2019 Annual Report
for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

and Fertilizer Canada

Project Title: Demonstrating 4R Nitrogen Management Principles in Spring Wheat

(Project #20180400)

Principal Applicant: Chris Holzapfel, MSc, PAg

Indian Head Agricultural Research Foundation, Box 156, Indian Head, SK, S0G 2K0

Correspondence: cholzapfel@iharf.ca

Project Identification

1. **Project Title:** Demonstrating 4R N Management Principles in Spring Wheat
2. **Project Number:** 20180400
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):** October-2018 to February-2020
6. **Project contact person & contact details:**

Chris Holzapfel, Research Manager
Indian Head Agricultural Research Foundation
P.O. Box 156, Indian Head, SK, S0G 2K0
Phone: 306-695-4200
Email: cholzapfel@iharf.ca

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 timing and 4) right placement method. These factors are not necessarily independent of each other. For example, depending on the source, application timing or placement options that might normally be considered high risk can become more viable. The objective of this trial was to demonstrate the overall nitrogen (N) rate response along with the feasibility of various N management strategies using spring wheat as a test crop. The N rates included in the demonstration were adjusted for soil residual nitrate (NO_3-N) and ranged from nil (i.e. no supplemental N applied) to nearly double a somewhat conservative soil test recommendation of 125 kg N/ha total N (residual plus fertilizer). The management strategies varied with regard to timing (fall versus spring), placement (surface broadcast versus side-band), and formulation (untreated urea, ESN®, Agrotain® treated urea, and SuperU®). Although it was not practical to include all possible approaches to N management, the treatments encompassed all of the major considerations (source, rate, time and placement) for 4R nutrient management and included several options and comparisons which are of practical relevance to western Canadian producers.

8. **Project Rationale:**

Nitrogen is the most commonly limiting nutrient in annual crop production and is often one of the most expensive crop inputs, particularly for crops with large N requirements like high protein spring wheat. Most inorganic N fertilizers contain ammoniacal-N (i.e. anhydrous ammonia, urea) but some (i.e. urea ammonium-nitrate) also contain NO_3-N. Both forms are readily available for crop uptake but are also subject to unique and important environmental losses. Urea-based fertilizers initially convert to NH_3 which, in addition to potentially being harmful to seedlings, can be readily lost via volatilization if on or near the soil surface before converting to NH_4. In contrast, under saturated conditions, NO_3-N can be leached beneath the rooting zone or lost through denitrification as soil microbes seek alternate forms of oxygen and convert it back to N_2 or N_2O. Such losses not only result in substantial economic losses but may also lead to environmental harm such as ground/surface water contamination and climate change (i.e. manufacturing N fertilizers is energy intensive and N_2O is a powerful greenhouse gas).

Since the advent of no-till and the innovations in direct seeding equipment that followed, side- or mid-row band applications and single pass seeding/fertilization quickly became the standard and most commonly recommended BMP for N. Side- or mid-row banding is effective with all the major forms of N including anhydrous ammonia (82-0-0), urea (46-0-0) and urea ammonium-nitrate (28-0-0) and the combination of concentrating fertilizer away from the seed and beneath the soil surface dramatically reduced the potential for environmental losses while maintaining acceptable levels of seed safety. Fall applications have also been popular, at least on a regional basis, in that fertilizer prices are usually lower and applying N in a separate pass can reduce logistic pressure during seeding. While fall applied anhydrous ammonia is always banded beneath the soil surface, granular products are more commonly surface broadcast as this is a much faster and less expensive option than in-soil applications. With narrow seeding windows, large farm sizes, and higher fertilizer rates to consider, many growers are reverting to or considering two-pass seeding/fertilization strategies. Despite certain inefficiencies, two-pass seeding/fertilization systems are seen as a means of spreading out the workload and managing logistic challenges associated with handling large product volumes during seeding. While the timing and/or placement associated with two-pass systems are often less than ideal, enhanced efficiency formulations (EEF) such as polymer coatings (i.e. ESN), volatilization inhibitors (i.e. Agrotain®), nitrification inhibitors (i.e. eNtrench®) and volatilization/nitrification inhibitors (i.e. SuperU®) can reduce the potential risks associated with applying N well ahead of peak crop uptake (i.e. fall applications) or sub-optimal placement methods (i.e. surface-broadcast). Enhanced efficiency N products are more expensive than traditional formulations; however, this higher cost may be justified by improvements in efficacy (i.e. higher yields and protein), especially when considered along with the logistic advantages. Even with optimal management there can be merits to EEF products as banded N can still be prone to denitrification under wet conditions and, when placed shallow into dry soils, volatilization losses can still occur with unprotected ammoniacal N sources.

This project is relevant to producers because, for many, there has been a movement back to two-pass seeding fertilization systems as a means of increasing efficiency at seeding. While the goal is not to specifically encourage growers to move away from single-pass seeding/fertilization systems (i.e. side- or mid-row banding), it is important that they have a certain amount of flexibility in terms of how they manage N on their farms. By demonstrating different nutrient management strategies according to the 4R principles and providing efficacy data relative to benchmark practices, farmers can make better informed decisions regarding this important issue. Spring wheat is an ideal test crop since it is rotationally and economically important throughout Saskatchewan and sensitive to N management with regard to both grain yield and protein; however, the principles being demonstrated can be applied to all non-N fixing, spring seeded crops..

Methodology and Results

9. Methodology:

A field trial with spring wheat was initiated in the fall of 2018 near Indian Head, Saskatchewan (50.556 N, 103.606 W) to evaluate response to various N fertilizer application rates and management options. Indian Head is situated in the thin-Black soil zone of southeast Saskatchewan. The treatments were a combination of N rates, sources, and timing/application methods. The treatments were arranged as two separate RCBD trials with shared treatments and common objectives. Each treatment was replicated four times. To assess the response to N fertility levels, seven fertilizer rates ranging from nil (no N fertilizer applied) to 219 kg N/ha (soil residual plus fertilizer) were evaluated. Additionally, four N sources (urea, ESN®, Agrotain®, and SuperU®) were utilized in either a fall broadcast, spring broadcast, or side-band application to evaluate several contrasting N management strategies. To evaluate the management strategies, the relatively conservative N rate of 125 kg N/ha (soil residual plus fertilizer) was utilized in order to increase the likelihood that differences in N use-efficiency would result in measureable yield and protein differences. The various treatments are provided in Table 1 and an illustration of how the treatments were arranged within the field trial follows in Fig. 2.

Table 1. Treatments evaluated in 4R Nitrogen Management Demonstration at Indian Head (2018-19).

Trial #1: Right Rate*	Trial #2: Right Time, Right Place, Right Form***
1) 0x (39 kg total N/ha) **	1) Fall Broadcast – untreated urea
2) 0.5x (68 kg total N/ha)	2) Fall Broadcast – ESN®
3) 0.75x (94 kg total N/ha)	3) Fall Broadcast – Agrotain® treated urea
4) 1.0x (125 kg total N/ha)	4) Fall Broadcast – SuperU®
5) 1.25x (156 kg total N/ha)	5) Side-band – untreated urea
6) 1.50x (188 kg total N/ha)	6) Side-band – ESN®
7) 1.75x (219 kg total N/ha)	7) Side-band – Agrotain® treated urea
	8) Side-band – SuperU®
*side-banded urea in all trts, specified rates include residual N and N from 11-52-0	9) Spring Broadcast – untreated urea
	10) Spring Broadcast – ESN®
**Background levels of 39 kg N/ha from residual NO_3-N and seed-placed 11-52-0	11) Spring Broadcast – Agrotain® treated urea
	12) Spring Broadcast – SuperU®
	***1.0x rate (soil + fertilizer = 125 kg N/ha) in all trts

401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418

301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318

201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218

101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118

Trial #1 Treatments (side-banded untreated urea rates)	Trial #1 & 2 Shared Treatment (1x rate side-banded untreated urea)	Trial # 2 Treatments (N timing/placement/form options)

Figure 1. Generalized plot layout for 4R Nitrogen Management Demonstration at Indian Head (2018-19).

Selected agronomic information is provided in Table 2. Side-banding was completed as part of the seeding operation on May 6 (2019) while fall and spring broadcast was completed on October 9 (2018) and May 4 (2019), respectively. The wheat was direct-seeded approximately 2 cm (0.75”) deep into canola stubble with seeding rates adjusted for seed size and germination to target 325 viable seeds/m^2. Monoammonium phosphate was seed-placed to provide 35 kg P_2O_5/ha for all treatments. Weeds were controlled using registered pre-emergent and in-crop herbicide applications. Foliar fungicide was applied during heading to reduce the potential for disease to become a yield and quality limiting factor. Insecticides were not considered necessary or applied. Pre-harvest glyphosate was applied at maturity (August 15) and five centre rows from each plot were straight-combined on August 30.

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 at the late flag-leaf stage using a handheld GreenSeeker®. Leaf chlorophyll, or SPAD measurements, were completed for the flag leaf on two occasions, July 3 (late flag-leaf stage) and July 10 (anthesis). Because the treatment effects were similar for both measurement dates, the SPAD values were averaged for each plot. Grain yields were determined from the harvested grain samples and are corrected for dockage and to a uniform moisture content of 14.5%. Protein was 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 4R N management demonstration at Indian Head (2018-19).

Factor / Field Operation	Details / Description
Previous Crop	Canola
Pre-emergent herbicide	894 g glyphosate/ha May-12-2019
Seeding Date	May-6-2019
Seed Rate	325seeds/m^2 (133 kg/ha)
kg P_2O_5-K_2O-S ha^{-1}	35-0-0
N Broadcast Applications	Oct-9-2018 (fall) and May-4-2019 (spring)
NDVI	Jul-3-2019
SPAD	Jul-3-2019 and Jul-10-2019
In-crop Herbicide	400 g 2,4-D ester/ha + 100 g flurox + 15 g pyroxsulam/ha Jun-14-2019
Foliar Fungicide	100 g prothioconazole/ha + 100 g tebuconazole/ha Jul-9-2019
Pre-harvest herbicide	894 g glyphosate/ha Aug-15-2019
Harvest date	Aug-30-2019

All response data were analysed using the Mixed procedure of SAS and two separate models. The first focussed on the response to varying rates of side-banded urea with N rate (NR) effects considered fixed and replicate effects considered random. Treatments means were separated using Fisher's protected LSD test and orthogonal contrasts were used to test whether the observed responses to N rate were linear or quadratic. The purpose of the second model was to evaluate the contrasting N management strategies using a factorial analyses where the effects of N timing/placement (TP), N source (S), and the TP x S interaction were considered fixed while replicated effects were treated as random. Again, treatment effects and differences between means were considered significant at $P \leq 0.05$.

10. Results:

Growing season weather and residual soil nutrients

There were no major precipitation events between the fall broadcast treatments and winter freeze-up but a cumulative total of 5 mm of rain fell within a week of application and temperatures were cool, likely slowing down the chemical reactions that could lead to higher N losses. The first major precipitation events following the May 4 spring applications did not occur until mid-June (17 mm on June 14-15) but a few smaller showers within the first two weeks of application helped to dissolve the fertilizer and start moving N into the rooting zone where it could become increasingly available to the crop and protected from losses (i.e. 6 mm and 4 mm on May 10 and 15, respectively). Overall moisture reserves going into the 2019 growing 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. 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 environmental conditions encountered were conducive to approximately average wheat yields and moderate risks of N losses for both the fall and spring broadcast applications.

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 the fall fertilizer applications (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 5.3% and residual N was reasonably low with 32 kg NO_3-N/ha measured in the 0-60 cm soil profile. Residual P was 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 7.5 (0-15 cm) and 8.0 (15-60 cm) were also considered typical for soils in the region.

Table 4. Selected soil test results for 4R N management demo at Indian Head, Saskatchewan (2018-19).

Attribute / Nutrient	0-15 cm	15-60 cm	0-60 cm
pH	7.5	8.0	–
S.O.M. (%)	5.3	–	–
NO_3-N (kg/ha)^Z	12	20	32
Olsen-P (ppm)	5	–	–
K (ppm)	557	–	–
S (kg/ha)	27	34	61

Trial #1: Right Rate of Nitrogen

Results for N rate effects on the response variables evaluated are presented in Figs. 2-5 below and also in Table 7 of the Appendices. Normalized difference vegetation index (NDVI) is an indirect measure of crop biomass or canopy density. As expected, NDVI increased with N rate (NR) with the greatest increases associated with the first 68 kg N/ha and smaller increases continuing to approximately 125 kg N/ha at which point NDVI no longer significantly increased with further additions of N. This observation was supported by the overall F-test and quadratic orthogonal contrast which were both highly significant ($P < 0.001$; Fig. 2; Table 7).

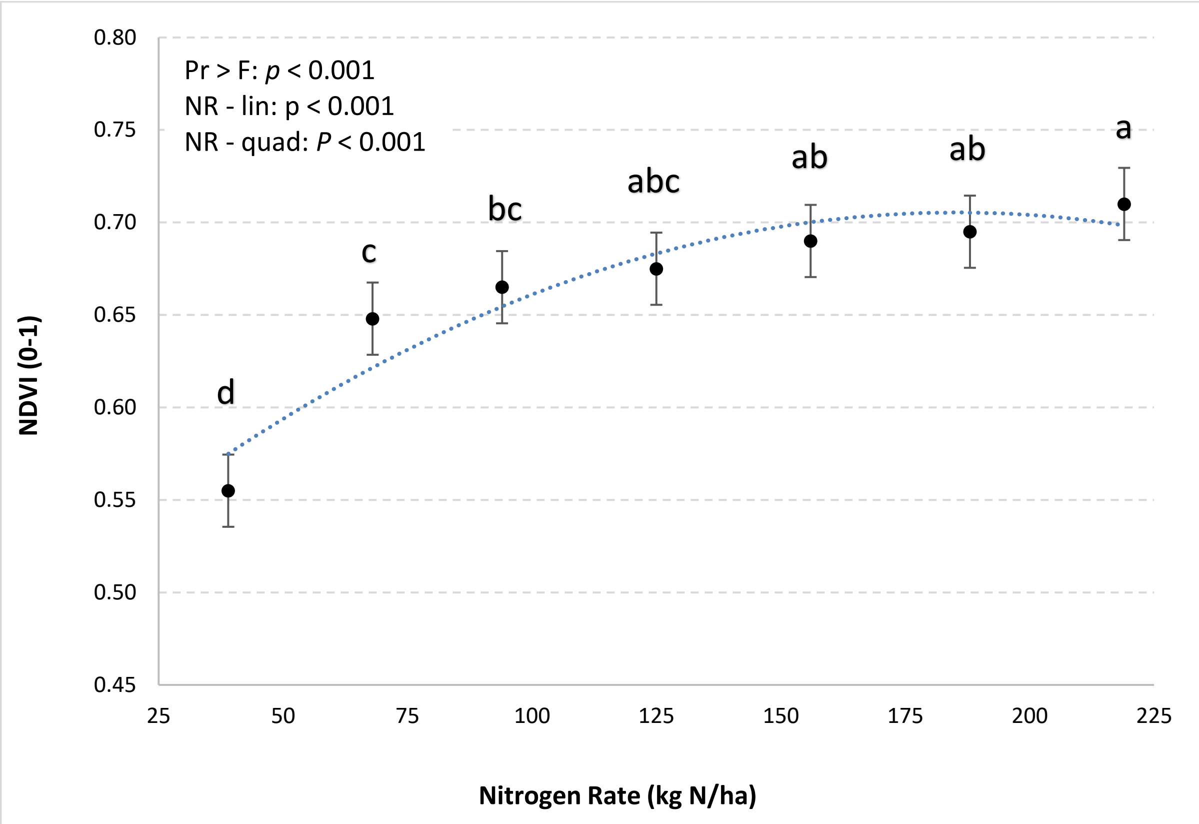

Figure 2. Nitrogen fertilizer rate effects on wheat NDVI (flag leaf stage) at Indian Head (2019). N rates are residual soil NO_3-N plus fertilizer and the primary N source was side-banded urea. Error bars are S.E.M.

Chlorophyll meter (SPAD) readings also increased with N fertilization (Fig. 3; Table 7) but were somewhat less sensitive than NDVI with no further significant increases in SPAD values as fertility levels were increased past 94 kg N/ha. Again, both the overall F-test and quadratic responses were highly significant ($P < 0.001$-0.022).

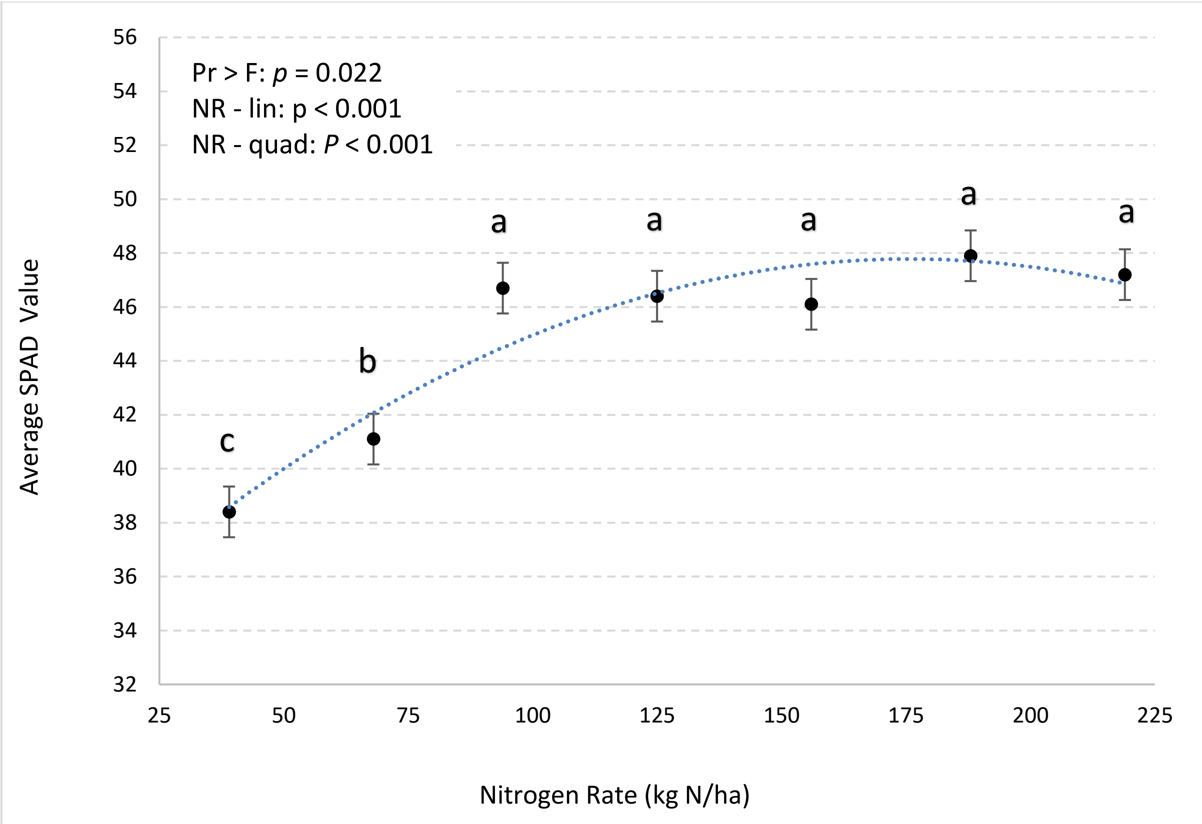

Figure 3. Nitrogen fertilizer rate effects on wheat flag leaf chlorophyll (SPAD) measurements (average of two dates) at Indian Head (2019). N rates are residual soil NO_3-N plus fertilizer and the primary N source was side-banded urea. Error bars are S.E.M.

A strong overall yield response to N fertilization was observed (Fig. 4; Table 7) with all fertilized treatments yielding significantly higher than the control and increases of nearly 50% observed at the highest N rates (Table 7). Spring wheat yields increased with increasing N right up to 156 kg N/ha (soil plus fertilizer) at which point further additions of N no longer significantly increased yield; thus yield was more sensitive to N fertility than either NDVI or SPAD values. Similar to the previously discussed variables, both the overall F-test and quadratic responses were highly significant ($P < 0.001$).

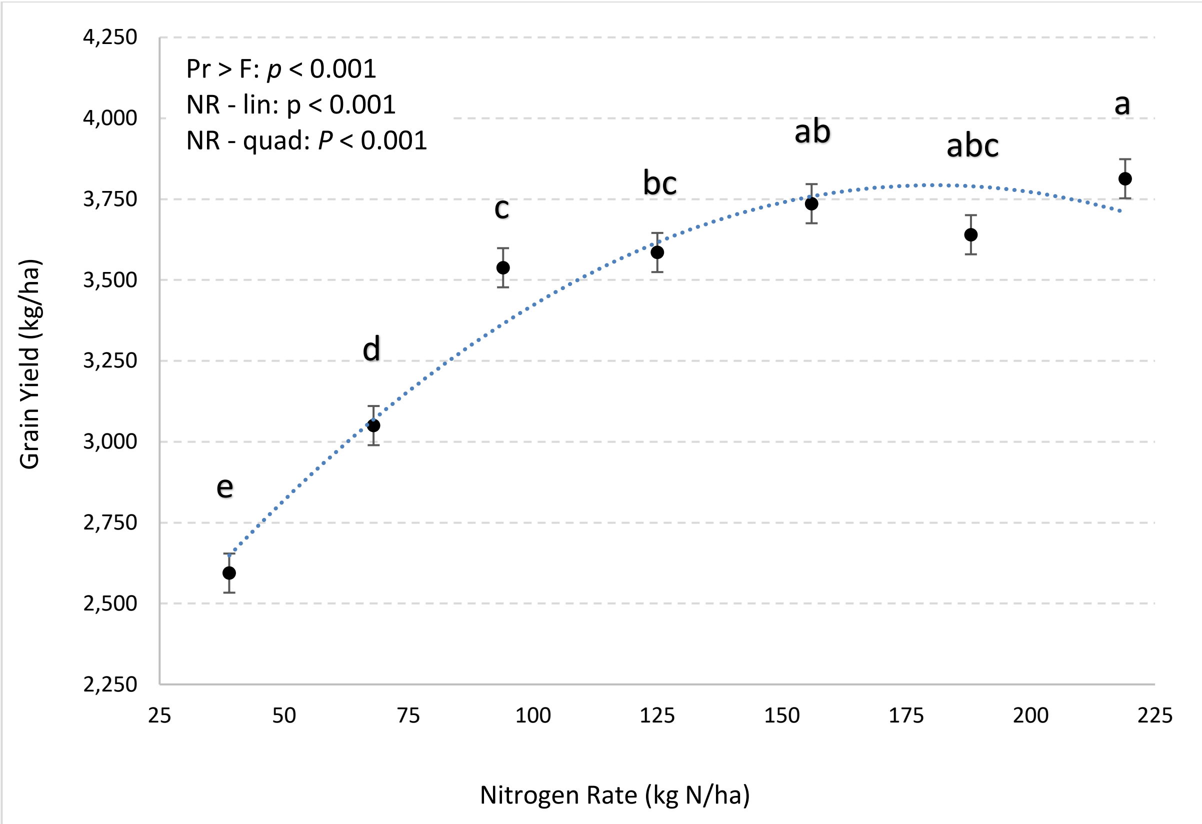

Figure 4. Nitrogen fertilizer rate effects on wheat grain yield at Indian Head (2019). Nitrogen rates are residual soil NO_3-N plus fertilizer and the primary N source was side-banded urea. Error bars are S.E.M.

Grain protein concentrations in wheat are normally even more sensitive to N fertility than yield and this was true in the current demonstration (Fig. 5; Table 7). Protein increased from a low of 11.5% in the control to a peak of 16.1% at the second highest N level of 188 kg N/ha. Again, the overall F-test was highly significant ($P < 0.001$) and, with no further increases in protein going from 188 kg N/ha to 219 kg N/ha, the quadratic response was as well ($P < 0.001$).

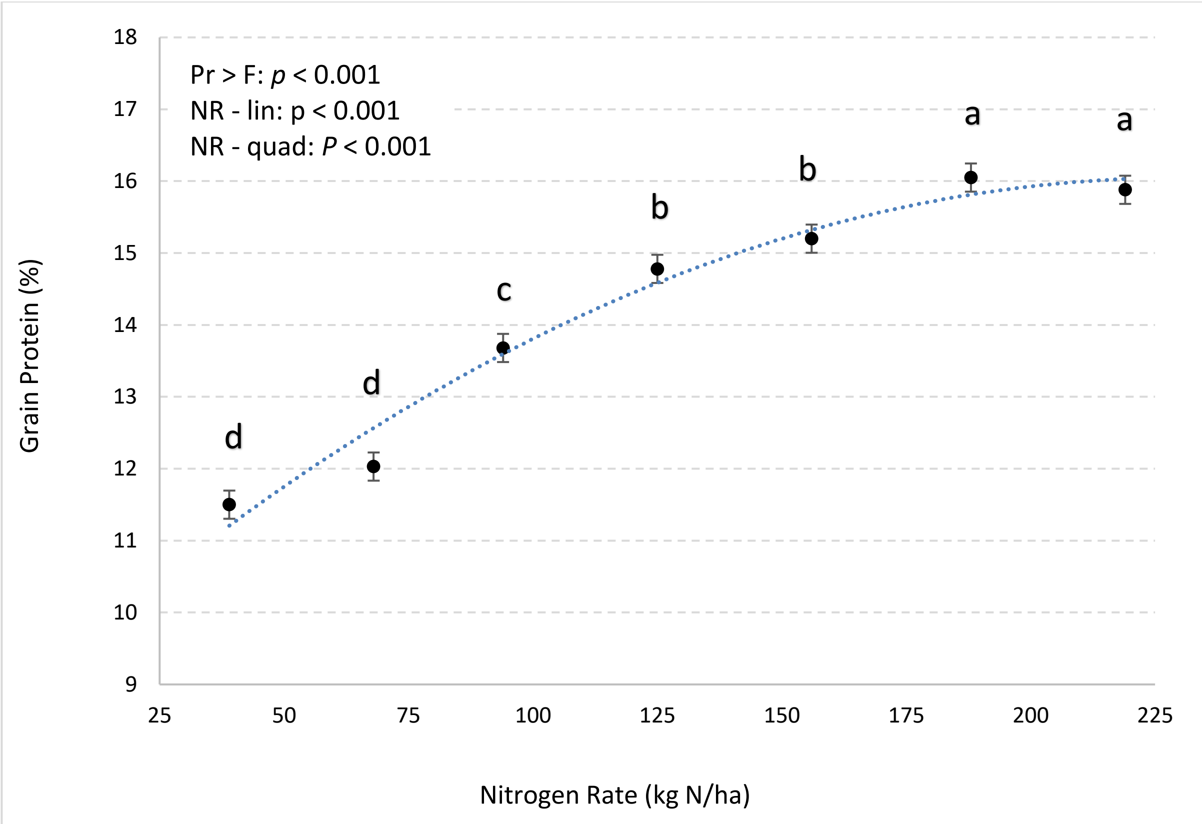

Figure 5. Nitrogen fertilizer rate effects on wheat percent grain protein at Indian Head (2019). N rates are residual soil NO_3-N plus fertilizer and the primary N source was side-banded urea. Error bars are S.E.M.

Trial #2: Right Source, Timing, and Placement of Nitrogen

Again, the second analyses explored the effects of different nutrient sources and timing/placement options for N fertilization of spring wheat on the response variables. Results from the overall tests of fixed effects and main effect means are provided below in Table 6 while the individual treatment means are reserved for Table 8 of the Appendices.

Normalized difference vegetation index (NDVI) was affected by both N source (S; $P = 0.012$) and timing/placement (TP; $P < 0.001$) along with the S x TP interaction ($P = 0.004$). The main effect means showed an overall advantage to side-banding (NDVI = 0.686) over both fall (NDVI = 0.661) and spring (NDVI = 0.630) applications. The interaction appeared to be due to certain inconsistencies in source effects depending on the application method whereby NDVI with ESN tended to be lower when broadcast while the values with fall broadcast SuperU® was as high any side-banded treatments (Table 8). The leaf chlorophyll (SPAD) measurements were affected by N timing/placement ($P < 0.001$) but not source ($P = 0.129$) and there was no TP x S interaction ($P = 0.179$; Table 6). Similar to NDVI, the average SPAD values were highest with side-banding (46.4); however, the values did not differ between spring and fall broadcast applications (43.1-44.1) for this variable. Again, the observed SPAD values did not significantly differ across N sources and the actual observed range was 43.9-45.3 when averaged across timing/placement strategies.

Table 5. Overall F-test results from factorial analyses and main effect means for N source and N timing/placement effects on 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, $P \leq 0.05$).

Source / Main Effect	**NDVI**	**SPAD**	**Grain Yield**	**Grain Protein**
	--------------------------------- (p-value)			---------------------------------
N Source (S)	0.012	0.129	0.392	0.232
N Timing/Placement (TP)	<0.001	<0.001	0.003	<0.001
S x TP	0.004	0.179	0.719	0.750
N Source	----- (0-1) -----	-----------------	---- (kg/ha) ----	------ (%)------
1) Untreated Urea	0.667 a	44.7 a	3463 a	14.05 a
2) ESN®	0.648 b	43.9 a	3409 a	14.33 a
3) Agrotain®	0.658 ab	45.3 a	3510 a	14.35 a
4) SuperUrea®	0.663 a	44.8 a	3529 a	14.11 a
S.E.M.	0.0072	0.45	59.4	0.219
N Timing/Placement (TP)				
1) Side-band	0.686 a	46.4 a	3619 a	14.99 a
2) Fall Broadcast	0.661 b	43.4 b	3397 b	13.25 c
3) Spring Broadcast	0.630 c	44.1 b	3417 b	14.39 b
S.E.M.	0.0069	0.41	53.2	0.210

Spring wheat grain yield was affected by N timing/placement ($P < 0.001$) but not source ($P = 0.392$) and there was no TP x S interaction detected ($P = 0.719$) for this variable (Table 6). The TP effect was such that yields were highest with side-banding (3619 kg/ha) but did not significantly differ between the fall (3397 kg/ha) and spring (3417 kg/ha) surface broadcast applications. Averaged across TP options, yields for the various N sources were consistent ranging from 3409-3529 kg/ha and the lack of an interaction suggests that this was true regardless of how the N was managed.

Grain protein concentrations were also affected by N timing/placement ($P < 0.001$) but not source ($P = 0.230$) and there was no TP x S interaction detected ($P = 0.750$; Table 6). Again, the TP effect was such that grain protein was highest with side-band (15.0%) but there was further separation between the fall (13.3%) and spring (14.4%) broadcast applications. Observed protein concentrations for the various sources ranged from 14.1-14.4% and, again, the lack of an interaction suggests that protein concentrations were similar across N sources regardless of timing/placement option.

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 practices. The plots were also visited during a tour on July 12 for approximately 60 Federated Co-operatives Limited. (FCL) agronomists from throughout the province. Chris Holzapfel presented highlights from the project at a CropSphere (Saskatoon, Jan. 15) session entitled 'Agronomy of High Yielding Wheat', 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 275-300 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 the overall spring wheat response to a wide range of application rates and a selection of fundamentally different N management strategies where the fertilizer sources, timing of application, and placement method were varied. The N fertility rates included soil residual NO_3-N (0-60 cm depth) and yields were optimized at approximately 156 kg N/ha while protein continued to increase until the N rate reached 188 kg N/ha. The estimated residual NO_3-N was 32 kg/ha; thus, the actual fertilizer N amounts where yield and protein were optimized were 124 kg N/ha and 156 kg N/ha. While both the NDVI and SPAD values increased with N fertilization, neither measurement predicted the extent of the response as both peaked at lower N rates than either yield or protein. There was a distinct advantage to side-banding N fertilizer as opposed to the broadcast applications for all response variables. Differences between fall and spring broadcast applications were somewhat inconsistent whereby the fall applications resulted in higher NDVI but no difference in SPAD or yield and lower protein concentrations relative to the spring broadcast applications. Focussing on the broadcast treatments, it is possible that the fall applications resulted in better early season N availability (and subsequent vegetative growth) but the spring applications resulted in increased N availability later in the season and a small protein advantage. The N source effects were never statistically significant and there were no interactions for either yield or protein to suggest that the EEF products were more advantageous with the fall and/or surface broadcast applications. It is important to acknowledge that the results of field trials such as this can vary widely depending on the specific conditions encountered. While side- or mid-row banding N at seeding generally provides consistently good results across a broad range of conditions, the reasons for utilizing two-pass systems are frequently not agronomic and EEF sources are recognized as a way to mitigate risks associated with sub-optimal timing/placement options.

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, overall F-test and orthogonal contrast results for nitrogen fertility rate effects on spring wheat NDVI, SPAD values (leaf chlorophyll), grain yield, and protein content. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

Nitrogen Rate (residual NO_3-N + fertilizer)	NDVI	SPAD	Grain Yield (kg/ha)	Grain Protein (%)
0.00x – 39 kg total N/ha	0.555 d	38.4 c	2594 e	11.50 d
0.50x – 68 kg total N/ha	0.648 c	41.1 b	3050 d	12.03 d
0.75x – 94 kg total N/ha	0.665 bc	46.7 a	3538 c	13.68 c
1.00x – 125 kg N/ha	0.675 abc	46.4 a	3585 bc	14.78 b
1.25x – 156 kg N/ha	0.690 ab	46.1 a	3736 ab	15.20 b
1.50x – 188 kg N/ha	0.695 ab	47.9 a	3640 abc	16.05 a
1.75x – 219 kg N/ha	0.710 a	47.2 a	3813 a	15.88 a
S.E.M.	0.013	0.94	60.5	0.196
	---------------------------------- p-value ----------------------------------			
Overall F-test	<0.001	0.022	<0.001	<0.001
NR – linear	<0.001	<0.001	<0.001	<0.001
NR - quadratic	<0.001	<0.001	<0.001	<0.001

Table 7. Individual treatment means for N source by timing/placement options in 4R N demonstration with spring wheat at Indian Head in 2019. The interaction between these two factors was only significant for NDVI; however, means are presented for all variables for information purposes.

Source / Main Effect	NDVI	SPAD	Grain Yield	Grain Protein
N Timing/Placement/Source	---- (0-1) ----	----------------	--- (kg/ha) ---	----- (%)-----
1) Side-band – Urea	0.690 a	46.4	3585	14.78
2) Side-band – ESN®	0.683 ab	45.8	3611	15.08
3) Side-band – Agrotain®	0.695 a	46.5	3681	15.08
4) Side-band – SuperU®	0.675 ab	47.1	3596	15.03
5) Fall broadcast – Urea	0.668 bc	43.6	3334	12.98
6) Fall broadcast – ESN®	0.643 d	43.0	3309	13.43
7) Fall broadcast – Agrotain®	0.648 cd	44.9	3475	13.60
8) Fall broadcast – SuperU®	0.688 ab	42.1	3471	13.00
9) Spring broadcast – Urea	0.643 d	44.1	3470	14.40
10) Spring broadcast – ESN®	0.618 e	43.0	3307	14.50
11) Spring broadcast – Agrotain®	0.633 de	44.5	3373	14.38
12) Spring broadcast – SuperU®	0.628 de	45.1	3521	14.30
S.E.M.	0.0092	0.71	95.4	0.282

Figure 6. Dan Heaney from Fertilizer Canada discussing 4R N management principles at the Indian Head Crop Management Field Day (July 16, 2019).

Figure 7. Spring wheat plots approaching maturity in the ADOPT-Fertilizer Canada 4R N Management Demonstration at Indian Head (August 9, 2019).

Abstract

13. Abstract/Summary:

A field trial was established near Indian Head to demonstrate spring wheat response to a range of N fertilizer rates and contrasting management strategies. Nitrogen rates were adjusted for residual nitrate and ranged from 39-219 kg N/ha (soil plus fertilizer). Seven N fertility levels were evaluated and, for this aspect of the trial, all N was side-banded urea. Yields were optimized at approximately 156 kg N/ha and peaked at 3813 kg/ha, 46% higher than the control which yielded 2594 kg N/ha. Grain protein increased with N rates up to 188 kg N/ha, peaking at 16.1% compared to 11.5% in the control. Although both NDVI and leaf chlorophyll (SPAD) values increased with N fertilization, they did not predict the magnitude of response as the values peaked at substantially lower N rates than either yield or protein. Focussing on N management strategies, four N sources (untreated urea, ESN®, Agrotain®, and SuperU®) were either side-banded or broadcast (without incorporation) in the fall or early-spring. For all response variables (NDVI, SPAD, yield, and protein), there was a significant overall advantage to side-banding over the broadcast applications. Differences between fall versus spring broadcast applications were somewhat inconsistent with NDVI suggesting an early-season advantage to the fall applications but the protein ultimately responses showed a greater advantage to the spring application timing. The only variable affected by N source was NDVI where an interaction suggested slightly lower values with ESN when left on the surface and a subtle advantage to fall broadcast SuperU® over the other formulations when applied in the same manner. Neither yield nor protein were affected by N source and there were no interactions with the timing/placement options suggesting that the relative performance of the difference sources was consistent regardless of how the N was managed. The results of field trials such as this this can vary widely depending on the environmental conditions encountered. While side- or mid-row banding N generally provides consistent results across a broad range of conditions, EEF formulations are still recognized as a way to mitigate the risks associated with less optimal timing/placement options.