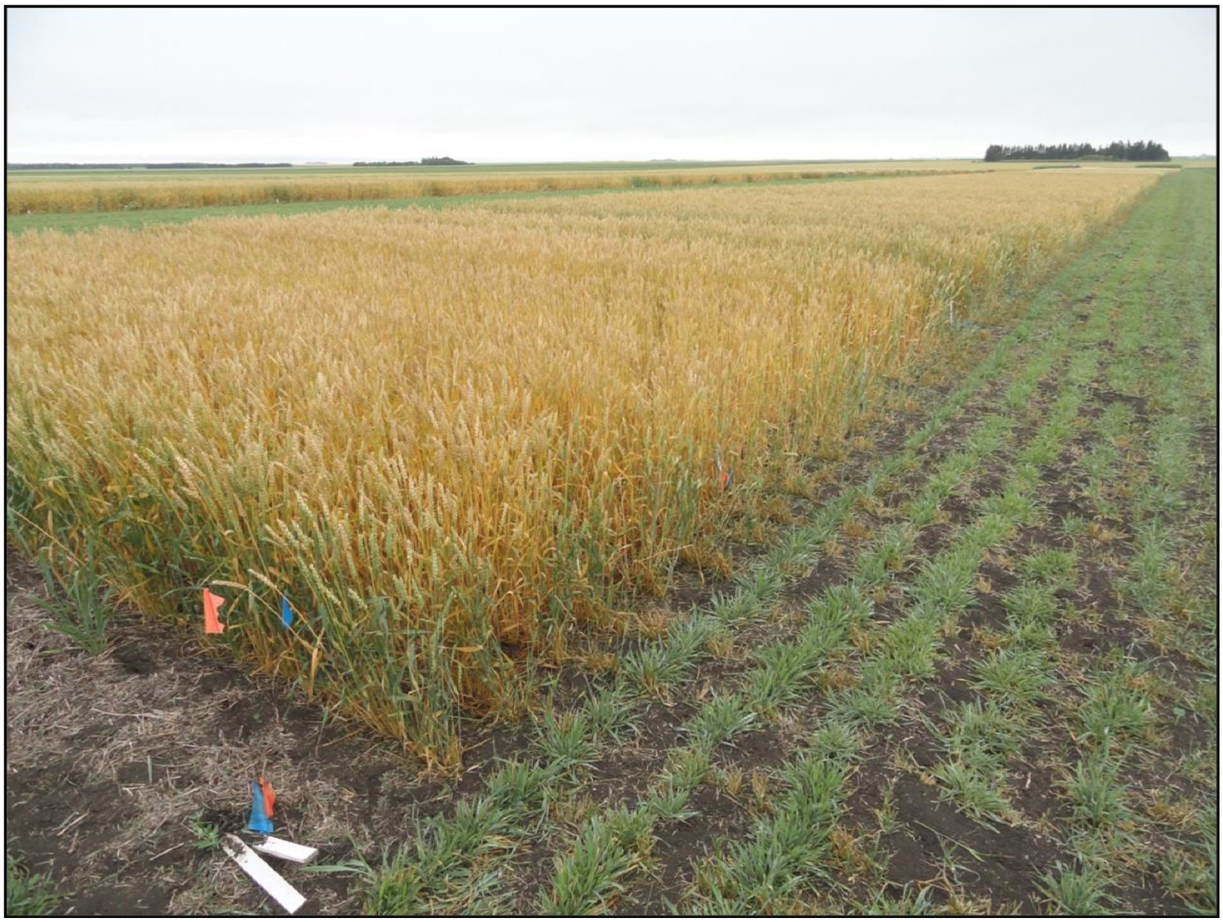
2017 Annual Report
for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Demonstrating 4R Nitrogen Principles in Wheat

(Project #20160394)



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Project Identification

1. **Project Title:** Demonstrating 4R Nitrogen Principles in Wheat
2. **Project Number:** 20160394
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):** April-2017 to February-2018
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 emphasize using the: 1) right source, 2) right rate, 3) right time and 4) right place. These factors are not necessarily independent of each other. For example, depending on the N source, application timings or placement options that would normally be considered high risk can be viable. The objective of this project was to demonstrate CWRS wheat response to varying rates of nitrogen (N) fertilizer along with different combinations of formulations, timing and placement methods relative to side-banded, untreated urea as a control. The treatments in this demonstration encompassed all four considerations (source, rate, time and place) for 4R nutrient management.

8. **Project Rationale:**

Nitrogen is the most commonly limiting nutrient in annual crop production and often accounts for one of the most expensive crop nutrients, particularly for crops with high N requirements like wheat and canola. Most inorganic N fertilizers contain NH_4-N but some (i.e. UAN) also contain NO_3-N. Since the advent of no-till and innovations in direct seeding equipment, side-band 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 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 (safely away from the seed row) and placing it beneath the soil surface dramatically reduces the potential for environmental losses while maintaining seed safety. Fall applications have always been popular for many producers (with regional exceptions), largely because fertilizer prices tend to be lower and applying N in a separate pass can reduce logistic pressure during seeding when labour and time are limited. It is primarily for such logistic reasons that there is increased uptake of two pass seeding / fertilization strategies amongst growers. While the timing and/or placement associated with two-pass systems are usually not ideal, enhanced efficiency formulations (EEF) such as polymer coats (ESN), volatilization inhibitors (i.e. Agrotain) and volatilization / nitrification inhibitors (Super Urea) can reduce some of the 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 their traditional counterparts; however, this higher cost may be offset by potential improvements in efficacy and logistic advantages of alternative fertilization practices.

This project is relevant to producers because, for many, there has been movement back to two pass seeding / fertilization system due to logistics while others have struggled with excess moisture and simply want to improve the efficiency of their N fertilizer through either in-soil applications of EFF products or split-applications. Agronomists throughout western Canada frequently receive questions regarding the potential merits of EEF products for pre-seed, side or mid-row band, and post-seeding / post-emergent applications and the overall risks associated with surface-applications under less favourable environmental conditions. While most do not specifically want to encourage growers to revert to two pass seeding / fertilization systems, it is important for producers to have flexibility with respect to how they manage N on their farms. By demonstrating different N fertilization strategies according to the 4R principles and providing regional data on their relative efficacy, this project was intended to help producers make better informed N management decisions with consideration to the potential advantages and disadvantages of the various options. Wheat is a good candidate for this project as it is a widely adapted, economically important crop and highly responsive to N applications for both yield and protein.

Methodology and Results

9. Methodology:

A field trial was initiated in the spring of 2017 near Indian Head, Saskatchewan (50.553 N, 103.608 W) to evaluate the response of CWRS wheat to various N strategies relative to the conventional practice of banding all N during the seeding operation. Indian Head is situated in the thin-Black soil zone of southeast Saskatchewan and the soil is classified as an Indian Head clay with typical organic matter concentrations of 4.5-5.5%. The treatments were a combination of varying rates of side-banded urea relative to alternative sources of N and placement/timing options. The application rates were based on a 1x target set at 130 kg/ha of total mineral N (residual NO_3-N plus fertilizer). The forms evaluated were untreated granular urea, liquid urea ammonium-nitrate, granular Agrotain® (volatilization inhibitor) and granular SuperUrea® (volatilization and nitrification inhibitors). In addition to side-banding, the placement/timing options evaluated were pre-seed, surface dribble-band / broadcast applications and split-application where 50% of the fertilizer N was side-banded urea and the remainder was applied at early stem elongation as a post-emergent surface dribble-band or broadcast application. The twelve N fertilizer treatments were arranged in Randomized Complete Block Design (RBCD) with four replicates and are described in Table 1.

Table 1. Nitrogen management treatments in 4R Nitrogen demonstration with wheat (Indian Head, 2017).			
#	Formulation	Timing / Placement	Fertilizer Rate [Z]
1	N/A	N/A	N/A
2	Urea	Side-band (during seeding)	0.5x (50 kg N/ha)
3	Urea	Side-band (during seeding)	1.0x (100 kg N/ha)
4	Urea	Side-band (during seeding)	1.5x (150 kg N/ha)
5	Urea	Pre-seed surface broadcast	1.0x (100 kg N/ha)
6	Urea Ammonium-Nitrate (UAN)	Pre-seed surface dribble-band	1.0x (100 kg N/ha)
7	Agrotain® (AT)	Pre-seed surface broadcast	1.0x (100 kg N/ha)
8	SuperUrea® (SU)	Pre-seed surface broadcast	1.0x (100 kg N/ha)
9	Urea / Urea	50:50 Split Application [Y]	1.0x (100 kg N/ha)
10	Urea / UAN	50:50 Split Application	1.0x (100 kg N/ha)
11	Urea / Agrotain®	50:50 Split Application	1.0x (100 kg N/ha)
12	Urea / SuperUrea®	50:50 Split Application	1.0x (100 kg N/ha)

[Z] 30 kg/ha residual NO_3-N as determined by fall composite soil sample for the site. Target total (soil plus fertilizer) N rates were: 0x = 30 kg N/ha, 0.5x = 80 kg N/ha, 1.0x = 130 kg N/ha, 1.5x = 180 kg N/ha

[Y] 50 kg N/ha side as side-banded 11-52-0, 21-0-0-24 and 46-0-0 plus a post-emergent surface application of 50 kg N/ha (forms varied as per protocol) during stem elongation (5-6 leaf stage)

Selected agronomic information is provided in Table 2. While fertilizer rates were adjusted based on fall soil sampling results, the site was resampled intensively in the spring (0-15 cm, 15-60 cm) and analysed for select quality parameters and residual nutrients. CDC Utmost CWRS wheat seed was direct-seeded into soybean stubble on May 5 at a target rate of 325 seeds/m^2. A blend of monoammonium phosphate (11-52), potash (0-0-60) and ammonium-sulphate (21-0-0-24) was side-banded in all treatments except the unfertilized control where it was assumed that N would be the most important yield limiting nutrient. Weeds were controlled using registered pre-emergent and in-crop herbicide applications while fungicides were applied at both the flag-leaf stage and anthesis to ensure that neither leaf disease nor fusarium head blight were limiting to yield or quality. Pre-harvest glyphosate was applied at physiological maturity and the centre five rows of each plot were straight-combined.

Various data were collected over the growing season and from the harvest samples. To assess N response during the season, the NDVI of each plot was measured at the late flag-leaf stage using a handheld Trimble GreenSeeker sensor. A chlorophyll meter (SPAD-502) was also used at this time and again prior to senescence at the late-milk stage (10 flag-leaves per plot at each crop stage). 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 from the cleaned sub-samples by a third-party (Irrigation Crop Diversification Corporation) using a calibrated NIR instrument. Daily temperatures and precipitation were recorded at the Environment Canada weather station located approximately 3 km from the field site.

Table 2. Selected agronomic information for the 4R Nitrogen demonstration with wheat at Indian Head (2017).

Factor / Field Operation	Indian Head 2017
Previous Crop	Soybean
Pre-emergent herbicide	894 g glyphosate/ha (May-9-2017)
Soil Nutrient Sampling	May-4-2017
Pre-seed N applications	May-4-2017 (as per protocol)
Variety / Seeding Rate	CDC Utmost VB 325 seeds/m^2
Seed Treatment	None
Seeding Date	May 5-2017
Row spacing	30 cm
kg P_2O_5-K_2O-S ha^{-1}	30-15-15
In-crop herbicide	2.5 g florasulam/ha + 100 g fluroxypyr/ha + 360 g MCPA ester/ha + 15 g pyroxsulam/ha (Jun-11-2017)
In-crop N applications	Jun-20-2017 (as per protocol)
NDVI measurements	Jul-2-2017 (late flag-leaf)
SPAD measurements	Jul-3-2017 (late flag-leaf) Jul-21-2017 (late milk)
Foliar fungicide	65 g pyraclostrobin/ha + 40 g metconazole/ha (Jun-28-2017) 101 g prothioconazole/ha + 101 g tebuconazole/ha (Jul-8-2017)
Pre-harvest herbicide	894 g glyphosate/ha (Aug-20-2017)
Harvest date	Aug-29-2017

Response data were analysed using the GLM procedure of SAS with the treatment effects considered fixed and replicate effects treated as random. Treatment means were separated using Fisher's protected LSD test and orthogonal contrasts were used to determine whether the observed responses to side-banded N rate were linear or quadratic (curvilinear). An additional contrast compared the pre-seed surface applications to the split applications across all forms. All treatment effects and differences between means were considered significant at $P \leq 0.05$.

10. Results:

Growing season weather

Weather data for 2017 growing season at Indian Head is presented with the long-term (1981-2010) averages in Table 3. Despite less than normal precipitation through the winter months (60% of average from November 2016 through April 2017), with the wet fall, initial soil moisture conditions in 2017 were considered excellent. However, less than half of the long-term average precipitation was received during the growing season (May through August 2017). Nonetheless, crop establishment was good and stored soil moisture along with timely and substantial rainfall in mid-June (10 mm on June 9 and 50 mm on June 14) prevented drought from becoming a major limiting factor leading to high overall yields. With regard to temperature, on May 18 (shortly after the crop had emerged), temperatures fell to -6 °C; however, only superficial crop damage was observed. Averaged across the four month period, temperatures were normal; however, May was warmer than the long-term average while August was cooler. Temperatures were approximately normal in June and July and conditions were such that disease pressure was negligible throughout the season.

Table 3. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) averages for the 2017 growing season at Indian Head, SK.

Year	May	June	July	August	Avg. / Total
	Mean Temperature (°C)				
IH-2017	11.6	15.5	18.4	16.7	15.6
IH-LT	10.8	15.8	18.2	17.4	15.6
	Precipitation (mm)				
IH-2017	10.4	65.6	15.4	25.2	117
IH-LT	51.8	77.4	63.8	51.2	244

Field Trial Results

Residual soil test nutrient levels are presented for the site in Table 4. Soil pH and percent organic matter were typical for the region at 7.8 and 5.1%, respectively. Residual NO_3-N in the spring was low at 23 kg/ha (0-60 cm), slightly less than the fall estimate of 30 kg N/ha which was used to determine N rates. Residual phosphorus was considered very low, while potassium and sulphur were sufficient; however, all nutrients other than N were intended to be non-limiting in the trial.

Table 4. Selected soil test results for 4R Nitrogen Trial with wheat at Indian Head, Saskatchewan (2017).

Attribute / Nutrient	**0-15 cm**	**15-60 cm**	**0-60 cm**
pH	7.8	–	–
S.O.M. (%)	5.1	–	–
C.E.C. (meq)	45.3	–	–
NO_3-N (kg/ha)[Z]	10	13	23
Olsen-P (ppm)	3	–	–
K (ppm)	545	–	–
S (kg/ha)	11	27	38

[Z] Nitrogen rates based on fall-composite sample showing 30 kg/ha residual NO_3-N

Individual treatment means and other statistics are presented in Table 5 of the Appendices while the results are also summarized graphically in Figures 1-10 below.

Normalized difference vegetation index (NDVI) is an indirect measure of above-ground biomass / plant health that takes in to account both overall vegetative cover and chlorophyll status (i.e. greenness) of the canopy being measured. Nitrogen rate effects on NDVI are presented in Fig. 1and showed a quadratic response where NDVI increased substantially when N was increased from the 0-0.5x rates (30-80 kg/ha total N) but more subtlety with further increase in N rate with no significant differences amongst the 0.5-1.5x (80-180 kg /ha total N) N rates. Focussing on N sources and timing/placement methods, which all received a 1x rate, a few subtle treatment differences were noted (Fig. 2). While no treatments had a significantly lower NDVI than the benchmark practice of side-banding urea, values were higher for 3/4 of the split-application strategies (urea-urea, urea-UAN and urea-AT). The split application of urea-SU did not differ from side-banded urea for NDVI, possibly suggesting that N availability was delayed slightly with the combination of dry weather and the top-dressed N being temporarily retained in the less mobile NH_4-N form following application. The higher values observed with split-applications of the other forms suggest some mid-season benefit (i.e. either increased growth or leaf chlorophyll content) to the in-crop applications of N at this time. While differences in emergence/crop stage cause NDVI to vary and many factors can continue to affect the crop between sensing and harvest, previous research has shown that in-season NDVI measurements are correlated with wheat yield potential and N status.

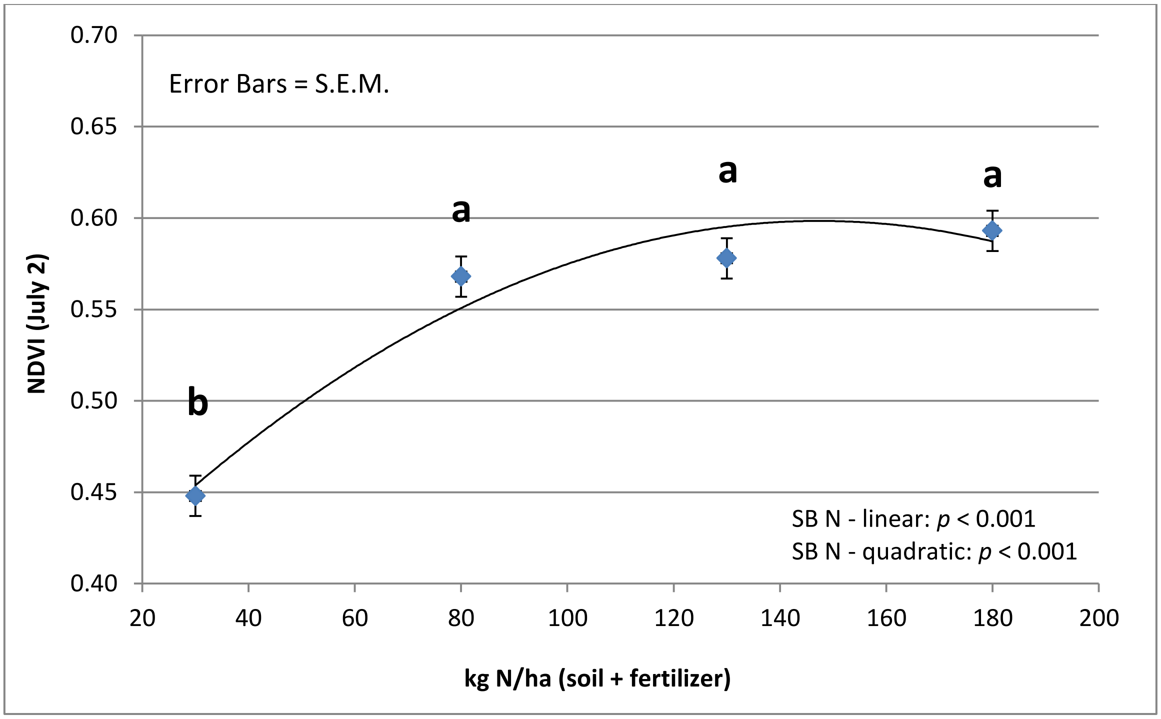

Figure 1. Side-banded urea rate effects on NDVI values in wheat (July 2, late flag) at Indian Head (2017).

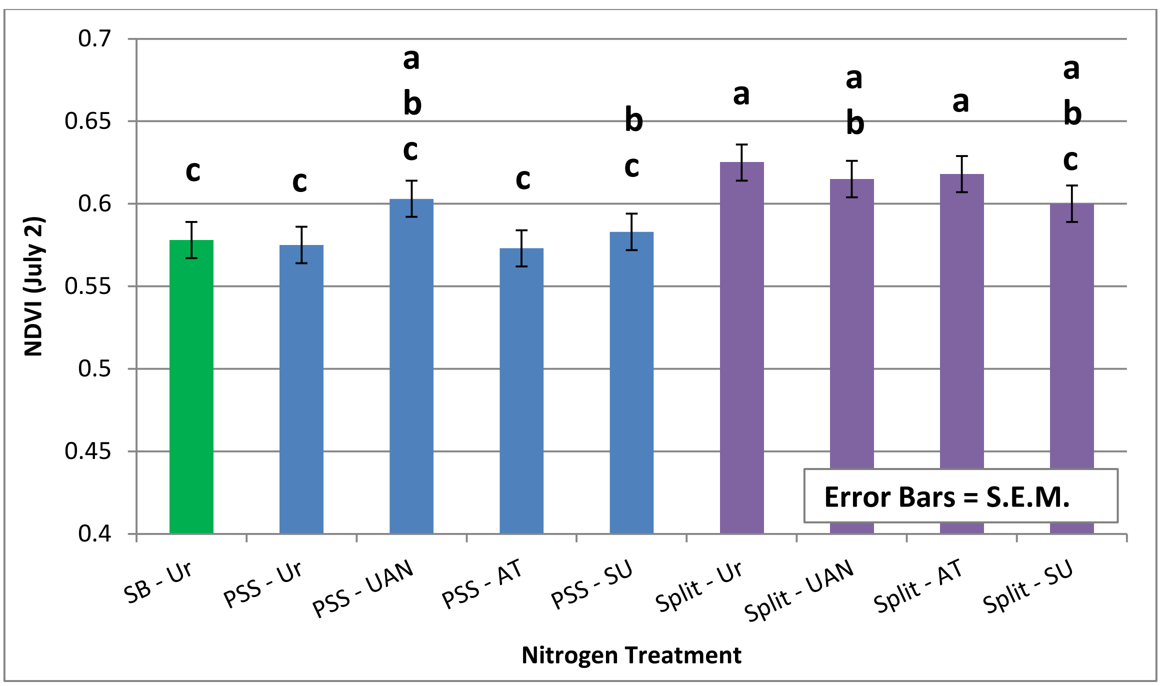

Figure 2. Nitrogen form/placement/timing effects on NDVI values in wheat (July 2, late flag) at Indian Head (2017). SB – side-band, PSS – pre-seed surface, Split – 50% side-banded urea 50% post-emergent surface, Ur - u–treated urea, UAN – urea ammonium-nitrate, AT – Agrotain, SU – SuperUrea.

Chlorophyll meter readings of individual flag leaves (10 per plot) were completed at two crop stages, once with the NDVI measurements (July 3, Figs. 3 and 5) and again at the late milk stage, prior to crop senescence (July 21, Figs. 4 and 6). Both the absolute SPAD meter values and overall trends in terms of treatment effects were similar at both timings. Compared to NDVI, there was greater separation between N rates with significant increases from 0-0.5x (30-80 kg/ha total N) and from 0.5-1.0x (80-130 kg/ha total N) but no differences between the 1.0-1.5x treatments (130-180 kg/ha total N; Figs. 3-4). Focussing on form/timing/placement options, the highest values always occurred with side-banded N (Figs. 5-6). There was less overall variability at the first date where the mean value with side-banded urea was 45.5, higher than all other treatments (where the same N rate was applied) which ranged from 42.2-43.0. At the later date, side-banded urea again produced the highest values but those of the split-applications with urea, Agrotain® and SuperUrea® had increased to where they were no longer significantly lower than those with side-banded urea. This was not observed with the split-application where UAN was top-dressed. The treatment effects on SPAD values were inconsistent with NDVI where values were amongst the lowest with side-banded urea; however, NDVI takes into account the entire canopy and is more sensitive to crop stage, plant density and variability in emergence while SPAD measurements are specific to the chlorophyll content of individual leaves.

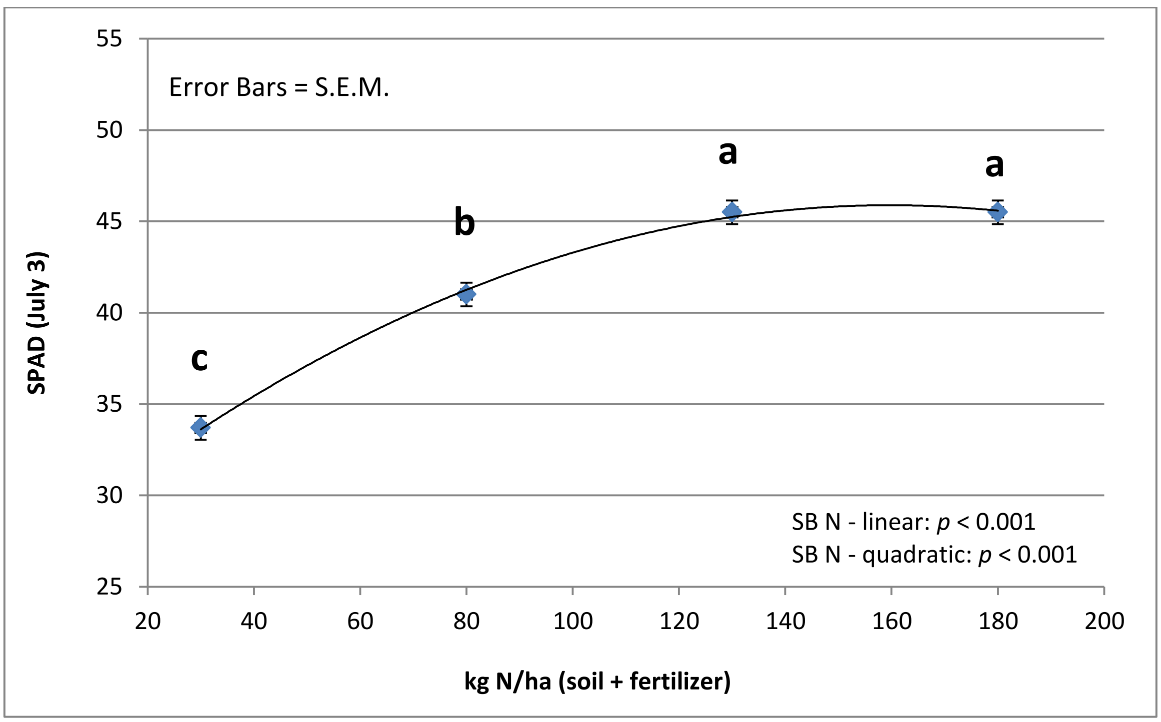

Figure 3. Side-banded urea rate effects on SPAD values in wheat (July 3, late flag) at Indian Head (2017).

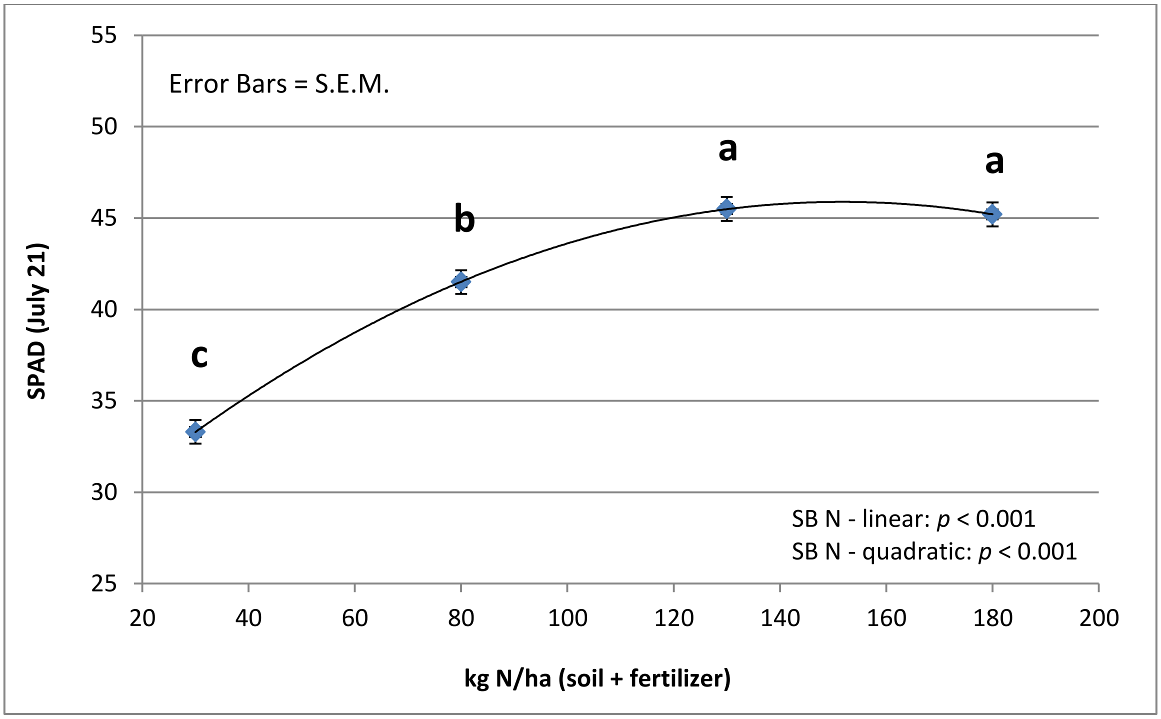

Figure 4. Side-banded urea rate effects on SPAD values in wheat (July 21, late milk) at Indian Head (2017).

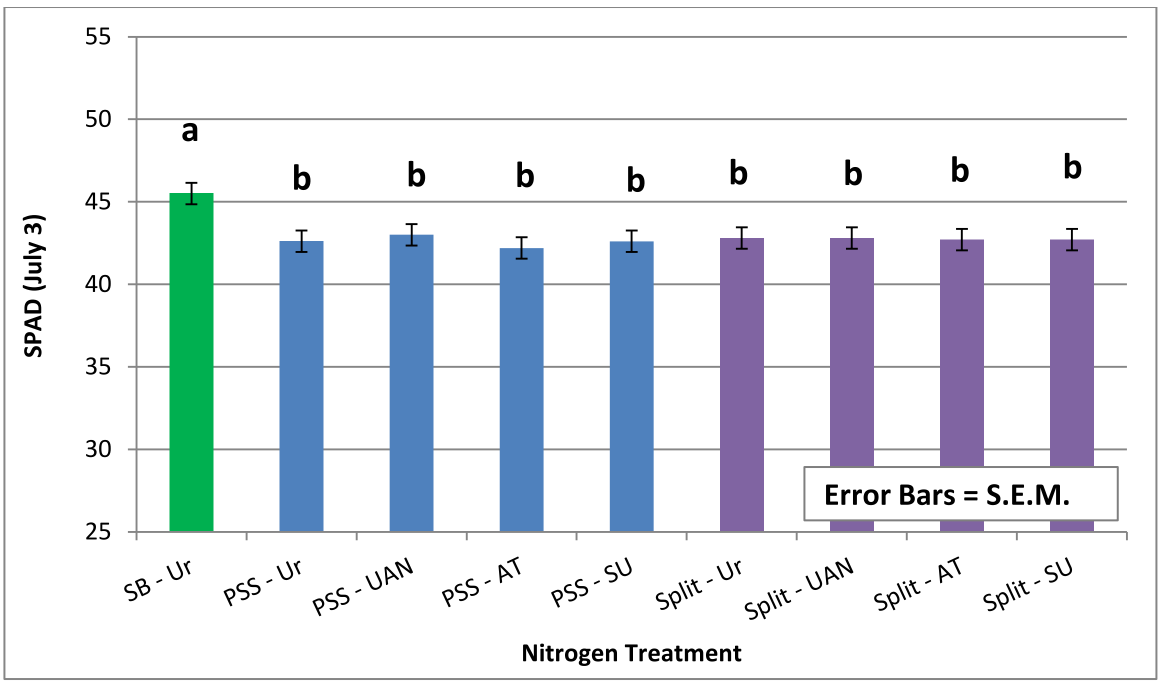

Figure 5. Nitrogen form/placement/timing effects on SPAD meter values in wheat (July 3, late flag) at Indian Head (2017). SB – side-band, PSS – pre-seed surface, Split – 50% side-banded urea 50% post-emergent surface, Ur - u–treated urea, UAN – urea ammonium-nitrate, AT – Agrotain, SU – SuperUrea.

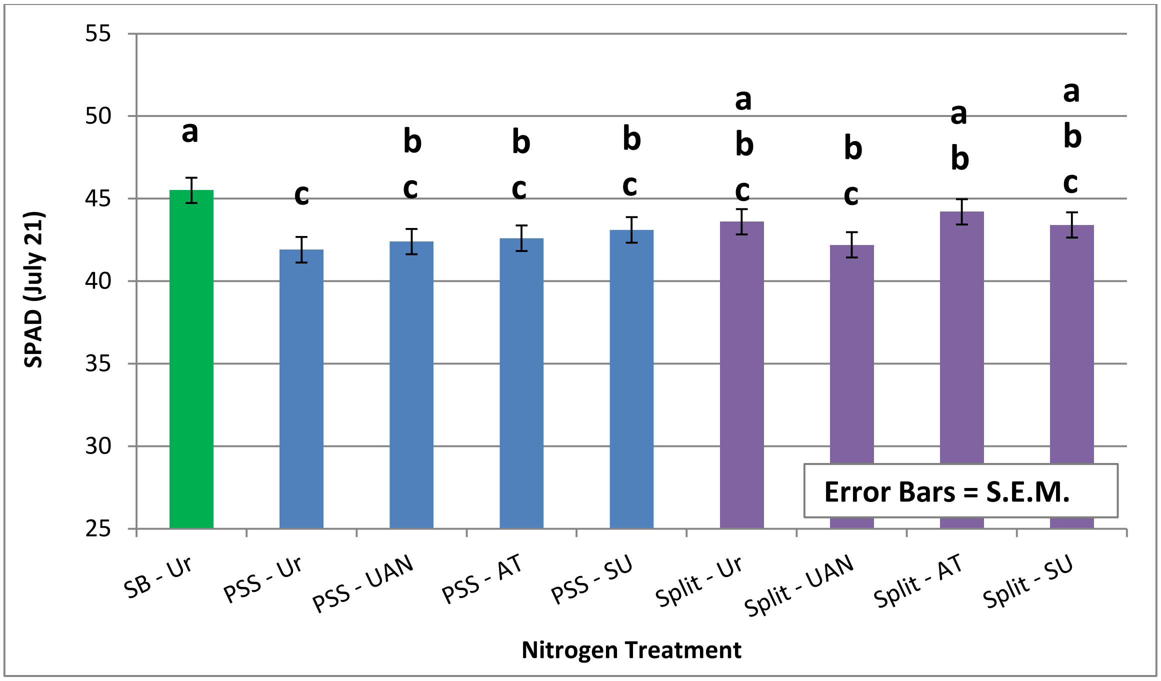

Figure 6. Nitrogen form/placement/timing effects on SPAD meter values in wheat (July 21, late milk) at Indian Head (2017). SB – side-band, PSS – pre-seed surface, Split – 50% side-banded urea 50% post-emergent surface, Ur - u–treated urea, UAN – urea ammonium-nitrate, AT – Agrotain, SU – SuperUrea.

Overall, the rate response to N was strong with yields continuing to increase beyond the 1x rate of 130 kg/ha soil plus fertilizer N (Fig. 7). This was desirable as the 1x rate was intended to be within the responsive range so that differences in N use-efficiency amongst the different management strategies could be detected in yield and protein. Yields were high overall considering the dry conditions, reaching 4595 kg/ha at the highest N rate and averaging 4251 kg/ha across all treatments where the 1x rate was applied. While there was some variation (4132-4349 kg/ha), no yield differences amongst the 1x treatments were significant (Fig. 8); however, yields with the pre-seed broadcast of urea and UAN tended to be lower and did not significantly differ from those achieved at the lower rate of side-banded urea. These two treatments were considered the riskiest of all those evaluated with nearly 80% of the N applied left on the surface with no protection against volatilization. Volatilization risk with UAN is lower than urea since only 75% of the N is ammoniacal; however, the NO_3-N can be more prone to losses through leaching or denitrification in the period immediately follow application. It is for this reason that UAN is generally considered a less desirable option for fall applications. That being said, the risk of denitrification or leaching in the current study was low under the dry conditions.

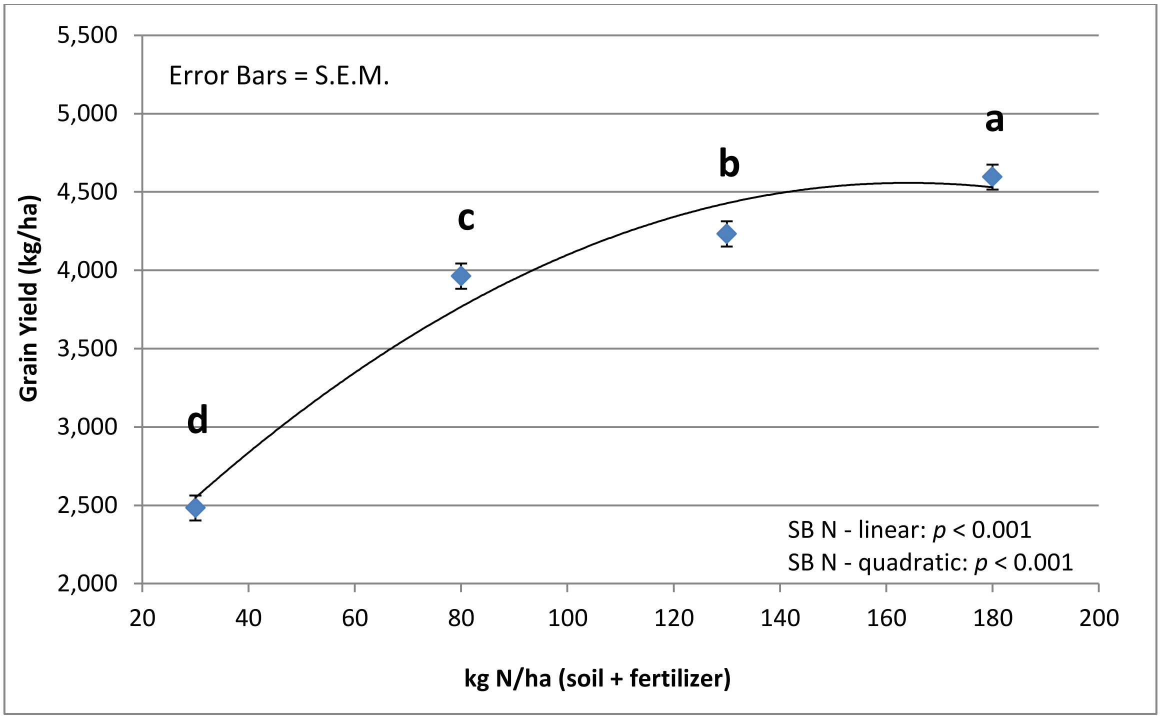

Figure 7. Side-banded urea rate effects on wheat grain yield at Indian Head (2017).

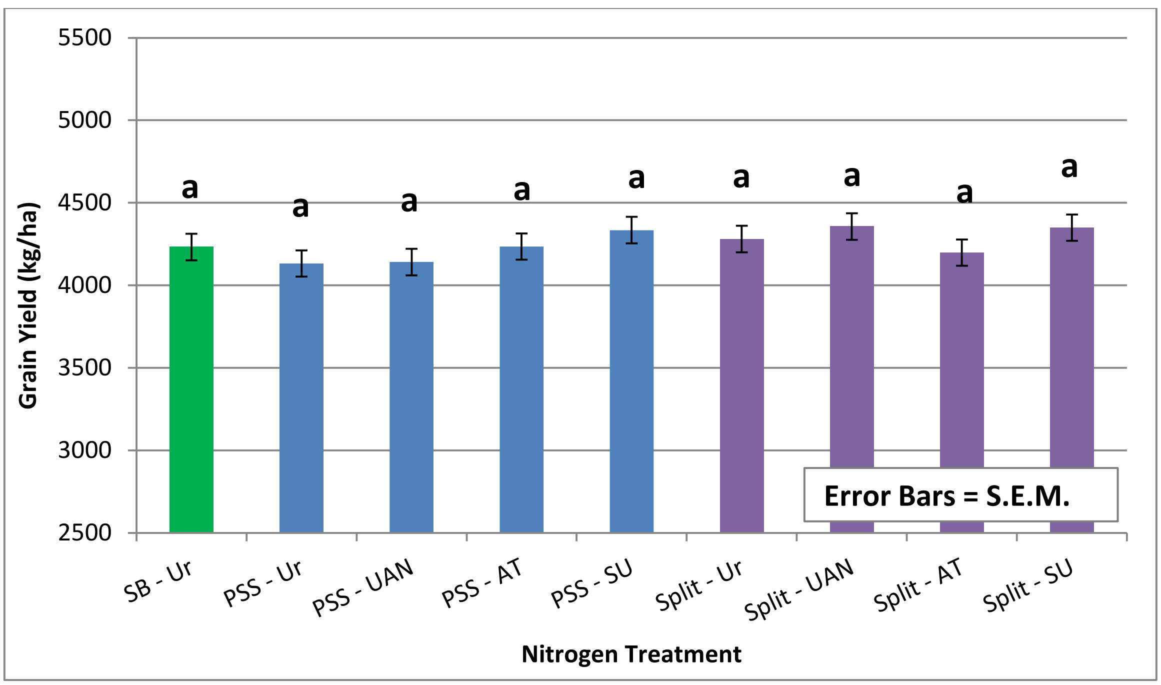

Figure 8. Nitrogen form/placement/timing effects on wheat grain yield at Indian Head (2017). SB – side-band, PSS – pre-seed surface, Split – 50% side-banded urea 50% post-emergent surface, Ur - u–treated urea, UAN – urea ammonium-nitrate, AT – Agrotain, SU – SuperUrea.

Although the quadratic orthogonal contrast was significant ($P = 0.044$), the relationship between N fertilizer rate and wheat protein was nearly linear in appearance (Fig. 9). The observed ranged was 9.7% where no N fertilizer was applied to 14.5% at the highest N rate (150 kg N/ha as side-banded urea plus 30 kg/ha residual NO_3-N). At the 1x rate, used in the majority of treatments, the average protein concentration was 13.6% for side-banded urea. Notably, this was substantially and significantly higher than that of all other 1x treatments which ranged from 11.6-12.4% (Fig. 10). Protein concentrations for split-applications of urea, Agrotain® and SuperUrea® were similar to each other and higher than those achieved with split-UAN or pre-seed broadcast/dribble-band applications of urea, UAN or Agrotain®. When the entire N amount was broadcast before seeding, protein tended to be highest with SuperUrea® where it did not significantly differ from the split-applications with urea, Agrotain® and SuperUrea®.

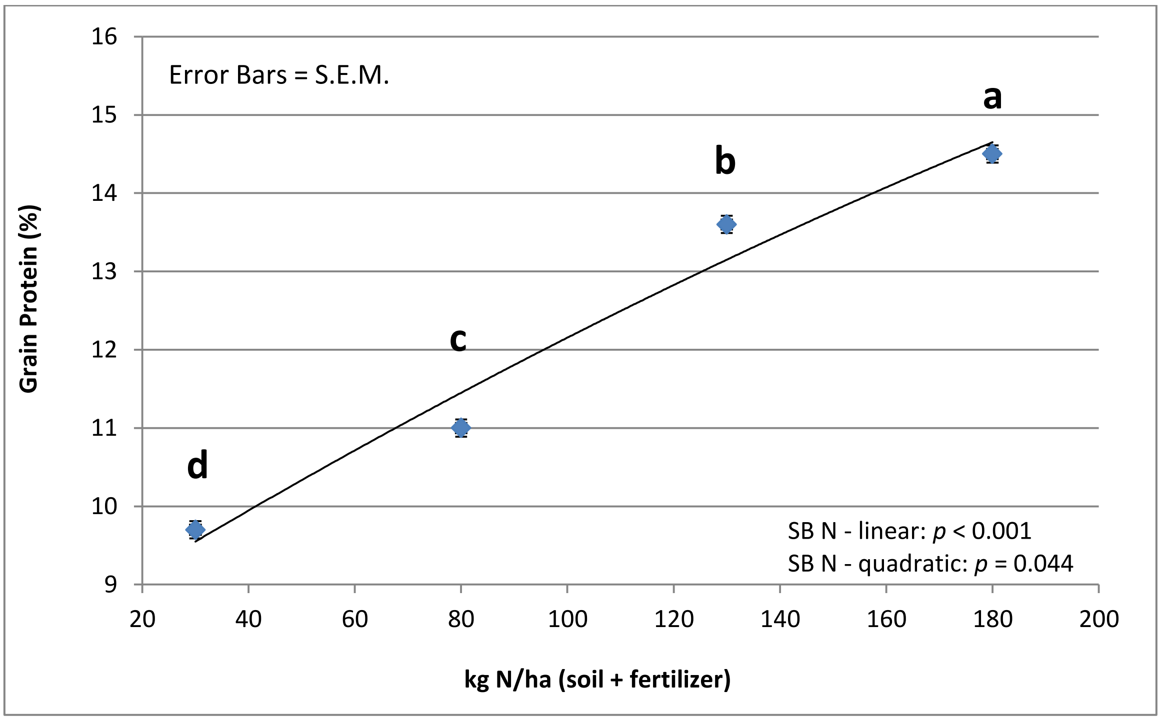

Figure 9. Side-banded urea rate effects on wheat grain protein at Indian Head (2017).

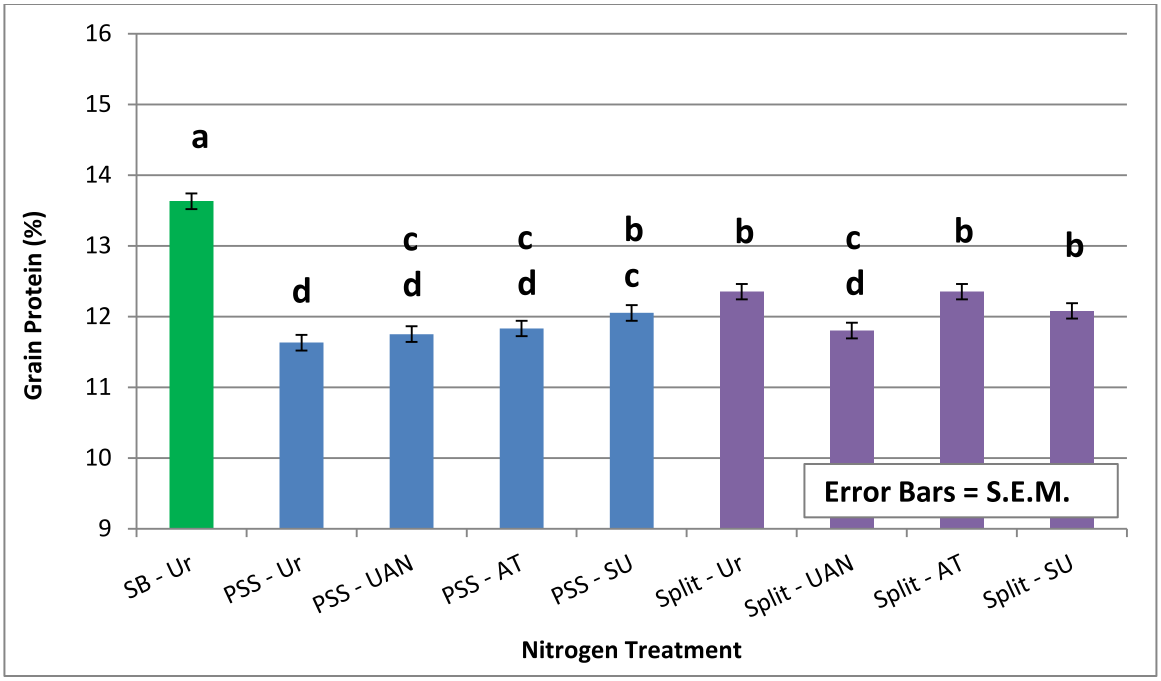

Figure 10. Nitrogen form/placement/timing effects on wheat grain protein at Indian Head (2017). SB – side-band, PSS – pre-seed surface, Split – 50% side-banded urea 50% post-emergent surface, Ur - u–treated urea, UAN – urea ammonium-nitrate, AT – Agrotain, SU – SuperUrea.

Extension Activities and Dissemination of Results

While this specific project could not be shown at the Indian Head Crop Management Field Day on July 18, it was discussed in detail and a similar trial with canola was shown to approximately 200 guests. A detailed discussion on 4R N management principles and was led by Chris Holzapfel (IHARF) with contributions from Stewart Brandt (NARF) and Rigas Karamanos (Koch Agronomic Services). Additionally, the site was toured during two smaller guided tours held for Federated Co-Op (July 13) and Richardson-Pioneer (July 21) agronomists. The full project report will be made available online (www.iharf.ca) and potentially elsewhere in the winter of 2017-18. Results will also be made available through a variety of other media (i.e. oral presentations, popular agriculture press, fact sheets, etc.) as opportunities arise. Data may be combined with other sites in the future for extension purposes.

11. Conclusions and Recommendations

This project has demonstrated the overall response of wheat to varying rates of N fertilizer along with different strategies for managing N involving various formulations (urea, UAN, Agrotain® and SuperUrea®) and timing/placement options (side-band, pre-seed surface broadcast/dribble-band, split application with both side-banded and post-emergent surface applications of N). The growing season at Indian Head was dry with less than half the long-term average growing season precipitation; however, initial soil moisture along with the overall yield potential of the wheat was high. Under these conditions, the best performance was observed with the traditionally recommended practice of banding fertilizer in the soil during seeding when both yield and grain protein concentrations were considered. Interestingly, grain yields did not significantly differ across form/timing/placing treatments; however, protein was substantially and significantly higher when the all of the N was side-banded. Previous research has shown that early in-soil applications are most advantageous in dry years while, under more optimal conditions, N fertilizer placement and timing of application tend to be less critical. In very wet years, environmental losses can be high regardless of application method depending on the formulation. It is in these years that denitrification inhibitors or split-applications are likely to be most beneficial.

It is well accepted that surface-applications of N need either incorporation or substantial precipitation to move the fertilizer into the rooting zone and minimize losses. This would, to a large extent, explain why the surface applications did not perform as well as side-banded N especially when protein was considered. The risk of volatilization and stranding for both application dates was substantial since rainfall following application was always negligible and, with less than 10% seed-bed utilization, the seeding operation did not constitute incorporation for the pre-seed applications. This was evident in the results with the better performance of the soil-applied N but also a slight (not significant) trend for higher yield and protein with Agrotain® and SuperUrea®, particularly with the pre-seed applications. Split-applications performed significantly better than the pre-seed surface application with respect to protein but not yield when averaged across formulations. While split-applications (particularly where some N is placed beneath the soil surface) may generally be considered less risky than broadcasting the entire N amounts prior to seeding (fall or early spring), results can vary from year-to-year depending on precipitation amounts and timing. That being said, a significant advantage to split-applications is the ability to adjust N rates during the season for crop and moisture conditions. In extremely dry springs, which may be the case for many Saskatchewan growers in 2018, there can be a reluctance to apply high rates of N based on average or above-average yields when the actual yield potential could vary dramatically with growing season precipitation. With split applications, there is the option to apply a portion of the fertilizer at seeding, largely protecting against early season deficiency and subsequent yield loss, but only applying the remainder if justifiable by the actual growing conditions and the anticipated yield potential part way through the season. Split applications can also be beneficial in very wet fields or years where the potential for losses is high if N is applied too far ahead of uptake and, furthermore, precipitation is usually adequate to move top-dressed N into the rooting zone where it can be utilized by the crop.

Supporting Information

12. Acknowledgements:

This project was jointly supported by the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canada-Saskatchewan Growing Forward 2 bi-lateral agreement and Fertilizer Canada as part of their 4R nutrient stewardship program. Specialty fertilizer products were provided in-kind by Koch Agronomic Services and crop protection products were provided in-kind by Dow AgroSciences, Bayer CropScience and BASF. The many contributions of IHARF staff Danny Petty, Christiane Catellier, Dan Walker, Karter Kattler, and Shaelyn Stadnyk are greatly appreciated.

13. Appendices

Table 5. Individual treatment means for selected response variables in the ADOPT/Fertilizer Canada 4R Nitrogen Principles in Wheat demonstration at Indian Head, 2017. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

Entry	NDVI (July 2)	SPAD-1 (July 3)	SPAD-2 (July 21)	Grain Yield (kg/ha)	Protein (%)
1) Control (0x)	0.448 e	33.7 d	33.3 e	2483 d	9.7 g
2) Ur – SB – 0.5x	0.568 d	41.0 c	41.5 d	3963 c	11.0 f
3) Ur – SB – 1x	0.578 cd	45.5 a	45.5 a	4232 b	13.6 b
4) Ur – SB – 1.5x	0.593 a-d	45.5 a	45.2 ab	4595 a	14.5 a
5) Ur – PSS – 1x	0.575 cd	42.6 bc	41.9 d	4132 bc	11.6 e
6) UAN – PSS – 1x	0.603 abc	43.0 b	42.4 cd	4141 bc	11.8 de
7) AT – PSS – 1x	0.573 cd	42.2 b	42.6 cd	4235 b	11.8 de
8) SU – PSS – 1x	0.583 bcd	42.6 bc	43.1 bcd	4334 b	12.1 cd
9) Ur – Split – 1x	0.625 a	42.8 bc	43.6 a-d	4280 b	12.4 c
10) UAN – Split – 1x	0.615 ab	42.8 bc	42.2 cd	4356 b	11.8 de
11) AT – Split – 1x	0.618 a	42.7 bc	44.2 abc	4198 b	12.4 c
12) SU – Split – 1x	0.600 a-d	42.7 bc	43.4 a-d	4349 b	12.1 c
S.E.M.	0.011	0.65	0.77	80.1	0.11
PSS vs Split (*p*-value)	< 0.001	0.799	0.130	0.143	< 0.001
Pr > *F* (*p*-value)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
C.V. (%)	3.9	3.1	3.6	3.9	1.9

N Rates (kg N/ha - residual NO_3-N + fertilizer N): 0x – 30, 0.5x – 80, 1x = 130, 1.5x = 180

Formulations: Ur = untreated urea, UAN = urea ammonium-nitrate, AT = Agrotain®, SU = SuperUrea®

Timing/placement: SB = side-band at seeding, PSS – pre-seed surface application, Split – 50:50 side-band/post-emergent surface application

Figure 11. Site overview at Indian Head, Saskatchewan (August 9, 2017).

Figure 12. Spring wheat with no supplemental N fertilizer (~30 kg/ha residual NO_3-N) at Indian Head, Saskatchewan (August 9, 2017).

Figure 13. Spring wheat with 150 kg N/ha supplemental N fertilizer plus ~30 kg/ha residual NO_3-N (1.5x rate) at Indian Head, Saskatchewan (August 9, 2017).

Abstract

14. Abstract/Summary:

In the spring of 2017 a field trial was conducted near Indian Head, Saskatchewan to demonstrate the response of CWRS wheat to varying rates, forms, and placement/timing options of N fertilizer. The midge tolerant variety CDC Utmost VB was seeded in early May and, as side-banded urea, the total N rates were 30, 80, 130 and 180 kg/ha (included 30 kg/ha residual). At the 130 kg total N/ha rate, various alternative N management strategies incorporating untreated urea, urea ammonium-nitrate, Agrotain® and SuperUrea® and pre-seed surface broadcast or post-emergent (split) applications were evaluated. While it was a dry season with less than half the long-term average precipitation but initial soil moisture and overall yield potential were high. In-season assessments using a handheld GreenSeeker (NDVI) or SPAD (chlorophyll) meter both distinguished between rates to some extent; however, the SPAD meter was better able to detect subtle differences amongst rates and management strategies. The yield response to N was high with significant increases right through the highest rates, but there were no significant yield differences amongst the form/timing/placement strategies. The effects of N rate on protein concentration were even stronger than for yield with a nearly linear increase in protein right through the higher fertilizer rate. Under the environmental conditions encountered, side-banding the entire N amount produced higher protein wheat than any of the treatments where pre-seed surface broadcast or split-applications were utilized. This is consistent with previous research which has shown that early in-soil applications are generally most advantageous under dry conditions. Under optimal moisture conditions, timing and placement methods tend to be less important while, under extremely wet conditions, enhanced efficiency products and split-applications generally have the greatest potential

to be advantageous. With respect to formulations, urea and UAN tended to be least effective when applied as a pre-seed broadcast application while urea, Agrotain®, and SuperUrea® all performed similarly in the split-applications. Both application dates of (surface-applied) N were subject to stranding at the soil surface and volatilization as the most significant rainfall events of the season occurred over five weeks after the pre-seed applications and prior to the split applications. Overall, these results support the recommendation of banding N during seeding and suggest that this is the least risky and most efficient application method for N regardless of form; however, results can vary widely from season to season with weather conditions.
