2015 Annual Report

for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

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

(Project #20140431)

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Project Identification

1. **Project Title:** Optimal seeding rates for wheat with and without plant growth regulators
2. **Project Number:** 20140431
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:**

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Objectives and Rationale

7. **Project objectives:**

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

8. **Project Rationale:**

Producers may see a benefit of increasing seeding rate of spring wheat beyond those typically recommended when targeting high yields. Generally, a more dense plant stand allows the crop to compete better with weeds because the developing plants can cover the ground quickly and shade out unwanted plant species. Higher seed rates also lead to reduced tillering meaning that a higher proportion of heads reach flowering stage at the same time. This makes it easier to time certain pesticide applications such as those targeting fusarium head blight or orange blossom wheat midge which, in turn, could enhance crop yield and quality. Previous research has shown that wheat yields can be increased by increasing seeding rates; however, there is a point where the benefits of an increased plant population do not outweigh the costs of additional seed. In addition, as seeding rate is increased, there is a point above which lodging often become more severe. 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 in 2012 and 2013 showed a relatively flat, or even negative, response to increasing seeding rates; however, lodging was also quite severe during this period. In an effort to manage lodging in wheat, many growers have switched to semi-dwarf varieties, which may yield lower, or have held back on other inputs (i.e. seed rate, fertility) 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) were achieved at this location in 2013, 2014 and 2015 respectively. We speculate that higher yields can be achieved with a combination of PGR applications and higher seeding rates 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 seeding 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 seeding rates (100, 200, 300, 400 and 500 seeds m^{-2}) and two PGR treatments (untreated, 1.8 l Manipulator 620 ha^{-1}).

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 with a total of 125-35-35-12 kg N-P_2O_5-K_2O-S ha^{-1} supplied to all treatments. 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 reduce the potential for disease to become a limiting factor, 0.5 l ha^{-1} 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 stage amongst 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. Actual plant densities were determined on June 2 by counting the number of plants in two separate 1 m sections of crop row and converting the values to plants m^{-2}. 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 $seeds^{-1}$.

Response data were analysed using the GLM procedure of SAS 9.3 with the effects of seed rate (SR), PGR and SR×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:

Growing Season Weather

Mean monthly temperatures and precipitation amounts for the 2015 growing season at Indian Head are presented relative to the long-term averages in Table 1. While seed and fertilizer were placed into adequate soil moisture, the spring as a 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 considered average to slightly above average overall.

Table 1. 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 Seeding Rates and Plant Growth Regulator

As expected, actual spring wheat plant densities increased with increasing seeding rates but were not affected by PGR treatment and there was no interaction between these two factors (Table 3). While the observed response to the range of seeding rates evaluated was largely linear, mortality appeared to be increasing at the highest rates suggesting the densities were starting to level off. Average populations ranged from 97 plants m^{-2} at the 100 seeds m^{-2} rate to 352 plants m^{-2} at the 500 seeds m^{-2} rate. Traditional seeding rate recommendations for wheat have been to target approximately 250 plants m^{-2}.

Plant height was affected by both seeding rate and PGR treatment but with no interaction between the two factors. The application of a PGR resulted in an average height reduction of 11 cm, or 12%. The seeding rate effect was such that plant height declined linearly with increasing seeding rate; however, the effect was small with only a 3 cm difference between the shortest and tallest treatments.

Lodging was also affected by both seeding rate (SR) and PGR treatment but with a significant SR × PGR interaction. While the treatment effects were statistically significant, lodging was considered relatively minor in all treatments; however, the average rating (1-10) was reduced from 4.1 to 2.4 with a PGR application. The interaction was due to a slightly different seeding rate effect with and without PGR. Without PGR, lodging was the worst at the lowest and highest seeding rates, while with PGR, lodging was more severe at the lowest rates but declined as seeding rate increased and was essentially eliminated at 300-500 seeds m^{-2} (Table 4).

Table 2. Main effect means, analyses of variance and orthogonal contrasts for spring wheat plant density, height and lodging 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 Density	Plant Height	Lodging Index
	----------- plants m^{-2} ---------	--------------- cm -------------	------------- 1-10 -------------
Seed Rate			
100 seeds m^{-2}	97.2 e	93.6 ab	3.9 a
200 seeds m^{-2}	163.2 d	94.4 a	3.1 b
300 seeds m^{-2}	236.8 c	93.7 a	3.0 b
400 seeds m^{-2}	322.8 b	91.8 bc	3.1 b
500 seeds m^{-2}	352.5 a	91.4 c	3.0 b
S.E.M.	7.95	0.65	0.12
PGR Treatment			
Control	237.5 a	98.3 a	4.1 a
PGR Applied	231.5 a	87.7 b	2.4 b
S.E.M.	5.03	0.41	0.08
C.V. (%)	9.6	2.0	10.6
Effect / Contrast [z]	------------------------	p-value	------------------------
SR	< 0.001	0.009	< 0.001
PGR	0.413	< 0.001	< 0.001
SR × PGR	0.209	0.080	0.016
Seed-Rate (lin)	< 0.001	0.002	< 0.001
Seed-Rate (quad)	0.053	0.132	0.003

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

Table 3. Individual treatment means and orthogonal contrasts for spring wheat plant density, height and lodging 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 Density		Plant Height		Lodging Index	
	----------- plants m^{-2} ---------		--------------- cm -------------		------------- 1-10 -------------	
Seed Rate	Control	PGR	Control	PGR	Control	PGR
100 seeds m^{-2}	100 e	95 e	97.2	90.0	4.5 a	3.3 d
200 seeds m^{-2}	149d	178 d	100.1	88.8	3.8 c	2.5 e
300 seeds m^{-2}	232 c	242 c	99.1	88.4	4.0 cb	2.0 f
400 seeds m^{-2}	334 ab	312 b	97.8	85.9	4.3 ab	2.0 f
500 seeds m^{-2}	343 ab	362 a	97.4	85.3	4.0	2.0 f
S.E.M.	11.2		0.91		0.17	
Contrast [z]	------------------------		p-value		------------------------	
Seed-Rate (lin)	< 0.001	< 0.001	0.500	< 0.001	0.365	< 0.001
Seed-Rate (quad)	0.158	0.169	0.058	0.834	0.131	0.004

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

Grain yield was affect by both seeding rate and PGR treatment but there was no interaction between the two factors for this variable (Table 5). Yields were highest at approximately 200-300 seeds m^{-2} and lower at the highest and lowest seeding rates. While significant, the difference between the highest and lowest seeding rates was relatively small at 294 kg ha^{-1} (4.4 bu ac^{-1}). By comparison, yields were increased 400 kg ha^{-1} (5.9 bu ac^{-1}) with the PGR application.

The PGR treatments did not affect test weight or seed weight. The lowest seeding rate resulted in significantly lower test weight than with rates of 200-500 seeds m^{-2} but seed weight (g 1000 $seeds^{-1}$) was not affected by seeding rate.

Table 4. Main effect means, analyses of variance and orthogonal contrasts for spring wheat yield, test weight and seed weight 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).

	Grain Yield	Test Weight	Thousand Kernel Weight
	----------- kg ha^{-1} -----------	------------ g 0.5 l^{-1} ----------	------- g 1000 $seeds^{-1}$ -------
Seed Rate			
100 seeds m^{-2}	4508 bc	395.7 b	31.2 a
200 seeds m^{-2}	4704 a	399.4 a	31.3 a
300 seeds m^{-2}	4584 ab	400.0 a	31.1 a
400 seeds m^{-2}	4513 bc	399.9 a	31.4 a
500 seeds m^{-2}	4413 c	400.1 a	31.2 a
S.E.M.	54.9	0.38	0.29
PGR Treatment			
Control	4340 b	398.9 a	31.3 a
PGR Applied	4749 a	399.1 a	31.2 a
S.E.M.	34.7	0.24	0.18
C.V. (%)	3.4	0.3	2.6
Effect/Contrast [Z]	---------------- p-value ----------------		
SR	0.013	< 0.001	0.979
PGR	< 0.001	0.554	0.661
SR × PGR	0.938	0.471	0.424
Seed-Rate (lin)	0.038	< 0.001	0.988
Seed-Rate (quad)	0.013	< 0.001	0.846

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

Table 5. Individual treatment means and orthogonal contrasts for spring wheat yield, test weight and seed weight 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).

	Grain Yield		Test Weight		Thousand Kernel Weight	
	----------- kg ha^{-1} -----------		------------ g 0.5 l^{-1} ----------		------- g 1000 $seeds^{-1}$ -------	
Seed Rate	Control	PGR	Control	PGR	Control	PGR
100 seeds m^{-2}	4274 e	4742 ab	395.4 b	396.1 b	31.7 a	31.1
200 seeds m^{-2}	4506 cd	4901 a	399.8 a	399.1 a	31.6 a	31.1
300 seeds m^{-2}	4361 de	4808 ab	399.6 a	400.5 a	31.5 a	31.1
400 seeds m^{-2}	4339 de	4688 abc	400.2 a	399.7 a	31.3 a	31.0
500 seeds m^{-2}	4222 e	4605 bc	399.8 a	400.4 a	31.3 a	30.7
S.E.M.	77.6		0.54		0.41	
Contrast ^{z}	p-value					
Seed-Rate (lin)	0.274	0.057	< 0.001	<0.001	0.463	0.451
Seed-Rate (quad)	0.058	0.089	< 0.002	0.002	0.495	0.682

^{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 modest but significant agronomic benefits to the PGR applications but no advantage to higher than recommended seeding rates. There was a slight linear decline in plant height with increasing seeding rate (approximately 3 cm, or 3% difference between shortest and tallest treatments) and plant height was reduced by 11 cm, or 12%, with PGR application. While lodging was minor in all treatments, there was a significant interaction where lodging was most severe at the lowest and highest seeding rates without PGR but was effectively eliminated in all but the lowest seeding rate with a PGR application. There was no interaction between seeding rate and PGR for grain yield suggesting a similar response to seeding rate regardless of whether a PGR was applied. The response to seeding rate was somewhat unexpected with the highest yields at 200 seeds m^{-2} and plant populations below the typically recommended 250 plants m^{-2}; however, the range between the highest and lowest seeding rates was only 294 kg ha^{-1} (4.4 bu ac^{-1}). The application of a PGR resulted in a modest but significant yield increase of 400 kg ha^{-1} (5.9 bu ac^{-1} or 9.4%) when averaged across seeding rates. 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 CWRS wheat field trial was conducted to demonstrate crop response to seeding rates with and without PGR. The treatments were a factorial combination of five seeding rates (100-500 seeds m^{-2}) and two PGR treatments (untreated, Manipulator 620 applied at Zadoks GS31). Increasing seeding rate resulted in a 3% height reduction while PGR reduced plant height by 12% on average. Lodging was minor in all treatments, but there was a significant interaction where, without PGR, lodging was most severe at the lowest and highest seeding rates, while with PGR, lodging was lower overall and effectively eliminated at all but the lowest seeding rates. The highest grain yields occurred at a relatively low seeding rate of 200 plants m^{-2}. PGR application resulted in an average yield increase of 9% when averaged across seeding rates. Test weight and seed weight were unaffected by PGR; however, there test weight was reduced at the lowest seeding rate.