Project Identification

1. **Project Title:** Demonstrating the Use of Plant Growth Regulators to Reduce Lodging While Realizing Yield Potential Through Increased N Fertilization in Oats
2. **Project Number:** 20200505
3. **Producer Group Sponsoring the Project:** Saskatchewan Conservation Learning Centre
4. **Project Location(s):** Conservation Learning Centre – Prince Albert, SK
   SW 20 46 26 W2 RM #461
   Coordinates of corners: N53˚01.298' W105˚50.289'
   N53˚01.300' W105˚50.250'
   N53˚01.286' W105˚50.288'
   N53˚01.286' W105˚50.251'
5. **Project start and end dates (month & year):** April 2021 to February 2022
6. **Project contact person & contact details:**
   Primary Contact: Robin Lokken (General Manager)
   Phone: 1-306-960-1834
   Email: info@conservationlearningcentre.com

   Secondary Contact: Ryan Scragg (BOD Chair)
   Phone: 1-306-961-2240
   Email: ryan_scragg@hotmail.com

Objectives and Rationale

7. **Project objectives:**

This project was intended to evaluate the benefits of using plant growth regulators in oats to reduce lodging and determine if they can help increase profits. The trial also evaluated the potential of achieving greater yielding oats by applying higher rates of nitrogen.

8. Project Rationale:

Plant Growth Regulators (PGRs) were first discovered in 1965, since then they have been widely utilized across the United States and Europe (Gov AB, 2018). On the Canadian prairies, PGRs have mostly been applied to wheat crops. With new products coming onto the market there is an opportunity to use PGRs in a wider variety of crops. In Saskatchewan, most research has taken place at southern research stations and studied the effects of PGRs on wheat and durum (Japp, 2020). A 1995 study, originating from Finland found that the combination of increased nitrogen rates and the use of PGRs increased oat yields (Pietola et al. 1999). More recently, a study in Alberta demonstrated that PGRs can effectively reduce the height of oats while allowing yield potentials to be reached through the use of increased application of nitrogen (King, 2015). Increased nitrogen rates often result in higher yields. However, with increased yields producers can expect to see heavier heads and taller stalks, which sometimes leads to lodging (King, 2015). Research has found that lodging can reduce cereal yields from 7 to 35 percent (Strydhorst et al.). Plant growth regulators can be a great tool to combat this issue. PGRs are synthetic compounds that change the way a plant grows by altering its hormonal balance. PGRs reduce stem length, reduce cell elongation, and alter the diameter of stems (Strydhorst et al.). Results of the study discussed in King's article were varied and site-specific, indicating the importance of local demonstrations. Yan et al. illustrated in 2017 that higher rates of nitrogen increased yields and also had beneficial effects on the quality of the oats produced. Both of these parameters are significant for producers looking to increase profits made from growing oats.

Oats are important in north-central Saskatchewan and they have the potential to become a high-value crop. This is especially true for producers in the Parkland region since oats are known to grow best in moist black soils (King, 2015). Oats are increasing in popularity among Saskatchewan farmers. In the 2020 season 916, 966 acres of oats were insured through the Saskatchewan Crop Insurance Corporation (SCIC). An increase from the 809, 666 acres of oats insured in the 2019 growing season (SCIC, 2020). Higher levels of precipitation in north-central Saskatchewan in combination with higher rates of nitrogen could lead to high-yielding oats. The effects that PGRs have on specific species and varieties of crops is different. Producers are very interested in learning about the outcomes of using PGRs on common varieties of oats found within the region.

In the 2020 growing season, the Manipulator brand of PGR expanded its label to include barley and oats. The expansion of the Manipulator label has stirred-up local interest in PGRs as lodging continues to be an issue for farmers in the area. With the high yield potential for oats in the parkland region, PGRs could be a tool for producers to use in their operations (Strydhorst et al.). This project showcased the efficacy of PGRs under regional conditions. It also served to expand the knowledge base of local producers wanting to attain high-yielding oats with decreased lodging in north-central Saskatchewan.

References:

"Annual Reports for 2019-2020 | SCIC." *SCIC*, Saskatchewan Crop Insurance Corporation, 2020, https://www.scic.ca/about-us/annual-reports/.

Government of Alberta. 2018. Plant growth regulators: What agronomists need to know. Retrieved October 29, 2020 from https://open.alberta.ca/dataset/6b02fbf7-fb8a-42ee-88ca1266803f623f/resource/d32b3d5d-72d9-4e97-9e9a-15a9828cfb1d/download/100-584-1.pdf

Japp, M. 2020. Plant growth regulator option now available on oats and barley. Retrieved October 28, 2020 from https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmersand-ranchers/sask-ag-now/crops/crop-production-news/cpn-2020-2/growth-regulator

King, C. 2015. Optimizing oat production. Retrieved October 28, 2020, from https://www.topcropmanager.com/optimizing-oat-production-17710/

Karki, D. 2020. Plant growth regulator reduces height, lodging in oats. Retrieved October 28, 2020 from https://extension.sdstate.edu/plant-growth-regulator-reduces-height-lodging-oats L, Pietola., R, Tanni., and P, Elonin. 1999. Responses of yield to N use of spring sown crops to N fertilization, with special reference to the use of plant growth regulators. Agriculture and food science in Finland. 8:423- 440.

Strydhorst, Sheri, et al. "Plant Growth Regulators : What Agronomists Need to Know ." *Open Government Program | Alberta.Ca*, Government of Alberta, Sept. 2018, https://open.alberta.ca/publications/agdex-100-548-1.

Yan, W., Fregeau-Reid, J., Ma, B.L., Pageau, D., Vera, C. (2017). Nitrogen fertilizer complements breeding in improving yield and quality of milling oat, 57(6), 3291-3302. http://dx.doi.org/10.2135/cropsci2017.05.0290

Methodology and Results

9. Methodology:

This 1-year project aimed to demonstrate the benefits of using plant growth regulators to reduce lodging in oats. It also served to determine the potential for increased profits and achieving higher-yielding oats through the use of higher nitrogen rates. This demonstration was set up in a randomized complete block design. The 10 treatments were replicated 4 times and plots were approximately 2 m x 7 m. Plant growth regulators (PGRs) were applied in 5 of the treatments with no PGRs being applied in the remaining 5 treatments. Treatments also received different fertility N rates. A treatment summary can be found below in Table 1.

Table 1. Treatments used in "Demonstrating the Use of Plant Growth Regulators to Reduce Lodging While Realizing Yield Potential Through Increased N Fertilization in Oats"

TRT #	Nitrogen rate	Plant Growth Regulator
1	0x the recommendation	No
2	1x the recommendation	No
3	1.25x the recommendation	No
4	1.5x the recommendation	No
5	2x the recommendation	No
6	0x the recommendation	Yes
7	1x the recommendation	Yes
8	1.25x the recommendation	Yes
9	1.5x the recommendation	Yes
10	2x the recommendation	yes

On May 28th, CS Camden oats were seeded at a rate of 140 kg/ha for a target plant stand of 350 plants/m^2. Seeding occurred with a Fabro Plot Seeder and 10-inch row spacing. A composite soil sample from the trial area was submitted to Agvise Laboratories for analysis. Agvise then provided fertilizer

recommendations based on soil sample results and an oat yield goal of 145bu/ac. The nitrogen rates for the trial were 0x, 1x, 1.25x, 1.5x, 2x the recommended N fertilizer rates. All N fertilizer was midrow banded.

Pre-emergent herbicide was sprayed on June 15th, at a rate of 510 mL Dyvel/ac to 40 L water/ac. On July 6th, Manipulator was applied on treatments 6, 7, 8, 9, and 10 when plants were around BBCH stage 37-39 at a rate of 0.93 L Manipulator/ac to 80 L water/ac. Folicur fungicide was applied to all plots on July 13th, at a rate of 202 mL fungicide/ac to 60 L of water/ac.

Data collection for this trial included plant density counts, height at maturity, lodging rating, protein analysis, yield, and economic analysis. Plant density was determined on June 18th, by counting 2 x 1 m sections from the front and back of each plot. The Belgian lodging scale (area [1-10] x intensity [1-5] x 0.2) was used to rate lodging on August 19th and September 23rd. All plots were harvested on September 23, 2021, with the CLC's Wintersteiger Quantum plot combine. The oat yield was measured and corrected to 14% seed moisture content. An economic analysis was evaluated using yield and input cost parameters. An agronomic summary can be found in Table 2.

Data analysis was completed by ANOVA using Statistix 10 software. Any non-parametric data was analyzed using the Kruskal-Wallis test. Post-hoc tests used were LSD for parametric data and Dunn's multiple comparisons test for non-parametric data.

Table 2. Agronomic Summary

Seeding date	May 28th, 2021
Seeding Method	Fabro plot seeder with double disc openers and 10 in row spacing
Seeding Rate	CS Camden Oats @ 140 kg/ha
Soil Temp at Seeding	11.4°C
Stubble	Canola
Seed Depth	1.25 inches
Fertilizer	Fertilizer was placed at a depth of approximately 3 inches · *1x* = urea @ 118 kg N/ha · *1.25x* = urea @ 147 kg N/ha · *1.5x* = urea @ 177 kg N/ha · *2x* = urea @ 236 kg N/ha All treatments also received MAP @ 45 kg P/ha in the seed row.
Emergence	June 8th, 2021
Pre-Emergent Herbicide	Dyvel @ 510 mL/ac to 40 L of water/ac on June 15th
Plant Growth Regulator	Manipulator @ 0.93 L/ac to 80L of water/ac to treatments 6, 7, 8, 9, and 10 on July 6th - BBCH 37-39
Spring Plant Density	Number of plants in 2 x 1 m sections from the front and back of each plot on June 18th
Fungicide	Folicur @ 202 mL/ac to 60 L of water/ac on July 13th
Lodging	Lodging was rated on August 19th and September 23rd using the Belgian

	lodging scale (area [1-10] x intensity [1-5] x 0.2)
Plant Heights	Measured to the nearest centimetre on August 19th
Harvest Date	September 23rd, 2021
Harvest Method	Entire plot using a Wintersteiger Quantum plot combine
Soil Type	Clay loam
Soil Zone	Black

10. Results

Weather

The 2021 growing season at the CLC was very hot and dry compared to past years (Table 3). The average temperature for the entire growing season was nearly 1˚C warmer than the long-term average. Total precipitation in the 2021 growing season was 97.1 mm lower than the long-term average. Precipitation was very low in May, but a timely rain on May 24 helped with emergence. July was also exceptionally dry (9.6 mm) when compared to the long-term average of 84.6 mm, and hot with 10 days above 30°C. Higher than average precipitation in June and August likely mitigated some drought-related losses. The first fall frost occurred on October 2 (-0.9˚C). The complete monthly weather summaries can be downloaded from src.sk.ca/download-weather-summaries.

Table 3. Weather conditions in the 2021 growing season at the Conservation Learning Centre from the onsite SRC weather station.

	May	June	July	August	September	October	Average/Total
				--- Mean Temperature (°C) ---			
2021	10.1	18.3	20.3	17.0	13.5	4.9	14.0
2012-2020	11.4	15.9	18.5	17.1	11.4	2.9	12.9
				--- Precipitation (mm) ---			
2021	29.8	84.0	9.6	57.0	9.5	13.9	202.3
2012-2020	40.4	79.6	84.6	42.9	31.2	20.7	299.4

Soil Test

Soil samples were collected using a Dutch soil auger on May 15, 2021 and sent to Agvise Laboratories for analysis. Soil test results indicated nitrogen was low with 27 lb/ac in the top 30 cm (Table 4). Phosphorus was very low at 4 ppm and potassium was high at 284 ppm. Sulfur was medium with 34 lb/ac available in the top 30 cm.

Table 4. Composite soil test results from May 15, 2021.

Depth (cm)	N (lb/ac)	P (ppm)	K (ppm)	S (lb/ac)	Zn (ppm)	OM (%)	pH	Salts (mmho/cm)
0 to 15	15	4	284	16	1.93	5.8	5.9	0.17
15 to 30	12			18			6.4	0.21
0 to 30	27							

Data Analysis

Plant height differed significantly between treatments (Table 5). Plants in the 1-2x N rate NO PGR treatments were significantly taller than plants in all other treatments. The 0x N rate YES PGR treatment was significantly shorter than all other treatments, which indicates that the plant growth regulator did successfully reduce plant height.

While lodging was relatively low overall due to a hot and dry growing season, there were significant differences in lodging between treatments when rated on September 23rd (Table 5). Lodging was significantly more severe in the 1.5x N rate NO PGR treatment at 2.5 than in the 0x and 1x N rate YES PGR treatments where no lodging was detected. At each application rate of N, the treatments where no plant growth regulator was used had more severe lodging than the treatments where plant growth regulators were applied. This confirms that the use of a plant growth regulator can successfully reduce lodging in oats. This impact may have been even more pronounced in a wetter growing season.

Yield differed significantly between treatments (Table 5). The yield goal was 145 bu/ac, based on the 2021 Crop Planning Guide target for the black soil zone. Yield was significantly lower in treatments where no N fertilizer was applied than in all other treatments, averaging at 97.7 bu/ac without PGR and 108.1 bu/ac with PGR. While yield was not significantly different between the NO PGR and YES PGR treatments at the 1x, 1.25x, 1.5x and 2x N application rates, yields were observably 10 bu/ac higher when PGR was applied than when no PGR was applied at each rate of N fertilizer. This suggests there could be a potential yield benefit to the application of a plant growth regulator. Yield was highest in the 1x N rate YES PGR treatment at 153.1 bu/ac.

Grain protein content was significantly different between treatments (Table 5). The treatments where no N was applied had significantly lower protein at 10.3-10.5%, compared to the 2x N rate NO PGR and the 1.25x N rate YES PGR treatments that both had protein of 14.4%. This indicates that increasing N above 1x the recommended rate does improve grain protein. However, this effect does not necessarily scale linearly with increasingly higher rates of N, especially under less than ideal growing conditions.

Table 5. Summary of means in "Demonstrating the Use of Plant Growth Regulators to Reduce Lodging While Realizing Yield Potential Through Increased N Fertilization in Oats" trial.

Trt #	Description	Plant Density (plants/m^2)	Plant Height (cm)	Lodging (0-9)		Yield (bu/ac)	Protein (%)
				Aug 19	Sep 23		
1	0x N rate NO PGR	242	76.1 B	0.0	0.5 AB	97.7 B	10.3 B
2	1x N rate NO PGR	282	85.6 A	0.0	1.8 AB	132.2 A	13.5 AB
3	1.25x N rate NO PGR	277	85.5 A	0.0	2.3 AB	137.7 A	13.8 AB
4	1.5x N rate NO PGR	284	87.4 A	0.0	2.5 A	133.3 A	14.0 AB
5	2x N rate NO PGR	271	85.3 A	0.0	2.0 AB	134.2 A	14.1 A
6	0x N rate YES PGR	242	62.9 C	0.3	0.0 B	108.1 B	10.5 B
7	1x N rate YES PGR	262	72.1 B	0.8	0.0 B	153.1 A	13.2 AB
8	1.25x N rate YES PGR	259	73.4 B	0.0	0.5 AB	145.4 A	14.1 A
9	1.5x N rate YES PGR	276	71.1 B	0.5	0.5 AB	143.3 A	13.5 AB
10	2x N rate YES PGR	282	75.6 B	0.5	1.0 AB	145.5 A	14.0 AB
	p-value	0.7716	<0.0001	0.1074	0.0001	0.0004	<0.0001

†Values with the same letter are not statistically different (P>0.05)

An economic analysis was conducted in order to help compare revenue potential between treatments (Table 6). The application of a plant growth regulator did increase net revenue of oats in the 2021 growing season. Net revenue was lowest in the 0x N rate NO PGR treatment at $646.73/ac, and only slightly higher in the 0x N rate YES PGR treatment at $706.40/ac. The 1x N rate YES PGR treatment had the highest net revenue at $964.19/ac, a $136.28/ac advantage over the 1x N rate NO PGR treatment and a $317.46/ac advantage over the 0x N rate NO PGR treatment. Higher application rates of N, on the other hand, did not consistently translate to higher profits. Due to the hot and dry conditions experienced throughout the growing season, the oats may not have benefitted from higher nitrogen rates. Under wetter growing conditions, the oats may have responded differently to high fertilizer rates. While it was not considered in this economic analysis, another expense that a producer should consider is the additional costs of equipment wear, fuel, and labour involved with the application of a plant growth regulator product.

Table 6. Economic analysis for "Demonstrating the Use of Plant Growth Regulators to Reduce Lodging While Realizing Yield Potential Through Increased N Fertilization in Oats" trial. Expenses for this trial included the cost of seed, fertilizer and plant growth regulator only. Net revenue is provided as an estimate and is only meant to be used to help discern differences in revenue potential between treatments.

Trt #	Description	Mean Yield (bu/ac)	Gross Revenue[1] ($/ac)	Total Expenses[2] ($/ac)	Net Revenue ($/ac)
1	0x N rate NO PGR	97.7	713.60	66.87	646.73
2	1x N rate NO PGR	132.2	965.71	137.81	827.91
3	1.25x N rate NO PGR	137.7	1005.66	156.22	849.44
4	1.5x N rate NO PGR	133.3	973.67	174.64	799.04
5	2x N rate NO PGR	134.2	979.74	211.47	768.26
6	0x N rate PGR	108.1	789.41	83.01	706.40
7	1x N rate PGR	153.1	1118.13	153.95	964.19
8	1.25x N rate PGR	145.4	1061.75	172.36	889.39
9	1.5x N rate PGR	143.3	1046.85	190.78	856.07
10	2x N rate PGR	145.5	1062.41	227.61	834.80

[1]Based on an estimated Saskatchewan oat market price of $473.64/tonne from www.statpub.com/index.php/prices/spotbids on January 18, 2022. This estimate of gross revenue does not include dockage or premiums based on grain protein content.
[2]Expenses were calculated using prices from the spring of 2021 for oat seed, MAP, urea and Manipulator PGR. Oat seed was estimated at $31.43/ac according to the 2021 Crop Planning Guide. Other input prices were obtained from Lake Country Co-op Agro, putting MAP at $1015/tonne, urea at $710/tonne, and Manipulator PGR at $16.14/ac. Additional expenses that were not considered include pesticides, machinery wear and fuel, labour, property taxes, etc.

11. Conclusions and Recommendations

The application of a plant growth regulator (PGR) product in oats successfully reduced plant height and lodging and improved yield. Plant height and lodging were significantly lower and yield was observably higher in treatments where a PGR was applied. The potential benefit of increasing nitrogen fertilization rates on oats was less clear. Treatments where no nitrogen fertilizer were applied had significantly lower yield and grain protein content than treatments where nitrogen fertilizer was applied. Increasing N above 1x the recommended rate did improve grain protein. However, this effect did not scale linearly with increasingly higher rates of N. Additionally, it was determined that net revenue was maximized when using a plant growth regulator at 1x the recommended nitrogen fertilization rate based on 2021 oat yields. It is recommended that this trial be repeated in a wetter year, in order to examine the effects of the plant growth regulator and high fertilization rates under more optimal growing conditions.

Supporting Information

12. Acknowledgements

The Conservation Learning Centre graciously acknowledged the Ministry's support through signage directly in field with the project, verbally during the Field Day and on the Field Day agenda handed out to all visitors. The CLC would also like to thank sales representatives from BELCHIM Crop Protection for donating the plant growth regulator used in the trial.

Abstract

13. Abstract/Summary

This trial aimed to demonstrate the benefits of combining high nitrogen fertilization rates with the use of a plant growth regulator (PGR) to reduce lodging while increasing profits and yields in oats. CS Camden oats were seeded in 2021 at the Conservation Learning Centre south of Prince Albert, SK. There were 10 treatments, consisting of five different N fertilization rates (0X, 1X, 1.25X, 1.5X, and 2X based off soil test recommendation) that were duplicated where half the treatments received a PGR and the other half did not. Manipulator PGR was applied to five treatments at a rate of 0.93 L/ac on July 6th between BBCH stages 37-39. The 2021 growing season was hot and dry. Total precipitation was 97.1 mm lower than the long-term average. Plants were significantly shorter and lodging and yield were observably higher when a PGR was applied. This suggests a potential yield benefit from the application of a PGR. Yields ranged between 97.7-137.7 bu/ac with no PGR applied, compared to between 108.1-153.1 bu/ac with a PGR applied. The benefits of increasing N fertilizer were less clear. Treatments where no nitrogen fertilizer were applied had significantly lower yield and grain protein content than treatments where nitrogen fertilizer was applied. Increasing N above the recommended rate did improve grain protein. However, this effect did not scale with higher rates of N. Yield was highest (153.1 bu/ac) when a PGR was applied at the 1x N fertilization rate, and protein was highest when a PGR was used at a 1.25x nitrogen rate and when no PGR was used at a 2x nitrogen rate, at 14.1%. Based on 2021 oat yields, it was determined that net revenue was maximized when using a plant growth regulator at 1x the recommended nitrogen fertilization rate. This resulted in a $136.28/ac advantage over the treatment at the same fertilization level where no PGR was applied. Higher rates of N fertilizer did not consistently translate to higher profits. It is recommended that this trial be repeated in order to examine the effects of the PGR and high fertilization rates under more optimal growing conditions.