2015 Annual Report

for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Optimal Nitrogen Rates for Wheat with and without Plant Growth Regulators

(Project #20140433)

Principal Applicant: Chris Holzapfel, MSc, PAg

Indian Head Agricultural Research Foundation, Box 156, Indian Head, SK, S0G 2K0

Correspondence:

Project Identification

1. **Project Title:** Optimal nitrogen rates for wheat with and without plant growth regulators
2. **Project Number:** 20140433
3. **Producer Group Sponsoring the Project:** Indian Head Agricultural Research Foundation
4. **Project Location(s):** Indian Head, Saskatchewan, R.M. #156
5. **Project start and end dates (month & year):** April 2015 to January 2016
6. **Project contact person & contact details:**

Chris Holzapfel, Research Manager

Indian Head Agricultural Research Foundation

P.O. Box 156, Indian Head, SK, S0G 2K0

Phone: 306-695-4200

Email:

Objectives and Rationale

7. **Project objectives:**

The objective of this project is demonstrate the yield benefits associated with increasing nitrogen (N) fertilizer rate in wheat accompanied by plant growth regulators as a means of reducing the risk of crop lodging, which often becomes problematic at high N rates.

8. **Project Rationale:**

Crop responses to N fertility are well documented and, for crops such as wheat where high protein is desirable, it is important to use adequate fertilizer rates or grain quality can decline. Unfortunately, one of the challenges with higher N rates is that the potential for lodging also increases, and, when lodging occurs, yield benefits are often reduced or yields can even decline. Registration of Manipulator (chlormequat chloride) plant growth regulator has opened up a series of opportunities to further enhance wheat yield and quality. Previous research at Indian Head and Melfort has shown that wheat yield responds to increasing fertilizer N up to a point beyond which yield no longer increases and often decreases with addition N inputs. Quite often, the point where yield ceases to increase is near the point where crop lodging starts. In an effort to manage this, many growers have switched to semi-dwarf varieties, which may yield lower, or have held back on fertilizer rates at the risk of lower yield and quality. Past industry funded trials at Indian Head have shown that lodging can be overcome with the application of a plant growth regulator. With proper application timing combined with high fertility, mean yield increases of approximately 940, 670 and 540 kg ha^{-1} (14, 10 and 8 bu/ac) have been achieved at Indian Head in 2013, 2014 and 2015 respectively. This raises further questions regarding whether higher N fertilizer rates are required with PGR applications in order to optimize yields while maintaining grain quality. We hypothesise that higher yields can be achieved with a combination of PGR applications and increased N fertility than would be possible with either of these two factors on their own. This project was initiated to demonstrate to local producers the potential yield and grain quality benefits that can be achieved by adopting higher N fertilizer rates when utilizing PGR applications to reduce lodging and crop height.

Methodology and Results

9. Methodology:

A field trial with spring wheat was established on a heavy clay soil east of Indian Head, Saskatchewan (R.M. #156; -103.575 W 50.555 N). Ten treatments were arranged in a Randomized Complete Block Design and replicated four times. The treatments were five N fertilizer rates (0, 50, 100, 150 and 200 kg N ha^{-1}) and two PGR treatments (untreated, 1.8 l Manipulator 620 ha^{-1}).

On May 4, a three depth (0-15, 15-30, 30-60 cm) composite soil sample was collected and submitted to ALS Laboratory Group (Saskatoon, SK) for residual nutrient analyses. Unity VB CWRS wheat was direct-seeded into field pea stubble at 275 seeds m^{-2} (111 kg ha^{-1}) kg ha^{-1} on May 5. Urea and potassium sulphate fertilizer were side-banded while monoammonium phosphate was placed in the seed row. A total of 35-35-12 kg P_2O_5-K_2O-S ha^{-1} was supplied to all treatments while N rates were varied as per protocol. Weeds were controlled using a pre-emergent application of 890 g glyphosate ha^{-1} (May 1) plus an in-crop application of Prestige (0.32 l Prestige A ha^{-1} plus 2.0 l Prestige B ha^{-1}) tank mixed with 0.5 l Simplicity ha^{-1} (June 8). The PGR treatments were applied on June 16 (Zadoks GS31) in 224 l ha^{-1} solution, with the high water volume required to facilitate treatment of individual plots with a field sprayer. To minimize the potential for disease to become a limiting factor, 0.5 l ha^{-1} of Twinline was applied on June 28 followed by 800 l Prosaro ha^{-1} applied on both July 8 and July 11. Two applications of Prosaro were required to account for variability in growth stages caused by the treatments. The plots were terminated with 890 g glyphosate ha^{-1} on August 20 and the centre five rows of each plot were straight-combined using a Wintersteiger plot combine on August 29.

Various data were collected over the course of the growing season and from the harvested grain samples. Plant height was determined on August 17 by measuring 4 separate plants per plot and averaging the individual values. Lodging was assessed on August 16 by rating each plot on the basis of the percent plot area affected (A=1-10) and the intensity of the affected area (I=1-5). Lodging index was calculated using the following equation: $A \times I \times 0.2$. Yields were determined from the harvested grain samples and are corrected for dockage and to 14% seed moisture content. Test weights were determined using standard Canadian Grain Commission methodology and are expressed in g 0.5 l^{-1}. Thousand kernel weights were determined by mechanically counting and weighing a minimum of 1000 seeds and converting the values to g 1000 $seeds^{-1}$. Grain protein was determined using an NIR analyser.

Response data were analysed using the GLM procedure of SAS 9.3 with the effects of N rate (NR), PGR and NR×PGR considered fixed. Individual treatment means were separated using Fisher's protected LSD test and orthogonal contrasts were used to determine whether the responses were linear or quadratic (curvilinear) in shape. All treatment effects and differences between means were considered significant at $P \leq 0.05$.

10. Results:

Soil test results and Growing Season Weather

Soil test results for the trial site are presented in Table 1. In general, all macronutrients except for K were considered deficient to marginal with good potential for a yield response to N fertilization. Soil pH was 8.0 for the 0-15 cm profile and the soil was classified as a non-saline clay loam.

Table 1. Soil test results for the Indian Head (2015) spring wheat N-Rate by PGR demonstration. The samples were collected on May 4 and submitted to ALS Laboratory Group for analyses.

Soil Depth	Nitrogen (NO_3)	Phosphorus (P)	Potassium (K)	Sulphur (SO_4)	pH
	---------- kg ha^{-1} ----------				—
0-15 cm	16	19	> 605	3	8.0
15-30 cm	7	—	—	6	8.2
30-60 cm	12	—	—	7	8.4
Total [z]	35	19	> 605	16	—

[z] 0-60 cm for N and S; 0-15 cm for P and K

Mean monthly temperatures and precipitation amounts for the 2015 growing season at Indian Head are presented relative to the long-term averages in Table 2. While seed and fertilizer were placed into adequate soil moisture, the spring as whole was extremely dry with no significant precipitation events until late in the third week of June, during the stem elongation stage. From this point onwards, moisture conditions were generally considered adequate and wheat yields were average to slightly above average overall.

Table 2. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) averages for the 2013-15 growing seasons at Indian Head, SK.

Year	May	June	July	August	Avg. / Total
	---------- Mean Temperature (°C) ----------				
2015	10.3	16.2	18.1	17.0	15.4
Long-term	10.8	15.8	18.2	17.4	15.6
	---------- Precipitation (mm) ----------				
2015	15.6	38.3	94.6	58.8	207
Long-term	51.8	77.4	63.8	51.2	244

Crop Response to Nitrogen Rates and Plant Growth Regulator Application

Spring wheat plant heights were affected by both nitrogen rate (NR) and plant growth regulators (PGR) with a significant interaction between the two factors for this variable (Table 3). On average, plant height was increased by 17% with N fertilization from 82 cm to a maximum of 96 cm at 100 kg N ha^{-1} where further increases in N no longer resulted in measurable height increases. Furthermore, wheat treated with PGR was 13%, or 12.5 cm, shorter than the untreated wheat when averaged across N rates. Plant height for both treated and untreated wheat increased with N fertilization; however, the untreated wheat appeared to reach its maximum height at lower rates of N than wheat treated with PGR (Table 4).

Similar to height, lodging was also affected by NR and PGR with a significant NR×PGR interaction. In general, lodging occurred late in the season and was considered relatively minor in all treatments. On average, lodging increased linearly with N rate but was significantly reduced with PGR (Table 3). The interaction was such that, without PGR, lodging was

increased relative to the control at all N rates while, with PGR, significantly higher lodging (relative to the control) only occurred at the 200 kg N ha^{-1} rate (Table 4).

Table 3. Main effect means, analyses of variance and orthogonal contrasts for spring wheat plant height, lodging and yield at Indian Head (2015). Data were analyzed using the GLM procedure of SAS and values followed by the same letter do not significantly differ (Fisher's protected LSD test).

	Plant Height	Lodging Index	Grain Yield
	---------- cm ----------	---------- 1-10 ----------	---------- kg ha^{-1} ----------
Nitrogen Rate			
7 kg N ha^{-1}	81.9 c	2.00 c	3100 d
50 kg N ha^{-1}	93.0 b	2.38 bc	4086 c
100 kg N ha^{-1}	95.8 a	2.75 b	4650 b
150 kg N ha^{-1}	96.0 a	3.25 a	4862 a
200 kg N ha^{-1}	96.0 a	3.50 a	4650 b
S.E.M.	0.46	0.15	57.7
PGR Treatment			
Control	98.8 a	3.2 a	4132 b
PGR Applied	86.3 b	2.4 b	4408 a
S.E.M.	0.29	0.09	36.5
C.V. (%)	1.4	14.8	3.8
Effect/Contrast [Z]	---------- p-value ----------		
NR	<0.001	<0.001	<0.001
PGR	<0.001	<0.001	<0.001
NR × PGR	<0.001	0.019	0.341
N-Rate (linear)	<0.001	<0.001	<0.001
N-Rate (quad)	<0.001	0.659	<0.001

[Z] P-values ≤ 0.05 indicate that an effect/contrast was significant and not due to random variability

Wheat yields were affected by both N rate and PGR but the interaction was not significant, indicating that the response to N was similar with and without PGR. Focussing on NR, wheat yields increased quadratically with increasing fertilizer rates, peaking at 150 kg N ha^{-1} with a slight but significant yield reduction observed when the rate was increased to 200 kg N ha^{-1}. At the 150 kg N ha^{-1} rate, wheat yields were 56% higher than the control and significantly higher than for any other fertilizer rates (Table 3). Even with relatively little lodging, PGR applications resulted in 6% yield increase when averaged across fertilizer rates. With no interaction, the effect of PGR was consistent and resulted in significantly higher yields relative to the untreated plots for all but lowest N treatment. At 5030 kg ha^{-1} (75 bu ac^{-1}), the highest yielding individual treatment was 150 kg N ha^{-1} combined with a PGR application (Table 4).

Table 4. Individual treatment means and orthogonal contrasts for spring wheat plant height, lodging and grain yield at Indian Head (2015). Data were analyzed using the GLM procedure of SAS and values followed by the same letter do not significantly differ (Fisher's protected LSD test).

	Plant Height		Lodging Index		Grain Yield	
	---------- cm ----------		---------- 1-10 ----------		---------- kg ha^{-1} ----------	
Nitrogen Rate	Control	PGR	Control	PGR	Control	PGR
7 kg N ha^{-1}	91.4 b	72.4 d	2.0 e	2.0 e	3071 f	3130 f
50 kg N ha^{-1}	100.3 a	85.7 c	2.8 bcd	2.0 e	3941 e	4231 d
100 kg N ha^{-1}	101.7 a	90.0 b	3.3 b	2.3 de	4460 cd	4839 ab
150 kg N ha^{-1}	100.3 a	91.8 b	4.0 a	2.5 cde	4693 bc	5030 a
200 kg N ha^{-1}	100.3 a	91.7 b	4.0 a	3.0 bc	4493 c	4807 ab
S.E.M.	0.65		0.21		81.6	
Contrast [z]	---------- p-value ----------					
N-Rate (linear)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
N-Rate (quad)	<0.001	<0.001	0.078	0.240	<0.001	<0.001

[z] P-values ≤ 0.05 indicate that an effect/contrast was significant and not due to random variability

Test weight was affected by NR with a significant NR×PGR interaction but was not affected PGR on its own at the desired probability level (P = 0.062; Table 5). Without PGR, the only significant effect of NR on test weight was a slight linear reduction with increasing N rate. With PGR, a positive quadratic response was detected whereby test weight was lowest in the control but did not differ amongst the fertilized treatments (Table 6). Thousand kernel weights were not affected by NR or PGR and there was no interaction between the two factors for this variable. Grain protein concentration, an important grading factor, was affected by NR but, again, the PGR effect was not significant at the desired level (P = 0.063) and there was no interaction between these factors. Focussing on NR effects, average protein concentrations increased linearly from 11% in the control to approximately 15% with rates of 150-200 kg N ha^{-1}. While not significant at the desired probability level, there was a tendency for lower protein content with PGR where slightly higher yields were achieved. In other field trials, where larger yield responses to PGR were observed, grain protein was lower in the treated plots suggesting that, depending on the response, higher N rates may be required to maintain protein levels at the higher yields that can potentially be achieved with PGR.

Table 5. Main effect means, analyses of variance and orthogonal contrasts for spring wheat test weight, seed weight and grain protein at Indian Head (2015). Data were analyzed using the GLM procedure of SAS and values followed by the same letter do not significantly differ (Fisher's protected LSD test).

	Test Weight	Thousand Kernel Weight	Protein Concentration
	---------- g 0.5 l^{-1} ----------	------- g 1000 $seeds^{-1}$ -------	---------- g 100 g^{-1} ----------
Nitrogen Rate			
7 kg N ha^{-1}	398.7 b	31.6 a	11.0 d
50 kg N ha^{-1}	400.6 a	31.7 a	11.9 c
100 kg N ha^{-1}	400.6 a	31.9 a	13.5 b
150 kg N ha^{-1}	400.0 a	31.4 a	14.6 a
200 kg N ha^{-1}	398.8 b	31.2 a	14.9 a
S.E.M.	0.39	0.30	0.14
PGR Treatment			
Control	400.1 a	31.8 a	13.3 a
PGR Applied	399.4 a	31.3 a	13.1 a
S.E.M.	0.25	0.19	0.09
C.V. (%)	0.3	2.7	3.1
Effect/Contrast [Z]	---------- p-value ----------		
NR	0.002	0.502	<0.001
PGR	0.062	0.116	0.063
NR × PGR	0.026	0.281	0.708
N-Rate (linear)	0.702	0.200	<0.001
N-Rate (quad)	<0.001	0.260	0.001

[Z] P-values ≤ 0.05 indicate that an effect/contrast was significant and not due to random variability

Table 6. Individual treatment means and orthogonal contrasts for spring wheat test weight, seed weight and grain protein at Indian Head (2015). Data were analyzed using the GLM procedure of SAS and values followed by the same letter do not significantly differ (Fisher's protected LSD test).

	Test Weight		Thousand Seed Weight		Protein Concentration	
	---------- g 0.5 l^{-1} ----------		------- g 1000 $seeds^{-1}$ -------		---------- g 100 g^{-1} ----------	
Nitrogen Rate	Control	PGR	Control	PGR	Control	PGR
7 kg N ha^{-1}	400.2 abc	397.1 d	32.3 a	30.9 b	11.3 de	10.8 e
50 kg N ha^{-1}	401.0 a	400.1 abc	31.7 ab	31.7 ab	12.1 c	11.8 bc
100 kg N ha^{-1}	400.3 ab	400.9 a	32.0 ab	31.8 ab	13.5 b	13.5 b
150 kg N ha^{-1}	400.2 abc	399.8 abc	31.9 ab	31.0 b	14.7 a	14.6 a
200 kg N ha^{-1}	398.7 cd	399.0 bc	31.0 b	31.3 ab	15.1 a	14.8 a
S.E.M.	0.56		0.42		0.20	
Contrast [Z]	---------- p-value ----------					
N-Rate (linear)	0.032	0.097	0.082	0.960	<0.001	<0.001
N-Rate (quad)	0.064	<0.001	0.558	0.310	0.090	0.002

[Z] P-values ≤ 0.05 indicate that an effect/contrast was significant and not due to random variability

Extension and Acknowledgement

While this demonstration could not be shown at the 2015 IHARF Crop Management Field held on July 21 due to logistic constraints, the site was visited by agronomists, farmers and industry representatives on several occasions throughout the growing season. Results from this project will be made available in the 2015 IHARF Annual Report (available online) and also through a variety of other media (i.e. oral presentations, popular agriculture press, fact sheets, etc.) as opportunities arise.

11. Conclusions and Recommendations

Despite being a relatively dry year with minimal potential spring wheat yield loss due to lodging, this trial demonstrated a strong response to N fertilizer and modest but significant agronomic benefits to the PGR applications. Plant height was reduced by 13% with PGR and the severity of lodging was not increased relative to the unfertilized control for any but the 200 kg N ha^{-1} rate when PGR was applied. Without PGR, lodging increased linearly with NR and, although minor, was observed at rates well below those required to optimize grain yield. The fact that there was no interaction between NR and PGR for grain yield suggests that wheat responded similarly to N regardless of the PGR treatment; however, the highest yields were achieved with the combination of 150 kg N ha^{-1} and PGR. The PGR effect on grain protein was not significant at the desired level but there was a trend for lower protein with PGR (due to higher yields) and other field trials have suggested that, when large yield increases occur, higher N rates may be required to maintain protein levels with PGR. For 2016, growers are advised to check with their potential grain buyers to confirm that doing so is permissible before using Manipulator 620; however, these results, combined with previous experience, support the use of PGR to reduce CWRS wheat height and lodging while increasing yields.

Supporting Information

12. Acknowledgements:

This project was financially supported by the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canada-Saskatchewan Growing Forward 2 bi-lateral agreement. Acknowledgement of the Saskatchewan Ministry of Agriculture's support for this demonstration will be included as part of all written reports and oral presentations that arise from this work. Manipulator 620 was provided by Engage Agro and several of the crop protection products used in this demonstration were provided in-kind by Dow AgroSciences, BASF and Bayer CropScience. The support and contributions of Christiane Catellier, Dan Walker, Carly Miller and Danny Petty are greatly appreciated.

13. Appendices

Abstract

14. Abstract/Summary:

A field trial with CWRS wheat was conducted at Indian Head to demonstrate the response to N fertilizer rates with and without PGR. The treatments were a factorial combination of five N-fertilizer rates (7-200 kg N ha^{-1}) and two PGR treatments (untreated, Manipulator 620 applied at Zadoks GS31). While N fertilization resulted in a 17% increase in plant height, PGR application reduced plant height by 13% when averaged across N rates. Lodging was quite minor in all treatments, but increased linearly with N rate and was effectively eliminated at all but the highest N rates with a PGR application. There was a strong response to N fertilizer with yields optimized at approximately 150 kg N ha^{-1} and PGR

application resulting in an average yield increase of 6%. Test weight and thousand kernel weight were not affected by PGR application; however, there was a slight tendency for lower protein with the higher yielding PGR treatments.