demonstrate the response of different commonly grown milling oat varieties to registered plant growth regulators applied in a single or dual application. To demonstrate this a small-plot trial was set-up in the RM of Start City near Melfort, SK where a 3 by 5 factorial experiment arranged as a randomized complete block design was used to examine the effect of oat variety and PGR product on the plant density, plant height, days to maturity, lodging, yield, and grain quality of oat. Conditions were drier and warmer than normal in Melfort in 2021, which may have impacted PGR response. Crop yield was not significantly affected by changes in oat variety or PGR used. Oat variety had a significant effect on plant density, plant height, and days to maturity. Of the varieties, CDC Arborg had a significantly lower plant density as compared to CDC Ruffian and CS Camden. CDC Arborg was also significantly taller than the other two varieties. When comparing maturity of the varieties CS Camden had a significantly reduced days to maturity as compared to CDC Ruffian and CDC Arborg. The application of a PGR had a significant impact on plant height, maturity, test weight, and TKW. The application of Moddus significantly decreased plant height and significantly prolonged maturity as compared to the control. Quality was also significantly impacted by PGR application, whereas a single application of Moddus significantly reduced test weight and a dual application of Manipulator significantly decreased TKW as compared to the control. Considering the dry and hot conditions in 2021 at Melfort, varietal responses to PGRs may vary as compared to more typical growing season conditions for the respective area.

Finances

Budget Report

See attached excel spreadsheet