Project Identification

1. **Project Title:** 4Rs-Fall and Spring Applied Urea on Spring Canola
2. **Project Number:** 20180390
3. **Producer Group Sponsoring the Project:** Conservation Learning Centre
4. **Project Location(s):** SW 20-46-26 W2 RM #461 (Prince Albert)
5. **Project Start and End Dates (Month & Year):** Fall 2018 to February 2020
6. **Project Contact Person & Contact Details:**

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Objectives and Rationale

7. Project Objectives:

The objective of this project was to 1) demonstrate the higher N efficiency of spring banding compared to broadcasting urea in the fall or post spring seeding, and 2) demonstrate how using SuperU or Agrotain in the fall or spring and ESN in the fall can reduce N losses and improve N efficiency when compared to broadcasting urea.

8. Project Rationale:

Banding nitrogen while seeding is considered the most efficient and best practice for fertilization, but it can slow down seeding operations. With increases in larger farms, producers have a limited time in the spring, and as a result many are broadcasting their fertilizer in either the spring or fall to save time. Broadcasting is considered an inefficient use of N and can cause economic losses and environmental degradation. Broadcast applications of urea are more prone to volatilization if not incorporated by sufficient and timely rainfall. If moisture is excessive nitrate can be lost to leaching and denitrification. Denitrification occurs in anaerobic water-logged soils where microbes use up nitrate as an oxygen source. These losses are more likely to occur with fall applications. There are a number of products available to reduce the risks of volatilization and denitrification.

However, these risks can be minimized by using N efficiency products such as Agrotain, Super U and ESN that reduce N losses to the environment. SuperU is a specialized form of urea, which provides some added protection from 3 pathways of nitrogen loss. SuperU slows the conversion of urea to ammonia which protects the granules from volatilization (gassing off). It also slows the conversion of ammonium to nitrate which reduces the loss of N to leaching and denitrification. Agrotain also provides protection from volatilization but does not reduce the risk of denitrification. Both of these products provide protection whether broadcasted in fall or spring. ESN is a polymer coated product that is best used for fall applications. It protects the urea by slowing its release. Spring broadcast applications of ESN may result in yield loss as the release of N may be too slow. The purpose of this study is to help inform producers about the potential risks associated with broadcasting N in either the spring or fall and supply alternative solutions to allow them flexibility with their N management plans.

Methodology and Results

9. Methodology:

This demonstration was set up as a randomized complete block design with four replicates. The treatments are summarized in Table 1. The 1X nitrogen rate was based off the soil test recommendations to achieve a 40 bu/ac crop of canola. The first 4 treatments were used to create a N response curve.

Table 1. Treatments applied in the "4Rs-Fall and Spring Applied Urea on Spring Canola" project.

Treatment #	N Rates	Timing and Placement	Type
1	0	Control	Control (none)
2	0.5X	Spring side banded	Urea
3	0.75X	Spring side banded	Urea
4	1X	Spring side banded	Urea
5	1X	Fall broadcast	Urea
6	1X	Fall broadcast	Agrotain
7	1X	Fall broadcast	SuperU
8	1X	Fall broadcast	ESN
9	1X	Spring broadcast	Urea
10	1X	Spring broadcast	Agrotain
11	1X	Spring broadcast	SuperU
12	1X	Spring broadcast	ESN

Table 2. Fall 2018 soil test results from a composite soil sample.

Soil Depth (cm)	Nutrient			
	N (lb/ac)	P (ppm)	K (ppm)	S (lb/ac)
0-15	6	4	234	36
15-30	3			30

Each plot was approximately 2m by 7m and seeded by a Fabro plot seeder with 10-inch row spacing. Seeding occurred on May 22nd into wheat stubble at a seeding depth between 0.5 to 1 inch using the canola variety PV 760. The canola seed was treated with Helix vibrance and lumiderm seed treatment. Based on soil test results (Table 2) for a yield goal of 40 bu/ac, 126 lbs/ac of N was applied to treatments 4-12, and N rates of 0, 63, and 95 lbs/ac of N were applied to treatments 1-3 respectively. Fall fertilizer was broadcast October 24th, 2018, and spring broadcast fertilizer was applied on May 10th, 2019. For each plot, 25 lbs/ac of phosphorous was also applied. No pre-emergent herbicide was applied because the dry conditions reduced spring weed growth, but glyphosate was used as a post emergent herbicide. Plots were staged and scouted weekly for pests and disease. There was some minor flea beetle pressure and no disease was observed. Reglone was applied on September 6th as a preharvest desiccant, but before harvest could occur, the renter of the land accidentally swathed the first four plots of every rep and parts of other plots in rep 1. On September 24th, five rows per plot were harvested of the remaining plots using a Wintersteiger plot combine.

Data collection included plant density, yield, and an economic analysis. Plant density was determined 3 weeks after seeding by counting two 1m sections of row. Yield was measured after cleaning and weighing the plot samples and was then corrected to 10% seed moisture content. The first four treatments were analyzed separately to determine the N response curve. Due to accidental swathing some treatments had less than 3 replicates and it was not possible to carry out ANOVA. However, a Pearson correlation test was used to compare canola yield and N rates. Plant density and yield data were analyzed by ANOVA using the R program.

10. Results:

The late and relatively cool spring delayed seeding until May 22nd. The below average spring precipitation (Table 4), and the previously dry year made for very dry spring conditions and resulted in poor and patchy crop emergence in the region. These dry conditions extended into the summer (Table 4), but they did not appear to drastically affect yields. The yields met and exceeded the 40 bu/ac yield goal for most of the plots when applied at the 1X nitrogen rate (Table 4).

Table 3. Mean temperatures and precipitation recorded by Saskatchewan Research Council's Climate Station located on site at the Conservation Learning Centre.

	May	June	July	August	September	October	Average/Total
				--- Temperature (°C) ---			
2019	9.5	15.8	17.4	15.1	11.6	1.0	11.7
2018	13.3	16.3	17.4	15.7	6.5	1.4	11.8
2012-2017	11.5	16.0	18.7	17.6	12.5	3.8	13.4
				--- Precipitation (mm) ---			
2019	30.0	54.4	57.4	16.8	59.6	11.6	229.8
2018	12.5	49.8	112.4	38.4	29.3	8.6	251.0
2012-2017	69.4	85.4	93.3	49.6	25.2	26.0	348.7

Overall there was a treatment effect on plant stand (Table 4). Spring side banded at 1X had the best stand establishment versus spring broadcasted urea and ESN that had the lowest establishment. Banding nitrogen is considered the best practice for fertilization as was demonstrated. The efficiency product ESN is typically recommended for use with fall applications because release may be too slow when applied in spring, especially under dry conditions. This may explain the lower plant stand for spring applied broadcasted N. However, low plant establishment did not directly translate to lower yields. When each 4 R factor was analysed separately, there was no effect of rate, placement, timing or source on plant density (Table 5).

Table 4. Mean plant establishment and yields of canola grown at the CLC in 2019 when N fertilizer varies in rate, placement, timing and form.

TRT #	N Rates	Timing and Placement	Type	Stand (plants/m^2)	Yield (kg/ha)	Yield (bu/ac)
1	0	Control		71 ab	1260	23
2	0.5X	Spring side banded	Urea	92 ab	2092	37
3	0.75X	Spring side banded	Urea	76 ab	3049	54
4	1X	Spring side banded	Urea	106 a	2777	50
5	1X	Fall broadcast	Urea	90 ab	3108	55
6	1X	Fall broadcast	Agrotain	82 ab	3467	62
7	1X	Fall broadcast	SuperU	95 ab	3352	60
8	1X	Fall broadcast	ESN	83 ab	2681	48
9	1X	Spring broadcast	Urea	61 b	3721	66
10	1X	Spring broadcast	Agrotain	82 ab	3696	66
11	1X	Spring broadcast	SuperU	66 ab	3298	59
12	1X	Spring broadcast	ESN	62 b	3345	60
	P-value			0.0325		

†values with the same letter are not statistically different (P>0.05). Statistical analysis was not completed on yield due to some treatments n=2 or n=1 due to accidental swathing of a portion of the trial.

There was a clear yield response to N (Figure 1) and there was a strong relationship between yield and N rate ($r=0.89$, $p<0.001$). Residual soil N was low as indicated in the soil test (table 2). When N was applied at 95 lb/ac, yield was 2.5X greater than when no N fertilizer was applied. Due to reduced replicates, only timing and formulation of N fertilizer could be investigated for effect on yield. There was no difference between spring and fall broadcast applications of fertilizer and no differences between the actual formulation used. Any source of N fertilizer and either spring or fall timing provided higher yields than not providing any N fertilizer as represented by the control treatment. Unfortunately, it was not possible to investigate an interaction effect between timing and formulation of fertilizer due to unequal sample sizes, however, ESN had low yields when compared to the other sources and Agrotain appeared to perform similar to urea in both the spring and fall. The best yield was achieved with spring broadcasting urea and Agrotain; however, side-banded urea only had 1 rep and spring broadcast SuperU had 2 reps for yield data. Weather conditions were not favorable for showcasing how well efficiency products like SuperU and ESN can work under saturated scenarios.

Figure 1. Nitrogen yield response curve of canola at the CLC in 2019.

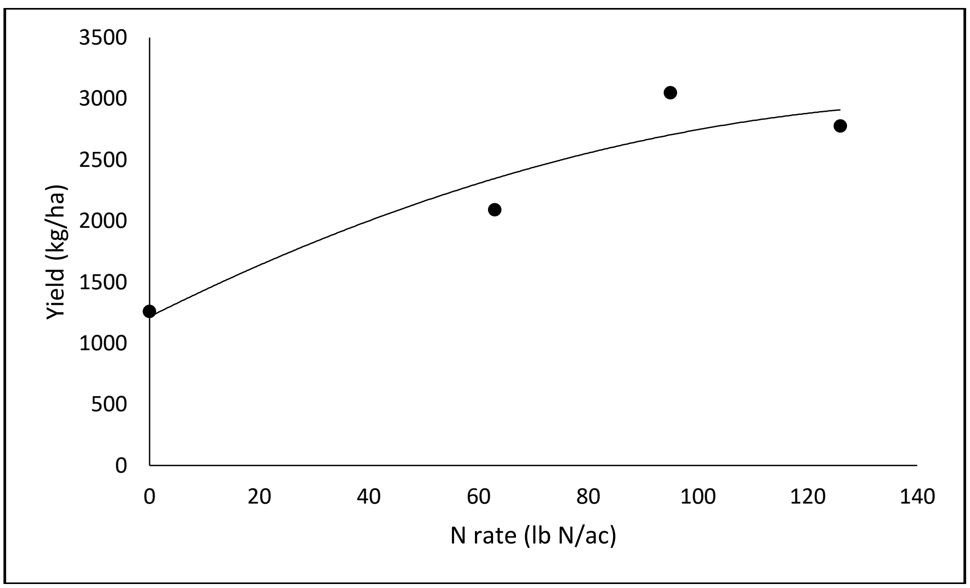

Table 4. Summary of statistical analyses and means of main effects for Adopt Management of 4Rs-Fall and Spring applied Urea on Spring Canola at the Conservation Learning Centre in 2019.

Treatment	Plant Density plants/m^2	Yield bu/ac
	P-value	
Rate (R)	0.5507	
Placement (P)	0.1016	
Timing (T)	0.2128	<0.001
Fertilizer Type (FT)	0.5910	0.0014
	Means	
Rate (R)		
0 (control)	70.5	
0.5x	91.5	
0.75x	76.0	
1x	80.6	
Placement (P)		
None (control)	70.5	
Broadcast	77.5	
Side-band	91.0	
Timing (T)		
None (control)	70.5	24.8[b]
Spring	77.6	63.9[a]
Fall	87.4	55.2[a]
Fertilizer Type (FT)		
None (control)	70.5	24.9[b]
Urea	84.8	62.5[a]
Agrotain	81.5	62.7[a]
SuperU	80.5	58.9[a]
ESN	72.5	53.5[a]

†values with the same letter are not statistically different (P>0.05). Treatments 2 and 3 were omitted from all statistical analysis except for the effect of rate on plant stand. It was not possible to complete ANOVA on effects of rate and placement on yield due to n=2 and n=1 for some treatments.

Table 6. Estimated cost analysis of efficiency products compared to industry standard of urea as of November 2019.

Treatment	Cost	N Rate	Actual Product rate		Total cost	Total cost
	$/t	Kg/ha	Kg/ha	t/ha	$/ha	$/ac
Urea	500	141	302	0.302	151	61
Agrotain	580	141	302	0.302	175	71
SuperU	630	141	302	0.302	190	77
ESN	625	141	315	0.315	197	80

Table 7. Economic analysis of different timing, placement and source of N fertilizer used on canola grown at the CLC in 2019.

Timing/Placement	Fertilizer Source	Yield bu/ac	†Expenses	Gross Revenue	Net Revenue
Spring side band	Urea	50‡	355.45	535.0	179.55
Fall broadcast	Urea	55	355.45	588.5	233.05
Fall broadcast	Agrotain	62	365.45	663.4	297.95
Fall broadcast	SuperU	60	371.45	642.0	270.55
Fall broadcast	ESN	48	374.45	513.6	139.15
Spring broadcast	Urea	66	355.45	706.2	350.75
Spring broadcast	Agrotain	66	365.45	706.2	340.75
Spring broadcast	SuperU	59	371.45	631.3	259.85
Spring broadcast	ESN	60	374.45	642.0	267.55

†A breakdown of the costs included in the economic analysis are ($/ac): seed=66.19, P+S=35.16, plant protection=109.40, machinery operating=31.33, hired labour=21.05, insurance=9.72, and utilities and miscellaneous=12.61. Values presented do not consider all production costs and are only estimates retrieved from Saskatchewan 2020 Crop Planning Guide. Broadcast treatments do not include expenses incurred from completing an extra pass during application. Cost for N fertility is based off of table 6.
‡The side band treatment is not fairly represented and is a single data point due to the loss of 3 other reps. Therefore, it cannot be assumed and is not recommended to broadcast over side banding.

Nitrogen efficiency products are more expensive than the industry standard urea. Estimates of product cost, as of November 2019, used in this study are presented in Table 6. An economic analysis was completed but should be interpreted with caution. Actual input costs and revenues could vary by region. Side banding nitrogen is the recommended best practice, since it places the fertilizer close to the root and prevents volatilization and surface runoff losses. It is unfair to compare the broadcast treatments in this trial to the side band treatment that only had a sample size of n=1. However, spring broadcasting provided a better return over fall broadcasting. Agrotain performed similarly or better than urea implying that there may have been some reduced losses due to volatilization. ESN and SuperU had the lowest returns due to the higher cost of the product and dry conditions.

11. Conclusion and Recommendations:

Side-banded N as urea had the best stand establishment versus spring broadcasting urea or ESN. Spring broadcasting ESN can be unideal under very dry conditions because the N may be released too slowly for plant uptake. Statistically there were no differences between timing of fertilizer applications and the type of fertilizer used, and due to loss of yield replicates, it was not possible to look at the interaction effect on yield. ESN and SuperU were outcompeted by Agrotain due to the dry conditions experienced in 2019 and higher product costs. The results of this study are somewhat unexpected, due to the extremely dry conditions in the spring and summer, and the accidentally swathed plots reduced our statistical power and ability to do a full analysis. It would be of value to repeat this study in a wetter more typical growing season and ensure the trial is not swathed.

11. Acknowledgements:

The Conservation Learning Centre graciously acknowledged the Ministry's support through signage directly in field with the project, verbally during the Field Day and on the Field Day agenda handed out to all visitors.

12. Abstract:

Spring side or midrow banding fertilizer while seeding is considered the best management practice for N, but can become time consuming on large farming operations. In recent years, some agricultural producers have been switching to broadcasting urea in the fall or post-seeding in the spring to save time during seeding. Broadcasting urea makes it more prone to volatilization and runoff, which has economic and environmental consequences. Appling urea in the fall, far in advance of plant uptake makes N more susceptible to leaching and denitrification losses. There are N efficiency products that can reduce N losses, which would allow producers more flexibility when creating a N management plan. These efficiency products are more expensive, but the amount of reduced N losses could make up for the cost. Firstly, this study established a N response curve by comparing different rates of spring banded urea; 0X, 0.5X, 0.75X, and 1X the recommended N rate to achieve a 40 bu/ac canola crop. The main purpose of this study was to examine the differences between spring side banding urea and broadcasting different types of fertilizer in either the spring or fall. These different types of fertilizer included Agrotain, SuperU, ESN, and urea. There was a strong canola yield response to added N especially when applied at 0.75X and 1X the recommended N rate. Unfortunately, accidental partial swathing of the trial had reduced replicates preventing true analysis of the yield results. However, the dry growing conditions were not conducive to excessive N losses by leaching or denitrification and the trial was unable to demonstrate the expected benefits of using N efficiency products when broadcasting N fertilizer.