

2022 Final Report

From the

**Northeast Agriculture Research Foundation
and
Indian Head Agricultural Research Foundation**

Project Title: Oat varietal response to Plant Growth Regulators



Principal Investigators:

Brianne McInnes¹ and Chris Holzapfel²

¹Northeast Agriculture Research Foundation, Melfort, SK

²Indian Head Agricultural Research Foundation, Indian Head, SK

Project Identification

- 1. Project Title:** Oat varietal response to plant growth regulators
- 2. Project Number:** ADOPT20211057 (NARF) & ADOPT20211113 (IHARF)
- 3. Producer Group Sponsoring the Project:** Northeast Agriculture Research Foundation (NARF) and the Indian Head Agricultural Research Foundation (IHARF)
- 4. Project Location(s):** Melfort, SK (RM #428) and Indian Head, SK (RM #458)
- 5. Project Start and End Dates (Month & Year):** March 2022 to February 15, 2023
- 6. Project Contact Person & Contact Details:**

Brianne McInnes, Operations Manager
Northeast Agriculture Research Foundation (NARF)
PO Box 1240, Melfort, SK, S0E 1A0
Work: (306) 920-9393; Cell: (306) 231-8900; Email: neag.agro@gmail.com

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

Objectives and Rationale

7. Project Objectives:

The objective of this project was to demonstrate the response of different oat milling varieties to applications of the registered plant growth regulators Moddus® and Manipulator®.

8. Project Rationale:

As of the 2021 growing season, both Plant Growth Regulators (PGR) Moddus® and Manipulator® are registered for use in oats in Saskatchewan. Moddus® and Manipulator® contain different active ingredients; however, both work by similar mechanisms. Both trinexepac-ethyl in Moddus® and chlormequat chloride in Manipulator® reduce stem internode length by inhibiting gibberellin biosynthesis. Gibberellin promotes stem elongation; therefore, inhibiting production of this hormone reduces plant height. Through previous research, both products have been found to decrease plant height, which diminishes the risk of lodging in cereal crops (3,4,5). When comparing applications of both products in wheat, barley, and oats, oats have been documented as being the least responsive to height reductions (3,4). Browne et. al. conducted research on oat seeding rate, nitrogen rates, and PGR application and found no yield response with the applications of chlormequat chloride, while research from Alberta Agriculture and the University of Alberta also found no yield response; however, height reductions with the application of Manipulator® or Moddus® were documented (1,3). Overall, slightly greater height reductions in oats occurred when Moddus® was applied as compared to Manipulator® (3).

Lodging has the potential to cause yield losses of 7-35% in cereal crops and can subsequently lead to significant reductions in grain quality (2). Plant height in oats is often increased with enhanced fertility as more available nitrogen results in more rapid plant growth (3). This rapid growth often leads to decreased

stem strength and thus increased lodging in oats, yet more available nitrogen can lead to higher yields. It is suspected that different varieties may respond differently to PGR applications as a result of different genetics for yield, lodging, and height characteristics. Under enhanced fertility, varieties with lower lodging resistance and/or greater height are more prone to lodge, and thus may demonstrate a more positive response to PGR application.

The black soil zone is the largest oat producing area in Saskatchewan. Due to higher moisture retaining capacities of fine textured soils, the oat crops in this region are tall and yield well, but are prone to lodging. Lodging in oats leads to reduced seed quality and difficulties during harvesting. The consequences of crop lodging often result in significantly reduced profitability, and thus having management options for reducing lodging is important for producers to ensure profits are maximized from their oat crop. Tools to help ensure that harvest can be completed efficiently are also important, especially in the more northern regions where growing seasons and harvest windows can be relatively short. As in other cereal crops, such as wheat and barley, preliminary research in oats has demonstrated varying varietal responses to PGR applications. Understanding varietal response to plant growth regulators is important for producers to better understand whether an application of Manipulator® or Moddus® will benefit their oat crop.

Literature Cited

[1] Browne, R.A., E.M. White and J.J. Burkge. 2003. Effect of Nitrogen, Seed Rate and Plant Growth Regulator (Chlormequat Chloride) on the grain quality of oats (*Avena Sativa*). *J. Agri. Sci.* 141: (3-4): 249-258.

[2] Fischer, R.A. and M. Stapper. 1987. Lodging effects on high-yielding crops of irrigated semidwarf wheat. *Field Crops Research.* 17 (3-4): 245-258.

[3] Investigating PGRs. 2020. Top Crop Manager. <http://www.topcropmanager.com/investigating-pgrs/>

[4] Sheri Strydhorst, Joseph Aidoo, and Linda Hall. "Optimizing Oat Yield, Quality and Standability in Central Alberta." Prairie Oat Growers Association 17th Annual Conference. Banff, AB. December 4, 2014. https://poga.ca/images/pdf/agm2014/Optimizing_Oat_Yield_and_Standability_in_Centra_Alberta.pdf

[5] Sheri Strydhorst. 2014. "Plant Growth Regulators: What agronomists need to know." https://umanitoba.ca/faculties/afs/agronomists_conf/media/MAC_2014-Strydhorst_Full_Paper-Dec_9.pdf

Methodology and Results

9. Methodology:

The demonstration was conducted at two locations including Melfort and Indian Head, SK in 2022. Both sites are located in the black soil zone. Within the black soil zone one site was southern (Indian Head) and one site was within the northern area (Melfort) of the province. These locations were selected to allow us to demonstrate responses across different environmental conditions.

The small-plot demonstration was set-up as a factorial combination of treatments with four replications. The factorial combination consisted of two factors, which were variety and plant growth regulator (PGR). The varieties were CS Camden, CDC Dancer, CDC Arborg, and Summit, while the PGRs used were either no PGR, Moddus®, or Manipulator®. The four varieties used differed in varietal characteristics for height and lodging. The two taller varieties were CDC Arborg and CDC Dancer, and the two shorter varieties were CS Camden and Summit. Of these varieties CDC Arborg and CS Camden have very good lodging resistance, while CDC Dancer and Summit only have good lodging resistance. All varieties used were combined with no PGR, Moddus, or Manipulator to create a total of 12 treatments (Table 1). Treatments were completely randomized within each replication at both sites. All varieties were seeded to target 350 live seeds/m², while correcting for germination and thousand seed weights.

Table 1. Treatments used in Oat varietal response to plant growth regulators at Melfort and Indian Head, SK in 2022

Treatment #	Plant Growth Regulator ^x	Variety
1	No PGR	CS Camden
2		CDC Dancer
3		CDC Arborg
4		Summit
5	Moddus® ^y	CS Camden
6		CDC Dancer
7		CDC Arborg
8		Summit
9	Manipulator® ^z	CS Camden
10		CDC Dancer
11		CDC Arborg
12		Summit

^x PGRs were applied in a single application at GS 31 (1st node detectable)

^y Moddus was applied at 0.83L/ha

^z Manipulator was applied at 2.3L/ha

Seeding equipment and crop management varied by location (Table 2). The previous crop was canola at both sites, and the oats were seeded on May 23rd at Indian Head and May 24th at Melfort. Weeds, insects, and disease were controlled using registered products at each participating site at the discretion of each site manager for best management practices. All fertility was applied at both sites based on soil sample results to be non yield limiting (Table 3). All plots were harvested with a plot combine on September 6th at Melfort and on September 16th and 17th at Indian Head.

Table 2. Agronomic information and dates of operation for Oat varietal response to plant growth regulators at Melfort and Indian Head, SK in 2022.

Factor/Operation	Melfort	Indian Head
Previous Crop	Canola	Canola
Pre-Emergent Weed Control	Glyphosate 540 at 0.67L/ac May 21	Glyphosate 540 at 0.67L/ac May 22 & 27
Seeding Date	May 24	May 23
Row Spacing (cm)	0.3048m	0.3048m
Plot size	16.5m ²	25.6m ²
Kg N-P₂O₅-S/ha (K₂O as per treatment)	84-49-11-0	125-35-17.5-17.5
Post-emergent herbicide	Prestige XC (166mL/ac A 809mL/ac B) June 28	Prestige XL at 0.85L/ac June 19
Emergence Counts	June 16	June 13
PGR Application	June 28	June 23
Lodging	September 6	September 3
Maturity	August 25-September 1	August 23-25
Foliar Fungicide	None	Nexicor 0.2L/ac July 6
Crop Height	August 10	July 25
Pre-harvest Application	None	None
Harvest Date	September 6	September 16 & 17

Table 3. Soil sample results for Oat varietal response to plant growth regulators at Melfort and Indian Head, SK in 2022.

Depth	NO₃-N (kg/ha)	Olsen-P (ppm)	K (ppm)	S (kg/ha)	pH	Organic Matter (%)	Salts (mmho/cm)
Melfort							
0-15cm	44	13	453	36	5.8	9.5	0.35
15-30cm	34			49	6.1		0.38
Indian Head							
0-15cm	2.2	5	572	11.2	8.1	4.9	0.42
15-60cm	13.4			53.8	8.3		0.50

Data collection at all sites consisted of plant density (PPMS), height, days to maturity (DTM), lodging, grain yield, test weights (TW), and thousand kernel weights (TKW). Plant density was measured by counting the seedlings along two 1-meter sections of crop row per plot. The average between the two counted rows was then divided by the row spacing at each respective site to determine the plants/m² (PPMS). Crop height was determined by measuring the average height of the plants to the nearest cm in six areas per plot after panicle emergence was complete and the plants had finished elongating. Lodging was determined by rating every plot for severity of lodging prior to harvest. A scale of 0 to 9 was used where 0 equated to no lodging, and 9 equated to the whole plot laying flat. Days to maturity (DTM) was noted by recording the day the majority of plants in a plot reached the hard dough stage (Zadoks 87). This was

then converted to the number of days from seeding that it took each plot to reach maturity. Grain yield was determined at each site by weighing each harvested plot sample and converting the grams per plot to a kg/ha equivalent, while correcting to consistent moisture of 13.5%. Test weights (TW) were determined by weighing the grams of seed in a 0.5-litre to the nearest hundredth of a gram. Thousand kernel weight (TKW) was determined by counting and weighing a minimum of 500 seeds per plot, and converting the weight into grams per 1000 seeds. Lastly, statistical analysis was completed for each site separately using factorial analysis in Statistix 10.

10. Results:

Environmental Conditions:

Throughout the 2022 growing season, both of the participating sites experienced slightly above average temperatures (+0.2-0.3°C) alongside above average precipitation (106-117% of the long-term average) (Table 3). Melfort had above average precipitation at 106% of the long-term average (240.3mm) with an average growing season temperature of 15.5°C, which was only an increase of 0.3°C from the long-term average. Indian head also had above average precipitation at 117% of the long-term average (285.6mm) and an average growing season temperature of 15.8°C, which was a 0.2°C increase from the long-term average.

Table 4. Mean temperatures and precipitation collected from the Environment Canada Weather Station at Melfort, Yorkton, Indian Head, and Swift Current, SK for May to August 2022.

	May	June	July	August	Average/Total
--Temperature(°C)--					
Melfort 2022	9.9	15.2	18.2	18.7	15.5
Long-term^x	10.7	15.9	17.5	16.8	15.2
Indian Head 2022	10.9	16.1	18.1	18.3	15.8
Long-term^x	10.8	15.8	18.2	17.4	15.6
--Precipitation(mm)--					
Melfort 2022	90.8	78.1	34.9	36.5	240.3 (106%)
Long-term^x	42.9	54.3	76.7	52.4	226.3
Indian Head 2022	97.7	27.5	114.5	45.9	285.6(117%)
Long-term^x	51.7	77.4	63.8	51.2	244.1

^x Long-Term Climate Normal from each locations nearest Environment Canada Weather Station (1981-2010)

Plant Density (PPMS)

The only significant treatment affect of PPMS was variety at Melfort (p=0.031). At Melfort CDC Arborg (244 PPMS) had significantly increased PPMS as compared to CS Camden (220 PPMS). Although CDC Dancer and Summit both had greater average PPMS as compared to CS Camden, the difference was not significant. There were no significant treatment affects to PPMS at Indian Head. Overall, average PPMS was lower at Melfort (224 PPMS) as compared to Indian Head (268 PPMS).

Height

Height was significant for variety at Indian Head ($p < 0.0001$) and Melfort ($p < 0.0001$). At Indian Head all varieties were significantly different from one another. CDC Arborg (98.6cm) had the greatest height followed by CDC Dancer (94.6cm), CS Camden (84.4cm), and then Summit (81.7cm). At Melfort CDC Arborg (107.3cm) had significantly greater height than all other varieties. CDC Dancer (97.5cm) had significantly reduced height as compared to CDC Arborg, but was significantly greater than both CS Camden (88.6cm) and Summit (88.8cm). PGR also had a significant effect on height at both Melfort ($p < 0.0001$) and Indian Head ($p < 0.0001$). At Melfort, both PGRs significantly reduced height as compared to when no PGR was applied. Manipulator resulted in a height reduction of 8.1cm and Moddus in a 16.7cm height reduction as compared to the control. Moddus also significantly decreased plant height as compared to Manipulator at Melfort. At Indian Head, Manipulator was the only PGR that significantly reduced height as compared to the control, with an average height reduction of 5.3cm. Moddus also numerically reduced height from the control, but the difference was not significant. There was also a significant two-way interaction between variety and PGR at both Melfort ($p = 0.0001$) and Indian Head ($p = 0.0116$). At Indian Head the significant two-way interaction was that CS Camden and CDC Arborg had no significant height reductions when either PGR was applied as compared to the control, and Summit and CDC Dancer only had significantly reduced height with the application of Manipulator. At Melfort, CS Camden and Summit (shorter varieties) had comparable height reductions with both PGR products; however, CDC Dancer and CDC Arborg (taller varieties) either had no height reduction with Manipulator (CDC Arborg), or had a greater height reduction with the application of Moddus as compared to Manipulator (CDC Dancer). Overall, average plant height was greater at Melfort (95.5) as compared to Indian Head (89.8)

Lodging

Lodging was significant for variety at Melfort ($p < 0.0001$) and Indian Head ($p < 0.0001$). At Melfort, Summit (3.5) had significantly increased lodging as compared to all other varieties. CDC Dancer (1.3) also had increased lodging, but it was only significantly greater than CDC Arborg (0.3), and not CS Camden (0.4). At Indian Head, CDC Arborg (0.8) and CDC Dancer (1.1) had significantly greater lodging as compared to CS Camden (0.3) and Summit (0.4). At Indian Head, the taller varieties (CDC Arborg and CDC Dancer) demonstrated greater lodging as compared to the shorter varieties (CS Camden and Summit); however, at Melfort the varieties that had greater lodging (CDC Dancer and Summit) had less varietal resistance to lodging as compared to the varieties that demonstrated less lodging (CDC Arborg and CS Camden). Lodging was also significant for PGR at Melfort ($p < 0.0001$) and Indian Head ($p < 0.0001$). The same trend occurred at both sites where lodging was significantly reduced when a PGR was applied as compared to the control; however, there was no significant difference between products. There was also a significant two-way interaction for variety and PGR only at Melfort ($p < 0.0001$). The interaction was that varieties with greater varietal resistance to lodging (CS Camden and CDC Arborg) demonstrated no significant difference in lodging when a PGR was applied; however, varieties with less varietal resistance to lodging (CDC Dancer and Summit) demonstrated significant reductions in lodging when a PGR was applied, with no significant difference between products. Indian Head demonstrated a similar trend; however, the difference was not quite significant ($p = 0.0533$). Overall, average lodging was greater at Melfort (1.4) as compared to Indian Head (0.7). At Indian Head in particular, lodging was very minor and didn't interfere with harvest, regardless of variety or PGR treatment.

Days to Maturity (DTM)

DTM was significant for variety at both Melfort ($p < 0.0001$) and Indian Head ($p < 0.0001$). At Melfort Summit (99.2) had significantly longer DTM as compared to CS Camden (96.4), CDC Dancer (95.3), and CDC Arborg (95.5). At Indian Head, Summit (93.7) also had significantly longer DTM as compared to CS Camden (92.2), CDC Dancer (92.2), and CDC Arborg (92.8); however, CDC Arborg also had significantly longer DTM as compared to CS Camden and CDC Dancer as well. DTM was also significant for PGR application, but only at Melfort ($p < 0.0001$). DTM was significantly increased as compared to the control (95.2) with the application of Manipulator (97.4) and Moddus (97.3). There were no significant two-way interactions for variety and PGR for DTM at any of the sites. Overall, average DTM was longer at Melfort (96.6) as compared to Indian Head (92.7).

Grain Yield

Grain Yield was significant for variety at both Melfort ($p < 0.0001$) and Indian Head ($p < 0.001$). At Melfort, CDC Arborg (7803.7kg/ha) had significantly greater yield as compared to CS Camden (7071.5kg/ha), CDC Dancer (6701.4kg/ha) and Summit (6987.2kg/ha). All other varieties were not significantly different from one another. At Indian Head, CDC Arborg (6510.8kg/ha) and CS Camden (6487.8kg/ha) both had significantly greater yield than CDC Dancer (5459.2kg/ha) and Summit (6237.1kg/ha). PGR application also significantly affected yield, but only at Indian Head ($p < 0.0001$). At Indian Head, yield was significantly increased from the control (6063.5kg/ha) with the application of Moddus (6175.2kg/ha) and Manipulator (6282.4kg/ha). Yield was also significantly affected by PGR product, where Manipulator significantly increased yield as compared to Moddus. There were no two-way interactions between variety and PGR for yield at either of the sites. Overall, average yields were higher at Melfort (7140.9kg/ha) as compared to Indian Head (6173.7kg/ha).

Test Weight (TW)

TW was significant for variety at both Melfort ($p < 0.0001$) and Indian Head ($p < 0.0001$). At Melfort, CDC Dancer (270.0g/0.5L) and Summit (268.6g/0.5L) had significantly greater test weights than CDC Arborg (259.4g/0.5L) and CS Camden (257.6g/0.5L). At Indian Head, CDC Dancer (246.4g/0.5L), CDC Arborg (244.3g/0.5L), and Summit (247.0g/0.5L) all had significantly greater test weights than CS Camden (233.0g/0.5L). TW was also significant for PGR applications, but only at Melfort ($p < 0.0001$). The significant effect at Melfort was that the application of Moddus (258.9g/0.5L) significantly reduced TW as compared to Manipulator (264.9g/0.5L) and the control (267.9g/0.5L). Although average TW was reduced for Manipulator as compared to the control, the difference was not significant. There were no significant two-way interactions of variety and PGR for TW at either of the sites. Overall, average TW was higher at Melfort (263.9g/0.5L) as compared to Indian Head (242.7g/0.5L)

Thousand Kernel Weight (TKW)

TKW was significant for variety at both Melfort ($p = 0.0003$) and Indian Head ($p < 0.0001$). At Melfort, CS Camden (38.1g) and CDC Arborg (38.1g) had significantly greater TKW as compared to CDC Dancer (35.9g) and Summit (35.9g). At Indian Head, CDC Arborg (38.0g) had significantly greater TKW than all other varieties; however, CS Camden (36.5g) also had significantly greater TKW than CDC Dancer (34.6g) and Summit (35.2g). TKW was also significant for PGR applications, but only at Melfort ($p < 0.0001$). At Melfort, TKW was significantly reduced from the control (37.8g) with the application of Moddus (36.4g) and Manipulator (36.8g), but there was no significant difference between products. There were no significant

two-way interactions of variety and PGR for TKW at either site. Overall, average TKW was higher at Melfort (37.0g) as compared to Indian Head (36.1g).

11. Conclusion and Recommendation:

At both sites in this demonstration there were many significant treatment effects of oat variety and PGR applications on PPMS, height, DTM, lodging, grain yield, TW, and TKW. When variety was significant, taller varieties (CDC Arborg and CDC Dancer) had greater height, varieties with less lodging resistance (CDC Dancer & Summit) had a greater degree of lodging, and varieties with greater varietal TW (Summit and CDC Dancer) demonstrated higher TW. DTM was not always consistent across sites for varieties, but Summit did demonstrate the greatest DTM at both sites followed by CDC Arborg (only at Indian Head). Significant varietal differences in grain yield were also not always consistent; however, at both sites numerical differences in grain yield were consistent with CDC Arborg having the greatest yields followed by CS Camden, Summit, and then CDC Dancer. When PGR was significant, the application of a PGR as compared to the control reduced height, lodging, TW, and TKW, and increased DTM and yield. When there was significant difference between products there was an opposing site result for height where Moddus reduced height at Melfort as compared to Manipulator, but Manipulator reduced height as compared to Moddus at Indian Head. For grain yield at Indian head, Moddus significantly increased yields from the control; however, Manipulator significantly increased yield as compared to Moddus. At Melfort, Moddus was the only product that significantly reduced TW as compared to the control. Furthermore, the only significant two-way interactions for variety and PGR occurred for height (Melfort and Indian Head) and Lodging (Melfort only). For height, the results between sites were not consistent. At Melfort, shorter varieties (CS Camden and Summit) had comparable height reductions regardless of PGR product; however, the taller varieties (CDC Arborg and CDC Dancer) demonstrated greater height reductions with Moddus. At Indian Head, varieties with greater lodging resistance (CS Camden and CDC Arborg) had no significant height reductions in response to PGR applications; however, varieties with less lodging resistance (CDC Dancer and Summit) only had significant height reductions with an application of Manipulator. Lastly, for the two-way interaction for lodging, varieties with greater lodging resistance (CS Camden and CDC Arborg) demonstrated no significant difference in lodging when a PGR was applied; however, varieties with less varietal resistance to lodging (CDC Dancer and Summit) demonstrated significant reductions in lodging when a PGR was applied. Overall, there were many significant differences amongst the data collected that suggest there was a difference in oat varietal response to PGRs for crop height and lodging, and that PGR applications may result in height, TW, TKW, and lodging reductions with the potential to increase DTM and grain yield.

Supporting Information:

- 12. Acknowledgements:** This project was funded under the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canadian Agricultural Partnership bi-lateral agreement between the federal government and the Saskatchewan Ministry of Agriculture. The Indian Head Agricultural Research Foundation and 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. Thank you to all participating sites including the Indian Head Agricultural Research Foundation and the Northeast Agriculture Research Foundation staff for their hard work in completing this demonstration.

13. Extension:

There has been no extension of results on this project to date; however, both the Northeast Agriculture Research Foundation and Indian Head Agricultural Research Foundation will post the final report to their respective websites at www.neag.ca and www.iharf.ca. At Indian Head, the project was signed and scheduled to be shown at the Indian Head Crop Management Field Day on July 18, but the site could not be visited due to heavy rain. Alternatively, the project was introduced by Chris Holzapfel during indoor presentations to approximately 120 participants. The Northeast Agriculture Research Foundation has not yet, but plans to create a short YouTube video highlighting this project and the results that will be posted to their YouTube Channel [Northeast Agriculture Research Foundation - YouTube](#). This will be completed within the next few months.

14. Abstract and Summary:

The black soil zone is the largest oat producing area in Saskatchewan. Due to higher moisture retaining capacities of fine textured soils, the oat crops in this region are tall and yield well, but can be prone to lodging. Lodging in oats leads to reduced seed quality and difficulties during harvesting. Plant growth regulators (PGR) can be applied to oats at the 1st node stage (GS 31) to reduce stem internode length, which may reduce crop height and decrease crop lodging. With many different oat varieties available to be grown with varying height and lodging resistance, differences in varietal response to PGR may be expected but are not well understood. To demonstrate oat varietal response to PGRs, a small-plot demonstration was conducted at Indian Head and Melfort, SK in 2022. Four varieties were selected, all with varying height and lodging resistance, and two registered PGR products were used known as Manipulator[®] and Moddus[®], which both work by similar mechanisms to reduce crop height. Data collection consisted of plant density, height, days to maturity (DTM), lodging, grain yield, test weights (TW) and thousand kernel weights (TKW). When variety was significant, varieties generally performed as expected based on their characteristics in the Saskatchewan Seed Guide with respect to height, lodging, yield, and test weight. When PGR was significant, PGR applications reduced height, lodging, TW, and TKW, while sometimes increasing DTM and grain yield. When there was a significant two-way interaction between variety and PGR, taller varieties had greater height reductions with Moddus[®] and shorter varieties had similar height reductions regardless of product at Melfort; however, at Indian Head the two varieties with lesser lodging resistance were the only varieties with significant height reduction when Manipulator[®] was applied. Lastly, the significant two-way interaction for lodging at Melfort was that varieties with lesser lodging resistance demonstrated greater reductions in lodging when a PGR was applied as compared to varieties with greater varietal resistance to lodging.

15. Appendices:

Table 5. Statistical analyses and treatment means for Oat varietal response to plant growth regulators at Melfort, SK in 2022. Means within a column followed by the same letter do not significantly differ (Tukey-Kramer, $P \leq 0.05$).

Melfort							
	PPMS ^z	Height ^z	DTM ^z	Lodging ^z	Grain Yield ^z	TW ^z	TKW ^z
Variety (Var)	0.031	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0003
PGR	0.2127	<0.0001	<0.0001	<0.0001	0.2581	<0.0001	<0.0001
Var X PGR	0.2913	0.0001	0.3256	<0.0001	0.1906	0.3192	0.983
Grand Mean	223.6	95.54	96.6	1.4	7140.9	263.9	37.0
CV	11.8	2.62	1.4	63.2	5.5	1.4	2.45
<u>Var</u>							
CS Camden	219.5ab	88.6c	96.4b	0.4bc	7071.5b	257.6b	38.1a
CDC Dancer	212.6b	97.5b	95.3b	1.3b	6701.4b	270.0a	35.9b
CDC Arborg	244.0a	107.3a	95.5b	0.3c	7803.7a	259.4b	38.1a
Summit	218.3ab	88.8c	99.2a	3.5a	6987.2b	268.6a	35.9b
<u>PGR</u>							
None	227.0a	103.8a	95.2b	2.8a	7147.9a	267.9a	37.8a
Manipulator	213.9a	95.7b	97.4a	1.1b	7019.2a	264.9a	36.8b
Moddus	229.9a	87.1c	97.3a	0.4b	7255.6a	258.9b	36.4b
<u>Var X PGR</u>							
None Camden	236.6a	96.5b	95.5cde	0.8c	7236.7abc	260.1bcd	38.8ab
None Dancer	194.8a	109.1a	93.5e	3.3b	6448.5c	273.8a	36.7bcd
None Arborg	242.4a	112.3a	94.0de	0.3c	7882.8ab	262.5bcd	39.0a
None Summit	234.2a	97.2b	97.8abc	6.8a	7023.7abc	275.0a	36.8abcd
Moddus Camden	217.8a	82.9c	96.5bcde	0.0c	6938.5bc	254.0d	37.8abc
Moddus Dancer	232.5a	85.9c	97.0abcd	0.0c	7184.6abc	263.2bc	35.2d
Moddus Arborg	246.5a	98.3b	95.5cde	0.0c	7951.7a	254.6cd	37.4abcd
Moddus Summit	222.7a	81.4c	100.0a	1.5bc	6947.7bc	263.9b	35.2d
Manipulator Camden	204.0a	86.5c	97.2abc	0.4c	7039.2abc	258.7bcd	37.8abc
Manipulator Dancer	210.4a	97.5b	95.5cde	0.8c	6470.9c	273.1a	35.8cd
Manipulator Arborg	243.2a	111.4a	97.0abcd	0.8c	7576.6ab	261.2bcd	38.0abc
Manipulator Summit	198.1a	87.7c	99.7ab	2.4bc	6990.1abc	266.8ab	35.8cd

^zSignificance level of the p-value: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6. Statistical analyses and treatment means for Oat varietal response to plant growth regulators at Indian Head, SK in 2022. Means within a column followed by the same letter do not significantly differ (Tukey-Kramer, $P \leq 0.05$).

Indian Head							
	PPMS	Height	DTM	Lodging	Grain Yield	TW	TKW
Variety (Var)	0.0993	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
PGR	0.9913	<0.0001	0.1252	<0.0001	<0.0001	0.4603	0.2146
Var X PGR	0.8108	0.0116	0.7835	0.0533	0.1384	0.1583	0.5190
Grand Mean	268.7	89.8	92.7	0.7	6173.7	242.7	36.1
CV	12.02	2.33	0.48	47.81	1.85	1.34	2.1
<u>Var</u>							
CS Camden	285.7a	84.4c	92.2c	0.3b	6487.8a	233.0b	36.4b
CDC Dancer	270.9a	94.6b	92.2c	1.1a	5459.2c	246.4a	34.6c
CDC Arborg	266.3a	98.6a	92.8b	0.8a	6510.8a	244.3a	38.0a
Summit	251.7a	81.7d	93.7a	0.4b	6237.1b	247.0a	35.2c
<u>PGR</u>							
None	267.8a	92.0a	92.6a	1.1a	6063.5c	243.1a	36.3a
Manipulator	269.2a	86.7b	92.9a	0.4b	6282.4a	241.8a	35.8a
Moddus	268.9a	90.7a	92.6a	0.5b	6175.2b	243.0a	36.1a
<u>Var X PGR</u>							
None Camden	285.8a	86.3cd	92.0c	0.6bcd	6451.1ab	234.4b	37.0abcd
None Dancer	263.7a	97.1a	92.0c	1.8a	5280.9e	244.7a	35.1def
None Arborg	277.6a	99.7a	92.8abc	1.0ab	6371.9abc	245.5a	38.0ab
None Summit	244.0a	84.9d	93.5ab	0.9bc	6150.1c	247.9a	35.3def
Moddus Camden	296.9a	84.6d	92.3c	0.1cd	6477.5a	233.1b	36.2bcde
Moddus Dancer	272.7a	95.7ab	92.0c	0.9bc	5467.5de	247.0a	34.3f
Moddus Arborg	257.6a	98.4a	92.5bc	0.5bcd	6588.4a	242.7a	38.5a
Moddus Summit	248.5a	84.5d	93.8a	0.4bcd	6167.5bc	249.5a	35.2def
Manipulator Camden	274.4a	82.4d	92.3c	0.1cd	6534.6a	231.5b	36.0cdef
Manipulator Dancer	262.5a	90.9bc	92.5bc	0.6bcd	5629.2d	247.4a	34.5ef
Manipulator Arborg	277.6a	97.6a	93.0abc	0.9bc	6572.1a	244.7a	37.6abc
Manipulator Summit	262.5a	75.8e	93.8a	0.0d	6393.5abc	243.7a	35.2def

^zSignificance level of the p-value: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$