2019 Annual Report
for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

and Fertilizer Canada

Project Title: Winter Wheat Response to Nitrogen Fertilizer Placement and Timing Options

(Project #20180401)

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Project Identification

1. **Project Title:** Winter wheat response to contrasting N fertilizer placement and timing options
2. **Project Number:** 20180401
3. **Producer Group Sponsoring the Project:** Indian Head Agricultural Research Foundation
4. **Project Location(s):** Indian Head, Saskatchewan, R.M. #156
5. **Project start and end dates (month & year):** September-2018 to February-2020
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **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 since the growing season is much longer relative to spring seeded crops 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 vary with conditions, it is often recommended that N fertilizer applications be split between fall side- or mid-row band applications and an early spring surface broadcast application. 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 nutrient deficiencies and subsequent yield loss. Consequently, split-applications of N tend to be the least risky option when averaged over time and across a broad range of conditions.

A key objective of this project is to demonstrate the relative winter wheat responses to N fertilizer rate when all of the fertilizer was applied either as side-banded urea, early-spring broadcast urea, or a split-application with 50% of the supplemental N fertilizer side-banded and the remainder applied in an early season broadcast application. While the form of N was not varied in this demonstration and enhanced efficiency N products can be a good fit with winter cereals, urea is the most commonly used N formulation in western Canada and an appropriate choice to illustrate fundamental differences amongst the rates and placement/timing options being evaluated.

8. **Project Rationale:**

In order to minimize potential N fertilizer losses due to leaching and denitrification, the traditional recommendation for 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 to purchase in bulk quantities for many years and producers have been forced to explore other options. Such options include urea, which is less suitable for surface applications, or enhanced efficiency fertilizer (EEF) products (i.e. NBPT) which can reduce potential losses but also increase input costs and do not always result in higher yields/protein (relative to traditional options), depending on the specific conditions encountered. Liquid UAN is a popular choice for spring applications because it can be applied with a field sprayer and contains 25% NO_3-N which is not prone to volatilization; however, the NO_3-N also makes it a poor choice for fall applications.

Considering that urea is less suitable for broadcast applications than inaccessible or more expensive options 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 can offset the higher potential for leaching or denitrification losses under wet conditions. On the other hand, depending on when seeding is completed and the specific fall weather, applying high rates of N at seeding can cause excessive vegetative growth which can reduce winter hardiness along with N supply the following spring when it is needed most. Furthermore, 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 or if spring application is delayed. Regardless of the form, N fertilizer needs precipitation to move it into the rooting zone before it can be fully utilized by crops. If this does not occur soon enough in the spring after the fertilizer is applied, early N deficiencies can lead to irreversible yield loss. Furthermore, dry conditions after application of untreated urea increases the potential for NH_3 volatilization, 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, particularly if not enough 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 favorable conditions, it is for the aforementioned reasons that split-applications are often considered the least risky option over the long-term and for 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 was intended to demonstrate and provide a forum for discussion 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 was designed to provide information on choosing the ‘right rate’ of N fertilizer as a function of soil test recommendations and taking into account both yield and protein responses.

Methodology and Results

9. Methodology:

A field trial with winter wheat was initiated in September 2018 near Indian Head, Saskatchewan (50.556 N, 103.606 W) to evaluate response to contrasting N fertilizer timing/placement options and a range of application rates. Indian Head is situated in the thin-Black soil zone of southeast Saskatchewan. The treatments were a factorial combination of three N timing/placement options and five N fertility levels ranging from 60-180 kg N/ha (residual NO_3 plus fertilizer N) in addition to a control where no supplemental urea was applied. Side-banding was completed as part of the seeding operation on September 21 (2018) and spring broadcast applications were completed on April 16 (2019). Importantly, 15 mm of rainfall fell within 24 hours of the spring broadcast applications. This would have been largely sufficient to move the recently applied N into the rooting zone where it would be available to the crop and mostly safe from volatilization. The sixteen treatments are listed in Table 1.

Table 1. Winter wheat N fertilizer management by rate treatments at Indian Head in 2018-19

#	Timing / Placement	Total N Rate [Z]
1	N/A	18 kg N/ha [Y]
2	Side-Band	60 kg N/ha
3	Side-Band	90 kg N/ha
4	Side-Band	120 kg N/ha
5	Side-Band	150 kg N/ha
6	Side-Band	180 kg N/ha
7	Spring Broadcast	60 kg N/ha
8	Spring Broadcast	90 kg N/ha
9	Spring Broadcast	120 kg N/ha
10	Spring Broadcast	150 kg N/ha
11	Spring Broadcast	180 kg N/ha
12	Split Application (50/50)	60 kg N/ha
13	Split Application	90 kg N/ha
14	Split Application	120 kg N/ha
15	Split Application	150 kg N/ha
16	Split Application	180 kg N/ha

[Z] Residual NO_3-N (0-60 cm) plus fertilizer N
[Y] Provided from residual NO_3-N and seed-applied 11-52-0

Selected agronomic information is provided in Table 2. The winter wheat was direct-seeded approximately 2 cm (0.75”) deep into canola stubble with seeding rates adjusted for seed size and germination to target 400 viable seeds/m^2. Monoammonium phosphate was seed-placed to provide 35 kg P_2O_5/ha across the entire study area. Weeds were controlled using registered pre-emergent and in-crop herbicide applications and foliar fungicide was applied during heading to reduce the potential for disease to be a yield and quality limiting factor. Insecticides were not considered necessary or applied. Pre-harvest glyphosate was applied at physiological maturity and the centre five rows of each plot were straight-combined as soon as possible after it was fit to do so.

Various data were collected during the growing season and from the harvested grain samples. To assess treatment effects on vegetative growth, the average normalized difference vegetation index (NDVI) was determined for each plot using a handheld GreenSeeker®. These measurements were completed three times between June 11-24, or the early to full flag leaf growth stages. SPAD measurements, an indicator of leaf chlorophyll content, were completed for the flag leaf on two occasions, June 24 (full flag) and July 3 (late milk). The measurements were completed on 10 flag leaves per plot on both dates. Because the treatment effects were similar across individual measurement dates, both NDVI and SPAD values were averaged. Grain yields were determined from the harvested grain samples and are corrected for dockage and to a uniform moisture content of 14.5%. Grain protein concentrations were determined for each plot using an NIR instrument. Daily temperatures and precipitation amounts were recorded at an Environment Canada weather station located approximately 3 km from the plots.

Table 2. Selected agronomic information for winter wheat at Indian Head (2018-19).

Factor / Field Operation	**Details / Description**
Previous Crop	Canola
Pre-emergent herbicide	894 g glyphosate/ha + 5 g florasulam/ha Sep-27-2018
Seeding Date	Sep-21-2018
Seed Rate	400 seeds/m^2 (137 kg/ha)
kg P_2O_5-K_2O-S ha^{-1}	35-0-0
N Broadcast Applications	Apr-16-2019
NDVI	Jun-11, Jun-19, and Jun-24 (2019)
SPAD	Jun-24 and Jul-3 (2019)
In-crop Herbicide	560 g MCPA/ha + 100 g clopyralid/ha + 15 g pyroxsulam/ha Jun-10-2019
Foliar Fungicide	100 g prothioconazole/ha + 100 g tebuconazole/ha Jul-1-2019
Pre-harvest herbicide	894 g glyphosate/ha Aug-8-2019
Harvest date	Aug-16-2019

All response data were analysed using the Mixed procedure of SAS and two separate models. The first was a basic ANOVA with the treatment effects considered fixed and replicate effects considered random. Orthogonal contrasts were used to describe whether the observed responses to N rate were linear or quadratic for each N timing/placement option and when averaged across options. For the second analyses, the unfertilized control treatment was removed and the remaining treatments were analysed as a factorial with N timing/placement (TP), N rate (NR), and the TP x NR interaction effects considered fixed and replicate effects considered random. The rationale for the second analyses was to improve our ability to test for differences in the N rate response for the timing/placement options. Individual treatment means were separated using Fisher's protected LSD test and all treatment effects and differences between means were considered significant at $P \leq 0.05$.

10. Results:

Growing season weather and residual soil nutrients

The winter wheat was seeded into moisture on September 21 but cool temperatures followed and there was little above-ground growth observed going into winter despite seemingly excellent initial germination. Despite there being sufficient moisture for germination, overall reserves were low and conditions were drier than normal for much of the spring with less than 60% of normal precipitation received from October 2018 through April 2019. Again, 15 mm of precipitation was received on April 17, the day after the spring broadcast applications – this was timely and likely sufficient to move the recently applied N into the rooting zone where it would be available to the crop and largely protected from volatilization losses. Weather data for May through August 2019 at Indian Head is presented with the long-term (1981-2010) averages in Table 3. The dry weather continued through May and early June at which point moisture conditions began to improve, eventually to the extent where precipitation amounts were above normal for the month of August. Overall, the specific environmental conditions encountered were conducive to excellent establishment, somewhat below average winter wheat yield potential, and low- to moderate-risks of N losses due to denitrification or leaching for the fall banded fertilizer or volatilization for the spring, surface broadcast N.

Table 3. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) averages for the 2019 growing season at Indian Head, SK.

Year	May	June	July	August	Avg. / Total
	------------ Mean Temperature (°C) ------------				
IH-2019	8.9	15.7	17.4	15.8	14.5
IH-LT	10.8	15.8	18.2	17.4	15.6
	------------ Precipitation (mm) ------------				
IH-2019	13.3	50.4	53.1	96.0	148
IH-LT	51.8	77.4	63.8	51.2	244

A composite soil sample was collected prior to seeding (0-15 cm, 15-60 cm) and analyzed for basic properties and residual nutrient levels (Table 4). The site had fairly typical organic matter levels for the region of 5.4% and residual N levels were extremely low with less than 12 kg NO_3-N/ha measured in the 0-60 cm soil profile. Residual P was also considered very low while K and S levels were higher; however, all nutrients other than N were intended to be non-limiting across treatments. The pH levels of 7.8 (0-15 cm) and 8.1 (15-60 cm) were also considered typical for soils in the region.

Table 4. Selected soil test results for winter wheat demonstration at Indian Head, Saskatchewan (2018-19).

Attribute / Nutrient	0-15 cm	15-60 cm	0-60 cm
pH	7.8	8.1	–
S.O.M. (%)	5.4	–	–
NO_3-N (kg/ha)^Z	5	7	12
Olsen-P (ppm)	3	–	–
K (ppm)	436	–	–
S (kg/ha)	22	34	29

Field Trial Results

Results for the overall tests of fixed effects for the two analyses are presented in Table 5 below. The overall F-test for the basic ANOVA (which included the control) was significant for all variables (P < 0.001-0.022). For the factorial analyses, NDVI was affected by N rate (NR; P < 0.001) but not timing/placement (TP; P = 0.990), and the NR x TP interaction was not significant (P = 0.682). Chlorophyll (SPAD) values were not affected according to the factorial analyses (P = 0.222-0.941); thus indicating that SPAD values differed in the unfertilized control but were otherwise similar where N was applied. Grain yield was affected by NR (P < 0.001) but not TP (P = 0.832) or the interaction (P = 0.659). Protein was affected by both TP (P = 0.018) and NR (P < 0.001) but no interaction between these two factors was detected (P = 0.117)

Table 5. Overall tests of fixed effects for selected winter wheat response variables. Data were analysed using two separate models including a basic ANOVA which included all treatments and a second, factorial analyses where the unfertilized control had to be excluded.

Variable	Overall F-test ^{Z}	Time/Place (TP) ^{Y}	N Rate (NR) ^{Y}	TP × NR ^{Y}
	------------ p-values ------------			
NDVI (avg)	**<0.001**	0.990	**<0.001**	0.682
SPAD (avg)	**0.022**	0.866	0.222	0.941
Yield (kg/ha)	**<0.001**	0.832	**<0.001**	0.659
Protein (%)	**<0.001**	**0.018**	**<0.001**	0.117

^{Z} Simple ANOVA including all 16 treatments as fixed effects and replicate effects as random

^{Y} Factorial analyses (control removed) including time/place (TP), N rate (NR), and TP x NR as fixed effects and replicate effects as random

Detailed treatment means and results of the multiple comparisons tests and orthogonal contrasts are deferred to the Appendices (Tables 6-8) while simplified graphical representations of the results for each variable are provided in Figs. 1-4.

Normalized difference vegetation index (NDVI) is an indirect measure of crop biomass or canopy density. When averaged across N timing/placement options, NDVI increased with N rate (NR) with the greatest increases associated with the first 60 kg N/ha and a diminishing response as N rate was increased beyond 120 kg N/ha. The responses were not entirely consistent across timing/placement (TP) methods but no consistent trends were identified and the factorial analyses did not indicate either a timing/placement effect or TP x NR interaction (Fig 1; Tables 6-7). The linear responses to N rate (Table 8) were always highly significant ($P < 0.001$) while the quadratic responses were always at least marginally significant ($P = 0.003$-0.075).

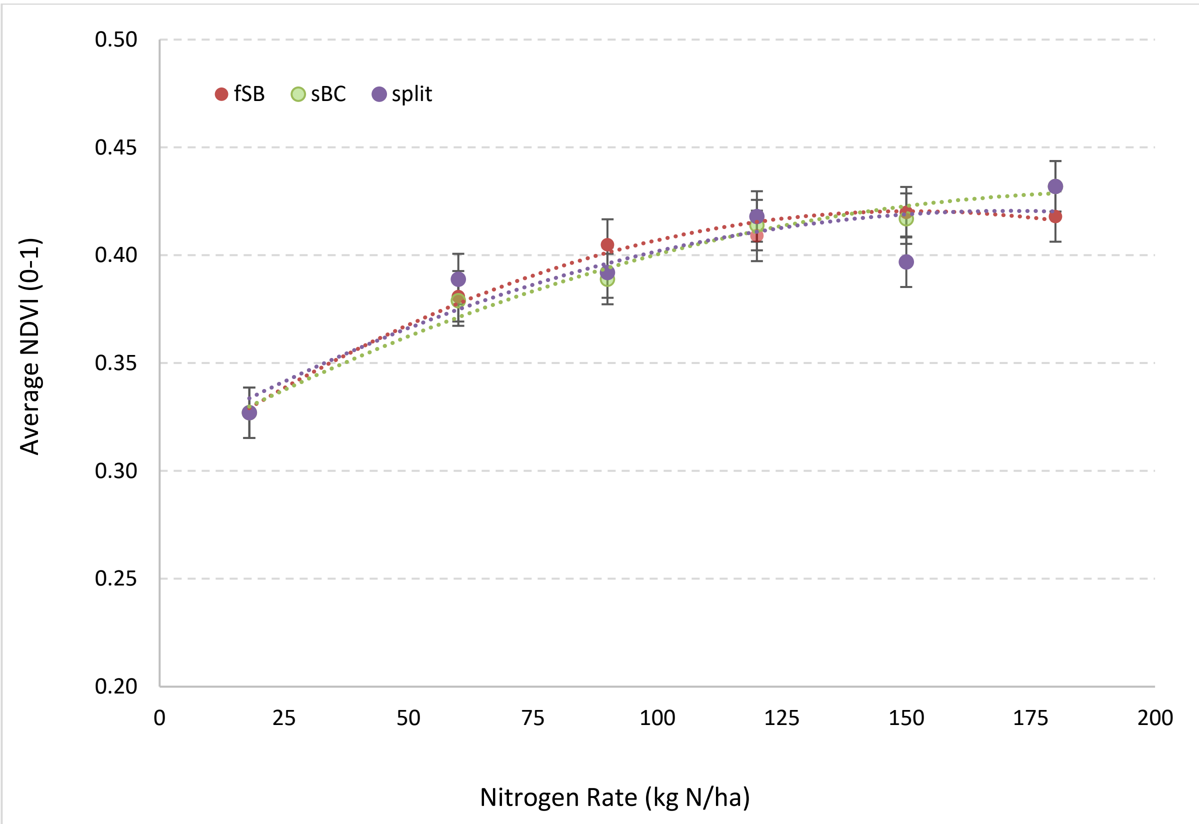

Figure 1. N fertilizer rate by timing/placement effects on winter wheat NDVI (average of three dates) at Indian Head (2018-19). N rates are residual soil NO_3-N plus fertilizer and the timing/placement options were 1) fall side band (fSB), 2) spring surface broadcast (sBC), and 3) a 50/50 split application (split). Error bars are S.E.M.

Chlorophyll meter (SPAD) readings also increased with N fertilization (Fig. 2; Table 6); however, there were no significant differences amongst the fertilized treatments (Table 6) or N timing/placement effects detected (Table 7; $P = 0.866$). Both the linear and quadratic responses to N rate were significant for SPAD regardless of timing/placement ($P < 0.001$-0.049; Table 8).

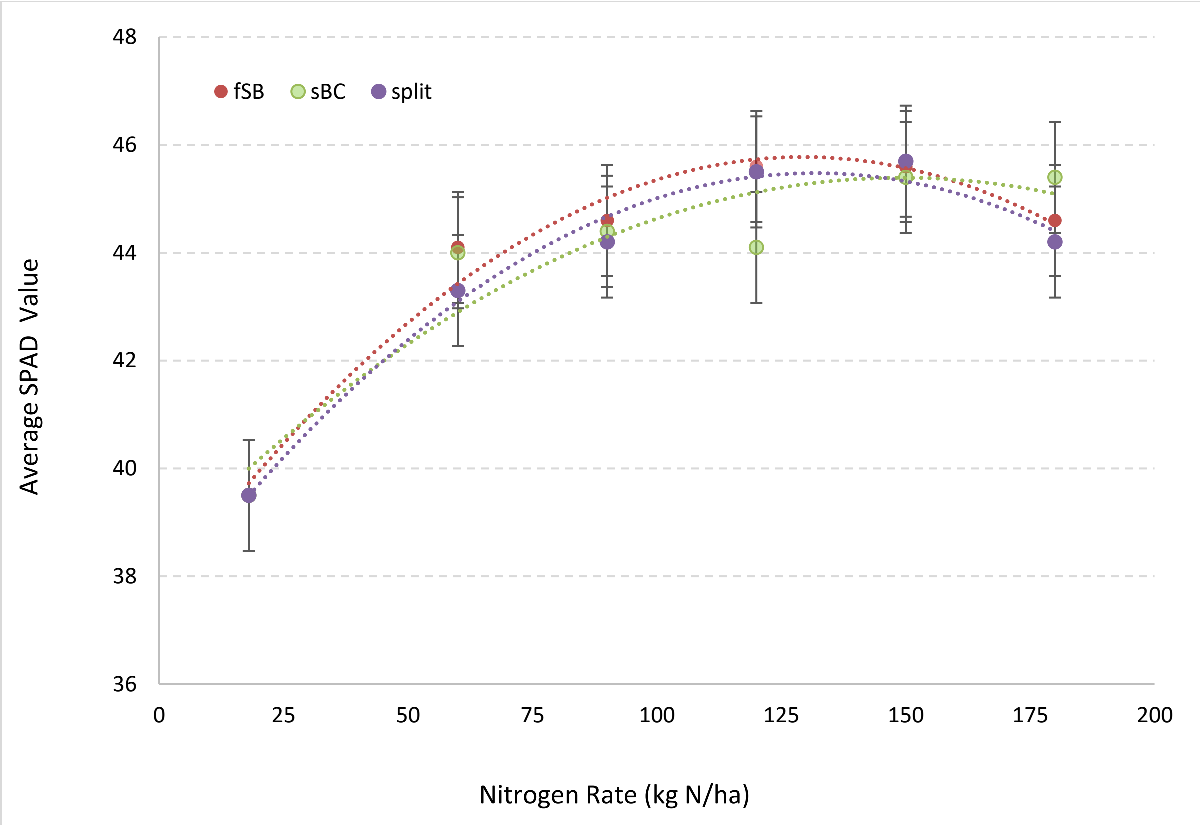

Figure 2. N fertilizer rate by timing/placement effects on winter wheat flag leaf SPAD measurements (average of two dates, full flag to milk stage) at Indian Head (2018-19). N rates are residual soil NO_3-N plus fertilizer and the timing/placement options were 1) fall side band (fSB), 2) spring surface broadcast (sBC), and 3) a 50/50 split application (split). Error bars are S.E.M.

A strong overall yield response to N fertilization was observed (Fig. 3) with all fertilized treatments yielding significantly higher than the control and increases of nearly 60% observed in certain cases (Table 6). When averaged across timing/placement options, winter wheat yields increased significantly right up to 150 kg N/ha (soil plus fertilizer) at which point further increases in N rate no longer significantly increased yield. Neither timing/placement (P = 0.832) nor the TP x NR interaction (P = 0.659) were significant (Table 7); thus, indicating that that the yield response to N was similar regardless of how the fertilizer was managed. Furthermore, both the linear and quadratic responses to N rate were highly significant (P < 0.001) whether for individual N timing/placement options or on average (Table 8).

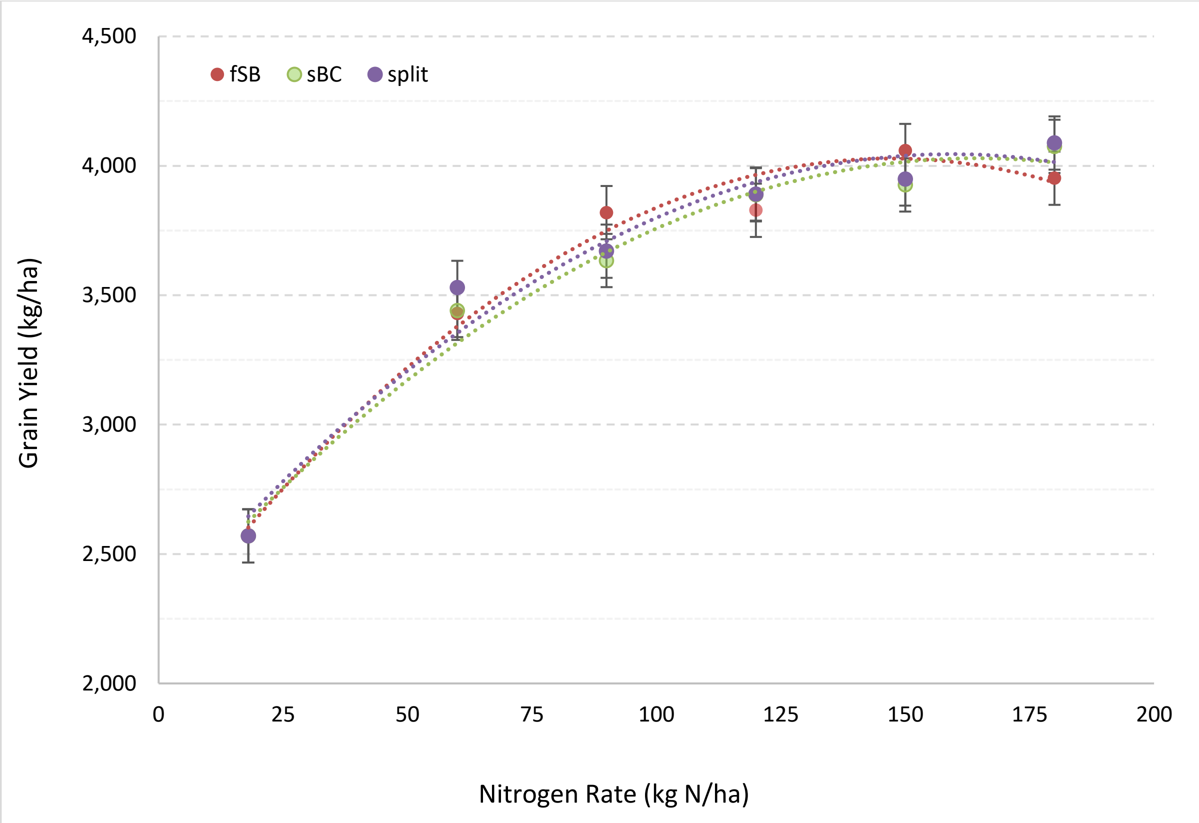

Figure 3. N fertilizer rate by timing/placement effects on winter wheat grain yield at Indian Head (2018-19). N rates are residual soil NO_3-N plus fertilizer and the timing/placement options were 1) fall side band (fSB), 2) spring surface broadcast (sBC), and 3) a 50/50 split application (split). Error bars are S.E.M.

As expected and indicated by the overall F-tests, there was a strong protein response associated with N fertilization (Fig. 4) and, again, grain protein concentrations were also affected by N timing/placement ($P = 0.018$) in addition to N rate ($P < 0.001$). The lack of a TP x NR interaction that responses to N rate were reasonably consistent regardless of how the N was managed and vice versa. Although the differences were fairly small, the factorial analyses (Table 7) showed that protein concentrations were highest with the spring broadcast applications (12.9%), lowest with fall side-banding (12.6%) and intermediate with the split applications (12.75%). Averaged across timing/placement methods, the highest protein occurred at 180 kg N/ha (13.8%) but this was not significantly higher than at the 150 kg N/ha rate (13.5%) and the quadratic response ($P = 0.005$; Table 8) indicated that the increases were diminishing at higher rates. For individual timing/placement options, the linear responses were always highly significant ($P < 0.001$) while the quadratic response was highly significant with side banding ($P = 0.002$), marginally significant with split applications ($P = 0.059$), and not significant for spring broadcast N ($P = 0.194$). However, with no TP x NR interaction we cannot say with confidence that the response differed depending on timing/placement method. Inspection of individual treatment means and the multiple comparisons test results suggest that the advantage to spring applied N was most evident at the highest rates.

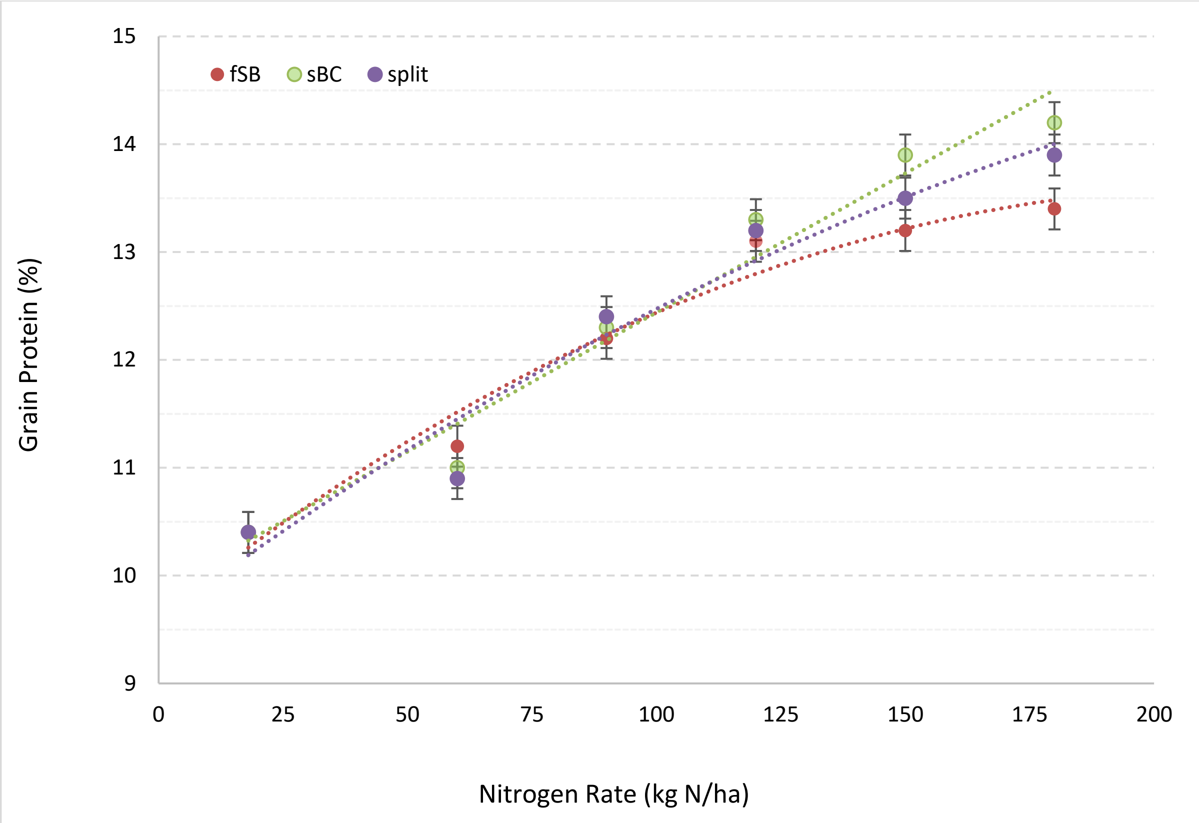

Figure 4. N fertilizer rate by timing/placement effects on winter wheat grain yield at Indian Head (2018-19). N rates are residual soil NO_3-N plus fertilizer and the timing/placement options were 1) fall side band (fSB), 2) spring surface broadcast (sBC), and 3) a 50/50 split application (split). Error bars are S.E.M.

Extension Activities and Dissemination of Results

This project was discussed and the plots were toured by approximately 125 guests at the Indian Head Crop Management Field Day on July 16, 2019. In addition to Chris Holzapfel introducing the project and discussing the specific objectives, Dan Heaney with Fertilizer Canada led a broader discussion on 4R nitrogen management principles as they pertain to western Canadian crop production. The plots were also visited on July 12 during a tour for approximately 60 Federated Co-operatives Limited (FCL) agronomists from throughout the province. Chris Holzapfel presented highlights from the project at an Independent Consulting Agronomists Network (ICAN) meeting in Regina (Feb. 4) and the IHARF Winter Meeting and AGM in Balgonie (Feb. 5) with an estimated combined attendance of 175-200 people. The full project report will be made available online on the IHARF website (www.iharf.ca) and results will continue to be made available through a variety of other media (i.e. oral presentations, popular agriculture press, fact sheets, etc.) as appropriate opportunities arise.

Conclusions and Recommendations

This project demonstrated winter wheat response to fundamentally different N management strategies and a wide range of application rates. All of the N timing/placement options (side-band, spring broadcast, and split-application) worked reasonably well under the specific conditions encountered; the protein responses revealed a slight advantage to the spring broadcast applications. Past research has suggested that, while side-banding the crops entire N requirements can be feasible in dry environments, it is risky under wet conditions and saturated soils can frequently occur during the early spring thaw period even in relatively dry years/regions. In contrast, there can also be a risk of nutrient deficiency associated with deferring too much N until the following spring. This can be the case if dry conditions result in reduced availability of the spring broadcast N or if spring broadcast applications are delayed (i.e. wet weather). To alleviate the risk of N losses in the fall/early spring while also minimizing the potential for N deficiencies, split applications are commonly recommended as an ideal option for a wide range of environmental conditions and the results from the current project support this recommendation.

Supporting Information

11. Acknowledgements:

This project was jointly funded by Fertilizer Canada and the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canadian Agricultural Partnership bi-lateral agreement between the federal government and the Saskatchewan Ministry of Agriculture. Crop protection products were provided in-kind by Corteva Agriscience and Bayer CropScience. IHARF also has a strong working relationship and framework agreement with Agriculture & Agri-Food Canada which helps to make work like this a possibility.

12. Appendices

Table 6. Treatment means and overall F-test results for individual N timing/placement by rate treatment effects on winter wheat NDVI, SPAD values (leaf chlorophyll), grain yield, and grain protein. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

Treatment	NDVI (average)	SPAD (average)	Grain Yield (kg/ha)	Grain Protein (%)
1) Control – 18 kg N/ha	0.327 e	39.5 b	2570 e	10.4 g
2) fSB – 60 kg N/ha	0.381 d	44.1 a	3430 d	11.2 f
3) fSB – 90 kg N/ha	0.405 a-d	44.6 a	3819 abc	12.2 e
4) fSB – 120 kg N/ha	0.409 a-d	45.6 a	3828 abc	13.1 d
5) fSB – 150 kg N/ha	0.420 ab	45.6 a	4059 a	13.2 d
6) fSB – 180 kg N/ha	0.418 abc	44.6 a	3952 a	13.4 cd
7) sBC – 60 kg N/ha	0.379 d	44.0 a	3441 d	11.0 f
8) sBC – 90 kg N/ha	0.389 cd	44.4 a	3634 cd	12.3 e
9) sBC – 120 kg N/ha	0.414 abc	44.1 a	3888 abc	13.3 d
10) sBC – 150 kg N/ha	0.417 abc	45.4 a	3926 ab	13.9 ab
11) sBC – 180 kg N/ha	0.432 a	45.4 a	4075 a	14.2 a
12) split – 60 kg N/ha	0.389 bcd	43.3 a	3530 d	10.9f
13) split – 90 kg N/ha	0.392 bcd	44.2 a	3670 bcd	12.4 e
14) split – 120 kg N/ha	0.418 abc	45.5 a	3891 abc	13.2 d
15) split – 150 kg N/ha	0.397 bcd	45.7 a	3949 a	13.5 bcd
16) split – 180 kg N/ha	0.432 a	44.2 a	4088 a	13.9 abc
S.E.M.	0.0117	1.03	102.9	0.19
	------------------------------------ p-value ------------------------------------			
Overall F-test	<0.001	0.022	<0.001	<0.001

Table 7. Overall F-test results from factorial analyses and main effect means for N timing/placement and N rate effects on winter wheat NDVI, SPAD values (leaf chlorophyll), grain yield, and grain protein. Means for each main effect within a column followed by the same letter do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Source / Main Effect	Average NDVI	Average SPAD	Grain Yield	Grain Protein
	--------- (p-value) ---------			
N Time / Place (TP)	0.990	0.866	0.832	0.018
N Rate (NR)	<0.001	0.222	<0.001	<0.001
TP x NR	0.682	0.941	0.659	0.117
N Time / Place (TP)	----- (0-1) -----	-----------------	---- (kg/ha) ----	------ (%)------
1) Fall side-band (fSB)	0.406 a	44.9 a	3825 a	12.63 b
2) Spring broadcast (sBC)	0.406 a	44.7 a	3817 a	12.93 a
3) Split Application (split)	0.0405 a	44.6 a	3793 a	12.75 ab
S.E.M.	0.0065	0.51	56.9	0.111
N-Rate (NR)				
0) 18 kg N/ha	(0.327)	(39.5)	(2570)	(10.40)
1) 60 kg N/ha	0.383 c	43.8 a	3467 d	11.02 d
2) 90 kg N/ha	0.395 bc	44.4 a	3708 c	12.29 c
3) 120 kg N/ha	0.414 a	45.1 a	3869 b	13.18 b
4) 150 kg N/ha	0.411 ab	45.6 a	3978 ab	13.54 a
5) 180 kg N/ha	0.427 a	44.7 a	4038 a	13.81 a
S.E.M.	0.0077	0.615	65.5	0.126

Table 8. Orthogonal contrast results for winter wheat response to N rate when averaged across timing / placement options and for individual timing/placement options. N rates ranged from 18-180 kg N/ha (residual NO_3-N plus fertilizer) and the timing/placement options were fall side-band (fSB), spring broadcast (sBC), and a 50/50 split-application.

Orthogonal Contrast	Average NDVI	Average SPAD	Grain Yield	Grain Protein
	--------- (p-value) ---------			
All – linear	<0.001	<0.001	<0.001	<0.001
All – quadratic	0.003	<0.001	<0.001	0.005
fSB – linear	<0.001	<0.001	<0.001	<0.001
fSB – quadratic	0.004	0.003	<0.001	0.002
sBC – linear	<0.001	<0.001	<0.001	<0.001
sBC – quadratic	0.075	0.049	<0.001	0.194
Split – linear	<0.001	<0.001	<0.001	<0.001
Split – quadratic	0.034	0.005	<0.001	0.059

Figure 5. Winter wheat field trial overview at Indian Head (August 6, 2019).

Figure 6. Winter wheat with no supplemental urea applied (Indian Head, August 6, 2019).

Abstract

13. Abstract/Summary:

A field trial with winter wheat was established near Indian Head to demonstrate response to a range of N fertilizer rates and three timing/placement strategies including side-banding, spring broadcast, and a 50/50 split-application. In addition to a control where no supplemental urea was applied (received 18 kg N/ha soil plus fertilizer), the N rates were 60, 90, 120, 150, and 180 kg N/ha. Although the crop was seeded into sufficient moisture for germination, the fall was cool and dry with minimal growth prior to winter and a reasonably low risk of environmental N losses. The following spring was dry, which normally would favour fall in-soil over spring surface broadcast applications of N; however, the broadcast N was applied early (April 16) and 15 mm of rain fell less than 24 hours after the applications. This timely precipitation presumably helped move the recently applied N into the rooting zone where it would be available for crop uptake and protected against volatilization. Normalized difference vegetation index (NDVI) and leaf chlorophyll (SPAD) measurements were completed during the late-vegetative/early-reproductive growth stages to assess the N response during the growing season. While values for both measurements increased with N fertilization, NDVI was more sensitive than SPAD with greater separation between application rates. Neither measurement detected any differences between the N timing/placement strategies evaluated. Focussing on grain yield, there was a strong response to N fertilization with yields increasing significantly up to the 150 kg N/ha (soil plus fertilizer) rate. Yields were similar regardless of the timing/placement method. Grain protein concentrations in wheat tend to be even more sensitive to N management than yield and this appeared to be the case in the current demonstration. While protein concentrations generally peaked at similar N rates as yield, small differences were detected between the timing/placement options. The results favoured spring broadcast N (12.9%) over side-banding (12.6%) with intermediate protein levels observed with the split application (12.8%). Overall, these results support the recommendation that either fall side-band or spring broadcast applications of N can perform well but split-applications provide consistent results across the broad range of conditions that can potentially occur in southeast Saskatchewan.