2020

Annual Report

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Introduction

The East Central Research Foundation (ECRF) is a non-profit, producer directed research organization which works closely with various levels of government, commodity groups, private industry and producers. Founded in 1996, the mission of ECRF is to promote profitable and sustainable agricultural practices through applied research and technology transfer to the agricultural industry.

In 2013, ECRF signed a memorandum of understanding with Parkland College that allow the partners to jointly conduct applied field crop research in the Yorkton area. The City of Yorkton renewed the lease with ECRF/Parkland College providing a 3-year lease of land (108 acres) located just a half mile South of the city on York Lake road and another 60-acre parcel located just West of the city. We will be entering the 8th year of leased land provided by the City of Yorkton.

Parkland College is the first regional college in Saskatchewan to undertake an applied research program. Parkland College is thrilled to be involved in applied research because it fits with one of their mandates to "serve regional economic development". The partnership also provides the college with a location and equipment to use for training students. Both partners benefit from each other's expertise and connections. ECRF and Parkland College also have access to different funding sources which is another strength of the partnership.

On April 18, 2020 SaskCanola informed ECRF that once again they were the recipients of Morris Sebulsky endowment fund. The $14,000 endowed to them went towards purchasing a 15ft Degelman mower that will mainly be used for yard and trial alleyway maintenance.

Parkland College was awarded $200,000 over 2 years through a NSERC IE grant in March 2020. These funds will help pay for research farm summer students, equipment (sea-can and weigh wagon), land rental, parts, etc. Parkland College was also awarded $60,440 from the Western Grains Research Foundation. ECRF contributed $14,625 from the 2019 SaskCanola Morris Sebulsky endowment fund in supporting funds to enable Parkland College to secure the Western Grains Research Foundation's grant. In total, Parkland College gained access to $75,065 to purchase a ¾ ton truck, weigh wagon, dump trailer, Clipper seed cleaner + screens, custom built sampler drier, custom built bleachers, and video equipment. The funds that Parkland College was able to secure will largely contribute to upgrading and maintaining equipment and securing funds for summer students and land rental.

ECRF Board of Directors

ECRF is led by an 8-member Board of Directors consisting of producers and industry stakeholders who volunteer their time and provide guidance to the organization. Residing all across East-central Saskatchewan, ECRF Directors are dedicated to the betterment of the agricultural community as a whole.

Within the past year, Wade Olynyk resigned as a board member and Jeff Just became a new board member. Jeff Just raises Herford cattle and grain farms on a farm just West of Yorkton.

The 2019 ECRF Directors are:

- Blair Cherneski (Chairperson) - Goodeve, SK
- Gwen Machnee (Vice Chairperson) - Yorkton, SK - Co-ordinator for University and Applied Research-Parkland College
- Fred Phillips - Yorkton, SK
- Dale Peterson - Norquay, SK
- Brent Ulmer- Goodeve, SK
- Brian Ulmer- Goodeve, SK
- Lutz Foerster- Theodore, SK
- Jeff Just- Yorkton, SK

Ex-Officio

- Charlotte Ward - Regional Forage Specialist - Saskatchewan Agriculture
- Samantha Marcino - Regional Crops Specialist - Saskatchewan Agriculture

Staff

- Mike Hall - Research Coordinator
- Heather Sorestad - Research Assistant
- Kurtis Peterson - Administrator
- Clark Anderson - "On Call" Equipment Technician
- Brendan Dzuba - Summer Student
- Emma Just – Summer Student

Agri-Arm

The Saskatchewan Agri-ARM (Agriculture Applied Research Management) program connects eight regional, applied research and demonstration sites into a province-wide network. Each site is organized as a non-profit organization, and is led by volunteer Boards of Directors, generally comprised of producers in their respective areas.
Each site receives base-funding from the Saskatchewan Ministry of Agriculture to assist with operating and infrastructure costs, with project-based funding sought after through various government funding programs, producer / commodity groups and industry stakeholders. Agri-ARM provides a forum where government, producers, researchers and industry can partner on provincial and regional projects.

The eight Agri-ARM sites found throughout Saskatchewan include:
- Conservation Learning Centre (**CLC**), Prince Albert
- East Central Research Foundation (**ECRF**), Yorkton
- Indian Head Agricultural Research Foundation (**IHARF**), Indian Head
- Irrigation Crop Diversification Corporation (**ICDC**), Outlook
- Northeast Agriculture Research Foundation (**NARF**), Melfort
- South East Research Farm (**SERF**), Redvers
- Western Applied Research Corporation (**WARC**), Scott
- Wheatland Conservation Area (**WCA**), Swift Current

For more information on Agri-ARM visit http://Agri-ARM.ca/

Research and Statistical analysis

Unless otherwise stated all trials are small plot research. Plot size is typically either 11 or 22 feet wide and 30 feet long. The trials are seeded with a 10 foot wide SeedMaster drill which has 12inch row spacing. The middle 4 rows of plots are harvested using a small plot Wintersteiger combine. In the case for forage trials, the middle 4 rows of each plot are harvested with a small plot forage harvester.

Treatments are replicated and randomized throughout the field so that data may be analyzed. If a treatment is seeded in multiple plots throughout the field, experience tells us we are unlikely to obtain the same yield for each of these plots. This is the result of experimental variation or variation within the trial location. This variation must be taken into consideration before the difference between two treatment means can be considered "significantly" different. This is accomplished through proper trial design and statistical analysis.

Trials are typically set up as Randomized Complete Blocks, Factorial or Split-Plot designs and replicated 4 times. This allows for an analysis of variance. If the analysis of variance finds treatments to differ statistically then means are separated by calculating the least squares difference (lsd). For example, if the lsd for a particular treatment comparison is 5 bu/ac then treatment means must differ more than 5 bu/ac from each other to be considered significantly (statically) different. In this example, treatment means that do not differ more than 5 bu/ac are not considered to be significantly different. All data in our trials must meet or exceed the 5% level of significance in order to be considered significantly different. In other words, the chance of concluding there is a significant difference between treatments when in reality there is not, must be less than 1 out of 20. For the sake of simplicity, treatment means which are not significantly different from each other will be followed by the same letter.

Extension Events

Speaking engagements

2020 Videos-Website

- 4R Nitrogen Management of Winter Wheat during a Drought
- Managing Post Anthesis Nitrogen to Reduce Leaf Burn and Increase Grain Protein in Wheat
- Oat Test Weight in the Good and the Bad
- Grain Millers Oat Variety Trial
- Virtual Tour: Blackstrap dry bean response to added nitrogen
- Yorkton's Research Farm 2020 Virtual Field Tour Introduction
- Virtual Tour: Input management for malt vs feed barley
- Virtual tour: In-season applications of UAN vs dissolved urea for increasing wheat protein
- Virtual tour: Oat test Weight
- Virtual Tour: Effect of Nozzle type and boom height on fusarium head blight suppression in wheat

2019 Videos- Website

- Post-Emergent UAN vs Melted Urea for Increasing Wheat Protein 2019
- A Introduction to Yorkton's Research Farm
- Why Did Fungicide Not Control Leaf Disease on Our Oats? 2019 (89)
- CDC Blackstrap Dry Bean Inoculation and Nitrogen Fertilization 2019 (44)
- Should feed barley be fertilized with more nitrogen than malt? 2017-2019 (86)
- Maintaining Test Weight Stability of Milling Oats 2019 (120)
- Getting the Most out of Nitrogen 2019 (217)
- Farm Tour Promo 2019 (36)

2018 Videos- Website

- Are Farmers Applying Enough Nitrogen and Phosphorus to Flax 2016 to 2018? (161)
- Wheat Profitability Study 2017:18 (165)
- Oats Busting Bins and Making the Grade (115)
- Inoculant Options for Faba Beans 2015-2017 (114)
- Increasing Wheat Protein with a Post Emergent Application of UAN 2018 (187)
- Control of Glyphosate Resistant Canola in Glyphosate Resistant Soybeans 2018 (107)
- Strategies for Managing Feed and Malt Barley 2017/2018 (158)
- Oat Vigour Improves with Larger Seed Size 2018 (124)
- 4R Fall Applied Urea to Spring Wheat 2018 (650)
- Farm Tour Promo 2018- (90)

2017 Videos- Website

- Strategies for Management of Feed and Malt Barley 2017- (69)
- Wheat Profitability 2017-(64)
- Hastening Maturity of Oats without Pre-Harvest Glyphosate 2017- (174)
- Soybean Expectations versus Results 2013-2017- (54)
- Importance of Dual Inoculation and Seeding Soybeans into Warm Soil - (78)
- Demonstrating 4R Nitrogen Principles in Canola the benefit of Agrotain and SuperU - (153)
- Effect of Seeding Date, Seeding Rate and Seed Treatment on Winter Wheat - (150)
- An Introduction to ECRF- (129)

2016 Videos- Website

1. Evaluating Inoculant Options for Faba beans - (56)
2. Flax Response to Nitrogen and Phosphorus - (130)
3. Effect of Variety, and Nitrogen Rate on Oat Yield and Test Weight - (339)
4. Effect of Variety, Nitrogen Rate ad Seeding Rate on Forage Corn - (78)
5. Effect of Fall Cultivation on Soybeans Seeded Early, Mid, and Late May - (58)
6. Effect of Preceding Legume Crop on Spring Wheat – (55)
7. Effect of Nozzle Selection and Boom Height on Fusarium Head Blight - (98)
8. Lentil Production in the Black Soil Zone - (240)

2015 Videos -Website

- Flax Studies with IHARF and NARF - (75)
- Early Defoliation of Cereals for Swath Grazing - (230)
- Canary Seed Fertility - (342)
- Soybean Stature by Row Spacing - (169)
- Manipulator Effects on Lodging in Wheat 2015 - (899)

2014 Videos - Website

- Forage Termination 2015 - (100)
- Cereal Forage by Seeding Date - (48)
- Soybean Variety by Seeding Date - (134)
- Wheat Fungicide Timing - (259)

Total website views (6,536) as of Feb. 11, 2020

Environmental Data

Data for Yorkton was obtained from Environment Canada from the following internet site: [http://www.climate.weatheroffice.gc.ca/climateData/canada_e.html].

Mean monthly temperatures and precipitation amounts for 8 Agri-Arm sites during the 2019 season are presented relative to the long-term averages in Table 1 and 2. All sites in 2020 other than Scott received precipitation below their long term total precipitation. In 2020 Outlook, Redvers, Swift Current and Yorkton achieved higher than average long term temperatures. The only sites that received lower than average temperatures were Prince Albert and Scott. The rest of the Agriarm sites experienced their average long term temperature.

Table 1. Mean monthly temperatures amounts along with long-term (1981-2010) normals for the 2020 growing seasons at 8 sites in Saskatchewan.

Location	Year	May	June	July	August	Avg. / Total
		Mean Temperature (°C)				
Indian Head	2020	10.7	15.6	18.4	17.9	15.6
	Long-term	***10.8***	***15.8***	***18.2***	***17.4***	***15.6***
Melfort	2020	10.1	14.3	18.8	17.6	15.2
	Long-term	***10.7***	***15.9***	***17.5***	***16.8***	***15.2***
Outlook	2020	11.3	15.9	19.1	18.8	16.2
	Long-term	***11.5***	***16.1***	***18.9***	***18.0***	***16.1***
Prince Albert	2020	9.2	13.4	17.6	16.1	14.1
	Long-term	***10.4***	***15.3***	***18.0***	***16.7***	***15.1***
Redvers	2020	10.5	16.8	19.2	18.5	16.3
	Long-term	***12***	***16***	***19***	***18***	***16.3***
Scott	2020	10.2	14.6	17.1	16	14.5
	Long-term	***10.8***	***14.8***	***17.3***	***16.3***	***14.8***
Swift Current	2020	10.9	16.6	18.2	19.5	16.3
	Long-term	***11***	***15.7***	***18.4***	***17.9***	***15.8***
Yorkton	2020	10.5	16.4	19.9	18.3	16.3
	Long-term	***10.4***	***15.5***	***17.9***	***17.1***	***15.2***

Table 2. Precipitation amounts along with long-term (1981-2010) normals for the 2020 growing seasons at 8 sites in Saskatchewan.

Location	Year	May	June	July	August	Avg. / Total
		------------------------------ *Precipitation (mm)* --------------------				
Indian Head	2020	27.3	23.5	37.7	24.9	113.4
	Long-term	***51.7***	***77.4***	***63.8***	***51.2***	***241.4***
Melfort	2020	26.7	103.7	52.4	18.5	201.3
	Long-term	***42.9***	***54.3***	***76.7***	***52.4***	***226.3***
Outlook	2020	27.8	79.2	29.6	19.0	155.6
	Long-term	***42.6***	***63.9***	***56.1***	***42.8***	***205.4***
Prince Albert	2020	68.4	91.4	32.2	33.2	225.2
	Long-term	***44.7***	***68.6***	***76.6***	***61.6***	***251.5***
Redvers	2020	22.9	59.7	47.8	36.1	166.5
	Long-term	***60***	***91***	***78***	***64***	***293***
Scott	2020	48.3	70.2	129.4	25.8	273.7
	Long-term	***38.9***	***69.7***	***69.4***	***48.7***	***226.7***
Swift Current	2020	36.3	80.0	62.5	6.5	185.3
	Long-term	***42.1***	***66.1***	***44***	***35.4***	***187.6***
Yorkton	2020	16.7	33.6	80.1	49.3	179.7
	Long-term	***51***	***80***	***78***	***62***	***272***

Increasing Wheat Protein with Post Emergent Applications of UAN vs Dissolved Urea

Mike Hall[1], Heather Sorestad[1], Robin Lokken[2], Chris Holzapfel[3], Brianne McInnes[4], Jessica Slowski[4], Lana Shaw[5] Garry Hnatowich[6], Jessica Enns[7], Amber Wall[8] and Bryan Nybo[8]

[1]East Central Research Foundation, Yorkton, SK.
[2]Conservation Learning Centre, Prince Albert, SK
[3]Indian Head Research Foundation, Indian Head, SK.
[4]Northeast Agriculture Research Foundation, Melfort, SK
[5]South East Research Farm, Redvers, SK
[6]Irrigation Crop Diversification Centre, Outlook, SK
[7]Western Applied Research Corporation, Scott, SK
[8]Wheatland Conservation Area Inc., Swift Current, SK

1. Abstract/Summary:

In 2019 and 2020, trials were established at 8 AgriARM locations across Saskatchewan to demonstrate the potential of increasing either wheat yield or grain protein with late season applications of N in the form of UAN or dissolved urea. All late season applications of N were intended to be applied at 30 lb N/ac to a base rate of 70 lb N/ac of side-banded urea. Due to a calculation error, dissolved urea was only applied at 25 lb N/ac. However, the results did support many of the principles the study set out to demonstrate. Earlier dribble band applications of UAN at the boot stage caused less flag leaf burn compared to post-anthesis applications. Using less concentrated forms of UAN was not necessary to reduce leaf burn when dribble banding at either stage. When applying post-anthesis, dribble banding UAN caused significantly less flag leaf burn compared a broadcast spray which caused the most damage of any treatment. Leaf injury from broadcast spraying was substantially reduced when using dissolved urea instead of UAN. While this phenomenon is supported by past study, the lower rate of N with the dissolved urea in this study would also contribute to greater crop safety. In general, split applications of N were able to raise the grain protein relative to applying all the N at seeding but they also tended to result in less yield. Protein increases and yield decreases were less pronounced with the boot stage timing compared to the post-anthesis timing. Economically, split applications did not prove to be economic because the value of the protein increases were negated by the associated yield losses even when assuming a healthy protein spread of $0.6/%/bu. This was true whether considering the all site/years combined, the top 8 yielding sites combined or the lowest 8 yielding sites combined. In other words, the benefit of split applications were not more economical for a high yielding crop compared to a low yield crop when assuming the same protein spread.

2. Project Objectives:

The overall objective of this project was to demonstrate the potential of an additional 30 lb N/ac applied late season to increase either wheat yield or grain protein compared to applying all nitrogen (N) at seeding. The impact of nitrogen source, crop staging and application method were compared.

Specifically, the intent was to demonstrate the following concepts:

a. Dribble banded applications of UAN cause less flag leaf burn than broadcast foliar sprays applied post-anthesis.

b. Dribble banding UAN at the earlier boot stage causes less flag leaf burn than when applied post-anthesis.

c. Diluting dribble band applications of UAN is not necessary and may actually increase flag leaf burn.

d. Strategies resulting in less flag leaf burn will produce a better yield/protein response (ie: more protein/ac).

3. Project Rationale:

Recently, producers have been disappointed by low levels of grain protein. When regional protein levels are low, the premiums offered for high protein wheat tend to increase. This has left producers wondering what can be done to increase protein levels in the future. Many studies, dating back to the 1990s, have shown post-emergent applications of nitrogen can increase grain protein when made at late vegetative stages. Guy Lafond assessed the feasibility of applying foliar N at both the boot stage and post-anthesis for spring and winter wheat [1]. He determined that this practice had merit, but the results could vary depending on initial N supply and weather conditions. However, dribble banding at the earlier boot stage increased grain protein more consistently and reduced the potential for flag leaf burn. UAN (28-0-0) produces large drops that do not disperse on the leaf surface because they have a high surface tension and tend to roll off. Dilution may reduce surface tension and actually increase leaf burn [2], or increased leaf burn may just be a function of a higher volume applied.

Western Canadian research has found little reason to support the use of broadcast foliar sprays over dribble banding. Broadcast foliar sprays cause more leaf burn, and since little nitrogen is actually absorbed through the leaves, there is little benefit to the practice. The University of Manitoba found the recovery of foliar applied 15N labelled urea (in solution) was only 4-27% compared to 32-70% with soil application. Under field conditions with foliar UAN, most of the uptake occurs after rainfall events wash the N into the soil, where it is taken up through the roots [3].

Despite these results, broadcast foliar sprays post-anthesis are popular in the northern United States and are practiced in Manitoba. The general recommendation is to dilute UAN 50:50 with water and spray when conditions are cool to reduce leaf burning. While foliar applications of UAN post-anthesis frequently increase protein, this practice does not always prove to be economical. Research lead by John Heard with Manitoba Agriculture evaluated the benefit of post-anthesis UAN on 15 farm sites from 2015 to 2016 [4]. The impact on protein was largely positive and statistically significant 60% of the time. On average, protein of CNHR varieties was increased 0.6% when an additional 30 lb N/ac was applied post-anthesis. However, post-anthesis UAN only proved to be economical at 2 of 15 sites, and premiums for higher protein concentrations are not guaranteed.

Broadcast foliar sprays with dissolved urea, instead of UAN may prove to be more beneficial. Amy Mangin with the University of Manitoba recently found broadcast foliar sprays of dissolved urea sprayed post-anthesis not only resulted in less leaf burn but also produced greater yields and higher grain protein compared to UAN [5]. Dissolved urea is a standard product used for foliar applications in the UK and is considered to be safer on the crop than UAN. While both UAN and dissolved urea were applied at 30 lb N/ac in Mangin's study, the % N concentration of the solutions differed between the products. The UAN solution was 14%, whereas the urea solution was only 9%. This may have also contributed to the greater crop safety observed with dissolved urea. In our demonstration, the intent was to compare UAN and dissolved urea at 14% N to provide a fair comparison. However, this did not occur, and the logic for this comparison is flawed. Later in the paper this will be discussed in full.

Producers can create their own solution of urea on farm, however, care must be taken as dissolving urea is extremely endothermic and can freeze lines. Urea should be dissolved slowly into warm water and not into cold water pulled from a well. In addition, producers should only dissolve urea with less than 1% biuret. Biuret is a by-product that can cause severe leaf burning, but it is normally not a concern with urea manufactured in North American.

[1] Lafond, G and J. McKell. 1998. The Effects of Foliar Applied Nitrogen on Grain Protein Concentration in Spring and Winter Wheat. Proceedings of the Wheat Protein Symposium 298-304

[2] Stu Brandt personal communication

[3] Rawluk, C. D. L., Racz, G. J. and Grant, C. A. 2000. Uptake of foliar or soil application of 15N-labelled urea solution at anthesis and its affect on wheat grain yield and protein. Can. J. Plant Sci. 80: 331–334.

[4] Heard, J., Sabourin, B., Faroq, A. and L. Kaminski. On-farm-tests evaluate nitrogen rate, source and timing for spring wheat yield and protein. Poster.

[5] http://umanitoba.ca/faculties/afs/agronomists_conf/media/7__1_30_PM_DEC_14_MANGIN_MAC_2017_NOV23.pdf

4. Methodology:

In 2019 and 2020 trial sites were initiated near Swift Current (dry Brown), Outlook (Brown), Scott (Dark Brown), Indian Head (thin Black), Yorkton (Black), Melfort (moist Black), Prince Albert (Grey) and Redvers (Dark Brown). Treatments were designed to compare boot stage and post-anthesis timings of split N relative to side-banding all the N at seeding. Dribble band and broadcast applications of UAN and dissolved urea were compared. All split applications of N were supposed to be 30 lb N/ac applied to a base rate of 70 lb N/ac. While late season applications of UAN and diluted UAN were applied at the targeted 30 lb N/ac, dissolved urea treatments (trts 7 and 9) were only applied at 25 lb N/ac due to a calculation error more fully described in the appendix. Other macronutrients were applied at each site to be non-limiting to yield.

Treatments (Table 1) were arranged in a Randomized Complete Block Design (RCBD) with 4 replicates at each site. Plot size, row spacing, and fertilizer application techniques at seeding varied between locations depending on equipment. Tables 2 and 3 describe how the trials were maintained and provides the dates of key operations. All trials were seeded in good time, with dates ranging from May 8 to 24 in 2019 and from May 7 to 28 in 2020. Fungicide for leaf disease or leaf disease plus fusarium head blight were applied at all site years except Melfort and Scott in 2019 and Outlook and Swift Current in 2020. The vast majority of sites were harvested in August and September in good condition. Grain yield was cleaned and corrected to a uniform moisture of 14.5%. Precipitation and temperatures for each location were compiled from the nearest Environment Canada weather station (Tables 4 and 5). To aid with the interpretation of results, composite soil samples were collected from each location and the results are presented in Table 6.

Table 1. Treatment List for the Increasing Wheat Protein with Post Emergent Applications of UAN vs Dissolved Urea Trial

Treatment #	Seeding	Post emergence application				
	Lb N/ac of Side- banded Urea	N (lb/ac)	Product	%N	method	Stage
1	70	na	Na	na	na	na
2	100	na	Na	na	na	na
3	70	30	UAN	15.7	dribble[1]	boot
4	70	30	UAN	28	dribble[2]	boot
5	70	30	UAN	15.7	dribble[1]	Post-anthesis
6	70	30	UAN	28	dribble[2]	Post-anthesis
7	70	25	Urea Sol'n	14	Dribble [3]	Post-anthesis
8	70	30	UAN	15.7	Broadcast[4]	Post-anthesis
9	70	25	Urea Sol'n	14	Broadcast[5]	Post-anthesis

[1] Sprayed with dribble band nozzle at 20 US gal/ac to deliver 30 lb N/ac (10 gal/ac UAN + 10 gal/ac water = 15.7% N solution by weight)

[2] Sprayed with dribble band nozzle at 10 US gal/ac to deliver 30 lb N/ac (undiluted UAN =28% N solution by weight)

[3] Sprayed with dribble band nozzle at 20 gal/ac to deliver 25 lb N/ac (1.66 Kg of urea dissolved in 1 US gallon of water = 14% N solution)

[4] Sprayed with 02 flat fan nozzles at 20 gal/ac to deliver 30 lb N/ac (10 gal/ac UAN + 10 gal/ac water = 15.7% N solution by weight)

[5] Spray with 02 flat fan nozzles at 20 gal/ac to deliver 25 lb N/ac (1.66 Kg of urea dissolved in 1 US gallon of water = 14% N solution)

Table 2. Dates of operations in 2020 for each participating location								
	----------------------------Date----------------------------							
Activity	**Indian Head**	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**
Pre-seed Herbicide Application	May 14 (Roundup Transorb)	May 24 (Heat LQ + Glyphosate 540)	May 19 (Cleanstart + AIM)	N/A	May 14 (Glyphosate)	May 9 (Glyphosate 540 + AIM)	May 4 (Glyphosate + AIM)	N/A
Seeding	May 12	May 23	May 28	May 25	May 8	May 14	May 16	May 7
Emergence Counts	June 4	June 16	June 9	June 15	May 26	June 11	June 4	May 26
In-crop Herbicide Application	June 15 (Octain + Simplicity)	June 23 (Prestige XC) & July 3 (Axial)	June 9 (Infinity) & June 10 (Simplicity)	June 10 (Infinity)	June 2 (Infinity FX)	June 15 (Axial Ipak)	May 29 (Liquid Achieve + Buctril M +Turbocharge ADJ)	June 2 (Prestige) June 8 (Simplicity)
Boot N application	June 30	July 16	July 13	July 10	June 29	July 6	June 22	June 22
Post-anthesis N application	July 16	Aug 13	July 29	July 27	July 10	July 27	July 23	July 13
Flag leaf burn Rating	July 20	Aug 20	July 31	Aug 6	July 16		July 30	July 20
In-crop Fungicide Application	July 11 (Prosaro XTR)	July 24 (Caramba)	N/A	July 21 (Twinline)	June 7 (Caramba)	July 16 (Caramba)	N/A	July 2 (Caramba)
Lodging Rating	Aug 13	Sept 16	N/A	Sept 21	N/A	N/A	Aug 25	N/A
Desiccant	Aug 19 (Roundup Transorb)	N/A	N/A	N/A	N/A	Aug 25 (Glyphosate 540)	N/A	(Roundup Transorb)
Harvest	Aug 26	Sept 16	Sept 16	Sept 23	Aug 20	Sept 11	Aug 26	Aug 11

Table 3. Dates of operations in 2019 for each participating location

Activity	Indian Head	Melfort	Outlook	Prince Albert	Redvers	Scott	Swift Current	Yorkton
	------------------------Date------------------------							
Pre-seed Herbicide Application	May 12 (Roundup Weathermax 540)	May 24 (Glyphosate + Heat)	N/A	N/A	N/A	May (Glyphosate 540 + AIM)	May 7 (Glyphosate)	N/A
Seeding	May 14	May 24	May 15	May 23	May 7	May 14	May 8	May 13
Emergence Counts	June 3	June 26	N/a	June 13	June 5	June 11	June 17	June 12
In-crop Herbicide Application	June 17 (OcTTain XL + Simplicity GoDRI)	June 27 (Axial) July 4 Prestige XC	June 10 (Badge II + Simplicity)	June 19 (Axel Extreme, MCPA, Kinetic Copron)	June 10 (Clodinafop + Buctril M)	June 26 (Axial + Buctril M)	June 14 (Varro + OcTTain XL + Agral90)	June 12 (Simplicity + Prestige) June 25 (MCPA) July 3 (MCPA)
Boot N application	July 3	July 16	July 6	July 9	July 3	July 4	July 3	July 3
Post-anthesis N application	July 20	Aug 8	July 19	July 26	July 20	July 23	July 29	July 19
Flag leaf burn Rating	July 25	Aug 16	July 22	July 19 and July 29	N/A	July 11, 18, 30 & Aug 5	N/A	July 25
In-crop Fungicide Application	July 11 (Prosaro)	N/A	July 18 (Caramba)	June 19 (Pivot 418EC)	July 12 (Caramba)	N/A	July 10 (Acapella)	July 11 (Caramba) July 14 (Caramba)
Lodging Rating	Aug 9	N/A	N/A	Sept 23	Sept 7	N/A	Aug 19	Sept 3
Desiccant	Aug 28 (Roundup Weathermax 540)	N/A	N/A	Sept 5 (Glyphosate)	N/A	Sept 6 (Heat LQ + Roundup 540 + Merge)	N/A	Sept 3 (Roundup Transorb)
Harvest	Sept 6	Oct 6	Sept 24	Sept 23	Sept 7	Sept 22	Aug 21	Sept 16

Soil test Nitrate levels for each location are presented in Table 6. Two sites, testing extremely high in background soil N, were Prince Albert in 2020 and Swift Current in 2019. The rest of the site years had more typical background levels of soil N for continuous cropping systems.

Table 6. Soil Test Nitrate Levels for each location (lb N/ac) in 2019 and 2020.

Nitrate Levels (lbs NO_3-N/ac)	Indian Head	Melfort	Outlook	Prince Albert	Redvers	Scott	Swift Current	Yorkton
2020								
0-15cm (0-6in)	8	19	4	45 (0-6")	22	17	23	27
15-30cm (6-12in)		25	4	40 (6-17")				
15-60cm (6-24in)	15				39	12	27	33
Total 0-60cm (0-24in)	23	66[1]	16	127[1]	61	35	50	60
Total 0-30cm (0-12in)		44		85 (0-17")				
2019								
0-15cm (0-6in)	16	18	6	15	29	14	42	14
15-30cm (6-12in)				10				
15-60cm (6-24in)	33	17	9		42	18	186	18
Total 0-60cm (0-24in)	49	35	15	37.5[1]	71	32	228	32
Total 0-30cm (0-12in)				25				

[1]Estimation (**Total** 0-30cm (0-12inch) lb N/ac value *1.5)

Table 7 shows temperature at the time of boot stage and post-anthesis applications. It is generally recommended to spray at temperatures below 20°C for broadcast sprays of UAN to reduce the potential for leaf burn. At the boot stage application, only 7 out of 16 site/years were sprayed below 20°C. However, this temperature limit is likely of less concern for dribble band applications, particularly at the boot stage. For the post-anthesis timing, 13 of the 16 site/years started spraying at temperatures below 20°C. The date of significant rainfall after application is also indicated in table 7. Significant rainfall of 10 mm or greater occurred within two weeks after most applications and are indicated in green (Table 7). However, observing or not observing a significant rainfall event was not always a good predictor of protein response.

Table 7. Date of Post-Emergent Nitrogen Application, Temperature and Amount of Rain after Post-Emergent Nitrogen Application in 2019 and 2020.

	Date of Application		Temperature During Application		Next Significant Rainfall after Post-emergent N Application (>10mm)	
	Boot	Post-Anthesis	Boot	Post-Anthesis	Boot	Post-Anthesis
2020						
Indian Head	June 30	July 16	22-25 C	20-22C	None	None
Melfort	July 16	Aug 13	20 C	12C	None	None
Outlook	July 13	July 29	17 C	18.5C	July 18 (12.5mm)	Aug 1 (12.5mm)
Prince Albert	July 10	July 27	18 C	13C	Aug 3 (13mm)	Aug 3 (13mm)
Redvers	June 29	July 10	23 C	15 C	June 30 (15mm)	None
Scott	July 6	July 27	24 C	19.5-22.7C	July 8 (68mm)	Aug 27 (17mm)
Swift Current	June 22	July 23	20 C	21C	June 29 (16.7mm)	None
Yorkton	June 22	July 13	20C	18-19C	July 13 (17 mm)	July 20 (29mm)
2019						
Indian Head	July 3	July 20	18-20ºC	17-18ºC	July 13 – 17 (30mm)	Aug 9- 12 (61mm)
Melfort	July 16	Aug 8	20.9ºC	19-20ºC	July 17-18 (29.3mm)	Aug 22-23 (15mm)
Outlook	July 6	July 19	16.3ºC	15.5ºC	July 14-16 (22.4mm) + Irrigation July 9 and 11 (20.5mm)	Aug 22 (22.8mm) + Irrigation Aug 1 (12.5mm)
Prince Albert	July 9	July 26	19ºC	22ºC	July 17-19 (24.3 mm)	Sept 2 (16.2 mm)
Redvers	July 3	July 20	18-20 ºC	19-21ºC	July 9 (21.3mm)	Aug 12 (20.3mm)
Scott	July 4	July 23	17.9ºC	15.7ºC	July 11-12 (12mm) & July 19-20 (28.7mm)	Aug 7-8 (31.6mm)
Swift Current	July 3	July 29	18ºC	18-22ºC	Aug 11-12 (35.4mm)	Aug 11-12 (35.4mm)
Yorkton	July 3	July 19	20ºC	14ºC	July 6 (20.7mm)	Aug 25-27 (20.2mm)

Significant rainfall events of 10 mm or greater occurring within two weeks of application is printed in green

At Redvers in 2019 and Scott in 2020, crop emergence was a little low at 160 and 163.5 plants/m^2, respectively (Table 8). Emergence was a little high at 393 plants/m^2 for Swift Current in 2019. However, the rest of the site/years had decent to excellent emergence. Lodging was not an issue for any of the site/years (data not shown).

Table 8. Average Crop Emergence for all sites in 2019 and 2020		
	Emergence	
	----------------------------------Plants/m^2--------------------------	
Site	**2020**	**2019**
ECRF-Yorkton	291.3	254.5
SERF-Redvers	203.2	160.0
IHARF-Indian Head	252.0	214.7
WCA-Swift Current	321.6	393.0
WARC-Scott	163.5	232.0
ICDC-Outlook	191.7	N/A
CLC-Prince Albert	263.8	236.1
NARF-Melfort	221.6	186.9

Figure 1 shows the average flag leaf burn ratings for treatments 3 to 9 averaged over 10 site/years. Flag leaf burn data from Scott in 2019-2020, Swift Current in 2019-2020, Melfort in 2019 and Yorkton in 2020 were omitted from this combined analysis for a variety of reasons including the use of a different rating system at Scott and no blind ratings for treatments 3-4 at the other sites (refer to note 1 in appendix for further explanation). However, flag leaf burn ratings were recorded at all sites and the individual site/year data are in Tables 10 and 11 of the appendix.

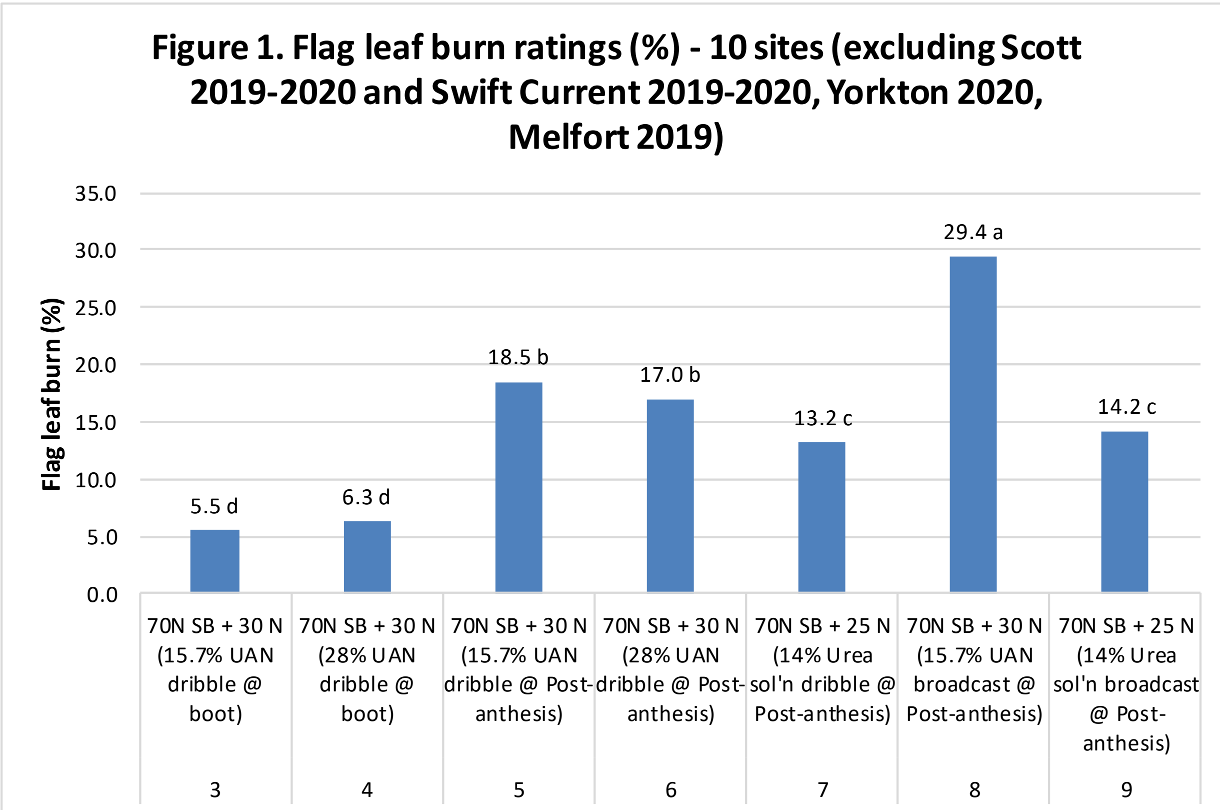
From the combined analysis, all post-anthesis applications of UAN and dissolved urea (trts 5-9), whether dribble banded or broadcast sprayed, significantly increased flag leaf burn relative to dribble banded UAN (15.7 or 28% N) at the boot stage (trts 3-4) (Figure 1). This supports past study by Guy Lafond who also observed less flag leaf burn from boot stage applications of UAN compared to applications made post-anthesis.

Post-anthesis applications of nitrogen caused the most flag leaf burn when UAN (15.7% N) was broadcast sprayed (trt 8) compared to dribble banded. Broadcast spraying caused more leaf burn due to greater foliar coverage compared to dribbling banding. Diluting UAN from 28% to 15.7% N had no effect on flag leaf burn when dribble banding (trt 8 vs 5 and 6) (Figure 1). In other words, diluting UAN was not necessary to further reduce flag leaf burn from dribble banded applications. Unlike UAN, dribble banding dissolved urea did not reduce flag leaf burn relative to broadcast spraying (trt 7 vs 9). However, the level of flag leaf burn resulting from broadcast applications of dissolved urea was already much lower compared to broadcast UAN, leaving relatively less potential to further improve crop safety by dribble banding. While less leaf burn with dissolved urea in this study is supported by past research, it should be noted that the dissolved urea was only applied at 25 lb N/ac and not 30 lb N/ac to match UAN applications as intended. This was due to a calculation error described in Note 2 of the appendix.

There was a significant site/year by treatment interaction ($p<0.00001$) for the flag leaf burn data (Table 9), meaning not all sites within the combined data reported the same relative treatment effects. While the vast majority of sites rated flag leaf burn to be lower for boot stage applications, differences between post-anthesis applications were less consistent. An exception to the general trend between post-anthesis applications occurred at Outlook in 2019. Dribble banded dissolved urea caused significantly more leaf burn than dribble banded UAN instead of less (Tables 10 and 11 in the appendix). However, this occurrence was likely an anomaly, because in the same year and at the same site (Outlook, 2019), broadcast sprayed dissolved urea caused significantly less leaf burn than broadcast sprayed UAN. While there was variability between sites, the overall trend was for more flag leaf burn with foliar broadcast sprays and for less damage with dissolved urea.

Table 9. Significance of F-values

	10 sites	All 16 site/years		Top 8 yielding site/years		Bottom 8 yielding site/years	
	Flag burn	Yield	Protein	Yield	Protein	Yield	Protein
Site/year (S)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Treatment (T)	<0.00001	<0.00001	<0.00001	0.0017	<0.00001	0.013	<0.00001
S by T	<0.00001	0.38	<0.00001	0.33	<0.00001	0.37	<0.00001



While there was no significant site/year by treatment interaction for the yield data, there was for the grain protein data (Table 9). Treatments receiving the best combination of yield and grain protein did differ somewhat between locations (Tables 12-15 in appendix), and these differences will be discussed. However, the data will first be discussed averaged over site/year as combining the data smooths out variations and provides results that make the most intuitive sense.

When averaged across all 16 site/years, a number of trends emerged. Sites were responsive to added N. Increasing the rate of side-banded urea from 70 to 100 lb N/ac significantly increased yield from 4261 to 4476 kg/ha (63.4 to 66.6 bu/ac) and significantly increased grain protein from 13.3 to 13.8%, respectively (Figure 2). Split applications of N (trts 5-9) resulted in higher grain protein, but lower yield compared to just side-banding all the N at seeding (trt 2). Post anthesis split N applications showed much larger increases in grain protein and decreases in yield than boot stage split N applications. For example, dribble banding UAN (28% N) post-anthesis at 30 lb N/ac to a base rate of 70 lb N/ac (trt 6) significantly increased grain protein by 0.32% but significantly decreased yield by 322 kg/ha (4.8 bu/ac), compared to the side-banded check of 100 lb N/ac (trt 2). In contrast, dribble banding UAN (28% N) earlier at the boot stage (trt 4), resulted in a more modest grain protein increase of 0.15% but with a relatively lower yield loss of only 55 kg/ha (0.8 bu/ac). The grain yield and protein differences between boot stage and post-anthesis applications may be related to differences in flag leaf burn. Dribble banding UAN post-anthesis caused more flag leaf damage than to the boot stage timing (Figure 1), which may have reduced yield and in turn, increased grain protein (Figure 2). However, it is also possible that more of the N from the boot stage application favored yield over protein because it was earlier than the post-anthesis application. Overall, using dissolved urea post-anthesis tended to result in smaller grain protein increases (0.1%) than UAN. This was likely the result of applying a little less N with dissolved urea (ie: 25 vs 30 lb N/ac).

Producers are more likely to try and increase grain protein with split applications of N when the yield potential of their crop is high and grain protein level is low. To test the benefit of this approach, the trial data was divided into the top 8 and bottom 8 yielding site/years and was then analyzed again separately. The top 8 yielding site/years combined were Prince Albert 2020, Indian Head 2020, Melfort 2019-2020, Scott 2020, Outlook 2019, Redvers 2019 and Yorkton 2019 (Figure 3). The bottom 8 yielding site/years combined were Yorkton 2020, Outlook 2020, Redvers 2020, Swift Current 2019-2020, Prince Albert 2019, Indian Head 2019 and Scott 2019 (Figure 4). While background soil N did differ substantially between site/years, average levels were relatively similar between the top and bottom 8 site/years at 50.5 lb N/ac and 61 lb N/ac in the top 24 inches of soil, respectively (Table 6).

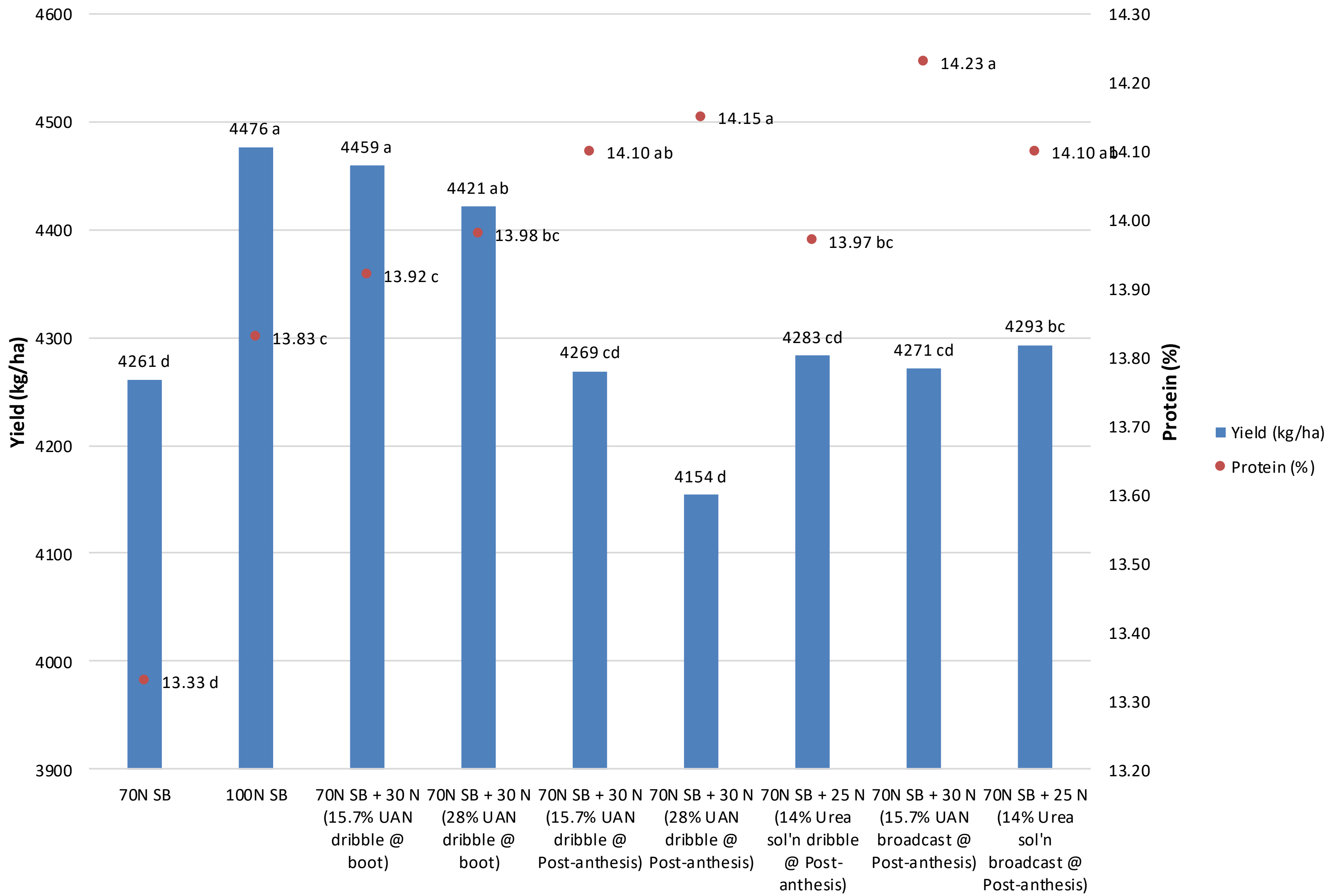
On average, the top yielding site/years produced 5242 kg/ha (78 bu/ac) of wheat at 12.9% grain protein (Figure 3) and the bottom yielding site/years produced 3399 kg/ha (51 bu/ac) of wheat at 14.6% grain protein (Figure 4). The higher level of protein with the lower yielding sites makes sense as environmental conditions that reduce yield potential (ie: moisture stress) tend to result in elevated grain protein. This is one reason why producers are generally less interested in increasing grain protein when the yield potential of their crop looks to be below average.

The general yield and protein response to treatment between the top and bottom site/years was remarkably similar (Figures 3 and 4) and followed a similar pattern to the combined data (Figure 2). Increasing the rate of side-banded N from 70 to 100 lb/ac increased yield and grain protein by 178 kg/ha and 0.4% for the top sites and by 253 kg/ha and 0.5% for the bottom sites, respectively. For top and bottom yielding sites, split applications of N tended to increase grain protein but also reduced yield compared to applying all the N at seeding (trt 2). Again, this was particularly evident for post-anthesis applications and to a lesser extent when applying at the boot stage. On average, split applications of N at the boot stage and post-anthesis raised grain protein by 0.22 and 0.24% for the top sites and by 0.26 and 0.33% for the bottom sites, respectively. The greater protein increase with bottom yielding sites likely occurred because there was less yield potential to dilute protein increases. However, few of these split applications proved economic because of the yield loss associated with gaining higher protein and the added cost of split application.

The economics for each treatment when considering the bottom 8 yielding sites, the top 8 yielding sites and all sites combined are found in tables 16-18. Each table assumes a base price of $5.84 per bushel of grain at 12.5% protein with a protein premium or discount of $0.6/%/bu and an N cost of $0.5/lb, regardless of product used. In addition, an extra cost of $5/ac is assigned to all split applications. The last column of each table shows the gross returns minus the variable costs of N and split applications so that a fair comparison of economic returns can be made between treatments. Treatment #2 where all the N is side-banded at seeding at 100 lb N/ac is the check for comparison. Only treatment 4 from the top yielding site/years combination generated a little more income (Table 18). All other comparisons generated less income. It would appear split applications are not economical on average. However, as mentioned at the beginning of the discussion, there is a significant site/year by treatment interaction for the grain protein data, which has an impact on economics.

Tables 19 and 20 list the gross returns minus the variable costs of N and split application for each site/year. Eight of the site/years (Indian Head 2019-2020, Redvers 2020, Yorkton 2019, Scott 2019-2020 and Melfort 2019-2020) followed the general trend where no split application of N provided greater economic returns compared to just side-banding all the N down at seeding (trt 2). Of the remaining 8 trials, where at least one of the split application treatments provided greater economic returns, these returns were extremely slim at Yorkton 2020 and only one treatment provided greater returns at Swift Current 2020. At Swift Current 2019, Redvers 2019 and Prince Albert 2020, split applications appeared more economical because the 100 lb N/ac side-banded check was either inexplicably low yielding or had low grain protein even relative to the 70 lb N/ac side-banded check. At Prince Albert in 2019, a few of the split applications were more economical, mostly due to the relatively large and unexpected yield increases as grain protein actually decreased by 0.12% on average. However, these yield increases were not statistically significant. The only site where there was some compelling evidence for an economic benefit from split applications of N was at the irrigation site near Outlook. In 2019, a few split applications of N were more economical than the 100 lb N/ac side-banded check (trt 2) due to increases in grain protein averaging 0.44%. In 2020, all but one split application of N provided greater economic returns that the check (trt 2) due to large and often significant increases in grain protein averaging 1.36%. The reason for the relatively larger protein responses to split applied N at Outlook may be related to better infiltration of N into the root system under irrigation; however, this is just speculation.

Figure 2. Effect of treatment on wheat yield and grain protein (All sites)



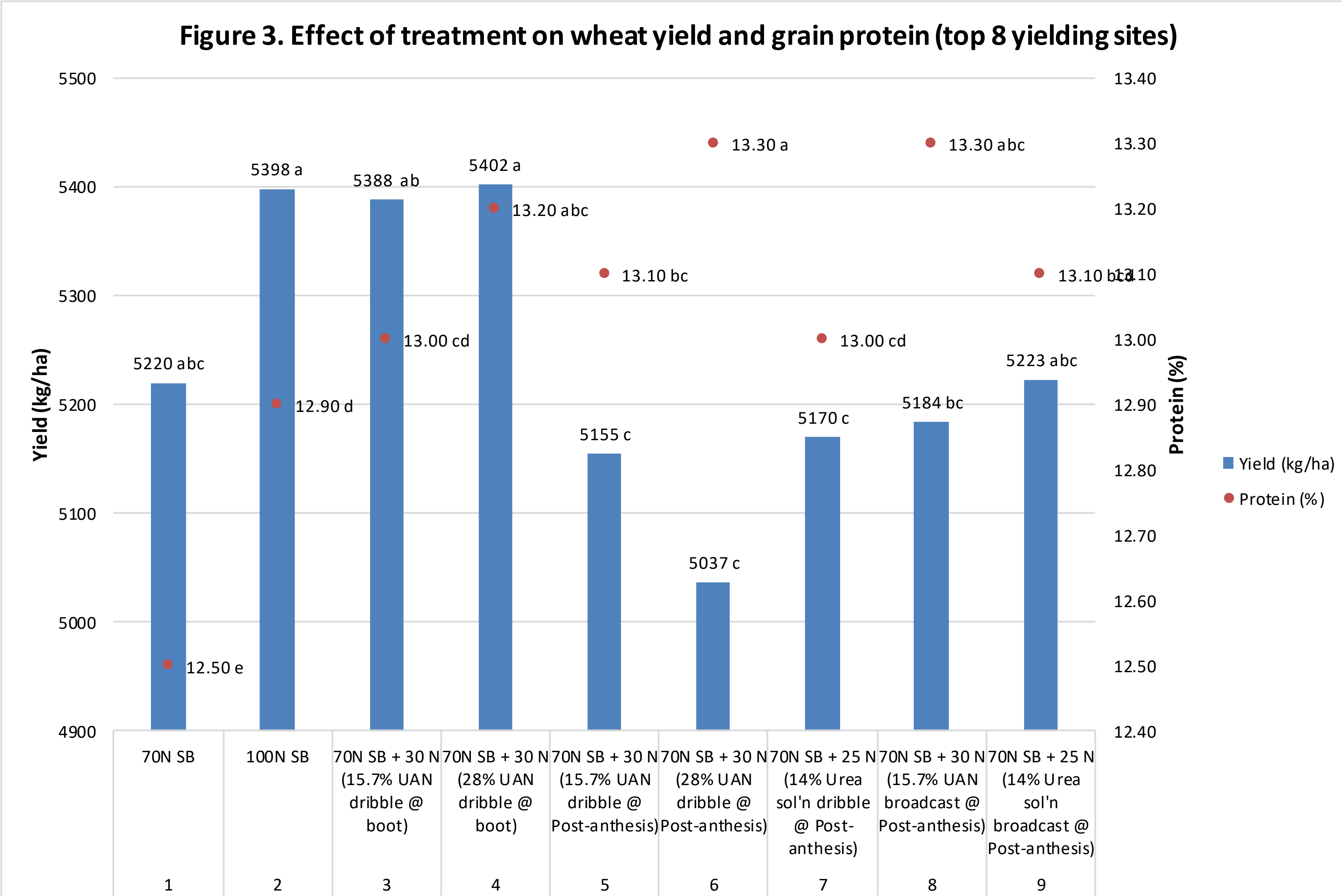


Figure 3. Effect of treatment on wheat yield and grain protein (top 8 yielding sites)
Yield (kg/ha)
Protein (%)
5500
5400
5300
5200
5100
5000
4900
13.40
13.30
13.20
13.10
13.00
12.90
12.80
12.70
12.60
12.50
12.40
5220 abc
5398 a
5388 ab
5402 a
5155 c
5037 c
5170 c
5184 bc
5223 abc
12.50 e
12.90 d
13.00 cd
13.20 abc
13.10 bc
13.30 a
13.00 cd
13.30 abc
13.10 bcd
70N SB
100N SB
70N SB + 30 N (15.7% UAN dribble @ boot)
70N SB + 30 N (28% UAN dribble @ boot)
70N SB + 30 N (15.7% UAN dribble @ Post-anthesis)
70N SB + 30 N (28% UAN dribble @ Post-anthesis)
70N SB + 25 N (14% Urea sol'n dribble @ Post-anthesis)
70N SB + 30 N (15.7% UAN broadcast @ Post-anthesis)
70N SB + 25 N (14% Urea sol'n broadcast @ Post-anthesis)
1
2
3
4
5
6
7
8
9
Yield (kg/ha)
Protein (%)

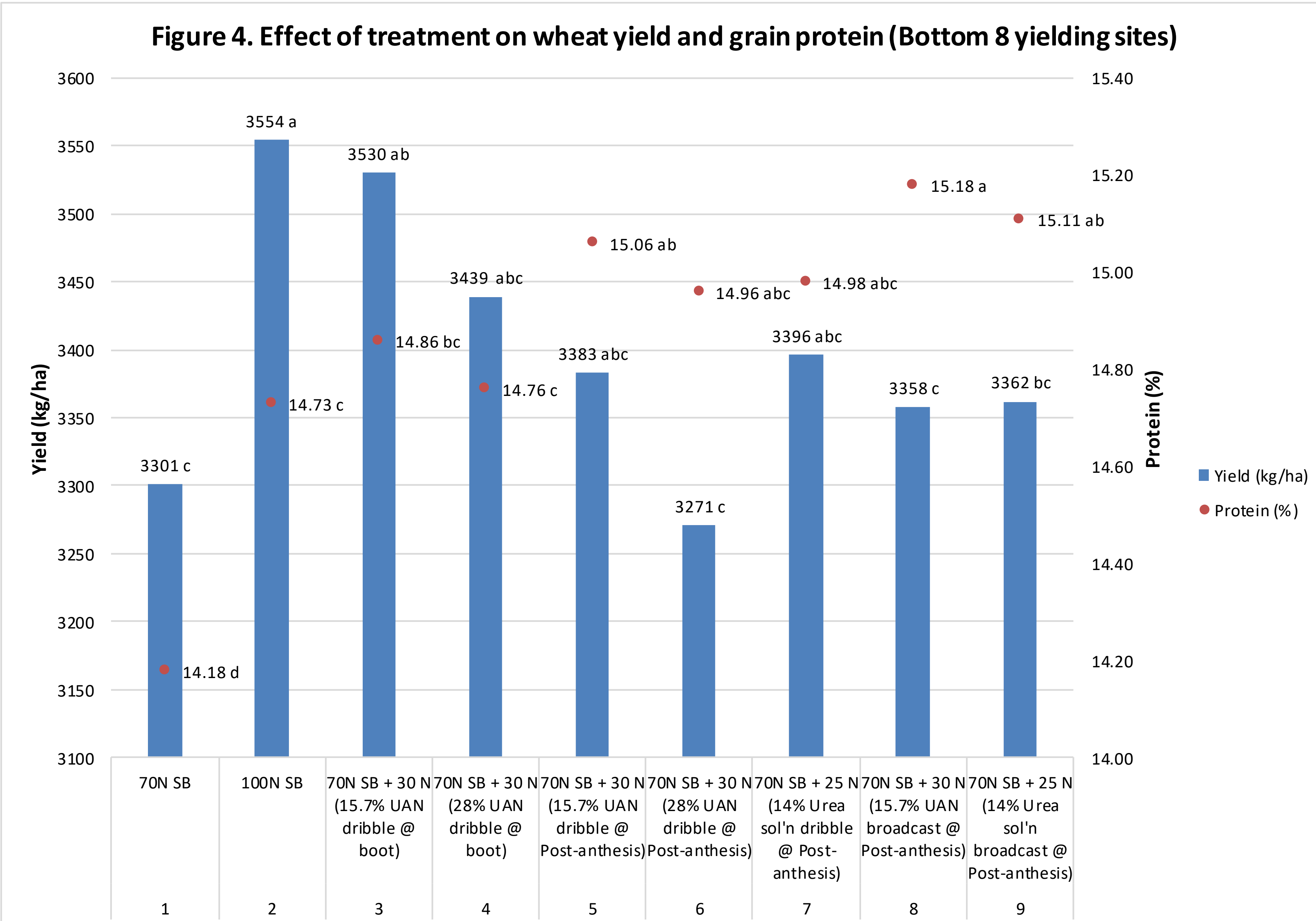


Figure 4. Effect of treatment on wheat yield and grain protein (Bottom 8 yielding sites)
Yield (kg/ha)
Protein (%)
3600
3550
3500
3450
3400
3350
3300
3250
3200
3150
3100
15.40
15.20
15.00
14.80
14.60
14.40
14.20
14.00
3301 c
3554 a
3530 ab
3439 abc
3383 abc
3271 c
3396 abc
3358 c
3362 bc
14.18 d
14.73 c
14.86 bc
14.76 c
15.06 ab
14.96 abc
14.98 abc
15.18 a
15.11 ab
Yield (kg/ha)
Protein (%)
70N SB
100N SB
70N SB + 30 N (15.7% UAN dribble @ boot)
70N SB + 30 N (28% UAN dribble @ boot)
70N SB + 30 N (15.7% UAN dribble @ Post-anthesis)
70N SB + 30 N (28% UAN dribble @ Post-anthesis)
70N SB + 25 N (14% Urea sol'n dribble @ Post-anthesis)
70N SB + 30 N (15.7% UAN broadcast @ Post-anthesis)
70N SB + 25 N (14% Urea sol'n broadcast @ Post-anthesis)
1
2
3
4
5
6
7
8
9

5. Conclusions and Recommendations

Many of the concepts this study set out to demonstrate were accomplished when analyzing the data combined over site/years. As supported by past research, dribble banding UAN earlier at the boot stage caused less flag leaf burn than applications post-anthesis. Post-anthesis applications of UAN also caused less flag leaf burn when dribble banded compared to broadcast sprayed. This was true whether concentrated (28% N) or diluted (15.7% N) UAN was dribble banded. In other words, there is no reason to dilute the UAN when dribble banding. This is intuitive as dribble band applications should provide less leaf coverage and greater safety compared to broadcast spraying. It would not be unreasonable to infer that this might also be the case for dissolved urea. However, there were no significant differences in flag leaf burn between dribble banded and broadcast applications when using dissolved urea. The lack of a difference can be attributed to already low levels of flag leaf burn with a broadcast application of dissolved urea compared to broadcast UAN. While dissolved urea has also caused less flag leaf burn in past research, the dissolved urea in this study was erroneously applied at only 25 lb N/ac instead of 30 lb N/ac to match the UAN rate. Still, the difference in flag leaf burn between broadcast UAN and dissolved urea was quite large, suggesting the difference could be attributed to more than just a 5 lb N/ac difference. Application strategies, which reduced flag leaf burn, did not usually produce a yield/protein response that maximized economic returns as anticipated, even when a healthy grain protein premium of $0.6/%/bu was considered. On average, split applications of N at the boot or post-anthesis stage raised grain protein by 0.22 and 0.24% for the top sites and by 0.26 and 0.33% for the bottom sites, respectively. But this was not enough to compensate for the associated yield losses and extra cost of the split application. Overall, it was more economical to side-band all 100 lb N/ac at seeding rather than side-band 70 lb N/ac and split apply 30 lb N/ac in the case for UAN or 25 lb N/ac in the case for dissolved urea. This held true when considering the 8 lowest yielding sites together and the 8 top yielding sites together. In other words, the benefit of split applications were not more economical for a high yielding crop compared to a low yield crop as producers would anticipate. However, this conclusion was made using the same protein spread for the low and high yielding scenarios, and in reality, protein spreads are likely to be higher when the region has a bumper crop with low protein and high protein wheat is in short supply. There were a few cases where split applications of nitrogen to raise grain protein were economical. The strongest cases occurred at Outlook where grain protein responded well to a number of the split applications of N, resulting in substantial economic gains. Outlook is an irrigation site, and applications of late season N may have leached more successfully into the root zone. However, this is speculation. Overall, there was little evidence to support the economic use of split nitrogen to increase grain protein. This practice should be considered more of a rescue treatment for under fertilized wheat rather than a planned practice.

6. <u>Extension Activities</u>

The information generated from this study was used or will be used in the following extension events:

<u>Public speaking engagements</u>

- December 10, 2019 - Agronomy Research Update @ Saskatoon : Getting the Most out of Nitrogen (190 attendees)

- March 3, 2020 - SaskWheat @ Assinibioa talk "Getting the Most out of your Nitrogen" (15 attendees)
- March 4, 2020 - SaskWheat @ Davidson "Getting the Most out of your Nitrogen" (40 attendees)
- March 4, 2020 - Warc Crop Opportunities @ North Battleford "N Management for High Protein Wheat, Milling Oats, Feed Barley and Malt" (160 attendees)
- Material from this project was requested by Chris Holzapfel (IHARF) and John Ippolito (Saskatchewan Agriculture) for their presentations
- March 3, 2021 - Warc Crop Opportunities Webinar "Increasing wheat protein with post-emergent application of UAN vs dissolved urea" (? Hasn't occurred yet)
- March 5, 2021 ECRF/Parkland College Video Webinar: Do Newer Malt Barley Varieties Require more Nitrogen? **UAN vs Dissolved Urea for Increasing Wheat Grain Protein.** Oat Test Weight in the good times and the bad. (42 registrants as of Feb 25)

Tours

- July 23, 2019 - Yorkton annual farm tour (100 attendees)
- August 8, 2019 – Agratactics Tour of Yorkton Research Farm (37 attendees)
- July 16, 2020- Private ECRF Board Tour (11 attendees)
- July 20, 2020-Private SIA tour (3 attendees)

Articles

- Top Crop Manager (In press) "Managing yield and protein in spring wheat" by Bruce Barker

Video

- SaskWheat Youtube:
    - Getting the Most Out of Nitrogen (94 views) (https://www.youtube.com/watch?v=dxYlADUsZUE)
- ECRF/Parkland College Youtube:
    - Virtual tour: In-season applications of UAN vs dissolved urea for increasing wheat protein (132 views) https://www.youtube.com/watch?v=8wfGDz2E5aw
    - Getting the Most out of Nitrogen (328 views) https://www.youtube.com/watch?v=GYLLviErfFM&t=1s
    - UAN vs Dissolved Urea for Increasing Wheat Grain Protein (Video not be released until after ECRF/Parkland College video webinar on March 5, 2021)
- Warc Youtube:
    - Warc plans to record and release a video of my presentation for them on March 3, 2021

7. Acknowledgements:

This project was funded through the Saskatchewan Wheat Development Commission.

8. Appendices

Note 1. Explanation of site removal from the combined flag leaf burn analysis

Sites that rated all reps of treatments 3-4 as zero have been removed from the combined analysis. This should not have been done as fertilizer flag leaf burn ratings are really an assessment of actual fertilizer burn plus other causes of leaf senescence. Assuming no damage on treatments 3-4 is not correct. Assuming treatments 1-2 are zero is also problematic as it makes fertilizer burn appear worse for the remaining treatments. When the whole trial is rated blindly, the ratings for treatments 1-2 is an indication of damage resulting from abiotic and biotic factors other than fertilizer burn and the difference between the other treatments and treatments 1-2 is a measure of fertilizer burn.

Note 2. Explanation of N rate calculation error for dissolved urea

All late season applications of N were intended to be applied at 30 lb N/ac. All UAN treatments were applied at 30 lb N/ac but the dissolved urea treatments (# 7 and 9) were applied at 24.8 lb N/ac due to a calculation error. The concentration of N in liquid fertilizer is express as percent based on weight. UAN has 2.98 lb N/US gallon and a US gallon of UAN weighs 10.63 lbs. Thus UAN is 28 percent N by weight (2.98 lb N/10.63 lb/ US gal of UAN * 100% =28% N). Mistakenly, it was thought cutting UAN in half with water would decreased the UAN to 14% N. This is not correct as the added water in the 50/50 UAN to water mixture only weighs 8.34 lb/US gal compared to the 10.63 lb/ US gal of UAN. Thus cutting UAN in half with water creates 15.7% N on a weight basis and not 14% (2.98 lb N/(10.63 lb of UAN +8.34 lb of water)*100% = 15.7% N).

A 14% N solution of dissolved urea was successfully created by dissolving 3.66 lb urea per US gal of water (3.66 lb urea *0.46 lbN/lb urea/(3.66 lb urea + 8.34 lb water)*100% = 14% N. It was erroneously thought applying the same volumes of what was thought to be 14%N UAN and 14% N dissolved urea would supply the same amount of actual N /ac. This would not have been correct even if both solutions were 14% N because the densities of two solutions were not same and % N is based on weight basis. Through experimentation it was discovered that adding 3.66 lb of urea to 1 US gallon resulted in 1.35 US gallons of solution. Thus every US gal of solution contained 1.24 lb N/US gal (1.68 lb N/1.35 US gal).

While applying 20 US gal/ac of 15.7% N UAN or 10 US gal/ac of 28% N UAN did supply 30 lb N/ac, applying 20 US gal/ac of 14% N dissolved urea only supplied 24.8 lb N/ac (20 US gal * 1.24 lb N/US gal) and not 30 lb N/ac as intended.

Table 10. Main Effect of Nitrogen Rate, Post Emergent Nitrogen Rate, Post Emergent Nitrogen Product, Post Emergent Application Method, Post Emergent Application Timing on wheat flag leaf burn at Indian Head, Melfort, Outlook, Prince Albert, Redvers, Scott, Swift Current and Yorkton in 2020.

	Flag Leaf Burn							
	I.H.	**Melfort**	**Outlook**	**P.A.**	**Redvers**	**Scott**	**S.C.**	**Yorkton**
	----------------------------------%----------------------------------							
1. 70 lb N/ac side-banded	1.1 c	NA	7.4 c	NA	NA	NA	NA	20.2 a
2. 100 lb N/ac side-banded	0.8 c	NA	3.8 c	NA	NA	NA	NA	19.9 a
3. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN dribble banded @ boot	2.0 c	2.5 c	4.5 c	2.4 c	1.1 c	NA	NA	NA
4. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ boot	2.6 c	4.9 b	4.0 c	1.8 c	4.4 bc	NA	NA	NA
5. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN dribble banded @ post-anthesis	11.8 b	15.5 a	6.4 c	27.6 a	4.3 b	NA	11.7 a	21.4 a
6. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ post-anthesis	12.1 b	14.0 a	7.4 c	22.6 a	5.5 b	NA	4.5 a	23.6 a
7. 70 lb N/ac side-banded + 25[1] lb N/ac of 14% Dissolved Urea dribble banded @ post-anthesis	4.2 c	14.3 a	5.4 c	13.1 b	10.5 b	NA	6.8 a	20.4 a
8. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN broadcast foliar sprayed @ post-anthesis	23.3 a	17.1 a	56.0 a	25.3 a	25.3 a	NA	8.1 a	21.5 a
9. 70 lb N/ac side-banded + 25[1] lb N/ac of 14% Dissolved Urea broadcast foliar sprayed @ post-anthesis	4.5 c	16.2 a	42.0 b	6.4 bc	10.5 b	NA	6.5 a	16.7 a
P-values	<0.00001	<0.00001	<0.00001	<0.00001	0.000011	NA	NS	NS
L.S.D.	4.8	4.3	6.5	7.24	6.5	NA	NS	NS

NA: flag leaf burn ratings were assumed to be 0 with blind rating or different rating system used.

Table 11. Main Effect of Nitrogen Rate, Post Emergent Nitrogen Rate, Post Emergent Nitrogen Product, Post Emergent Application Method, Post Emergent Application Timing on wheat flag leaf burn at Indian Head, Melfort, Outlook, Prince Albert, Redvers, Scott, Swift Current and Yorkton in 2019.

	Flag Leaf Burn							
	I.H.	**Melfort**	**Outlook**	**P.A.**	**Redvers**	**Scott**	**S.C.**	**Yorkton**
	----------------------------------%----------------------------------							
1. 70 lb N/ac side-banded	NA	NA	0.5 c	NA	28.5 b	NA	NA	4.1 c
2. 100 lb N/ac side-banded	NA	NA	0.4 c	NA	29.8 b	NA	NA	3.4 c
3. 70 lb N/ac side-banded + 30 lb N/ac of 15.7 % UAN dribble banded @ boot	5.3 d	NA	0.5 c	11.3 ab	21.2 bc	NA	NA	4.8 c
4. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ boot	5.5 d	NA	0.8 c	13.3 ab	22.4 bc	NA	NA	3.0 c
5. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN dribble banded @ post-anthesis	22.9 b	9.0 a	1.8 c	11.3 ab	48.1 a	NA	NA	35.1 a
6. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ post-anthesis	19.9 bc	11.5 a	10.5 b	11.7 ab	29.9 b	NA	NA	36.4 a
7. 70 lb N/ac side-banded + 25[1] lb N/ac of 14% Dissolved Urea dribble banded @ post-anthesis	12.8 c	3.4 a	8.6 b	4.6 c	35.5 ab	NA	NA	23.0 b
8. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN broadcast foliar sprayed @ post-anthesis	31.9 a	3.5 a	26.8 a	17.5a	34.8 ab	NA	NA	36.4 a
9. 70 lb N/ac side-banded + 25[1] lb N/ac of 14% Dissolved Urea broadcast foliar sprayed @ post-anthesis	11.4 cd	5.7 a	12.1 b	10.4 bc	10.8 c	NA	NA	18.2 b
P-values	<0.00001	NS	<0.00001	0.03	0.012	NA	NA	<0.00001
L.S.D.	6.3	NS	3.3	6.4	17.0	NA	NA	8.9

NA: flag leaf burn ratings were assumed to be zero without actual blind rating or different rating system used.

Table 12. Main Effect of Nitrogen Rate, Post Emergent Nitrogen Rate, Post Emergent Nitrogen Product, Post Emergent Application Method, Post Emergent Application Timing on wheat yield at Indian Head, Melfort, Outlook, Prince Albert, Redvers, Scott, Swift Current and Yorkton in 2020.

	Yield								
	I.H.	**Melfort**	**Outlook**	**P.A.**	**Redvers**	**Scott**	**S.C.**	**Yorkton**	**All Sites**
	----------------------------------kg/ha----------------------------------								
1) 70 lb N/ac side-banded	4401 c	4639 a	3517 a	4589 a	3958 a	4951 b	3224 a	1973 a	3906
2) 100 lb N/ac side-banded	4723 a	4910 a	3948 a	4202 a	4605 a	5266 a	3453 a	2003 a	4139
3) 70 lb N/ac side-banded + 30 lb N/ac of 15.7 % UAN dribble banded @ boot	4637 ab	4632 a	3971 a	4814 a	4111 a	5003 ab	3721 a	1984 a	4109
4) 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ boot	4515 bc	4644 a	3899 a	5263 a	4093 a	4962 b	3467 a	1968 a	4101
5) 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN dribble banded @ post-anthesis	4468 c	4424 a	3678 a	4165 a	3743 a	4598 c	3426 a	2114 a	3827
6) 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ post-anthesis	4419 c	3976 a	3524 a	3936 a	3456 a	4674 c	3294 a	1986 a	3658
7) 70 lb N/ac side-banded + 25[1] lb N/ac of 14% Dissolved Urea dribble banded @ post-anthesis	4475 c	4597 a	3594 a	4495 a	4017 a	4811 bc	3406 a	1989 a	3923
8) 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN broadcast foliar sprayed @ post-anthesis	4465 c	4729 a	3573 a	4534 a	3886 a	4848 bc	2914 a	2012 a	3870
9) 70 lb N/ac side-banded + 25[1] lb N/ac of 14% Dissolved Urea broadcast foliar sprayed @ post-anthesis	4484 bc	4507 a	3631 a	4248 a	3886 a	4852 bc	2949 a	2052 a	3826
P-values	0.005197	NS	0.064722	NS	NS	0.002577	NS	NS	
L.S.D.	158	NS	360	NS	NS	274	NS	NS	

[1]Rate was not 30 lb N/ac as originally intended due to calculation error described in appendix

Table 13. Main Effect of Nitrogen Rate, Post Emergent Nitrogen Rate, Post Emergent Nitrogen Product, Post Emergent Application Method, Post Emergent Application Timing on wheat yield at Indian Head, Melfort, Outlook, Prince Albert, Redvers, Scott, Swift Current and Yorkton in 2019.

	Yield								
	I.H.	**Melfort**	**Outlook**	**P.A.**	**Redvers**	**Scott**	**S.C.**	**Yorkton**	**All Sites**
	----------------------------------kg/ha----------------------------------								
1. 70 lb N/ac side-banded	3330 bc	5179 bc	7213 a	3538 a	5179 a	3830 a	3038 a	5611 a	4615 a
2. 100 lb N/ac side-banded	3598 a	5566 a	7909 a	3544 a	4754 a	4018 a	3263 a	5856 a	4814 a
3. 70 lb N/ac side-banded + 30 lb N/ac of 15.7 % UAN dribble banded @ boot	3422 ab	5331 ab	7489 a	3936 a	5144 a	3857 a	3242 a	6056 a	4810 a
4. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ boot	3388 b	5111 bc	7795 a	3600 a	5202 a	3858 a	3239 a	5729 a	4740 a
5. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN dribble banded @ post-anthesis	3226 bcd	5071 cd	7623 a	3623 a	5206 a	4002 a	3251 a	5688 a	4711 a
6. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ post-anthesis	3378 bc	4837 d	7722 a	3720 a	5020 a	3759 a	3055 a	5715 a	4651 a
7. 70 lb N/ac side-banded + 30 lb N/ac of 14% Dissolved Urea dribble banded @ post-anthesis	3188 cd	5123 bc	7199 a	3846 a	4942 a	3950 a	3177 a	5716 a	4643 a
8. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN broadcast foliar sprayed @ post-anthesis	3266 bc	5161 bc	7182 a	4026 a	4918 a	4110 a	3075 a	5636 a	4672 a
9. 70 lb N/ac side-banded + 30 lb N/ac of 14% Dissolved Urea broadcast foliar sprayed @ post-anthesis	3045 d	5232 bc	7437 a	3952 a	5012 a	4059 a	3325a	6017 a	4760 a
P-values	0.000593	0.000462	NS	NS	NS	NS	NS	NS	NS
L.S.D.	197.8129	243.635	NS	NS	NS	NS	NS	NS	NS

Table 14. Main Effect of Nitrogen Rate, Post Emergent Nitrogen Rate, Post Emergent Nitrogen Product, Post Emergent Application Method, Post Emergent Application Timing on wheat protein at Indian Head, Melfort, Outlook, Prince Albert, Redvers, Scott, Swift Current and Yorkton in 2020.									
	Protein								
	I.H.	**Melfort**	**Outlook**	**P.A.**	**Redvers**	**Scott**	**S.C.**	**Yorkton**	**All Sites**
	------------------------------------%------------------------------------								
1. 70 lb N/ac side-banded	12.5 f	11.6 c	10.8 e	13.6 b	14.4 c	12.5 b	10.6 d	17.2 a	12.9
2. 100 lb N/ac side-banded	14.0 a	11.9 abc	11.1 de	13.6 b	14.8 b	13.2 a	13.1 ab	17.7 a	13.7
3. 70 lb N/ac side-banded + 30 lb N/ac of 15.7 % UAN dribble banded @ boot	12.9 e	12.0 abc	11.8 cd	14.9 a	14.7 bc	13.4 a	14.0 a	17.6 a	13.9
4. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ boot	13.0 de	12.3 ab	11.7 cde	15.4 a	14.7 bc	13.5 a	13.1 ab	17.5 a	13.9
5. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN dribble banded @ post-anthesis	13.2 de	12.1 abc	13.9 a	14.8 ab	14.7 bc	13.4 a	12.6 bc	17.7 a	14.1
6. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ post-anthesis	13.3 cd	12.4 a	12.0 bcd	14.6 ab	15.2 a	13.4 a	11.7 c	18.0 a	13.8
7. 70 lb N/ac side-banded + 30 lb N/ac of 14% Dissolved Urea dribble banded @ post-anthesis	12.9 e	11.8 bc	12.9 b	14.7 ab	15.2 a	13.3 a	12.2 bc	17.9 a	13.8
8. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN broadcast foliar sprayed @ post-anthesis	13.9 ab	11.8 bc	12.9 b	15.4 a	15.4 a	13.7 a	12.4 bc	17.7 a	14.2
9. 70 lb N/ac side-banded + 30 lb N/ac of 14% Dissolved Urea broadcast foliar sprayed @ post-anthesis	13.6 bc	11.9 abc	12.4 bc	14.7 ab	15.2 a	13.5 a	12.3 bc	17.8 a	13.9
P-values	<0.00001	0.054787	0.000015	0.024175	0.000027	0.028407	0.000024	NS	
L.S.D.	0.3	0.5	0.9	1.2	0.3	0.6	1.0	NS	

Table 15. Main Effect of Nitrogen Rate, Post Emergent Nitrogen Rate, Post Emergent Nitrogen Product, Post Emergent Application Method, Post Emergent Application Timing on wheat protein at Indian Head, Melfort, Outlook, Prince Albert, Redvers, Scott, Swift Current and Yorkton in 2019.									
	Protein								
	I.H.	**Melfort**	**Outlook**	**P.A.**	**Redvers**	**Scott**	**S.C.**	**Yorkton**	**All Sites**
	----------------------------------%---------------------------------								
1. 1. 70 lb N/ac side-banded	15.6 c	11.3 a	12.0 c	13.7 a	14.4 e	14.5 cde	16.9 a	12.1 a	13.8 d
2. 2. 100 lb N/ac side-banded	15.9 bc	11.5 a	12.2 bc	14.6 a	14.5 de	14.7 ab	16.1 a	12.7 a	**21.5.1.1**
3. 3. 70 lb N/ac side-banded + 30 lb N/ac of 15.7 % UAN dribble banded @ boot	15.6 c	11.5 a	12.3 bc	14.2 a	14.7 cde	14.7 bc	16.5 a	12.4 a	14.0 cd
4. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ boot	15.7 c	11.3 a	12.7 bc	14.0 a	14.8 bcd	14.9 a	16.7 a	12.7 a	14.1 bc
5. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN dribble banded @ post-anthesis	16.0 b	11.5 a	12.9 b	14.3 a	15.0 abc	14.5 cd	16.8 a	12.5 a	14.2 bc
6. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ post-anthesis	15.8 c	11.4 a	13.8 a	15.0 a	15.3 a	14.6 bcd	17.5 a	12.6 a	14.5 a
7. 70 lb N/ac side-banded + 30 lb N/ac of 14% Dissolved Urea dribble banded @ post-anthesis	16.0 b	11.6 a	12.0 c	14.5 a	15.1 ab	14.6 bcd	16.6 a	12.4 a	14.1 bc
8. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN broadcast foliar sprayed @ post-anthesis	16.6 a	11.4 a	12.5 bc	14.6 a	15.2 ab	14.3 e	17.5 a	12.4 a	14.3 ab
9. 70 lb N/ac side-banded + 30 lb N/ac of 14% Dissolved Urea broadcast foliar sprayed @ post-anthesis	16.8 a	11.7 a	12.1 bc	14.5 a	15.0 abc	14.5 cde	17.5 a	12.3 a	14.3 ab
P-values	<0.00001	NS	0.000523	NS	0.001682	0.000092	NS	NS	
L.S.D.	0.34	NS	0.72	NS	0.43	0.18	NS	NS	

Table 16 All 16 site/years economics combined[1]					
	Yield (kg/ha)	**Yield (bu/ac)**	**Protein (%)**	**($/bu)**	**Gross-N cost and cost of any split application/ac**
1. 70 lb N/ac side-banded	4261	63.4	13.3	6.34	398.31
2. 100 lb N/ac side-banded	4476	66.6	13.8	6.64	437.07
3. 70 lb N/ac side-banded + 30 lb N/ac of 15.7 % UAN dribble banded @ boot	4459	66.3	13.9	6.69	433.97
4. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ boot	4421	65.8	14.0	6.73	432.55
5. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN dribble banded @ post-anthesis	4269	63.5	14.1	6.80	421.91
6. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ post-anthesis	4154	61.8	14.2	6.83	412.13
7. 70 lb N/ac side-banded + 25 lb N/ac of 14% Dissolved Urea dribble banded @ post-anthesis	4283	63.7	14.0	6.72	420.86
8. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN broadcast foliar sprayed @ post-anthesis	4271	63.5	14.2	6.88	427.07
9. 70 lb N/ac side-banded + 25 lb N/ac of 14% Dissolved Urea broadcast foliar sprayed @ post-anthesis	4293	63.9	14.1	6.80	426.84

[1]Each table assumes a base price of $5.84 per bushel at 12.5% with a protein premium of $0.6/%/bu and an N cost of $0.5/lb regardless of product used. In addition, an extra cost of $5/ac is assumed for all split applications.

Table 17 Bottom 8 yielders economics combined.[1]

	Yield (kg/ha)	Yield (bu/ac)	Protein (%)	($/bu)	Gross-N cost and cost of any split application
1. 70 lb N/ac side-banded	3301	49.1	14.2	6.86	333.42
2. 100 lb N/ac side-banded	3554	52.9	14.7	7.16	373.61
3. 70 lb N/ac side-banded + 30 lb N/ac of 15.7 % UAN dribble banded @ boot	3530	52.5	14.9	7.28	372.35
4. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ boot	3439	51.2	14.8	7.22	359.43
5. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN dribble banded @ post-anthesis	3383	50.3	15.1	7.40	362.47
6. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ post-anthesis	3271	48.7	15.0	7.34	347.22
7. 70 lb N/ac side-banded + 25 lb N/ac of 14% Dissolved Urea dribble banded @ post-anthesis	3396	50.5	15.0	7.34	363.37
8. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN broadcast foliar sprayed @ post-anthesis	3358	50.0	15.2	7.46	362.72
9. 70 lb N/ac side-banded + 25 lb N/ac of 14% Dissolved Urea broadcast foliar sprayed @ post-anthesis	3362	50.0	15.1	7.40	362.66

[1]Each table assumes a base price of $5.84 per bushel at 12.5% with a protein premium of $0.6/%/bu and an N cost of $0.5/lb regardless of product used. In addition, an extra cost of $5/ac is assumed for all split applications.

Table 18 Top 8 yielders economics combined.[1]

	Yield (kg/ha)	Yield (bu/ac)	Protein (%)	($/bu)	Gross-N cost and cost of any split application
1. 70 lb N/ac side-banded	5220	77.7	12.5	5.84	450.07
2. 100 lb N/ac side-banded	5398	80.3	12.9	6.08	483.31
3. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN dribble banded @ boot	5388	80.2	13.0	6.14	482.22
4. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ boot	5402	80.4	13.2	6.26	493.14
5. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN dribble banded @ post-anthesis	5155	76.7	13.1	6.20	465.53
6. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ post-anthesis	5037	74.9	13.3	6.32	463.64
7. 70 lb N/ac side-banded + 25 lb N/ac of 14% Dissolved Urea dribble banded @ post-anthesis	5170	76.9	13.0	6.14	464.8
8. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN broadcast foliar sprayed @ post-anthesis	5184	77.1	13.3	6.32	477.46
9. 70 lb N/ac side-banded + 25 lb N/ac of 14% Dissolved Urea broadcast foliar sprayed @ post-anthesis	5223	77.7	13.1	6.20	474.31

[1]Each table assumes a base price of $5.84 per bushel at 12.5% with a protein premium of $0.6/%/bu and an N cost of $0.5/lb regardless of product used. In addition, an extra cost of $5/ac is assumed for all split applications.

Table 19. Gross Returns ($/ac) – Cost of N and split application for all locations ($/ac) in 2020

	$/ac							
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**
1. 70 lb N/ac side-banded	345.41	328.72	215.67	407.75	374.30	395.15	189.02	219.62
2. 100 lb N/ac side-banded	423.62	350.35	244.60	356.36	443.69	441.55	269.29	216.17
3. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN dribble banded @ boot	364.47	326.78	264.30	465.37	381.14	417.58	316.43	206.86
4. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ boot	355.44	338.11	254.23	537.38	380.15	421.52	264.03	203.41
5. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN dribble banded @ post-anthesis	359.14	314.60	309.77	391.46	344.59	380.46	246.45	225.82
6. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ post-anthesis	359.50	286.10	235.44	360.81	327.07	386.60	206.97	215.00
7. 70 lb N/ac side-banded + 30 lb N/ac of 14% Dissolved Urea dribble banded @ post-anthesis	350.77	314.66	269.30	421.83	389.98	396.31	231.84	213.24
8. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN broadcast foliar sprayed @ post-anthesis	387.81	327.40	266.63	457.36	382.37	418.16	196.25	213.67
9. 70 lb N/ac side-banded + 30 lb N/ac of 14% Dissolved Urea broadcast foliar sprayed @ post-anthesis	377.62	311.43	257.21	397.58	376.29	410.95	194.64	219.44

Table 20. Gross Returns ($/ac) – Cost of N and split application for all locations ($/ac) in 2019								
	$/ac							
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**
1. 70 lb N/ac side-banded	344.96	358.35	561.18	309.53	501.69	365.32	348.24	431.28
2. 100 lb N/ac side-banded	370.18	382.72	614.28	322.75	445.81	378.91	336.90	466.65
3. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN dribble banded @ boot	337.75	358.22	582.34	344.93	490.67	354.14	342.50	465.76
4. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ boot	334.60	334.35	636.23	305.21	504.95	362.88	347.85	450.42
5. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN dribble banded @ post-anthesis	326.08	338.09	631.14	318.02	511.19	365.06	351.49	436.67
6. 70 lb N/ac side-banded + 30 lb N/ac of 28% UAN dribble banded @ post-anthesis	336.49	318.87	707.31	350.40	505.49	342.93	346.81	447.91
7. 70 lb N/ac side-banded + 30 lb N/ac of 14% Dissolved Urea dribble banded @ post-anthesis	322.27	348.94	538.38	347.80	489.15	363.18	335.85	437.82
8. 70 lb N/ac side-banded + 30 lb N/ac of 15.7% UAN broadcast foliar sprayed @ post-anthesis	348.32	342.76	570.67	370.27	490.81	369.08	350.16	428.45
9. 70 lb N/ac side-banded + 30 lb N/ac of 14% Dissolved Urea broadcast foliar sprayed @ post-anthesis	325.79	362.23	566.34	358.90	491.21	370.13	382.33	458.40

Can Winter Wheat Provide Grazing and Grain?

Mike Hall[1] and Heather Sorestad[1]

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1. Abstract/Summary:

A trial was established near Yorkton, SK to demonstrate how winter wheat grown for grain can also provide grazing when forage is often limiting in fall and early spring. The trial did establish well for both the early (August 15) and later (August 30) seeding dates. However, the winter wheat for the early seeding date was competing with a heavy population of volunteer barley. So much of the fall defoliating consisted of barley. Regardless, the fall defoliation provided very little forage due to dry conditions and had little impact on crop maturity or grain yield the following year. Spring defoliation before bolting provided 425 kg/ha of dry forage for the cost of losing 2.9 bu/ac of grain. Delaying defoliation to bolting was much harder on the crop, providing 667 kg/ha of dry forage for the sacrifice of 10 bu/ac of grain. Defoliating twice prior to and during bolting sacrificed 12.8 bu/ac for 885 kg/ha of dry forage. Uprooting plants and the hoof action of real grazing would likely have caused more damage to winter wheat than was caused by the simulated grazing in this study. The economics of grazing winter wheat will depend on the desperation for feed as the practice can be highly destructive to grain yield. Early grazing either in fall or early spring may be a viable option, providing some forage yield for a modest grain loss and change in maturity. However, grazing at bolting should be avoided as it will result in serve grain yield loss of over 40%.

2. Project objectives:

The objective of this project is to demonstrate how winter wheat grown for grain can also provide grazing when forage is often limiting in fall and early spring. This demonstration will simulate the impact of grazing winter wheat at different times using a forage harvester.

3. Project Rationale:

Producers often run into feed shortages early and late in the growing season, when stored feed is running low in the spring and pastures become dormant in the fall. Winter cereals establish easily and maintain forage quality late into the growing season compared to perennial forage crops. Winter wheat seeded in late summer can provide fall and spring grazing when feed sources are diminishing. Providing early spring grazing with winter wheat can take the pressure off perennial forage stands. For every day spring grazing is delayed on perennial pasture, 3 additional days of fall grazing are gained[1]. Winter wheat is also a great feed source late in the grazing season because it is high in protein[2] and low in fibre (highly digestible) compared to perennial grasses at that time of year. This demonstration will show producers that winter cereals can compensate for feed shortages and still be taken for grain. However, required management differs if the grazing is required in fall or spring. Grazing too quickly after emergence or at the wrong growth stage can severely impact grain yield.

[1] Government of Manitoba. Annual Crops: an Excellent Way to Increase Your Feeding Flexibility. https://www.gov.mb.ca/agriculture/crops/production/forages/print,annual-crops-an-excellent-way-to-increase-your-feeding-flexibility.html

[2] Peter Johnoson. Winter Cereal Forage Quallity. http://www.ontariosoilcrop.org/wp-content/uploads/2016/02/V12-2015CrpAdv_Gen10_Winter-Cereal-Forage-Opportunities.pdf

4. Methodology:

The trial was seeded to barley in the spring of 2019 and then taken for greenfeed. This was necessary to provide adequate stubble for early seeded winter cereals. The trial was setup as a Randomized Complete Block Design (RCBD) with 4 replicates. Plot size was 11 by 30 feet and seeded with a 10 foot Seedmaster drill on 12 inch spacings. Emerson winter wheat was seeded at 350 seeds/m^2. Urea and monoammonium phosphate were side-banded at seeding at 54 lb/ac and 59 lb/ac, respectively. The remaining urea was broadcasted at 60 lb/ac in the spring 2020. A small plot forage harvester was used to simulate grazing in the fall of 2019 and spring 2020. Winter wheat grain yield was harvested from the middle 4 rows of each plot using a Wintersteiger plot combine in the summer of 2020. The list of treatments are in Table 1 below. Treatment 3's defoliation timing was changed from “early spring before 6 inch growth” to “early spring before bolting and late spring during bolting” because plants were too short to harvest with the forage harvester early in spring due to drought.

Table 1. Treatment List for "Can Winter Wheat Provide Grazing and Grain" Trial		
Crop	**Seeding Date**	**Defoliation timing**
1. Winter Wheat	By August 15, 2019	In Fall after 6 inches of growth
2. Winter Wheat	By August 15, 2019	In Fall after 6 inches of growth and again in early Spring before bolting
3. Winter Wheat	(Aug 30 – Sept 15)	Early Spring before bolting and late Spring during bolting
4. Winter Wheat	(Aug 30 –Sept 15)	Early Spring before bolting.
5. Winter Wheat	(Aug 30 –Sept 15)	Late Spring during bolting
6. Winter Wheat	(Aug 30 –Sept 15)	No defoliation

Dates of operations are listed in Table 2 below.

Table 2. Dates of operations in 2019 and 2020 for the "Can Winter Wheat Provide Grazing and Grain" Trial	
Operations in 2019	Yorkton
Pre-seed Burnoff	n/a
Seed Barley for Greenfeed	May 17, 2019
In-crop Herbicide	June 10, 2019 (Frontline)
Harvest Barley for Greenfeed	Aug 6, 2019
Pre-seed Burnoff for all Treatments	Aug 13, 2019 Roundup Transorb 1L
Early Seeding of winter wheat Treatment# 1 and 2	Aug 14, 2019
Pre-seed Burnoff to Treatments# 3-6	Aug 28, 2019 (Roundup Transorb 0.66L/ac)
Normal Timing Seeding of winter wheat Treatment# 3-6	Aug 30, 2019
Fall Emergence Counts	Sept 18, 2019
Fall Biomass Yield For Treatment 1 and 2 after 6 inches of growth	Oct 8, 2019
Winter Survival Rating in Spring	May 12, 2020
Broadcast N fertilizer 60lb N/ac	May 20, 2020
Spring Herbicide Application	N/A
Biomass Yield (g): Trim Trt 3 in early Spring before bolting	June 1, 2020
Biomass Yield (g):Trim Trt 2 and 4 in early Spring before bolting	June 1, 2020
Biomass Yield (g): Trim Trt 3 & 5 in Late Spring during bolting	June 9, 2020
Fungicide Application	N/A
Maturity Rating (Date of Soft Dough stage)	July 21 and 27, 2020
Harvest	Aug 17

5. Results:

Growing Season Weather

Mean monthly temperatures and precipitation amounts for Yorkton are listed in Table 3. Monthly temperatures were above the long term average. Precipitation was well below the long term average and soil moisture reserves were depleted resulting in drought stress.

Table 3. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) normals for the 2019 growing seasons at Yorkton in Saskatchewan.

Location	Year	August	September	October	Avg. / Total
		------------------------*Mean Temperature (°C)*			---------------
Yorkton	2019	16.1	12.2	6.8	14.8
	Long-term	***17.1***	***11.1***	***3.7***	***15.2***
		-------------------------- *Precipitation (mm)*			------------------
Yorkton	2019	32.2	53.8	2.6	174
	Long-term	***62***	***45***	***27***	***272***

Table 4. Mean monthly temperatures and precipitation amounts for 2020 along with long-term normals (1981-2010) for Yorkton in Saskatchewan.

Location	Year	April	May	June	July	August	Avg. / Total
		---------------------*Mean Temperature (°C)*					--------------------
Yorkton	2020	0	10.5	16.4	19.9	18.3	16.3
	Long-term	***3.2***	***10.4***	***15.5***	***17.9***	***17.1***	***15.2***
		---------------------- *Precipitation (mm)*					----------------------
Yorkton	2020	6.2	16.7	33.6	80.1	49.3	179.7
	Long-term	***21.6***	***51***	***80***	***78***	***62***	***272***

Barley silage was harvested prior to seeding winter wheat. Unfortunately, this operation resulted in a lot of shelling and a heavy volunteer population of barley emerged. The volunteer population was sprayed with glyphosate before the first seeding date of winter wheat on August 14. However, more volunteer barley emerged after that application so the early seeded winter wheat was still competing with a heavy population of barley. Despite this, the winter wheat did establish well (313 plants/m^2) in the fall of 2019. A second application of glyphosate was applied before seeding winter wheat at the later timing on August 30 (treatments 3-6) and this more effectively controlled the volunteer barley. Again, the winter wheat established well (263 plants/m^2) in 2019 with the later seeding date. Barley volunteers were not a continuing issue for any treatment the following spring. Overall, winter wheat yields were very low due to drought. Even the undefoliated check only yielded 1967 kg/ha (29.2 bu/ac).

While later and more frequent defoliations resulted in more forage yield, they also delayed maturity and lowered grain yield. The impact of all defoliations are measured against the "no defoliation" check (trt 6), which was the earliest maturing and highest yielding treatment at 1967 kg/ha (29.2 bu/ac). The fall defoliation provided very little dry forage (trt 1-76 kg/ha) and a good part of that forage was actually volunteer barley (Table 5). While the fall defoliation had no effect on yield relative to the "no defoliation" check (trt 6), it did delay maturity by 2 days. It also appeared to have poorer winter survival compared to winter wheat seeded later on August 30 with no fall defoliation (trts 3-6). While the fall defoliation is likely responsible for the reduced winter survival, early seeding date and competition with volunteer barley may have also played a role. Defoliating the early seeded winter wheat in fall and again the following spring before bolting provided more dry forage (trt 2-269.8 kg/ha) but delayed maturity by 5 days and reduced grain yield by 176 kg/ha (2.6 bu/ac) relative to "no defoliation" check.

For winter wheat seeded later on August 30, spring defoliation prior to bolting provided 425 kg/ha of dry forage, significantly delayed maturity by 5 days and reduced grain yield by 196 kg/ha (2.9 bu/ac). Delaying spring defoliation to bolting gathered more forage yield (trt 5- 667 kg/ha dry) but was harder on the crop, delaying maturity by 10 days and reducing yield by 671 kg/ha (10 bu/ac). Defoliating twice in spring, prior to and during bolting provided the greatest forage yield of 885 kg/ha (dry weight) but resulted in the sharpest grain yield loss of 860 kg/ha (12.8 bu/ac).

6. Conclusions and Recommendations

With later and more frequent defoliations, forage yields increased but at the cost of lower grain yield and later maturity. Winter wheat is an early maturing crop, so delays in maturity were not of great agronomic significance. However, some of the delays were large enough to void the operational benefits of the early maturing crop. Fall defoliation provided very little forage due to dry conditions but also had little effect on grain yield. Spring defoliation before bolting provided 425 kg/ha of dry forage for the cost of losing 2.9 bu/ac of grain yield. Delaying defoliation to bolting was much harder on the crop, providing 667 kg/ha of dry forage for the sacrifice of 10 bu/ac of grain. Defoliating twice prior to and during bolting sacrificed 12.8 bu/ac for 885 kg/ha of dry forage. Uprooting plants and the hoof action of real grazing would likely have caused more damage to winter wheat than was caused by the simulated grazing in this study. Moreover, real grazing may not be uniform potentially causing large maturity differences in field during grain harvest. The economics of grazing winter wheat will depend on the desperation for feed as the practice can be highly destructive to grain yield. Early grazing either in fall or early spring may be a viable option, providing some forage yield for a modest grain loss and change in maturity. However, grazing at bolting should be avoided as it will result in serve grain yield loss of over 40%.

Supporting Information

7. Acknowledgements:

This project was funded through the Agriculture Demonstration of Practices and Technologies ADOPT.

8. Appendices

Table 5. Significance of main effects of Seeding Rate and Defoliation Timing on Winter Wheat Grain and Grazing Yield.

Treatment	Winter Survival (%)	Grain Yield (kg/ha @14.5%)	Total Grazing Yield (kg/ha @ 0%)	Maturity Julian Day
9. Seeded Aug 15 + defoliated after 6 inches of growth	62.5 b	1930 a	76.0 e	204.0 bc
10. Seeded Aug 15 + defoliated after 6 inches of growth & in spring before bolting	57.5 b	1791 a	269.8 d	206.5 b
11. Seeded Aug 30 + defoliated early spring before bolting + late Spring during bolting	77.5 a	1107 b	884.8 a	211.3 a
12. Seeded Aug 30 + early spring before bolting	72.5 a	1771 a	424.8 c	206.3 b
13. Seeded Aug 30 + late spring during bolting	73.8 a	1296 b	666.8 b	211.8 a
14. Seeded Aug 30 + no defoliation	72.5 a	1967 a	0 e	201.8 c
P-values	0.000363	0.000033	0.00001	.00024
LSD	7.2	286	113.1	3.8

4R Nitrogen Management for Winter Wheat-Timing, Product and Method of Application

Mike Hall[1] and Heather Sorestad[1]

[1]East Central Research Foundation, Yorkton, SK.

1. Abstract/Summary:

A trial was established near Yorkton to demonstrate the impact of nitrogen management on yield and grain protein of winter wheat. Conditions were dry and it was more economic to side-band either urea or SUPERU at seeding instead of dribble banding or broadcasting urea in spring. Side banded SUPER resulted in the highest yield and economic returns suggesting that denitrification was still a significant issue despite the relatively dry conditions. The spring applied N performed poorly because it was received too late to maintain yield potential due to a lack of timely and adequate rainfall. However, the economics did improve when Agrotain was added to broadcast urea or dribble-banded UAN. Side-banding ESN at seeding resulted in less yield and higher grain protein than side-banding urea but was less economic than all treatments excepting the no N check. N release from the ESN was too late to maintain yield potential and the value of the higher protein grain was not enough to offset the lower yield. ESN would likely have performed better if it only constituted a portion of the side-banded urea instead of the entire amount. Spring applied N would likely have looked more favourable if environmental conditions had be wetter during this study. Producers may wish to change their management of N based on environmental conditions.

2. Project objectives:
The overall objective is to demonstrate how nitrogen can be managed to reduce nitrogen losses from leaching, denitrification and volatilization to increase yield and/or protein of winter wheat.

Specifically, the objective is to demonstrate the following N management concepts for winter wheat:

- Side banding the total nitrogen requirement as urea at seeding can lead to N losses (leaching, denitrification) and reduced yield/protein, particularly if soil conditions are wet in fall and spring.
- Side banding ESN at seeding can reduce N losses and increase yields by delaying nitrogen release until late fall or the following spring.
- Side banding SUPERU at seeding can increase yields by inhibiting nitrification.
- Applying nitrogen in spring instead of fall can increase yields/protein by avoiding nitrogen losses from leaching and denitrification. However, nitrogen loss to volatilization may occur if the urea is not adequately leached into the soil with rain.
- Volatilization of spring applied nitrogen can be minimized by broadcasting Agrotain or banding UAN which should lead to higher yield/protein.
- Volatilization loss from spring banding UAN can be reduced further by adding agrotain.

3. Project Rationale:
Applying the total N requirement for winter wheat at the time of seeding can lead to N losses (leaching and denitrification), reduced yields and/or lower grain protein. Denitrification is the process where soil bacteria use up nitrate as an oxygen source when soils are warm, water logged and anaerobic. In Manitoba, Heard et al. found grain yield resulting from fall applied N was always inferior to spring application [1]. Applying the whole nitrogen requirement in fall can also reduce winter survival [2,3]. As a result the general recommendation from Manitoba Agriculture is to apply N to winter wheat in early spring [4]. However, in areas where fall and spring soil conditions are relatively dry, little difference may be observed between fall and spring applications of N.

Side banding Environmentally Smart Nitrogen (ESN) or SUPERU instead of straight urea can reduce N loss to leaching or denitrification. When applied to warm soil in fall, straight urea has lots of time to be converted to nitrate and to be subsequently lost to denitrification. ESN protects against this lost by delaying the release of urea until late fall or spring. SUPERU contains a nitrification inhibitor which slows the conversion of ammonium to nitrate. This in turn reduces N loss because unlike nitrate, ammonium is not lost to denitrification or leaching.

Loses to denitrification and leaching can also be reduced by applying the bulk of the nitrogen in spring. However, spring broadcast applications of urea are vulnerable to volatilization losses unless leached into the soil by significant rainfall. Volatilization losses can be reduced by using products with urease inhibitors such as Agrotain or SUPERU. Dribble banding UAN can also reduce N losses because the nitrate portion is not prone to volatilization and applying the product in a concentrated band helps to reduce volatilization of the urea portion. Additionally, adding

Agrotain to the UAN solution will further reduce losses because it will protect the urea from volatilization.

This project will focus on the right time, right product, and right method as it relates to nitrogen management for winter wheat.

[1] Heard, J. Fraser, B. and Gares, R. 2001. Field scale evaluations of nitrogen sources, timing and placement for zero-tilled winter wheat. Manitoba Agriculture College.

[2]Grant, C.A., Stobbe, E.H. and Racz, G.E. 1984. The effect of N and P fertilization on winter survival of winter wheat under zero-tilled and conventionally tilled management. Can. J. Soil Sci. 64: 293- 296. http://www.nrcresearchpress.com/doi/pdf/10.4141/cjss84-030

[3]Gusta, L.V. O'Conner, B.J., and Lafond, G.L. 1999. Phosphorus and nitrogen effects on the freezing tolerance of Norstar winter wheat. Can. J. Plant Sci. 79: 191-195. http://www.nrcresearchpress.com/doi/pdf/10.4141/P98-026

[4] Manitoba Agriculture and Food. 2003. Winter wheat – production and management. [Online] Available: http://www.gov.mb.ca/agriculture/crops/cereals/bfg01s01.html

4. Methodology:

Winter wheat was seeded into barley stubble where the crop had been removed for green feed. This ensured that winter wheat can be seeded by September 15th in order to maximize winter survival. The winter wheat trial was established as a RCBD with 4 replications. Plots were 11 by 30 feet and seeded with a SeedMaster plot drill on 12 inch row spacing. Monoammonium phosphate was side-banded at seeding at 59 lb/ac. Emerson winter wheat had a seeding rate that targeted 350 seeds/m^2. Each plot of winter wheat was harvested for grain using a Wintersteiger small plot combine. The following treatments listed in the table below was established to evaluate nitrogen form, application method and timing on winter wheat yield and protein.

#	Lb N/ac	Product	Application method	Timing
1	None	na	na	na
2	110	Urea	Side-banded	Seeding (Sept 1-7)
3	110	ESN	Side-banded	Seeding (Sept 1-7)
4	110	Super U	Side-banded	Seeding (Sept 1-7)
5	110	Urea	Broadcast	Late April/Early May
6	110	Agrotain	Broadcast	Late April/Early May
7	110	UAN	Dribble banded	Late April/Early May
8	110	UAN + Agrotain	Dribble banded	Late April/Early May
9	110	urea	55 N SB 55 N broadcast	Seeding/then late April/Early May

Dates of operations complete thus far are listed in Table 2 below.

Table 2. Dates of operations in 2019 for the "Can Winter Wheat Provide Grazing and Grain" Trial	
Operations in 2019	Yorkton
Pre-seed Burnoff	n/a
Seed Barley for Greenfeed	May 17, 2019
In-crop Herbicide	June 10, 2019 (Frontline)
Harvest Barley for Greenfeed	Aug 6, 2019
Soil Test	Aug 12, 2019
Pre-seed Burnoff	Aug 13, 2019 (Roundup Transorb) + Aug 28, 2019 (Roundup Transorb)
Seeded Winter Wheat	Aug 30
Emergence Counts	Sept 18
Early Spring Broadcast Urea and Agrotain (trt 5,6, 9)	April 24
Early Spring Dribble Band UAN and UAN + Agrotain (trt 7,8)	May 11
Winter Survival Rating (%)	May 12
In-crop herbicide application (if required)	N/A
Fungicide Application (if required)	N/A
Lodging (0-5) 0-no lodging	Aug 4
Harvest	Aug 5

Soil test results can be viewed in Figure 1.

5. Results:

Winter wheat was seeded on August 30th into good soil moisture and emergence was uniform averaging 287 plants/m^2. Visual ratings of winter survival the following spring varied from 55 to 71% depending on treatment (Table 4). Winter wheat receiving side-banded urea at seeding (trt 2) had significantly better winter survival compared to many of the treatments not receiving N at seeding. However, winter survival was decent for all treatments with no dead patches apparent. On average, winter wheat receiving 110 lb N/ac averaged between 2360 to 2956 kg/ha (35 to 44 bu/ac) with grain proteins between 12.5 and 13.9% depending on how the N was applied (Table 4). In comparison, the no nitrogen check only produced a 1462 kg/ha (21.8 bu/ac) crop of winter wheat with a grain protein of 10.9%. In other words, there was a strong N response to added N despite overall yields being quite low due to the drought. Though not statistically significant, side-banding SUPERU at seeding resulted in a yield increase of 170 kg/ha (2.5 bu/ac) and a 0.5% increase in grain protein compared to side-banded urea (trt 4 vs 2). The SUPERU likely reduced denitrification and leaching losses, particularly since the winter wheat was seeded early (August 30), allowing lots of time for urea to convert to nitrate. Side-banding all the N as ESN resulted in a 425 kg/ha (6.3 bu/ac) yield loss but a 1.2% gain in grain protein compared to side-banded urea (trts 3 vs 2). Side-banding all the N as ESN likely resulted in a late release of N that increased grain protein but was too late to maintain yield potential. Having only a portion of the N as ESN may have been more beneficial in terms of yield but unfortunately this treatment was not part of the study.

Spring Broadcast applications of urea or Agrotain treated urea on April 24 produced similar yields to dribble-banded UAN or UAN + Agrotain applied on May 11. Ideally, dribble banded and broadcast applications should have occurred on the same date to allow for fair comparisons however, enough rainfall to incorporate the product was not received for 2 weeks after either application date. Neither yield nor grain protein significantly differed between these methods of spring applying N. However, crop yield and grain protein were numerically higher when Agrotain was used with urea or UAN, implying Agrotain was providing some protection from volatilization loss. All spring applications of N (trt 5-8) produced less yield than fall side-banded urea or SUPERU (trt 2 and 4) with differences being statistically significant relative to side-banded SUPERU. However, all the grain proteins for spring applications were statistically higher than the grain protein resulting from side-banded urea (trt 5-8 vs 2). The lower yields and higher protein from spring applications implies the availability of N was delayed relative to side-banded applications at seeding in the previous fall. This stresses the importance of applying spring N early for winter wheat and the importance of early season rainfall to move product into the root zone. When application of urea was split in half between fall side-banding and spring broadcasting the result in terms of yield and grain protein was very similar to placing all the urea in the side-band at seeding (trt 9 vs 2). Again, this shows the importance of early season N for maintaining yield in this study.

Perhaps kg/ha of protein produced by each treatment (table 4) could be considered a relative measure of nitrogen use efficiency (NUE) between treatments 2 to 9 as these treatments all received the same amount of N. Treatments with high NUE tended to provide the best economic returns. The relative profitability of each treatment has been expressed in table 5 as gross returns minus the cost of N and minus the cost of an additional application cost. The $/bu are based on protein spreads provided in table 6. The cost of N is assumed to be $0.5/lb for both urea and UAN sources. The additional costs per lb of N for ESN, SUPERU, Agrotain treated urea and Agrotain treated UAN are assumed to be $0.14/lbN, $0.12/lbN, $0.09/lbN and $0.07/lbN, respectively. The extra cost of broadcasting or dribble banding N is assumed to be $5/ac. Based on these assumptions, side-banded SUPERU at seeding provided the best NUE (377 kg/ha of protein; Table 4) and greatest gross returns ($203/ac; Table 5). Side-banding all the N as ESN provided the worst NUE (321.5 kg/ha of protein; Table 4) and lowest economic returns ($157.2/ac; Table 5), excepting economic returns from the no N check ($113/ac). Side-banded urea produced a NUE and economic return that was similar to broadcast applications, however the N for side-banded urea was available earlier in the season and partitioned more towards yield and less towards protein. While not large, the use of agrotain with broadcast urea and dribble banded UAN improved NUE and economic gains.

6. Conclusions and Recommendations

Side-banded N when seeding winter wheat is safe from volatilization loss but is prone to denitrification and leaching loss once the urea has been converted to nitrate. The earlier winter wheat is seeded, the greater the potential for N loss, particularly if soils are warm and wet. Producers can reduce these losses by using products like SUPERU and ESN. Even under the relatively dry conditions of this study, side-banding SUPERU significantly increased the NUE and economic returns by reducing N loss. Side-banding 100% ESN produced the poorest NUE and economic return under the conditions of our study. The release of N was too late to maximize yield and the protein boost was not enough to compensate economically for the yield loss. Performance may have improved if only a portion of the side-banded urea was ESN. Broadcasting or dribble banding N in spring can also avoid denitrification and leaching loses. However, surface applications are prone to volatilization loss. Volatilization loss can be reduced by using agrotain and there was some evidence of greater NUE and economic returns when this product was used with urea and UAN in this study. In this study, surface applications of urea or UAN produced less yield but more grain protein than side-banded urea in the fall. This indicates that spring applications of N were not getting to the plant in time with spring applications to maintain yield potential. While the economic returns were similar to side-banded urea due to increase grain protein with spring applications, this still illustrates the risk of surface applications when precipitation is not timely or adequate in spring. During dryer cycles producers are better off putting all their nitrogen down in the fall at seeding. If soil moisture is very high applying a large portion of the N requirement in spring is advised. SUPERU in fall and either SUPERU or Agrotain in spring is advised to reduce N loss.

<u>Supporting Information</u>

7. Acknowledgements:

This project was funded through the Agriculture Demonstration of Practices and Technologies ADOPT and Fertilizer Canada.

8. Appendices

Figure 1. Soil test results taken in the fall of 2019 before trial establishment.

Nutrient In The Soil	Depth	Result	Interpretation (VLow / Low / Med / High)
Nitrate	0-12"	6 lb/acre	****
Phosphorus	Olsen	2 ppm	***
Potassium		203 ppm	******************************
Chloride			
Sulfur	0-12"	24 lb/acre	****************
Boron			
Zinc		0.79 ppm	***************
Iron			
Manganese			
Copper			
Magnesium			
Calcium			
Sodium			
Org. Matter		5.0 %	********************
Carbonate(CCE)			
Sol. Salts	0-12"	0.3 mmho/cm	*******

	1st Crop Choice		2nd Crop Choice		3rd Crop Choice	
Crop	Wheat-Winter		Grass/Alfalfa		Wheat-Spring	
YIELD GOAL	60	BU	4	Tons	50	BU
SUGGESTED GUIDELINES	Band		Band		Band	
	LB/ACRE	APPLICATION	LB/ACRE	APPLICATION	LB/ACRE	APPLICATION
N	135		51		126	
P_2O_5	47	Band *	51	Broadcast	30	Band *
K_2O	10	Band (Starter)*	0		10	Band (Starter)*
Cl						
S	5	Band (Trial)	5	Band (Trial)	5	Band (Trial)
B						
Zn	0		0		0	
Fe						
Mn						
Cu						
Mg						
Lime						

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.6							

Crop 1: Soil nitrate for 0-24 inch depth is estimated 9 lb/acre nitrate-N. *CAUTION: Seed-placed fertilizer can cause injury.* May respond to starter P & K, even on high soil tests. Crop nutrient removal: P2O5 = 38 K2O = 23 AGVISE Band guideline will build P & K test levels to the medium range over several years.

Crop 2: Soil nitrate for 0-24 inch depth is estimated 9 lb/acre nitrate-N. *CAUTION: Seed-placed fertilizer can cause injury.* May respond to starter P & K, even on high soil tests. Crop nutrient removal: P2O5 = 40 K2O = 192 AGVISE Band guideline will build P & K test levels to the medium range over several years.

Crop 3: Soil nitrate for 0-24 inch depth is estimated 9 lb/acre nitrate-N. *CAUTION: Seed-placed fertilizer can cause injury.* May respond to starter P & K, even on high soil tests. Crop nutrient removal: P2O5 = 31 K2O = 19 AGVISE Band guideline will build P & K test levels to the medium range over several years.

Table 4. Treatment Effects on Winter Survival, Yield and Protein				
Treatment	**Winter Survival (%)**	**Grain Yield (kg/ha)**	**Protein (%)**	**Kg Pro/ha**
1. No fertilizer control	63.8 ab	1462.8 d	10.9 e	159.0 c
2. 110 lb N/ac Urea side-banded at seeding	71.3 a	2786.0 ab	12.5 d	346.8 ab
3. 110 lb N/ac ESN side-banded at seeding	65.0 ab	2360.8 c	13.7 a	321.5 b
4. 110 lb N/ac SUPERU side-banded at seeding	63.8 ab	2956.0 a	13.0 bcd	376.7 a
5. 110 lb N/ac Urea Broadcasted in early Spring	60.0 bc	2423.8 bc	13.6 ab	328.5 b
6. 110 lb N/ac Agrotain Broadcasted in early Spring	55.0 c	2518.5 bc	13.8 a	347.5 ab
7. 110 lb N/ac UAN Dribble banded in early Spring	60.0 bc	2515.0 bc	13.3 abc	333.5 ab
8. 110 lb N/ac UAN + Agrotain Dribble banded in early Spring	63.8 ab	2528.8 bc	13.9 a	351.8 ab
9. 55 lb N/ac Urea side-banded at seeding + 55 lb N/ac Broadcasted in early Spring	63.8 ab	2756.8 abc	12.7 cd	348.2 ab
P-value	0.046417	0.000016	<0.00001	
LSD	8.3	422.2	0.71	42.2

Table 5. Treatment Effects on Economic returns					
Treatment	**Bu/ac**	**$/bu[1]**	**N cost $/ac[2]**	**additional application cost $/ac**	**gross $/ac- costs of N and application**
1. No fertilizer control	21.8	5.19	0	0	113.0
2. 110 lb N/ac Urea side-banded at seeding	41.5	5.84	55	0	187.1
3. 110 lb N/ac ESN side-banded at seeding	35.1	6.44	69	0	157.2
4. 110 lb N/ac SUPERU side-banded at seeding	44.0	6.14	67	0	203.0
5. 110 lb N/ac Urea Broadcasted in early Spring	36.1	6.44	55	5	172.2
6. 110 lb N/ac Agrotain Broadcasted in early Spring	37.5	6.79	64	5	185.4
7. 110 lb N/ac UAN Dribble banded in early Spring	37.4	6.44	55	5	181.0
8. 110 lb N/ac UAN + Agrotain Dribble banded in early Spring	37.6	6.79	62	5	188.5
9. 55 lb N/ac Urea side-banded at seeding + 55 lb N/ac Broadcasted in early Spring	41.0	5.84	55	5	179.5

[1]$/bu based on protein spreads presented in table 6.

[2]N cost assumed to be $0.5/lb N for urea and UAN. Added cost for ESN, SUPERU, Agrotain treated urea and Agrotain treated UAN are $0.14/lbN, $0.12/lbN , $0.09/lbN and $0.07/lbN, respectively.

Table 6. Wheat prices available from Yorkton on Feb 9, 2018 for CWRS No 1	
Grain Protein (%)	$/bushel
15.5	7.74
15	7.44
14.5	7.14
14	6.79
13.5	6.44
13	6.14
12.5	5.84
12	5.54
11.5	5.24
11	5.19
10.5	5.04
10	4.89

Dry bean response to nitrogen fertilizer rate in dryland solid-seeded production

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1. Abstract/Summary:

A trial was established near Yorkton in 2020 to demonstrate the response of dryland, solid-seeded black beans to varying levels of soil + fertilizer nitrogen (N). Yield and test weight increased linearly up to the highest rate of soil + fertilizer N (165 kg N/ha). Compared to the unfertilized check with a background soil level of 22 kg N/ha, the highest rate of N double grain yield from 400 to 810 kg/ha and increased test weight from 188 to 219 g/0.5l. The high rate of applied N was highly beneficial despite the dry conditions experienced during the demonstration.

2. Project Objectives:

The objective of the proposed project is to demonstrate the response of dryland, solid-seeded black beans to varying nitrogen (N) fertilizer rates.

3. Project Rationale:

Dr. Steve Shirtliffe conducted some dryland N fertility trials in 1999-2000 using CDC Camino and CDC Expresso. There was a response to N fertilizer applications but overall productivity was low. Nitrogen recommendations from Sask Pulse Growers are currently based on irrigated production trials from Alberta. There is a need to develop N recommendations for dryland bean production systems in Saskatchewan.

Because dry beans are notoriously poor at fixing atmospheric N and production of effective inoculant products has been problematic, most commercial production relies on N fertilizer and soil N to meet crop needs as opposed to atmospheric N fixation like most other pulse crops (Garry Hnatowich, personal communication). In Maine, Liebman et al. (1995) found that dry bean yields increased linearly with N rates up to 135 kg N/ha for both no-till and conventional systems. There is some uncertainty regarding the overall yield potential and optimal N rates for black beans under dryland production in Saskatchewan.

Literature Cited

Liebman, M., Corson, S., Row, R. J., and W. A. Halterman. 1995. Dry bean responses to nitrogen fertilizer in two tillage and residue management systems. Agron. J. 87: 538-546.

Shirtliffe, S and J. Painchaud. 2000. The effect of nitrogen fertilizer on the yield of dry beans in Saskatchewan. Reports of Bean Improvement Cooperative and National Dry Bean Council Research Conference. Pg. 120-121

4. Methodology:

The trial was set up as a Randomized Complete Block Design (RCBD) with 4 replications. Plot size was 11 by 30ft seeded with a 10ft Seedmaster drill on 12inch row spacings. CDC Blackstrap black beans were seeded at 40 live seeds/m^2. Monoammonium phosphate was applied in a side-band at 28 kg/ha. Nitrogen fertilizer was supplied as side-banded to deliver the following rates of soil + fertilizer N:

1. Soil available N= 22 kg N/ha
2. Soil + Fertilizer = 45 kg N/ha
3. Soil + Fertilizer = 75 kg N/ha
4. Soil + Fertilizer = 105 kg N/ha
5. Soil + Fertilizer = 135 kg N/ha
6. Soil + Fertilizer = 165 kg N/ha

The top 12 inches of soil contained 22 kg N/ac. The beans were not inoculated with a commercial rhizobial inoculant product. Only the middle 4 rows by 30ft were harvested from each plot to reduce edge effects.

Table 2. Dates of operations "Dry bean response to nitrogen fertilizer rate in dryland solid-seeded production" trial.	
Operations in 2020	Yorkton
Pre-seed Herbicide Application	N/A
Seeding Date	May 19
Emergence Counts	June 2
In-crop Herbicide Application	July 1 (Viper ADV + Basagran Forte + UAN) & July 9 (Centurion)
Fungicide Application	N/A
Disease Rating	July 31
Maturity Rating	Aug 24
Plant Height	Aug 4
Harvest	Sept 10

5. Results:

Dry bean emergence was excellent, achieving the target population of 40.3 plants/m^2. Emergence did not significantly vary between treatments as rate of side-banded urea was increased (Data not shown). The season was very dry and little leaf disease was observed regardless of N rate (Table 4). For some unknown reason, less bacteria blight was rated in plots receiving 75 kg N/ha but the difference is not of agronomic significance. Bean height tended to increase with added N but significant increases in height were not apparent beyond 45 kg/ha of soil + fertilizer N. As expected, increasing N significantly delayed maturity (Figure 1) which could have been of agronomic significance if an early frost had occurred. Yield and test weight significantly increased linearly with increasing N all the way to 165 kg/ha of soil + fertilizer N (Table 4, Figures 2 and 3).

Table 4. Data for "Dry bean response to nitrogen fertilizer rate in dryland solid-seeded production" trial.

Trt#	Soil + Fertilizer N (kg/ha)	**Maturity (Julian Day)**	**Bacterial Blight (1-10)**	**Height (cm)**	**Test Weight (g/0.5L)**	**Yield (kg/ha @16%)**
1	22	235.5 c	1.6 a	25.7 c	188.4 b	400.0 d
2	45	236.3 bc	1.4 a	26.2 bc	179.1 b	330.5 d
3	75	238 abc	1.0 b	29.5 abc	186.0 b	548.4 c
4	105	238.5 ab	1.4 a	32.8 a	206.8 a	647.6 b
5	135	241 a	1.4 a	29.5 abc	212.4 a	660.5 b
6	165	240.3 a	1.4 a	29.7 ab	218.8 a	810.2 a
P-value		0.0031	0.013789	0.016614	0.000029	<0.0001
L.S.D		2.65	0.29	3.9	12.8	84.0

Figure 1. Black strap dry beans: 165 kg N/ha on the left and 45 kg N/ha on the right.

Figure 2. Effect of soil + fertilizer N on yield of dry bean

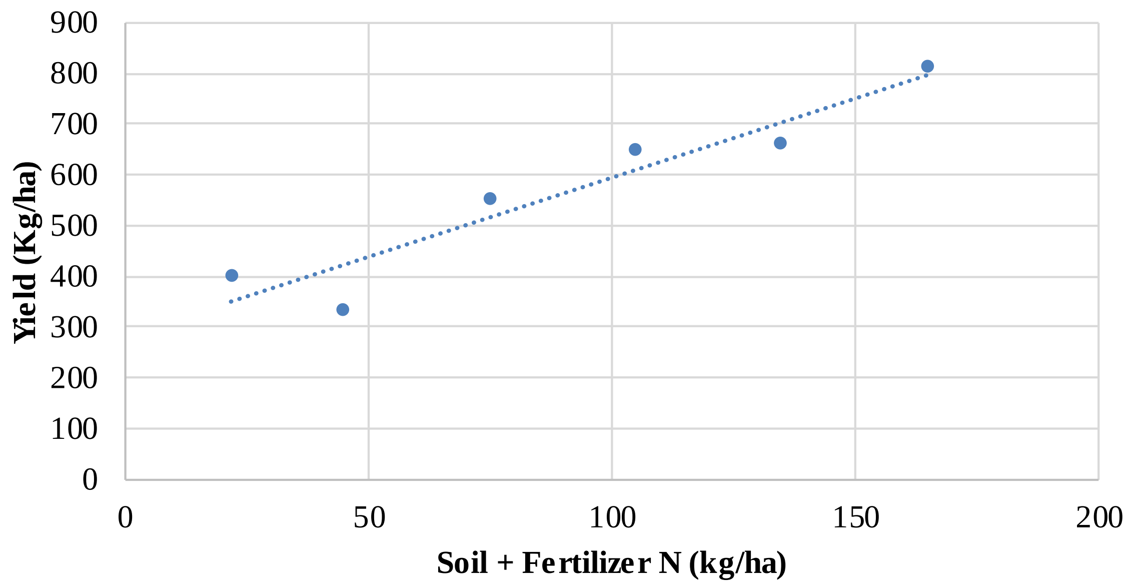
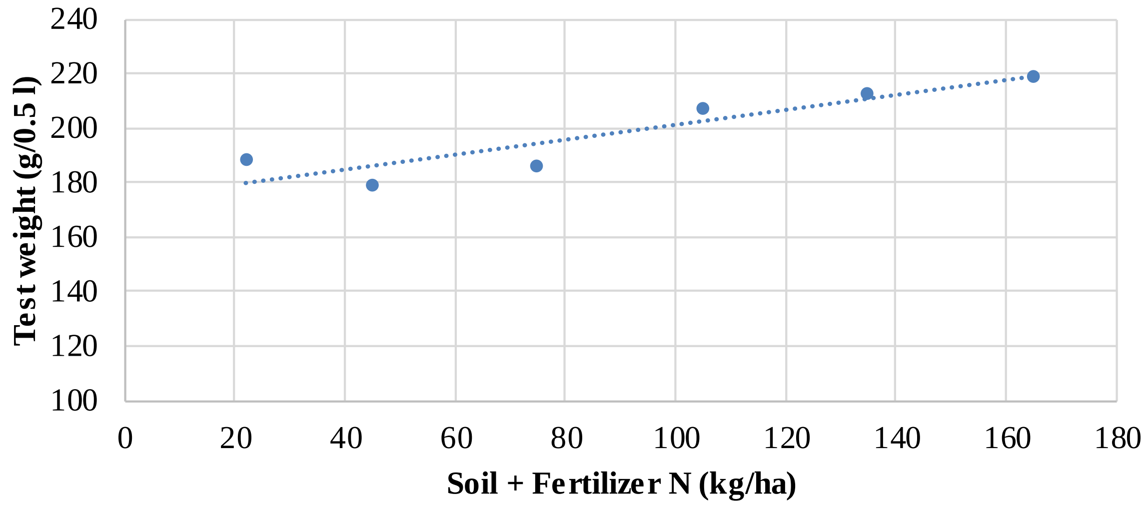


Figure 3. Effect of soil + fertilizer N on test weight of dry bean



6. Conclusions and Recommendations

There are few if any inoculant options for black dry beans. Past research by Agriarm locations have found black dry beans to be unresponsive to available inoculants. As a result, producers must rely on added nitrogen to increase black dry bean yields. The results from this study found the black beans to be highly responsive to added N despite the dry environmental conditions. Increasing soil + fertilizer N to 165 kg/ha doubled dry bean yield from 400 to 810 kg/ha. Test weights also increased substantially with added N and maturity was substantially delayed. The application of high rates of N were extremely beneficial in this study. However, this report only covers the Yorkton site. Separate reports will also be generated from other participating Agriarm sites and it would be interesting to combine sites.

<u>Supporting Information</u>

7. Acknowledgements:

This project was funded through the Agriculture Demonstration of Practices and Technologies ADOPT.

Dormant versus Spring Seeding of Perennial Forages

Mike Hall[1] and Heather Sorestad[1]

[1]East Central Research Foundation, Yorkton, SK.

1. Abstract/Summary:
A trial was established in Yorkton to demonstrate the best management practices for fall dormant seeding of perennial forages and to compare establishment success relative to early spring seeding. As expected, fall dormant seeding was a much more viable option with forage grasses than it was for alfalfa. Fall seeding produced dry matter yields of 1581, 283 and 1910 kg/ha for meadow brome, alfalfa and smooth brome whereas, spring seeding produced 1094, 2303 and 1637 kg/ha, respectively. Increasing seeding rate did not significantly affect emergence or yield for either the forage grasses or alfalfa.

2. Project objectives:
The objective is to demonstrate the best management practices for fall dormant seeding of perennial forages and to compare establishment success relative to early spring seeding. Specifically the following concepts will demonstrated:

- Dormant seeding should occur in late fall (mid-November) when soil temperatures are <2ºC to reduce the chance of fall germination and in turn winter-kill.
- Grass forages are more likely to establish well with dormant seeding that alfalfa.
- Recommended seeding rates for forage should be increased by 25% when dormant seeded in fall to compensate for winter-kill.

3. Project Rationale:

Dormant fall seeding of perennial forage is an acceptable recommendation in Saskatchewan and other parts of western Canada. However, winter kill is a concern and it is generally recommended to increase seeding rates by 25% to compensate for seed mortality[1][3][4]. Grass forages are more likely to establish well when dormant seeded than perennial legumes. A study conducted by the Peace River Forage Association of British Columbia found that legumes birdsfoot trefoil, multi-foliate alfalfa and white Dutch clover all produced similar ground cover by July 31 whether broadcasted in late fall (Nov 7 and 15) or spring (June 4 and 6)[2]. In the same study, grasses such as creeping red fescue, crested wheatgrass, fowl bluegrass, slender wheatgrass and smooth bromegrass all produced more ground cover by July 31 when broadcasted in late fall (Nov 7 and 15) compared to spring (June 4 and 6)[2].

Fall dormant seeding can provide logistical benefits. Perennial forages typically have small seeds and must be seeded shallow into moist soil. This can be accomplished by seeding in early spring but producers generally favor seeding their cash crops first and then forages later when soil conditions are typically drier. Fall dormant seeding helps to spread the workload, and ensures seeds are germinating in early spring when soil moisture is usually adequate. Fall seeding may also allow access to saline areas which are usually too wet to seed in early spring.

To increase the likelihood of success, dormant seeding must be delayed until late fall (mid-November) when soil temperature is below 2°C to prevent germination[1]. The survival of seeds which germinate in fall will be greatly reduced. Forages should be banded at the time of seeding instead of broadcasted. This improves seed to soil contact, reduces seed predation and in turn improves stand establishment.

[1] Saskatchewan Forage Council. 2007. "Successful Forage Crop Establishment"
[2] Peace River Forage Association of British Columbia. 2015. "Spring Verses Fall Seeding Does it Really Matter?"
[3] Kowalchuk,T. 2018. "Dormant seeding forage crops- sometimes it pays to delay". Canadian Cattlemen.
[4] Alberta Agriculture and Forestry. 2003. "Late Fall or Dormant Seeding Frequently Asked Questions"

4. Methodology:

The demonstration was setup as a 3 level factorial with 4 replicates. Plots were 6 by 30 ft and seeded with a cone seeder on 12 inch row spacing into canola stubble.
The first factor contrasted 2 seeding dates:

1. Dormant Seeding in late fall when soil is <2°C (November 1-15)
2. Spring Seeding (May 1-15)

The second factor contrasted the following 3 commonly grown forage species:

1. Meadow fescue
2. Alfalfa
3. Smooth brome

The third factor contrasted two seeding rates. The first seeding rate was what is typically recommended for spring seeding that forage specie and the second seeding rate was increased by 25%.

Fertilizer was applied at 30 lb $P_2 0_5$/ac and 5 lb S/ac to all treatments in the spring. Urea was applied at 100 lb N/ac to all the grass treatments (1-4 and 9-12) excluding treatments 5-8 (alfalfa). Plots were hand weeded throughout the spring/summer. Plots were harvested by hand as establishment was spotty.

Trt #	Seeding Date	Forage Species	Seeding Rate
1	Dormant	Meadow Brome	Normal (12 lb/ac)
2	Spring	Meadow Brome	Normal (12 lbs/ac)
3	Dormant	Meadow Brome	25% greater than normal (15 lb/ac)
4	Spring	Meadow Brome	25% greater than normal (15 lb/ac)
5	Dormant	Alfalfa	Normal (8 lb/ac)
6	Spring	Alfalfa	Normal (8 lb/ac)
7	Dormant	Alfalfa	25% greater than normal (10 lb/ac)
8	Spring	Alfalfa	25% greater than normal (10 lb/ac)
9	Dormant	Smooth Brome	Normal (10lb/ac)
10	Spring	Smooth Brome	Normal (10lb/ac)
11	Dormant	Smooth Brome	25% greater than normal (12.5 lb/ac)
12	Spring	Smooth Brome	25% greater than normal (12.5 lb/ac)

Dates of operations are listed in Table 2 below.

Table 2. Dates of operations for the "Dormant versus Spring Seeding of Perennial Forages" Trial

Operations in 2020	Yorkton
Dormant Seeding (trt # 1,3,5,7,9, and 11)	Oct 30, 2019 into snow
Spring Seeding (trt# 2,4,6,8,10, and 12)	May 4, 2020
Broadcasted Fertilizer in Spring	May 13, 2020
Emergence Counts	June 2, 2020
Percent Ground Cover	July 29, 2020
Harvest	July 30, 2020

5. Results:

Dormant seeded forage emergence was extremely poor for both grasses and alfalfa. It was thought that the dormant seeded forages did poorly because of a combination of seed bridging in the seeders hoses and winter-kill. The dormant seeded forages were seeded into cold soil with a couple of inches of light snow on top. The snow never melted until spring. Because of the variable emergence due to seeder issues, counts and yields were taken from the best portions of the plots.

There were significant interactions between seeding date and plant specie for the emergence and yield data (table 4). When averaged over seeding rate, plant emergence and dry matter forage yield did not significantly differ between the grass species seeded in the fall or spring (table 5). While not significant, fall seeding meadow brome and smooth brome actually increased yields by 45 and 17% compared to spring seeding, respectively. Higher yield with fall seeded grasses may have been related to earlier emergence and better utilization of limited soil moisture. For alfalfa, the opposite was true. Emergence and yield of fall dormant seeded alfalfa was substantially and significantly lower compared to spring seeded alfalfa (table 5). When averaged over seeding rate, fall seeding alfalfa only produced 9.4 plants/m² and 283 kg/ha of dry matter compared to 130 plants/m² and 2303 kg/ha of dry matter when seeded in spring.

Table 4. Significant of a 3 level factorials main effects of Seeding Date (D), Forage Species (F) and Seeding Rate (R) on Forage Dry Yield

Seeding Date (D)	**Emergence (plants/m²)**	**% ground cover**	**Forage Dry Yield (Kg/ha @ 0%)**
Dormant	51.8 a	9.6 b	1258.2 b
Spring	86.5 a	40.7 a	1678.0 a
LSD	NS	12.0	392.0
Forage Species (F)			
Meadow Brome	55.0 a	23.1 a	1337.5 a
Alfalfa	69.7 a	22.4 a	1293.0 a
Smooth Brome	82.9 a	29.9 a	1773.9 a
LSD	NS	NS	NS
Seeding Rate (R)			
Normal	69.2 a	27.5 a	1582.3 a
25% Greater	69.2 a	22.8 a	1353.9 a
LSD	NS	NS	NS
P-values			
D (date)	NS	<0.00001	0.034
F (forage)	NS	NS	NS
R (rate)	NS	NS	NS
D*F	0.0439	NS	<0.00001
D*R	NS	NS	0.035808
F*R	NS	NS	NS
D*F*R	NS	NS	NS

Table 5. Significant of a 3 level factorials main effects of Seeding Date (D), Forage Species (F) and Seeding Rate (R) on Forage Dry Yield			
Seeding Date (D)	**Forage Species (F)**	**Emergence (plants/m^2)**	**Forage Dry Yield (Kg/ha @ 0%)**
Dormant (fall)	Meadow Brome	41.8 ab	1581 ab
	Alfalfa	9.4 b	283 c
	Smooth Brome	104.2 ab	1911a
Spring	Meadow Brome	68.1 ab	1094 b
	Alfalfa	130.0 a	2303 a
	Smooth Brome	61.5 ab	1637 ab
	LSD	101	758

6. Conclusions and Recommendations

The results of this trial are somewhat suspect as there would appear to have been issues with the seeder. However, fall dormant seeding of forages did appear to be a viable option for grass forages but not for alfalfa. Dormant seeded alfalfa did not survive the winter well to produce an acceptable crop. Increasing seeding rate did not improve stand establishment for either the forage grasses or alfalfa.

Supporting Information

7. Acknowledgements:

This project was funded through the Agriculture Demonstration of Practices and Technologies ADOPT.

8. Appendices

Table 6. Significance of main effects of Seeding Dates (D), Forage Species (F) and Seeding Rates on Emergence, % Ground Cover and Forage Dry Yield.			
	Emergence (plants/m^2)	**% Ground Cover**	**Average Forage Dry Yield (Kg/ha @ 0%)**
D X F X R			
1. Dormant Seeded Meadow Brome Normal	32.8 a	11.3 a	2169.2 a
2. Spring Seeded Meadow Brome Normal	67.3 a	38.8 a	1191.9 a
3. Dormant Seeded Meadow Brome 125%	50.9 a	14.8 a	992.3 a
4. Spring Seeded Meadow Brome 125%	68.9 a	27.5 a	996.5 a
5. Dormant Seeded Alfalfa Normal	0 a	0.5 a	389.3 a
6. Spring Seeded Alfalfa Normal	76.3 a	53.0 a	2054.8 a
7. Dormant Seeded Alfalfa 125%	18.9 a	0.5 a	177.1 a
8. Spring Seeded Alfalfa 125%	183.7 a	35.8 a	2550.9 a
9. Dormant Seeded Smooth Brome Normal	183.8 a	20.0 a	2182.5 a
10. Spring Seeded Smooth Brome Normal	55.0 a	41.3 a	1506.4 a
11. Dormant Seeded Smooth Brome 125%	24.6 a	10.5 a	1639.2 a
12. Spring Seeded Smooth Brome 125%	68.1 a	48.0 a	1767.4 a
LSD	NS	NS	NS

Canola seed safety and yield response to novel P sources in Saskatchewan soils

Mike Hall[1] and Heather Sorestad[1]

[1]East Central Research Foundation, Yorkton, SK.

1. Abstract/Summary:

A trial was established near Yorkton, SK to demonstrate canola response to increasing rates of struvite (i.e. Crystal Green), alone or in a blend, relative to other common P fertilizer formulations with a focus on stand establishment and seed yield. Stand establishment was best with Crystal Green and MES15 resulted the lowest plant populations. Canola yield responded significantly to increasing rates of P2O5 for MAP and MES15 but not for Struvite or a 50/50 blend of Struvite with MAP. However, the starting point for the yield response to MES15 was well below that of the other products and the no phosphorus check, making conclusions regarding relative product performance difficult. Perhaps MAP can be considered the best performing product in this study, as canola yield responded significantly to added MAP and MAP provided the highest yield at the highest rate of P_2O_5 for the lowest cost.

2. Project objectives:

The objectives of the proposed project are to demonstrate canola response to increasing rates of struvite (i.e. Crystal Green), alone or in a blend, relative to other common P fertilizer formulations with a focus on stand establishment and seed yield.

3. Project Rationale:

All of the products we propose to evaluate are commercially available and have, to varying degrees, been assessed under western Canadian field conditions. When it comes to P fertilizer forms, most research has shown that the fate of different forms along with the potential crop response is similar, regardless of initial differences. Of the growers who apply P fertilizer to canola, monoammonium phosphate (11-52-0) holds 73% of the market by volume (Stratus Ag Research, 2015).

While not exclusively a P product, MES15 is a multi-nutrient fertilizer which is often perceived as having the benefits of improved seed-safety (relative to MAP/AS blends) and providing season long sulphur with the S consisting of equal parts SO4-S and elemental forms. Promotional material and internal research on MES15 from Mosaic showed significantly higher plant populations and a 2.6 bu/ac advantage (average of 24 trials over a three-year period) over MAP plus ammonium sulphate (AS) blends. Independent University of Manitoba research (Grenkow et al. 2013) showed improved seed safety over MAP/AS but also warned that MES15 may not be as effective at providing plant available S as conventional products (i.e. MAP/AS blends). That aside, the claim specific to P is that the combination of nutrients in MES15 creates a more acidic environment, which helps keep the P in plant available, soluble forms for a longer period of time leading to better overall uptake. A previous ADOPT project conducted at Indian Head in 2018 showed a 1 bu/ac yield advantage to MES15 (over MAP) when averaged across application rates; however, the response was not significant at the desired probability level ($P = 0.063$; Holzapfel 2019).

Struvite is marketed under the brand name Crystal Green® (5-28-0 plus 10% Mg) and, according to promotional material, boasts superior crop safety with a salt index of 7.7 (compared to 27 in MAP and 21 in MES15) along with improved season long availability relative to more traditional products (crystalgreen.com/nutrient-recovery). While it does not appear in the scientific literature or regional field trials to the same extent as MAP or diammonium phosphate, relevant peer-reviewed research on struvite as a P fertilizer source does exist. Early work at the University of Manitoba found that, at the applied rates, struvite (whether derived from liquid manure or chemically pure) increased dry matter yields and P recovery over the control but not to the same extent as MAP. The authors suggested that this may have been due to the lower initial solubility of struvite in the high pH Manitoba soils (Ackerman et al. 2013). In later evaluations with wheat and canola, Katanda et al (2016) saw similar early season dry matter yield and uptake efficiency with struvite compared to MAP and, at higher rates, greater biomass yields and P recovery with struvite during the later crop phases. They concluded that struvite can supply sufficient P to sustain yields and overall P used efficiencies matching or exceeding those for MAP. Citing Ag Quest trials with canola, the company boasts 16% higher plant populations and an 11% yield advantage to struvite compared to 111 kg/ha (total product) of MES15 (crystalgreen.com/agriculture/canola). While there is solid evidence that struvite is effective as a P fertilizer source, independent evaluations under Saskatchewan field conditions will help increase producer awareness and of this product and help them understand if and when it may have a fit in their operations.

Canola is known to respond well to P applications in low P soils but is also relatively sensitive to seed placement and, as such, is an excellent test crop for this project.

Literature Cited

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Grenkow, L. 2013. Effect of seed-placed phosphorus and sulphur fertilizers on canola plant stand, early season biomass and yield. M.Sc. Thesis. University of Manitoba, Winnipeg, MB. Online [Available]: https://mspace.lib.umanitoba.ca/xmlui/handle/1993/22150 (Nov. 12, 2019).

Holzapfel, 2019. Seed-placed phosphorus fertilizer forms and P. bilaii effects on canola emergence, phosphorus uptake, and yield. ADOPT #20170410 Project Report. Online [Available]: https://iharf.ca/wp-content/uploads/2019/05/Seed-placed-phosphorus-fertilizer-forms-and-P-bilaii-effect-on-canola.pdf (Nov. 12, 2019).

Katanda, Y., Zvomuya, F., Flaten, D. and N. Cicek. 2016. Hog-manure recovered struvite: effects on canola and wheat biomass yield and phosphorus use efficiencies. Soil Sci. Soc. Am. J. 80: 135-146.

Methodology and Results

4. Methodology:

A site testing relatively low in phosphorus at 7 ppm (olsen) was selected for the trial (Figure 1). Plots (11 by 30ft) were seeded with a 10ft Seedmaster on 12 inch row spacings. The thirteen P fertilizer treatments were replicated four times in an RCBD and are described below in Table 1. In addition to a control where no P fertilizer is applied, four fertilizer forms of phosphorous were applied at three rates.

Table 1. Treatment List

#	Form [Z]	Rate
1	Control (n/a)	0 kg P_2O_5/ha
2	100% MAP	25 kg P_2O_5/ha
3	100% MES15®	25 kg P_2O_5/ha
4	100% Crystal Green®	25 kg P_2O_5/ha
5	50% MAP 50% Crystal Green®	25 kg P_2O_5/ha
6	100% MAP	45 kg P_2O_5/ha
7	100% MES15®	45 kg P_2O_5/ha
8	100% Crystal Green®	45 kg P_2O_5/ha
9	50% MAP 50% Crystal Green®	45 kg P_2O_5/ha
10	100% MAP	65 kg P_2O_5/ha
11	100% MES15®	65 kg P_2O_5/ha
12	100% Crystal Green®	65 kg P_2O_5/ha
13	50% MAP 50% Crystal Green®	65 kg P_2O_5/ha

[Z] MAP, 11-52-0-0; MES15®, 13-33-0-15; Crystal Green®, 5-28-0-0 + 10%Mg

The canola was seeded in mid-May, recognizing that the potential for phosphorus fertilizer response tends to be greater with early seeding (into cool soils). All P fertilizer was applied in the seed-row. Ammonium sulphate and urea were side-banded. Nitrogen was applied to be non-limiting with the total N rates balanced across treatments. The presence of 83 lb/ac of ammonium sulphate was maintained for each treatment to ensure sulphur was not limiting for any treatment including the MES15 treatments with elemental sulphur. A clubroot and pod-shatter resistant canola variety (45CM39) was seeded at a target seeding rate of 105 seeds/m^2 to target plant stands of roughly 50-90 plants/m^2. Only the middle 4 rows by 30ft of each plot were harvested by a Wintersteiger plot combine to avoid edge effects. Dates of operations are found in table 2.

Table 2. Dates of operations "Canola seed safety and yield response to novel P sources in Saskatchewan soils" trial.

Operations in 2020	Yorkton
Pre-seed Herbicide Application	N/A
Seeding Date	May 14
Emergence Counts	June 2
Insecticide Application	May 29 (Decis)
In-crop Herbicide Application	June 5 (Roundup Transorb) June 11 (Centurion)
Maturity Rating	Aug 19
Harvest	Sept 2
Final Plant Density	Sept 4

9. Results:

The canola emerged well. In early spring, the average plant count across the whole trial was 62.2 plants/m^2, which was substantially lower than the average count of 104 plants/m^2 determined after harvest. Crop emergence may have been delayed due to dry conditions and spring counts were likely taken before the whole crop had emerged. Differences in spring emergence between treatments could not be detected. However, treatment differences were apparent with plant counts taken post-harvest (Table 4). The main effect of increasing seed placed phosphorus from 25 to 65 kg P_2O_5/ha significantly delayed maturity by 5.7 days, which was likely the result of reducing plant population, as added phosphorous typically hastens maturity. Maturity differences were not detected between phosphorus products. When averaged across P_2O_5 rate, post-harvest plant counts for crystal green at 122.9 plants/m^2 were significantly higher compared to other forms of applied phosphorus, indicating less seedling toxicity (Table 4). Compared to Crystal Green, mono ammonium phosphate (MAP) reduced plant emergence by 19% to 99.9 plants/m^2. As would be expected, the emergence for the 50/50 blend of MAP and Crystal Green was half way between the two products at 107.7 plants/m^2. The product with the greatest seedling toxicity was MES15, as only 85.4 plants/m^2 emerged when this form of phosphorus was used. MES15 was likely more toxic to seedlings because it also contains ammonium sulphate, further adding to salt and ammonia toxicity of the product.

The main effect of increasing phosphorus from 25 to 65 kg P_2O_5/ha significantly increased canola yield from 52.7 to 56.2 bu/ac, respectively (table 4). However, yield response to increasing phosphorus was not consistent as there was a significant product by rate interaction. Figure 2 and table 5 shows the response to added phosphorus for each product. Canola yield was responsive to increasing phosphorus for MAP and particularly for MES15. However, the yield response to MES15 started at relatively low yield, significantly lower than the no phosphorus control (table 5). The reason for this is not clear. In contrast, a yield response to increasing phosphorus with crystal green or a 50/50 blend of Crystal Green with MAP was not apparent. However, the starting yield for those two treatments was relatively high.

10. Conclusions and Recommendations

Crystal Green had the greatest seedling safety whereas, MES15 caused the most seedling injury because it delivered a heavier nutrient load in the seed row. It is a difficult to draw conclusions regarding the efficacy of these products in terms of increasing yield. Canola yield responded significantly to increasing phosphorus rates when using MAP and MES15 but not Crystal Green or a 50/50 blend of Crystal Green with MAP. While canola yield was significantly responsive to added MES15 the beginning of the response was oddly well below the yield of the no P control and the other products. Perhaps MAP can be considered the best performing product in this study, as canola yield responded significantly to added MAP and MAP provided the highest yield at the highest rate of P_2O_5 for the lowest cost.. A report combining all the results for other participating Agriarm locations will be written by IHARF who developed the protocol for this project.

Supporting Information

11. **Acknowledgements:**

This project was funded through the Agriculture Demonstration of Practices and Technologies ADOPT and Fertilizer Canada.

12. Appendices

Figure 1. Soil test results taken in the spring of 2020 prior to seeding

Table 4. Main effects of Emergence, Days to Maturity and Yield.				
Phosphorus Rate ($kg\ P_2O_5/ha$)	**Spring Emergence ($plants/m^2$)**	**Fall Plant count ($stems/m^2$)**	**Days to Maturity**	**Yield (bu/ac)**
0	69.3	102.9	101.3	52.7
25	67.8 a	112.7 a	96.7 c	52.7 c
45	63.4 a	106.3 ab	99.6 b	54.7 b
65	55.6 a	93.0 b	102.4 a	56.2 a
P-value	NS	0.004377	0.000417	0.000042
LSD	NS	11.3	2.6	1.4
Product				
MAP	54.5 a	99.9 b	99.5 a	56.1 ab
MES15	60.3 a	85.4 c	98.3 a	50.1 c
Crystal Green	67.0 a	122.9 a	99.8 a	54.7b
50% MAP + 50% Crystal Green	67.1 a	107.7 b	100.7 a	57.2 a
P-value	NS	0.000023	NS	<0.00001
LSD	NS	13.1	NS	1.6
P rate by Product Interaction	NS	NS	NS	0.00047

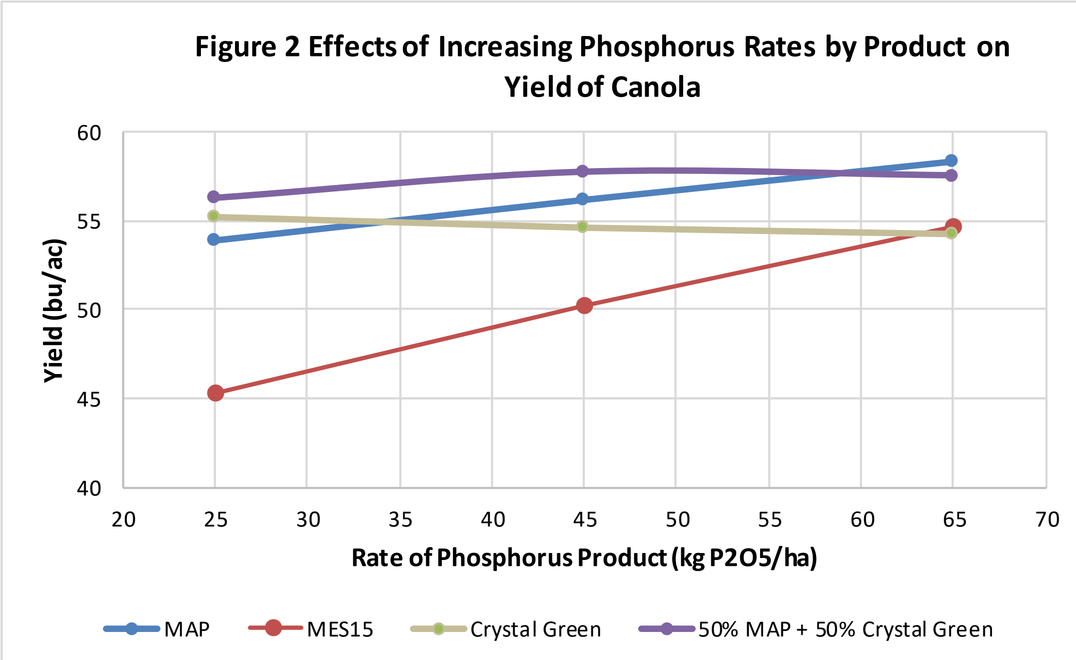

Table 5. Individual treatment effects on Emergence, Days to Maturity and Yield.

Treatment	**Spring Emergence (plants/m^2)**	**Fall Plant count (stems/m^2)**	**Days to Maturity**	**Yield (bu/ac)**
1. Control (no P)	69.3 a	103.0 bcd	101.3 abc	52.7 de
2. 25 kg P_2O_5/ha MAP	51.3 a	106.6 abcd	97.5 cd	53.9 cd
3. 25 kg P_2O_5/ha MES15	71.0 a	95.6 cde	94.0 d	45.3 f
4. 25 kg P_2O_5/ha Crystal Green	68.1 a	123.0 ab	98.3 bcd	55.2 bcd
5. 25 kg P_2O_5/ha 50% MAP + 50% Crystal Green	80.8 a	125.5 ab	97.0 cd	56.2 abc
6. 45 kg P_2O_5/ha MAP	54.6 a	103.7 abcd	100.0 abc	56.1 abc
7. 45 kg P_2O_5/ha MES15	65.2 a	87.8 de	97.0 cd	50.3 e
8. 45 kg P_2O_5/ha Crystal Green	68.9 a	128.8 a	99.5 abc	54.6 cd
9. 45 kg P_2O_5/ha 50% MAP + 50% Crystal Green	64.8 a	105.0 abcd	101.8 abc	57.7 ab
10. 65 kg P_2O_5/ha MAP	57.8 a	89.4 de	101.0 abc	58.4 a
11. 65 kg P_2O_5/ha MES15	44.7 a	73.0 e	103.8 a	54.6 cd
12. 65 kg P_2O_5/ha Crystal Green	64.0 a	116.9 abc	101.8 abc	54.3 cd
13. 65 kg P_2O_5/ha 50% MAP + 50% Crystal Green	55.8 a	92.7 cde	103.3 ab	57.5 ab
P-value	NS	0.0019	0.0227	<0.00001
LSD	NS	25.3	5.2	2.8

Managing post-anthesis applications of nitrogen to reduce "leaf burn" and improve the yield/protein response of wheat

Mike Hall[1] and Heather Sorestad[1]

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1. Abstract/Summary:

A trial was established near Yorkton Saskatchewan to demonstrate how nitrogen applied post-anthesis at 30 lb N/ac can be managed to reduce leaf burn and optimize the yield/protein response of wheat grain. In this study post-anthesis N increased grain protein more compared to just side-banding all the N down at seeding. However, the magnitude of the protein increase varied between methods of application. Applications during the day at 25^{o}C increased grain protein content more than applications at night when it was cool (14^{o}C). This occurred without day-time applications increasing leaf burn or reducing yield. Broadcast applications of either dilute UAN (14%) or melted urea at 14% or 9% concentrations of N also resulted in higher grain protein than dribble banded UAN (28%N). While contentious, this may have been the result of better leaf absorption of N from broadcast applications during a drought, which may have impeded root absorption of N. The study failed to observe less leaf burn with evening/night-time spraying and with melted urea. While post-anthesis N was capable of increasing grain protein by as much as a percent over applying all the N at seeding, the economic value of this is questionable during a drought when regional protein is likely to be high and protein spreads narrow.

2. Project Objectives:

The objective is to demonstrate how nitrogen applied post-anthesis at 30 lb N/ac can be managed to reduce leaf burn and optimize the yield/protein response of wheat grain. This demonstration will show leaf burn from applied N can be reduced by:

a. spraying in late evening when temperatures are cooler compared to the "heat of the day".
b. dribble banding instead of broadcasting foliar sprays of UAN
c. using dissolved urea instead of UAN for broadcast sprays at the same concentration of N

The study will also determine if any of the split applications of N were able to increase grain protein/yield more than placing all the nitrogen requirement down at seeding.

3. Project Rationale:

While an application of N post-anthesis on wheat can increase grain protein, it may also reduce yield by burning the crop. Increasing grain protein by reducing crop yield is counter productive. There are a number of ways to manage post-anthesis applications of N to reduce crop burn. For example, dribble banding UAN typically causes less leaf burn than foliar sprays and is an effective way to apply N as most nitrogen is taken up by the roots and little is absorbed by the foliage [1]. However, success does depend on sufficient and timely rainfall to leach the N into the soil.

Despite being less effective than dribble banding, broadcast sprays post-anthesis are popular in the northern United States and is practiced in Manitoba. The general recommendation is to dilute UAN 50:50 with water and spray when conditions are cool to reduce leaf burning. Leaf burning can be further reduced by using a solution of urea. Amy Mangin with the University of Manitoba recently found foliar sprays of dissolved urea applied post-anthesis not only resulted in less leaf burn but also produced greater yields and higher grain protein compared to UAN [2]. Dissolved urea is a standard product used for foliar applications in the UK and is considered to be safer on the crop than UAN. While both UAN and dissolved urea were applied at 30 lb N/ac in Mangin's study, the % N concentration of the solutions differed between the products. The UAN solution was 14%, whereas the urea solution was only 9%. This may have also contributed to the greater crop safety observed with dissolved urea. In our study the products will be compared at the same concentration of 14% N. Producers can create their own solution of urea on farm, however, care must be taken as dissolving urea is extremely endothermic and can freeze lines. Urea should be dissolved slowly into warm water and not into cold water pulled from a well. In addition, producers should only dissolve urea with less than 1% biuret. Biuret is a by-product that can cause severe leaf burn but it is normally removed from North American production.

Leaf burning from applied N can also be reduced by spraying when temperatures are cool. The Government of Saskatchewan recommends applying foliar sprayed UAN into the evening to avoid "leaf scorch". In the heat of the day, finer droplets produced by foliar broadcast spraying has a greater chance of drying on the leaf, particularly when humidity is low. When conditions are cooler and more humid, the foliar spray is more likely to roll off the leaf [3]. These conditions typically occur at night when the dew arrives.

Proper N management of post-anthesis applications can increase the chance of obtaining a positive economic response.

[1] Rawluk, C. D. L., Racz, G. J. and Grant, C. A. 2000. Uptake of foliar or soil application of 15N-labelled urea solution at anthesis and its affect on wheat grain yield and protein. Can. J. Plant Sci. 80: 331–334.

[2]http://umanitoba.ca/faculties/afs/agronomists_conf/media/7__1_30_PM_DEC_14_MANGIN_MAC_2017_NOV23.pdf

[3]Government of Saskatchewan. Nitrogen Fertilization in Crop Production. www.publications.gov.sk.ca/redirect.cfm?p=75197&i=84107

Methodology and Results

4. Methodology:

The trial was established with 10 treatments as a randomize complete block with 4 replicates (Table 1). Plots were seeded with a 10 foot SeedMaster drill on 12 inch row spacing. A Wintersteiger plot combine harvested only the middle 4 rows to avoid edge effects Treatments 3 to 8 were also be analyzed separately as 2 order factorial. The first factor compared the effect of applying post-anthesis N in the "heat of day" (12-4 pm) versus the cool evening (after 11 pm) on the same day. The second factor looked at the following 4 methods of applying 30 lb N/ac post-anthesis:

- UAN (28% N sol'n) dribble banded
- UAN (14% N sol'n) foliar broadcast sprayed
- Urea (14% N sol'n) foliar broadcast sprayed
- Urea (9% N sol'n) foliar broadcast sprayed

Treatments comparisons with the 70 N check (treatments 1) will determine if any split application of nitrogen increased grain yield or protein and comparisons with the 100 N check (treatment 2) will determine if any increases were superior to just side-banding all the N at seeding.

Table 1. Treatment List

#	Seeding	Post-Anthesis Application of Nitrogen				
	Lb N/ac of Side- banded Urea	N (lb/ac)	Product	%N	method	Timing
1	70	na	na	na	na	na
2	100	na	na	na	na	na
3	70	30	UAN	28	Dribble[1]	Heat of day (12-4pm)
4	70	30	UAN	28	Dribble[1]	Cool late evening (11 pm)
5	70	30	UAN	14	Foliar[2]	Heat of day (12-4pm)
6	70	30	UAN	14	Foliar[2]	Cool late evening (11 pm)
7	70	30	Urea Sol'n	14	Foliar[3]	Heat of day (12-4pm)
8	70	30	Urea Sol'n	14	Foliar[3]	Cool late evening (11 pm)
9	70	30	Urea Sol'n	9	Foliar [3]	Heat of the day (12-4pm)
10	70	30	Urea Sol'n	9	Folia [3]	Cool late evening (11pm)

[1] Sprayed with dribble band nozzle at 10 ga/ac (undiluted UAN =28% N solution)
[2] Sprayed with 02 flat fan nozzles at 20 ga/ac (10 ga/ac UAN + 10 ga/ac water = 14% N solution)
[3] Spray with 02 flat fan nozzles at 20 ga/ac (1.66 Kg of urea dissolved in 1 US gallon of water = 14% N solution)

Dates of operations are listed in Table 2 below.

Table 2. Dates of operations "Managing post-anthesis applications of nitrogen to reduce "leaf burn" and improve the yield/protein response of wheat" trial.	
Operations in 2020	Yorkton
Pre-seed Herbicide Application	none
Seeding Date	May 5
Emergence Counts	May 25
In-crop Herbicide Application	Prestige-June 2, Simplicity-June 9
UAN and Urea in Solution Application at post-anthesis in the heat of the day (12-4pm) (trt# 3,5,7, & 9).	July 16 at 25°C
UAN and Urea in Solution Application at post-anthesis in the cool evening (11 pm) (trt# 2,6,8, & 10).	July 15 (10 pm – 1 am at 14°C)
Fungicide Application	Caramba-July 2
Leaf burn rating	July 20-21
Lodging	None to rate
Harvest	August 11

5. Results:

Crop emergence was good, averaging 329 plants/m^2 and 313 plants/m^2 for plots respectively receiving 70 lb N/ac and 100 lb N/ac of side-banded urea. Averaged across all treatments, wheat yielded only 35.5 bu/ac and grain protein was very high at 17% because of the drought. Only 50 mm of precipitation fell in May and June. The long-term average for that time frame is 131 mm. All treatments have been analyzed as a single factor RCBD (Table 4). Treatments 3-10 have also been analyzed as 2 order factorial to gain statistical power to detect differences between the time and method of applying post-anthesis N (Table 5).

Yield differences were not detected between treatments by either method of analysis (Tables 4 and 5). However, applying 30 lb N/ac post-anthesis to a base rate of 70 lb N/ac increased grain protein from 16.23% (trt 1- 70 lb N/ac side-banded) to a range between 16.75 to 17.78% depending on the method of application (Table 4). Some methods even resulted in statistically higher levels of grain protein compared to putting all the N down at seeding (ie: trt 2- 100 lb N/ac side-banded). The factorial analysis revealed gains in grain protein were significantly higher (by 0.36%) when a post-anthesis application was made in the heat of the day instead of the cool of the evening (Table 5). This was not necessarily expected. The result implies that more N entered the plant with day-time spraying, as the increase in protein could not be attributed to reduced yield from greater leaf burn. In fact, spraying at night resulted in 38.1% flag leaf burn which was significantly more 28.2% when spraying during the heat of day (Table 5). It should be noted, these figures are based on all leaf damage resulting from drought and fertilizer burn as it is difficult to distinguish between the causes. However, it would be fair to conclude that about 17.6% leaf damage could be attributed to stressors other than fertilize burn as this was the average level of damage observed for treatments 1 and 2 which did not receive post-anthesis N (Table 4).

Differences in flag leaf burn could not be detected between methods of applying post-anthesis N (Table 5). However, dribble banding UAN resulted in numerically less leaf burn compared to broadcast applications. Leaf burn was virtually identical between broadcast applications of UAN and dissolved urea regardless of concentration. Overall, broadcast applications of N increased grain protein relative to a dribble band application of UAN (28% N). A broadcast application of UAN (14%N) or dissolve urea (9%N) significantly increased grain protein over dribble banding UAN (28% N) by 0.66 and 0.46%, respectively. A broadcast application of dissolved urea (14%N) also gave a relative protein increase of 0.37% but the difference was not statistically significant. Broadcast applications of N are taken up by the plant through the soil and through crop leaves. Western Canadian research would suggest little N is taken up through leaves even when broadcast sprays are applied[1]. However, some American and European research suggest otherwise [2,3]. Some have also suggested that broadcast application may perform better during a drought because leaves provide an additional route for absorption. While 29 mm of rain was received 5 days after the post-anthesis N, the depth of dry surface soil may have been too great to allow enough movement of the dribble band towards the roots. Whatever the reason, dribble banded N was less effective than broadcast sprays in this study.

Economic comparisons between treatments depends on assumptions. Table 6a shows the economic comparisons assuming a protein premium of $0.6/%/bu between all protein levels. However, the protein levels in the study were very high due to the drought and making this assumption unlikely to be realistic. Grain elevators may cap protein premiums at 16.5%. Table 6b shows the economic comparisons assuming a protein premium of $0.6/%/bu but only up to 16.5% protein. Both tables assume $0.5/ lb N for all forms used and an application cost of $5/ac for those treatments receiving the split application of nitrogen. These variable costs were removed from the gross returns in each table so that fair economic comparisons could be made between treatments. Even when considering protein premiums between all levels of protein, few treatments resulted in higher returns compared to either 70 or 100 lb/ac of side-banded N (Table 6a). The broadcast application of UAN provided the greatest returns, which was largely result of higher numerical yields and high protein. When considering a cap on premiums for grain protein above 16.5%, most economic returns for treatments were well below just applying 70 lb/ac of side-banded N. Under the dry conditions of this study, there was little economic reason to support the application of late season N.

[1] Rawluk, C. D. L., Racz, G. J. and Grant, C. A. 2000. Uptake of foliar or soil application of 15N-labelled urea solution at anthesis and its affect on wheat grain yield and protein. Can. J. Plant Sci. 80: 331–334.

[2] https://www.researchgate.net/publication/284189812_FOLIAR-APPLIED_NITROGEN_FERTILIZERS_IN_SPRING_WHEAT_PRODUCTION

[3] https://www.gov.mb.ca/agriculture/crops/soil-fertility/foliar-nitrogen-wheat-protein-enhancement.html

6. Conclusions and Recommendations

As anticipated, post-anthesis N at 30 lb/ac significantly increased grain protein and did not significantly affect yield. Protein increases were greatest with broadcast applications compared to dribble banding. Dribble banded UAN may have performed more poorly as there was little avenue for leaf absorption and reduced root uptake due to dry soil. However, this would be a contentious conclusion as western Canadian research would suggest little N is absorbed through the leaves. However, US and European studies have concluded that leaf absorption of N can be quite significant. Our study failed to observe less leaf burn and better N efficacy with applications in the cooler evening (14^{o}C) compared to mid-day at 25^{o}C. Instead, greater leaf burn was associated with evening application and higher protein gains were associated with day-time spraying even though yield was unaffected by application timing. This study also failed to observe less leaf burn with broadcast sprays of melted urea compared to UAN. The most efficacious treatment was broadcast spraying UAN (14%) in the heat of the day, which provided a 1.1% protein increase over side-banding all the nitrogen at seeding. Application of post-anthesis N would not normally be recommended to producers during a drought year when protein is already likely to be high. The economic value of increasing grain protein from 16.8% to 17.9% over a 34 bu/ac wheat crop is questionable, particularly if protein spreads are likely to be narrow or even capped at protein levels above 16.5%.

7. Acknowledgements:

This project was funded through the Agriculture Demonstration of Practices and Technologies ADOPT.

8. Appendices

Table 4 Main effects of methods of applications, time of day, and nitrogen product used on yield, protein and flag leaf burn

Method of Application (side-banded (SB) and post-anthesis)	Yield (bu/ac)	Protein (%)	Flag Leaf burn (%)
1. 70 lb N/ac Side-banded (SB)	35.8	16.23 e	18.8 cd
2. 100 lb N/ac Side-banded (SB)	36.3	16.65 de	16.3 d
3. 70 lb N/ac SB + 30 lb N/ac UAN (28%N) dribble banded[1] in heat of day	33.4	16.90 cd	26.7 bc
4. 70 lb N/ac SB + 30 lb N/ac UAN (28%N) dribble banded[1] in cool evening	35.6	16.75 cde	34.4 ab
5. 70 lb N/ac SB + 30 lb N/ac UAN (14%N) broadcast[2] in heat of day	37.5	17.78 a	25.3 bcd
6. 70 lb N/ac SB + 30 lb N/ac UAN (14%N) broadcast[2] in cool evening	38.1	17.20 abcd	42.0 a
7. 70 lb N/ac SB + 30 lb N/ac Urea Sol'n (14%N) broadcast[3] in heat of day	33.9	17.33 abc	27.5 bc
8. 70 lb N/ac SB + 30 lb N/ac Urea Sol'n (14%N) broadcast[3] in cool evening	34.2	17.08 bcd	42.4 a
9. 70 lb N/ac SB + 30 lb N/ac Urea Sol'n (9%N) broadcast[3] in heat of day	35.6	17.53 ab	33.5 ab
10. 70 lb N/ac SB + 30 lb N/ac Urea Sol'n (9%N) broadcast[3] in cool evening	34.4	17.05 bcd	33.5 ab
LSD	NS	0.57	18.8

[1] Sprayed with dribble band nozzle at 10 ga/ac (undiluted UAN =28% N solution)

[2] Sprayed with 02 flat fan nozzles at 20 ga/ac (10 ga/ac UAN + 10 ga/ac water = 14% N solution)

[3] Spray with 02 flat fan nozzles at 20 ga/ac (1.66 Kg of urea dissolved in 1 US gallon of water = 14% N solution)

Table 5. Main effects of time of day (T) and method of applying post-anthesis N (M) on yield, grain protein and flag leaf burn of wheat.

	Yield (bu/ac)	Grain Protein (%)	Flag leaf burn (%)
Time of post-anthesis N (T)			
Heat of Day	35.0	17.38 a	28.2 b
Cool of Evening	36.0	17.02 b	38.1 a
LSD	NS	0.31	5.6
Method of applying post-anthesis N (30 lb/ac) (M)			
UAN (28%N) dribble banded[1]	34.5	16.83 b	30.6
UAN (14%N) broadcast[2]	37.8	17.49 a	33.6
Urea Sol'n (14%N) broadcast[3]	34.1	17.20 ab	35.0
Urea Sol'n (9%N) broadcast[3]	35.0	17.29 a	33.5
LSD	NS	0.43	NS
V by N interaction	NS	NS	NS

[1] Sprayed with dribble band nozzle at 10 ga/ac (undiluted UAN =28% N solution)
[2] Sprayed with 02 flat fan nozzles at 20 ga/ac (10 ga/ac UAN + 10 ga/ac water = 14% N solution)
[3] Spray with 02 flat fan nozzles at 20 ga/ac (1.66 Kg of urea dissolved in 1 US gallon of water = 14% N solution)

Table 6a Economic comparisons assuming protein of $0.6/%/bu for all levels of protein.			
Method of Application (side-banded (SB) and post-anthesis)	**Gross ($/ac)[4]**	**Cost of N + Cost of split app ($/ac)[5]**	**Gross minus costs of N and split app ($/ac)**
1. 70 lb N/ac Side-banded (SB)	257.13	35	257.13
2. 100 lb N/ac Side-banded (SB)	257.10	50	257.10
3. 70 lb N/ac SB + 30 lb N/ac UAN (28%N) dribble banded[1] in heat of day	231.57	55	231.57
4. 70 lb N/ac SB + 30 lb N/ac UAN (28%N) dribble banded[1] in cool evening	248.31	55	248.31
5. 70 lb N/ac SB + 30 lb N/ac UAN (14%N) broadcast[2] in heat of day	287.00	55	287.00
6. 70 lb N/ac SB + 30 lb N/ac UAN (14%N) broadcast[2] in cool evening	278.76	55	278.76
7. 70 lb N/ac SB + 30 lb N/ac Urea Sol'n (14%N) broadcast[3] in heat of day	244.00	55	244.00
8. 70 lb N/ac SB + 30 lb N/ac Urea Sol'n (14%N) broadcast[3] in cool evening	242.54	55	242.54
9. 70 lb N/ac SB + 30 lb N/ac Urea Sol'n (9%N) broadcast[3] in heat of day	263.26	55	263.26
10. 70 lb N/ac SB + 30 lb N/ac Urea Sol'n (9%N) broadcast[3] in cool evening	244.28	55	244.28

[1] Sprayed with dribble band nozzle at 10 ga/ac (undiluted UAN =28% N solution)
[2] Sprayed with 02 flat fan nozzles at 20 ga/ac (10 ga/ac UAN + 10 ga/ac water = 14% N solution)
[3] Spray with 02 flat fan nozzles at 20 ga/ac (1.66 Kg of urea dissolved in 1 US gallon of water = 14% N solution)
[4] $/bu to determine Gross $/ac assumed $8.04/bu @ 16% protein and protein premiums of $0.6/%/bu for all protein levels.
[5] $0.5/ lb N was used for all N sources and cost of split application assumed to be $5/ac.

Table 6b Economic comparisons assuming no further protein premiums for 16.5% and higher.

Method of Application (side-banded (SB) and post-anthesis)	Gross ($/ac)[4]	Cost of N + Cost of split app ($/ac)[5]	Gross minus costs of N and split app ($/ac)
1. 70 lb N/ac Side-banded (SB)	292.13	35	257.128
2. 100 lb N/ac Side-banded (SB)	302.74	50	252.742
3. 70 lb N/ac SB + 30 lb N/ac UAN (28%N) dribble banded[1] in heat of day	278.56	55	223.556
4. 70 lb N/ac SB + 30 lb N/ac UAN (28%N) dribble banded[1] in cool evening	296.90	55	241.904
5. 70 lb N/ac SB + 30 lb N/ac UAN (14%N) broadcast[2] in heat of day	312.75	55	257.75
6. 70 lb N/ac SB + 30 lb N/ac UAN (14%N) broadcast[2] in cool evening	317.75	55	262.754
7. 70 lb N/ac SB + 30 lb N/ac Urea Sol'n (14%N) broadcast[3] in heat of day	282.73	55	227.726
8. 70 lb N/ac SB + 30 lb N/ac Urea Sol'n (14%N) broadcast[3] in cool evening	285.23	55	230.228
9. 70 lb N/ac SB + 30 lb N/ac Urea Sol'n (9%N) broadcast[3] in heat of day	296.90	55	241.904
10. 70 lb N/ac SB + 30 lb N/ac Urea Sol'n (9%N) broadcast[3] in cool evening	286.90	55	231.896

[1] Sprayed with dribble band nozzle at 10 ga/ac (undiluted UAN =28% N solution)
[2] Sprayed with 02 flat fan nozzles at 20 ga/ac (10 ga/ac UAN + 10 ga/ac water = 14% N solution)
[3] Spray with 02 flat fan nozzles at 20 ga/ac (1.66 Kg of urea dissolved in 1 US gallon of water = 14% N solution)
[4] $/bu to determine Gross $/ac assumed $8.04/bu @ 16% protein and protein premiums of $0.6/%/bu for all protein levels.
[5] $0.5/ lb N was used for all N sources and cost of split application assumed to be $5/ac.

Test Weight Stability of Grain Miller's Recommended Oat Varieties for Northeastern Saskatchewan

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1. Abstract/Summary:

A study was established near Yorkton, SK to demonstrated the impact of increasing rates of soil + fertilizer N (80, 120 and 160 lb N/ac) on 5 varieties of milling oats (CS Camden, Summit, CDC Ruffian, CDC Minstrel and Leggett). Drought stress resulted in a short crop and yields that were well below average. Increasing rates of N beyond 80 lb/ac did not increase oat yield but did reduce test weights. However, test weights for all varieties except CS Camden were not reduced below the discount level of 245 g/0.5l regardless of N rate. At rates of soil + fertilizer N of 120 lb/ac or more, CS Camden would have been discounted on the basis of low test weight. Summit had a significantly higher test weight than any other variety and producers who have struggled with test weight should consider this variety. Under the conditions of this study, CDC Ruffian had the best performance. It was significantly higher yielding than all other varieties by about 19% on average and maintained adequate test weight. While CDC Ruffian has performed well in other study it also had the lowest emergence rate in this study, which may have supported higher yield due to less interplant competition for moisture during the drought.

2. Project objectives:

The objectives of this project are to demonstrate the following concepts:

- Oat test weights decline with higher rates of nitrogen (N).
- Test weight for Summit and Leggett are higher than those for CS Camden, CDC Ruffian and CDC Minstrel at low and high rates of N.
- Yields of Summit and Leggett can be pushed by higher rates of N compared to CS Camden, CDC Ruffian and CDC Minstrel with less risk of rejection for milling based on low test weight.

3. Project Rationale:

Producers typically fertilize oats in the range of 60 to 90 kg N/ac. However, oat yield at the Yorkton research farm typically responds to rates of 120 kg N/ac or more. This is not uncommon, as May et al. found 120 kg N/ha was required to maximize yield at 6 out of 11 site years in a study conducted at various locations in eastern Saskatchewan from 2014 to 2016[1]. Producers do not typically apply N at rates to maximize yield in order to maintain milling acceptance, as high rates of N can lower test weights [2,3].

Grain Miller's have 5 oat varieties on their "Recommended" list for northeastern Saskatchewan. These varieties, listed in Table 1, are popular and constitute much of crop insured acres. Test weights, as published in Saskatchewan's "Varieties of Grain Crops 2019" vary substantially between these varieties (Table 1). Summit and Leggett have substantially higher test weights than the rest and have demonstrated greater test weight stability to increasing rates of N in a study lead by Bill May from AAFC Indian Head[1]. In this study, Stride was used as a check variety at each site but varietal comparisons differed between locations. So comparisons between all varieties are based on relative performance to Stride. Compared to the oat variety Stride, the test weight of Camden and Ruffian were 3.4 and 3.9 % lower, respectively at Indian Head and Minstrel was 4.6% lower at Melfort. Comparisons between Summit and Leggett with the check variety Stride were more similar with the test weight of Summit being only 1% lower at Yorkton and Leggett being 1.6% lower at Redvers. In other words, this study indirectly found the test weights of Summit and Leggett are higher and these varieties can receive more N before test weights are reduced to discount levels compared to CS Camden, CDC Ruffian and CDC Minstrel.

Table 1. Test weights and Saskatchewan acres of recommended varieties for milling oats (Grain Millers)

Variety	2018 Acres Grown in SK according to SCIC	Test Weight (g/0.5L) from Varieties of Grain Crops 2019
CS Camden	140,830	242
Summit	36,387	256
CDC Ruffian	21,761	247
CDC Minstrel	9,469	245
Leggett	8,920	256

[1]The Test Weight Stability and Yield Response of New and Established Oat Cultivars to Fertilizer N. Prairie Oat Growers Adopt 20150418

[2] May, W., Mohr, R., Lafond, G., Johnston, A. and C. Stevenson. 2004b. Effect of nitrogen, seeding date and cultivar on oat quality and yield in the eastern Canadian Prairies. Can. J. Plant Sci. 84: 1025-1036.

[3] Lafond, G., May, W. and C. Holzapfel. 2013. Row Spacing and Nitrogen Fertilizer Effect on No-Till Oat Production. Agron. J. 105: 1-10.

4. Methodology:

A factorial design was used to determine the response of 5 oat varieties (first factor) to increasing rates of N (second factor). Rates of applied N were adjusted based on soil N found in the top 2 feet of soil, which was 38 lb N/ac at the trial site. The 10 treatments were arranged as a Randomized Complete Block Design (RCBD) with 4 replicates (Table 2). Plot sizes were 11 by 30 ft and seeded with a 10 ft wide Seedmaster drill on 12-inch row spacing. Oat varieties had seeding rates targeting 350 seeds/m^2. Fungicide was not applied as little disease was present due to drought conditions. Every plot received 30 lb P_2O_5/ac of side-banded phosphorus. The middle 4 rows by 30ft of each plot were harvested with a Wintersteiger plot combine to reduce edge effects.

Table 2. Treatment List

Trt #	Variety	Lb N/ac (soil + Fertilizer)[1]
1	CS Camden	80
2	CS Camden	120
3	CS Camden	160
4	Summit	80
5	Summit	120
6	Summit	160
7	CDC Ruffian	80
8	CDC Ruffian	120
9	CDC Ruffian	160
10	CDEC Minstrel	80
11	CDEC Minstrel	120
12	CDEC Minstrel	160
13	Leggett	80
14	Leggett	120
15	Leggett	160

[1]Rate of N includes soil N in the top 2 feet of soil + applied fertilizer
Soil test results are in Figure 1.

Dates of operations are found in table 3.

Table 3. Dates of operations.	
Operations in 2020	Yorkton
Pre-seed Herbicide Application	N/A
Seeding Date	May 11
Emergence Counts	June 22
In-crop Herbicide Application	May 29 (Prestige)
Fungicide Application	N/A
Lodging	N/A
Height	July 17
Maturity	July 30
Harvest	Aug 26

5. Results

Seeding rates were adjusted for each variety to deliver 350 live seeds/m^2 based on vigor test results and 1000 kernel weight. When averaged across N rate, this resulted in an emergence rate as high as 318 plants/m^2 for CS Camden to a low of 236 plants/m^2 for CDC Ruffian (Table 5). Emergence rates for Summit, CDC Minstrel and Leggett were in the middle and did not significantly differ from each other. The variability in emergence between varieties was greater than desired, but populations for each variety were sufficient to be not yield limiting. Increasing rates of N were side-banded and did not significantly affect emergence.

While the crop got off to a good start, the season was very dry. The drought resulted in a very short, early maturing and low yielding crop. CS Camden at only 51.7 cm tall was significantly shorter than all other varieties (Table 5). Summit at 61.4 cm tall was significantly taller than all other varieties. CDC Ruffian, CDC Minstrel and Leggett were in the middle and did not significantly differ from each other. Increasing rate of N did not significantly affect height of any variety (ie: no interactions). There was absolutely no perceived level of lodging in this trial due to the drought and short stature of the crop (data not shown). CS Camden reached physiological maturity before all other varieties on the Julian day of 212.5 (Table 5). Summit matured a day later and the remaining varieties matured about 3 to 4 days later than CS Camden. Increasing rate of N delayed maturity by 1 day, which is not agronomically consequential. The average oat yield for the whole trial was 2514 kg/ha which is only 66 bu/ac and is about 40% of normal. At 2900.1 kg/ha, CDC Ruffian yielded significantly more than all other varieties. Having significantly lower emergence, relative to the other varieties during a drought, may have given CDC Ruffian a yield advantage due to less interplant competition for moisture. However, CDC Ruffian has been a high yielding variety in past studies. The yield of the remaining varieties did not statistically differ. Increasing rates of N did not increase oat yield for any variety. Oats were unresponsive to rates of soil + fertilizer N above 80 lb/ac due to reduced yield potential from the drought.

Despite drought stress during flowering and grain filling, test weights for all varieties except CS Camden were always above the discount level of 245 g/0.5l regardless of N rate (Table 6). At rates of soil + fertilizer N of 120 lb/ac or more, CS Camden would have been discounted on the basis of low test weight (Table 6). As discovered in past study, Summit had the highest test weight of all varieties. Significant differences between varieties were detected for % thins (Table

5). However, the levels were very low for each variety (ie: less than a percent). Based on % dehulls, many of the varieties were being threshed too hard. However, there were substantially significant differences between varieties. CS Camden and Leggett had relatively few dehulls ranging from 1.7 to 3.6 % compared to all the other varieties which ranged from 10.8 to 12.9%. The susceptibility to dehulling does not seem to be related to maturity as CS Camden and Leggett both had low levels of dehulling despite being at opposite extremes for maturity.

6. Conclusions and Recommendations

Some of the anticipated concepts were demonstrated by this project despite the drought. Oat test weight did decline with increasing rates of N and Summit did have the highest test weight of the varieties tested. Leggett also had a decent test weight but perhaps not as high as expected relative to CDC Ruffian and CDC Minstrel. CS Camden had the lowest test weight, which is in keeping with past research. The optimum N rate differing between varieties was not observed, as all varieties were unresponsive to N rates beyond the lowest rate tested in this study due to the drought.

Under the conditions of this study, CDC Ruffian had the best performance. It was significantly higher yielding than all other varieties by 19% on average and maintained adequate test weight. It did have a lot of dehulls but that should be possible to manage with proper combine setting. Like all other varieties in this study, Leggett yielded less than CDC Ruffian but it had a higher test weight and much fewer dehulls. CS Camden also had few dehulls but its low test weight is cause for concern. Producers who have had an issue with test weight in the past should consider growing Summit.

7. Acknowledgements:

This project was funded through the Agriculture Demonstration of Practices and Technologies ADOPT.

8. Appendices

Figure 1. Soil test results taken in the spring of 2020 prior to seeding

Nutrient In The Soil	Depth	Result
Nitrate	0-6"	27 lb/acre
	6-12"	23 lb/acre
	12-24"	10 lb/acre
	0-24"	60 lb/acre
Phosphorus	Olsen	10 ppm
Potassium		266 ppm
Chloride		
Sulfur	0-6"	62 lb/acre
	6-12"	16 lb/acre
Boron		
Zinc		1.45 ppm
Iron		
Manganese		
Copper		
Magnesium		481 ppm
Calcium		3923 ppm
Sodium		18 ppm
Org Matter		5.7 %
Carbonate(CCE)		
Sol. Salts	0-6"	0.47 mmho/cm
	6-12"	0.38 mmho/cm

	1st Crop Choice		2nd Crop Choice		3rd Crop Choice	
Crop	Wheat-Spring		Oats		Barley-Malting	
YIELD GOAL	70 BU		140 BU		80 BU	
SUGGESTED GUIDELINES	Band		Band		Band	
	LB/ACRE	APPLICATION	LB/ACRE	APPLICATION	LB/ACRE	APPLICATION
N	129		80		64	
P_2O_5	36	Band *	31	Band *	29	Band *
K_2O	10	Band (Starter)*	10	Band (Starter)*	10	Band (Starter)*
Cl						
S	0		0		0	
B						
Zn	0		0		0	
Fe						
Mn						
Cu						
Mg	0		0		0	
Lime						

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.2 6-24" 7.7		24.5 meq	(65-75) 80.1	(15-20) 16.4	(1-7) 2.8	(0-5) 0.3	(0-5) 0.4

General Comments: Medium-textured (CEC: 11-30 meq)
Percent hydrogen is estimated from water pH. CEC corrected for exchangeable acidity.

Crop 1: "CAUTION: Seed-placed fertilizer can cause injury." May respond to starter P & K, even on high soil tests. Crop nutrient removal: P2O5 = 44 K2O = 26 AGVISE Band guideline will build P & K test levels to the medium range over several years.

Crop 2: "CAUTION: Seed-placed fertilizer can cause injury." May respond to starter P & K, even on high soil tests. Crop nutrient removal: P2O5 = 35 K2O = 27 AGVISE Band guideline will build P & K test levels to the medium range over several years.

Crop 3: "CAUTION: Seed-placed fertilizer can cause injury." May respond to starter P & K, even on high soil tests. Crop nutrient removal: P2O5 = 38 K2O = 40 AGVISE Band guideline will build P & K test levels to the medium range over several years.

Table 5. Main Effects of Variety and Nitrogen Rate on Oat Emergence, Height, Maturity, Yield, Test Weight, Thins and Dehulls.					
	Emergence (plants/m^2)	**Height (cm)**	**Maturity**	**Yield (kg/ha)**	**Test Weight (g/0.5L)**
Variety (V)					
CS Camden	318.3 a	51.7 c	212.5 c	2484.2 b	245.1d
Summit	261.8 b	61.4 a	213.7 b	2296.3 b	269.0 a
CDC Ruffian	236.3 c	56.6 b	216.6 a	2900.1 a	252.9 c
CDC Minstrel	282.8 b	55.7 b	216.2 a	2449.3 b	260.5 b
Leggett	274.3 b	55.5 b	215.8 a	2440.4 b	259.7 b
LSD	24.76	2.91	0.95	283.20	4.39
Nitrogen Rate (R) (soil + fertilizer) (lb N/ac)					
80	285.9	57.3	214.4 b	2579.7	259.4
120	268.6	56.2	215.1 ab	2419.3	257.2
160	269.7	55.1	215.4 a	2543.1	255.7
LSD	NS	NS	0.74	NS	NS
V by N interaction	NS	NS	NS	NS	NS

Table 5 continued. Main Effects of Variety and Nitrogen Rate on Oat Emergence, Height, Maturity, Yield, Test Weight, Thins and Dehulls.		
	Thins (%)	**Dehulls (%)**
Variety (V)		
CS Camden	0.65 ab	1.7 b
Summit	0.65 ab	12.9 a
CDC Ruffian	0.32 c	11.9 a
CDC Minstrel	0.44 bc	10.8 a
Leggett	0.70 a	3.6 b
LSD	0.22	2.21
Nitrogen Rate (R) (soil + fertilizer) (lb N/ac)		
80	0.52 a	8.7 a
120	0.51 a	8.4 a
160	0.63 a	7.4 a
LSD	NS	NS
V by N interaction	NS	NS

Table 6. Variety and N Rate Interactions on Oat Emergence, Height, Maturity, Yield, Test Weight, Thins and Dehulls					
Treatment	**Emergence (plants/m^2)**	**Height (cm)**	**Maturity**	**Yield (kg/ha)**	**Test Weight (g/0.5L)**
Camden					
80	318.0	53.8	212.0	2575.0	248.9
120	311.8	50.5	212.8	2416.8	242.8
160	325.3	50.9	212.8	2460.8	243.6
Summit					
80	280.3	63.8	213.0	2544.5	272.1
120	249.8	58.3	214.3	2005.3	267.6
160	255.5	62.3	213.8	2339.0	267.5
Ruffian					
80	240.0	56.1	215.8	2887.5	252.8
120	241.5	60.4	216.8	2885.8	253.4
160	227.3	53.4	217.3	2927.0	252.3
Minstrel					
80	297.3	57.8	215.5	2580.3	262.7
120	257.3	54.4	216.5	2323.8	259.7
160	294.0	55.0	216.5	2443.8	259.0
Leggett					
80	293.8	55.3	215.8	2311.3	260.6
120	282.8	57.4	215.3	2465.0	262.5
160	246.3	53.9	216.5	2545.0	256.1
LSD	42.9	5.1	1.7	490.5	7.6

Table 6 continued. Variety and N Rate Interactions on Oat Emergence, Height, Maturity, Yield, Test Weight, Thins and Dehulls		
Treatment	**Thins (%)**	**Dehulls (%)**
Camden		
80	0.53	1.9
120	0.70	1.7
160	0.73	1.4
Summit		
80	0.55	13.3
120	0.63	14.1
160	0.78	11.3
Ruffian		
80	0.35	13.7
120	0.30	11.6
160	0.30	10.5
Minstrel		
80	0.48	10.2
120	0.48	11.6
160	0.38	10.7
Leggett		
80	0.68	4.4
120	0.45	3.4
160	0.98	3.1
LSD	0.39	3.83

Demonstrating 4 R Nitrogen principles in relation to yield and protein management of spring wheat.

Mike Hall[1] and Heather Sorestad[1]

[1]East Central Research Foundation, Yorkton, SK.

1. Abstract/Summary:

A trial was established near Yorkton, SK to demonstrate how different approaches to N management can affect yield and grain protein of spring wheat. The summer was very dry resulting in low yield but high grain proteins. There were no significant yield or grain protein differences detected between treatments. Numerically, there was little evidence that AGROTAIN provided any yield or grain protein increases for broadcast urea or dribble banded UAN at the 3 leaf stage. AGROTAIN treated UAN, dribble banded at the boot stage, resulted in a higher yield and lower protein which doesn't make agronomic sense as late season applications of N should have little effect on yield and increase grain protein. This unexpected difference is likely the result of experimental variation and was not statistically significant. Numerically, applying an extra 30 lb N/ac as dribble-banded UAN at the boot stage or as side-banded urea did increase grain protein by approximately 0.5% compared to either 70 or 100 lb N/ac of side-banded N. However, the yield associated with 100 lb N/ac of side-banded urea produced a higher yield. While increasing grain protein with late season N appeared possible, side-banding all the nitrogen at seeding likely was the better option under dry conditions as it tended to result in higher yield and provided greater economic returns.

2. Project Objectives:

The objective of this project was to demonstrate how nitrogen use efficiency can vary between different approaches to maximize wheat yield and grain protein.

Specifically, the following concepts were intended to be demonstrated:

- Side-banding N at seeding is ideal. However, full yield potential can still be realized provided surface applications of N are made prior to tillering and sufficient and timely rainfall is received to leach N into the root zone. If conditions are conducive for volatilization, nitrogen use efficiency as indicated by yield and protein responses will be greater for dribble banded UAN compared to broadcast urea and when the urease inhibitor AGROTAIN is used.
- Protein content of wheat grain can be increased by dribble banding 30 lb N/ac of UAN at the boot stage provided sufficient rainfall is received after application. Again, AGROTAIN will improve N efficiency if conditions are conducive for volatilization
- Protein content of wheat grain can also be increased by adding 30 lb N/ac of ESN in the side-band because the ESN will release N late in the season.
- Applying an extra 30 lb N/ac as either side-banded ESN or dribble-banded UAN at the boot stage may not improve yield or grain protein beyond what is achieved by just side-banding an extra 30 lb N/ac of urea and seeding.

3. Project Rationale:

Side-banding nitrogen (N) is generally recognized as the most efficient way to fertilize wheat in Saskatchewan. However, applying the full N requirement at seeding slows operations by increasing the time spent filling the seeder. Producers faced with time constraints may opt to apply the bulk of the required N post seeding. However, surface applied N must be leached into the rooting zone before tillering in order to maintain wheat yield [1,2]. If sufficient and timely rainfall is not received, N fertilizer may be stranded at the soil surface or lost to volatilization. Volatilization losses can be minimized by dribble banding UAN instead of broadcasting urea or using a urease inhibitor such as AGROTAIN. UAN is less prone to volatilization, because unlike urea, it does not increase the initial pH at the application site which encourages the production of ammonia gas [2].

When N is applied late in the growing season it goes mostly towards increasing grain protein and not yield. This is of interest to producers as high protein wheat can be sold for a premium. Many studies, dating back the 1990s, have shown post-emergent applications of nitrogen can increase grain protein when made at late vegetative stages. Guy Lafond assessed the feasibility of applying foliar N at both the boot stage and post-anthesis for spring and winter wheat [4]. He determined that this practice had merit but the results could be variable depending on initial N supply and weather conditions. However, dribble banding at the earlier boot stage increased grain protein more consistently and reduced the potential for leaf burn. To be effective, dribble banded UAN must be moved into the rooting zone by precipitation. Again, the addition of AGROTAIN has the potential to reduce N loss should conditions be conducive for volatilization.

Wheat grain protein can also be increased by using Environmentally Smart Nitrogen (ESN) [3]. ESN is urea coated in a polymer which delays the release of the granule. Producers can effectively delay the release of nitrogen by side-banding a portion of the urea as ESN. This late season release of nitrogen goes towards increasing protein.

[1]Roberts, T.L., H.H. Janzen and C.W. Lindwall. 1992. Nitrogen Fertilization of Spring Wheat by Point Injection. J. Prod. Agric. 5:586-590.

[2]Heard, J. and D. Flaten Spring Options for Applying Nitrogen Fertilizer to Cereals and Oilseeds in 2017. https://www.canolawatch.org/wp-content/uploads/2017/03/Spring-N-options-for-MB-cereals-oilseeds-2017.pdf

[3]Heard, J., B. Sabourin, A. Faroq and L.A. Kaminski. On Farm Trial Results published in a Nutrien Publication "Facts From the Field: ESN Can Significantly Increase Protein for Hard Red Spring Wheat" https://www.smartnitrogen.com/sites/default/files/general/documents/trial/2099_1108_AG_FFTF_ESN_CANADA_MB_HARDREDSPRINGWHEAT_FINALhi.pdf

[4]Lafond, G and J. McKell. 1998. The Effects of Foliar Applied Nitrogen on Grain Protein Concentration in Spring and Winter Wheat. Proceedings of the Wheat Protein Symposium 298-304

4. Methodology:

This trial established 9 treatments as a Randomized Complete Block Design (RCBD) with 4 replicates (Table 1). Plot sizes were double wide (22 by 30 ft) to accommodate a 3 point tractor sprayer and seeded with a 10 ft wide Seedmaster drill on 12-inch row spacing. Monoammonium phosphate was seed placed at a rate of 59 lb/ac at seeding. Redberry wheat was seeded targeting 300 seeds/m². The middle four rows from each plot were harvested with a Wintersteiger plot combine. Other macronutrients and pest control products were applied so as to be non limiting to crop production. Dates of operations are found in table 2.

Table 1. Treatment List

Trt #	Lb N/ac Side-banded	Lb N/ac broadcast or dribble banded prior to tillering	Lb N/ac dribble banded at boot stage
1	70 (Urea)	*none*	*none*
2	100 (Urea)	*none*	*none*
3	*none*	70 (Urea)	*none*
4	*none*	70 (Urea + AGROTAIN)	*none*
5	*none*	70 (UAN)	*none*
6	*none*	70 (UAN + AGROTAIN)	*none*
7	70 (Urea) + 30 (ESN)	*none*	*none*
8	70 (Urea)	*none*	30 (UAN)
9	70 (Urea)	*none*	30 (UAN + AGROTAIN)

Table 2. Dates of operations for the 2020 "Demonstrating 4 R Nitrogen principles in relation to yield and protein management of spring wheat." trial.	
Operations in 2020	Yorkton
Pre-seed Herbicide Application	N/A
Seeding Date	May 5
Emergence Counts	May 25
3 Leaf Stage Broadcast and Dribble Band Nitrogen Products	May 29
In-crop Herbicide Application	June 2 (Prestige) & June 8 (Simplicity)
Boot Stage Dribble Band Nitrogen Products	June 22
Fungicide Application	July 2 (Caramba)
Flag Leaf Burn Rating	July 2
Lodging	N/A
Harvest	Aug 11

5. Results:

Soil test results are in Figure 1.

The spring wheat emerged well averaging 285 plants/m^2. However, the season was very dry and the wheat only averaged 2115 kg/ha (31.5 bu/ac) with very high grain protein averaging 17.1%. Neither yield nor grain protein significantly differed between treatments. Numerically, increasing side-banded urea from 70 to 100 lb N/ac increased yield from 2199 to 2444 kg/ha and increased grain protein from 17.1 to 17.2% (Table 4). Broadcast urea and dribble banding UAN at 70 lb N/ac with and without AGROTAIN produced yields and grain proteins that were similar to those produced from 70 lb N/ac of side-banded urea. Broadcast and dribble-banded applications were made at the 3 leaf stage on May 29th. From June 6 to 8th, 15.7mm of rain was received, which may have been enough to move the N into the root zone. With hindsight, there should have been a 0 N check in this study to determine the responsiveness of the site to added N. This would have helped to determine if applications of N at the 3 leaf stage successfully maintained yield potential.

The addition of 30 lb N/ac as side-banded ESN or dribble banded UAN at the boot stage numerically increased grain protein by approximately 0.5% relative to 70 or 100 lb N/ac of side-banded urea. However, relative to 100 lb N/ac of side-banded urea, it resulted in numerically lower yield. Oddly, the addition of AGROTAIN to dribble banded UAN at the boot stage increased yield and decreased grain protein. Boot stage applications were made on June 22. On June 28, 7 mm of rainfall was the only substantial rainfall received within two weeks on application. Flag leaf burn from dribbled banded UAN at the boot stage was fairly low at 3.8%. This level of damage increased to 7.7% with the addition of AGROTAIN. Only AGROTAIN treated UAN resulted in statistically more leaf damage relative to an unsprayed check (trt 1).

In order to make fair economic comparisons between treatments, gross returns minus the cost of N rate and source along with any added cost of a split application has been presented in table 5. The gross returns have been presented with and without the benefit of a protein premium. When assuming a protein premium of $0.6/%/bu, applying 70 lb N/ac in the side-band was more economical than broadcasting urea or dribble banding UAN. The use of AGROTAIN with urea or UAN was even less economic due to the lower yield and protein and the added cost of the product. Protein levels were very high in this trial and realistically protein premiums would not likely be offered above 16.5% protein. However, the economic comparison did not change much when omitting the premium as protein varied modestly between these treatments. When applying 100 lb N/ac, side-banding the total amount as urea was considerably more economic than side-banding a blend of urea at 70 lb N/ac with ESN at 30 lb N/ac. This was particularly apparent when no premiums for protein were considered as the use of ESN did numerically increase grain protein. Split applying 70 lb N/ac of side-banded urea with 30 lb N/ac of dribble banded UAN or AGROTAIN treated UAN at the boot stage were also less economic compared to side-banding all the N as urea at seeding. However, the use of AGROTAIN with UAN in this instance did increase gross returns because of greater yields. While products such as AGROTAIN and ESN showed some benefits agronomically, side-banding all required N at seeding was most economic.

6. Conclusions and Recommendations

The lack of significant statistical differences between treatments makes it hard to draw strong conclusions. There was little evidence that the use of AGROTAIN with broadcast urea or dribble banded UAN at the 3 leaf stage or dribble banded UAN at the boot stage provided any yield or protein benefits. However, the addition of 30 lb N/ac as side-banded ESN or dribble banded UAN at the boot stage numerically increased grain protein by about 0.5%. The best approach under the dry conditions of this study was to side-band all the N requirement at seeding. This tended to result in the highest yield and produced the greatest economic returns.

7. Acknowledgements:

This project was funded through the Agriculture Demonstration of Practices and Technologies ADOPT and Fertilizer Canada.

8. Appendices

Figure 1. Soil test results taken in the spring of 2020 prior to seeding

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K_2O	10	Band (Starter)*	10	Band (Starter)*	10	Band (Starter)*
Cl						
S	0		0		0	
B						
Zn	0		0		0	
Fe						
Mn						
Cu						
Mg	0		0		0	
Lime						

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
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Crop 1: "CAUTION: Seed-placed fertilizer can cause injury." May respond to starter P & K, even on high soil tests. Crop nutrient removal: P2O5 = 44 K2O = 26 AGVISE Band guideline will build P & K test levels to the medium range over several years.

Crop 2: "CAUTION: Seed-placed fertilizer can cause injury." May respond to starter P & K, even on high soil tests. Crop nutrient removal: P2O5 = 35 K2O = 27 AGVISE Band guideline will build P & K test levels to the medium range over several years.

Crop 3: "CAUTION: Seed-placed fertilizer can cause injury." May respond to starter P & K, even on high soil tests. Crop nutrient removal: P2O5 = 38 K2O = 40 AGVISE Band guideline will build P & K test levels to the medium range over several years.

Table 4 Main Treatment Effects on Emergence, Yield and Protein			
Treatment	**Emergence (plants/m^2)**	**Yield (kg/ha)**	**Protein (%)**
1. 70 lb N/ac of Urea side-banded at seeding	295.8 a	2199.3 a	17.1 a
2. 100 lb N/ac of Urea side-banded at seeding	281.0 a	2444.0 a	17.2 a
3. 70 lb N/ac of Urea broadcasted prior to tillering	284.0 a	2082.3 a	17.3 a
4. 70 lb N/ac of AGROTAIN broadcasted prior to tillering	288.5 a	1900.8 a	16.9 a
5. 70 lb N/ac of UAN dribble banded prior to tillering	264.0 a	2021.0 a	16.9 a
6. 70 lb N/ac UAN +AGROTAIN dribble banded prior to tillering	271.0 a	2053.5 a	16.8 a
7. 70 lb N/ac of Urea + 30 lb N/ac of ESN side-banded at seeding	291.5 a	1945.3 a	17.7 a
8. 70 lb N/ac of Urea side-banded at seeding + 30 lb N/ac of UAN dribble banded at the boot stage	297.0 a	1915.5 a	17.6 a
9. 70 lb N/ac of Urea side-banded at seeding + 30 lb N/ac of UAN + AGROTAIN dribble banded at the boot stage	293.3 a	2477.5 a	16.9 a
P-values	NS	NS	NS
LSD	NS	NS	NS

Table 5 Main Treatment Effects on Emergence, Yield and Protein

Treatment	Gross (with protein premium)[1] minus Cost of N and split app. ($/ac)[3]	Gross (without protein premium)[2] minus cost of N and split app. ($/ac)[3]
1. 70 lb N/ac of Urea side-banded at seeding	249.68	228.09
2. 100 lb N/ac of Urea side-banded at seeding	268.54	242.36
3. 70 lb N/ac of Urea broadcasted prior to tillering	233.26	209.09
4. 70 lb N/ac of AGROTAIN broadcasted prior to tillering	196.35	181.08
5. 70 lb N/ac of UAN dribble banded prior to tillering	218.00	201.76
6. 70 lb N/ac UAN +AGROTAIN dribble banded prior to tillering	215.41	200.75
7. 70 lb N/ac of Urea + 30 lb N/ac of ESN side-banded at seeding	208.03	178.50
8. 70 lb N/ac of Urea side-banded at seeding + 30 lb N/ac of UAN dribble banded at the boot stage	201.50	174.14
9. 70 lb N/ac of Urea side-banded at seeding + 30 lb N/ac of UAN + AGROTAIN dribble banded at the boot stage	259.17	239.27

[1]Calculation based on $8.04/bu @16% protein with $0.6/%/bu protein premium for all values above 16%.

[2]Calculation based on $8.04/bu for all treatments (no protein premium)

[3]Cost of N is $0.5/lb of N for urea and UAN. ESN, SUPERU, AGROTAIN with UREA and AGROTAIN with UAN costs an additional $0.14, $0.12, $0.09 and $0.07 per lb N. Cost of split application is $5/ac.

Effect of spray management on leaf disease and Fusarium head blight of wheat

Mike Hall[1] and Heather Sorestad[1]

[1]East Central Research Foundation, Yorkton, SK.

1. Abstract/Summary:

A trial was established near Yorkton, SK with the objective to demonstrate the effect of nozzle type, boom height and water volume on spray coverage and control of leaf disease and Fusarium head blight of wheat. Using water sensitive paper, spray coverage using the Bubble Jet nozzle was determined to be good on the front but not the backside of a vertical target. Spray coverage of the front and back of vertical target could be achieved with the TADF dual nozzle which have forward and rearward sprays. However, when the TADF nozzle was used at an excessive height the backside coverage of vertical targets was lost. The optimum operating height for the TADF dual nozzle is only 15 inches above the crop canopy which might be hard to maintain for large sprayers. Unfortunately, the better performance of the TADF dual nozzle could not be related to improved Fusarium head blight control or better yield as the disease pressure was extremely low due to drought.

2. Project objectives:

The objective of this project is to demonstrate the effect of nozzle type, boom height and water volume on spray coverage and control of leaf disease and Fusarium head blight of wheat.

Specifically, the following concepts will be demonstrated:

- A dual nozzle (TADF) will provide better coverage of vertical targets and control of Fusarium head blight (FHB) than a conventional flat fan nozzle (Bubble Jet).
- Operation of nozzles above their optimum height will reduce spray coverage, canopy penetration and control of leaf disease and FHB.
- Increasing water volume improves canopy penetration, coverage and control of leaf disease and FHB

3. Project Rationale:

Dual nozzles, capable of spraying forward and backwards, have been designed to maximize coverage of a vertically standing target such as a wheat head. This is particularly important when applying fungicide for the suppression of fusaium head blight (FHB) in wheat. The Turbodrop Asymmetric DualFan (TADF) is an example of a nozzle designed for this purpose. It is an asymmetric dual fan with a 10-degree forward spray and a 50-degree rearward spray. The optimum height for this nozzle is only 15 inches above the target, which is much lower than it is for conventional nozzles and may be difficult for some producers to maintain. Operating the dual nozzle above its recommended height will reduce the spray coverage of vertical targets. In the March 2013 addition of Top Crop Manager Tom Wolf was quoted as follows: "With the asymmetric design, we also found that we could increase deposition on the vertical target significantly by keeping the boom low. When you have a high boom, the angle the spray leaves the nozzle at very quickly becomes irrelevant. Air resistance and gravity redirect the spray just to fall vertically, or move with prevailing winds. But when you spray very close to the target, the spray is still moving forward and backward as intended." [1]. Operating conventional and dual nozzles above their optimum height will also reduce canopy penetration and control of leaf disease [2].

Increasing water volume also improves coverage, canopy penetration and disease control. Tom Wolf indicates increasing water volume will increase total fungicide droplets reaching the target for enhanced control. While the label for many fungicides recommend a minimum of 10 US ga/ac, targeting water volumes closer to 15 US ga/ac will more likely be beneficial for wheat disease control [3].

[1] Dietz, J. Mar. 2013. "Asymmetric nozzles better for fungicides. Top Crop Manager". https://www.topcropmanager.com/asymmetric-nozzles-better-for-fungicides-13035/

[2] Wolf, T. Best Management Practices for Herbicide Application Technology. Prairie Soils & Crops Journal. Volume 2, 2009 pp 24-30.

[3] Wolf, Tom. Fungicide Application in Cereal, Pulse, and Oilseed Crops. Sprayer 101. https://sprayers101.com/fungicide-application-in-cereal-pulse-and-oilseed-crops/

4. Methodology:

The trial was established as a factorial with 3 factors. Two nozzle types (1st factor) were evaluated at optimum and excessive boom heights (2nd factor) and at water volumes of 8.3 and 12.5 US ga/ac (3rd factor). In this study, a flat fan Bubble Jet represents a conventional nozzle and a Turbodrop Asymmetric DualFan (TADF) with a 10-degree forward spray and a 50-degree rearward spray was representative of a dual nozzle. The 8 treatments that were established are listed in Table 1 and were arranged as a Randomized Complete Block Design (RCBD) with 4 replicates. Plot sizes were 22 by 30 ft and seeded with a 10 ft wide Seedmaster drill on 12-inch row spacing. Monoammonium phosphate and urea were applied as a side-band with rates of 59 lb/ac and 217 lb/ac, respectively. Brandon wheat was seeded targeting 300 plants/m^2. Caramba was applied to all treatments at recommended rates during heading (75% head emergence to 50% anthesis). Four rows from each plot were harvested with a Wintersteiger plot combine. All plots were sprayed at 50 PSI to maintain the same coarseness of spray between treatments. Water volumes were adjusted by changing travel speed and not spray pressure.

Spray coverage was determined using water sensitive paper in front of each plot for the first rep of treatments. A stand was constructed to hold the water sensitive paper in a vertical position to represent the height of the heads and at two horizontal positions to represent the height of the flag and penultimate leaves. This allowed for spray coverage determination on wheat heads (front and back) as well as flag and penultimate leaves.

Table 1. Treatment List

Trt #	Nozzle type	Boom height above target	Pressure psi	Speed mph	Water volume (ga/ac)[1]
1	Bubble Jet 02	Optimum (25 inches)	50	8	8.3
2	Bubble Jet 03	Optimum (25 inches)	50	8	12.5
3	Bubble Jet 02	Too high (36 inches)	50	8	8.3
4	Bubble Jet 03	Too high (36 inches)	50	8	12.5
5	TADF 02	Optimum (15 inches)	50	8	8.3
6	TADF 03	Optimum (15 inches)	50	8	12.5
7	TADF 02	Too high (36 inches)	50	8	8.3
8	TADF 03	Too high (36 inches)	50	8	12.5

Table 2. Dates of operations for the 2020 "Effect of spray management on leaf disease and Fusarium head blight of wheat" trial.	
Operations in 2020	Yorkton
Pre-seed Herbicide Application	N/A
Seeding Date	May 6
Emergence Counts	May 25
In-crop Herbicide Application	June 2 (Prestige) & June 8 (Simplicity)
Fungicide Application	July 3 (Caramba)
Leaf Disease Rating	July 21
FHB Rating	July 24
Lodging	N/A
Pre-harvest Dessicant	July 29? Roundup Transorb
Harvest	Aug 12

5. Results:

The trial emerged well averaging 360 plants/m^2. Due to the drought, yields were low averaging only 2315 kg/ha (34.4 bu/ac) and disease levels were extremely low. No Fusarium damaged heads were observed in field and Fusarium damaged kernels were only detected in a sample from one plot (data not shown). Flag leaf disease ratings were only just above 10% and much of that damage was likely leaf necrosis from drought. The main effects of nozzle type, operation height and water volume were insignificant on leaf disease, yield and grain protein (table 4). Without adequate disease pressure the method of applying fungicide had no influence on disease and therefore no influence on yield or protein. However, the method of application did have an effect on coverage, which was documented using water sensitive paper.

In front of each treatment in the first block, water sensitive paper was placed on a stand to determine the spray coverage received by vertical targets like the wheat head and horizontal targets like the flag and penultimate leaves (Figure 1). On horizontal surfaces, coverage was good for both the conventional Bubble Jet nozzle and the TADF nozzle whether they were operated at optimum or excessive heights above the canopy (figure 2). However, coverage on the vertical target differed between nozzle type and operation height. Spray coverage was excellent on the front but almost non-existent on the back of a vertical target when using a Bubble Jet nozzle (figure 3). This was true for optimum and excessive heights at 12.5 ga/ac and for the optimum height at 8 ga/ac. Strangely, the reverse happened for excessive height at 8 ga/ac. Why this occurred is unknown. The spray day was very calm but it is possible some unusual air current occurred around the boom during application. Front and back coverage of a vertical target was more uniform when using the TADF nozzle at the optimum height (Figure 4). When operated at an excessive height, the coverage of the back of a vertical target became poorer because the spray angle is not maintain over excessive distance due to gravity and wind resistance.

6. Conclusions and Recommendations

Spray coverage of horizontal surfaces like the flag and penultimate leaves was excellent regardless of nozzle type and operation height. However, this was not true for a vertical target such as a wheat head. While the Bubble Jet nozzle provided excellent cover on the front of a vertical target it provided very little coverage on the backside. In contrast, the TADF dual nozzle provided good coverage of the front and backside of a vertical target but only when operating at the optimum height above the canopy. At an excessive height, backside coverage of a vertical target was lost. Unfortunately, the better coverage from using the TADF dual nozzle could not be related to better disease control or improved production. It was a dry year and virtually no Fusarium head blight was present.

Supporting Information

7. Acknowledgements:

This project was funded through the Agriculture Demonstration of Practices and Technologies ADOPT.

8. Appendices

Table 4. Main Treatment Effects Nozzle Type, Height and Water Volume on Leaf Disease, Yield and Protein.

	Leaf Disease (%)	Yield (kg/ha@ 14.5%)	Protein (%)
Nozzle Type			
Bubble Jet	13.1	2238.7	17.3
TADF	11.1	2392.4	16.9
P-value	NS	NS	NS
LSD	NS	NS	NS
Height			
Optimum	11.8	2394.2	17.0
Too High	12.3	2236.9	17.2
P-value	NS	NS	NS
LSD	NS	NS	NS
Water Volume (gal/ac)			
8.3	11.6	2238.7	17.1
12.5	12.6	2392.4	17.2
P-value	NS	NS	NS
LSD	NS	NS	NS

Table 5. Individual Treatment Effects on Leaf Disease, Yield and Protein.			
Treatments	**Leaf Disease (%)**	**Yield (kg/ha)**	**Protein (%)**
1. Bubble Jet 02 nozzles at optimum height applied at 8.3 gal/ac	10.0 a	2261.5 a	17.4 a
2. Bubble Jet 03 nozzles at optimum height applied at 12.5 gal/ac	13.6 a	2180.5 a	17.5 a
3. Bubble Jet 02 nozzles at too high of height applied at 8.3 gal/ac	11.8 a	2128.8 a	17.2 a
4. Bubble Jet 03 nozzles at too high of height applied at 12.5 gal/ac	17.0 a	2384.0 a	17.2 a
5. TADF 02 nozzles at optimum height applied at 8.3 gal/ac	12.5 a	2868.8 a	16.2 a
6. TADF 03 nozzles at optimum height applied at 12.5 gal/ac	11.3 a	2266.0 a	16.9 a
7. TADF 02 nozzles at too high of height applied at 8.3 gal/ac	12.3 a	1695.8 a	17.4 a
8. TADF 03 nozzles at too high of height applied at 12.5 gal/ac	8.3 a	2739.0 a	17.1 a
9. No Fungicide Control (not replicated)	7.2	1931.9	17.5
P-values	NS	NS	NS
LSD	NS	NS	NS

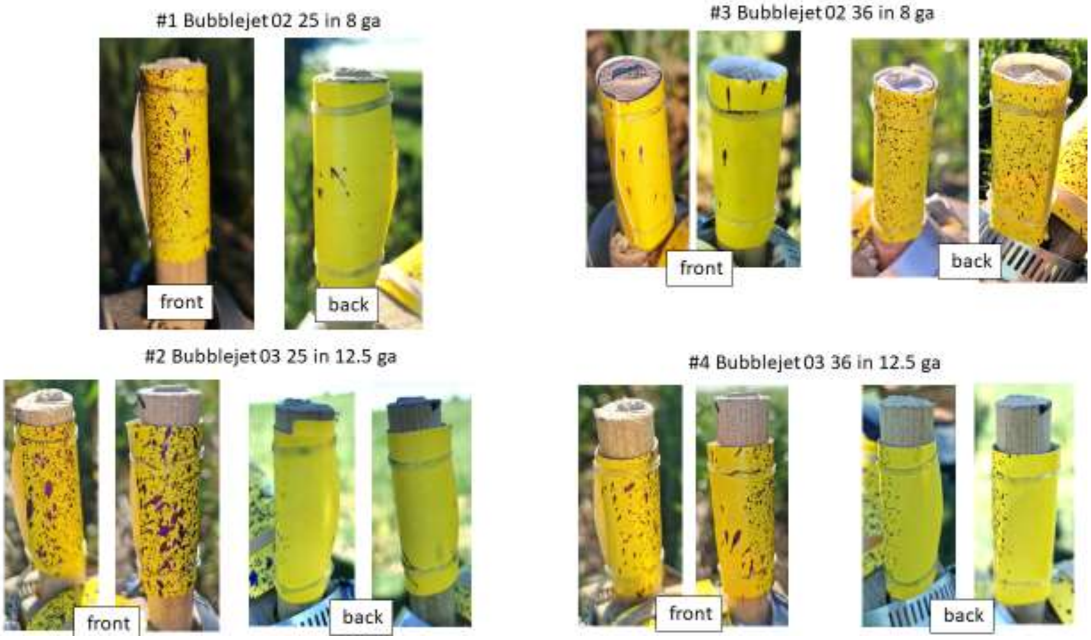
Figure 1. Stand with water sensitive paper to determine spray coverage received by wheat head, flag leaf and penultimate leaf.

Figure 2. Spray coverage from a Bubble Jet (conventional nozzle) and a TADF (dual nozzle) when operated at optimum[1] and excessive[2] heights at water volumes of 8 and 12.5 ga/ac.

[1]Optimum heights for the TADF and Bubble Jet nozzles were 15 and 25 inches above the canopy, respectively.

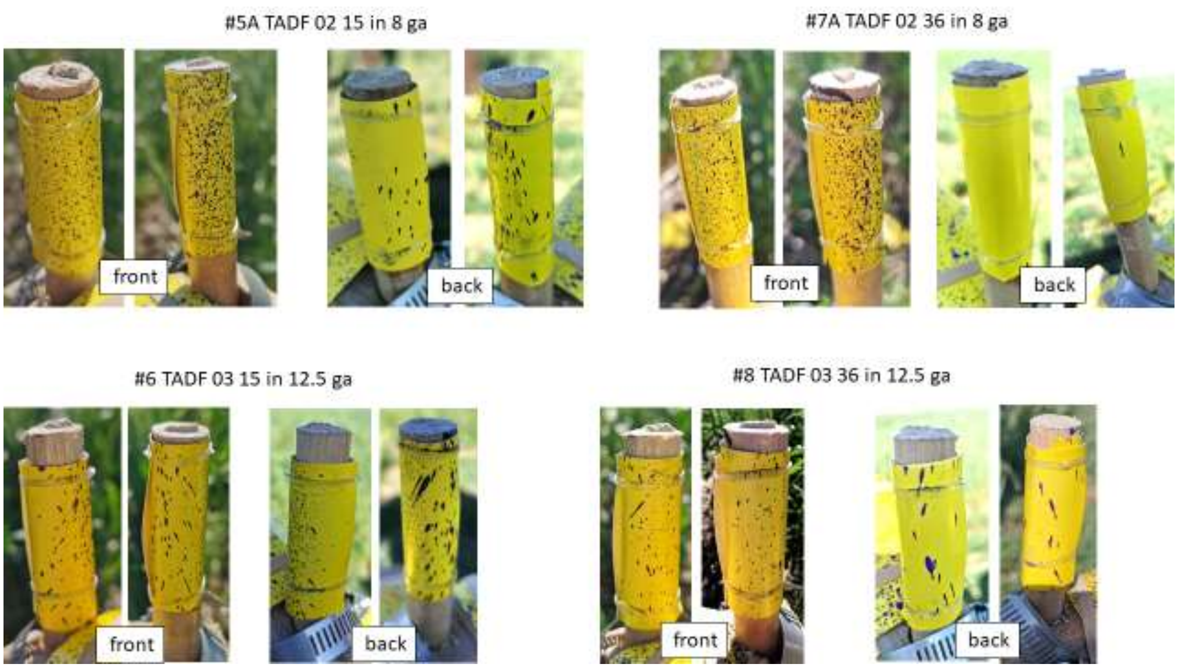
[2]Excessive heights for the TADF and Bubble Jet nozzles were 36 inches above the canopy.

Figure 3. Spray coverage of a vertical target by a Bubble Jet nozzle operated at optimum and excessive heights[1] above the canopy at 8 and 12.5 ga/ac.



[1]Optimum and excessive heights for the Bubble Jet nozzle were 25 and 36 inches above the canopy, respectively.

Figure 4. Spray coverage of a vertical target by a TADF nozzle operated at optimum and excessive heights[1] above the canopy at 8 and 12.5 ga/ac.



[1]Optimum and excessive heights for the TADF nozzle were 15 and 36 inches above the canopy, respectively.

Forage yield and quality of barley, oats and triticale under low and high inputs

Mike Hall[1] and Heather Sorestad[1]

[1]East Central Research Foundation, Yorkton, SK.

1. Abstract/Summary:

A trial was established near Yorkton to compare the effect of nitrogen rate and fungicide on the dry matter yield and forage quality of oat, barley, and triticale. As anticipated CDC Maverick barley produced somewhat better forage quality and CDC Haymaker oats were higher yielding than the barley. The yield of Bunker triticale was the lowest and that was unexpected. Increasing N rates and fungicide had little effect on forage yield due to low disease and drought. Under the conditions of this experience neither practice proved economic. Added N increased crude protein but had little effect on TDN and ADF. Fungicide had no effects on forage quality due to low disease pressure.

2. Project objectives:

The objective of this project is to compare the effect of nitrogen rate and fungicide on the dry matter yield and forage quality of oat, barley, and triticale.

It is anticipated that the following will be demonstrated:

- Dry Matter yield of forage oat and triticale will be approximately 10% higher than forage barley
- Feed quality of forage barley will be slightly better
- Higher N rates will increase forage yields
- Application of fungicide to increase forage yield and quality will be more beneficial for barley and triticale due to higher fungal disease pressures for the crops locally
- Application of fungicide will be more beneficial in denser canopies resulting from the higher rate of N.

3. Project Rationale:

Oats and barley are the most commonly grown cereals for forages across the province. Barley is considered to provide the best quality feed but oats can be higher yielding. Triticale is another cereal worth considering and also tends to be higher yielding than barley. When seeded late, the yield potential of barley declines relative to oats and triticale because the vegetative period of barley is shortened due to its photosensitivity [1]. So for the purposes of this study, the forages will be seeded in early spring to maximize the yield potential of all species.

The forage varieties in this comparison include CDC Marverick barley, CDC Haymaker oats and Bunker tritricale. CDC Maverick was bred from CDC Cowboy and has many of its attributes such as high forage yields and feed quality under low inputs. However, unlike CDC Cowboy it has smooth awns to reduce the occurrence of mouth sores in cattle. CDC Haymaker was released in 2015 and has a higher forage yield potential than its parental line CDC Baler. Bunker triticale is a forage variety with reduced awnlettes which is more attractive to cattle than older varieties.

Operations which continuously plant barley for feed or silage are finding leaf disease levels are greatly affecting yields and forage quality. To reduce losses resulting from barley leaf disease, producers can apply fungicide or rotate with other non host cereals such as oat or triticale (Kelly Turkington, personal communication). Cereals harvested for forage need to be managed slightly differently then those taken for grain yield. Disease suppression needs to target the leaves rather than the kernels as kernels will not mature before harvest. Foliar fungicides are known to protect the canopy, decrease lignification, increased grain fill, and improve nutritive value [2]. A study conducted by Nair et al. in Lacombe and Lethbridge, AB found when the foliar fungicide (Twinline) was applied in barley at the flag leaf stage the ADF and NDF value decrease, and forage nutrients such as water soluble carbohydrates and starch were preserved compared to the untreated check[2]. These finding prove that foliar fungicide does indeed improve forage quality.

The benefit from applying a fungicide is likely to be greater with higher rates of N which result in a denser canopy that is more conducive to disease development. The application of fungicide on oats may be less beneficial as local disease pressure for oats in the Yorkton area have been mostly bacterial (personal observation).

[1] Baron et al. 2012. Agronomy J 104: 393-404

[2] J. Nair, T. K. Turkington, R. Blackshaw, C. M. Geddes, N. Lupwayi, S. Xu, J. Yang, H. Yang, Y. Wang and T. A. McAllister. Impact of application of foliar fungicide on ensiling properties, feed value and core microbiome of barley silage. https://www.isc2018.de/downloads/presentations/Nair_ISC_2018_web.pdf

4. Methodology:

The trial was designed as a factorial with 3 factors with 4 replicates. The first factor compared 3 cereal species (oat, barley, triticale), the second contrasted 40 vs 80 lb N/ac and the third factor examined the application of fungicide. The fungicide used was Twinline (200 ml/ac) applied at the flag leaf stage because there are no grazing restrictions listed for this product. To minimize plant stand variability on dry matter yield, all varieties had seeding rates targeting a plant population of 300 plants/m^2. Plot size were 11 by 30ft and 22 by 30 ft for plots requiring fungicide to accommodate the 3 point hitch tractor sprayer. Plots were seeded with a 10ft wide Seedmaster drill on 12-inch row spacings. Four rows from each plot were harvested at the milk to early soft dough stage with a forage harvester. Sub-samples from each plot were taken and dried to determine dry weight yields. Forage quality was assessed on the basis of crude protein, total digestible nutrients and acid detergent fibre. Subsamples from each plot were taken to create a composite sample for quality testing. The composite samples were sent away to Central Testing Laboratory for analysis.

Table 1. Treatment List

Trt #	Variety	Lb N/ac	Fungicide
1	CDC Maverick Barley	40	None
2	CDC Maverick Barley	40	Twinline applied at flag leaf
3	CDC Maverick Barley	80	None
4	CDC Maverick Barley	80	Twinline applied at flag leaf
5	CDC Haymaker Oats	40	None
6	CDC Haymaker Oats	40	Twinline applied at flag leaf
7	CDC Haymaker Oats	80	None
8	CDC Haymaker Oats	80	Twinline applied at flag leaf
9	Bunker Triticale	40	None
10	Bunker Triticale	40	Twinline applied at flag leaf
11	Bunker Triticale	80	None
12	Bunker Triticale	80	Twinline applied at flag leaf

Table 2. Dates of operations for the 2020 "Forage yield and quality of barley, oats and triticale under low and high inputs." trial.

Operations in 2020	Yorkton
Pre-seed Herbicide Application	N/A
Seeding Date	May 12
Emergence Counts	May 29
In-crop Herbicide Application	June 2 (Prestige)
Fungicide Application	July 1
Leaf Disease Rating	July 17
Lodging	N/A
Dry Matter Harvest @ milk to early soft dough stage	July 23 for barley and July 28 for oats and triticale

5. Results:

The trial established well, averaging 315, 265 and 262 plants/m^2 for CDC Maverick barley, CDC Haymaker oats and Bunker triticale, respectively. However, the season was very dry, limiting yield and reducing the presence of leaf disease. Statistically, Bunker triticale had significantly more leaf disease than CDC Maverick barley (Table 4). However, the level of disease on the flag leaf was extremely low for all crop species and any differences were inconsequential. Nitrogen rate and application of fungicide had no significant effect on leaf disease or yield for any crop specie (no interactions). However, the yield of barley did appear to numerically increase with added N (Table 5). Overall, CDC Haymaker oats yielded significantly more than CDC Maverick barley and Bunker triticale (Table 4).

Forage quality is based off samples bulked over all 4 reps so no statistics can be applied to means. With that caveat, CDC Maverick barley did tend to have better forage quality than the other two species in terms of TDN and ADF. However, it also had slightly lower protein. Nevertheless, protein was very good for all species. Well above 9% required for a cow calf pair. When averaged across crop specie, increasing N from 40 to 80 lb/ac increased crude protein from 11.8 to 13.2%. However, increasing N seemed to have little effect on TDN or ADF. Application of Twinline did not appear to improve forage quality. Though differences were quite small, Twinline resulted in lower protein, lower TDN and higher ADF, averaged across crop specie.

Neither increasing the N rate or applying fungicide proved economic. Increasing N rate from 40 to 80 lb/ac increased dry forage yield by 0.2862 tonnes/ha and the application of Twinline only increased dry forage yield by 0.1037 tonnes/ha. Based on an average market price of $114.32/tonne[1], these yield increases from increasing N and applied fungicide resulted in gross net returns of $32.72/ha and $11.85/ha, respectively. However, increasing N and applying fungicide each cost approximately $50/ha and were thus highly uneconomic.

[1]2020 Winter Forage Market Price Discovery Saskatchewan. Saskatchewan Forage Council.

6. Conclusions and Recommendations

Yield and forage quality responses to added N and fungicide were poor and uneconomic. The lack of response is attributed to the drought causing a thin canopy, low disease pressure and suppressed yield potential. Added N did increase crude protein but crude protein overall was very good due to drought. CDC Haymaker oats had the greatest yield potential but CDC Maverick barley tended to provide somewhat better forage quality in terms of ADF and TDN.

7. Acknowledgements:

This project was funded through the Agriculture Demonstration of Practices and Technologies ADOPT.

8. Appendices

Table 4. Main Effects of Variety, Nitrogen Rate and Fungicide on Leaf Disease and Dry Forage Yield.

	Leaf Disease (%)	**Dry Forage Yield (kg/ha)**
<u>Variety</u>		
CDC Maverick Barley	2.9 b	4371.5 b
CDC Haymaker Oats	3.7 ab	4922.1 a
Bunker Triticale	4.1 a	3952.1 b
P-values	0.037	0.0019
LSD	0.99	527.1
<u>Nitrogen Rate (lb N/ac)</u>		
40	3.4 a	4272.2 a
80	3.7 a	4558.4 a
P-values	NS	NS
LSD	NS	NS
<u>Fungicide at Flag Leaf</u>		
None	3.6 a	4363.4 a
Twinline	3.6 a	4467.1 a
P-values	NS	NS
LSD	NS	NS

Table 5. Treatment Effects on Leaf Disease and Forage Yield		
Treatment	**Leaf Disease (%)**	**Dry Forage Yield (kg/ha)**
1. CDC Maverick Barley 40 lb N/ac No fungicide	3.1 a	4029.2 a
2. CDC Maverick Barley 40 lb N/ac Twinline	2.6 a	3985.6 a
3. CDC Maverick Barley 80 lb N/ac No fungicide	2.8 a	4569.5 a
4. CDC Maverick Barley 80 lb N/ac Twinline	3.1 a	4901.6 a
5. CDC Haymaker Oats 40 lb N/ac No fungicide	4.1 a	5011.8 a
6. CDC Haymaker Oats 40 lb N/ac Twinline	3.1 a	4736.1 a
7. CDC Haymaker Oats 80 lb N/ac No fungicide	3.8 a	5054.8 a
8. CDC Haymaker Oats 80 lb N/ac Twinline	3.9 a	4886.0 a
9. Bunker Triticale 40 lb N/ac No fungicide	3.7 a	3759.6 a
10. Bunker Triticale 40 lb N/ac Twinline	4.1 a	4110.8 a
11. Bunker Triticale 80 lb N/ac No fungicide	4.0 a	3755.7 a
12. Bunker Triticale 80 lb N/ac Twinline	4.8 a	4182.6 a
P-values	NS	NS
LSD	NS	NS

Table 6. Main Effects of Variety, Nitrogen Rate and Fungicide on Forage Quality			
	Crude Protein (%)	**TDN (%)**	**ADF (%)**
Variety			
CDC Maverick Barley	12.2	73.1	24
CDC Haymaker Oats	12.5	68.5	28.2
Bunker Triticale	12.8	71.5	25.4
P-values	N/A[1]	N/A[1]	N/A[1]
LSD	N/A[1]	N/A[1]	N/A[1]
Nitrogen Rate (lb N/ac)			
40	11.8	71.2	25.6
80	13.2	70.8	26.1
P-values	N/A[1]	N/A[1]	N/A[1]
LSD	N/A[1]	N/A[1]	N/A[1]
Fungicide at Flag Leaf			
None	12.6	71.1	25.7
Twinline	12.4	70.9	26.0
P-values	N/A[1]	N/A[1]	N/A[1]
LSD	N/A[1]	N/A[1]	N/A[1]

[1]Not applicable. No statistics as means are based on treatments bulked over replication.

Table 7. Treatment Effects on Forage Quality			
Treatment	**Crude Protein (%)**	**TDN (%)**	**ADF (%)**
1. CDC Maverick Barley 40 lb N/ac No fungicide	11.4	72.6	24.4
2. CDC Maverick Barley 40 lb N/ac Twinline	10.7	73.0	24.0
3. CDC Maverick Barley 80 lb N/ac No fungicide	13.0	72.7	24.3
4. CDC Maverick Barley 80 lb N/ac Twinline	13.7	74.0	23.1
5. CDC Haymaker Oats 40 lb N/ac No fungicide	11.9	68.7	28.1
6. CDC Haymaker Oats 40 lb N/ac Twinline	11.8	69.7	27.1
7. CDC Haymaker Oats 80 lb N/ac No fungicide	13.3	68.9	27.9
8. CDC Haymaker Oats 80 lb N/ac Twinline	13.0	66.8	29.8
9. Bunker Triticale 40 lb N/ac No fungicide	13.1	72.7	24.3
10. Bunker Triticale 40 lb N/ac Twinline	11.8	71.0	25.9
11. Bunker Triticale 80 lb N/ac No fungicide	12.8	71.4	25.5
12. Bunker Triticale 80 lb N/ac Twinline	13.4	70.9	26.0
P-values	N/A[1]	N/A[1]	N/A[1]
LSD	N/A[1]	N/A[1]	N/A[1]

[1]Not applicable. No statistics as means are based on treatments bulked over replication.

Starter fertilizer improves alfalfa stand establishment and forage yield.

Mike Hall[1] and Heather Sorestad[1]

[1]East Central Research Foundation, Yorkton, SK.

5. Abstract/Summary:

A trial was established near Yorkton, SK to demonstrate that alfalfa establishment and yield is improved with added fertilizer at seeding. Alfalfa dry matter yield was increased by 44% or 232 kg/ha in response to 23.4 lb N/ac + 50 lb P_2O_5/ac side-banded at seeding. Alfalfa yield was not increased further with the addition of 25 lb K_2O/ac + 15 lb S/ac. The trial will be continued next year to determine the nutrient response of established alfalfa.

6. Project objectives:

The objective is to demonstrate that alfalfa establishment and yield is improved with added fertilizer at seeding.

7. **Project Rationale:**

According Manitoba Agricultural Services Corporation statistics, an average yielding alfalfa crop in Manitoba is 2.3 tons/ac but with proper fertilization producers can expect yield from 3.5 to 5.5 tons/ac [1]. An average crop of 2.3 tons/ac will remove 34.5 lb P_2O_5/ac, 149.5 lb K_2O/ac and 16.1 lb S/ac[2]. Despite high removal rates, only ¼ of Manitoba alfalfa acres receive any fertilizer [1]. While fertilizer can be broadcast on established stands, producers should add fertilizer at the time of seeding.

Phosphorus is the most important nutrient to be applied at seeding as it increases seedling vigour. The Manitoba government states that supplying 30lb/ac of P_2O_5 fertilizer can increase alfalfa seedling size by 4 times compared to the no phosphorus fertilizer control [1]. Ross McKenzie suggests applying 50 lb P_2O_5/ac annually or 100 to 200 lb P_2O_5/ac at seeding to meet alfalfa requirements for 3 to 4 years of production[2].

Potassium is used to stimulate nitrogen fixation in alfalfa. Although Saskatchewan soils tend to be naturally high, inadequate soil potassium can cause large yield reductions due to limiting nitrogen fixation. Soils that may be low in potassium are sands or sandy loam soils. Since forage land is often placed on poorer quality ground, deficiencies may be observed more frequently compared to annual crop production land.

Alfalfa plants are large consumers of sulphur as it contributes to the protein in legume plants. Sulphur can be inconsistent in any given field so if a crop has high S nutrient requirements, S fertilizer is often given whether or not a soil test detects a deficiency. The University of Minnesota states soil tests for sulfur on fine-texture soils are not accurate therefore an annual application of 15-25 lb S/ac should be applied to alfalfa[3].

Starter N is not typically required for alfalfa and may actually interfere with nodulation. Small amounts of N fertilizer supplying about 25 lb. N per acre may enhance establishment when alfalfa is seeded in a coarse-textured soil[3].

[1] Fertilizing Alfalfa Forage.
https://www.gov.mb.ca/agriculture/crops/production/forages/pubs/forage_crops_fertilizer.pdf

[2] Mckenzie, Ross. Feb 2019. "Fertilizer management of alfalfa" Top Crop Manager.
https://www.topcropmanager.com/fertilizer-management-of-alfalfa/

[3] University of Minnesota. Alfalfa fertilizer recommendations. https://extension.umn.edu/crop-specific-needs/alfalfa-fertilizer-recommendations#other-nutrients-1065213

Methodology and Results

8. Methodology:

The trial was setup as a Randomized Complete Block Design (RCBD) with 5 treatments and 4 replicates (Table 1). Plot size was 11 by 30 ft and seeded with a 10 ft wide Seedmaster drill on 12-inch row spacing. Seeding of alfalfa was conducted in May to ensure plants had adequate biomass by the end of the growing season. Only the middle 4 rows of each plot were harvested with a forage harvester late August (2020) to avoid edge effects. However, the entire plot was mowed down after harvest. Harvest will also be taken again by mid-summer in 2021. Dates of operation are presented in table 2.

Table 1. Side Banded Starter Fertilizer

Trt#	lb N/ac	lb P_2O_5/ac	lb K_2O/ac	Lb S/ac
1	0	0	0	0
2	23*	0	0	0
3	23*	50	0	0
4	23*	50	25	0
5	23	50	25	15

*N was added to treatments 2-4 to balance N rates with N that comes with monoammonium phosphate and ammonium sulphate in treatment 5.

Table 2. Dates of operations for the 2020 "Starter fertilizer improves alfalfa stand establishment and forage yield" trial.

Operations in 2020	Yorkton
Pre-seed Herbicide Application	N/A
Seeding Date	May 15
Emergence Counts	June 2
In-crop Herbicide	July 1 (Viper ADV + UAN)
Stand Establishment Rating	July 22
Forage Yield August 2020	July 22
Forage Yield Mid-Summer 2021	To be Completed

9. Results:

Despite the drought conditions, the alfalfa emerged well averaging 125.7 plants/m^2. Emergence and stand establishment did not significantly differ between treatments. Dry matter forage yield was relatively low, as spring conditions were very dry and harvest was taken from the establishment year. Side-banding 23.4 lb N/ac at seeding numerically resulted in a higher yield of 659 kg/ha relative to 527 kg/ha for the unfertilized check (table 4). The further addition of 50 lb P_2O_5/ac significantly increased forage yield relative to the unfertilized check to 758 kg/ha. However, adding 25 lb K_2O/ac and 15 lb S/ac did not increase forage yield any further. The strong response to phosphorus and a lack of a response to added potassium and sulphur are in keeping with soil test results presented in Figure 1. Background level of soil phosphorus was determined to be low, whereas soil potassium and sulphur were high. A modest albeit insignificant response to add N alone was a little unexpected, particularly as background soil N was rated at a medium level.

10. Conclusions and Recommendations

Alfalfa yields were relatively low because it was the establishment year and due to drought. However, side-banding 23.4 lb N/ac + 50 lb P_2O_5/ac at seeding significantly increased dry matter yield by 44% or 232 kg/ha in the establishment year. The yield of alfalfa was not responsive to added potassium or sulphur. The plots will be harvested again next year to determine the nutrient response of established alfalfa, which typically has a higher yield potential.

Supporting Information

11. Acknowledgements:

This project was funded through the Agriculture Demonstration of Practices and Technologies ADOPT.

12. Appendices

Figure 1. Soil test results from the spring of 2020 prior to seeding

Nutrient In The Soil	Depth/Method	Result
Nitrate	0-6"	18 lb/acre
	0-12"	40 lb/acre
Phosphorus	Olsen	8 ppm
Potassium		334 ppm
Chloride		
Sulfur	0-6"	50 lb/acre
	0-12"	72 lb/acre
Boron		
Zinc		1.49 ppm
Iron		
Manganese		
Copper		
Magnesium		
Calcium		
Sodium		
Org. Matter		6.3 %
Carbonate (CCE)		
Sol. Salts	0-6"	0.45 mmho/cm
	0-12"	0.42 mmho/cm

	1st Crop Choice		2nd Crop Choice		3rd Crop Choice	
Crop	Alfalfa		Grass Seed		Grass/Pasture	
Yield Goal	3 Tons		1 Season		4 Tons	
Suggested Guidelines	Band		Broadcast		Band	
	LB/ACRE	APPLICATION	LB/ACRE	APPLICATION	LB/ACRE	APPLICATION
N	0		40		60	
P_2O_5	31	Band *	48	Broadcast	28	Band *
K_2O	15	Band (Starter)*	0		0	
Cl						
S	0		0		0	
B						
Zn	0		0		0	
Fe						
Mn						
Cu						
Mg						
Lime						

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" 7.2 6-24" 7.8							

Crop 1: Soil nitrate for 0-24 inch depth is estimated 60 lb/acre nitrate-N. *CAUTION: Seed-placed fertilizer can cause injury.* May respond to starter P & K, even on high soil tests. Crop nutrient removal: P2O5 = 30 K2O = 150 AGVISE Band guideline will build P & K test levels to the medium range over several years.

Crop 2: Soil nitrate for 0-24 inch depth is estimated 60 lb/acre nitrate-N. May respond to starter P & K, even on high soil tests. AGVISE Broadcast guideline will build P & K test levels to the high range over several years.

Crop 3: Soil nitrate for 0-24 inch depth is estimated 60 lb/acre nitrate-N. *CAUTION: Seed-placed fertilizer can cause injury.* May respond to starter P & K, even on high soil tests. Crop nutrient removal: P2O5 = 48 K2O = 180 AGVISE Band guideline will build P & K test levels to the medium range over several years.

Table 4. Main Treatment Effects on Emergence, Stand Establishment, and Forage Dry Yield.

Treatments	Emergence (plants/m2)	Stand Establishment (%)	2020 Forage Dry Yield (kg/ha)	2021 Forage Dry Yield
1. No Fertilizer control	121.8 a	8.3 a	526.7 b	To be completed
2. 23.4 lb N/ac	109.9 a	9.0 a	659.1 ab	To be completed
3. 23.4 lb N/ac* + 50 lb P_2O_5/ac	129.6 a	8.3 a	758.2 a	To be completed
4. 23.4 lb N/ac* + 50 lb P_2O_5/ac + 25 lb K_2O/ac	140.7 a	9.0 a	759.8 a	To be completed
5. 23.4 lb N/ac* + 50 lb P_2O_5/ac + 25 lb K_2O/ac + 15 lb S/ac	126.7 a	8.5 a	727.3 a	To be completed
P-value	NS	NS	0.047	To be completed
LSD	NS	NS	165.6	To be completed

*N was added to treatments 2-4 to balance N rates with N that comes with monoamonium phosphate and ammonium sulphate in treatment 5.

Grain Millers- Oat Variety Trial (Yorkton) 2020

Mike Hall[1] and Heather Sorestad[1]

[1]East Central Research Foundation, Yorkton, SK.

1. Project objectives:

The objective of this study is to compare yield and quality of oat varieties which are either recommended, under review, or upcoming by Grain Millers

2. Project Rationale:

As new oat varieties continue to emerge in the market place, farmers need to stay up to date on the newest genetics. This trial will show producers a local comparison of Zone 2 recommended varieties for Grain Millers as well as varieties under review and upcoming.

3. Methodology:

The trial was established as a Randomized Complete Block Design (RCBD) with 4 replications. Plots were 11 by 30 ft and were seeded with a 10 ft wide Seedmaster drill with 12 inch row spacings. Monoammonium phosphate (MAP) and urea were side banded at seeding at 59 lb/ac and 152 lb/ac, respectively. Oats were seeded to target 300 seeds/m^2 with corrections for vigour and thousand kernel weight taken into account. The middle 4 rows by 30 ft were harvested for yield with a Wintersteiger plot combine. The trial compared the yield and quality of oat varieties listed in Table 1.

Table 1. Oat Variety Treatments		
Treatment #	**Oat Variety**	**Status with Grain Millers**
1	Arborg	Recommended
2	Camden	Recommended
3	Summit	Recommended
4	Kongsore	Upcoming
5	Ruffian	Recommended
6	ORE3542	Under Review
7	Endure	Under Review
8	Sky	Upcoming

Table 2. Dates of operations in 2020 for the Grain Millers- Oat Variety Trial (Yorkton) 2020	
Operations in 2020	Yorkton
Seeded trial	May 12
Emergence counts	June 2
In-crop herbicide application:	June 2 (Prestige)
Height	July 17
Maturity Rating	July 30
Harvest	Aug 26

4. Results:

A seeding rate of 350 seeds/m^2 was targeted for each variety based on seed vigor and 1000 kernel weight. When averaged across variety, this produced 325 plants/m^2. While plant establishment did significantly vary between some varieties, plant populations were adequate for all varieties (Table 4). Overall, the crop emerged well. Unfortunately, a lack of soil moisture and precipitation resulted in an early maturing, short and low yielding crop of oats (Table 4). When averaged across variety, crop height was only 57.5 cm and oat yield was 2621 kg/ha or 69 bu/ac. This is well below historic yields of 180 bu/ac for this field. There were a number of statistical differences between varieties for yield. The highest yielding variety was Arborg at 3145 kg/ha (82 bu/ac) and the lowest yielding variety was ORE3542 at 2197 kg/ha (58 bu/ac). Physiological maturity of all varieties occurred within 3 days of each other. Percent thins were very low and few significant differences occurred between varieties. A number of statistical differences in test weight were detected between varieties. Summit had the highest test weight of 280.7 g/0.5 l and CS Camden had the lowest at 259.2 g/0.5 l. Past study has also found test weights for Summit to be much higher than for CS Camden. However, test weights for all varieties in this study were still well above the discount level of 245 g/0.5 l. Test weights were good despite drought stress during flowering and grain filling. In my opinion, the environmental impacts on test weight are not well understood. Dehull levels were beyond acceptable levels for many of the varieties, indicating the combine was not set appropriately. However, the level of damage substantially varied between varieties. Levels of dehulling were very low for CS Camden and very high for Summit. Perhaps this is can account for some of the test weight differences observed between these two varieties.

5. Acknowledgements

This project was funded through Grain Millers.

6. Appendices

Table 4. Crop Emergence, Height, Physiological Maturity and Yield for each Oat Variety.

Treatments	Emergence (plants/m^2)	Height (cm)	Physiological Maturity (Julian Day)	Yield (kg/ha @14%)
1. Arborg	373.6 a	63.4 ab	212.5 a	3145.0 a
2. CS Camden	317.0 ab	52.6 c	212.0 a	2557.8 cd
3. Summit	349.4 a	66.5 a	211.3 ab	2356.5 de
4. Kongsore	266.2 b	57.5 bc	211.0 ab	2479.5 de
5. Ruffian	258.0 b	52.6 c	210.3 b	2927.3 ab
6. ORE3542	304.7 ab	54.1 c	209.8 b	2197.3 e
7. Endure	373.6 a	55.9 c	209.8 b	2830.3 bc
8. Sky	359.2 a	57.4 bc	209.8 b	2472.5 de
P-Values				
LSD	75.6	6.0	1.5	297.9

Table 5. Dehulls, Thins an Test weight for each Oat Variety.			
Treatments	**Dehulls**	**Thins**	**Test weight**
1. Arborg	4.5 cd	0.3 b	265.0 bcd
2. CS Camden	1.8 d	0.2 b	259.2 d
3. Summit	21.0 a	0.2 b	280.7 a
4. Kongsore	6.8 bc	0.2 b	272.8 ab
5. Ruffian	18.0 a	0.2 b	265.0 bcd
6. ORE3542	9.4 b	0.3 b	271.4 bc
7. Endure	9.1 b	0.2 b	264.1 cd
8. Sky	5.2 cd	0.8 a	261.1 d
P-Values			
LSD	3.6	0.3	8.0

Barley MAX Experiment 2

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[4]Conservation Learning Centre, Prince Albert, SK
[5]Northeast Agriculture Research Foundation, Melfort, SK
[6]Wheatland Conservation Area Inc., Swift Current, SK

1. **Project objectives:**

Yield is primarily driven by nitrogen fertilizer rates, which are generally kept low in malt barley production to prevent higher than desirable protein levels. New barley varieties have improved agronomics that will allow producers to increase nitrogen rates to achieve higher yields, while maintaining malt quality protein levels. Experiment 2 will determine optimum nitrogen fertilizer recommendations for production of new malt barley varieties in comparison to a recent industry standard variety.

2. Project Rationale:

Western Canadian barley acres have shrunk by more than 50 per cent in the past 20 years. With the lowest rate of gain among major crops and competition with other low-cost feed options, fewer producers are choosing to grow barley. Yet, there remains optimism that barley can be competitive with other cropping options.

Compared to other crop types, the acceptance of new varieties with improved disease resistance and higher yields is limited. As a result, the majority of barley production is with 20-year-old technology. There are strong indications that the industry is shifting to newer varieties with improved agronomics, but the optimum agronomic input packages are not known for these newer varieties.

Barley is generally either malt or feed, with a significant price difference sometimes in place. As a result, producers are incentivized to manage for malt and sacrifice yield in order to do so. Research is needed to help producers increase their yields, while maintaining malt quality.

Significant advancements in barley agronomy were made under one of the recent barley clusters, but, the inputs investigated have not been looked at in a comprehensive package in Saskatchewan, with the most up-to-date varieties.

3. Methodology:

This trial was setup as a 2 level factorial with 4 replicates. The malt barley varieties AC Metcalfe, AC Synergy and CDC Bow were each tested at background levels of N and 60, 120 , 180 and 240 lb/ac of soil + fertilizer N (Table 1). The background level of soil N in the top 12 inches varied between location and these levels were taken into consideration when determining rates of applied fertilizer N. The plot size, row spacing, and fertilizer application techniques for seeding varied between locations depending on equipment used. Each location also applied 26.8 lb P_2O_5/ac and 13.4 lb K_2O/ac with every treatment. Herbicides and insecticides were applied based on industry standards and as required at each location. A complete list of operations and dates is available in table 2.

Table 1. Treatment List for "Barley Max Experiment 2" Trial		
Treatment #	**Variety**	**N (Soil + fert)**
1	AC Metcalfe	Background N
2	AC Metcalfe	60 lb N/ac
3	AC Metcalfe	120 lb N/ac
4	AC Metcalfe	180 lb N/ac
5	AC Metcalfe	240 lb N/ac
6	AC Synergy	Background N
7	AC Synergy	60 lb N/ac
8	AC Synergy	120 lb N/ac
9	AC Synergy	180 lb N/ac
10	AC Synergy	240 lb N/ac
11	CDC Bow	Background N
12	CDC Bow	60 lb N/ac
13	CDC Bow	120 lb N/ac
14	CDC Bow	180 lb N/ac
15	CDC Bow	240 lb N/ac

Table 2. Dates of operations for the 2020 "Barley MAX Experiment 2" trial.				
Operations in 2020	**Melfort**	**Prince Albert**	**Swift Current**	**Yorkton**
Pre-seed Herbicide Application	May 24 (Heat LQ + Glyphosate 540)	N/A	May 4 (Glyphosate + AIM + Merge)	N/A
Seeding Date	May 22	May 23	May 16	May 8
Emergence Counts	June 12	June 9	May 28	May 27
In-crop Herbicide	June 23 (Prestige XC) & July 3 (Axial)	June 10 (Infinity)	May 29 (Liquid Achieve + Buctril M & Turbocharge)	June 2 (Prestige) & June 8 (Axial)
Fungicide	July 24 (Prosaro)	July 21 (Twinline)	N/A	July 1 (Trivapro A &B)
Heading Date	July 22	July 17-20	July 21	July 6
Days to Maturity	Aug 17-21	Aug 13-20	Aug 6	July 30
Lodging Rating	Aug 31	Sept 2	N/A	N/A
Harvest	Sept 15	Sept 9	Aug 18	Aug 20

4. Results:

Table 4. Soil Test Nitrate Levels for each location (lb/ac).				
Nitrate Levels (lbs NO_3-N/ac)	**Melfort**	**Prince Albert**	**Swift Current**	**Yorkton**
0-15cm (0-6in)	21	18	20	20
15-30cm (6-12in)	24	28	11	18
15-60cm (6-24in)				
30-60cm (12-24in)				
Total 0-60cm (0-24in)				
Total 0-30cm (0-12in)	45	46	31	38

Background levels of soil N were relatively similar between locations and were typical of a continuous cropping system (Table 4). These background levels were taken into consideration when determining rates of urea required to deliver 60, 120, 180 and 240 lb N/ac.

All trial locations were seeded between May 8 and May 23 (Table 2). Timely harvest occurred between August 18 and September 15 and grain was taken-off in good condition. Data from the 2020 season was collected in full from all participating sites. Main effects and individual treatment effects for crop emergence, physiological maturity, yield and grain quality are found in tables 5-18 in the appendix.

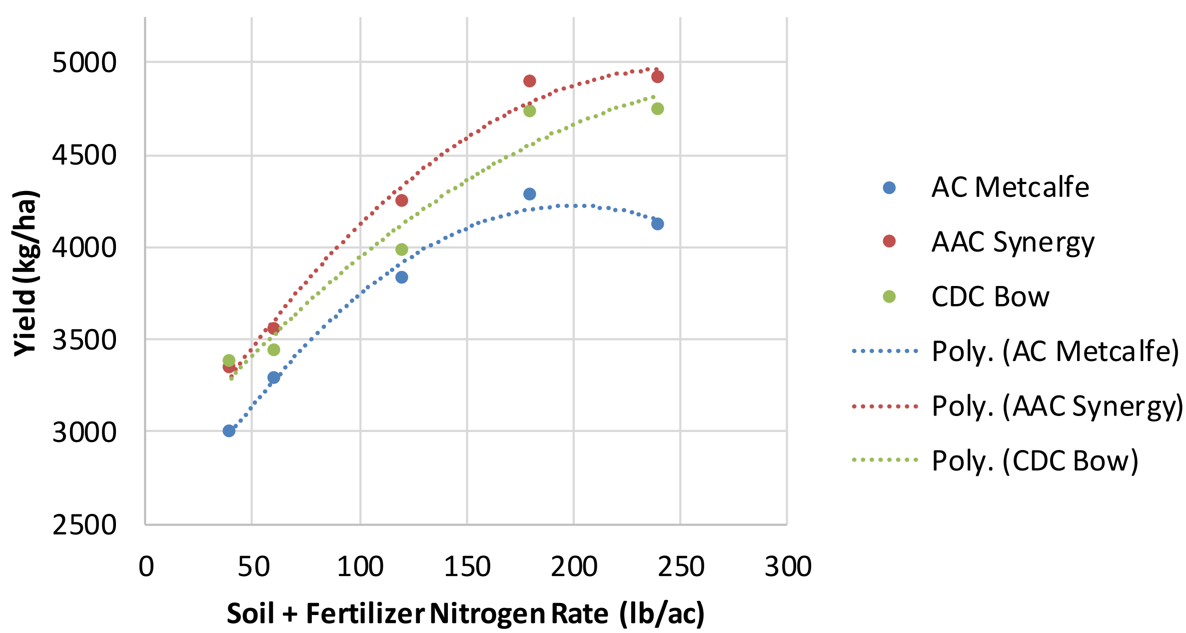
Emergence was fair to good between locations. Targeting 300 live seeds/m^2 resulted in average emergence of 213, 234, 179 and 278 plants/m^2 at Melfort, Prince Albert, Swift Current and Yorkton, respectively. Differences in emergence rates between varieties were minor at each location and not of agronomic significance (Table 5). Increasing rates of N significantly reduced crop emergence up to 25% and 21% at Melfort and Swift Current, respectively. However, emergence was unaffected by increasing N at Yorkton and Prince Albert. Varietal maturity differed significantly at all locations except Yorkton. However, differences were not consistent nor very substantial with each variety reaching physiological maturity within a day or two of each other at each location (Table 7). Surprisingly, increasing rates of N only significantly delayed maturity at Melfort. Increasing soil + fertilizer N at Melfort to 240 lb N/ac significantly delayed maturity by 2.5 days.

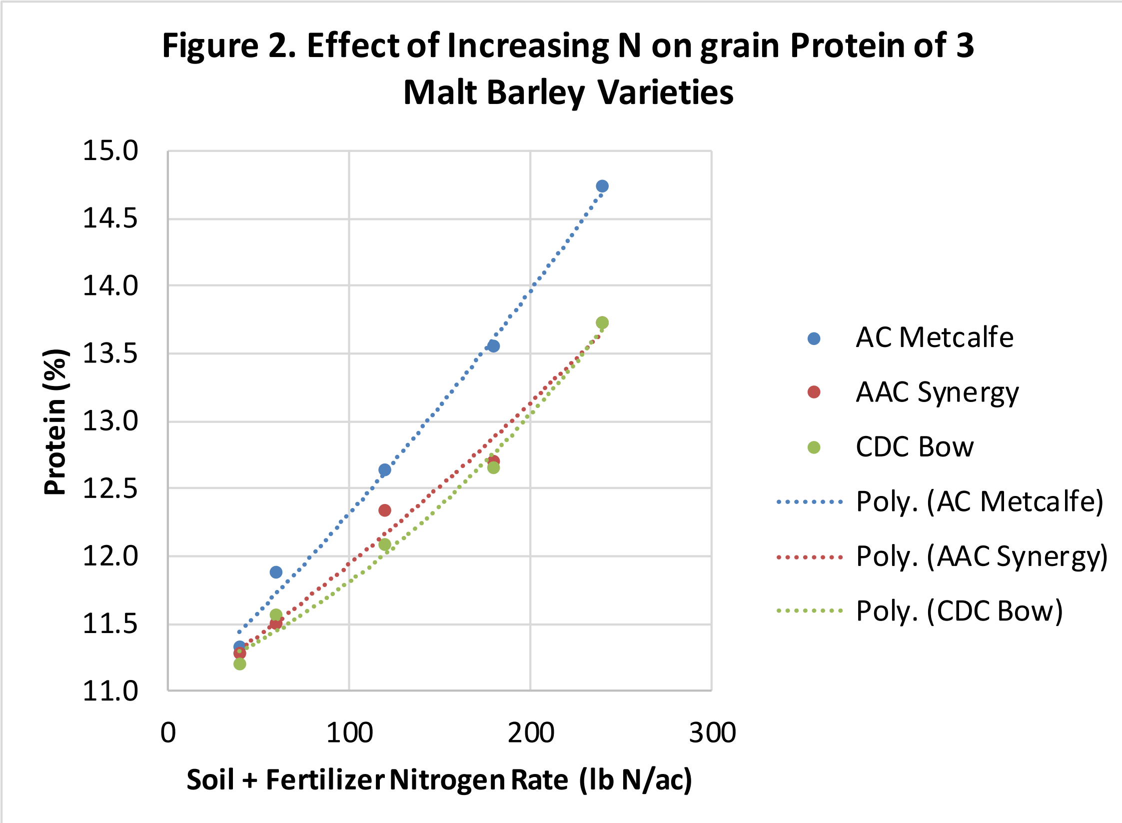
Yield varied substantially between locations (Table 9). Yorkton was by far the lowest yielding site producing only 2586 kg/ha or 48.1 bu/ac of grain due to drought. The remaining sites produced near normal yields with Melfort, Prince Albert and Swift Current producing 4096, 4702 and 4576 kg/ha, respectively. Combining the data from all sites revealed a significant location by variety interaction. While the old malt barley variety AC Metcalfe was lower yielding than the newer varieties as expected, the relative standing of the new varieties varied between location (Table 10). AAC Synergy was usually the highest yielding variety, yielding between 10 to 21% more than AC Metcalfe depending on location. The relative yield of CDC Bow was more variable averaging between 2 and 16% higher than AC Metcalfe.

When analysed over location, nitrogen rate significantly increased yield however the yield response differed between varieties as there was a variety by nitrogen rate interaction (Tables 10 and 11). The yield of the newer varieties were more responsive to incremental additions of N, particularly at the highest rates (Figure 1). In contrast, grain protein of the newer varieties, based on treatment samples bulked over 4 reps, were less responsive to added nitrogen than AC Metcalfe (Figure 2). This makes intuitive sense as the higher yield potential and responsiveness of AAC Synergy and CDC Bow to added N would dilute increases in protein. This means producers should be able to push rates of N a little higher for newer higher yielding varieties compared to the lower yielding AC Metcalfe. Based on the results in Figure 2, rates of soil + fertilizer N above 115 lb N/ac would result in rejection of AC Metcalfe for malt when assuming 12.5% grain protein as the maximum allowable limit. In contrast, rates above 150 lb N/ac (soil + fertilizer) would be required before AAC Synergy or CDC Bow would exceed 12.5% grain protein.

These rates of soil + fertilizer N should not be considered recommendations as the level of N required to reach 12.5% protein varied substantially between locations. Moreover, producers should not be aiming for 12.5% protein as there needs to be some wiggle room for making malt as the weather for the season cannot be anticipated. While statistics could not be applied to single rep protein data, the grain protein for AC Metcalfe, averaged across 5 rates of N was consistently higher than AAC Synergy and CDC Bow at every location (Tables 11, 13, 15 and 17). When averaged across all locations and rates of N, AC Metcalfe, AAC Synergy and CDC Bow produced 12.83%, 12.33% and 12.25% protein. Again stats cannot be put to these number but each one of those percentages is an average of 20 values (4 locations by 5 N rates).

Figure 1. Effect of Increasing N on Yield of 3 Malt Barley Varieties





The quality of the malt barley, based on treatment samples bulked over 4 reps, varied substantially between sites (Tables 11-18). At Melfort, quality was fairly good (Tables 11 and 12) with % plumps averaging over 97% for AAC Synergy and CDC Bow and close to 95% for AC Metcalfe. The 4ml germination tests we all excellent being over 95% germ yet, the 8 ml tests were poorer. However, the 8 ml germ tests tended to improve with increasing nitrogen. It is possible the maturity differences at harvest, as influenced by different rates of N, had some impact on germination.

Malt quality was poor at the remaining sites for various reasons. At Prince Albert, % plumps and thins were good but germination was terrible for the 4 ml and 8 ml germination tests (Tables 13 and 14). The reason for this is unclear but dormancy could also be a factor. At Swift Current, germination was excellent for both the 4 and 8 ml germination tests. However, the % plumps and thins were poor for all varieties and rates of N averaging 79.3% and 15.4%, respectively. This is not too surprising as Swift Current would not typically be considered a malt producing area. Yorkton is a malt producing area however, the season in 2020 was extremely dry. While % plumps and thins were excellent, the 4 ml and particularly the 8 ml germinations were poor. Again the reason is not well understood and could be related to dormancy.

An economic comparison between AC Metcalfe and AAC Synergy shows income could be increased by applying more N to AAC Synergy based on the combined site data in Figures 1 and 2. This conclusion assumes both varieties are worth $5.20/bu ($0.239/kg), soil background N is 40 lb/ac and the added cost of fertilizer nitrogen is $0.5/lb. Assuming the maximum allowable level of grain protein is 12.5%, no more than 115 lb/ac and 150 lb/ac of soil + fertilizer N can be applied to AC Metcalfe and AAC Synergy, respectively. Using the line of best fit in Figure 1, these rates of N would generate 3875 kg/ha and 4591 kg/ha of grain yield for AC Metcalfe and AAC Synergy, respectively. The gross returns minus the variable cost of N would be $337/ac and $389/ac for AC Metcalfe and AAC Synergy, respectively. However, if only 115 lb N/ac was applied to both varieties, this would reduce the gross returns minus N costs for AAC Synergy to $376/ac. In other words, if the varieties were fertilized the same at 115 lb N/ac (40 N soil + 75 N fert), AAC Synergy would generate $39/ac ($376/ac-$337/ac) more revenue than AC Metcalfe. If AAC Synergy was fertilized at the higher rate of 150 lb N/ac (40 N soil + 110 N fert), it would generate $52/ac more ($389/ac-$337/ac).

5. Conclusions and Recommendations

The combined site analysis supports the hypothesis that higher yielding malt varieties having lower grain protein can be fertilized with higher rates of N to even further increase economic returns. In this study, AC Metcalfe could not be fertilized with more than 115 lb N/ac (40 N soil + 85 N fert) without exceeding the assumed malting limited of 12.5% protein. In contrast, AAC Synergy and CDC Bow could be fertilized with 150 lb N/ac (40 N soil + 110 N fert) before exceeding 12.5% grain protein. If AAC Synergy generated $39/ac more revenue when both varieties were fertilized with 115 lb N/ac (soil + fert N). However, AAC Synergy generated even more revenue at $52/ac when it was fertilized at 150 lb N/ac (soil +fert N) but AC Metcalfe remained at 115 lb N/ac (soil + fert) due to protein restrictions. While these results averaged over location indicated more N can be supplied to the newer varieties, the optimum rate of N to apply varied substantially between locations. Thus these rates should not be considered a recommendation as grower experience with their own environmental conditions is key. However, producers switching from AC Metcalfe to AAC Synergy or CDC Bow could consider experimenting with somewhat higher rates of N than they typically apply.

<u>Supporting Information</u>

6. Acknowledgements:

This project was funded through the Strategic Field Program (SFP) and Saskatchewan Barley Development Commission.

7. Appendices

Table 5. Main effects of variety and nitrogen rate on barley emergence at Melfort, Prince Albert, Swift Current and Yorkton.

	Emergence (plants/m^2)			
	Melfort	**Prince Albert**	**Swift Current**	**Yorkton**
Variety				
AC Metcalfe	209.4 b	228.3 a	168.8 b	280.6 a
AAC Synergy	208.3 b	233.4 a	174.8 b	274.0 a
CDC Bow	221.0 a	239.4 a	192.8 a	280.6 a
P-value	0.039275	NS	0.012227	NS
LSD	10.8	NS	15.9	NS
Nitrogen Rate (Soil + fertilizer) (lb N/ac)				
Background N[1]	228.4 ab	232.3 a	193.3 a	280.7 a
60	220.2 b	238.2 a	191.3 ab	284.2 a
120	237.6 a	228.2 a	185.3 ab	281.8 a
180	205.3 c	230.0 a	171.5 bc	268.2 a
240	172.9 d	239.8 a	152.6 c	277.1 a
P-value	<0.00001	NS	0.001184	NS
LSD	13.9	NS	20.5	NS

[1]Background lb N/ac in top 12 inches of soil were 45, 46, 31, 38 for Melfort, Prince Albert, Swift Current and Yorkton, respectively. Averaging 40 lb N/ac for all locations combined.

Table 6. Individual treatment effects on barley emergence at Melfort, Prince Albert, Swift Current and Yorkton.

Emergence (plants/m^2)				
	Melfort	**Prince Albert**	**Swift Current**	**Yorkton**
1. AC Metcalfe + Background N[1]	226.0 a	208.0 d	182.0 a	276.3 a
2. AC Metcalfe + 60 lb N/ac	218.2 a	242.0 abc	194.5 a	296.0 a
3. AC Metcalfe + 120 lb N/ac	229.3 a	251.5 ab	171.0 a	289.3 a
4. AC Metcalfe + 180 lb N/ac	196.4 a	209.0 d	159.8 a	265.5 a
5. AC Metcalfe + 240 lb N/ac	177.2 a	231.0 abcd	136.8 a	276.0 a
6. AAC Synergy + Background N[1]	226.4 a	234.0 abcd	190.5 a	274.3 a
7. AAC Synergy + 60 kg N/ac	218.6 a	237.0 abcd	183.0 a	262.0 a
8. AAC Synergy + 120 kg N/ac	235.0 a	212.5 cd	183.3 a	277.5 a
9. AAC Synergy + 180 kg N/ac	198.1 a	238.0 abcd	162.8 a	281.0 a
10. AAC Synergy + 240 kg N/ac	163.2 a	245.5 ab	154.5 a	275.3 a
11. CDC Bow + Background N[1]	232.9 a	255.0 a	207.3 a	291.5 a
12. CDC Bow + 60 kg N/ac	224.0 a	235.5 abcd	196.3 a	294.5 a
13. CDC Bow + 120 kg N/ac	248.5 a	220.5 bcd	201.8 a	278.8 a
14. CDC Bow + 180 kg N/ac	221.5 a	243.0 abc	192.0 a	258.0 a
15. CDC Bow + 240 kg N/ac	178.4 a	243.0 abc	166.5 a	280.0 a
P-values	NS	0.031327	NS	NS
LSD	NS	32.3	NS	NS

[1]Background lb N/ac in top 12 inches of soil were 45, 46, 31, 38 for Melfort, Prince Albert, Swift Current and Yorkton, respectively. Averaging 40 lb N/ac for all locations combined.

Table 7. Main effects of variety and nitrogen rate on barley maturity at Melfort, Prince Albert, Swift Current and Yorkton.

Physiological Maturity (Julian Days)				
	Melfort	**Prince Albert**	**Swift Current**	**Yorkton**
Variety				
AC Metcalfe	231.2 b	228.2 b	218.3 ab	210.5 a
AAC Synergy	232.6 a	229.4 a	218.0 b	210.7 a
CDC Bow	232.2 a	227.5 b	218.8 a	211.0 a
P-value	0.002982	0.002765	0.008862	NS
LSD	0.8	1.0	0.5	NS
Nitrogen Rate (Soil + fertilizer) (lb N/ac)				
Background N[1]	231.3 bc	228.8 a	218.1 a	210.3 a
60	231.8 bc	228.2 a	218.3 a	210.4 a
120	230.8 c	228.3 a	218.8 a	210.6 a
180	232.2 b	228.3 a	218.1 a	211.1 a
240	233.8 a	228.1 a	218.5 a	211.1 a
P-value	0.000024	NS	NS	NS
LSD	1.0	NS	NS	NS

[1]Background lb N/ac in top 12 inches of soil were 45, 46, 31, 38 for Melfort, Prince Albert, Swift Current and Yorkton, respectively. Averaging 40 lb N/ac for all locations combined.

Table 8. Individual treatment effects on barley maturity at Melfort, Prince Albert, Swift Current and Yorkton.

Physiological Maturity (Julian Days)				
	Melfort	**Prince Albert**	**Swift Current**	**Yorkton**
1. AC Metcalfe + Background N[1]	231.0 a	228.3 a	217.8 a	210.5 a
2. AC Metcalfe + 60 lb N/ac	231.3 a	229.0 a	218.0 a	210.3 a
3. AC Metcalfe + 120 lb N/ac	230.0 a	227.8 a	219.3 a	210.3 a
4. AC Metcalfe + 180 lb N/ac	230.3 a	228.3 a	218.3 a	210.5 a
5. AC Metcalfe + 240 lb N/ac	233.3 a	227.8 a	218.3 a	210.8 a
6. AAC Synergy + Background N[1]	231.5 a	231.0 a	217.5 a	209.8 a
7. AAC Synergy + 60 kg N/ac	233.3 a	229.0 a	218.0 a	210.8 a
8. AAC Synergy + 120 kg N/ac	231.3 a	229.0 a	218.3 a	210.8 a
9. AAC Synergy + 180 kg N/ac	233.0 a	229.5 a	217.8 a	211.0 a
10. AAC Synergy + 240 kg N/ac	234.0 a	228.3 a	218.5 a	211.3 a
11. CDC Bow + Background N[1]	231.5 a	227.3 a	219.0 a	210.8 a
12. CDC Bow + 60 kg N/ac	230.8 a	226.5 a	218.8 a	210.3 a
13. CDC Bow + 120 kg N/ac	231.3 a	228.3 a	219.0 a	210.8 a
14. CDC Bow + 180 kg N/ac	233.3 a	227.3 a	218.3 a	211.8 a
15. CDC Bow + 240 kg N/ac	234.0 a	228.3 a	218.8 a	211.3 a
P-values	NS	NS	NS	NS
LSD	NS	NS	NS	NS

[1]Background lb N/ac in top 12 inches of soil were 45, 46, 31, 38 for Melfort, Prince Albert, Swift Current and Yorkton, respectively. Averaging 40 lb N/ac for all locations combined.

Table 9. Significance of main effects and interactions for yield data combined over location.

	P-value
Location (L)	<0.00001
Variety (V)	<0.00001
L by V	0.00015
Nitrogen (N)	<0.00001
V by N	0.0237
L by V by N	NS

Table 10. Main effects of variety and nitrogen rate on barley yield at Melfort, Prince Albert, Swift Current and Yorkton.

Yield (kg/ha @13.5%)					
	Melfort	**Prince Albert**	**Swift Current**	**Yorkton**	**All sites**
Variety					
AC Metcalfe	3649.9 c	4323.0 b	4387.1 b	2473.2 a	3708 c
AAC Synergy	4443.1 a	4761.9 a	4867.0 a	2718.6 a	4198 a
CDC Bow	4195.5 b	5021.6 a	4474.5 b	2564.3 a	4064 b
P-value	<0.00001	0.000104	0.000453	NS	<0.00001
LSD	217.3	294.3	236.6	NS	123
Nitrogen Rate (Soil + fertilizer) (lb N/ac)					
Background N[1]	2795.6 d	3576.6 d	4392.7 b	2229.8 a	3249 d
60	2525.8 d	4297.3 c	4371.0 b	2550.4 ab	3436 c
120	3817.9 c	4874.8 b	4798.0 a	2613.9 bc	4026 b
180	5509.5 b	5280.3 a	4855.1 a	2913.0 c	4639 a
240	5832.0 a	5481.8 a	4464.2 b	2619.5 bc	4599 a
P-value	<0.00001	<0.00001	0.003594	0.007732	<0.00001
LSD	280.6	379.9	305.4	343.67	159

[1]Background lb N/ac in top 12 inches of soil were 45, 46, 31, 38 for Melfort, Prince Albert, Swift Current and Yorkton, respectively. Averaging 40 lb N/ac for all locations combined.

Table 11. Individual treatment effects on barley yield at Melfort, Prince Albert, Swift Current and Yorkton.

Yield (kg/ha @13.5%)					
	Melfort	**Prince Albert**	**Swift Current**	**Yorkton**	**All sites**
1. AC Metcalfe + Background N[1]	2609.5 f	3309.0 a	4008.0 a	2079.5 a	3002 f
2. AC Metcalfe + 60 lb N/ac	2253.6 f	4146.8 a	4257.3 a	2527.0 a	3296 e
3. AC Metcalfe + 120 lb N/ac	3502.6 e	4762.0 a	4593.5 a	2500.8 a	3840 d
4. AC Metcalfe + 180 lb N/ac	4896.2 c	4705.5 a	4713.3 a	2816.3 a	4283 b
5. AC Metcalfe + 240 lb N/ac	4987.6 c	4691.8 a	4363.5 a	2442.3 a	4121 bc
6. AAC Synergy + Background N[1]	2854.3 f	3515.8 a	4652.0 a	2400.3 a	3356 e
7. AAC Synergy + 60 kg N/ac	2782.9 f	4192.0 a	4640.5 a	2642.5 a	3564 e
8. AAC Synergy + 120 kg N/ac	4080.6 d	4819.5 a	5268.0 a	2820.8 a	4247 bc
9. AAC Synergy + 180 kg N/ac	5969.8 b	5562.3 a	5031.8 a	3023.3 a	4897 a
10. AAC Synergy + 240 kg N/ac	6528.0 a	5720.0 a	4742.5 a	2706.0 a	4924 a
11. CDC Bow + Background N[1]	2923.2 f	3905.0 a	4518.0 a	2209.5 a	3389 e
12. CDC Bow + 60 kg N/ac	2540.8 f	4553.0 a	4215.3 a	2481.8 a	3448 e
13. CDC Bow + 120 kg N/ac	3870.6 de	5043.0 a	4532.5 a	2520.3 a	3992 cd
14. CDC Bow + 180 kg N/ac	5662.6 b	5573.3 a	4820.3 a	2899.5 a	4739 a
15. CDC Bow + 240 kg N/ac	5980.4 b	6033.8 a	4286.3 a	2710.3 a	4753 a
P-values	0.038331	NS	NS	NS	0.0237
LSD	486.0	NS	NS	NS	275

[1]Background lb N/ac in top 12 inches of soil were 45, 46, 31, 38 for Melfort, Prince Albert, Swift Current and Yorkton, respectively. Averaging 40 lb N/ac for all locations combined.

Table 12. Main effects of variety and nitrogen rate on barley grain quality at Melfort.

	Melfort					
	Thins (>5/64" %)	**Plump (<6/64",%)**	**1000 Kernel Weight (g)**	**Protein (%)**	**4 ml Energy Germination (%)**	**8ml Water Sensitivity Germination (%)**
Variety						
AC Metcalfe	4.8	94.6	46.1	11.2	99.1	88.4
AAC Synergy	1.8	97.7	49.8	10.5	98.2	90.6
CDC Bow	2.1	97.5	49.4	10.7	97.6	79.2
P-value	N/A	N/A	N/A	N/A	N/A	N/A
LSD	N/A	N/A	N/A	N/A	N/A	N/A
Nitrogen Rate (Soil + fertilizer) (lb N/ac)						
Background N[1]	3.1	96.2	46.7	10.6	98.7	81.3
60	3.0	96.4	46.9	10.3	97.3	77.5
120	2.7	97.0	47.7	10.1	97.8	87.8
180	2.8	96.9	49.5	10.8	98.3	91.5
240	3.0	96.5	51.3	12.2	99.3	92.2
P-value	N/A	N/A	N/A	N/A	N/A	N/A
LSD	N/A	N/A	N/A	N/A	N/A	N/A

[1]Background lb N/ac in top 12 inches of soil were 45, 46, 31, 38 for Melfort, Prince Albert, Swift Current and Yorkton, respectively. Averaging 40 lb N/ac for all locations combined.

Table 13. Individual treatment effects on barley grain quality at Melfort.						
Melfort						
	Thins (>5/64 ” %)	**Plump (<6/64”,%)**	**1000 Kernel Weight (g)**	**Protein (%)**	**4 ml Energy Germination (%)**	**8ml Water Sensitivity Germination (%)**
1. AC Metcalfe + Background N[1]	5.1	94.1	44.6	10.9	99.5	83.5
2. AC Metcalfe + 60 lb N/ac	4.9	94.4	44.3	10.7	98.0	79.0
3. AC Metcalfe + 120 lb N/ac	5.0	94.6	45.4	10.7	98.5	89.5
4. AC Metcalfe + 180 lb N/ac	4.7	94.9	47.2	11.2	100.0	94.0
5. AC Metcalfe + 240 lb N/ac	4.5	95.0	48.9	12.6	99.5	96.0
6. AAC Synergy + Background N[1]	2.0	97.5	47.8	10.3	98.0	88.5
7. AAC Synergy + 60 kg N/ac	2.2	97.1	48.6	10.0	96.5	85.5
8. AAC Synergy + 120 kg N/ac	1.2	98.6	49.1	9.6	98.5	90.0
9. AAC Synergy + 180 kg N/ac	1.6	98.0	50.7	10.4	98.0	94.5
10. AAC Synergy + 240 kg N/ac	1.9	97.3	53.0	12.0	100.0	94.5
11. CDC Bow + Background N[1]	2.1	97.0	47.8	10.5	98.5	72.0
12. CDC Bow + 60 kg N/ac	2.0	97.7	47.7	10.3	97.5	68.0
13. CDC Bow + 120 kg N/ac	1.8	97.7	48.7	9.9	96.5	84.0
14. CDC Bow + 180 kg N/ac	2.0	97.7	50.6	10.8	97.0	86.0
15. CDC Bow + 240 kg N/ac	2.5	97.2	52.0	11.9	98.5	86.0
P-values	N/A	N/A	N/A	N/A	N/A	N/A
LSD	N/A	N/A	N/A	N/A	N/A	N/A
[1]Background lb N/ac in top 12 inches of soil were 45, 46, 31, 38 for Melfort, Prince Albert, Swift Current and Yorkton, respectively. Averaging 40 lb N/ac for all locations combined.						

Table 14. Main effects of variety and nitrogen rate on barley grain quality at Prince Albert						
			Prince Albert			
	Thins (>5/64", %)	**Plump (<6/64",%)**	**1000 Kernel Weight (g)**	**Protein (%)**	**4 ml Energy Germination (%)**	**8ml Water Sensitivity Germination (%)**
Variety						
AC Metcalfe	2.5	96.9	51.2	12.4	52.3	25.3
AAC Synergy	1.3	98.0	53.8	12.0	40.4	20.3
CDC Bow	0.8	98.5	53.4	11.7	14.6	7.1
P-value	N/A	N/A	N/A	N/A	N/A	N/A
LSD	N/A	N/A	N/A	N/A	N/A	N/A
Nitrogen Rate (Soil + fertilizer) (lb N/ac)						
Background N[1]	1.4	98.1	53.5	11.4	35.3	17.3
60	1.1	98.2	53.0	11.3	34.2	17.5
120	1.3	98.1	53.3	11.7	36.0	15.8
180	1.6	97.7	52.6	12.1	36.3	20.0
240	2.5	96.9	51.7	13.4	37.0	17.2
P-value	N/A	N/A	N/A	N/A	N/A	N/A
LSD	N/A	N/A	N/A	N/A	N/A	N/A

[1]Background lb N/ac in top 12 inches of soil were 45, 46, 31, 38 for Melfort, Prince Albert, Swift Current and Yorkton, respectively. Averaging 40 lb N/ac for all locations combined.

Table 15. Individual treatment effects on barley grain quality at Prince Albert.						
Prince Albert						
	Thins (>5/64" %)	**Plump (<6/64",%)**	**1000 Kernel Weight (g)**	**Protein (%)**	**4 ml Energy Germination (%)**	**8ml Water Sensitivity Germination (%)**
1. AC Metcalfe + Background N[1]	2.0	97.4	52.0	11.5	54.0	23.0
2. AC Metcalfe + 60 lb N/ac	1.8	97.7	52.5	11.8	49.5	23.0
3. AC Metcalfe + 120 lb N/ac	2.3	97.3	51.2	11.8	48.5	25.0
4. AC Metcalfe + 180 lb N/ac	2.8	96.6	50.8	12.5	57.0	31.5
5. AC Metcalfe + 240 lb N/ac	3.8	95.7	49.6	14.2	52.5	24.0
6. AAC Synergy + Background N[1]	1.3	98.0	54.6	11.8	37.0	23.0
7. AAC Synergy + 60 kg N/ac	0.8	98.6	53.4	11.0	38.5	18.0
8. AAC Synergy + 120 kg N/ac	0.9	98.4	54.5	11.8	43.0	18.0
9. AAC Synergy + 180 kg N/ac	1.1	98.2	54.0	12.1	41.5	21.0
10. AAC Synergy + 240 kg N/ac	2.6	96.7	52.7	13.1	42.0	21.5
11. CDC Bow + Background N[1]	0.8	98.9	53.8	10.9	15.0	6.0
12. CDC Bow + 60 kg N/ac	0.7	98.4	53.2	11.0	14.5	11.5
13. CDC Bow + 120 kg N/ac	0.8	98.5	54.2	11.6	16.5	4.5
14. CDC Bow + 180 kg N/ac	0.9	98.4	53.0	11.8	10.5	7.5
15. CDC Bow + 240 kg N/ac	1.0	98.4	52.7	13.0	16.5	6.0
P-values	N/A	N/A	N/A	N/A	N/A	N/A
LSD	N/A	N/A	N/A	N/A	N/A	N/A
[1]Background lb N/ac in top 12 inches of soil were 45, 46, 31, 38 for Melfort, Prince Albert, Swift Current and Yorkton, respectively. Averaging 40 lb N/ac for all locations combined.						

Table 16. Main effects of variety and nitrogen rate on barley grain quality at Swift Current						
Swift Current						
	Thins (>5/64" %)	**Plump (<6/64",%)**	**1000 Kernel Weight (g)**	**Protein (%)**	**4 ml Energy Germination (%)**	**8ml Water Sensitivity Germination (%)**
Variety						
AC Metcalfe	17.7	76.9	41.3	13.4	100.0	97.8
AAC Synergy	12.9	82.7	43.7	13.1	99.5	98.8
CDC Bow	15.8	78.4	41.9	13.2	99.7	98.2
P-value	N/A	N/A	N/A	N/A	N/A	N/A
LSD	N/A	N/A	N/A	N/A	N/A	N/A
Nitrogen Rate (Soil + fertilizer) (lb N/ac)						
Background N[1]	10.3	86.1	43.6	11.5	99.7	97.9
60	13.0	82.1	43.0	12.5	99.7	97.5
120	13.5	82.0	42.3	12.8	99.8	98.5
180	18.2	76.2	41.7	14.2	99.7	99.0
240	22.4	70.0	40.9	15.4	99.8	98.5
P-value	N/A	N/A	N/A	N/A	N/A	N/A
LSD	N/A	N/A	N/A	N/A	N/A	N/A

[1]Background lb N/ac in top 12 inches of soil were 45, 46, 31, 38 for Melfort, Prince Albert, Swift Current and Yorkton, respectively. Averaging 40 lb N/ac for all locations combined.

Table 17. Individual treatment effects on barley grain quality at Swift Current.

Swift Current						
	Thins (>5/64" %)	**Plump (<6/64",%)**	**1000 Kernel Weight (g)**	**Protein**	**4 ml Energy Germination (%)**	**8ml Water Sensitivity Germination (%)**
1. AC Metcalfe + Background N[1]	9.9	86.6	43.1	10.7	100.0	97.5
2. AC Metcalfe + 60 lb N/ac	13.6	80.8	42.5	12.5	100.0	94.0
3. AC Metcalfe + 120 lb N/ac	13.9	82.4	41.6	12.6	100.0	99.5
4. AC Metcalfe + 180 lb N/ac	23.3	71.0	39.4	15.2	100.0	99.5
5. AC Metcalfe + 240 lb N/ac	27.8	63.5	39.7	16.1	100.0	98.5
6. AAC Synergy + Background N[1]	9.4	88.0	45.1	11.8	99.5	97.5
7. AAC Synergy + 60 kg N/ac	12.4	83.2	43.2	12.4	99.5	99.0
8. AAC Synergy + 120 kg N/ac	11.3	84.6	43.7	13.1	99.5	99.0
9. AAC Synergy + 180 kg N/ac	15.1	79.2	43.7	13.6	99.5	100.0
10. AAC Synergy + 240 kg N/ac	16.1	78.3	42.9	14.8	99.5	98.5
11. CDC Bow + Background N[1]	11.5	83.8	42.7	12.1	99.5	98.5
12. CDC Bow + 60 kg N/ac	12.9	82.3	43.2	12.5	99.5	99.5
13. CDC Bow + 120 kg N/ac	15.3	79.1	41.5	12.7	100.0	97.0
14. CDC Bow + 180 kg N/ac	16.1	78.4	42.0	13.7	99.5	97.5
15. CDC Bow + 240 kg N/ac	23.3	68.3	40.0	15.2	100.0	98.5
P-values	N/A	N/A	N/A	N/A	N/A	N/A
LSD	N/A	N/A	N/A	N/A	N/A	N/A

[1]Background lb N/ac in top 12 inches of soil were 45, 46, 31, 38 for Melfort, Prince Albert, Swift Current and Yorkton, respectively. Averaging 40 lb N/ac for all locations combined.

Table 18. Main effects of variety and nitrogen rate on barley grain quality at Yorkton						
Yorkton						
	Thins (>5/64" %)	**Plump (<6/64",%)**	**1000 Kernel Weight (g)**	**Protein (%)**	**4 ml Energy Germination (%)**	**8ml Water Sensitivity Germination (%)**
Variety						
AC Metcalfe	1.2	98.4	48.0	14.3	91.3	51.9
AAC Synergy	0.9	98.7	50.3	13.7	85.8	72.9
CDC Bow	0.9	98.7	50.1	13.4	52.3	42.1
P-value	N/A	N/A	N/A	N/A	N/A	N/A
LSD	N/A	N/A	N/A	N/A	N/A	N/A
Nitrogen Rate (Soil + fertilizer) (lb N/ac)						
Background N[1]	0.7	99.1	49.7	11.6	73.0	48.7
60	0.7	98.9	49.7	12.5	73.0	51.5
120	1.2	98.3	49.6	14.8	78.3	59.2
180	1.2	98.5	49.5	14.8	80.2	61.5
240	1.3	98.3	48.9	15.3	77.8	57.3
P-value	N/A	N/A	N/A	N/A	N/A	N/A
LSD	N/A	N/A	N/A	N/A	N/A	N/A

[1]Background lb N/ac in top 12 inches of soil were 45, 46, 31, 38 for Melfort, Prince Albert, Swift Current and Yorkton, respectively. Averaging 40 lb N/ac for all locations combined.

Table 19. Individual treatment effects on barley grain quality at Yorkton.

Yorkton						
	Thins (>5/64" %)	**Plump (<6/64",%)**	**1000 Kernel Weight (g)**	**Protein (%)**	**4ml Energy Germination (%)**	**8ml Water Sensitivity Germination (%)**
1. AC Metcalfe + Background N[1]	0.9	98.9	48.3	12.2	88.5	50.5
2. AC Metcalfe + 60 lb N/ac	1.1	98.6	48.8	12.5	89.5	49.5
3. AC Metcalfe + 120 lb N/ac	1.4	98.3	47.4	15.4	95.5	51.0
4. AC Metcalfe + 180 lb N/ac	1.3	98.2	47.7	15.3	92.0	57.5
5. AC Metcalfe + 240 lb N/ac	1.4	98.2	47.6	16.0	91.0	51.0
6. AAC Synergy + Background N[1]	0.6	99.2	51.3	11.2	76.5	59.0
7. AAC Synergy + 60 kg N/ac	0.6	99.0	50.2	12.6	80.0	70.5
8. AAC Synergy + 120 kg N/ac	0.9	98.6	49.9	14.8	91.0	75.5
9. AAC Synergy + 180 kg N/ac	1.2	98.5	50.6	14.7	91.5	80.5
10. AAC Synergy + 240 kg N/ac	1.3	98.2	49.7	15.0	90.0	79.0
11. CDC Bow + Background N[1]	0.7	99.3	49.4	11.3	54.0	36.5
12. CDC Bow + 60 kg N/ac	0.5	99.1	50.1	12.4	49.5	34.5
13. CDC Bow + 120 kg N/ac	1.2	98.1	51.6	14.1	48.5	51.0
14. CDC Bow + 180 kg N/ac	1.0	98.7	50.3	14.3	57.0	46.5
15. CDC Bow + 240 kg N/ac	1.3	98.4	49.3	14.8	52.5	42.0
P-values	N/A	N/A	N/A	N/A	N/A	N/A
LSD	N/A	N/A	N/A	N/A	N/A	N/A

[1]Background lb N/ac in top 12 inches of soil were 45, 46, 31, 38 for Melfort, Prince Albert, Swift Current and Yorkton, respectively. Averaging 40 lb N/ac for all locations combined.

Barley MAX Experiment 1

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1. **Project objectives:**

New barley varieties offer higher yields, improved disease resistance and increased straw strength to prevent lodging compared to older varieties. Standard management practices for older varieties may not be suitable to maximize the opportunity for increased production with these varieties. Experiment 1 will determine the optimum agronomic package for new varieties in comparison to a recent industry standard variety.

2. **Project Rationale:**

Western Canadian barley acres have shrunk by more than 50 per cent in the past 20 years. With the lowest rate of gain among major crops and competition with other low-cost feed options, fewer producers are choosing to grow barley. Yet, there remains optimism that barley can be competitive with other cropping options.

Compared to other crop types, the acceptance of new varieties with improved disease resistance and higher yields is limited. As a result, the majority of barley production is with 20-year-old technology. There are strong indications that the industry is shifting to newer varieties with improved agronomics, but the optimum agronomic input packages are not known for these newer varieties.

Barley is generally either malt or feed, with a significant price difference sometimes in place. As a result, producers are incentivized to manage for malt and sacrifice yield in order to do so. Research is needed to help producers increase their yields, while maintaining malt quality.

Significant advancements in barley agronomy were made under one of the recent barley clusters, but the inputs investigated have not been looked at in a comprehensive package in Saskatchewan, with the most up-to-date varieties.

3. Methodology:

This trial was setup as a Randomized Complete Block Design (RCBD) with 21 treatments and 4 replicates (Table 1). The plot size, row spacing, and fertilizer application techniques for seeding varied between locations depending on equipment used. Each site targeted a seeding date of May 10. Herbicides and insecticides were applied based on industry standards and as required at each location.

Table 1. Treatment List for the "Barley MAX Experiment 1" Trial

Trt #	Variety	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
1	AC Metcalfe	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
2	AC Metcalfe	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
3	AC Metcalfe	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
4	AC Metcalfe	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
5	AC Metcalfe	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
6	AC Metcalfe	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
7	AC Metcalfe	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes
8	AAC Synergy	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
9	AAC Synergy	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
10	AAC Synergy	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
11	AAC Synergy	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
12	AAC Synergy	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
13	AAC Synergy	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
14	AAC Synergy	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes
15	CDC Bow	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
16	CDC Bow	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
17	CDC Bow	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
18	CDC Bow	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
19	CDC Bow	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
20	CDC Bow	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
21	CDC Bow	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 2. Dates of operations for the 2020 "Barley MAX Experiment 1" trial.

Operations in 2020	**Melfort**	**Prince Albert**	**Scott**	**Swift Current**	**Yorkton**
Pre-seed Herbicide Application	May 24 (Heat LQ + Glyphosate)	N/A	May 15 (Glyphosate + AIM)	May 4 (Glyphosate + AIM + Merge)	N/A
Seeding Date + Seed Treatment	May 22 + Raxil Pro	May 23 + Raxil Pro	May 18 + Raxil Pro	May 16 + Raxil Pro	May 8 + Raxil Pro
Emergence Counts	June 11	June 9	June 10	May 28	May 28
In-crop Herbicide	June 23 (Prestige XC) & July 3 (Axial)	June 10 (Infinity)	June 15 (Axial Ipak)	May 29 (Liquid Achieve + Buctril M + Turbocharge)	June 2 (Prestige) & June 8 (Axial)
Plant Growth Regulator Application	July 3 Moddus	June 22 Moddus	June 19 Moddus	June 16 Moddus	June 16 Moddus
Flag Leaf Fungicide Application	July 11 Trivapro	July 3 Trivapro	July 6 Trivapro	June 24 Trivapro	July 1 Trivapro
Heading Date	July 22	July 13-24	July 14-20	July 21	July 6
Fusarium Head Blight Fungicide Application	July 24 (Caramba)		July 20 (Caramba)	July 21 (Caramba)	July 13 Caramba
Days to Maturity	Aug 17	Aug 13-22	Aug 10-18	Aug 6	July 30
Heads Counts	Aug 4	N/A	N/A	Aug 10	N/A
Kernel/Head Counts	Aug 12	N/A	N/A	Aug 25	N/A
Lodging Rating	Sept 1	Sept 2	Aug 14	N/A	N/A
Harvest	Sept 1	Sept 4 & 9	Aug 25	Aug 17	Aug 24

4. Results:

Table 4. Soil Test Nitrate, Phosphorus and Potassium Levels for each location.					
Nitrate Levels (lbs NO_3-N/ac)	**Melfort**	**Prince Albert**	**Scott**	**Swift Current**	**Yorkton**
0-15cm (0-6in)	21 lb/ac	18 lb/ac	14 lb/ac	20 lb/ac	27 lb/ac
15-30cm (6-12in)	24 lb/ac	28 lb/ac		11	23 lb/ac
15-60cm (6-24in)			21 lb/ac		
30-60cm (12-24in)					10 lb/ac
Total N 0-60cm (0-24in)			35 lb/ac		60 lb/ac
Total N 0-30cm (0-12in)	45 lb/ac	46 lb/ac		31 lb/ac	
Phosphorus (Olsen)	12 ppm	8 ppm	8 ppm	20 ppm	10 ppm
Potassium	469 ppm	197 ppm	295 ppm	482 ppm	266 ppm

All data was collected and received from participating sites. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination are presented in tables 6 to 10 in the appendix. Table 5. Shows the main effects of variety and management on barley yield and grain protein averaged over site. As anticipated, yield was greater and grain protein was lower for the newer variety AAC Synergy compared to the older variety AC Metcalfe. However, the yield difference was only 5.6% and not the 15% anticipated from past research. Management A with only 200 seeds/m², 90 kg/ha of soil + fertilizer N and 15 kg P_2O_5/ha was the lowest level of management, significantly producing the lowest yield (Table 5). Increasing seeding rate to 300 seeds/m², applying seed treatment, increasing rate of P_2O_5 to 30 kg/ha, adding 15 kg K_2O and applying fungicide for FHB (Management D) significantly increased yield by 298.8 kg/ha (5.3 bu/ac) relative to the lowest level of management (A). All remaining treatments yielded significantly more than management A or D but did not differ from each other. The lowest level of management from the group of highest yielding treatments was B, seeding at 300 seeds/m² with 120 kg/ha of soil + fertilizer N, 30 kg P_2O_5/ha and 15 kg K_2O. In other words, when N rate was increased from 90 to 120 kg/ha barley yield significantly increased, but the addition of seed treatment, PGR and fungicide at flag or heading for fusarium head blight did not significantly affect yield. With this in mind, the yield benefit from moving from management A to D can now be attributed to some combination of increasing seeding rate, increased P_2O_5 and added K_2O.

5. Conclusions and Recommendations

When averaged over location and variety, barley yield did not respond to PGR, seed treatment or fungicide at flag leaf or heading for fusarium headblight. Yield did respond to increasing soil + fertilizer N from 90 to 120 kg/ha and some combination of increasing seeding rate,. However, the relative impact of seeding rate, P_2O_5 and K_2O cannot be determined due to confounding. Discussion of interactions and an economic analysis will be available in a final report.

6. Acknowledgements:

This project was funded through the Strategic Field Program (SFP) and Saskatchewan Barley Development Commission.

7. Appendices

Table 5. Main effects of variety and management on protein and yield averaged over all sites.

	Protein (%)	Yield (kg/ha @13.5%)
Variety (V)		
AC Metcalfe	12.1	3829.8 b
AAC Synergy	11.4	4047.8 a
CDC Bow	11.2	3909.6 b
LSD	N/A	100.6
Management (M)[1]		
A	11.2	3335.8 c
B	11.5	4045.2 a
C	11.6	4066.7 a
D	11.5	3634.6 b
E	11.5	4195.7 a
F	11.7	4099.3 a
G	11.8	4126.2 a
LSD	N/A	153.7
V by M interaction	N/A	595.4

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 6. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Melfort.

	Emergence (plants/m^2)	Maturity (Julian days)	Lodging (1-10)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64",%)	Plumps (>6/64", %)	Thousand kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	201.1 c	234 a	0	4077 a	10.1	1.7	98.1	49.4	98.3	93.4
AAC Synergy	205.1 bc	232 b	0	3634 b	10.8	3.9	95.6	46.4	98.4	92.4
CDC Bow	219.3 a	234 a	0	3803 b	10.3	2.1	97.5	49.0	97.6	84.9
LSD	14.5	1.1	NS	247	N/A	N/A	N/A	N/A	N/A	N/A
Management (M)[1]										
A	157.5 d	237 a	0	2913 b	10.7	2.9	96.7	47.9	96.5	87.8
B	235.7 a	232 cd	0	4207 a	10.2	2.7	97.0	48.1	99.0	92.2
C	206.3 c	232 cd	0	4257 a	10.3	2.2	97.5	48.5	98.3	93.3
D	212.0 bc	235 ab	0	2970 b	10.5	2.2	97.5	48.1	98.0	86.5
E	229.1 ab	231 d	0	4169 a	10.2	2.0	97.7	48.2	98.8	91.8
F	217.5 abc	234 bc	0	4087 a	10.5	3.3	96.2	48.1	98.8	90.2
G	201.1 c	234 bc	0	4262 a	10.5	2.7	97.0	49.0	97.3	89.8
LSD	22.1	1.7	NS	377	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	NS	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management [1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 7. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Prince Albert.

	Emergence (plants/m²)	Maturity (Julian days)	Lodging (1-10)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64",%)	Plumps (>6/64",%)	Thousand Kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	200.7 a	230 a	0.3 a	3784 b	11.7	2.7	96.6	51.7	70.6	41.9
AAC Synergy	204.9 a	230 a	0.0 b	4176 a	11.2	1.4	98.0	53.2	58.4	34.7
CDC Bow	215.6 a	230 a	0.0 b	3883 ab	11.0	1.3	98.1	52.2	22.9	11.1
LSD	NS	NS	0.18	298	N/A	N/A	N/A	N/A	N/A	N/A
Management (M)[1]										
A	150.5 b	232 a	0.1 a	3055 b	11.4	1.8	97.4	52.9	59.2	33.3
B	221.2 a	229 b	0.0 a	3870 a	11.3	2.0	97.3	52.1	55.3	27.2
C	224.5 a	229 b	0.2 a	4157 a	11.0	1.9	97.6	52.9	50.7	32.3
D	214.5 a	229 b	0.3 a	3961 a	11.3	1.7	97.7	52.9	46.8	26.8
E	207.5 a	229 b	0.0 a	4069 a	11.3	1.7	97.7	52.5	41.8	27.2
F	218.2 a	230 b	0.1 a	4255 a	11.3	1.9	97.5	51.5	51.7	29.5
G	213.0 a	230 b	0.0 a	4265 a	11.5	1.8	97.6	51.8	49.0	28.3
LSD	19.7	1.3	NS	455	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	NS	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 8. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Scott.

	Emergence (plants/m²)	**Maturity (Julian days)**	**Lodging (1-10)**	**Yield (kg/ha @13.5%)**	**Protein (%)**	**Thins (>5/64",%)**	**Plumps (>6/64",%)**	**Thousand Kernel Weight (g)**	**4ml Energy Germination (%)**	**8ml Water Sensitive Germination (%)**
Variety (V)										
AC Metcalfe	152.9 b	227 a	0.1 a	5172 b	10.6	5.6	93.9	45.2	98.6	85.9
AAC Synergy	157.5 b	227 a	0 a	5665 a	10.0	2.5	97.0	46.7	97.7	80.4
CDC Bow	168.6 a	228 a	0 a	5344 b	9.5	3.0	96.9	46.3	97.7	80.6
LSD	10.1	NS	NS	197	N/A	N/A	N/A	N/A	N/A	N/A
Management (M)[1]										
A	132.9 b	229 a	0 a	4437 c	10.0	3.2	96.3	45.5	98.0	80.3
B	165.0 a	227 a	0.1 a	5536 a	10.1	4.1	95.6	46.1	97.7	84.2
C	159.7 a	227 a	0.1 a	5582 a	10.1	4.3	95.5	46.1	98.5	84.8
D	169.8 a	227 a	0 a	4991 b	9.8	3.6	96.4	46.2	98.3	78.2
E	168.8 a	227 a	0 a	5793 a	10.0	3.7	96.1	46.7	98.0	85.5
F	156.0 a	228 a	0 a	5660 a	10.2	4.2	95.5	45.7	98.8	79.7
G	165.4 a	228 a	0 a	5757 a	9.9	2.9	96.2	46.3	96.7	83.2
LSD	15.4	NS	NS	300	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	NS	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management[1]	**Seeding Rate**	**Seed Trt**	**N (soil + fert)**	**P**	**K**	**PGR**	**Flag Leaf fung.**	**FHB fung.**
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 9. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Swift Current.

	Emergence (plants/m2)	Maturity (Julian days)	Lodging (1-10)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64",%)	Plumps (>6/64", %)	Thousand Kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	177.4 a	218.0 b	0 a	4101 ab	11.6	9.8	87.4	42.4	95.7	95.0
AAC Synergy	174.9 a	218.1 b	0 a	4253 a	10.4	6.6	91.2	44.8	96.4	97.0
CDC Bow	179.3 a	218.9 a	0 a	4047 b	10.9	8.8	88.2	43.7	86.4	95.8
LSD	NS	0.4	NS	158	N/A	N/A	N/A	N/A	N/A	N/A
Management (M)[1]										
A	139.1 b	218.9 a	0 a	3723 d	9.8	5.0	93.3	44.8	96.5	95.7
B	176.3 a	217.9 c	0 a	4253 abc	10.7	8.2	89.4	43.3	91.0	96.3
C	179.8 a	218.1 bc	0 a	4128 bc	11.2	10.1	86.8	43.1	93.2	96.0
D	188.9 a	218.1 bc	0 a	4036 c	11.0	7.6	89.9	44.3	88.8	96.8
E	191.6 a	218.2 abc	0 a	4380 a	11.4	8.0	89.5	44.2	92.2	94.3
F	183.3 a	218.8 ab	0 a	4283 ab	11.3	8.8	88.5	43.2	95.7	96.8
G	181.3 a	218.6 abc	0 a	4133 bc	11.2	11.1	85.3	42.6	92.3	95.5
LSD	22.7	0.7	NS	242	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	NS	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management [1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Table 10. Main effects of variety and management on emergence, maturity, lodging, yield, grain protein, thins and plumps, 1000 kwt and germination of barley at Yorkton.

	Emergence (plants/m2)	Maturity (Julian days)	Lodging (1-10)	Yield (kg/ha @13.5%)	Protein (%)	Thins (>5/64",%)	Plumps (>6/64", %)	Thousand Kernel Weight (g)	4ml Energy Germination (%)	8ml Water Sensitive Germination (%)
Variety (V)										
AC Metcalfe	242.5 a	210 b	0.4 a	2015 b	16.3	1.6	98.0	46.9	99.1	68.2
AAC Synergy	249.1 a	210 b	0.6 a	2511 a	14.5	1.3	98.3	48.7	98.7	87.2
CDC Bow	290.9 a	211 a	0.6 a	2472 a	14.4	1.2	98.4	48.7	98.9	54.9
LSD	NS	0.6	NS	232	N/A	N/A	N/A	N/A	N/A	N/A
Management (M)[1]										
A	199.7 b	211 a	0.8 a	2551 a	13.9	0.9	98.8	49.2	97.8	73.3
B	277.7 a	211 a	0.5 a	2361 a	15.5	1.0	98.6	48.8	99.3	71.2
C	277.9 a	210 a	0.5 a	2210 a	15.5	1.2	98.4	48.4	99.3	68.3
D	280.2 a	210 a	0.6 a	2215 a	14.8	1.1	98.5	48.6	98.2	62.3
E	271.7 a	211 a	0.8 a	2568 a	14.6	1.0	98.8	48.7	99.3	65.3
F	257.3 ab	211 a	0.4 a	2211 a	15.5	2.2	97.3	46.8	99.3	74.5
G	261.3 ab	211 a	0.3 a	2214 a	15.6	2.2	97.3	46.2	98.8	75.7
LSD	65.3	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A
V by M interaction	NS	NS	NS	NS	N/A	N/A	N/A	N/A	N/A	N/A

Management[1]	Seeding Rate	Seed Trt	N (soil + fert)	P	K	PGR	Flag Leaf fung.	FHB fung.
A	200 seeds/m2		90 kg N/ha	15 kg P2O5/ha				
B	300 seeds/m2		120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
C	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			
D	300 seeds/m2	yes	90 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
E	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha			yes
F	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes		yes
G	300 seeds/m2	yes	120 kg N/ha	30 kg P2O5/ha	15 kg K2O/ha	yes	yes	yes

Can Farm-saved Seed Wheat (Triticum aestivum L.) Perform as well as Certified Seed in Saskatchewan?

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[8]Wheatland Conservation Area Inc., Swift Current, SK

1. Abstract/Summary:

In 2019 and 2020, a study was conducted in Saskatchewan to compare the vigor and yield performance of various lots of farm-saved wheat seed relative to the same varieties of certified seed. A second objective was to determine if seed vigor and yield potential of any seed lot could be improved by using seed treatment. In both years, trials were established at AgriARM locations near Yorkton, Redvers, Indian Head, Swift Current, Scott, Outlook, Prince Albert and Melfort. In each year, every site randomly selected 3 lots of farm saved seed, which local producers intended to plant. These seed lots were then matched against a certified seed lot of the same variety. Each of the 3 varietal comparisons were compared with and without seed treatment making a total of 12 treatments at each site. The variety selected for each of the 3 pairings varied between location and year. The vast majority of varietal pairings used CWRS varieties of wheat. However, all 3 varietal pairing at Swift Current were durum in both years and 1 varietal pairing at Redvers in 2019 was also a durum. A seed lot of FSS or certified seed was never used more than once. After two years this study has made 48 varietal comparisons between certified and FSS. On average, the FSS used in this study was 2.1 years removed from certified. The quality of all seed lots of farm-save and certified seed was determined after seeding and was not used as criteria for seed selection. Overall, the quality of FFS and certified seed was comparable. In 2019, the seed vigor was 93% on average for both certified and FSS. In 2020, the vigor of certified seed at 93.7% was a little higher than FSS at 91.1%. While not statistically different, levels of seed borne disease was about 1% higher on FSS, but on average seed borne disease was well below levels of concern. Overall, seed treatment had little effect on yield for either FSS or certified seed. This was likely the result of low levels of seed-borne disease and good growing conditions after seeding. There was little difference in the performance between FSS and certified seed. Seedling vigor did not differ between FSS and certified seed for the vast majority of cases. Where differences in seedling vigor existed the trend was inconsistent. On average, certified seed yielded 4453 kg/ha (66.3 bu/ac) with a grain protein of 13.4% and FSS yielded 4433 kg/ha (65.9 bu/ac) with a grain protein of 13.5%. These differences are neither large or statistically significant. Growing FSS was more economical in this study, because doing so incurred no yield or protein disadvantage, and certified seed is typically more expensive. However, certified seed has value as it is “true to type” which is of growing importance to the end user. Purchasing certified seed introduces improved genetics to the farm and supports a breeding system that keeps Canadian wheat producers globally competitive. This study does not discount the importance of certified seed. However, the popular approach of many farmers to grow farm saved seed for a couple of years between purchases of new certified seed appears economically sound.

2. Project objectives:

- To compare the vigor and yield performance of various lots of farm-saved wheat seed relative to the same varieties of certified seed.
- To determine the degree to which seed treatment can improve the vigor and yield potential of farm-saved and certified seed lots of wheat.

3. Project Rationale:

While the yield loss from growing saved seed from hybrid crops such as canola[1] has been well documented, little research has compared yields between certified and farm-saved seed for wheat in western Canada. Producers of cereal grains are free to retain seed for planting on their own farm. This retained seed is commonly referred to as "farm-saved seed" (FSS). Despite the guaranteed quality of certified seed, a phone survey of 800 producers in 2004 determined approximately 70 to 80% of cereal acres in western Canada were seeded with farm-saved seed[2]. Producers cited "reduced costs" and "knowing what is in the seed" as reasons preferring FSS. Farm-saved seed is typically a cheaper seed source than certified seed. A 13-year study in Alberta between 2003 and 2016 found the average price premium for certified wheat seed over FSS was $3.75/bu[3], even when assuming a 1.5 bu/ac yield benefit from using a new variety of certified seed. To be fair, the Canadian Seed Growers' Association does not mention higher yields when discussing "the certified advantage".[4] Certified seed is valuable because it is "true to type" meaning it has retained all the genetic benefits developed by the breeder. This helps with "quality assurance" for the end users which is of increasing importance as the industry moves toward a value chain model. In addition, to be "certified", seed must meet high standards of germination and freedom from impurities, which are determined by an officially recognized third-party agency[5]. Finally, it is important to support a system that ensures the development of new varieties to keep Canadian wheat producers globally competitive. The exact form of this support is currently under debate.

Many producers believe they are capable of producing quality FSS which is comparable to certified seed. Producers will typically grow FSS for 2-3 years and then purchase certified seed to introduce better genetics to the farm. This may prove to be true for many producers in Saskatchewan as past study with winter wheat in central Oklahoma found FSS could often perform as well as certified seed. However, the relative comparison changed between years in their study. In 2003, they observed 9 out of 19 farm-saved seed lots were inferior for grain production compared to the best certified seed source. In contrast, only 2 out of 27 farm-saved samples were inferior in 2004 and only 4 out of 17 were inferior in 2005.[6] The authors concluded "that if farms use quality control measures similar to those required for certified seed, farm-saved wheat seed can produce forage and grain yield comparable to that of certified seed" [6]. To ensure quality seed is being planted, seed must be sent away for testing.

There are a number of seed labs, which offer vigor testing and disease screening to help producers determine the suitability of a seed lot for seeding. Vigor tests are superior to the standard germination test as they will give a better indication of crop emergence and strength under adverse conditions. A fungal screen can determine the presence of a number of seed-borne pathogens that can also affect seed vigor. Low vigor seed lots with high fungal screens can be retested to determine if seed treatment can improve vigor[7]. Seed treatment will often improve the vigor of a seed lot by 10%. However, the level of seed-borne disease may help to determine if locating a better seed lot would be advisable.

The quality of farm-saved seed lots are likely to be more variable than certified seed, which must meet exacting standards. The intent of this study is to randomly compare the vigor and yield potential of FSS relative to certified seed in Saskatchewan from 2019-2021. The intent is to sample as many FSS and certified seed lots as possible. In the first two years of this study, 48 different seed lots of FSS were compared against the same varieties of 48 different seed lots of certified seed.

[1]Clayton, G.W., Brandt, S., Johnson, E.N., O'Donovan, J.T., Harker, K.N., Blackshaw, R.E., Smith, E.G., Kutcher, H.R., Vera, C., and M. Hartman. 2009. Comparison of Certified and Farm-Saved Seed on Yield and Quality Characteristics of Canola. Agron. J. 101: 1581-1588

[2]https://www.cropweek.com/presentations/2005/ssga.pdf

[3]Overview of Certified Seed and Farm-saved Seed, March 2018. Economics and Competitiveness Branch. Alberta Government.
https://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/econ15976/$FILE/Overview%20of%20Certified%20Seed%20and%20Farm%20Saved%20Seed%20II.pdf

[4]The Certified Advantage
https://seedgrowers.ca/farms/the-certified-advantage/

[5]What is Canadian Certified Seed?
http://seedgrowers.ca/seed-growers/what-is-canadian-certified-seed/

[6]Edwards, J.T. and E. G. Krenzer Jr. 2006. Quality of Farm-saved Wheat Seed is Variable in the Southern Great Plains. Online. Crop Management doi:10.1094/CM-2006-0531-01-RS

[7]What is a Fungal ScreenTM for Cereals? 20/20 Seed Labs
https://www.2020seedlabs.ca/what-is-a-fungal-screen-for-cereals/

Methodology and Results

4. Methodology:

The trials were setup as a 2 by 3 by 2 factorial in a randomized complete block design with 4 replicates. The plot size, row spacing, and fertilizer application techniques for seeding varied between locations. However, managers at each site applied macronutrients at rates to adequately compensate for any limitations and all small plots were direct seeded into standing stubble. Individual treatments are listed in Table 1 below. Seed treatments varied between locations and were either Raxil Pro, Cruiser Maxx Cereal or Cruiser Vibrance Quattro (Table 2). Lots were selected from FSS that producers intended to sow in each given year. Once a FSS lot was selected, a certified seed lot of the same variety was obtained from a certified seed grower for the varietal comparison. A seed lot of FSS and certified seed was never used more than once in this study, as the goal was to sample as many different seed lots as possible. All trials were seeded between May 6 and May 23 in both 2019 and 2020 (Table 2). Each site targeted 300 live seeds/m^2 and seed treatment was applied just prior to seeding using a cement mixer style of application. Dates of operations, measurements taken and products used in 2019 and 2020 are available in tables 2 and 3, respectively.

Table 1. Treatment list for 2020 "Can Farm-saved Seed Wheat (Triticum aestivum L.) perform as well as Certified Seed in Saskatchewan?" Trial

Trt #	**Seed treatment**	**Variety pairing**	**Seed type**
1	Untreated	A	Certified
2	Untreated	A	Farm-saved Seed
3	Untreated	B	Certified
4	Untreated	B	Farm-saved Seed
5	Untreated	C	Certified
6	Untreated	C	Farm-saved Seed
7	Treated	A	Certified
8	Treated	A	Farm-saved Seed
9	Treated	B	Certified
10	Treated	B	Farm-saved Seed
11	Treated	C	Certified
12	Treated	C	Farm-saved Seed

Table 2. Dates of operations in 2019 for the "Can Farm-saved Seed Wheat Perform as well as Certified Seed in Saskatchewan" trial

Activity	-----Date-----							
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**
Pre-seed Herbicide Application	May 12 (Glyphosate)	May 24 (Glyphosate + Heat LQ + Merge)	N/A	N/A	N/A	May 19 (Glyphosate 540 + AIM)	May 13 (RT540)	N/A
Seeding & Seed treatment applied	May 7 & (Raxil PRO)	May 23 & (Cruiser Vibrance Quattro)	May 14 & (Cruiser Vibrance Quattro)	May 23 & (Raxil PRO)	May 6 & (Raxil PRO)	May 14 & (CruiserMaxx Cereal)	May 16 & (Cruiser Vibrance Quattro)	May 7 and 8 & (CruiserMaxx Vibrance)
Emergence Counts	June 4	June 21	June 14	June 12	June 5	June 5	June 7	May 30
Vigour Rating	June 4	July 12	June 20	July 11	N/A	June 27		June 12 and June19
In-crop Herbicide Application	June 17 (OcTTain + Simplicity)	June 27th (Axial July 4 Prestige XC)	June 10 (Badge II & Simplicity)	June 27 (Stellar A + B)	June 10 (Buctril M + Clodinafop)	June 26 (Axial + Buctril M)	June 12 (Varro + Octane + Agral90)	June 12 (Prestige) June 25 (MCPA) July 3 (MCPA)
In-crop Fungicide Application	July 9 (Prosaro)	N/A	July 15 (Caramba)	N/A	July 12 (Caramba)	N/A	N/A	July 3 (Acapela)
Lodging Rating	N/A	Oct 9	N/A	N/A	N/A	Aug 26	Aug 20	Sept 3
Desiccant	Aug 28 (Glyphosate)	N/A	N/A	Sept 5 (Glyphosate)	N/A	Sept 6 (Heat LQ Roundup 540 Merge)	N/A	Sept 3 (Roundup Transorb)
Harvest	Sept 6	Oct 9	Sept 24	Oct 1	Aug 29	Sept 16	Aug 27	Sept 16

Table 3. Dates of operations in 2020 for the "Can Farm-saved Seed Wheat Perform as well as Certified Seed in Saskatchewan" trial

Activity	---Date---							
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**
Pre-seed Herbicide Application	May 14 (Glyphosate)	May 24 (Heat LQ + Glyphosate 540)	N/A	N/A	May 14 (Glyphosate)	May 9 (Glyphosate + AIM)	May 4 (Glyphosate +AIM)	N/A
Seeding & Seed treatment applied	May 20 (Raxil Pro)	May 23 (Raxil Pro)	May 22 (Cruiser Vibrance Quattro)	May 26 (Raxil Pro)	May 16 (Raxil Pro)	May 12 & (Cruiser Cereal)	May 8 (Cruiser Vibrance Quattro)	May 6 & (Vibrance Quattro)
Emergence Counts	June 12	June 2	N/A	June 15	June 4	June 11	June 4	May 25
Vigour Rating	June 22	June 29	June 16	June 29	June 10	June 15	June 9	June 12
In-crop Herbicide Application	June 15 (OcTTain + Simplicity GoDRI)	June 23 (Prestige XC) July 3 (Axial)	June 16 (Buctril M + Simplicity)	June 10 (Infinity)	June 2 (Infinity FX)	June 16 (Axial Ipak)	May 29 (Liquid Achieve + Buctril M + Turbocharge)	May 29 (Prestige) June 8 (Simplicity)
In-crop Fungicide Application	July 16 (Prosaro)	July 24 (Caramba)	N/A	July 21 (Twinline)	July 7 (Caramba)	July 16 (Caramba)	N/A	July 2 (Caramba)
Lodging Rating	N/A	Sept 16	Aug 18-24	Sept 21	N/A	Aug 21	Aug 23	N/A
Desiccant	July 19 (Roundup Weathermax)	Sept 8 (Glyphosate 540)	N/A	N/A	N/A	Aug 25 (Roundup)	N/A	(Roundup Transorb)
Harvest	Aug 27	Sept 16	Aug 31	Sept 25	Aug 23	Sept 11	Aug 24	Aug 12

5. Results:

Background levels of soil N varied between site-years. Levels were fairly average for continuous cropping systems, ranging between 23 to 81 lb N/ac for most site-years. However, background soil N tested extremely high at 253 lb N/ac and 199 lb N/ac at Swift Current in 2019 and Prince Albert in 2020, respectively (Table 6).

Table 6. Soil Test Nitrate Levels for each location (lb N/ac).

2020								
Nitrate Levels (lbs NO_3-N/ac)	**Indian Head**	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**
0-15cm (0-6in)	11	21	31	84	22	14	25	27
15-30cm (6-12in)		33		49				
15-60cm (6-24in)	12		42		39	21	24	33
Total 0-60cm (0-24in)	23	81[z]	73	199[z]	61	35	49	60
Total 0-30 cm (0-12in)		54		133				
2019								
Nitrate Levels (lbs NO_3-N/ac)	**Indian Head**	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**
0-15cm (0-6in)	16	9	8	17	29	14	28	14
15-30cm (6-12in)		10		12				
15-60cm (6-24in)	39		10		42	18	225	18
Total 0-60cm (0-24in)	55	29[z]	18	44[z]	71	32	253	32
Total 0-30 cm (0-12in)		19		29				

[z]Estimate based on 1.5*level found in 0-30 cm.

Seed Lot Quality

On average, seed lots of farm saved seed (FSS) used in this study were 2.1 years removed from certified. However, the FSS lots ranged from 1 to 5 years removed from certified. Tables 7 and 8 list the years FSS with removed from certified for each seed lot along with other seed quality parameters for all lots of certified and farm saved seed. The purpose of seed testing was to compare the quality of FSS against certified seed and was not used as a means to select lots of FSS.

Seeds lots were tested for germination, vigor, 1000 kernel weight and seed-borne disease (Tables 7 and 8). Of these parameters, vigor and seed-borne disease provide the best indication of seed quality. A vigor test gives a better indication of crop emergence under stressful conditions (ie: cold soils) than a standard germination test. When averaged over all seed lots used in 2019, the vigor of certified seed at 93.1% was not statistically different from the vigor of FSS at 93.3% based on a t-test. In 2020, the vigor of certified seed at 93.7% was a little higher than FSS at 91.1% (t-test p=0.096).

The 5 seed-borne pathogenic fungi which are typically screened for when determining seed quality include:

- *Cochliobolis sativus* – Seedling blight, foot and root rot or spot blotch (leaf blight)
- *Fusarium graminearum* – Head blight
- *Fusarium* spp. – Seedling blight, root and crown rot, and head blight
- *Pyrenophora* spp. – Leaf blight (leaf stripe, net blotch and tan spot), and seedling blight (oats)
- *Septoria* spp. – Leaf blotch

According to the 20/20 Seed Labs Inc. website, seed treatment may not provide sufficient control if infection with any one disease is higher than 8%, or if the total disease of 3 or more pathogens is more than 12%. While overall levels of seed-borne disease were low in both years, there were a few instances where limits were exceeded by certified and FSS lots. Total fusarium species was the most prevalent seed-borne pathogen but only averaged 1.6% for certified and 2.4% for FSS in 2019. The difference between these values was not statistically significant (t-test p=0.36). There was one case where farm saved AAC Brandon used at Prince Albert had 18.5% total fusarium (Table 7), which was relatively high.

In 2020, levels of seed-borne disease were higher but on average continued to be relatively low. The total fusarium species for certified and FSS were 3.7% and 4.8%, respectively. Again, these values did not differ significantly (t-test p=0.5). There were more seed lots in 2020 that exceeded either 8% for one disease or 12% total seed-borne disease thresholds. At Melfort, certified Cardale and Redberry as well as FSS lots of Cardale and AAC Elie exceeded thresholds (Table 8). Thresholds were also exceeded by FSS lots of AAC Brandon at Outlook and Redvers as well as certified Landmark and farm saved AAC Cameron at Prince Albert. However, there were only a couple instances where high levels of seed-borne disease was associated with a relatively low vigor rating. This occurred for certified Redberry (85% vigor-Melfort 2020) and certified Landmark (84% vigor- Prince Albert 2020). `

While seed vigor of FSS was 2% lower than certified seed in 2020 and seed borne diseases tended to be 1% higher for FSS in both years, none of the differences were statistically significant. For the most part, seed lots of FSS were of good quality and comparable to certified seed lots in both years. Good harvest conditions in recent years has resulted in the wide spread production of quality seed.

Site Establishment

While seeding rates for each seed lot were adjusted based on 1000 kernel weight and seed vigor to achieve 300 live seeds/m^2, crop emergence varied between locations. In 2019, average crop emergence was as high as 355 plants/m^2 at Indian Head and as low as 82 plants/m^2 at Prince Albert. The poor emergence rate at Prince Albert was the result of poor soil moisture conditions in 2019. Emergence at the remaining sites varied from 180 to 277 plants/m^2. The goal was to achieve similar emergence rates between certified and FSS lots. While emergence did not differ between certified and FSS lots for 5 of the locations, FSS did have significantly higher rates of emergence at Outlook, Redvers and Scott in 2019 (Tables 9 and 10). However, these differences were within 10% and not likely to have agronomic significance. The exception might be Outlook where the difference in emergence was 20% greater for FSS.

In 2020, emergence rates were a little tighter between locations varying on average between a low of 116 plant/m^2 at Prince Albert to a high of 317 plant/m^2 at Yorkton. The emergence for certified seed was significantly higher at Indian Head but significantly lower at Swift Current and Yorkton (Tables 11 and 12). However, emergence between certified and FSS lots were within 10% of each other with the exception of Swift Current (13% difference) and Indian Head (20% difference).

For the most part, emergence was similar between certified and FSS lots and differences would have had a minor impact on yield or grain protein results. The vast majority of sites established well.

<u>Relative Productivity of sites</u>

In 2019, Swift Current was by far the lowest yielding site at 2128 kg/ha (32 bu/ac). This is fairly typical as Swift Current is located in the less productive brown soil zone. Yorkton and Melfort were high yielding sites in 2019, averaging 6081 kg/ha (90 bu/ac) and 5471 kg/ha (81 bu/ac), respectively. The remaining sites yielded well, averaging between 3797 and 4794 kg/ha (56-71 bu/ac). The relative yield standing between locations changed in 2020, as Yorkton went from the highest yielding site in 2019 to the lowest yielding site in 2020 at 2511 kg/ha (37 bu/ac). This was the result of depleted soil reserves of moisture and very low levels of precipitation in the early summer of 2020. Swift current, Prince Albert and Melfort produced decent yields of 3897 kg/ha, 4000 kg/ha and 3867 kg/ha, respectively. Indian Head, Outlook and Redvers produced very good to excellent yields of 5294 kg/ha, 6080 kg/ha and 4777 kg/ha, respectively. Yields from Indian Head were better than would be anticipated based received precipitation. Overall, yields were good to excellent between site-years with the exception of Swift Current in 2019 and Yorkton in 2020 where yields were low.

<u>Effects of Seed Treatment</u>

Different seed treatments were used between site-years (Tables 2 and 3). Raxil Pro was used at Indian Head, Prince Albert and Redvers in both years and at Melfort in 2020. Cruiser Vibrance Quattro was applied both years at Outlook and Swift Current and at Melfort in 2019 and Yorkton in 2020. CruiserMaxx cereal was used in both years at Scott and CruiserMaxx Vibrance was applied at Yorkton in 2019. Site managers were free to choose seed treatments based on local preference and availability. The objective of this study was to determine the value of seed treatment in general and not to either support one seed treatments or comment on their relative efficacy.

A combined analysis of all 16 site years was done for seedling vigor ratings, crop yield, and grain protein data (Table 13). Unlike the individual site analysis, variety pairing was treated as a random effect in the model, as the variety pairings are different between each site year and it does not make sense to combine effect of each pairing across site-years. However, individual site analysis still has variety pairing as a fixed effect, which may be changed for the final report of this study but is likely to have minor effects on the interpretation of results.

When averaged across all site-years, the use of seed treatment significantly increased seedling vigor, albeit modestly, from a rating of 8.1 with the untreated check to a rating of 8.29 for treated seed based on a scale from 1 to 10 (Table 13). Seed treatment did not significantly affect yield. However, there were significant interactions between site-year and seed treatment for both the seedling vigor and yield data (analysis not shown). This means the effect of seed treatment on seedling vigor and yield between site-years was not consistent. When site-years were analyzed separately, neither seedling vigor nor yield was significantly affect by seed treatment for most site-years. However, there were a few exceptions. Treating seed did significantly increase seedling vigor at Swift Current in both years and at Scott and Melfort in 2020 (Tables 14-17). The increase in observed seedling vigor from seed treatment resulted in significant yield gains of 1.5% for Scott and 3.8% for Swift Current in 2020 (Tables 19 and 21). Yield at Melfort in 2020 did increase in response to seed treatment but the difference was not significant. Yield did not respond to seed treatment at Swift Current in 2019 either (Tables 18 and 20), despite differences in observed seedling vigor. In contrast, seed treatment significantly reduced seedling vigor at Indian Head in 2020 (Table 17) and yield was significantly reduced by 1.4% (Table 21). The use of seed treatment also significantly reduced yield by 11.9% at Prince Albert in 2020 (Table 21) and by 3.2% at Yorkton in 2019 (Table 20), despite no observations of reduced seedling vigor at these locations. The author has previously observed decreases in cereal yield resulting from seed treatment, particularly in the absence of significant disease pressure. This may be related to non-uniform coverage of seed with seed treatment. Most research stations treat small batches of seed using a cement mixer and this process may not provide uniform coverage. This could account for some of the observed yield reductions in this study. As an aside, some manufacturers will refuse to participate in seed treatment studies unless the seed has been treated commercially with a G40 applicator or better to ensure uniform coverage.

For the most part, individual site analysis (Tables 22-25) did not detect an effect of seed treatment on grain protein. The combined site analysis found grain protein was reduced from 13.52% with untreated seed to 13.43% when treated ($p=0.059$) (Table 13). Even if considered significant, this effect is very small and is of little agronomic consequence.

Varietal Comparisons

At an individual site level, there is little value discussing any observed differences between varietal comparisons. Moreover, combining the data between locations to discuss varietal comparison would make no sense as varietal comparisons A, B and C between site-years have no relation to each other. While values and statistical analysis for varietal comparison are included in each individual site table, their presence only serves to help the reader understand how the trials were structured and is not meant for discussion or drawing any conclusions.

Certified vs FSS

When averaged across all site-years, no significant differences in either seedling vigor, yield or grain protein could be detected between certified and farm saved seed (Table 13). While a site-year by seed type interaction was not detected for the yield and protein data, an interaction was detected for the seedling vigor data. This means seedling vigor comparisons between certified and farm saved seed was not consistent between site-years. While the vast majority of varietal comparisons found no significant difference in seedling vigor between certified and FSS, there were a few site-years that detected either a main effect of seed type and/or an interaction between seed type and varietal pairing (Tables 14 and 15). This occurred at Indian Head and Yorkton in 2019 and 2020 and Prince Albert in 2020. A closer examination of these individual site-years found seedling vigor, averaged over seed treatment, was significantly greater for certified seed for one varietal pairing at both Indian Head and Prince Albert in 2020 (data not shown). In contrast, one varietal comparison at Indian Head (2019) and Yorkton (2020) found FSS had significantly more seedling vigor (data not shown). Moreover, the main effect for seed type found seedling vigor was significantly higher for FSS at Yorkton 2019 (Table 14). All other seed type comparisons at these locations were not significantly different. When averaged over seed treatment, there are 3 comparisons between certified and FSS at each site-year. Out of a total of 16 site-years by 3 comparisons per site-year, seedling vigor was only significantly improved by using certified seed for two comparisons.

When all site-years were combined, no significant yield or grain protein differences were detected between seed types and neither was there a significant interaction between site-year and seed type (Table 13). While individual site analysis did not find any significant effects of seed type on yield (Tables 18-21), there was a seed type by varietal pairing interaction at Scott in 2019. At this site, the yield for certified seed in the B varietal comparison was 9% higher yielding. The seed vigor was lower for the FSS compared to certified in this varietal pairing (92 vs 99%) and this may have contributed to the yield difference. However, the vast majority of site-years did not detect an effect of seed type on crop yield. For the most part, grain protein was unaffected by seed type but there were a few varietal comparisons which were significantly different. At Outlook and Scott in 2019 and Swift Current in 2020, one varietal comparison found certified seed to have a higher protein content. In contrast, two varietal comparisons at Indian Head and Scott in 2020 found FSS had higher protein. So only two varietal comparisons out of 48 (16 site-years by 3 varietal comparisons) found certified seed produced grain with more protein. Overall, there was little evidence to support either yield or protein differences between the use of certified and FSS. On average, certified seed yielded 4453 kg/ha (66.3 bu/ac) with a grain protein of 13.4%. In comparison, FSS yielded 4433 kg/ha (65.9 bu/ac) with a grain protein of 13.5%. These differences are neither large or statistically significant.

Table 7. Discovery Seed Labs. Seed Quality Results 2019					
	Years from Certified	**Germination**	**Vigour**	**Thousand Kernel Weights**	**Fungal Screen**
Indian Head					
a. Certified AAC Brandon	-	98	99	33.8	0%
b. Certified AAC Brandon	-	99	98	41.8	0.5% Total *Fus.*
c. Certified AAC Elie	-	98	94	36.6	0%
a. Farm-saved AAC Brandon	2	99	96	41.1	0.5% Total *Fus.*
b. Farm- Saved AAC Brandon	2	99	95	41.7	2% Total *Fus.*
c. Farm-saved AAC Elie	2	99	97	35.4	2% Total *Fus.*
Melfort					
a. Certified AAC Brandon	-	98	96	40.5	0.5% Total *Fus.*
b. Certified AAC Brandon	-	96	92	38.1	2% Total *Fus.*0.5% Fus *gram.*
c. Certified AAC Brandon	-	97	94	44.8	3% Total *Fus.*
a. Farm-saved AAC Brandon	?	97	98	39.8	7.5% Total *Fus.*
b.Farm- Saved AAC Brandon	3	99	97	39.8	1% Total *Fus.*
c. Farm- Saved AAC Brandon	2	99	96	37.2	1% Total *Fus.*
Outlook					
a. Certified AAC Brandon	-	99	93	40.0	1% Total *Fus.*
b. Certified AAC Brandon	-	99	91	34.8	0%
c. Certified Cardale	-	99	92	36.0	0.5% Total *Fus.*
a. Farm-saved AAC Brandon	2	99	93	33.0	1.5% Total *Fus.*
b. Farm- Saved AAC Brandon	2	98	92	32.1	0%
c. Farm-saved Cardale	2	99	92	37.0	0%
Prince Albert					
a. Certified Cardale	-	96	89	39.1	2.5% Total *Fus.*; 0.5% Fus *gram.* & 1% Coch. *sat*.
b. Certified AAC Elie	-	77	74	39.3	4% Total *Fus.*
c. Certified AAC Brandon	-	99	99	39.4	3.5% Total *Fus.*
a. Farm-saved Cardale	1	94	95	35.9	0
b. Farm-saved AAC Elie	1	95	90	43	5.5% Total *Fus.*
c. Farm-saved AAC Brandon	3	88	92	40.4	18.5% Total *Fus.*& 1.5% Fus *gram.*
Redvers					
a. Certified AAC Brandon	-	97	89	40.1	1.5% Total *Fus.*
b. Certified AAC Brandon	-	98	97	39.3	2.5% Total *Fus.* & 1% Fus *gram.*
c. Certified Transcend Durum	-	94	89	45.0	1.5% Total *Fus.*
a. Farm-saved AAC Brandon	3	99	95	40.5	0.5% F. gram.

b. Farm-saved AAC Brandon	2	98	93	39.0	2% Total *Fus.* & 0.5% Fus *gram.*
c. Farm-saved Transcend Durum	2	97	86	43.0	0%
Scott					
a. Certified AAC Brandon	-	98	92	38.9	3% Total *Fus.*
b. Certified AAC Elie	-	98	97	39.3	2% Total *Fus.*
c. Certified Stettler	-	97	97	34.7	0.5% Total *Fus.*
a. Farm-saved AAC Brandon	2	96	96	39.2	3% Total *Fus.*
b. Farm-saved AAC Elie	2	92	92	33.2	0%
c. Farm-saved Stettler	2	99	94	40.2	1.5% Total *Fus.*
Swift Current					
a. Certified Transcend Durum	-	98	84	43.5	0%
b. Certified AAC Spitfire Durum	-	98	92	47.1	0.5% Total *Fus.*
c. Certified CDC Fortitude Durum	-	98	96	38.1	0.5% Total *Fus.*
a. Farm-saved Transcend Durum	3	97	93	47.1	0%
b. Farm-saved AAC Spitfire Durum	1	95	93	38.6	0%
c. Farm-saved CDC Fortitude Durum	3	93	84	40.3	0.5% Total *Fus.*
Yorkton					
a. Certified AAC Brandon	-	99	96	38.8	6% Total *Fus.*
b. Certified AAC Brandon	-	99	97	34.3	0%
c. Certified AAC Elie	-	99	98	40.7	3.5% Total *Fus.* & 0.5% Coch. *sat.*
a. Farm-saved AAC Brandon	2	99	95	40.5	6.5% Total *Fus.*
b. Farm-saved AAC Brandon	2	98	89	43.1	3.5% Total *Fus.*
c. Farm-saved AAC Elie	2	96	97	40.1	1.5% Total *Fus.*

Table 8. Discovery Seed Labs. Seed Quality Results 2020

	Years from Certified	Germination	Vigour	Thousand Kernel Weights	Fungal Screen
Indian Head					
a. Certified Faller	-	98	97	35.7	0.5% Total *Fus.*
b. Certified AAC Brandon	-	99	97	37.2	2.5% Total *Fus.*
c. Certified AAC Viewfield	-	99	98	39.4	1% Total *Fus.*

a. Farm-saved Faller	1	99	96	37.7	0
b. Farm-saved AAC Brandon	1	98	97	39	0.5% Fus *gram.* & 3% Total *Fus.*
c. Farm-saved AAC Viewfield	2	74	75	37.3	Coch. *sat.* 0.5% & 6% Total *Fus.*
Melfort					
a. Certified Cardale	-	97	94	37	2.5% Fus. *gram.* 10.5% Total *Fus.*
b. Certified AAC Elie	-	97	94	43	3% Total *Fus.*
c. Certified AAC Redberry	-	85	82	43	1% Fus. *gram.*, 0.5% Coch. *sat.* & 14% Total *Fus.*
a. Farm-saved Cardale	5	95	89	40	1% Fus. *gram.* & 12% Total *Fus.*
b. Farm-saved AAC Elie	3	98	93	47.1	0.5% Coch. *sat.* & 15% Total *Fus.*
c. Farm- Saved AAC Redberry	1	92	89	40.7	5.5% Total *Fus.*
Outlook					
a. Certified AAC Brandon	-	97	98	36.5	0%
b. Certified AAC Brandon	-	99	97	40.3	0%
c. Certified AAC Viewfield	-	99	92	37.4	0%
a. Farm-saved AAC Brandon	2	93	91	39.0	2.5% Fus. *gram.*, 1% Coch. *sat.* & 9.5% Total *Fus.*
b. Farm-saved AAC Brandon	2	94	91	39.7	0.5% Fus. *gram.* & 6% Total *Fus.*
c. Farm-saved AAC Viewfield	2	94	90	38.7	0.5% Fus. *gram.*, 0.5% Coch. *sat.* & 3% Total *Fus.*
Prince Albert					
a. Certified AAC Cameron VB	-	95	97	45.2	0.5%Total *Fus.*
b. Certified CDC Landmark VB	-	84	81	44.6	Fus *gram.* 3% & 15.5% Total *Fus.*
c. Certified AAC Cameron VB	-	98	95	46.9	0
a. Farm-saved AAC Cameron VB	1	85	75 or 48	34.7	0
b. Farm-saved CDC Landmark VB	1	97	93	38.0	0.5% Total *Fus.*
c. Farm-saved AAC Cameron VB	1	92	94	41.9	2% Fus *gram.* & 18% Total *Fus.*
Redvers					

a. Certified AAC Brandon	-	98	97	39.3	Fus *gram.* 1% & Total *Fus.* 2.5%
b. Certified AAC Brandon	-	95	N/A	36.2	N/A
c. Certified AAC Elie	-	98	N/A	37.9	N/A
a. Farm-saved AAC Brandon	4	99	94	41.0	1% Fus *gram.* & 15% Alternaria
b. Farm-saved AAC Brandon	2	94	88	36.7	N/A
c. Farm-saved AAC Elie	2	93	91	35.5	N/A
Scott					
a. Certified AAC Brandon	-	96	93	36.0	0.5% Fus. *gram.* & 4.5% Total *Fus.*
b. Certified AAC Viewfield	-	99	97	40.7	3%Total *Fus.*
c. Certified CDC Plentiful	-	97	94	34.5	0.5% Fus. *gram.* & 1.5% Total *Fus.*
a. Farm-saved AAC Brandon	3	97	95	45.3	0.5% Fus. *gram.* & 2.5% Total *Fus.*
b. Farm-saved AAC Viewfield	1	97	96	42.5	1% Total *Fus.*
c. Farm-saved CDC Plentiful	1	94	93	42.4	2.5% Total *Fus.*
Swift Current					
a. Certified Transcend Durum	-	95	91	46.5	0
b. Certified AAC Spitfire Durum	-	99	94	42.6	4.5% Total *Fus.*
c. Certified CDC Fortitude Durum	-	99	91	41.2	*1%* Total *Fus.*
a. Farm-saved Transcend Durum	2	97	93	38.9	0.5% Coch. *sat.*
b. Farm-saved AAC Spitfire Durum	3	96	91	43.3	0.5% Fus. *gram.* & 2.5% Total *Fus.*
c. Farm-saved CDC Fortitude Durum	4	99	94	42.8	0
Yorkton					
a. Certified AAC Connery	-	99	94	42.2	0.5%. Fus *gram.* & 2.5% Total *Fus.*
b. Certified AAC Brandon	-	99	95	44.8	7.5% Total *Fus.* & 0.5% Coch. *sat.*
c. Certified AAC Brandon	-	97	94	39.6	0.5% Fus *gram.* & 6.5% Total *Fus.*
a. Farm-saved AAC Connery	2	96	88	43.4	8.5% Total *Fus.*

b. Farm-saved AAC Brandon	1	98	94	38.6	0
c. Farm-saved AAC Brandon	2	98	93	44.5	4.5% Total *Fus.*

Table 9. Significance of seed treatment, variety, and type effects on wheat emergence at multiple locations in 2019.

	Emergence 2019							
	I.H.	**Melfort**	**Outlook**	**P.A.**	**Redvers**	**Scott**	**S.C.**	**Yorkton**
Effect	-- p-values Z -----------------------------------							
Seed Treatment (S)	NS	NS	NS	NS	0.014	NS	<0.00001	NS
Variety (V)	NS	NS	0.013	NS	0.075	0.075	0.0034	NS
S x V	NS	NS	NS	NS	0.016	NS	NS	NS
Type (T)	NS	NS	0.010	NS	0.01	0.00065	0.088	NS
S x T	NS	NS	NS	NS	NS	NS	NS	NS
V x T	0.028	NS	NS	NS	0.00087	<0.00001	0.0017	NS
S x V x T	NS	NS	NS	NS	0.063	NS	NS	NS

Table 10. Main effects of seed treatment, variety, and type of seed on wheat emergence at multiple locations in 2019.

Main effect	**Emergence 2019**								
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**	**All Sites Average**
Seed Treatment	------------------------ plants/m^2 ------------------------								
Untreated	358 a	177 a	212 a	78 a	243 a	232 a	165 b	277 a	218
Treated	352 a	184 a	196 a	85 a	225 b	226 a	217 a	276 a	220
LSD	NS	NS	NS	NS	14.4	NS	14.7	NS	--
Varietal comparison									
A	360 a	173 a	219 a	84 a	242 a	222 a	192 ab	272 a	220
B	351 a	189 a	168 b	81 a	222 a	239 a	206 a	279 a	217
C	355 a	179 a	224 a	80 a	237 a	226 a	174 b	279 a	219
LSD	NS	NS	41.3	NS	NS	NS	18.5	NS	--
Type									
Farm-saved	349 a	179 a	225 a	90 a	243 a	241 a	185 a	272 a	223
Certified	361 a	181 a	182 b	73 a	224 b	217 b	197 a	281 a	215
LSD	NS	NS	32.8	NS	14.4	13.0	NS	NS	--

Table 11. Significance of seed treatment, variety, and type effects on wheat emergence at multiple locations in 2020.

	Emergence 2020							
	I.H.	**Melfort**	**Outlook**	**P.A.**	**Redvers**	**Scott**	**S.C.**	**Yorkton**
Effect	-- p-values [z] --							
Seed Treatment (S)	<0.00001	NS	N/A	NS	NS	NS	NS	0.032
Variety (V)	0.00147	NS	N/A	NS	NS	NS	0.0033	0.0013
S x V	0.025685	NS	N/A	NS	NS	0.0059	0.018	NS
Type (T)	<0.00001	NS	N/A	NS	NS	NS	0.0016	0.012
S x T	0.005565	NS	N/A	NS	NS	0.00025	NS	NS
V x T	<0.00001	NS	N/A	NS	NS	0.0237	NS	0.00062
S x V x T	NS	NS	N/A	NS	0.023	NS	NS	0.02568

Table 12. Main effects of seed treatment, variety, and type of seed on wheat emergence at multiple locations in 2020.

Main effect	**Emergence 2020**								
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**	**All Sites Average**
Seed Treatment	---------- plants/m^2 ----------								
Untreated	264 a	244 a	N/A	115 a	207 a	161 a	151 a	307 b	207
Treated	236 b	238 a	N/A	117 a	219 a	164 a	158 a	326 a	208
LSD	11	NS	N/A	NS	NS	NS	NS	18	--
Varietal comparison									
A	257 a	253 a	N/A	108 a	214 a	162 a	162 a	304 b	208
B	236 b	231 a	N/A	122 a	210 a	165 a	161 a	305 b	204
C	257 a	239 a	N/A	118 a	208 a	160 a	140 b	341 a	209
LSD	13	NS	N/A	NS	NS	NS	14	22	--
Type									
Certified	277 a	241 a	N/A	121 a	218 a	161 a	145 b	306 b	210
Farm-saved	223 b	241 a	N/A	111 a	208 a	164 a	164 a	328 a	206
LSD	11	NS	N/A	NS	NS	NS	11	18	--

Table 13. Main effect means and significance of Seed Treatment and Seed Type and their interaction			
Main effect	**All 16 site-years combined**		
	Seedling Vigor (1-10)	**Yield (kg/ha)**	**Protein (%)**
Seed Treatment (S)			
Untreated	8.1 b	4445 a	13.52 a
Treated	8.29 a	4435 a	13.43 a
p-value	**0.0055**	0.71	**0.059**
Seed Type (T)			
Certified	8.24 a	4453 a	13.44 a
Farm-saved	8.14 a	4428 a	13.51 a
p-value	0.158	0.348	0.139
(S by T)			
Untreated Certified	8.20 a	4458 a	13.50 a
Untreated Farm-saved	8.00 a	4433 a	13.53 a
Treated Certified	8.28 a	4448 a	13.37 a
Treated Farm-saved	8.30 a	4423 a	13.48 a
p-value	0.115	0.99	0.406

Table 14. Significance of seed treatment, variety, and type effects on wheat Vigour at multiple locations in 2019.

	Vigour 2019							
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**
Effect	------------------------------------- p-values z ----------------------------------							
Seeding Treatment (S)	NS	NS	NS	NS	NS	NS	0.0006	NS
Variety (V)	NS	NS	0.0011	NS	NS	NS	0.0065	NS
S x V	NS	NS	NS	NS	NS	NS	NS	NS
Type (T)	0.023	NS	NS	NS	NS	NS	NS	0.014
S x T	NS	NS	NS	NS	NS	NS	NS	NS
V x T	0.00001	NS	NS	NS	NS	NS	NS	NS
S x V x T	NS	NS	NS	NS	NS	NS	NS	NS

z p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability

Table 15. Significance of seed treatment, variety, and type effects on wheat Vigour at multiple locations in 2020.

	Vigour 2020							
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**
Effect	------------------------------------- p-values z ----------------------------------							
Seeding Treatment (S)	0.020751	0.023983	NS	NS	NS	0.004893	0.029177	NS
Variety (V)	0.000026	NS	NS	<0.00001	NS	0.000206	0.032719	NS
S x V	NS	NS	NS	NS	NS	NS	NS	NS
Type (T)	<0.00001	NS	NS	0.003084	NS	NS	NS	NS
S x T	NS	NS	NS	NS	0.056702	0.018861	NS	NS
V x T	<0.00001	NS	NS	0.000162	NS	NS	NS	0.027832
S x V x T	NS	NS	NS	NS	0.017291	NS	NS	NS

z p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability

Table 16. Main effects of seed treatment, variety, and type of seed on wheat yield at multiple locations in 2019.									
Main effect	**Vigour 2019**								
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**	**All Sites Average**
Seed Treatment	-- 1-10 --								
Untreated	8.4 a	7.9 a	9.1 a	6.3 a	NS	5.9 a	8.5 b	7.3 a	7.7
Treated	8.1 a	7.8 a	9.3 a	7.0 a	NS	6.0 a	9.5 a	7.5 a	7.9
LSD	NS	NS	NS	NS	NS	NS	0.52	NS	--
Varietal comparison									
A	8.1 a	8.0 a	8.5 b	6.4 a	NS	6.2 a	9 a	7.3 a	7.7
B	8.4 a	7.7 a	9.6 a	6.9 a	NS	5.6 a	9.6 a	7.3 a	7.9
C	8.3 a	7.8 a	9.5 a	6.7 a	NS	5.9 a	8.5 b	7.6 a	7.8
LSD	NS	NS	0.64	NS	NS	NS	0.65	NS	--
Type									
Certified	8.0 a	7.9 a	9.3 a	6.6 a	NS	5.9 a	8.8 a	7.2 b	7.7
Farm Saved	8.5 a	7.8 a	9.2 a	6.7 a	NS	5.9 a	9.2 a	7.5 a	7.8
LSD	0.36	NS	NS	NS	NS	NS	NS	0.23	--

Table 17. Main effects of seed treatment, variety, and type of seed on wheat yield at multiple locations in 2020.

Main effect	**Vigour 2020**								
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**	**All Sites Average**
Seed Treatment	-- 1-10 --								
Untreated	8.1 a	7.3 b	9.6 a	7.7 a	9.0 a	7.0 b	9.5 a	8.0 a	8.3
Treated	7.7 a	8.1 a	9.8 a	7.6 a	9.0 a	7.5 a	9.8 a	8.1 a	8.5
LSD	0.4	0.7	NS	NS	NS	0.3	0.3	NS	--
Varietal comparison									
A	8.4 a	7.4 a	9.6 a	7.0 c	9.0 a	6.8 b	9.8 a	8.1 a	8.3
B	7.2 b	7.9 a	9.9 a	8.2 a	8.9 a	7.2 b	9.8 a	7.9 a	8.4
C	8.1 a	7.7 a	9.8 a	7.7 b	9.1 a	7.7 a	9.4 b	8.1 a	8.5
LSD	0.5	NS	NS	0.4	NS	0.4	0.3	NS	--
Type									
Certified	8.7 a	7.9 a	9.8 a	7.9 a	9.1 a	7.3 a	9.6 a	8.0 a	8.5
Farm-saved	7.1 b	7.4 a	9.7 a	7.4 b	8.9 a	7.2 a	9.8 a	8.1 a	8.2
LSD	0.4	NS	NS	0.3	NS	NS	NS	NS	--

Table 18. Significance of seed treatment, variety, and type effects on wheat yield at multiple locations in 2019.

	Yield 2019							
	I.H.	**Melfort**	**Outlook**	**P.A**	**Redvers**	**Scott**	**S.C.**	**Yorkton**
Effect	------------------------------------- p-values [Z] -----------------------------------							
Seeding Treatment (S)	NS	NS	NS	NS	NS	NS	NS	0.011
Variety (V)	Ns	NS	NS	NS	0.0074	<0.00001	NS	NS
S x V	0.0029	NS	NS	NS	NS	NS	NS	NS
Type (T)	NS	NS	NS	NS	NS	NS	NS	NS
S x T	NS	NS	NS	NS	NS	NS	NS	NS
V x T	NS	NS	NS	NS	NS	0.0045	NS	NS
S x V x T	0.0064	NS	NS	NS	NS	NS	NS	NS

[Z] p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability

Table 19. Significance of seed treatment, variety, and type effects on wheat yield at multiple locations in 2020.

	Yield 2020							
	I.H.	**Melfort**	**Outlook**	**P.A**	**Redvers**	**Scott**	**S.C.**	**Yorkton**
Effect	------------------------------------- p-values [Z] -----------------------------------							
Seeding Treatment (S)	0.015619	NS	NS	0.029177	NS	0.021772	<0.00001	NS
Variety (V)	0.027832	NS	0.000022	NS	NS	<0.00001	NS	NS
S x V	NS	NS	NS	NS	NS	NS	NS	NS
Type (T)	NS	NS	NS	NS	NS	NS	NS	NS
S x T	NS	NS	NS	NS	NS	NS	NS	NS
V x T	NS	NS	NS	NS	NS	NS	NS	NS
S x V x T	NS	NS	NS	NS	NS	NS	NS	NS

[Z] p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability

Table 20. Main effects of seed treatment, variety, and type of seed on wheat yield at multiple locations in 2019.									
Main effect	**Yield 2019**								
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**	**All Sites Average**
Seed Treatment	---------- kg/ha ----------								
Untreated	3951 a	5529 a	4286 a	3681 a	4393 a	4799 a	2139 a	6179 a	4370
Treated	3910 a	5412 a	4306 a	3912 a	4397 a	4788 a	2116 a	5982 b	4353
LSD	NS	NS	NS	NS	NS	NS	NS	152	--
Varietal comparison									
A	3942 a	5571 a	4180 a	3841 a	4450 a	5098 a	2147 a	6119 a	4419
B	3889 a	5385 a	4430 a	3728 a	4503 a	4755 b	2187 a	5999 a	4360
C	3961 a	5455 a	4277 a	3821 a	4232 b	4527 c	2048 a	6124 a	4306
LSD	NS	NS	NS	NS	180	157	NS	NS	--
Type									
Certified	3922 a	5520 a	4344 a	3620 a	4419 a	4843 a	2131 a	6086 a	4361
Farm Saved	3939 a	5420 a	4247 a	3973 a	4371 b	4745 a	2124 a	6076 a	4362
LSD	NS	NS	NS	NS	143	NS	NS	NS	--

Table 21. Main effects of seed treatment, variety, and type of seed on wheat yield at multiple locations in 2020.

Main effect	**Yield 2020**								
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**	**All Sites Average**
Seed Treatment	------------------------------- kg/ha -------------------------------								
Untreated	5331 a	3821 a	6052 a	4252 a	4703 a	5687 b	3823 b	2500 a	4521
Treated	5257 b	3912 a	6108 a	3747 b	4851 a	5775 a	3970 a	2522 a	4518
LSD	60	NS	NS	456	NS	74.6	126	NS	--
Varietal comparison									
A	5345 a	3748 a	5933 b	4077 a	4787 a	5745 b	3933 a	2360 a	4491
B	5245 b	4036 a	5934 b	4012 a	4772 a	5926 a	3923 a	2582 a	4553
C	5292 ab	3816 a	6373 a	3909 a	4773 a	5523 c	3834 a	2590 a	4514
LSD	76	NS	196	NS	NS	93.9	NS	NS	--
Type									
Certified	5309 a	3960 a	6093 a	4003 a	4800 a	5763 a	3920 a	2512 a	4545
Farm-saved	5279 a	3773 a	6066 a	3996 a	4755 a	5699 a	3873 a	2510 a	4494
LSD	NS	NS	NS	NS	NS	NS	NS	NS	--

Table 22. Significance of seed treatment, variety, and type effects on wheat protein at multiple locations in 2019.

	Protein 2019							
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**
Effect	------------------------------------- p-values [z] ----------------------------------							
Seeding Treatment (S)	NS	NS	NS	NS	NS	NS	0.02	NS
Variety (V)	NS	NS	0.012	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS	NS	0.045
Type (T)	NS	NS	0.006	NS	NS	NS	NS	NS
S x T	NS	NS	NS	NS	NS	NS	NS	0.048
V x T	NS	NS	<0.00001	NS	NS	0.007	NS	NS
S x V x T	NS	NS	NS	NS	NS	NS	NS	NS

[z] p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability

Table 23. Significance of seed treatment, variety, and type effects on wheat protein at multiple locations in 2020.

	Protein 2020							
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**
Effect	------------------------------------- p-values [z] ----------------------------------							
Seeding Treatment (S)	NS	0.007894	NS	NS	NS	NS	NS	NS
Variety (V)	<0.00001	0.000015	0.00076	0.045437	NS	0.000518	0.009357	0.000162
S x V	NS	NS	NS	NS	NS	NS	NS	NS
Type (T)	<0.00001	NS	NS	NS	NS	0.001555	NS	NS
S x T	NS	NS	NS	NS	NS	NS	NS	NS
V x T	<0.00001	0.053678	NS	NS	NS	0.035497	0.013698	NS
S x V x T	NS	NS	NS	NS	0.049375	NS	NS	NS

[z] p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability

Table 24. Main effects of seed treatment, variety, and type of seed on wheat protein at multiple locations in 2019.

Main effect	**Protein 2019**								
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**	**All Sites Average**
Seed Treatment	------------------------------------- % -------------------------------------								
Untreated	15.0 a	13.2 a	12.7 a	13.8 a	13.3 a	12.8 a	19.7 b	13.3 a	14.2
Treated	15.0 a	13.1 a	12.6 a	13.7 a	13.4 a	12.5 a	20.1 a	13.3 a	14.2
LSD	NS	NS	NS	NS	NS	NS	0.35	NS	---
Varietal comparison									
A	15.0 a	13.2 a	12.9 a	13.7 a	13.3 a	12.7 a	19.9 a	13.3 a	14.3
B	15.0 a	13.2 a	12.3 c	13.5 a	13.5 a	12.5 a	19.7 a	13.4 a	14.1
C	15.0 a	13.2 a	12.7 b	14.0 a	13.3 a	12.7 a	20.0 a	13.2 a	14.3
LSD	NS	NS	0.4	NS	NS	NS	NS	NS	---
Type									
Certified	15.0 a	13.2 a	12.9 a	13.6 a	13.4 a	12.8 a	19.8 a	13.3 a	14.3
Farm Saved Seed	15.0 a	13.2 a	12.4 b	13.9 a	13.3 a	12.5 a	19.9 a	13.3 a	14.2
LSD	NS	NS	0.34	NS	NS	NS	NS	NS	---

Table 25. Main effects of seed treatment, variety, and type of seed on wheat protein at multiple locations in 2020.									
Main effect	**Protein 2020**								
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**	**All Sites Average**
Seed Treatment	-- % --------------------------------------								
Untreated	12.2 a	12.8 a	12.7 a	12.0 a	12.8 a	12.2 a	10.4 a	17.3 a	12.8
Treated	12.2 a	12.4 b	12.7 a	11.6 a	12.5 a	12.1 a	10.4 a	17.3 a	12.7
LSD	NS	0.3	NS	NS	NS	NS	NS	NS	--
Varietal comparison									
A	12.2 b	13.2 a	12.8 a	11.8 ab	12.7 a	12.5 a	10.3 b	17.8 a	12.9
B	12.5 a	12.5 b	12.9 a	12.3 a	12.8 a	12.0 b	10.0 b	17.1 b	12.8
C	11.7 c	12.1 b	12.3 b	11.4 b	12.5 a	11.9 b	11.1 a	17.2 b	12.5
LSD	0.1	0.4	0.3	0.8	NS	0.3	0.7	0.3	--
Type									
Certified	12.0 b	12.6 a	12.6 a	11.7 a	12.5 a	11.9 b	10.5 a	17.3 a	12.6
Farm-saved	12.3 a	12.6 a	12.8 a	12.0 a	12.8 a	12.3 a	10.4 a	17.4 a	12.8
LSD	0.1	NS	NS	NS	NS	0.3	NS	NS	--

6. Conclusions and Recommendations

Farm saved seed used in this study was on average 2.1 years removed from certified on average. However, some seeds lots were up to 5 years removed. Overall, the quality of FFS and certified seed used in this study was comparable. In 2019, the seed vigor of certified seed was 93.1%, which did not differ significantly from the vigor of FSS at 93.3%, based on a t-test. In 2020, the vigor of certified seed at 93.7% was a little higher than FSS at 91.1% (p=0.096). While not significantly different in either year, seed-borne levels of total fusarium species in 2019 were on average 1.6% and 2.4% on FSS and certified seed, respectively. In 2020, levels of seed-borne fusarium species were a little higher at 3.7% for certified seed and 4.8% for FSS. However, these average levels would be considered low and of little concern in either year.

The affect of seed treatment on seedling vigor and crop yield was inconsistent. In the majority of cases seedling vigor and yield were unaffected by seed treatment. However, seed treatment did increase seedling vigor at 4 site-years and in two of these cases this lead to significantly higher yields and a numerically higher yield in another. In contrast, seed treatment significantly reduced seedling vigor at one site-year and significantly reduced yield. At two more site-years, seed treatment also significantly reduced yield. Overall, seed treatment had little affect on yield and poor performance may have been related to low disease pressure and possibly uneven coating of seed with product.

For the vast majority of site-years, seedling vigor did not differ between certified or FSS. Where differences were detected, the response was inconsistent. While two site-years found better seedling vigor with certified seed, another 3 site-years found FSS had better seedling vigor. Yield did not differ significantly between certified and FSS whether all site-years were analyzed collectively or individually. Effects of seed type on grain protein were usually insignificant and where they were significant the trends where inconsistent.

Overall, FSS performed as well as certified seed in this study. On average, certified seed yielded 4453 kg/ha (66.3 bu/ac) with a grain protein of 13.4% and FSS yielded 4433 kg/ha (65.9 bu/ac with a grain protein of 13.5%. These differences were neither large or statistically significant.

Growing FSS was more economical in this study, because doing so incurred no yield or protein disadvantage and certified seed is typically more expensive. However, there is certainly value in purchasing certified seed, to assure quality, true to type grain for end users and to introduce better genetics to the farm to stay competitive. Certified seed should be purchased at a premium as these assurances have value and there is value in supporting a system where new genetics can be developed and brought to the farm to keep Canadian producers globally competitive. Exactly how this support will continue is currently under debate. This study does not suggest that there is no value in purchasing certified seed only that there were no production risks to growing FSS during 2019 and 2020. Growing FSS for a couple years between purchasing new certified varieties with better genetics may prove to have little production risk. This would currently appear to be the approach of many producers, as approximately 70 to 80% of cereal acres in western Canada were seeded with FSS in 2004 based on a phone survey of 800 producers. Initial results from this study would indicate that wheat producers who use quality control measures similar to those required for certified seed can produce grain yield and protein comparable to that of certified seed. This study will continue for 1 more year before final conclusions are available.

Extension 2019

The trial was toured at Swift Current on July 9 during WCA directors and staff tour (20 attendees) and on July 30 during Swift Current Crop Club tour (12 attendees). The trial was also promoted on Swift Current's Facebook page and CKSW's weekly program "Walk the Plots" reaching thousands of listeners in southwest Saskatchewan. The trial was toured at Outlook during their July 11 CSIDC Field Day which 200 producers and agronomists attended. Indian Head toured the trial during their Indian Head Crop Management Field Day on July 16 (125 attendees).

Extension 2020

Covid restrictions did not allow for any physical tours of trials in 2020. However, Top Crop Magazine wrote the following article based upon the 2019 results:

"**A farm-saved seed/certified seed matchup" (Sept 6, 2020) by Carolyn King**
https://www.topcropmanager.com/farm-saved-seed-certified-seed-matchup/

John Morriss with Country Guide will be writing an article based on this research.

Supporting Information

7. Acknowledgements:

This project was funded by the Saskatchewan Wheat Development Commission.

8. Appendices

Individual treatment means

While individual treatment means for emergence, seedling vigor, yield and grain protein were not referenced in the results section, these values are available in the Appendix (Tables 26-32).

Table 26. Main effects of seed treatment, variety, and type of seed on wheat emergence at multiple locations in 2019.

Main effect	**Emergence 2019**								
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**	**All Sites Average**
Main Effects	---------- plant/m² ----------								
1. Untreated A Certified	349 a	167 a	243 ab	75 a	250 abc	223 cd	174 cde	271 a	219
2. Untreated A Farm-saved Seed	379 a	179 a	218 abc	84 a	266 ab	227 cd	148 de	270 a	221
3. Untreated B Certified	369 a	167 a	203 abc	106 a	240 abcd	284 a	180 cd	288 a	230
4. Untreated B Farm-saved Seed	348 a	190 a	124 c	54 a	239 abcd	208 cd	170 cde	263 a	200
5. Untreated C Certified	338 a	185 a	273 a	85 a	276 a	209 cd	130 e	273 a	221
6. Untreated C Farm-saved Seed	368 a	172 a	212 abc	65 a	186 e	240 bc	186 bcd	298 a	216
7. Treated A Certified	354 a	172 a	211 abc	82 a	227 bcde	227 cd	233 ab	272 a	222
8. Treated A Farm-saved Seed	357 a	173 a	206 abc	94 a	225 bcde	212 cd	213 abc	273 a	219
9. Treated B Certified	348 a	198 a	212 abc	88 a	209 cde	274 ab	217 abc	278 a	228
10. Treated B Farm-saved Seed	338 a	200 a	134 b	75 a	202 de	191 d	258 a	286 a	211
11. Treated C Certified	335 a	184 a	211 abc	106 a	258 ab	229 cd	174 cde	250 a	218
12. Treated C Farm-saved Seed	380 a	175 a	200 abc	67 a	228 bcde	225 cd	208 bc	297 a	223
L.S.D	52.8	NS	108.1	NS	47.4	42.7	48.3	NS	--

Table 27. Main effects of seed treatment, variety, and type of seed on wheat emergence at multiple locations in 2020.

Main effect	**Emergence 2020**								
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**	**All Sites Average**
Main Effects	---------- plant/m² ----------								
1. Untreated A Certified	277 a	261 a	N/A	127 a	186 b	157 a	160 a	252 d	203
2. Untreated A Farm-saved Seed	257 a	255 a	N/A	95 a	226 ab	155 a	179 a	331 ab	220
3. Untreated B Certified	321 a	228 a	N/A	123 a	207 ab	172 a	147 a	325 ab	218
4. Untreated B Farm-saved Seed	166 a	248 a	N/A	123 a	213 ab	164 a	155 a	265 cd	191
5. Untreated C Certified	298 a	248 a	N/A	108 a	219 ab	163 a	123 a	312 bc	210
6. Untreated C Farm-saved Seed	264 a	225 a	N/A	116 a	188 b	156 a	141 a	359 ab	181
7. Treated A Certified	242 a	261 a	N/A	103 a	251 a	157 a	150 a	307 bcd	210
8. Treated A Farm-saved Seed	254 a	233 a	N/A	107 a	194 ab	181 a	159 a	327 ab	208
9. Treated B Certified	286 a	215 a	N/A	137 a	209 ab	163 a	165 a	315 abc	213
10. Treated B Farm-saved Seed	169 a	235 a	N/A	105 a	210 ab	163 a	179 a	316 abc	197
11. Treated C Certified	240 a	235 a	N/A	126 a	235 ab	155 a	126 a	323 abc	206
12. Treated C Farm-saved Seed	226 a	249 a	N/A	122 a	218 ab	165 a	171 a	372 a	218
L.S.D	NS	NS	N/A	NS	58	NS	NS	58	--

Table 28. Main effects of seed treatment, variety, and type of seed on wheat yield at multiple locations in 2019.									
Main effect	**Vigour 2019**								
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**	**All Sites Average**
Main Effects	-- (1-10) --								
1. Untreated A Certified	7.3 cd	7.8 a	8.5 a	5.5 a	Na	6.5 a	8.5 abc	6.9 c	7.3
2. Untreated A Farm-saved Seed	9.3 a	8.3 a	8.3 a	5.8 a	Na	6.3 a	8.5 abc	7.1 abc	7.7
3. Untreated B Certified	9.0 a	7.5 a	10.0 a	6.8 a	Na	5.8 a	9.3 ab	7.3 abc	8.0
4. Untreated B Farm-saved Seed	8.5 ab	7.8 a	9.3 a	6.9 a	Na	5.5 a	9.5 ab	7.4 abc	7.8
5. Untreated C Certified	8.3 abc	8.5 a	9.5 a	7.0 a	Na	5.5 a	7.3 c	7.3 abc	7.6
6. Untreated C Farm-saved Seed	8.3 abc	7.5 a	9.3 a	5.8 a	Na	5.8 a	8.3 bc	7.8 a	7.5
7. Treated A Certified	7.0 d	7.5 a	8.5 a	6.9 a	Na	5.8 a	9.5 ab	7.5 abc	7.5
8. Treated A Farm-saved Seed	8.8 ab	8.5 a	8.8 a	7.5 a	Na	6.3 a	9.5 ab	7.6 abc	8.1
9. Treated B Certified	8.3 abc	8.3 a	9.8 a	5.6 a	Na	5.5 a	9.5 ab	7.0 bc	7.7
10. Treated B Farm-saved Seed	7.8 bcd	7.3 a	9.5 a	8.4 a	Na	5.8 a	10.0 a	7.6 abc	8.1
11. Treated C Certified	8.5 ab	7.8 a	9.3 a	7.8 a	Na	6.5 a	9.0 ab	7.5 abc	8.1
12. Treated C Farm-saved Seed	8.3 abc	7.3 a	10.0 a	6.1 a	Na	6.0 a	9.5 ab	7.7 ab	7.8
L.S.D	1.2	NS	1.7	NS	Na	NS	1.7	0.76	--

Table 29. Main effects of seed treatment, variety, and type of seed on wheat yield at multiple locations in 2020.									
Main effect	**Vigour 2020**								
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**	**All Sites Average**
Main Effects	--------------------------------------- (1-10) ---								
1. Untreated A Certified	8.8 a	7.3 a	9.3 a	7.9 a	9.0 ab	6.8 a	9.8 a	7.8 a	8.3
2. Untreated A Farm-saved Seed	8.3 a	6.8 a	9.5 a	6.3 a	9.3 ab	6.3 a	10.0 a	8.5 a	8.1
3. Untreated B Certified	9.3 a	7.8 a	9.8 a	8.1 a	9.3 ab	7.5 a	9.5 a	7.9 a	8.7
4. Untreated B Farm-saved Seed	5.5 a	7.3 a	10.0 a	8.3 a	8.5 b	6.8 a	9.8 a	7.6 a	8.0
5. Untreated C Certified	9.0 a	8.3 a	9.8 a	7.9 a	9.5 ab	7.5 a	8.8 a	8.0 a	8.6
6. Untreated C Farm-saved Seed	8.0 a	6.3 a	9.5 a	7.6 a	8.5 b	7.3 a	9.5 a	8.3 a	8.1
7. Treated A Certified	8.3 a	8.0 a	9.8 a	7.6 a	9.0 ab	7.0 a	9.8 a	8.0 a	8.4
8. Treated A Farm-saved Seed	8.3 a	7.8 a	9.8 a	6.1 a	8.8 ab	7.3 a	9.8 a	8.1 a	8.3
9. Treated B Certified	9.0 a	7.8 a	10.0 a	8.0 a	9.0 ab	7.0 a	10.0 a	8.1 a	8.6
10. Treated B Farm-saved Seed	5.0 a	8.8 a	9.8 a	8.5 a	8.8 ab	7.5 a	10.0 a	8.0 a	8.3
11. Treated C Certified	7.8 a	8.5 a	10.0 a	7.9 a	8.8 ab	8.0 a	9.8 a	8.0 a	8.6
12. Treated C Farm-saved Seed	7.8 a	7.8 a	9.8 a	7.5 a	9.8 a	8.0 a	9.8 a	8.1 a	8.6
L.S.D	NS	NS	NS	NS	1.2	NS	NS	NS	--

Table 30. Main effects of seed treatment, variety, and type of seed on wheat yield at multiple locations in 2019.									
Main effect	**Yield 2019**								
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**	**All Sites Average**
Main Effects	kg/ha								
1. Untreated A Certified	3979 ab	5571 a	4485 a	3584 a	4462 a	5253 a	2220 a	6113 ab	4458
2. Untreated A Farm-saved Seed	3855 b	5443 a	3864 a	3934 a	4407 a	5155 ab	2179 a	6147 ab	4373
3. Untreated B Certified	3864 b	5550 a	4164 a	3280 a	4627 a	4832 bc	2175 a	6202 ab	4337
4. Untreated B Farm-saved Seed	3839 b	5465 a	4593 a	3912 a	4426 a	4558 cd	2261 a	6179 ab	4404
5. Untreated C Certified	3930 b	5681 a	4384 a	3666 a	4194 a	4378 d	1967 a	6156 ab	4295
6. Untreated C Farm-saved Seed	4240 a	5463 a	4225 a	3713 a	4242 a	4619 cd	2033 a	6279 a	4352
7. Treated A Certified	4023 ab	5627 a	4245 a	3689 a	4525 a	4950 abc	2087 a	6089 ab	4404
8. Treated A Farm-saved Seed	3911 b	5643 a	4128 a	4156 a	4408 a	5037 ab	2104 a	6127 ab	4439
9. Treated B Certified	3836 b	5229 a	4545 a	3414 a	4463 a	5077 ab	2213 a	5878ab	4332
10. Treated B Farm-saved Seed	4018 ab	5295 a	4417 a	4306 a	4495 a	4555 cd	2100 a	5739 b	4366
11. Treated C Certified	3902 b	5466 a	4244 a	4089 a	4245 a	4569cd	2126 a	6075 ab	4340
12. Treated C Farm-saved Seed	3772 b	5210 a	4256 a	3818 a	4248 a	4544 cd	2066 a	5986 ab	4238
L.S.D	267.5	NS	NS	NS	471.3	410.3	NS	500.5	---

Table 31. Main effects of seed treatment, variety, and type of seed on wheat yield at multiple locations in 2020.	
Main effect	**Yield 2020**

	Indian Head	Melfort	Outlook	Prince Albert	Redvers	Scott	Swift Current	Yorkton	All Sites Average
Main Effects	-- kg/ha --								
1. Untreated A Certified	5450 a	3887 a	5851 a	4484 a	4778 a	5701 a	3897 a	2434 a	4560
2. Untreated A Farm-saved Seed	5360 a	3547 a	5832 a	4051 a	4582 a	5673 a	3835 a	2257 a	4392
3. Untreated B Certified	5335 a	4122 a	5902 a	4001 a	4796 a	5937 a	3890 a	2523 a	4563
4. Untreated B Farm-saved Seed	5254 a	3509 a	5883 a	4645 a	4792 a	5798 a	3875 a	2802 a	4570
5. Untreated C Certified	5303 a	3920 a	6353 a	4170 a	4676 a	5502 a	3625 a	2738 a	4536
6. Untreated C Farm-saved Seed	5285 a	3941 a	6492 a	4163 a	4596 a	5513 a	3815 a	2245 a	4506
7. Treated A Certified	5286 a	3986 a	6159 a	3956 a	4823 a	5805 a	4173 a	2326 a	4564
8. Treated A Farm-saved Seed	5285 a	3574 a	5889 a	3817 a	4964 a	5802 a	3828 a	2425 a	4448
9. Treated B Certified	5223 a	4249 a	5945 a	3565 a	4924 a	6106 a	4042 a	2481 a	4567
10. Treated B Farm-saved Seed	5168 a	4264 a	6007 a	3838 a	4577 a	5862 a	3885 a	2525 a	4516
11. Treated C Certified	5258 a	3596 a	6352 a	3842 a	4801 a	5529 a	3897 a	2569 a	4481
12. Treated C Farm-saved Seed	5323 a	3806 a	6296 a	3461 a	5018 a	5546 a	3998 a	2809 a	4532
L.S.D	NS	NS	NS	NS	NS	NS	NS	NS	--

Table 32. Main effects of seed treatment, variety, and type of seed on wheat yield at multiple locations in 2019.

Main effect	**Protein 2019**								
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**	**All Sites Average**
Main Effects	---	---	---	---	%	---	---	---	---
1. Untreated A Certified	15.2 a	13.1 a	12.6 a	13.4 a	13.1 a	12.9 a	19.6 a	13.6 a	14.19
2. Untreated A Farm-saved Seed	14.9 a	13.2 a	13.5 a	13.7 a	13.3 a	12.8 ab	19.8 a	13.5 a	14.34
3. Untreated B Certified	15.1 a	13.2 a	13.4 a	13.2 a	13.5 a	13.0 a	19.7 a	13.4 ab	14.31
4. Untreated B Farm-saved Seed	15.0 a	13.3 a	11.4 b	14.0 a	13.5 a	12.4 ab	19.4 a	13.4 ab	14.05
5. Untreated C Certified	15.1 a	13.4 a	12.6 a	14.0 a	13.5 a	12.6 ab	19.4 a	13.2 ab	14.23
6. Untreated C Farm-saved Seed	14.9 a	13.3 a	12.6 a	14.3 a	13.0 a	13.0 a	20.1 a	13.0 ab	14.28
7. Treated A Certified	15.0 a	13.2 a	12.6 a	13.7 a	13.5 a	12.3 ab	20.3 a	12.8 b	14.18
8. Treated A Farm-saved Seed	15.1 a	13.2 a	12.8 a	14.0 a	13.3 a	12.9 a	20.1 a	13.4 ab	14.35
9. Treated B Certified	14.9 a	13.1 a	13.0 a	13.5 a	13.4 a	13.1 a	19.8 a	13.5 a	14.29
10. Treated B Farm-saved Seed	15.0 a	13.2 a	11.3 b	13.5 a	13.7 a	11.7 b	19.9 a	13.4 ab	13.96
11. Treated C Certified	15.0 a	13.1 a	13.1 a	13.7 a	13.4 a	12.9 a	20.0 a	13.1 ab	14.29
12. Treated C Farm-saved Seed	15.0 a	12.8 a	12.7 a	13.8 a	13.3 a	12.4 ab	20.4 a	13.4 ab	14.23
L.S.D.	NS	NS	1.11	NS	NS	1.11	NS	0.61	---

Table 33. Main effects of seed treatment, variety, and type of seed on wheat yield at multiple locations in 2020.									
Main effect	**Protein 2020**								
	Indian Head	**Melfort**	**Outlook**	**Prince Albert**	**Redvers**	**Scott**	**Swift Current**	**Yorkton**	**All Sites Average**
Main Effects	%								
1. Untreated A Certified	12.2 a	13.7 a	12.6 a	11.9 a	12.7 ab	12.6 a	10.1 a	17.7 a	12.9
2. Untreated A Farm-saved Seed	12.4 a	13.1 a	12.9 a	12.1 a	13.1 ab	12.7 a	10.8 a	18.0 a	13.1
3. Untreated B Certified	12.2 a	12.4 a	13.1 a	12.3 a	13.0 ab	11.4 a	9.8 a	17.2 a	12.7
4. Untreated B Farm-saved Seed	12.8 a	12.8 a	12.6 a	12.9 a	12.2 ab	12.6 a	9.7 a	16.8 a	12.8
5. Untreated C Certified	11.8 a	12.2 a	12.5 a	11.6 a	12.7 ab	11.7 a	12.3 a	17.1 a	12.7
6. Untreated C Farm-saved Seed	11.6 a	12.6 a	12.7 a	11.6 a	13.2 ab	12.0 a	10.2 a	17.3 a	12.7
7. Treated A Certified	12.1 a	13.2 a	12.9 a	11.3 a	12.6 ab	12.3 a	9.7 a	17.6 a	12.7
8. Treated A Farm-saved Seed	12.3 a	12.7 a	13.0 a	11.8 a	12.4 ab	12.4 a	10.7 a	17.9 a	12.9
9. Treated B Certified	12.1 a	12.3 a	12.8 a	11.7 a	12.2 ab	11.7 a	9.9 a	17.1 a	12.5
10. Treated B Farm-saved Seed	12.8 a	12.4 a	13.2 a	12.4 a	13.8 a	12.3 a	10.5 a	17.2 a	13.1
11. Treated C Certified	11.8 a	11.7 a	11.9 a	11.3 a	11.9 b	11.8 a	11.1 a	17.2 a	12.3
12. Treated C Farm-saved Seed	11.8 a	12.0 a	12.2 a	11.0 a	12.3 ab	12.2 a	10.8 a	17.1 a	12.4
L.S.D.	NS	NS	NS	NS	1.7	NS	NS	NS	--