2015 Annual Report
for the
Agriculture Demonstration of Practices and Technologies
(ADOPT) Program

Project Title: Spring wheat response to nitrogen fertilizer with the addition of a plant growth regulator applied at various crop stages

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Producer Group Sponsoring the Project: Western Applied Research Corporation

Project Location: AAFC Scott Research Farm, R.M. #380, NE 17-39-21 W3

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Objectives and Rationale

Project Objectives

To determine if the plant growth regulator (PGR) "Manipulator" can reduce straw height and/or lodging and increase grain yield of spring wheat grown under various levels of N fertility in northwest Saskatchewan.

Project Rationale

Farmers in northwest Saskatchewan have experienced higher than average grain yields in the past few years. To maintain these higher grain yields, farmers are increasing their nitrogen fertilizer applications in an effort to maximize yield potential. However, many of the popular CWRS wheat varieties grown in northwest Saskatchewan are not lodge resistant and the nitrogen fertilizer applications required to maximize yield potential can lead to excessive vegetative growth, crop lodging and higher disease levels. To control plant height of cereals under high input management systems, European farmers use PGRs; however, they have only recently been registered for use in western Canada. Manipulator, distributed by Engage Agro (commercially available in 2015), is a gibberellin synthesis inhibitor, which, when applied at the proper application timing, reduces stem elongation and increases straw strength, thus reducing plant height and lodging risk. This demonstration will allow farmers to observe the effect of PGRs on spring wheat under various levels of nitrogen fertility and demonstrate to most effective application timing for PGRs.

Methodology and Results

Methodology

This demonstration was conducted at the AAFC Scott Research Farm in 2015. The demonstration was set up as a 3 x 4 factorial in a randomized complete block design with four replicates. The first factor is the application of the PGR "Manipulator" applied at optimal timing (Zadoks 31), early timing (Zadoks 21) and late timing (Zadoks 39), and no PGR (check). The second factor, nitrogen fertilizer rate, was applied at 100, 125 and 150% of the recommended rate based on soil test levels and a target yield of 50 bu/ac (Table 1). All other nutrients and pesticides were applied to optimize grain yield (Appendix A1). A lodging susceptible CWRS variety (CDC Shaw) was used to detect the potential improvement in grain yield and straw strength using a PGR with increasing nitrogen rates. Wheat was seeded at a recommended seeding rate (250 viable seeds/m2).

Table 1. Detailed treatment list for the trial "Spring wheat response to nitrogen fertilizer with the addition of a plant growth regulator applied at various crop stages" at Scott, Saskatchewan, 2015.

Treatment #	PGR Application Timing	N Fertilizer Rates
1	No PGR	100% N Rate
2	No PGR	125% N Rate
3	No PGR	150% N Rate
4	Zadoks 21	100% N Rate
5	Zadoks 21	125% N Rate
6	Zadoks 21	150% N Rate
7	Zadoks 31	100% N Rate
8	Zadoks 31	125% N Rate
9	Zadoks 31	150% N Rate
10	Zadoks 39	100% N Rate
11	Zadoks 39	125% N Rate
12	Zadoks 39	150% N Rate

Plant densities were assessed when there were visible rows to determine plant emergence among treatments. These were assessed by counting two 1 m rows in the front and back of the plot for a total of four rows per plot. The average of the four rows was converted to plants per m^{-2} based on 10 inch row spacing. Plant height was taken by measuring ten plants and then averaged to determine total plant height per plot. Lodging was assessed at Zadoks 87 using the Belgian lodging scale (area x intensity x 0.2 - area rated on 1-10 scale, intensity rated on 1-5 scale). The days to maturity were also assessed when the crop reached physiological maturity (Zadoks 87). Grain yields were determined after plots were mechanically harvested, cleaned and corrected to 14.5 % seed moisture. Test weights were determined using the Canadian Grain Commission protocols (Canadian Grain Commission, 2014) and percent protein was determined at the Scott Research Farm laboratory.

Statistical Analysis

An analysis of variance (ANOVA) was conducted on all response variables using the PROC MIXED in SAS 9.3. PGR application timing and nitrogen rate were considered as fixed effect factors and replicates and their interaction with fixed effects were considered a random effect factor. The assumptions of ANOVA (equal variance and normally distributed) were tested using Levene's test, and Shapiro-Wilks. The data fitted to the ANOVA assumptions. Treatment means were separated according to Tukey's Honestly Significant Difference (HSD) and considered significant at $P \leq 0.05$. PROC GLM regression was used on treatments of both PGR application timing and N fertilizer rates. Weather data was collected from the Scott Environment Canada weather station (Table 2).

Weather Conditions

In 2015, the early growing season was very dry with only 4.1 mm and 19.4 mm accumulated precipitation during the month of May and June, respectively. July received 36 % less rainfall compared to the long term average. However, August received 39 % more moisture compared to the long-term average. The mean monthly temperatures were comparable to previous years (Table 2).

Table 2. Mean monthly temperature, precipitation and growing degree day accumulated from May to September 2015 at Scott, SK

Year	**May**	**June**	**July**	**August**	**September**	**Average /Total**
			Temperature (°C)			
2015	9.3	16.1	18.1	16.8	10.9	14.24
Long-term[z]	10.8	15.3	17.1	16.5	10.4	14.0
			Precipitation (mm)			
2015	4.1	19.4	46.4	74.5	49.6	194.0
Long-term[z]	36.3	61.8	72.1	45.7	36.0	215.9
			Growing Degree Days			
2015	140.3	332	405.1	365.8	179.8	1423.0
Long-term[z]	178.3	307.5	375.1	356.5	162.0	1379.4

[z]Long-term average (1981-2010)

Results

Plant Height

The applications timing of Manipulator^{TM} played a significant role in reducing the height of the wheat crop (Table 3). This was an expected result, as this is the nature of the product. The PGR used in this study controlled plant height by inhibiting the production of gibberellins, the primary plant hormones responsible for cell elongation. Therefore, these growth-retardant effects are primarily seen in stem, petiole, and flower stalk tissues. PGR applications were significant on plant height when applied at Z31 and Z39, however, the effect of PGR applied at Z21 was not significantly different compared to the untreated control (Table 3). Although the PGR applications did result in shorter plants compared to the untreated check and the Z 21 application timing, it is important to note that there was no lodging reported in any of the treatments. This is likely attributed to the drought during the growing season, resulting in shorter plants overall. When PGR was applied at Z31 and Z39, plant height decreased by 8.5% and 7%, respectively (Figure 1). The early application (Z21) should have resulted in some shortening in comparison to the untreated check. This is because the PGR was applied before the elongation hormones are produced and thus the plant can readily metabolize the PGR. However, the PRG application was applied during a drought, and at a time in which plant growth was minimal, which may have resulted in a lack of response to the PGR applications.

In contrast, the later applications were much shorter, due to the PGR preventing the elongation hormone from being synthesized. The very late applications will not be as short because some of the stem height has already been set. The Z 31 timing was the shortest and averaged 80 cm in height, while the control was 88 cm (Table 3). It was also found that the Z 31 and Z 39 timings were not statistically different from each other, however, they did differ from the control and Z 21 timing (Table 3). Neither fertility nor the interaction of fertility and timing affected plant height. This would suggest that the growth regulator was equally effective across all fertility levels. These results are similar to those documented at Melfort in 2014 and 2015 (NARF final report, 2015). Similarly, Shekoofa and Emam (2008) found similar results in which PGR treatments reduced the plant height and this reduction played an important role in the increase of the grain yield in wheat, via the alteration of dry matter partitioning into the spikes. Results of several field experiments also showed that in winter wheat the number of spikes per unit area generally increases when treated with PGR (CCC) (Karchi, 1969; Knapp and Harms, 1988).

Table 3. The effect of PGR and N rate and their interaction on wheat plant height (cm). Means separated by Tukey's HSD test and deemed significant at P<0.05.

	Plant Height (cm)
	-----------*p* value -----------
N Rate	0.808
N Rate * PGR	0.907
PGR	0.0001
No PGR	88 A
Z21	89 A
Z31	80 B
Z39	82 B

Grain Yield & Seed Quality

A yield increase was expected between the significantly shortened plants (Z 31 and Z39 treatments) compared to the untreated check, as this has been documented in several cases (Karchi, 1969; Knapp and Harms, 1988; Shekoofa and Emam, 2008). However, yield was not significantly affected by either PGR application timing or N rate. A general trend was noted however, with an increase in yield with increased N rate and PGR applications compared to the untreated check. On average, the PGR applications produced 4043 kg/ ha (60 bu/ac) while the untreated check produced 3845 kg/ha (57 bu /ac). A greater yield increase may have been reported if there had been a greater difference in height, as Zhang et al. (2004) found that water use efficiency increased in shorter plants allowing the yield to be less effected by drought stress. However, as the Z31 and Z39 treated plants were only 8.5% and 7% shorter compared to the untreated check, water use efficiency would not been significantly influenced.

Table 4. The effect of PGR and N rate and their interaction on wheat days to maturity, yield, thousand kernel weight (TKW), bushel weights (BuW), protein, and FDK. Means separated by Tukey's HSD test and deemed significant at P<0.05.

	Days to Maturity	Yield	TKW	BuW	Protein	FDK
	P value					
N Rate	0.102	0.891	0.291	0.264	<.0001	0.479
PGR	0.069	0.654	0.0011	<.0001	0.0028	0.021
N Rate * PGR	0.480	0.968	0.495	.9845	0.2726	0.658

Although there was no significant yield benefit associated with the PGR applications, there was a significant decline in seed quality when PGR was applied at Z31 and Z39 (Figure 2). The decline in thousand kernel weights and bushel weights were highly correlated to the timing of PGR application (r = 0.97) (Figure 2), indicating that the later applications significantly reduced seed quality. Currently, the cause for this decline is unknown. Although there are studies looking into the yield benefits of PGR, its effect on seed quality has not been well researched. The cause for this decline could be attributed to the environmental conditions (drought) or it may be a side effect from the PGR applications. Regardless, this negative attribute should be further investigated. It is also critical to note that although there was a slight yield benefit from PGR applications the decline in seed quality may outweigh the yield benefit associated with PGR.

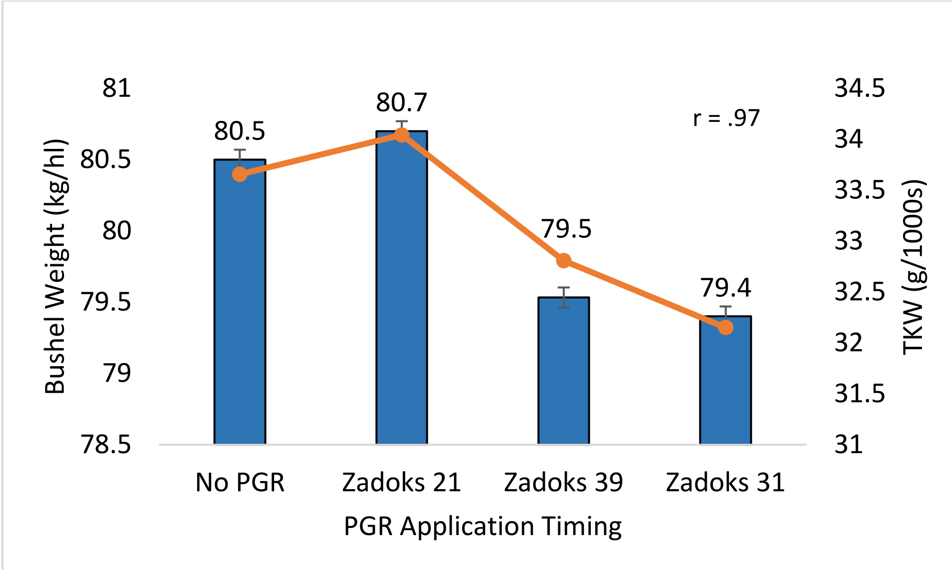

Figure 2. The effect of PGR application timing on wheat seed bushel weights (kg/hl) and thousand kernel weights (g/1000s).

The seed protein content was also negatively affected by the Z31 and Z39 PGR applications, resulting in a reduction of 1.4% and 2%, respectively (Figure 3a). These results corroborate with the studies conducted at both Indian Head (IHARF) and Melfort (NARF) research trials, in which the later applications had the lowest protein content. There justification for this was that the later applications resulted in the shortest plants with the highest yields, and therefore less N was available for protein synthesis (Pratchler 2015). However, as there was not a significant yield increase associated with the PGR applications, it seems unlikely that this would be the case. The cause for the decline in protein, without a sustainable increase in yield using the PGR application is unclear, and requires further investigation. Furthermore, protein content was also highly influenced by N rate applications ($P < .0001$) (Table 4). The N rate applications of 150% and 125% resulted in a higher protein content of 4.7% and 2.7% compared to the control (100%) (Figure 3b). This result was anticipated, as protein content for cereals is largely influenced by N rate (Campbell et al. 1977). Higher N rates typically result in higher protein content, as more available N can be used for protein synthesis. However, protein content is typically has an inverse relationship to yield. Higher yields typically result in lower protein contents, because when yield increases it dilutes the available N and depletes the seed N required for protein synthesis (Campbell et al. 1977; Clark et al. 1990). This was not the case, as yield was not significantly different between N rate treatments.

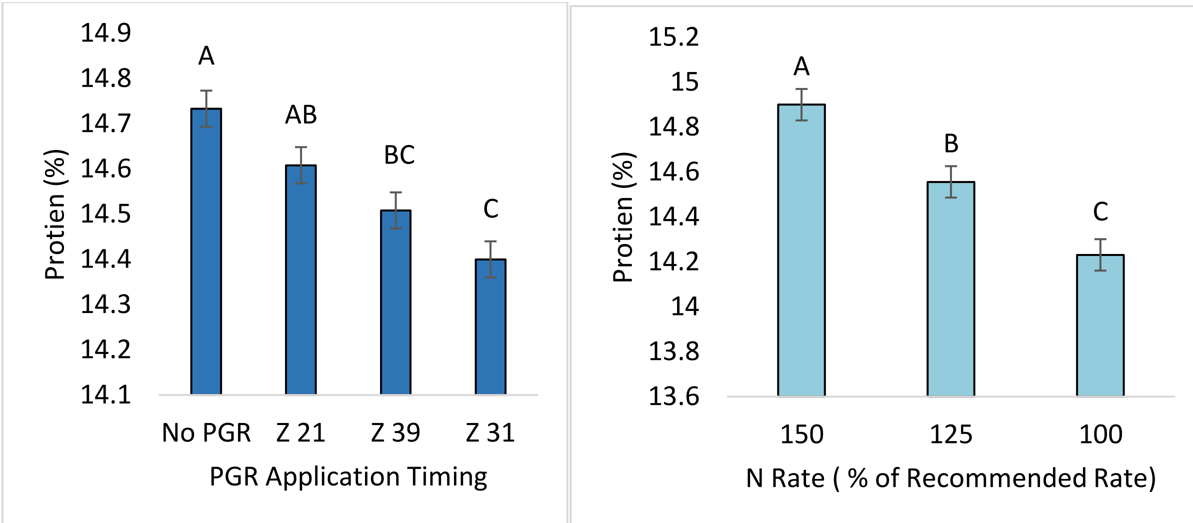

Figure 3. The effect of PGR application timing [a] and the effect of nitrogen (N) rate on wheat seed protein content (%) [b].

Conclusions and Recommendations

Overall, the PGR application did result in significant height reductions when applied at the Z31 and Z39 growth stage, but this reduction did not translate into a yield benefit. This could be attributed to the short stature of the plants, as there was limited rainfall during the application timing. Furthermore, the PGR applications at the later growth stages resulted in decrease in seed thousand kernel weights, bushel weights and protein content. The cause for this decline in seed quality has yet to be determined. Further research is required to determine if this negative effect is weather dependent, or it if is a negative attribute of the product. The differing rates of N had little effect on yield, but it did significantly influence seed protein. N rate applications of 150% and 125% resulted in a higher protein content of 4.7% and 2.7% compared to the control (100%). In all, the effect of PGR on seed quality needs to be further studied in order to determine its influence on seed quality.

<u>Supporting Information</u>

Acknowledgements

We would like to thank the Ministry of Agriculture for the funding support on this project. We would also like to acknowledge the support of Herb Schell and our summer staff for their technical assistance with project development and implementation. This report will be distributed through WARC's website and included in WARC's annual report. A combined result from WARC (Scott) and NARF (Melfort) was presented at the Agri-ARM Research Update on January 14, 2016 during the Crop Production Week.

Appendices

Appendix A – Agronomic information for the demonstration

Abstract

Abstract/Summary

Manipulator™ is a plant growth regulator that has proven to be successful in Northeast Saskatchewan, but has yet to be thoroughly tested in Western Saskatchewan. This plant growth regulator (PGR) is marketed to produce wheat crops that are better, stronger, and shorter. Thus the objective of this trial was to determine the effects that various PGR application timings and fertility levels have on height, lodging, yield, seed quality, and proteins in spring wheat. This trial was demonstrated on CDC Shaw, with Manipulator™ applied at Zadoks 21, 31, and 39 over three fertility levels representing 100, 125, and 150% of fertility from soil test recommendations. Overall, the PGR application did result in significant height reductions when applied at the Z31 and Z39 growth stage, but this reduction did not translate into a yield benefit. This could be attributed to the short stature of the plants, as there was limited rainfall during the application timing. Furthermore, the PGR applications at the later growth stages resulted in decrease in seed thousand kernel weights, bushel weights and protein content. The cause for this decline in seed quality has yet to be determined. Further research is required to determine if this negative effect is weather dependent, or it if is a negative attribute of the product. The differing rates of N had little effect on yield, but it did significantly influence seed protein. N rate applications of 150% and 125% resulted in a higher protein content of 4.7% and 2.7% compared to the control (100%). In all, the effect of PGR on seed quality needs to be further studied in order to determine its influence on seed quality.

Appendix A
Agronomic information for 2015 demonstration

Table A.1. Selected agronomic information for the "*: Spring wheat response to nitrogen fertilizer with the addition of a plant growth regulator applied at various crop stages*" at Scott, Saskatchewan, 2015.

Seeding Information	**2015**
Seeder	R-Tech Drill, 10 inch row spacing, knife openers
Seeding Date	May 19, 2015
Cultivar	Hard Red Spring Wheat – Shaw VB
Seeding Rate	250 seeds m^{-2}
Stubble Type	Canola
Fertilizer applied	Applied based on treatment list
Plot Maintenance Information	
Pre-plant herbicide	Roundup ¾ L/ac + Pardner 0.4 L/ac (May 15, 2015)
In-crop herbicide	Buctril M 0.4 L/ac + Axial 0.48 L/ac (June 10, 2015)
Desiccation	Glyphosate @ 1L/ac (August 20, 2015)
Harvest Date	September 03, 2015

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