AWC-DUC Winter Wheat Agri-Science Project 2016 Activity 3 Update

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Beres, B. L.[1], Turkington, T. K.[2], Kutcher, H.R.[3], Coles, K.[4]

[1]Agriculture and Agri-Food Canada, Lethbridge Research Centre, 5403 1st Avenue South Lethbridge, Alberta, Canada T1J 4B1 (e-mail: brian.beres@agr.gc.ca); [2]Agriculture and Agri-Food Canada, Lacombe Research Centre, Lacombe, Alberta, Canada T4L 1W1; [3]Crop Development Centre, University of Saskatchewan, Saskatoon, SK.; [4]Farming Smarter, #100, 5401 – 1st Ave S. Lethbridge, Alberta T1J 4V6

Despite the challenges of getting this project initiated, we have now completed our second field season of the winter wheat project. Although, preliminary, activities are starting to report some interesting results. The following is a brief update of the project.

Human Resources.

The retirements of Dr. Byron Irvine from AAFC-Brandon and Mr. Eric Johnson from AAFC-Scott have created some variances. Dr. Ramona Mohr has stepped in to assume all of the Brandon activities and the transition has been seamless. Projects and manuscripts that Mr. Johnson oversaw have been delayed as a replacement has not been hired. We anticipate that the manuscripts will be completed by the end of 2017.

Update on Sub-Activities.

Sub-activity 3.1

The efficacy of seed treatments in dual purpose grazing systems to maintain optimal stands of winter wheat.

Introduction

Can you make more money by grazing your winter cereals? A producer near Medicine Hat, Alberta successfully grazes winter wheat and winter triticale from October to April and still harvests a silage crop. A new research project digs into this approach that maximizes returns from the land while minimizing costs associated with stored feed. The project will address questions such as which winter cereal and varieties perform best, do seed treatments help and will it pay?

Trial #1 – Improved survivability when grazing winter cereals using novel seed treatments
Objective: Evaluate the economic and agronomic potential of winter grazing systems on winter cereal production.
Sites: Medicine Hat
Design: Factorial RCBD for grazed and not grazed trials with 4 replicates
Treatments:

- Factor 1 – Crop (Hazlet, Prima, Fridge, Luoma, Moats, Ptarmigan, Prima + Fridge, Prima + Ptarmigan, Fridge + Ptarmigan)
- Factor 2 – Fungicide Treatment (Untreated or Cruiser Maxx Vibrance treated seed)

Trial #2 – Optimum seeding dates for fall grazed winter wheat
Objective: Determine the differences in seeding dates on winter wheat varieties Moats and Ptarmigan.
Sites: Medicine Hat
Design: Factorial RCBD for grazed and not grazed trials with 4 replicates
Treatments:

- Factor 1 – Crop variety & seed treatment (Moats untreated, Moats treated, Ptarmigan untreated, Ptarmigan treated)
- Factor 2 – Seeding date (August 15, September 1, September 15)

Data Collection
Data collected included crop density and crop biomass in the fall before freeze-up, crop silage yield, and crop grain yield.

Background

Investments in breeding and agronomic research significantly improved winter cereal grain production systems in Western Canada in the past 20 years. Cultivars have better winter hardiness, improved disease resistance and higher yield potential. Also, improved agronomic management such as higher seeding rates, use of seed treatments, better weed control and optimized fertility creates a new profit opportunity for producers.

Objectives

1. Evaluate the economic and agronomic potential of winter grazing systems on winter cereal production.
   a. Determine effect on biomass (silage) and yield production on winter wheat, fall rye, triticale and blends of each.
   b. Determine differences in crop type and varietal suitability.
   c. Quantify potential differences in winter survival with the application of a seed treatment.
   d. Complete an economic analysis of silage value following grazing vs. un-grazed and the potential to carry the crop through to yield.
2. Determine the differences in seeding dates on winter wheat varieties Moats and Ptarmigan
   a. Determine potential differences between Ptarmigan and Moats

b. Quantify potential differences in winter survival with the application of a seed treatment

c. Complete an economic analysis of silage value following grazing vs. un-grazed at each seeding date and the potential to carry the crop through to yield.

Project timeline

Start August 1, 2014, completed by March 31, 2018

Trials

Table 1. Trial information

Trial #	Trial Name	Plot design	Treatments
1	Improved survivability when grazing winter cereals using novel seed treatments	Randomized complete block with factorial arrangement	Factor 1 – Crop - Hazlet, Prima, Fridge, Luoma, Moats, Ptarmigan, Prima + Fridge, Prima + Ptarmigan, Fridge + Ptarmigan Factor 2 – Fungicide treatment - Untreated or treated seed (Cruiser Maxx Vibrance Cereals)
2	Optimum seeding dates for fall grazed winter wheat	Randomized complete block with factorial arrangement	Factor 1 – Crop variety & seed treatment - Moats untreated, Moats treated, Ptarmigan untreated, Ptarmigan treated Factor 2 – Seeding date - August 15, September 1, September 15

Results

Crop stand densities taken in the fall before freeze-up were acceptable for all crops; ranging from 123 to 175 plants/m2.

There were no significant differences in fall plant biomass among the various crops and crop blends. Biomass values ranged from 1382 to 1705 kg/ha.

There were no significant differences in silage yields among the various crops and crop blends. Silage yields ranged from 834 to 1245 kg/ha.

The highest grain yields were attained with the two winter triticale cultivars. Luoma and Fridge triticale yielded 3702 and 3119 kg/ha, respectively. Ptarmigan winter wheat was among the lowest yielding treatments. The crop blends tended to give intermediate yields to those of the individual crops.

Crop and Cultivar	Density (#/m2)	Fall Biomass (kg/ha)	Silage (kg/ha)	Grain (kg/ha)
Fall rye - Hazlet	125 d	1479 a	1053 a	3082 b
Fall rye – Prima	123 d	1459 a	905 a	2615 cd
Winter triticale – Fridge	124 d	1399 a	1032 a	3119 ab
Winter triticale - Luoma	130 cd	1382 a	1245 a	3702 a

Winter wheat – Moats	137 bc	1705 a	971 a	2772 bcd
Winter wheat – Ptarmigan	149 ab	1655 a	902 a	2513 d
Prima + Fridge	175 a	1518 a	976 a	2838 bcd
Prima + Ptarmigan	143 ab	1565 a	834 a	2994 bc
Fridge + Ptarmigan	140 abc	1385 a	968 a	3022 bc

The trial examining the effect of various seeding dates on the productivity of fall grazed winter wheat found that the August 1 seed date produced the greatest fall biomass (1.9 tonnes/ha). Delaying the seed date to September 10 resulted in very little fall biomass production (0.06 tonnes/ha).

Seeding Date	Fall Biomass (tonnes/ha)
August 1	1.9
August 20	0.7
September 10	0.06

Ungrazed winter wheat attained the highest grain yield (3982 kg/ha) with the September 10 seed date.

Seeding Date	Grain Yield (kg/ha)
August 1	2398
August 20	3791
September 10	3982

Project will continue as planned in 2017. Data will be summarized over years at the conclusion of this study.

Sub-activity 3.2

The role of crop growth regulators and in-crop N applications to alter crop canopy architectures for improved grain quality and production.

Summary

This study will identify the risks and benefits (in terms of winter wheat stands, yield and quality, and economics) associated with applying PGRs to mitigate lodging and UAN to manage tiller production in winter wheat in western Canada over a wide range of soil and climatic conditions. It will also identify the most effective of three PGRs to optimize yield and quality of winter wheat grown under western Canadian conditions. The study has the potential to provide growers with a means of mitigating or eliminating lodging in winter wheat, and the yield, quality and revenue losses associated with lodging. The economics of high sowing densities to manage tillers compared to a system of lower input cost of reduced seeding rates followed in spring with in-crop UAN treatments. Assessment of risks and benefits will be greatly facilitated by the large number of site-years over which the study is conducted. This is a unique aspect of the study. Most previous studies have been conducted at one or two locations over two or three years.

The results of the study could result in an increase in the adoption of winter wheat as many growers in high production areas report issues with lodging of winter wheat when optimum stands are achieved.

Materials and methods

Objectives: To assess the feasibility of, and risks associated with, applying plant growth regulators and in-crop liquid N applications to achieve crop/stand/canopy uniformity, and to mitigate lodging and associated quality and yield loss of winter wheat.

Hypotheses: 1) A PGR application will optimize yield and quality of winter wheat by mitigating the effects of lodging at high seeding rates and N rates.

2) Tiller number will be altered through split applications and timing of UAN and will positively effect yield and yield components.

3) PGR's and N stabilizer forms provide positive economic net returns to the farm gate.

4) Improvements to weed competitive ability and dockage may be obtained by replacing semi—dwarf cultivars with a system integrating taller cultivars managed with PGR's.

EXPERIMENT I

The first experiment will determine the interactive effects of PGR (trinexapac-ethyl), timing of application and cultivar, using an optimum seeding rate at a high nitrogen rate (180 kg N ha-1) on winter wheat quality and yield.

Treatments:
Factor 1: Cultivars (3)
1. Cultivar carrying Rht gene – Flourish
2. Tall cultivar not carrying Rht gene – Moats
3. Fall rye cultivar – Hazlet

Factor 2: PGR (5):
1. Control – No PGR
2. Trinexapac applied at 1x farmer practice (Allen Terry, Syngenta to supply) at pre-boot (Feekes 7 – 8 Zadoks 32-37)
3. Trinexapac applied at 1x farmer practice (Allen Terry, Syngenta to supply) at late-tilllering (Feekes 4-5 – Zadoks 30)
4. Trinexapac applied at 0.6x farmer practice (Allen Terry, Syngenta to supply) at pre-boot (Feekes 7 – 8 Zadoks 32-37)
5. Trinexapac applied at 0.6x farmer practice (Allen Terry, Syngenta to supply) at late-tillering (Feekes 4-5 – Zadoks 30)

Total factorial combination treatments = 15

EXPERIMENT II

The second experiment will determine if plant stands and tiller management are best maintained through in-crop liquid N applications or through optimum seeding rates. A cultivar (Moats) will be subjected to varying rates of sowing density in combination with in-crop foliar applications of liquid urea ammonium nitrate (UAN) treated with Agrotain Plus or Agrotain Ultra.

Treatments:
Factor 1: Seeding Rate (3):
1. 150 seeds m-2
2. 300 seeds m-2
3. 450 seeds m-2

Factor 2: UAN dribble-band treatments (3)
1. 60 kg N ha-1 at seeding + 70 kg N ha-1 jointing
2. 30 kg N ha-1 at seeding + 100 kg N ha-1 jointing
3. 10 kg N ha-1 at seeding + 120 kg N ha-1 at jointing

Total factorial combination treatments = 9 treatments.

Cultivar: Foundation or certified Flourish and Moats Canada Western Red Winter; Hazlet fall rye - all treated with Raxil WW. (Brian Beres and Steven Simmill to source and supply).

Seeding Rate: 450 seeds m-2 for Experiment I, see design for Experiment II.

Experimental Design and Data Analysis: The factorial arrangement of treatments arranged in a Split-plot design with cultivar as Main Plot and PGR as the subplot - 4 replicates. Data will be analyzed with PROC MIXED of SAS. ANOVA will be used to test for significance of main effects and their interactions.

Timelines:

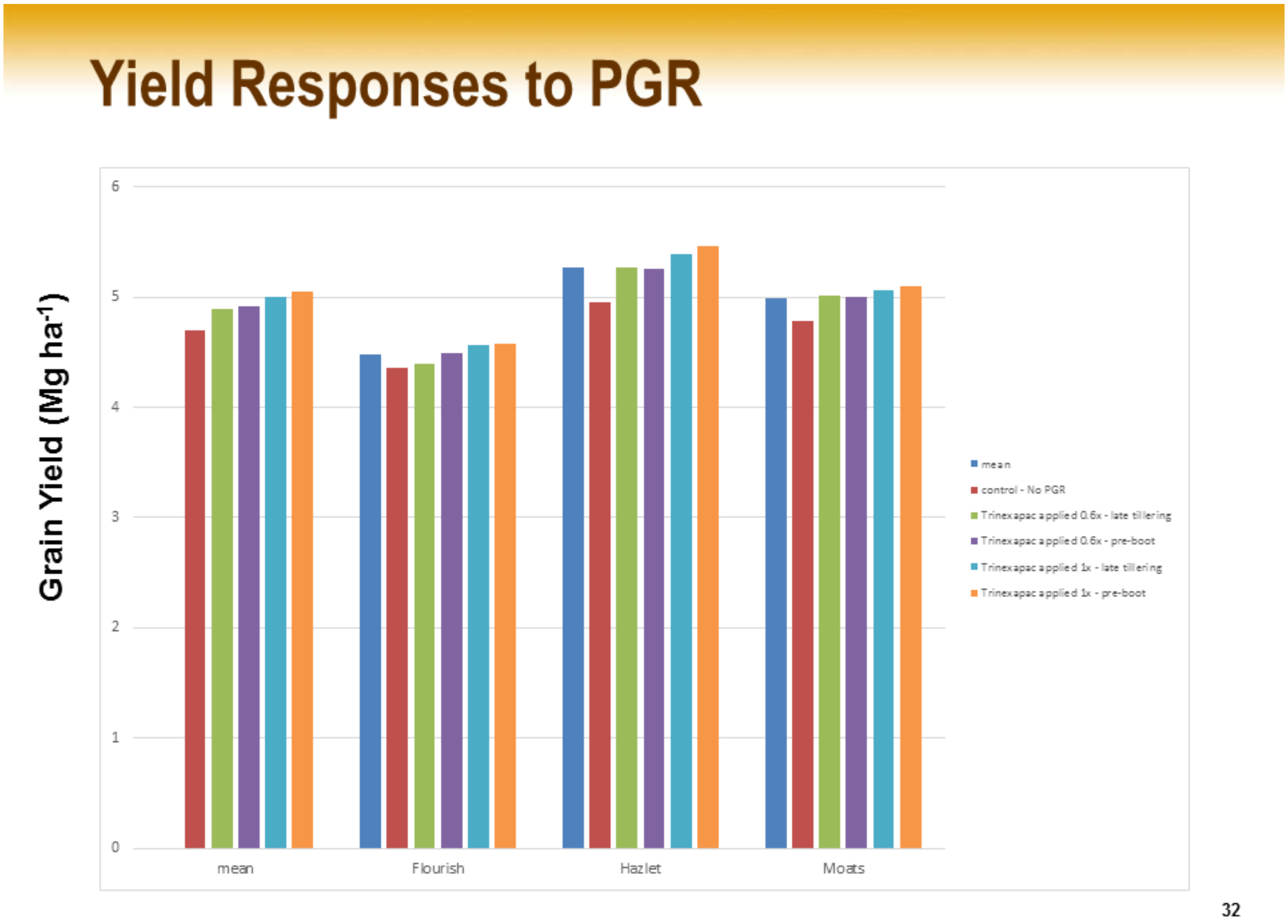
2013 – Trials established in the fall. An interim report will be prepared.
2014 – Year 1 of trial will be conducted. An interim report will be prepared.
2015 – Year 2 of trial will be conducted. An interim report will be prepared.
2016 – Year 3 of trial will be conducted. An interim report will be prepared. Data analysis from all site-years, and final report and scientific paper preparation will commence.
2017 – Data analysis will be finalized, a final report with ecommendations will be prepared, technology transfer documents will be finalized, and scientific papers will be prepared and submitted.

Results to Date:

Experiment I

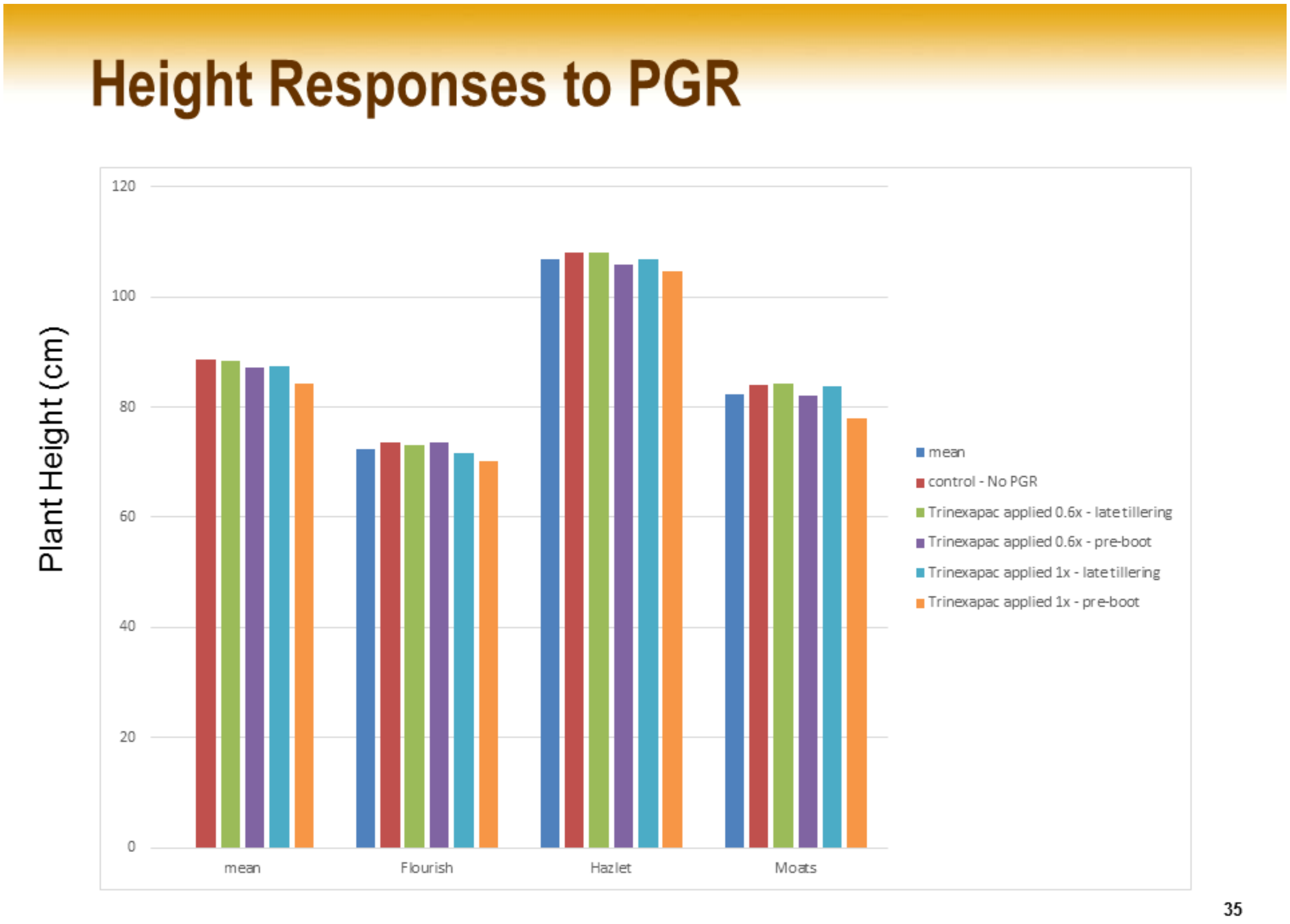
The ANOVA results to date indicate that use of a PGR (trinexapac-ethyl) can significantly increase yield (P=0.04) and would marginally reduce plant height

(P=0.10). While there were many expected variety effects, which indicates varietal effects elicited response variable differences, there were no interactions with PGR. This is an indication that all winter cereals would respond the same ie. improved grain yield with a slight reduction in height. This was a surprise as the expectation for a very short-stature variety like Flourish is that it would not respond similarly to the very tall fall rye variety, Hazlet. Effects to stem wall thickness and internode length were non-significant but diameter does appear slightly greater when PGR was applied at the late-tillering stage, and internode length at the 2nd and 3rd internodes appear to reduce when applied at pre-boot and full rates. The benefit of a PGR is not necessarily based on the presence of lodging as lodging has not been an issue to date and no effect from the PGR has been observed on lodging.



Yield Responses to PGR

Figure 1. Influence of PGR timing and dose on height response of winter wheat and fall rye.



Height Responses to PGR

Figure 2. Influence of PGR timing and dose on height response of winter wheat and fall rye.

Experiment II

Seeding rate more often affected responses relative to nitrogen timing. However, efficacy of split applications becomes apparent at the highest sowing density as less N at planting and the balance applied at Feekes 4 in-crop appears to be a superior strategy (Fig. 3). Thus, seeding rate will largely govern plant and spike density, and high rates when used in environments with sufficient precipitation will respond to variations in split N applications. This also means that N timing is less important in lower production environments but higher productivity or management intensity appears to dictate a split N strategy.

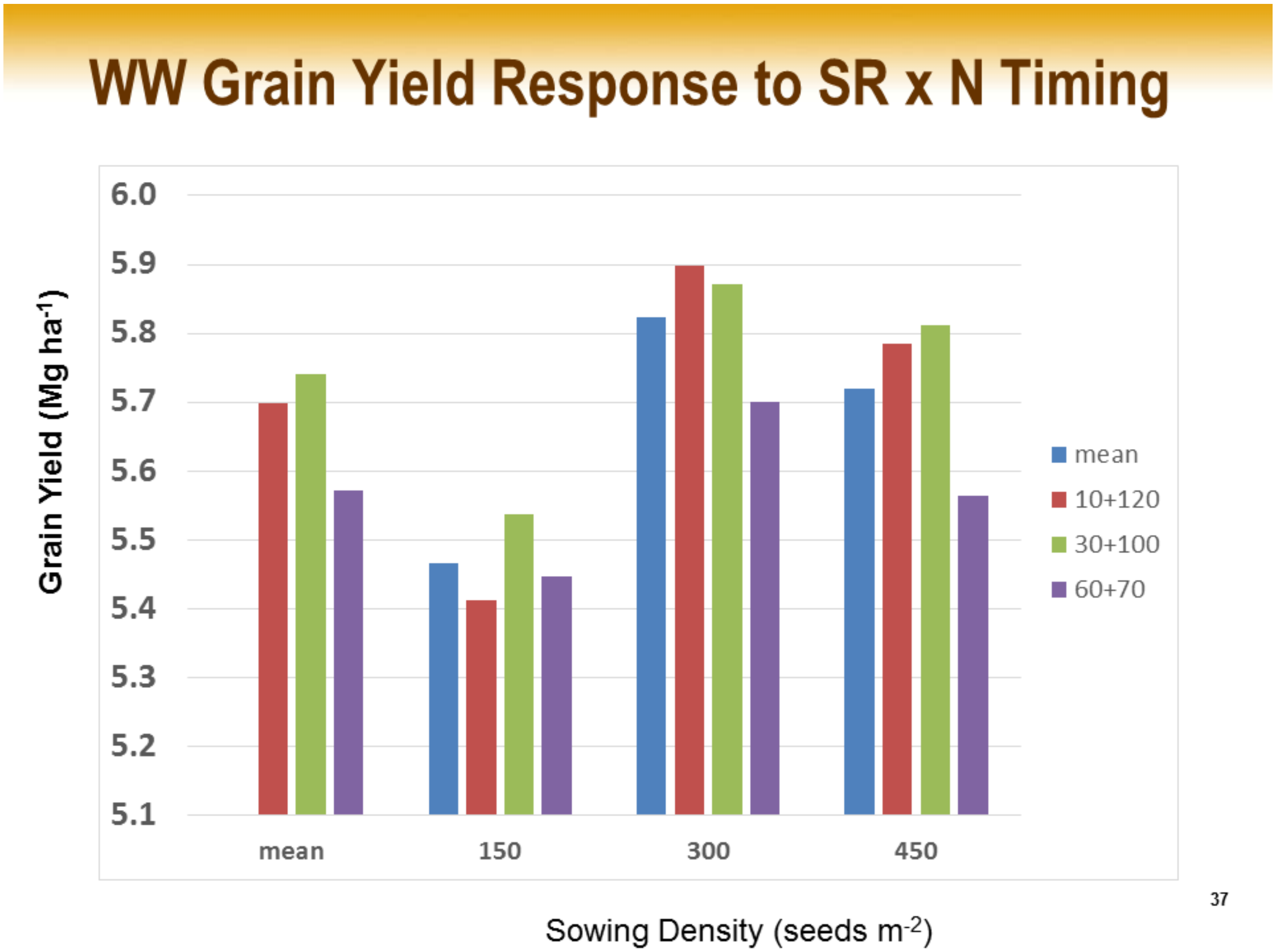


Figure 3. Influence of N timing and placement on yield of winter wheat at increasing levels of sowing density. Amounts shown in legend are amounts of UAN treated with Agrotain Ultra (kg N ha^{-1}) sidebanded at seeding + in-crop at Feekes 4.

Sub-activity 3.3

Integration of cultivar resistance with fungicide strategies to control stripe rust of winter wheat.

Summary

This activity consists of experiments at four locations (Saskatoon, Indian Head, Lethbridge and Lacombe) over three years (harvest years of 2105-2017). The study examines four cultivars of winter wheat that vary in resistance to stripe rust and leaf spot diseases and the use of fungicide applied at two timings (autumn and spring), and the interaction of cultivar resistance with fungicide use and appropriate fungicide application timing.

This report includes some of the data from the 2016 Saskatoon site. The experiment was seeded the fall of 2015. Disease severity at the Saskatoon field site was not high in 2016, however, stripe rust severity on the susceptible varieties was reduced when fungicide was applied in the spring and both (fall and

spring), but not in the treatment where fungicide was applied in the fall. The cultivar Moats was the most resistant to stripe rust, but resistance of Radiant has broken down. There was little difference in terms of yield among the cultivars. However, fungicide application timings showed an improvement for plots sprayed on the spring and both timings (fall and spring). Yield parameters showed that TW was only improved on the cultivars Bellatrix and Osprey. TKW showed a positive effect with fungicide application for all the cultivars at the spring and two applications (fall and spring). Fungicide application in the fall was ineffective in terms of quality.

Materials and methods

The experiment was a four-replicate, randomized complete block design with four fungicide treatments:

1. unsprayed control,
2. fall-applied fungicide,
3. spring-applied fungicide and
4. Both spring- and fall-applied fungicide (Twinline® a.i pyraclostrobin and metconazole).

The four cultivars were:
AC Bellatrix (stripe rust susceptible),
Moats (strip rust resistant),
CDC Osprey (stripe rust susceptible) and
Radiant (stripe rust resistant or susceptible depending on location).

Disease ratings were conducted on the check plots previous to each fungicide treatment in fall 2015 and spring 2016. All plots were assessed for stripe rust and leaf spot symptoms at soft dough stage (July 2016). Stripe rust disease severity was estimated with the modified Cobb scale and leaf spot diseases were rated using the Horsfall – Barratt scale (0-11), then converted to percent of leaf area affected by the disease. The McFadden scale was used to determine the level of severity over whole plants.

Plots were managed with common agronomic practices: no-till, appropriate herbicide and insecticide applications, straight cutting at harvest, fertilizer application based on soil tests for target yield. Stripe rust inoculation of spreader rows with a local inoculum mix was done in late September 2015 and again in early June 2016. Harvest data included: plot yield (kg/ha), test weight (kg/hL), thousand kernel weight (g) and protein content (not available yet).

All statistical analyses were performed using the mixed procedure of SAS version 9.4 statistical software (SAS Institute Inc., Cary, NC), and treatment means separated with the Tukey-Krammer test ($P < 0.05$). The effects of treatments were considered fixed effects, and blocks within location*cultivar were considered random effects. The DDFM = kenwardroger option was considered for approximating the degrees of freedom for means.

Results and discussion

Saskatoon. Disease severity at the Saskatoon field trial site in 2016 was not high. The trend for stripe rust severity of all cultivars (Bellatrix, Osprey and Moats) was reduced for the spring and both timing fungicide applications, but no significant differences among treatments were detected. The cultivar Radiant had a significant reduction of leaf spot disease from 17% of the unsprayed check to 4% when fungicide was applied in the spring and in both (fall and spring) timings (Table 1). Stripe rust disease severity was higher than in 2015 due to more conducive weather conditions for the development of the disease. Bellatrix had the highest stripe rust disease severity (21% for the unsprayed check), followed by Osprey (14%) and Radiant (12%); a significant reduction was observed for these cultivars with fungicide application at spring and both applications (Table 1 and Fig. 1). No positive effect was observed when fungicide was applied in the fall.

Test weight seemed to be affected by disease severity on Bellatrix and Osprey and these cultivars benefited by fungicide application. The unsprayed checks had a TW of 76 kg/hL for both cultivars and had a significant increase with fungicide sprayed at spring and both timings. No effect was observed for plots sprayed in the fall on these cultivars. No differences were found for TW on Moats and Radiant regardless of the treatment or application timing (Table 1).

Thousand kernel weight was improved with fungicide application in spring and both timings compared to the unsprayed checks of all cultivars, despite the differences in disease severity. No benefits were observed when plots were sprayed in the fall (Table 1).

There was no interaction between fungicide application timings and cultivars (P = 0.5408) for yield. However, differences were observed: there was a difference in the application timings (P <.0001) and among cultivars (P <.0001). The mean yield for the unsprayed checks was 5195 kg/ha, and was increased marginally but not significantly by fungicide application in the fall (5409 kg/ha). Plots sprayed at the spring application timing had an increase of 12% and plots sprayed at both timings an increase of 16% (Table 2 and Fig. 3). When a comparison was made among the cultivars, Radiant had the highest yield (6137 kg/ha) and yield was significantly higher than the cultivars Osprey (5332 kg/ha) and Bellatrix (5284 kg/ha). Yield of Moats was between Osprey and Radiant and no difference was found when it was compared to these cultivars (Table 3 and Fig. 4).

Protein data did not show an interaction between fungicide application timings and cultivars (P = 0.3471). Nevertheless, a difference among fungicide application timings was detected (P = 0.0064) and among cultivars (P = 0.0010). The unsprayed check and the plots sprayed in the fall had a slight but significantly less protein content than the plots sprayed in spring (Table 2).

Protein comparison among cultivars showed that Moats and Radiant had the highest content (10.7%). Bellatrix and Osprey (10.2%) had slightly lower protein content when compared to Moats (Table 3).

The cultivar Moats was the more resistant to stripe rust; Radiant was more susceptible to stripe rust in Saskatchewan, when compared to the trial in 2014. The benefits from fungicide application in terms of yield wer only observed in susceptible cultivars. However, TKW showed an improvement in all cultivars.

Table 1. Leaf spot and stripe rust disease severity, and seed quality of four winter wheat cultivars to fungicide application timings in Saskatoon, SK in 2016. Values represent means ± SE (n = 4)

Cultivar	Fungicide timing treatment	Leaf spot disease severity (%)	Stripe Rust disease severity (%)	Test weight (kg/hL)	Thousand kernel weight (g)
Bellatrix	Check	11.1 ± 2.3 ^{abc}	20.6 ± 3.0 ^{a}	76.2 ± 0.5 ^{d}	30.2 ± 0.2 ^{e}
	Fall	8.2 ± 1.3 ^{abc}	15.6 ± 2.8 ^{a}	76.5 ± 0.1 ^{d}	31.3 ± 0.5 ^{de}
	Spring	5.8 ± 1.3 ^{c}	3.4 ± 1.5 ^{cde}	78.9 ± 0.2 ^{abc}	35.7 ± 0.7 ^{ab}
	Both	5.1 ± 1.5 ^{c}	1.9 ± 0.6 ^{de}	78.9 ± 0.0 ^{abc}	35.5 ± 0.4 ^{ab}
Osprey	Check	8.4 ± 1.5 ^{abc}	14.4 ± 4.3 ^{ab}	76.1 ± 0.4 ^{d}	31.0 ± 0.6 ^{de}
	Fall	11.2 ± 1.7 ^{abc}	13.8 ± 2.2 ^{abc}	76.0 ± 0.5 ^{d}	30.9 ± 0.6 ^{de}
	Spring	4.3 ± 1.3 ^{c}	4.0 ± 2.9 ^{bcde}	77.7 ± 0.1 ^{c}	33.4 ± 0.6 ^{bcde}
	Both	3.9 ± 0.9 ^{c}	1.6 ± 1.1 ^{de}	78.0 ± 0.2 ^{abc}	33.4 ± 0.4 ^{bcde}
Moats	Check	6.4 ± 1.6 ^{c}	0.3 ± 0.1 ^{e}	79.0 ± 0.2 ^{ab}	31.8 ± 0.6 ^{cde}
	Fall	7.3 ± 1.4 ^{bc}	1.4 ± 1.2 ^{de}	79.0 ± 0.1 ^{ab}	30.8 ± 0.5 ^{de}
	Spring	4.9 ± 1.2 ^{c}	0.6 ± 0.6 ^{e}	79.2 ± 0.2 ^{a}	32.0 ± 0.3 ^{cde}
	Both	6.1 ± 1.0 ^{c}	0.1 ± 0.1 ^{e}	79.2 ± 0.1 ^{a}	31.2 ± 0.5 ^{de}
Radiant	Check	16.6 ± 4.6 ^{a}	11.9 ± 2.8 ^{abcd}	78.2 ± 0.1 ^{abc}	33.8 ± 1.6 ^{bcd}
	Fall	15.3 ± 0.8 ^{ab}	11.9 ± 2.4 ^{abcd}	77.9 ± 0.2 ^{bc}	35.0 ± 0.2 ^{de}
	Spring	3.5 ± 0.7 ^{c}	1.3 ± 0.6 ^{e}	78.9 ± 0.2 ^{abc}	37.6 ± 0.3 ^{a}
	Both	3.9 ± 0.7 ^{c}	1.5 ± 0.7 ^{de}	78.8 ± 0.1 ^{abc}	37.9 ± 0.6 ^{a}

Table 2. **Yield and protein content of winter wheat with different fungicide application timings.**

Fungicide timing treatment	Yield (kg/ha)	Protein (%)
Check	5195 ± 210.4 ^{b}	10.3 ± 0.1 ^{b}
Fall	5404 ± 103.3 ^{b}	10.2 ± 0.1 ^{b}
Spring	5920 ± 159.7 ^{a}	10.7 ± 0.1 ^{a}
Both	6018 ± 128.6 ^{a}	10.6 ± 0.1 ^{ab}

Table 3. Yield and protein content of four winter wheat cultivars.

Cultivar	Yield (kg/ha)	Protein (%)
Bellatrix	5284 ± 193.8 ^{c}	10.2 ± 0.1 ^{b}
Osprey	5332 ± 135.5 ^{bc}	10.2 ± 0.1 ^{b}
Moats	5784 ± 84.7 ^{ab}	10.7 ± 0.1 ^{a}
Radiant	6137 ± 181.5 ^{a}	10.6 ± 0.1 ^{ab}

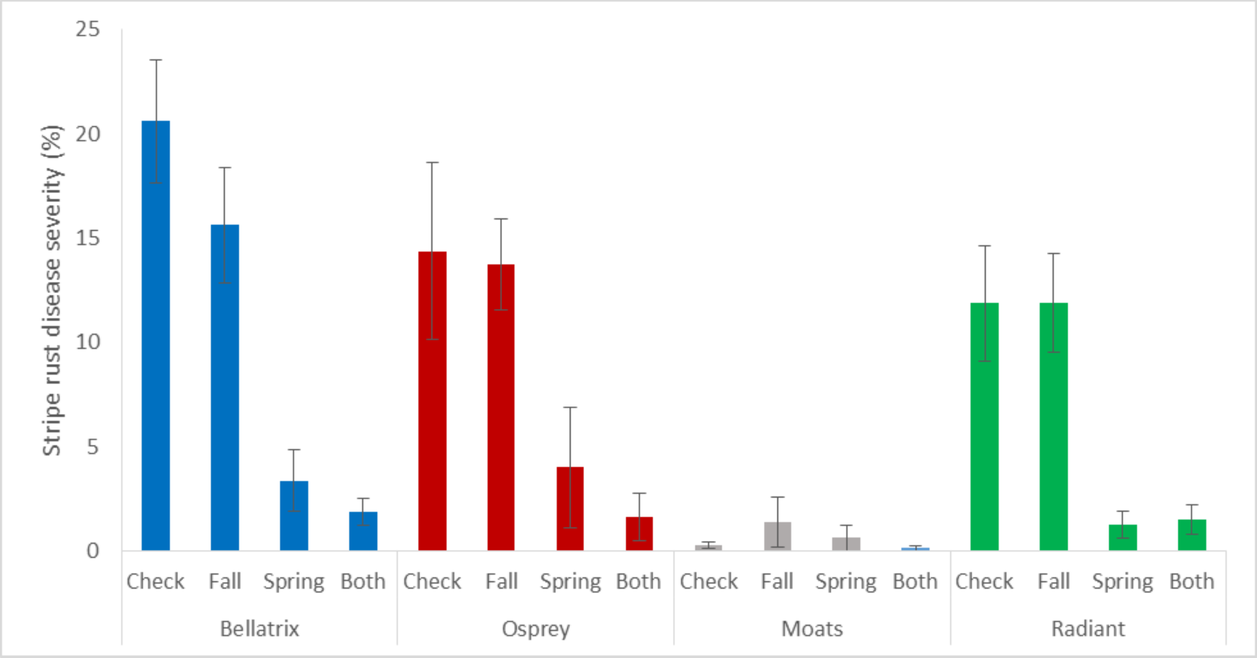


Figure 1. Stripe rust disease severity of four winter wheat cultivars with different application timings in Saskatoon, SK in 2016.

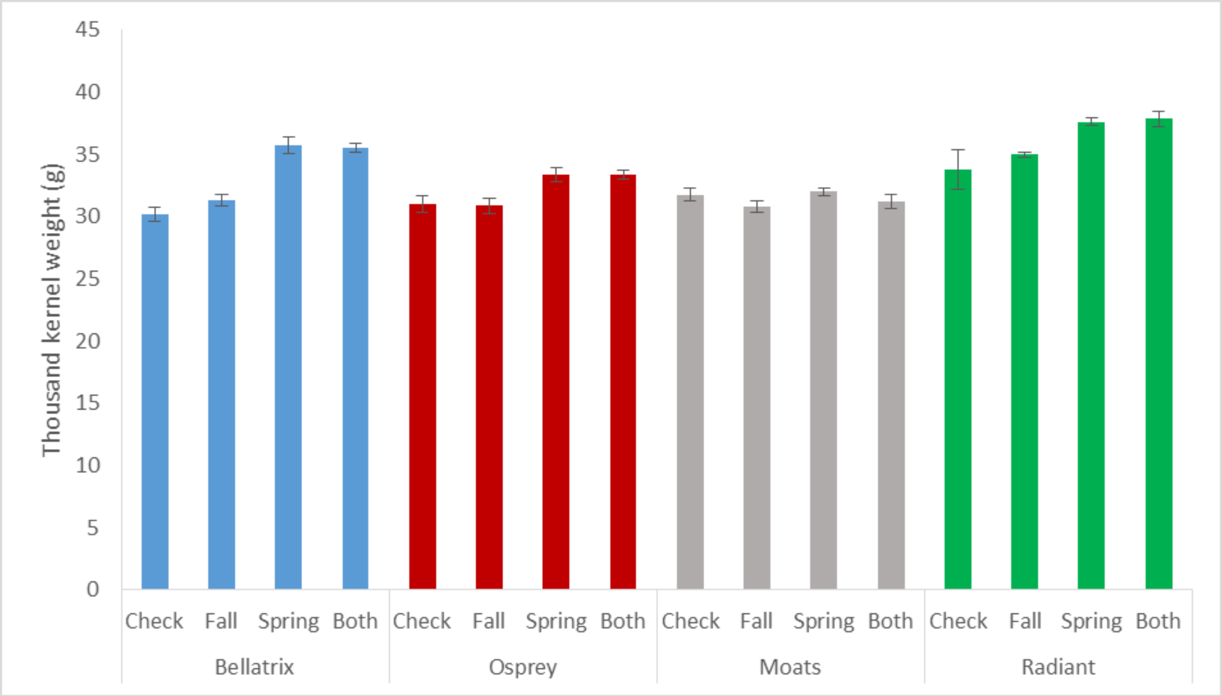


Figure 2. Thousand kernel weight for four winter wheat cultivars with different fungicide application timings in Saskatoon, SK in 2016.

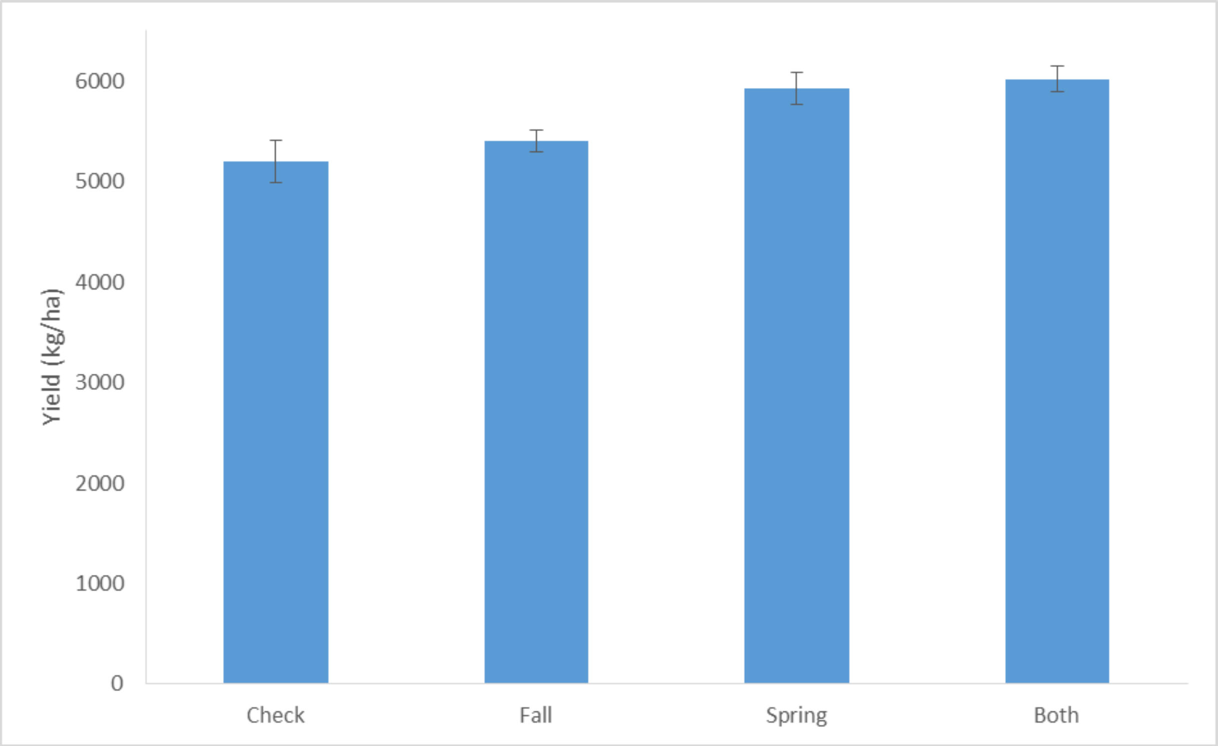


Figure 3. Yield of winter wheat with different fungicide application timings in Saskatoon, SK in 2016.

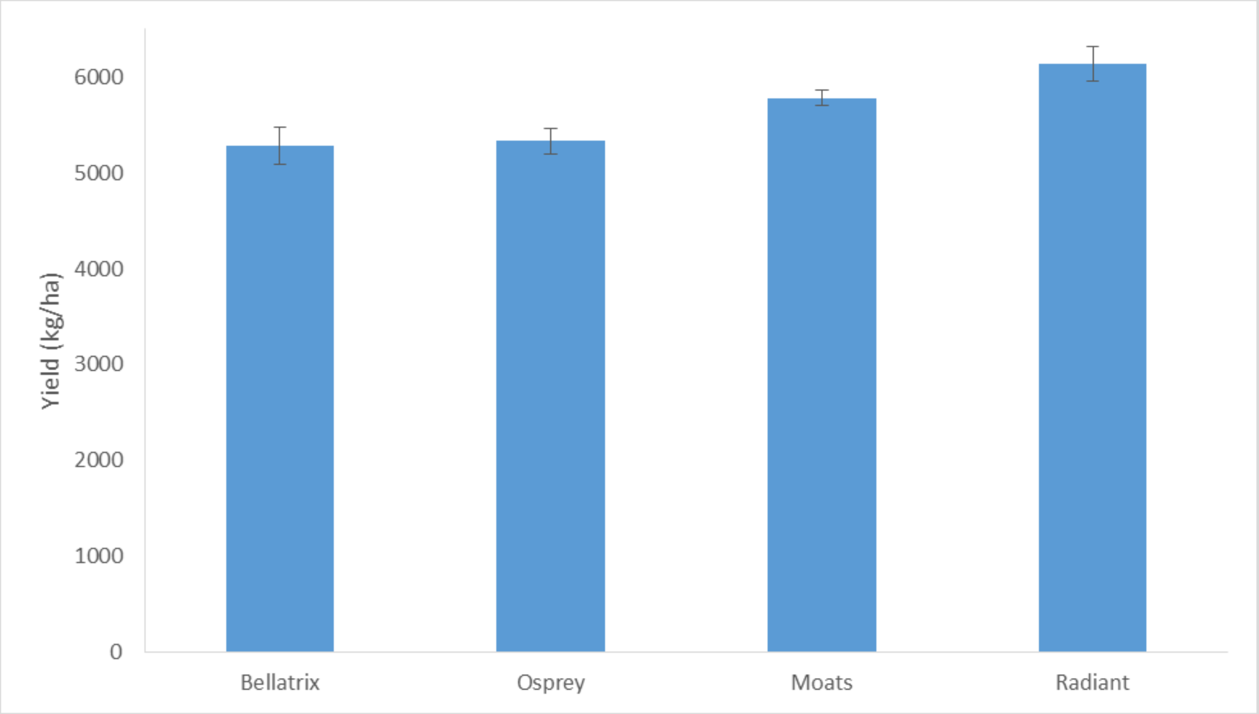


Figure 4. Yield of four winter wheat cultivars in Saskatoon, SK in 2016.

Sub-activity 3.4

Limiting losses and improved N efficiency through stabilized N applications

Objectives: Our overall objective is to determine if N stabilizers can mitigate losses that are often associated with liquid N applications, particularly in winter wheat systems as some or all of the crop N requirements are applied in fall. The information generated will assist growers and agronomists to decide if nitrogen stabilizers are a good investment in liquid and granular systems. This project will also provide new science-based knowledge on net GHG (N_2O and CO_2) emissions related to N fertilization in winter wheat cropping systems.

Hypotheses: 1) Winter wheat yield and yield components may benefit from controlled release or N stabilizers over conventional N granular and liquid forms.

2) Controlled-release and N stabilizer forms of N mitigate losses and increase the rate of N recovery in winter wheat cropping systems.

3) Controlled-release urea and N stabilizer forms provide positive economic net returns to the farm gate.

Deliverables: Unlike many agriculture products (including pesticides) that require data to prove efficacy prior to registration, efficacy verification of fertilizer and fertility supplements is not required prior to sale in Canada. But there are a wide range of products available, and the benefit claims of these products are difficult to evaluate. All of the products included in the proposed research have shown utility in other crops, or in other environments where winter wheat is grown. Currently growers have no economic comparisons of most of these products. We will provide an unbiased economic assessment. Compared to environments such as the UK, New Zealand, Australia and southern USA where nitrogen stabilizers are routinely used, Alberta's short growing season, cool spring soils, lack of abundant moisture and reduced leaching may limit the utility of nitrogen stabilizers. Producers have reasons to doubt the utility and the economic return of nitrogen products that add incremental costs. We believe that unbiased information for producers making decisions will be useful. In addition to the benefits for producers making important economic decisions, the graduate student, in conjunction with U of A soil scientists will assemble basic information about the relative importance of nitrification and urease inhibitors in Alberta and where they are expected to be most effective in the life cycle of wheat. Experimentally derived data combined with a more theoretical approach may allow us to understand why these products are effective or why they are not. Although we have emphasized the economic consequences of choosing nitrogen stabilizers, additional benefits to nitrogen use efficiency include a reduction of greenhouse gas emissions (Zaman and Blennerhassett 2010; Wolt 2004). While greenhouse gas emissions will not drive the decisions of growers at this point, documenting practice improvement may prove useful and aid to further refine the existing greenhouse gas offset protocols for farm operations in Alberta (Nitrous oxide Emission Reduction Protocol (NERP) of the Carbon Offset market).

Grower efficiency and profitability is a key component of industry sustainability and nitrogen is the largest input cost for Western Canadian growers. Nitrogen use efficiency is a significant research target being addressed by many techniques and technologies: by enhanced diversification of crop rotations; within metabolic pathways of the plant to effectively recycle nitrogen (Good, Johnson et al. 2007); in fertilizer type choice and time of application (McKenzie et al 2004, Beres et al 2010); or by slowing the soil transformations of nitrogen, and maintaining nitrogen in a plant available form. All technologies aim to increase yield and protein but impose additional costs onto crop production. Growers make economic decisions with limited information, frequently confounded by active promotion of products with unsubstantiated claims. This small piece of research will add to the information that growers can use to make decisions.

The study results will also describe how fertilizer best management practices (BMPs) impact crop N use and GHG emissions in a winter wheat system. This information is crucial to sustain soil resources, provide health economy and adapt to climate change.

Knowledge transfer will begin with field tours of the trials each year. Attendees will include industry and government agronomists, and producers. The trial will be included in the Southern Alberta Diagnostic tour and St. Albert Field days. After the second year of results has been analyzed, results will be extended through farm publications and oral presentations at producer meetings. The findings will be published in a peer-reviewed journal, and researchers and the graduate student will present talks and posters at venues including workshops and academic meetings.

Collaborators: Xiying Hao @ AAFC Lethbridge (Doug Marchbank); Ramona Mohr @ AAFC Brandon (Gordon Finlay); Linda Hall @ University of Alberta (Keith Topinka); Chris Holzapfel @ IHARF; Vance Yaremko and JP Pettyjohn@SARDA.

Locations:

The study will be conducted at **five locations**, Edmonton, Falher, and Lethbridge, AB; Indian Head, SK; and Brandon, MB.

EXPERIMENT I

Experiment I is designed to compare the crop response to the addition of urea plus the nitrogen stabilizer, Instinct; compared to SuperU; polymer-coated urea (Environmentally Smart Nitrogen [ESN]) and untreated urea. All fertilizer treatments will be applied at 80% of soil test recommended rate that targets an 80 bu/ac crop, using the Western Ag Innovations Plant Root Simulator (PRS) probe system.

Treatments:
Factor 1: N form (4):
-Instinct impregnated urea (nitrification inhibitor)
-SuperU (nitrification and urease inhibitor)
-Polymer-coated urea (ESN)
-Untreated Urea

Factor 2: Timing and Placement (3)
- All N banded in fall at planting

- 30 % banded at planting: 70% applied late fall.
- 30 % banded at planting: 70% applied in-crop at Feekes GS 4.

Total factorial combination treatments = 12 + control of 0N for 13 treatments.

Experimental Design and Data Analysis: The factorial arrangement of treatments arranged in a complete block design with 4 replicates. Total plots = **52**. Data will be analyzed with PROC MIXED of SAS. ANOVA will be used to test for significance of main effects and their interactions.

EXPERIMENT II

Experiment II will compare the effects of liquid N systems based on urea ammonium nitrate (UAN) treated with the nitrogen stabilizers Instinct, Agrotain, or Agrotain Plus, compared to untreated UAN, urea and polymer coated urea.

Split Application: All fertilizer treatments will be applied at 80% of soil test recommended rate with 50% of the application at planting (side- or midrow-banded),
and 50% broadcast in-crop at Feekes growth stage 4.

Treatments:
N system (6)
-UAN 28-0-0 with Instinct (nitrification inhibitor)
-UAN 28-0-0 with Agrotain Plus (nitrification and urease inhibitor)
-UAN 28-0-0 with Agrotain Ultra (urease inhibitor)
- UAN 28-0-0
- Urea 46-0-0
-Polymer-coated urea (ESN) 50% banded at seeding, 50% broadcast untreated urea in-crop.
Total factorial combination treatments = 6 + control of 0N for 7 treatments.

Experimental Design and Data Analysis: A randomized complete block design with 4 replicates. **Total plots = 28.** Data will be analyzed with PROC MIXED of SAS. ANOVA will be used to test for significance of main effects.

For GHG flux determination, gas samples will be collected and analyzed weekly throughout the five year study for Lethbridge and Brandon sites. GHG fluxes will be determined using a vented static chamber (30 cm diameter, 10 cm tall) consisting of a PVC base collar installed at a point maintained free of vegetation, and a removable PVC cover. From each chamber, gas samples (11.3 mL) will be collected with a syringe and transferred to an evacuated vial (5.8 mL) at 0, 10, 20, 30 and 60 min after securing the chamber cover to the collar. Gas samples will be analyzed for CO_2, CH_4 and N_2O concentrations using a Varian 3800 GC and Varian 4300 Micro-GC (Varian Inc, Walnut Creek, CA).

Timelines:

2013 – Trials established in the fall.

2014 – Year 1 of trial will be conducted. An interim report will be prepared.

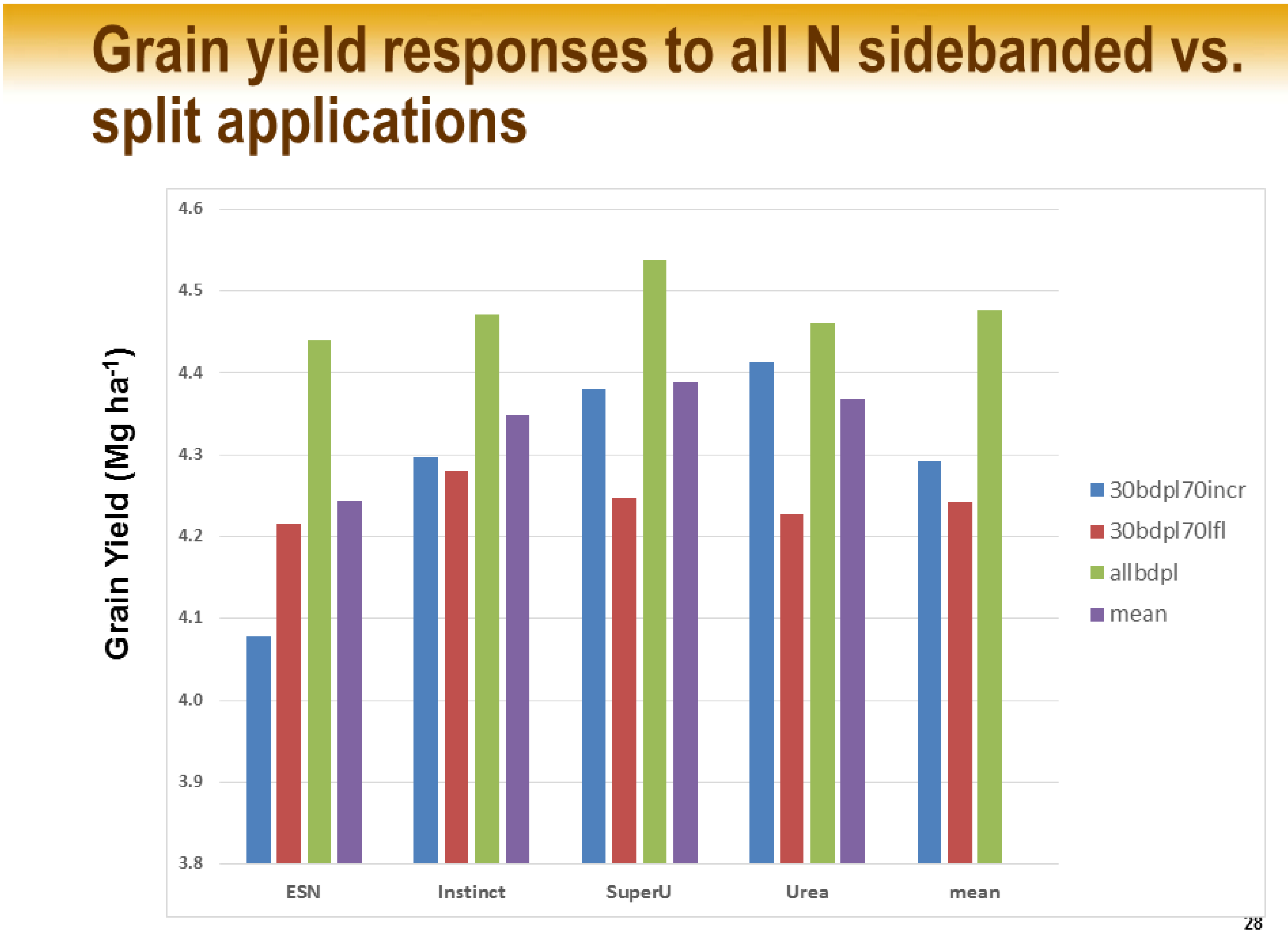
2015 – Year 2 of trial will be conducted. An interim report will be prepared.

2016 – Year 3 of trial will be conducted. An interim report will be prepared. Data analysis from all site-years, and final report and scientific paper preparation will commence.

2017 – Data analysis will be finalized, a final report with recommendations will be prepared, technology transfer documents will be finalized, and scientific papers will be prepared and submitted.

Results:

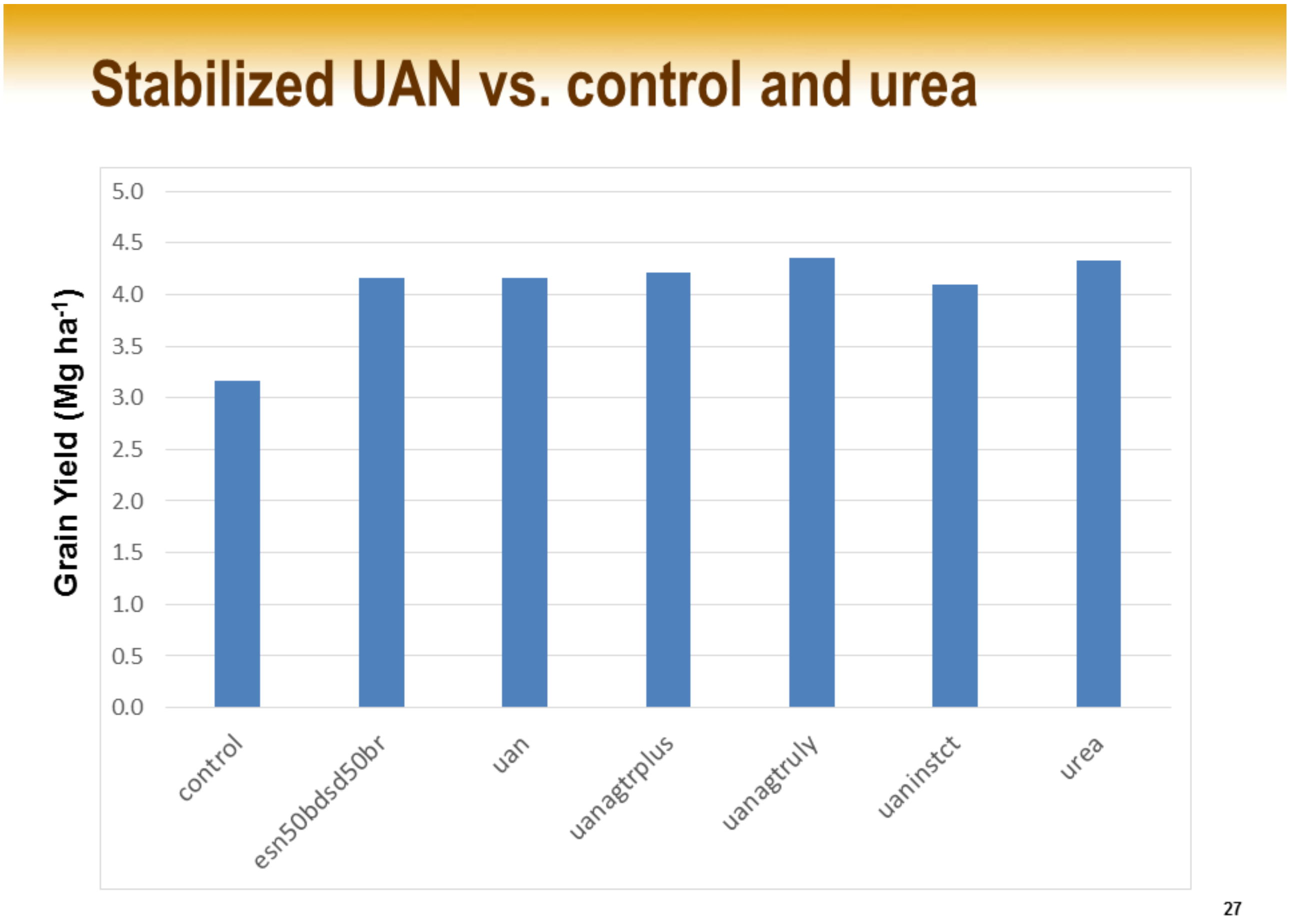
Responses to enhanced efficiency nitrogen treatments have thus far been somewhat modest as conditions to date may not be conducive to nitrogen loss. A possible indication for this is that the untreated UAN is providing similar grain yield results to date than when treated with either the Agrotain Plus or Agrotain Ultra stabilizers. However, as data is compiled over site-years the ANOVA does reveal significant effects from both N form and placement. In experiment I, placing all N at planting, irrespective of N form, provided higher grain followed by the split N where the balance of N is applied in spring at Feekes 4. The split N timing of late fall provides reduced yield with exception of Instinct where it is similar to N applied in spring and for ESN, where it provided improved yield over applications in spring. Super U appears to provide the highest overall numerical grain yield responses (Fig. 1).



Grain yield responses to all N sidebanded vs. split applications

Figure 1. Influence of N form, timing and placement on yield of winter wheat. Amounts shown in legend are percentages of overall recommendation for N. Placement was either banded at planting ('bdpl') or in-crop in late-fall ('lfl') or in-crop in spring at Feekes 4 ('incr').

As reported in Activity 2.6, the percentage of N placed at planting may create differential responses depending on the potential for productivity or the intensity of the management. The fact that responses in Expt II are somewhat similar irrespective of form may be an indication of this and also of an environment where no N losses are experienced (Fig. 2). All strategies/N forms provide similar grain yield including uncoated urea and UAN without any N stabilizer.



Stabilized UAN vs. control and urea

Figure 1. Influence of on yield of winter wheat when 50% of recommended rate is applied sideband at planting the balance applied in-crop in spring at Feekes 4.

So far we only have data collection activities from greenhouse gas objectives. Data collected includes greenhouse gas emission rate (weekly over winter wheat growing season, less frequent non-growing season), soil N availability (monthly over growing season, every two months non growing season). The wheat grain sample analysis will be conducted in 2016, which will provide results for the next annual report.

There are no measureable outputs yet, but Dr. Xiying Hao is planning to present the GHG data at the 2017 Alberta Soil Science Workshop (Feb 2017 to be held in Lethbridge).