2015 Annual Report
for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Controlled Release Nitrogen Products for Wheat Yield and Protein

(Project #20140432)

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Project Identification

1. **Project Title:** Controlled release nitrogen products for wheat yield and protein
2. **Project Number:** 20140432
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 2015 to January 2016
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **Project objectives:**

The objectives of this project were to demonstrate the effects of several controlled release fertilizer nitrogen (N) treatments for their effect on yield, lodging and protein concentrations in wheat.

8. **Project Rationale:**

Wheat continues to be a very popular crop in southeast Saskatchewan; however, in recent years the region has experienced very high yields coupled with declining grain protein concentrations. Protein is important for both feed and milling, thus when protein drops too low, the value of the crop can drop significantly. Growers have attempted to increase protein by simply applying more fertilizer N; however this often leads to increased lodging and associated yield loss/difficulty with harvest in addition to potentially higher environmental losses. Several enhanced efficiency products for use on fertilizer N can delay the release of plant available N, leaving more available for uptake later in the growing season to support protein formation. Delaying N availability until later in the season could also have the added benefit of reducing early season vegetative growth and, in some cases, lodging along with reducing the potential for environmental and economic losses of N.

Two of the most well-known and proven slow release N products include ESN (Agrium) and SUPERU (Koch Agronomic Services); however these two products work in quite distinct manners. ESN is urea with a polymer coating that regulates how quickly the dissolved fertilizer can move into the soil solution where it converts to plant available NH_4 and NO_3-N. SuperU is urea impregnated with the urease inhibitor NBPT and the nitrification inhibitor DCD. While both products are proven to work as intended, whether the agronomic benefits that are realized under field conditions justify the added cost of such products is less certain. Due to the higher cost and the fact that we want some N to be available very early in the season, controlled release N (CRN) products are typically applied in a blend with untreated urea (i.e. 50:50 to 75CRN:25urea). The dilemma that growers face is in knowing whether the potential benefits to these products justify the added cost and, if so, which options or combinations are likely to be most effective. The intent of this project of is to demonstrate the performance of common controlled release N products and to identify the most effective strategies for simultaneously optimizing yield and grain protein in CWRS wheat.

Methodology and Results

9. Methodology:

A field trial with CWRS spring wheat was established on a heavy clay soil east of Indian Head, Saskatchewan (R.M. #156; -103.575 W 50.556 N). Eleven N fertilizer treatments were arranged in a Randomized Complete Block Design and replicated four times. The treatments were a control (no N fertilizer) plus a factorial combination of five N fertilizer formulations (untreated urea and varying blends of untreated urea with SuperU or ESN) and two N rates (75 kg N ha^{-1} and 140 kg N ha^{-1}). The fertilizer blends consisted of either 50% or 25% untreated urea combined with either 50% or 75% of the slow release formulations. All N fertilizer was side-banded and monoammonium phosphate and potassium sulphate were also applied to provide 35 kg P_2O_5 ha^{-1}, 35 kg K_2O ha^{-1} and 12 kg S ha^{-1} for all treatments.

A three depth (0-15 cm, 15-30 cm and 30-60 cm) composite soil sample was collected on May 2 and submitted to ALS laboratory group for residual nutrient analyses. On May 2, CDC Utmost VB wheat was seeded into field pea stubble at 275 seeds m^{-2} using SeedMaster plot drill with eight openers on 30 cm spacing. The targeted seed depth was 1.9 cm and side-banded fertilizer was placed 1.9 cm (0.75") below and 3.8 cm (1.5") beside the seed-row (www.seedmaster.ca/openers.php). Weeds were controlled using a pre-emergent application of 890 g glyphosate ha^{-1} (May 2) plus an in-crop application of Prestige (0.32 l Prestige A ha^{-1} and 2 l Prestige B ha^{-1}) tank-mixed with 0.5 l Simplicity ha^{-1} on June 8. To reduce the likelihood of disease becoming a limiting factor, 0.5 l Twinline ha^{-1} was applied on June 28 followed by 0.8 l Prosaro ha^{-1} on July 6. The plots were terminated with 890 g glyphosate ha^{-1} on August 14 and the centre five rows of each plot were straight-combined using a Wintersteiger plot combine on August 25.

Various data were collected over the course of the growing season and from the harvested grain samples. Lodging was assessed on August 16 by rating each plot on the basis of the percent plot area affected (A=1-10) and the intensity of the affected area (I=1-5). Lodging index was calculated using the following equation: $A \times I \times 0.2$. Yields were determined from the harvested grain samples and are corrected for dockage and to 14% seed moisture content. Test weights were determined using standard Canadian Grain Commission methodology and are expressed in g 0.5 l^{-1}. Thousand kernel weights were determined by mechanically counting and weighing a minimum of 1000 seeds and converting the values to g 1000 $seeds^{-1}$ (data not presented). Grain protein was determined using an NIR analyser.

Response data were analysed using the GLM procedure of SAS 9.3 with the effects of fertilizer treatment (n=11) considered fixed and the effects of replicate considered random. Contrasts were used to compare the two N rates (across forms) and to compare the slow release blends to untreated urea (across rates). To test for interactions between formulations and rates, a second model was used where the unfertilized control was excluded and data were analysed in a factorial manner where the effects of N rate, N formulation and their interaction were considered fixed. All treatment effects and differences between means were considered significant at $P \leq 0.05$.

10. Results:

Soil test results and Growing Season Weather

Soil test results and nutrient recommendations for the trial site are presented in Table 1. In general, all macronutrients except for K were considered deficient to marginal with good potential for a yield response to N, P and S fertilization. To target a 4 Mt ha^{-1} (60 bu ac^{-1}) yield and 14% protein content, the soil test recommendation was for 150-160 kg N ha^{-1}, 45-50 kg P_2O_5 and 17-22 kg S ha^{-1}.

Table 1. Soil test results for the Indian Head (2015) canola phosphorus fertilization demonstration. The samples were collected on May 5 and submitted to ALS Laboratory Group for analyses.

Soil Depth	Nitrogen (NO_3)	Phosphorus (Olsen-P)	Potassium (K)	Sulphur (SO_4)	pH
	------------------------------ kg ha^{-1} ------------------------------				—
0-15 cm	15	10	> 605	3	8.1
15-30 cm	8			3	8.2
30-60 cm	11	—	—	7	8.4
Total [Z]	26	10	> 605	18	—
Recommended Rate (kg ha^{-1})	150-160	44-50	0-17	17-22	—

[Z] 0-60 cm for N and S; 0-15 cm for P and K
[Y] 4 Mt ha^{-1} (60 bu ac^{-1}) target yield and 14% target protein

Mean monthly temperatures and precipitation amounts for the 2015 growing season at Indian Head are presented relative to the long-term averages in Table 2. While seed and fertilizer were placed into adequate, but not excessive moisture, the spring as whole was extremely dry with no significant precipitation events until late in the third week of June when canola was approaching the early bolting stage. From this point onwards, moisture conditions were generally adequate and CWRS yields were considered slightly above-average overall.

Table 2. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) averages for the 2015 growing season at Indian Head, SK.

Year	May	June	July	August	Avg. / Total
	-------------------------------------- Mean Temperature (°C) --------------------------------------				
2015	10.3	16.2	18.1	17.0	15.4
Long-term	10.8	15.8	18.2	17.4	15.6
	--- Precipitation (mm) ---				
2015	15.6	38.3	94.6	58.8	207
Long-term	51.8	77.4	63.8	51.2	244

Wheat Response to N Fertilizer Treatments

Individual treatment means and basic inferential statistics are presented for lodging and grain yield in Table 3 and for test weight and protein in Table 4. For those seeking more

Lodging was relatively minor in all treatments but, as would be expected, was least severe in the control and was generally worse at the higher of the two N rates. There were no apparent differences in lodging observed amongst the formulations.

Focussing on grain yield, there was a strong response to N fertilizer with a 55% average yield increase over the control at the 140 kg N ha^{-1} rate. Yields at this rate were significantly higher than those at the 75 kg N ha^{-1} rate (Tables 5 and 6) but only by 205 kg ha^{-1}, or approximately

5%. At both rates, the highest yields were achieved with 75:25 ESN:urea where there was a significant advantage over urea according to both the multiple comparison test (Table 3) and the single degree-of-freedom contrasts (Table 6). While significant, the observed advantage to 75% ESN over urea was relatively small averaging 181.5 kg ha^{-1}, or 4%. While this does not take protein content into consideration, it is interesting to note that yields at 75 kg N ha^{-1} as 75% ESN did not significantly differ from those with 140 kg N ha^{-1} as untreated urea. None of the additional slow release blends evaluated yielded significantly higher than the untreated urea according to both the multiple comparisons tests (Table 3) and the contrasts (Table 6).

Table 3. Treatment means and tests of significance for lodging and grain yield in the CRWS Wheat Protein Demonstration at Indian Head in 2015.

	------------- Lodging (1-10) -------------		------------- Yield (kg ha^{-1}) -------------	
Treatment	75 kg N ha^{-1}	140 kg N ha^{-1}	75 kg N ha^{-1}	140 kg N ha^{-1}
Control (0 N)	2.0 e		2912 f	
Untreated Urea	3.3 cd	4.3 a	4259 e	4467 bc
50 ESN/50 Urea	3.0 d	4.0 ab	4313 de	4570 ab
50 SuperU/50 Urea	3.0 d	4.0 ab	4384 cde	4518 bc
75 ESN/25 Urea	3.3 cd	3.8 abc	4417 cd	4672 a
75 SuperU/25 Urea	3.5 bcd	4.3 a	4243 e	4413 cd
S.E.M.	0.19		50.6	
C.V. (%)	10.7		2.4	
Pr. > *F* [Z]	< 0.001		< 0.001	

[Z] P-values ≤ 0.05 indicate that an effect was significant and not due to random variability

Table 4. Treatment means and tests of significance for test weight and protein in the CRWS Wheat Protein Demonstration at Indian Head in 2015.

	--------- Test Weight (g 0.5 l^{-1}) ---------		--------------- Protein (%) ---------------	
Treatment	75 kg N ha^{-1}	140 kg N ha^{-1}	75 kg N ha^{-1}	140 kg N ha^{-1}
Control (0 N)	393.5 c		10.5 f	
Untreated Urea	397.3 a	397.1 ab	12.6 c	14.5 ab
50 ESN/50 Urea	398.3 a	397.5 a	12.0 e	14.4 ab
50 SuperU/50 Urea	397.0 ab	397.2 a	12.2 de	14.6 a
75 ESN/25 Urea	397.9 a	397.6 a	12.3 cd	14.3 b
75 SuperU/25 Urea	397.6 a	395.7 b	12.2 de	14.7 a
S.E.M.	0.51		0.11	
C.V. (%)	0.3		1.71	
Pr. > *F* [Z]	< 0.001		< 0.001	

[Z] P-values ≤ 0.05 indicate that an effect was significant and not due to random variability

Test weight was affected by fertilizer treatment in that the unfertilized control had significantly lower test weight than all of the fertilized treatments (Table 4). While there was some minor variation amongst fertilized treatments, there were no consistent trends with respect to rate or form and none of the pre-determined contrast comparisons were significant.

There was an extremely strong grain protein response to N fertilizer rate whereby the control had a mean protein concentration of 10.5%, levels increased to 12.3% at 75 kg N ha^{-1} and reached 14.5 at 140 kg N ha^{-1} when averaged across formulations (Table 4). There was some variation in protein concentrations amongst formulations and a marginally significant RATE × FORM interaction (P = 0.054) for this variable (Table 5). At the lower rate, protein levels were significantly higher than all forms except 75% ESN with untreated urea; however, at the higher N rate wheat grown with 75% N had the lowest protein of the various formulations evaluated. According to the contrasts, protein was higher on average with untreated urea than with either 50% or 75% ESN but did not differ from the SuperU blends (Table 6). It is worth noting that protein was generally inversely related to yield (amongst the formulations) whereby those that resulted in the highest yields generally had lower protein.

Extension and Acknowledgement

While this demonstration could not be shown at the 2015 IHARF Crop Management Field held on July 21 due to logistic constraints, the site was visited by agronomists, farmers and industry representatives on several occasions throughout the growing season. Results from this project will be made available in the 2015 IHARF Annual Report (available online) and also through a variety of other media (i.e. oral presentations, popular agriculture press, fact sheets, etc.) as opportunities arise.

11. Conclusions and Recommendations

The project has demonstrated the importance of adequate fertilization as a means of optimizing both grain yield and protein concentration in CWRS spring wheat. Yields increased by over 50% with the first 75 kg N ha^{-1} and climbed an addition 5% when the N rate was increased to 140 kg N ha^{-1}. Protein concentrations also increased with yield for the initial 75 kg N ha^{-1} with an average 1.8% absolute increase in protein relative to the control. While the yield benefit to increasing N rates to 140 kg N ha^{-1} was only about 200 kg ha^{-1} (5%), protein concentrations increased dramatically from 12.3% to 14.5% (an 18% relative increase) at the higher of the two rates. Focussing on fertilizer formulations, no products had a consistent advantage for both yield and protein, which were generally inversely related to one another. While the blends containing ESN generally resulted in the highest yields, they also had the lowest protein. It should be noted that the 2015 growing season at Indian Head was extremely dry for the first 6-7 weeks after planting; however, the plots were seeded into adequate moisture. Consequently, the potential for environmental N losses early in the season was relatively low despite the fact that moisture conditions improved dramatically in July and August. The performance of the products evaluated may differ under wetter spring conditions when the potential for losses due to denitrification and, to a lesser extent, leaching is much higher.

Supporting Information

12. Acknowledgements:

This project was financially supported by the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canada-Saskatchewan Growing Forward 2 bi-lateral agreement. Acknowledgement of the Saskatchewan Ministry of Agriculture's support for this demonstration will be included as part of all written reports and oral presentations that arise from this work. Fertilizer formulations were provided in-kind by Koch Agronomic Services and Agrium while several of the crop protection products were provided by BASF, Bayer CropScience and Dow Agrosciences. The support and contributions of Christiane Catellier, Dan Walker, Carly Miller and Danny Petty are greatly appreciated.

13. Appendices

Table 5. Factorial analyses of variance for effects of fertilizer formulation (FORM), rate (RATE) and FORM × RATE on CWRS wheat lodging, yield, test weight and protein concentration. Data were analyzed using the GLM procedure of SAS and, due to the factorial design, the 0 N control was excluded.

Effect	Lodging (1-10)	Yield (kg ha^{-1})	Test Weight (g 0.5 l^{-1})	Protein (%)
	----------	----------	p-value ----------	----------
FORM	0.189	< 0.001	0.094	0.028
RATE	< 0.001	< 0.001	0.054	< 0.001
FORM × RATE	0.623	0.516	0.226	0.054

[Z] P-values ≤ 0.05 indicate that an effect was significant and not due to random variability

Table 6. Predetermined contrast results comparing high versus low fertilizer rates and various slow release N formulations to untreated urea. Data were analyzed using the GLM procedure of SAS.

Contrast	Lodging (1-10)	Yield (kg ha^{-1})	Test Weight (g 0.5 l^{-1})	Protein (%)
	----------	----------	p-value ----------	----------
75N vs 140N	< 0.001	< 0.001	0.070	< 0.001
Urea vs 50ESN	0.188	0.131	0.180	0.003
Urea vs 50SU	0.188	0.091	0.903	0.228
Urea vs 75ESN	0.188	0.001	0.299	0.025
Urea vs 75SU	0.5059	0.493	0.293	0.377

[Z] P-values ≤ 0.05 indicate that the difference between means was significant and not due to random variability

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<u>Abstract</u>

14. Abstract/Summary:

A trial was conducted at Indian Head to evaluate N fertilizer rates and formulations for managing yield and protein in spring wheat. The treatments were a factorial combination of two rates (75 or 140 kg N ha^{-1}), five formulations (untreated urea, 50% ESN, 50% SuperU, 75% ESN and 75% ESN) plus a control. The weather was initially dry but moisture conditions improved dramatically for the latter half of the season. Lodging was always minor but least severe in the control and worst at the 140 kg N ha^{-1} rate with no differences amongst formulations. Yields increased by up to 55% with N fertilizer relative to the control with higher yields at the 140 kg N ha^{-1} rate and, to a lesser extent, with the 75% ESN blend. While protein increased substantially when the rate was increased from 75-140 kg N ha^{-1}, no protein advantage to the slow release formulations was detected and, amongst formulations, protein was inversely related to yield.