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FERTILIZER CANADA

Wheatland Conservation Area Inc.
Swift Current, SK.

Winter Wheat Response to Contrasting Placement/Timing Options for N Fertilizer

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Final Report

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Abstract

In 2018 a trial was established in Swift Current, Saskatchewan titled "Winter Wheat Response to Contrasting Placement/Timing Options for N Fertilizer." This project consisted of a 4-replicate RCBD demonstration where the treatments consisted of five N fertilizer rates and three timing/placement options plus a control where no supplemental N fertilizer was applied. In addition to the control, the rates are 1) 60, 2) 90, 3) 120 4) 150 and 5) 180 kg total N/ha (adjusted for both residual NO3-N and N provided by 11-52-0). The timing/placement options were 1) 100% side-banded, 2) 100% spring broadcast and 50%/50% side-band/spring broadcast. AAC Wildfire (CWRW) was the variety of choice to ensure best winter wheat survival rates. Potential yields for the 2019 growing season were closely related to environmental conditions with dry soil and lower than normal spring temperatures followed by numerous rainfall events from late June through to Fall. Timing of precipitation ultimately favoured treatments with some or all of the N applied in the fall, resulting in a negative correlation between emergence and yield. The highest yielding treatments resulted from 180 kg/ha N applied in the fall side-band, or as a split application (59 bu/ac), but were not significantly different than the 120 kg/ha N split application (58.3 bu/ac). Yields varied, but showed a general decline in spring broadcast treatments, especially as N rate decreased. Protein was affected by N as increased rates lead to increased protein levels. The highest rate of nitrogen (180 kg/ha) side-banded and split applied resulted in the highest protein level of 13.7%. This trial was brought to the attention of the group on the Annual Field Day held July 18, 2019 (120 participants) by Dan Heaney on behalf of Fertilizer Canada and the 4R Initiative and was also promoted on a CKSW radio program called "Walk the Plots" broadcasted on a weekly basis throughout the summer. This project was presented by Amber Wall at the Agri-ARM research update at the Crop Production Show January 16, 2020 in Saskatoon, SK[1], as well as Chris Holzapfel, Indian Head Agricultural Research Foundation at the IHARF Soil and Crop Management Seminar, February 5, 2020.

[1] http://www.wheatlandconservation.ca/files/For_Website_WCA_Winter_Wheat.pdf

Project Objectives

Developing Best Management Practices (BMPs) for nutrient applications has long been focussed on the 4R principles which refer to using the: 1) right source, 2) right rate, 3) right time and 4) right placement. This can create unique challenges for winter cereals, however, the growing season is much longer and crop requirements for N are relatively small for the 8- to 9-month period after seeding. Consequently, and especially when considering that establishment of winter cereals can be variable from year-to-year, it is often recommended that N applications be split between fall side- or mid-row band applications and an early spring surface broadcast. This results in extra cost / labour for producers; however, N applied in the fall can be more prone to losses prior to crop uptake (especially in wet falls) while spring applied N can also be subject to loss and is not always available early enough to prevent early season deficiencies and subsequent yield loss. Consequently, split applications tend to be the least risky option when averaged over time and across a broad range of conditions.

Project Rationale

Winter wheat is known to be responsive to N fertilization and, for milling varieties, high protein is also desirable and may require N rates higher than required to simply optimize yield. How and when the N has been applied can also have an impact. While fall fertilizer applications are relatively common for spring crops in western Canada, it is recommended that such applications be deferred late into the fall when the soils have cooled down – usually well past the optimal winter wheat seeding window. Fall applications of N fertilizer are more prone to loss in wetter environments and/or lower landscape positions or poorly drained fields. As such, side-or mid-row banding the entire N requirements at seeding is commonly practice in dry areas but can be quite risky in wet years or regions. Recent IHARF-ADOPT projects illustrated this to some extent whereby, under dry conditions (2012-13), side-banded N performed consistently better than spring broadcast applications (regardless of formulation) but the opposite tended to occur the following year when the fall/early spring were much wetter (see ADOPT #20130313).[2] The split applications performed consistently well, regardless of conditions. This is an agreement with more recent and quite extensive research led by Brian Beres (AAFC-Lethbridge)[3] which found that, on average, yields were consistently highest with a split-applications and lowest when 100% of the N was broadcast in the spring. Side-banding 100% of the N also performed consistently well but might not always be desirable for reasons such as potentially poor establishment or environmental concerns. Bere's et al. concluded that there was no single optimal solution and that optimal N management will vary depending on environmental and operational considerations.

In order to minimize N fertilizer losses due to leaching and denitrification in the early spring, the traditional recommendation for fertilizing winter wheat in southeast Saskatchewan has been to broadcast the majority of the crop's N fertilizer requirements early in the spring. However, the preferred product, ammonium nitrate (34-0-0), has not been readily available for many years and producers have had to explore other options. Such options include urea, which is less suitable for surface applications, or enhanced efficiency fertilizer (EEF) products which can reduce potential losses but increase input costs and do not always result in higher yields/protein, depending on the

2 https://iharf.ca/wp-content/uploads/2016/04/Nitrogen-Fertilizer-Management-Options-for-Winter-Wheat.pdf

3 B.L. Beres., et al. Enhanced nitrogen management strategies for winter wheat production in the Canadian prairies. *Canadian Journal of Plant Science*, 2018, 98:683-702. https://doi.org/10.1139/cjps-2017-0319

weather conditions encountered. Liquid UAN can be a popular choice for spring applications because it can be applied with a field sprayer; however, it is a poor choice for fall applications. Considering that urea is generally less suitable for broadcast applications than difficult to access or more expensive formulations such as ammonium-nitrate or EEF products, there is some incentive to simply band the entire N fertilizer requirements during seeding. This practice is operationally easiest for most farmers and, in many cases, the reduced potential for volatilization with in-soil banding may offset the higher potential for leaching or denitrification losses under wet conditions. On the other hand, depending on when winter cereals are seeded and the fall weather conditions encountered, too much N applied at seeding can cause excessive vegetative growth which can reduce winter hardiness along with N availability the following spring when it is needed most. In addition, establishment of winter wheat can be variable depending on conditions; therefore, many growers, for good reason, are hesitant to commit too many input dollars prior to assessing crop condition in the early spring.

Deferring a large percentage of the N requirements until spring also has inherent risks, particularly yield loss and delayed N availability under dry conditions. Regardless of the form, N fertilizer needs precipitation to move it into the rooting zone before it can be utilized by crops. If this does not occur soon enough in the spring after the N is applied, early N deficiencies can lead to irreversible yield loss. Furthermore, dry conditions after application increase the potential for volatilization as NH_3, a permanent loss which results in lower use-efficiency of the applied N. Although spring, surface applied N tends to be more effective under wetter conditions, when it is too wet, growers can have difficulty accessing the fields to apply the fertilizer in a timely manner. This also potentially leads to early season deficiencies if inadequate N was applied the previous fall.

While either applying the entire N requirements of winter wheat during seeding or the following spring can be as effective as any other option under ideal conditions, it is for the aforementioned reasons that split applications are often considered the least risky option over the long-term and under a broad range of conditions. The premise is to apply enough N up front to carry the crop through the fall and early spring and top up the remainder closer to peak crop uptake, after the crop has been successfully established and the high-risk conditions associated with snow melt in the late winter/very early spring have passed.

This project is relevant to producers because it will provide a forum for discussion and information on the advantages and disadvantages of fundamentally different N management strategies for winter wheat. The performance of the placement/timing treatments will vary depending on the specific environmental conditions encountered and there is no ‘one size fits all’ solution to the challenges discussed; however, it is important for producers to understand the risks and benefits associated with these practices. Additionally, the project will provide information on choosing the ‘right rate’ of N fertilizer as a function of soil test recommendations along with relationships between grain yield and protein concentrations.

Methods

In the Fall of 2018, this trial was direct seeded into durum stubble using a Fabro built Cone Seeder with Atomjet openers and 9” row spacing. AAC Wildfire (CWRW) was seeded at 120lb/ac with a target plant stand of 30plants/ ft^2, and treated with Cruiser Vibrance Quattro (CVQ) at label rates. All treatments received N in the form of Urea and balanced PKS. Having a dry previous growing season, fall soil tests revealed that a relatively high amount of nitrogen (25lbs/ac N) already remained in the soil. This protocol is set up similar to that submitted by Chris Holzapfel at IHARF who developed the protocol. The treatments were arranged in a four replicate RCBD. In addition to the control, the proposed rates are 1) 60, 2) 90, 3) 120 4) 150 and 5) 180 kg total N/ha (adjusted for both residual NO3-N and N provided by 11-52-0). The proposed timing/placement options are 1) 100% side-banded, 2) 100% spring broadcast and 50%/50% side-band/spring broadcast. A full treatment list is provided in Table 1.

Table 1. List of Treatments

#	Total N Rate (soil + fert)	Timing / Placement
1	0x (no added N fertilizer)	N/A
2	60 kg soil + fert N/ha	Fall Side-Band
3	90 kg soil + fert N/ha	Fall Side-Band
4	120 kg soil + fert N/ha	Fall Side-Band
5	150 kg soil + fert N/ha	Fall Side-Band
6	180 kg soil + fert N/ha	Fall Side-Band
7	60 kg soil + fert N/ha	Spring Broadcast
8	90 kg soil + fert N/ha	Spring Broadcast
9	120 kg soil + fert N/ha	Spring Broadcast
10	150 kg soil + fert N/ha	Spring Broadcast
11	180 kg soil + fert N/ha	Spring Broadcast
12	60 kg soil + fert N/ha	Split Application (50/50)
13	90 kg soil + fert N/ha	Split Application (50/50)
14	120 kg soil + fert N/ha	Split Application (50/50)
15	150 kg soil + fert N/ha	Split Application (50/50)
16	180 kg soil + fert N/ha	Split Application (50/50)

The following measurements were taken:

1. Soil nutrient/properties – fall composite sample used for background information and N fertilizer rate determination
2. Plant Emergence Counts – determined for each plot 3-4 weeks after seeding
3. Leaf chlorophyll – determined at full flag / early heading using a SPAD meter from 10 flag leaves per plot
4. Seed yield – corrected for dockage and to 14.5% seed moisture content
5. Grain Protein – determined from NIR for each plot

Other field notes were as follows:

Table 2. 2018-2019 List of Operations

Operations	
29-Aug-18	Soil Sample (0-6, 6-12) = 15N in Soil + 6N applied with 11-52-0
4-Sep-18	Seeded AAC Wildfire WW @120#/ac treated with CVQ at label rates TKW: 35g 94% germ 9" row spacing **Fertility:** 30#P (57.7lbs/ac) 11-52-0 sidebanded at time of seeding
4-Sep-18	100% fall sideband and 50% fall sideband applied at seeding as per protocol
27-Sep-18	Fall Emergence Counts
14-May-19	100% Spring Broadcast and 50% Spring Broadcast as per protocol
28-May-19	Achieve @ .2L/ac + Infinity @.33L/ac + Turbo Charge @.2L/ac
18-Jun-19	Spad Meter
27-Aug-19	Harvested 7 rows with Zurn

2019 General Site Conditions

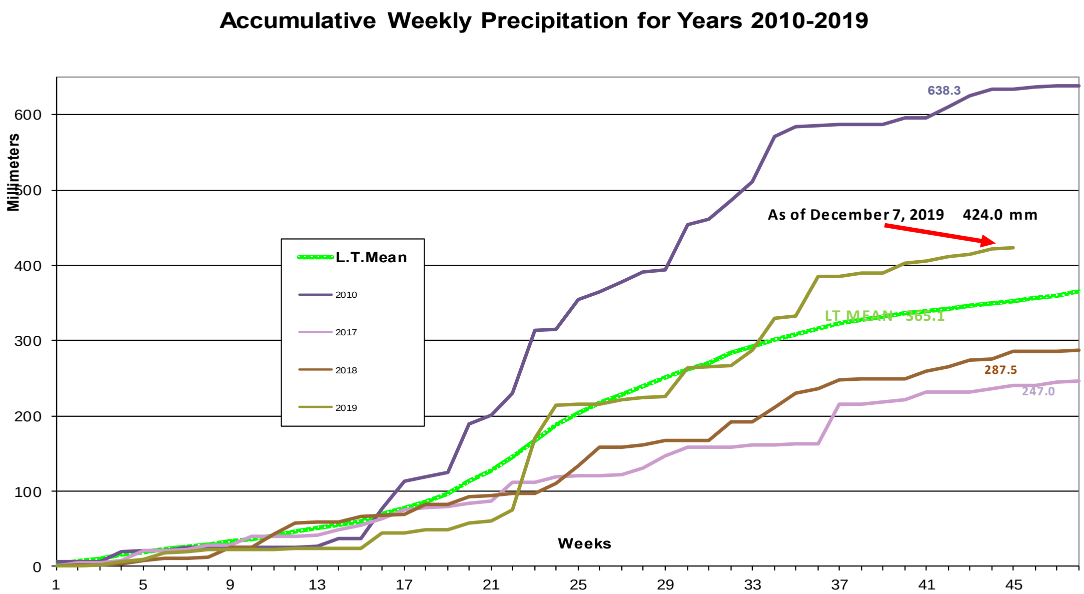


Figure 1. Accumulative weekly precipitation for years 2010 (record high), and 2017-2019 (AAFC Swift Current)

Winter Wheat was seeded into very dry soil, but from seeding to harvest the crop received adequate moisture, with most of the rainfall accumulating from June 14, 2019 to harvest (Figure 1) and plots emerged well before winter. Spring was cool and frost occurred more than once from May 18th to May 20th. With strong winds and little rainfall, the already moisture deficient fields resulted in crop progression that was behind normal stages of development. As the season progressed, lack of moisture and warm temperatures caused some thinning, and the already stunted winter cereal crops to prematurely head-out. Much needed rainfall began June 14th leading to highly variable crop conditions and second growth. Although still behind normal developmental stages, moisture helped later-seeded crops to fill and replenish topsoil moisture, but a variety of growth stages resulted. Topsoil moisture again continued to deteriorate into July with these conditions generally resulting in poor yield. Winter Wheat plots were harvested August 27, 2019 before significant rainfall events caused harvest delays through September and late into October.

Results and Discussion

Overall, results were very dependent on the winter and lack of early spring moisture. Plant Density counts showed a wide range of emergence (260-325 plants/m2) between timing and placement options, as well as increasing nitrogen (Figure 2). All plots emerged before winter, therefore plants counts were done that fall, prior to the spring broadcast application. Although winter wheat does not actually require a lot of moisture to germinate, seedling emergence varied considerably due to moisture being delayed until mid-June. A dry seedbed likely delayed emergence and increased winterkill leading to non-uniform plots. Spring treatments that had not yet received any nutrients when counts were done ranged from 290-325 plants/m2. In terms of emergence, plants benefited from treatments that had less than 60 kg/ha N applied in the fall. Fall applied N over 60kg/ha, (T3-T6), more specifically side-banded N, showed poor stand establishment, possibly due to the dry year, or too much N at seeding that can cause excessive vegetative growth before winter, reducing winter hardiness, and the available N in the spring. At 90 kg/ha side-banded N the plant stand is significantly lower dropping from over 300 plts/m2 to 260 plants/m2. The split application treatments of increasing N are not significantly different. In the fall when the split application treatments had received half their full N rate, 60 kg/ha N fall side-banded (T2), and the split application rate of 120 kg/ha N (T14), did not show significant differences in emergence counts, but the split application did yield significantly higher meaning the additional 60kg/ha N applied later in the spring increased yield in this particular year.

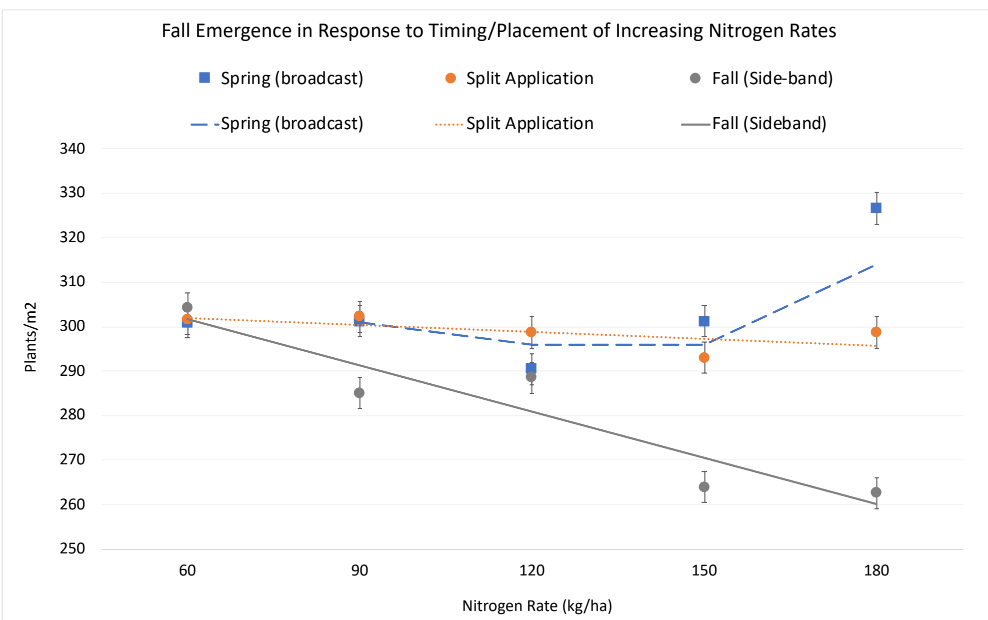


Figure 2. Winter wheat spring emergence counts in response to fertilizer timing/placement being 100% spring broadcasted, 50/50 split application, and a 100% fall side-band, each at increasing Nitrogen rates. (CV=8.01%, LSD=7.03 plants/m2)

Although stored soil moisture was at an extreme low until mid-June, all treatments yielded above the provincial average of 37 bu/ac[4]. According to the Crop Report, winter wheat yields vary greatly throughout the province (30-43 bu/ac) depending on how early the crop was seeded and the amount of moisture received throughout the growing season. However, optimal N will vary depending on the environment as nitrogen fertilizer requires precipitation to move into the rooting zone. Timing of precipitation ultimately favoured treatments with some or all of the N applied in the fall, resulting in a negative correlation between emergence and yield. The highest yielding treatments resulted from 180 kg/ha N applied in the fall side-band, or as a split application (59 bu/ac), but were not significantly different than the 120 kg/ha N split application (58.3 bu/ac). Yields varied, but showed a general decline in spring broadcast treatments, especially as N rate decreased. This is a result of the dry spring conditions as broadcasted N would have sat on the soil surface for a long time without any precipitation, unable to penetrate the soil.

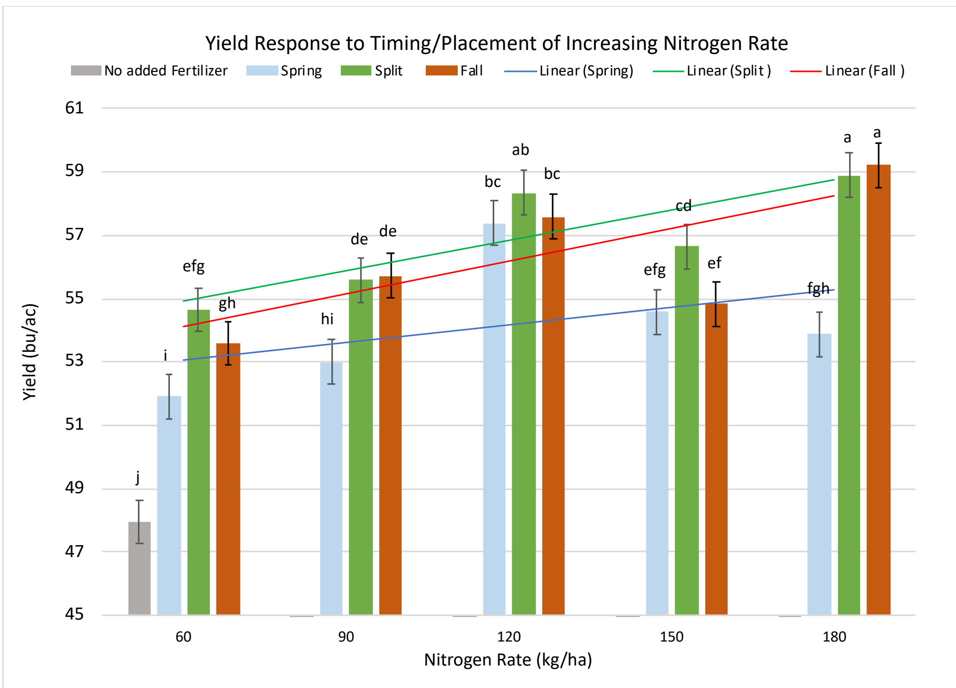


Figure 3. Winter Wheat Yield in response to fertilizer timing/placement being 100% spring broadcasted, 50/50 split application, and a 100% fall side-band, each at increasing Nitrogen rates. (CV=7.5%, LSD=1.2 bu/ac)

Protein was affected by N, as increased rates lead to increased protein levels. The highest N rate (180 kg/ha) side-banded and split applied resulted in the highest protein level of 13.7%. Only the check treatment with no additional nitrogen fertilizer fell under the minimum accepted protein of 11%.

[4] https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/market-and-trade-statistics/crops-statistics/crop-report

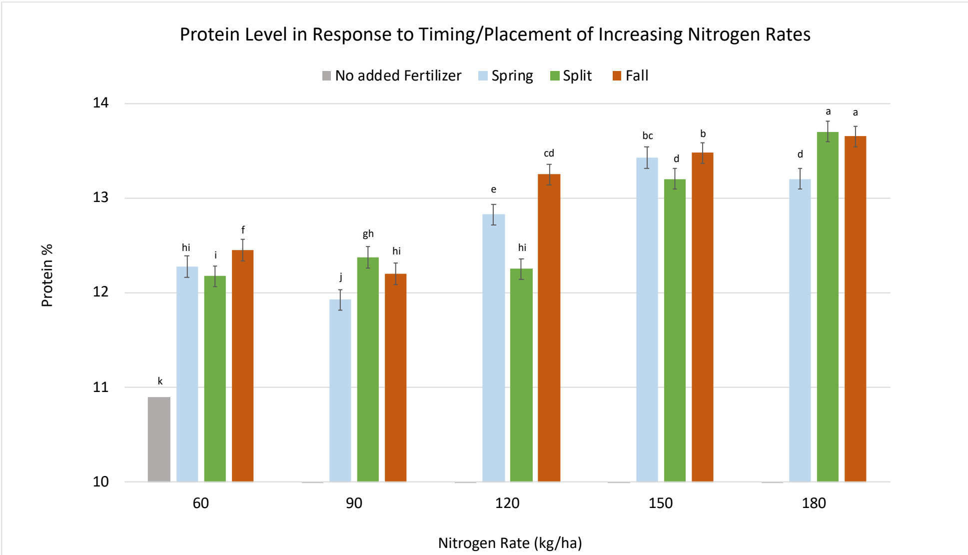


Figure 4. Winter wheat grain protein levels in response to fertilizer timing/placement being 100% spring broadcasted, 50/50 split application, and a 100% fall side-band, each at increasing Nitrogen rates. (CV=4.9%, LSD=0.19%)

A chlorophyll content meter (CCM-200 Plus) was also used at full flag/early head (average of 10 flag-leaves per plot) to measure chlorophyll content index, as a relative indicator of chlorophyll concentration of individual leaves[5] (Table 3). The chlorophyll content was not shown to be statistically significant.

The lack of spring moisture and cool temperatures negatively impacted crop emergence in 2019. With the lack of precipitation from the last 2 growing seasons topsoil moisture conditions were largely deficient and a strong stand was not established. Harvest was extremely delayed in the southwest region with winter wheat maturity greatly delayed by moisture late in the fall and crops behind normal developmental stages come August. Yields in much of the south western region were affected by frequent and excessive rainfall late in the season. Crops did not fill properly and the mid-season heat caused already stunted winter wheat crops to head out prematurely.

This trial was brought to the attention of the group on the Annual Field Day held July 18, 2019 (120 participants) by Dan Heaney on behalf of Fertilizer Canada and the 4R Initiative and was also promoted on a CKSW radio program called "Walk the Plots" that was broadcasted on a weekly basis throughout the summer. This project was presented by Amber Wall at the Agri-ARM research update at the Crop Production Show January 16, 2020 in Saskatoon, SK, as well as Chris Holzapfel, Indian Head Agricultural Research Foundation at the IHARF Soil and Crop Management Seminar, February 5, 2020. Results will be also shared locally and a summary can be found on our website at www.wheatlandconservation.ca

[5] Parry, C., Blonquist, J.M., Jr. and Bugbee, B. (2014), The optical/absolute chlorophyll relationship. Plant Cell Environ, 37: 2508-2520. doi:10.1111/pce.12324

Conclusions and Recommendations

Both split applications and fall side-band treatments performed consistently well in terms of yield in these conditions. This compliments the research of Brian Beres (AAFC Lethbridge) where yields were consistently highest with split-applications and lowest when 100% of the N was broadcast in the spring. Although side-banding 100% of the N performed well, this option might not always be desirable for reasons such as potentially poor establishment, or environmental concerns. When soil moisture is adequate at the time of seeding, side band application of all nitrogen fertilizer can be considered, particularly in the Brown and Dark Brown soil zones where potential N losses are low. If potential for N loss is a high, there are other products available such as SuperU that may be more effective in these situations, but if conditions for N loss are minimal, then urea is the most economical product to use. A split application is ultimately the least risky as splitting a fertilizer application between the fall and spring gives the flexibility to see how the crop survives over the winter before adding more fertilizer. Flexibility in the spring allows you to better time the fertilizer application with forecasted moisture and subsequent yield potential, allowing for a more effective application, limiting N losses.

There is no single optimal solution for N management for producers, therefore understanding the available options and outcomes can allow for fertilizer application flexibility. In this particular year, split applications of nitrogen showed a similar yield and protein response as applying all of the nitrogen at seeding in the fall. Broadcasting of urea resulted in substantial nitrogen losses due to volatilization and run-off, especially in hot, dry and windy conditions. If using a broadcast system, it may be worth consulting your local agronomist to help you consider an N stabilizer and apply these products in a timely matter, possibly prior to a rainfall to help with breakdown into the soil.

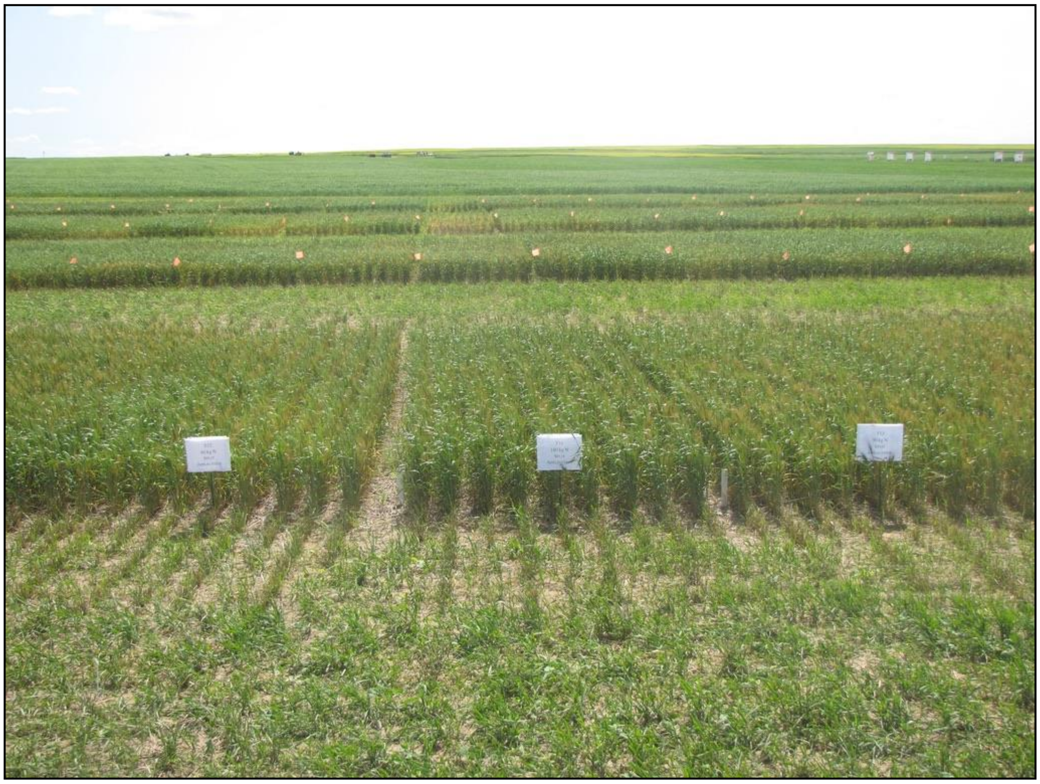
Acknowledgements

We thank the Ministry of Agriculture for all ADOPT projects including plot signage and verbal acknowledgement at field days and on PowerPoint slides during presentations. This will continue at each venue where an extension activity occurs. We also thank Shannon Chant with the Saskatchewan Ministry of Agriculture, Chris Holzapfel, Indian Head Agricultural Research Foundation, as well as Fertilizer Canada.

Table 3. Individual treatment means for selected response variables at Swift Current, 2019.

	Timing/Placement	Nitrogen Rate (Soil + Fert)	Emergence (plants/m2)	Grain Yield (kg/ha)	Protein (%)
1	N/A	**0**	309.4 b	3230.4 j	10.90 k
2	Fall Side-banded	**60**	304.2 bc	3610.0 gh	12.45 f
3	Fall Side-banded	**90**	285.0 h	3753.4 de	12.20 hi
4	Fall Side-banded	**120**	288.6 gh	3879.5 bc	13.25 cd
5	Fall Side-banded	**150**	264.0 i	3694.6 ef	13.48 b
6	Fall Side-banded	**180**	262.6 i	3988.9 a	13.65 a
7	Spring Broadcast	**60**	300.9 cde	3497.2 i	12.28 hi
8	Spring Broadcast	**90**	301.2 cd	3570.2 hi	11.93 j
9	Spring Broadcast	**120**	290.5 gh	3865.9 bc	12.83 e
10	Spring Broadcast	**150**	301.2 cd	3676.7 efg	13.43 bc
11	Spring Broadcast	**180**	326.6 a	3629.6 fgh	13.20 d
12	Split Application (50/50)	**60**	301.7 cd	3681.1 efg	12.18 i
13	Split Application (50/50)	**90**	302.3 cd	3744.7 de	12.38 gh
14	Split Application (50/50)	**120**	298.7 c-f	3930.4 ab	12.25 hi
15	Split Application (50/50)	**150**	293.0 fg	3816.5 cd	13.20 d
16	Split Application (50/50)	**180**	298.7 c-f	3967.1 a	13.70 a

Image 1. Trial overview at Swift Current, SK (July 19, 2019)



Images 2-3. Winter wheat (T1) with no additional nitrogen fertilizer (left) and winter wheat (T16) with 180 kg/ha N (soil + fertilizer) applied as a split application (right). (July 19, 2019).