Strategic Field Program (SFP)
Project Final Report

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Project Title: Efficacy of Enhanced Efficiency Fertilizers for Banded Applications in Spring Wheat

SFP File Number: 20230433

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Abstract *(maximum 500 words)*

Detail an outline on overall project objectives, methods, key findings and conclusions for use in publications and in the ministry's database. The abstract should address the following (usually 1–2 sentences per topic):

- Key aspects of the literature review
- Problem under investigation
- Clearly stated hypothesis or hypotheses
- Methods used (including brief descriptions of the study design, sample, and sample size)
- Study results
- Conclusions

In 2024 and 2025, trials were conducted at Yorkton, Indian Head, Scott, Prince Albert and Melfort to determine if the use of enhanced efficiency fertilizers (EEF) can improve upon the nitrogen use efficiency (NUE) of urea in wheat with side-band placement. The trials compared urea, eNtrench (nitrification inhibitor) and SuperU (dual inhibitor) at soil + fertilizer N rates of 80, 120 and 160 lb/ac. While not part of the factorial analysis, a no N check was also included in the treatment list for comparison. For most site/years, increasing soil + fertilizer N from 80 to 160 lb/ac significantly delayed maturity and increased grain yield, grain protein and N uptake. Side-banding enhanced efficiency N fertilizers (ie: eNtrench and SuperU) over untreated urea delayed crop maturity at some site/years. While this implies there may have been more N available when side-banding enhanced efficiency N fertilizers, there were no detectable gains in yield, grain protein or N uptake. In other words, any potential reduction in N loss from side-banding enhanced efficiency N fertilizers was not large enough to have an agronomic benefit for the producer. Based on the results from this study, side-banding enhanced efficiency N fertilizers would come at a cost to producers; however, responses may differ under wetter conditions. Our results suggest that, to reduce the risk of N_2O emissions, financial incentives would be necessary to encourage producers to side-band eNtrench or SuperU over untreated urea.

Extension Messages *(3 to 5 bullet point in plain language)*

Provide key outcomes and their importance for producers/processors and the relevant industry sector.

- Any potential reductions in N loss from side-banding eNtrench or SuperU over untreated urea were too small to have a detectable impact on either wheat yield, grain protein or N uptake.
- Increased adoption of these enhanced efficiency N fertilizers in the side-band to reduce N_2O emissions would require economic incentives.

Introduction *(maximum 1,500 words)*

Provide a brief project background and rationale.

One of Saskatchewan's 30 goals for 2030 is to deliver on Saskatchewan's climate change strategy. Optimizing N use efficiency supports this goal as well as the ministry's goal of increasing adoption of nutrient stewardship practices that protect the environment and enhance productivity and resiliency. Nitrogen fertilizer not used by crops can be lost through volatilization as NH_3 (ammonia), and denitrification (N_2 and N_2O emissions). Any N loss is an economic loss for producers and, while NH_3 and N_2 are not considered greenhouse gases, N_2O is a potent greenhouse gas. In 2021, N_2O accounted for 4.5% of all Canadian greenhouse gas emissions from human activities [1], with agricultural soils accounting for 77% of all N_2O emissions. The impact of 1 pound of N_2O on warming the atmosphere is 265 times that of 1 pound carbon dioxide. The use of enhanced efficiency fertilizers (EEF) can help to reduce N_2O emissions. The product eNtrench NXTGEN™ contains Nitrapyrin, a nitrification inhibitor that reduces N losses to denitrification and leaching, which are more prevalent when soil moisture is high. SUPERU© contains a dual urease and nitrification inhibitor [N-(n-Butyl) thiophosphoric triamide (NBPT) + dicyandiamide (DCD)]. The urease inhibitor slows the conversion of urea to ammonia, thereby giving more time for the fertilizer to dissolve and move deeper into the soil where it will be protected from volatilization.

While the use of EEF will have the greatest benefit when timing and/or placement leaves the N more susceptible to loss, these products have also reduced N_2O emissions from spring banded applications. Over the full duration of a growing season and with spring application, Thilakarathna et al. (2020) reduced cumulative N_2O emissions by 15% with eNtrench (nitrapyrin) over untreated urea. SUPERU© has also been reported to reduce N_2O emissions from spring side banding, but these studies were unable to detect a corresponding yield benefit [3,4,5]. While N_2O loss from denitrification represents a small amount of N loss, N_2 loss can be substantial but is difficult to measure directly. It is generally assumed a reduction in N_2O emissions associated with the use of an enhanced efficiency N fertilizer will also reduce N_2 losses, but it is unclear by how much (personal conversation Chris Holzapfel and Richard Farrell). Nevertheless, some studies have shown a yield benefit from side-banded applications of SUPERU© when the fertilizer was either shallow banded with canola [6] or was side-banded with winter wheat [7]. Shallow banding is more prone to volatilization loss of NH_3 [8], and side-banding N with winter wheat will be more prone to denitrification as it sits in moist soil from early fall to early spring before it is used by the crop.

More study is required to determine if a yield benefit from spring banded SUPERU© over straight urea can be detected. Differences in N loss from past study may not have been great enough to significantly affect yield. Alternatively, N rates may have been too high for N losses to have a significant impact on grain yield or grain protein. The effect of N loss on yield or protein will not be easily detected at the top of the yield response curve to added N. To address this issue, this study proposes to evaluate spring side-banded applications of urea vs SUPERU© at increasing rates of N on yield of spring wheat. Using spring wheat as the test crop, means yield and grain protein responses can both be used to detect any improvements in N use efficiency between products. Even if spring side-banding SUPERU© is substantially reducing N_2O emissions, the benefit of these reductions needs to correlate with a yield or grain protein benefit to encourage producer adoption.

[1] Environment and Climate Change Canada. 2023. National Inventory Report 1990–2021: Greenhouse Gas Sources and Sinks in Canada, Part 3.

[2] Thilakarathna, S. K., Hernandez-Ramirez, G., Puurween, D., Kryzanowski, L., Lohstraeter, G., Powers, L., Quan, N., and Tenuta, M. 2020. Nitrous oxide emissions and nitrogen use efficiency in wheat: Nitrogen fertilization timing and formulation, soil nitrogen, and weather effects. 84: 1910-1927.

[3] Gao, X., Asgedom, H., Tenuta, M., and Flaten, D. 2015. Agron. J. Enhanced efficiency urea sources and placement options on nitrous oxide emissions. 107: 265-277.

[4] Tenuta, M., Gao, X.,Tiessen, K. H. D., Baron, K., & Sparling, B. (2023).Placement and nitrogen source effects on N2Oemissions for canola production in Manitoba.Agronomy Journal,115,2369–2383.https://doi.org/10.1002/agj2.21408

[5]Farrell, R., Congreves, K., and Phan, T. Balancing Agronomic and Environmental Outcomes Using Enhanced Efficiency Nitrogen Fertilizers. ADF File No. 20180193

[6] Shallow banding N risks volatilization loss - Top Crop ManagerTop Crop Manager

[7] Beres, B. L., Graf, R. J., Irvine, R. B., O'Donovan, J. T., Harker, K. N., Johnson, E.N., Brandt, S., Hao, X., Thomas, B. W., Turkington, T. K., and Stevenson, F. C. 2018. Enhanced nitrogen management strategies for wheat production in the Canadian prairies. 98: 683-702.

[8] Rochette P., Angers D.A., Chantigny M.H., Gasser M.-O., MacDonald J.D., Pelster D.E., Bertrand N. Ammonia Volatilization and Nitrogen Retention: How Deep to Incorporate Urea? J. Environ. Qual. 2013;42:1635–1642. doi: 10.2134/jeq2013.05.0192.

Objectives and Progress *(add additional lines as needed)*

Please list the original objectives and/or revised objectives if ministry-approved revisions have been made to original objectives. A justification is needed for any deviation from original objectives.

Objective	**Progress** *(i.e., completed/in progress)*
To determine if the use of enhanced efficiency fertilizers (EEF) can improve the nitrogen use efficiency (NUE) of spring banded applications of urea for spring wheat.	Complete
Can spring banding a product containing a nitrification inhibitor (ie; eNtrench) or a dual urease & nitrification inhibitor (ie; SuperU©) increase N uptake, grain yield or grain protein of spring wheat relative to bare urea, at soil + fertilizer N rates of 80, 120, and 160 lb/ac.	Complete

Methodology *(maximum of five pages)*

Specify project activities undertaken during this reporting period. Include approaches, experimental design, tests, materials, sites, etc. Please note that any significant changes from the original work plan will require written approval from the ministry.

Spring wheat trials were established at Yorkton (ECRF), Scott (WARC), Indian Head (IHARF), Melfort (NARF) and Prince Albert (CLC) in 2024 and 2025. Trial design was a 3 x 3 factorial with treatments arranged in a four replicate Randomized Complete Block Design (RCBD). The first factor contrasted different side-banded products (urea vs eNtrench vs SUPERU©). The second factor evaluated each of these products at 80, 120, and 160 lb N/ac of soil + fertilizer N. These rates were accurate at all locations as soil N reserves were below 80 lb N/ac at all locations. While it was excluded from the statistical analysis, a no side-banded N check was added to the treatment list to assess the responsiveness of sites to added N. All treatment combinations are listed in Table 1. Spring wheat was the test crop, as grain protein in addition to yield can be used to assess the relative nitrogen use efficiency between products. The specific HRS wheat variety varied between locations based on regional adaption and seed availability. Except N, all macronutrients (PKS) were intended to be non-limiting. Weeds, insects and plant diseases were controlled by pesticides at the discretion of site managers. All trials were small plot, but plot size varied depending on available equipment at each site. Plant biomass samples from 2- 0.5m sections of crop row were taken from the front and back of plots at the hard dough stage (kernel holds a thumbnail impression). Samples were dried and weighed before sending to the lab for total %N determination. This information was used to calculate the N uptake of the crop in kg N/ha. These values are intended to determine relative differences between treatments, not to accurately assess the total N taken up by the crop. Grain yields were determined by straight-combining each plot using small plot combines and weighing the harvested grain. Yields are corrected for dockage and to a uniform moisture content of 14.5%. Depending on plot size only centre rows were harvested to avoid edge effects on results. Factors measured included:

- Spring Soil Nutrients (minimum of NPKS, EC pH)
- Emergence (plants/m^2)

- Maturity (Julian days to soft dough)
- Yield (kg/ha adjusted to 14.5% moisture)
- Grain Protein (%)
- Biomass and total % N (2 X 0.5m of row at hard dough) to calculate N uptake (kg/ha)
- Weather Data
- Economic Analysis

Table 2 lists dates of key operations and products used at each location.

Nitrous oxide emissions or ammonia volatilization were not measured in this study as these measurements are expensive and currently beyond the capability of most AgriARM sites. While having this additional information would be valuable, its absence does not detract from the main objective of this study. This project parallels the study lead by Reynald Lemke (ADF file #20210863) that has shown significant N_2O emissions reductions (39% at Saskatoon and 22% at Melfort), by changing from conventional urea to SuperU. However, yield and protein impacts still need to be assessed.

Table 1. Treatment list

Trt #	Side-banded Product	N Rate (lb/ac soil + fert N)[1]
1	Urea	80
2	Urea	120
3	Urea	160
4	eNtrench	80
5	eNtrench	120
6	eNtrench	160
7	SUPERU©	80
8	SUPERU©	120
9	SUPERU©	160
10	Check: No side banded N	0

[1]Soil N will be based on (0-24" soil depth). Values from a 0-12" soil depth will be multiplied by 1.5 to approximate a 0-24" depth.

Table 2a. Dates of key operations for 2024 for Yorkton, Indian Head, Scott, Prince Albert, and Melfort.

	Yorkton	Indian Head	Scott	Prince Albert	Melfort
Soil test (min NPKS, EC pH)	April 22	May 12	April 4	May 6	April 30
Pre-seed Herbicide	May 12 *(Roundup Transorb @ 0.66 L/ac + AMS)*	May 14 & 21 *(Roundup Weathermax @ 0.67 L/ac)*	May 8 *(Glyphosate 540 @ 1L/ac + AIM @ 35 ml/ac)*	June 3 *(Roundup Transorb HC @ 1.27 L/ha)*	May 14 *(Start up (Glyphosate) @ 1 L/ac)*
Seeded Trial	May 10 *(Alida)*	May 13 *(Wheatland)*	May 9 *(Wheatland)*	May 31 *(Brandon)*	May 15 *(Starbuck)*
Emergence (plants/m^2)	May 31	June 6	May 28	June 26	June 3
In-crop Herbicide	June 8 *(Velocity + AMS)*	June 25 *(Prestige XL @ 0.95 L/ac + Simplicity GoDRI @ 28 g/ac)*	June 18 *(Buctril M @ 0.4 L/ac + Axial Extreme @ 0.5 L/ac)*	July 5 *(Infinity @ 0.83 L/ha)*	June 9 *(Enforcer M @ 510 ml/ac)*
	June 15				June 9

	(Axial + AMS)				*(Axial @ 500 ml/ac)*
					July 4 *(Enforcer M @ 510 ml/ac)*
In-crop Fungicide	July 8 *(Caramba)*	July 13 *(Sphaerex @ 0.216 L/ac)*	July 12 *(Caramba @ 400 ml/ac)*	July 16 *(Caramba @ 1L/ha)*	July 16 *(Prosaro @ 325 ml/ac)*
				July 30 *(Bravo ZN @ 2.5 L/ha)*	
Lodging (0-9) *optional*	July 12				September 10
Maturity (Julian)	August 16	August 13	August 15	August 16 – 29	August 14 - 19
Biomass Sample Harvested	August 20	August 16	August 19	August 27	August 22

Table 2b. Dates of key operations for 2025 for Yorkton, Indian Head, Scott, Prince Albert, and Melfort.					
	Yorkton	Indian Head	Scott	Prince Albert	Melfort
Soil test (min NPKS, EC pH)	April 25	October 18, 2024 + May 12, 2025	April 30	May 7	May 7
Pre-seed Herbicide	May 22 *(Transorb @ 1L/ac)*	May 13 *(Roundup Weathermax @ .67L/ac)*	May 7 *(Glyphosate 540 @ 1L/ac + AIM @ 35 ml/ac)*	May 10 *(Glyphosate @ 0.88 L/ac + Heat @ 29 ml/ac)*	May 15 *(Avadex @ 1.2L/ac + StartUp @ 670 ml/ac)*
Seeded Trial	May 26 *(Alida)*	May 14 *(Wheatland VB)*	May 9	May 22 *(Brandon)*	May 16 *(Wheatland VB)*
Emergence (plants/m^2)	June 6	June 6	May 28	June 13	June 3
In-crop Herbicide	June 16 *(Prestige XL @ 900 ml/ac)*	June 11 *(Octain XL @ 0.45L/ac + 28g/ac Simplicity GoDRI)*	June 16 *(Buctril M @ 0.4L/ac +Axial Extreme @ 0.5L/ac)*		June 20 *(Momentum @ 0.45L/ac, MCPA @0.38L/ac, and Puma Advance @ 413 ml/ac)*
	June 18 *(Axial @ 500 ml/ac + AMS 0.5% v/v)*				
	June 27 *(Axial + AMS)*				
In-crop Fungicide	July 8 *(Miravis ACE @ 404 ml/ac; 20GA)*	July 9 *(253 ml/ac Miravis Era A + 202 ml/ac Miravis Era B, + 0.125% Agral 90)*	July 5 *(Caramba @ 400 ml/ac)*	July 14 *(Miravis A +B)*	July 11 *(Miravis Era)*
Pre-Harvest Herbicide		August 24 *(Roundup Transorb HC @ 0.67L/ac)*			September 8 *(StartUp @ 0.67 L/ac)*
Lodging (0-9) *optional*	N/A	N/A	N/A		
Maturity (Julian)	August 25		August 29 to September		
Biomass Sample Harvested	Completed	August 21	August 28	August 26	September 5

Results and Discussions *(maximum of 30 pages (not including figures or tables))*

Describe project accomplishments during the reporting period under relevant objectives listed under "Objectives and Progress" section. Please accompany a written description of results with tables, graphs and/or other illustrations. Provide discussion necessary to the full understanding of the results. Where applicable, results should be discussed in the context of existing knowledge and relevant literature. Detail any major concerns or project setbacks.

In 2024, growing season temperatures were near long-term averages for all sites except Prince Albert, which experienced a cool season (Table 3). For all locations, June was unseasonably cool, but July and August were warmer than average. Precipitation was average to well above average for all locations in May and June. Wet conditions created difficulties during seeding for Prince Albert. July and August were drier than normal at all locations except Indian head where August was wetter than average. Yields were high at all locations, averaging 72, 85, 74, 63, and 76 bu/ac at Indian Head, Melfort, Prince Albert, Scott, and Yorkton, respectively.

In 2025, All locations were warmer than their long-term averages except Prince Albert. However, July was cooler than average at all locations, particularly Prince Albert. Precipitation was slightly below average at Prince Albert and slightly above at Melfort and Scott. Total precipitation was only 72% and 55% of the long-term average at Yorkton and Indian Head, respectively. At Yorkton, only August had above average rainfall. At Scott, Prince Albert and Melfort, June precipitation was well above average. Yields averaged 77, 87, 61, 47, and 63 bu/ac at Indian Head, Melfort, Prince Albert, Scott, and Yorkton, respectively.

Table 3. Mean monthly temperatures and precipitation amounts for 2024 and 2025 along with long-term normals for Yorkton, Indian Head, Scott, Prince Albert, and Melfort, Saskatchewan.

Location	Year	May	June	July	August	Avg./Total
		------------------------------*Mean Temperature (°C)* ------------------------------				
Yorkton	2024	10.5	14.2	20.3	17.7	15.7
	2025	12.4	15.7	17.5	18.3	15.98
	Long-term	***10.4***	***15.5***	***17.9***	***17.1***	***15.2***
Indian Head	2024	10.6	13.6	19.5	17.9	15.4
	2025	12.7	15.3	17.0	17.8	15.7
	Long-term	***10.8***	***15.8***	***18.2***	***17.4***	***15.6***
Scott	2024	9.8	13.3	18.9	17.4	14.9
	2025	12.9	14.6	15.8	17.4	15.2
	Long-term	***10.8***	***14.8***	***17.3***	***16.3***	***14.8***
Prince Albert	2024	8.4	11.3	18.1	15.2	13.25
	2025	11.2	12.7	14.9	17.1	13.98
	Long-term	***11.2***	***16.0***	***18.3***	***16.7***	***15.55***
Melfort	2024	10.1	13.2	19.4	17.4	15.025
	2025	13.8	15.0	17.0	18.0	15.95
	Long-term	***10.1***	***15.2***	***17.8***	***16.7***	***14.95***
		----------------------------------Precipitation (mm) ----------------------------------				
Yorkton	2024	56	120.4	22.9	42.3	241.6

	2025	23.6	63.4	36.8	71.2	195.0
	Long-term	***51***	***80***	***78***	***62***	***272***
Indian Head	2024	63.7	74.9	37.4	71.8	247.8
	2025	42.6	39.4	27.1	26.9	136.0
	Long-term	***51.7***	***77.4***	***63.8***	***51.2***	***244.1***
Scott	2024	74.2	112.0	26.7	42.8	255.7
	2025	11.8	103.7	28.7	64.5	273.2
	Long-term	***38.9***	***69.7***	***69.4***	***48.7***	***226.7***
Prince Albert	2024	69.6	118.8	31.4	42.0	261.8
	2025	2.2	137.6	8.6	51.2	199.6
	Long-term	***36.5***	***66.8***	***61.3***	***43.6***	***208.18***
Melfort	2024	73	84	36.1	31.9	225
	2025	4.8	93.2	25.9	113.5	237.4
	Long-term	***33.4***	***79.5***	***69.6***	***45.9***	***228.4***

Combined site analysis (overview)

Background levels of soil N (Top 24") were all below the minimum 80 lb/ac of soil + fertilizer N rate for every site/year (Table 4). In 2024, Yorkton had by far the highest level of background soil N at 63 lb/ac. Prince Albert and Scott had moderate levels in the 30's and the lowest levels of 10 and 17 lb N/ac were present at Indian Head and Melfort, respectively. In 2025, Yorkton and Prince Albert had the highest levels at 65 lb N/ac and 78 lb N/ac, respectively. Levels were much lower at Indian Head, Melfort and Scott ranging from 19 to 29 lb N/ac.

Table 4. Background nitrogen (lb/ac) in the top 24 inches of soil for each site/year.

Location	2024	2025
Yorkton	63	65
Indian Head	10	19
Scott	33	29
Prince Albert	36	78
Melfort	17	21

When combining all locations and years, the main effects of N rate and site/year were significant for all parameters measured (Tables 5 and 6) except % tissue N. Overall, as N rate increased, plant density decreased, maturity was delayed, and yield, protein, tissue N and N uptake were all increased. However, interactions between N rate and site/year were also significant for most parameters measured, indicating the effects of N rate need to be evaluated on a site-by-site basis. The use of different products (ie: urea vs eNtrench vs SuperU) did not have a significant effect on plant density, yield, grain protein, tissue N or N uptake and there were no interactions involving product with either N rate or site. Based on these key parameters, there is little evidence to suggest enhanced efficiency N fertilizers were supplying more N to the crop than untreated urea when side-banding. While product did have a significant effect on maturity (p=0.051). The use of eNtrench and SuperU significantly delayed maturity suggesting more N was supplied by those products compared to the straight urea. However, this effect was not readily apparent for all site/years.

Table 5. F-test results of mixed-effects model analysis of crop response variables assessing the presence of site/year interactions with Product and N rate. Effects are considered significant if P<0.05 and significant effects are bolded for emphasis.

	Plant Density	Maturity	Yield	Protein	% Tissue N	N Uptake
Fixed effects			*Pr(>F)*			
Product (P)	0.554	**0.051**	0.880	0.774	0.590	0.493
N rate (N)	**0.006**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Site/year (S)	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
P x N	0.526	0.455	0.975	0.331	0.8669	0.809
P x S	0.522	0.456	0.773	0.902	0.959	0.861
N x S	**0.021**	**0.001**	**<0.001**	**<0.001**	0.1722	**0.003**
P x N x S	0.900	0.913	0.997	0.996	0.5930	0.495

Table 6. Means and LSD separations for the main effects and interactions of product and N rate averaged over site/year.

Product (P)	Plant density (plants/m^2)	Maturity (Julian days)	Yield (kg/ha)	Grain Protein (%)	%N	N Uptake (kg N/ha)
A. Urea	247.4^a	232.3^b	4535.3^a	13.84^a	1.34^a	135.7^a
B. eNtrench	248.6^a	232.9^a	4556.9^a	13.89^a	1.36^a	134.1^a
C. SuperU	251.4^a	232.8^a	4533.0^a	13.83^a	1.36^a	138.1^a
S.E.M.	*2.63*	*0.18*	*36.86*	*0.0569*	*0.027*	*2.41*
N Rate (lb/ac soil + fert N) (N)						
80	253.3^a	231.6^c	4296.5^c	12.74^c	1.24^c	118.0^c
120	251.9^a	232.5^b	4604.5^b	13.94^b	1.36^b	138.6^b
160	242.3^b	234.0^a	4724.3^a	14.88^a	1.46^a	151.3^a
S.E.M.	*2.63*	*0.18*	*36.86*	*0.0569*	*0.027*	*2.41*
P x N						
Urea- 80 lb N/ac	254.9^{ab}	231.4^f	4270.4^b	12.82^c	1.21^c	115.4^d
Urea- 120 lb N/ac	247.9^{abc}	232.2^{de}	4614.5^a	13.95^b	1.36^b	138.4^{bc}
Urea- 160 lb N/ac	239.5^c	233.4^{bc}	4721.2^a	14.75^a	1.45^a	153.2^a

eNtrench- 80 lb N/ac	254.1[ab]	231.7[ef]	4304.5[b]	12.75[c]	1.27[c]	119.2[d]
eNtrench- 120 lb N/ac	249.1[abc]	232.5[de]	4615.3[a]	13.90[b]	1.36[b]	135.1[c]
eNtrench- 160 lb N/ac	242.6[bc]	234.6[a]	4751.0[a]	15.02[a]	1.46[a]	147.9[ab]
SuperU- 80 lb N/ac	250.8[abc]	231.7[ef]	4314.6[b]	12.66[c]	1.24[c]	119.4[d]
SuperU- 120 lb N/ac	258.6[a]	232.9[cd]	4583.7[a]	13.96[b]	1.37[b]	142.2[abc]
SuperU- 160 lb N/ac	244.7[bc]	234.0[ab]	4700.8[a]	14.88[a]	1.48[a]	152.7[a]
S.E.M.	*4.57*	*0.29*	*63.85*	*0.0958*	*0.028*	*4.18*
No N Check						

Plant Density

Increasing rate of Nitrogen significantly reduced emergence at Melfort in 2025 and at Scott in both years (Tables 7, 8a and 8b). Similar trends were also observed at Indian Head (p=0.066) and Melfort (p=0.06) in 2024. This implies some of the toxic effects of fertilizer (ie: salt and ammonia toxicity) may have been "bleeding in" to the seed row. At Scott and Melfort in 2024, the reduction in emergence was within 8% and was unlikely to have had any agronomic impact. At Indian Head in 2024, emergence numerically rose by 6% in response to increasing soil + fertilizer N from 80 to 120 lb/ac. As soil + fertilizer N increased further to 160 lb/ac the emergence fell back down by 6%. Again, this fluctuation in emergence at Indian Head was likely inconsequential. In 2025, reductions in plant emergence were larger at Melfort (13%) and Scott (18%). This may have had some mild effects on yield potential. As we shall cover again in the yield section, reduced plant emergence associated with high N rate may be partially responsible for the reduction in yield at Scott in 2025. At Prince Albert, plant populations were low in both years, averaging only 155 and 142 plants/m^2 in 2024 and 2025, respectively. While these low plant populations may have reduced yield potential, Prince Albert still reported an excellent yield of 72 bu/ac in 2024 and an average yield of 59 bu/ac in 2025. No main effects of product or interactions between product and nitrogen rate were detected for emergence, regardless of site. This suggests that the effect of increasing N on plant emergence was not influenced by the product used (ie: urea vs eNtrench vs SuperU).

Table 7. F-test results of mixed-effects models of **plant density** assessing the presence of Product and N rate interactions at each site individually. Effects are considered significant if P<0.05 and significant effects are bolded for emphasis.

	Indian Head		Melfort		Prince Albert		Scott		Yorkton	
	2024	*2025*	*2024*	*2025*	*2024*	*2025*	*2024*	*2025*	*2024*	*2025*
Fixed effects										
Product (P)	0.091	0.172	0.646	0.750	0.464	0.486	0.167	0.300	0.109	0.988
N rate (N)	0.066	0.894	0.060	**0.040**	0.916	0.278	**0.013**	**<0.001**	0.565	0.946
P x N	0.148	0.686	0.953	0.3712	0.871	0.734	0.125	0.145	0.708	0.470

Table 8a. Means, and LSD separations for the main effects and interactions of product and N rate on **plant density** in 2024.

Product (P)	Indian Head	Melfort	Prince Albert	Scott	Yorkton
A. Urea	373.2[a]	296.4[a]	150.6[a]	225.2[a]	309.4[a]
B. eNtrench	380.7[a]	312.8[a]	161.6[a]	237.0[a]	286.7[a]
C. SuperU	395.1[a]	304.6[a]	153.2[a]	231.0[a]	315.6[a]
S.E.M.	*6.82*	*12.29*	*6.45*	*4.22*	*9.76*

N Rate (lb/ac soil + fert N) (N)					
80	376.7^{a}	299.7^{a}	157.2^{a}	241.6^{a}	312.5^{a}
120	396.7^{a}	328.5^{a}	154.9^{a}	229.0^{b}	299.5^{a}
160	375.5^{a}	285.6^{a}	153.4^{a}	222.6^{b}	299.7^{a}
S.E.M.	*6.82*	*12.29*	*6.45*	*4.22*	*9.76*
P x N					
Urea- 80 lb N/ac	366.6^{a}	299.8^{a}	153.5^{a}	234.3^{ab}	315.8^{a}
Urea- 120 lb N/ac	397.4^{a}	317.0^{a}	145.7^{a}	225.9^{abc}	312.9^{a}
Urea- 160 lb N/ac	355.6^{a}	272.3^{a}	152.6^{a}	215.6^{bc}	299.4^{a}
eNtrench- 80 lb N/ac	384.3^{a}	310.5^{a}	168.3^{a}	244.3^{a}	308.0^{a}
eNtrench- 120 lb N/ac	394.9^{a}	333.8^{a}	159.0^{a}	225.9^{abc}	268.6^{a}
eNtrench- 160 lb N/ac	362.9^{a}	294.0^{a}	157.5^{a}	240.6^{a}	283.4^{a}
SuperU- 80 lb N/ac	379.3^{a}	288.7^{a}	149.6^{a}	246.1^{a}	313.7^{a}
SuperU- 120 lb N/ac	397.8^{a}	234.6^{a}	159.9^{a}	235.2^{ab}	317.0^{a}
SuperU- 160 lb N/ac	408.1^{a}	290.4^{a}	150.1^{a}	211.6^{c}	316.2^{a}
S.E.M.	*11.81*	*21.29*	*11.17*	*21.4*	*16.91*
No N Check	370.3	300.6	155.0	7.32	290.8

Table 8b. Means, and LSD separations for the main effects and interactions of product and N rate on **plant density** in 2025.

Product (P)	Indian Head	Melfort	Prince Albert	Scott	Yorkton
A. Urea	293.0^{a}	200.5^{a}	137.3^{a}	228.5^{a}	260.5^{a}
B. eNtrench	281.6^{a}	197.7^{a}	146.2^{a}	224.2^{a}	257.7^{a}
C. SuperU	274.9^{a}	205.3^{a}	141.3^{a}	234.0^{a}	259.0^{a}
S.E.M.	*6.63*	*7.17*	*5.15*	*4.35*	*12.64*
N Rate (lb/ac soil + fert N) (N)					
80	281.2^{a}	216.3^{a}	134.8^{a}	253.3^{a}	260.0^{a}
120	282.7^{a}	197.9^{ab}	143.8^{a}	224.2^{b}	261.7^{a}
160	285.6^{a}	189.3^{b}	146.1^{a}	209.3^{c}	255.8^{a}
S.E.M.	*6.63*	*7.17*	*5.15*	*4.35*	*12.64*
P x N					
Urea- 80 lb N/ac	296.5^{a}	210.4^{ab}	130.3^{b}	257.4^{a}	284.7^{a}
Urea- 120 lb N/ac	284.2^{a}	190.3^{b}	144.3^{ab}	213.3^{cd}	248.2^{a}
Urea- 160 lb N/ac	298.1^{a}	201.0^{ab}	137.4^{ab}	214.8^{cd}	248.6^{a}
eNtrench- 80 lb N/ac	284.2^{a}	204.6^{ab}	138.3^{ab}	250.5^{ab}	247.7^{a}
eNtrench- 120 lb N/ac	278.5^{a}	204.2^{ab}	141.9^{ab}	228.3^{c}	256.4^{a}
eNtrench- 160 lb N/ac	282.2^{a}	184.1^{b}	158.4^{a}	193.9^{d}	269.1^{a}
SuperU- 80 lb N/ac	262.9^{a}	233.8^{a}	135.9^{ab}	252.0^{ab}	246.5^{a}
SuperU- 120 lb N/ac	285.4^{a}	199.3^{ab}	145.4^{ab}	230.8^{bc}	280.6^{a}
SuperU- 160 lb N/ac	276.4^{a}	182.9^{b}	142.6^{ab}	219.2^{c}	250.0^{a}
S.E.M.	*11.48*	*12.41*	*8.93*	*7.53*	*21.9*

No N Check	289.5	201.8	141.9	265.5	232.2

Lodging

Lodging ratings were taken as an extra measurement at Yorkton (Table 9). Increasing N rate from 120 to 160 lb/ac of soil + fertilizer N significantly increased lodging from 2.7 to 5.5 (scale 0-9) (data not shown). Increasing N rate can often increase lodging under moist environments. Changing products did not significantly affect lodging and there was no interaction between product and N rate.

Table 9. F-test results of mixed-effects models of **lodging** assessing the presence of Product and N rate interactions at each site individually. Effects are considered significant if P<0.05 and significant effects are bolded for emphasis.

	Indian Head		Melfort		Prince Albert		Scott		Yorkton	
	2024	*2025*	*2024*	*2025*	*2024*	*2025*	*2024*	*2025*	*2024*	*2025*
Fixed effects										
Product (P)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.672	N/A
N rate (N)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**<0.001**	N/A
P x N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.235	N/A

Maturity

Increasing N significantly delayed maturity at Indian Head, Melfort and Yorkton in both years (Table 10, 11a and 11b). The delay in maturity for these site/years varied from 1.1 to 4.7 days. Comparisons between site/years are of little importance as differences in maturity are influenced by environment and ratings are somewhat subjective. Treatment comparisons within site are more meaningful. At Melfort (2025), a significant effect of product as well as a significant interaction between product and nitrogen rate were detected. While increasing N rate delayed maturity for all products, the effect was stronger when using eNtrench or SuperU compared to straight urea (Table 11b). While the reason for this is not certain, this may indicate more N was available later in the season when enhanced efficiency N products were used. Higher rates of N are well known to delay maturity. This trend (p=0.066) was also apparent at Prince Albert in 2024, where the use of eNtrench or SuperU delayed maturity by 2.3 days or more relative to using untreated urea (Table 11a). Nitrogen rate and product had little effect on maturity at Scott (2024). In 2025, there was a strong trend for delayed maturity (p=0.066) with increasing rate of N at Scott. There was also a small numeric delay in maturity from using enhance efficiency N products. Data from Prince Albert (2025) has been omitted because every plot was rated as having the same maturity.

Table 10. F-test results of mixed-effects models of **maturity** assessing the presence of Product and N rate interactions at each site individually. Effects are considered significant if P<0.05 and significant effects are bolded for emphasis.

	Indian Head		Melfort		Prince Albert		Scott		Yorkton	
	2024	*2025*	*2024*	*2025*	*2024*	*2025*	*2024*	*2025*	*2024*	*2025*
Fixed effects										
Product (P)	0.166	0.880	0.755	**0.002**	0.066	Omitted	0.954	0.474	0.824	0.761

N rate (N)	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.082	Omitted	0.724	0.066	**<0.001**	**<0.001**
P x N	0.873	0.597	0.592	**<0.001**	0.610	Omitted	0.496	0.785	0.814	0.089

Table 11a. Means, and LSD separations for the main effects and interactions of product and N rate on **maturity** (Julian day) in 2024.

Product (P)	Indian Head	Melfort	Prince Albert	Scott	Yorkton
A. Urea	226.6[a]	229.6[a]	234.7[a]	229.6[a]	227.1[a]
B. eNtrench	226.6[a]	229.7[a]	237.2[a]	229.6[a]	227.6[a]
C. SuperU	226.3[a]	229.4[a]	237.0[a]	229.8[a]	227.6[a]
S.E.M.	*0.14*	*0.24*	*0.8*	*0.45*	*0.65*
N Rate (lb/ac soil + fert N) (N)					
80	225.8[c]	227.8[c]	234.9[a]	229.4[a]	225.2[c]
120	226.4[b]	229.3[b]	236.3[a]	229.9[a]	227.2[b]
160	227.3[a]	231.6[a]	237.6[a]	229.6[a]	229.9[a]
S.E.M.	*0.14*	*0.24*	*0.8*	*0.45*	*0.65*
P x N					
Urea- 80 lb N/ac	225.8[de]	227.8[c]	233.0[a]	229.8[a]	225.3[d]
Urea- 120 lb N/ac	226.5[bc]	229.3[b]	235.0[a]	229.0[a]	227.3[bcd]
Urea- 160 lb N/ac	227.5[a]	231.8[a]	236.0[a]	230.0[a]	228.8[abc]
eNtrench- 80 lb N/ac	226.0[cde]	227.8[c]	235.3[a]	229.5[a]	225.3[d]
eNtrench- 120 lb N/ac	226.5[bc]	229.3[b]	236.5[a]	230.3[a]	226.8[cd]
eNtrench- 160 lb N/ac	227.3[a]	232.0[a]	239.8[a]	229.0[a]	230.8[a]
SuperU- 80 lb N/ac	225.5[e]	227.8[c]	236.5[a]	229.0[a]	225.0[d]
SuperU- 120 lb N/ac	226.3[cd]	229.5[b]	237.5[a]	230.5[a]	227.5[abcd]
SuperU- 160 lb N/ac	227.0[ab]	231.0[a]	237.0[a]	229.8[a]	230.3[ab]
S.E.M.	*0.24*	*0.41*	*1.39*	*0.77*	*1.13*
No N Check	226.0	227.8	236.0	230.3	225.0

Table 11b. Means, and LSD separations for the main effects and interactions of product and N rate on **maturity** in 2025.

Product (P)	Indian Head	Melfort	Prince Albert	Scott	Yorkton
A. Urea	231.7[a]	234.2[b]	omitted	241.8[a]	236.0[a]
B. eNtrench	231.8[a]	235.8[a]	omitted	242.2[a]	235.8[a]
C. SuperU	231.7[a]	235.7[a]	omitted	242.5[a]	235.8[a]
S.E.M.	*0.12*	*0.32*		*0.43*	*0.27*
N Rate (lb/ac soil + fert N) (N)					
80	231.1[c]	233.5[b]	omitted	241.7[b]	234.9[b]

120	231.8[b]	234.3[b]	omitted	241.8[b]	235.6[b]
160	232.2[a]	237.8[a]	omitted	243.0[a]	237.0[a]
S.E.M.	*0.12*	*0.32*		*0.43*	*0.27*
P x N					
Urea- 80 lb N/ac	231.0[c]	233.8[bc]	omitted	241.5[a]	234.5[d]
Urea- 120 lb N/ac	232.0[ab]	233.8[bc]	omitted	241.8[a]	235.5[bcd]
Urea- 160 lb N/ac	232.0[ab]	235.0[b]	omitted	242.0[a]	238.0[a]
eNtrench- 80 lb N/ac	231.1[c]	233.3[c]	omitted	241.5[a]	235.3[cd]
eNtrench- 120 lb N/ac	231.8[b]	234.5[bc]	omitted	241.5[a]	235.3[cd]
eNtrench- 160 lb N/ac	232.4[a]	239.8[a]	omitted	243.5[a]	236.8[ab]
SuperU- 80 lb N/ac	231.1[c]	233.5[bc]	omitted	242.0[a]	235.0[cd]
SuperU- 120 lb N/ac	231.8[b]	234.8[bc]	omitted	242.0[a]	236.0[bc]
SuperU- 160 lb N/ac	232.3[ab]	238.8[a]	omitted	243.5[a]	236.3[bc]
S.E.M.	*0.2*	*0.55*		*0.74*	*0.48*
No N Check	229.3	233.5		241.0	234.3

Yield

Increasing soil + Fertilizer N from 80 to 160 lb/ac significantly increased yield at all locations and years, except at Scott and Prince Albert (Tables 12, 13a and 13b). At Scott (2025), yield was significantly decreased by 9% as soil + fertilizer N increased from 80 to 160 lb/ac. The reason for this is not clear but may be related to a declining plant population from 253 plants/m^2 to 209 plants/m^2 in response to the toxic effects of added N. At this site/year a significant product by N rate interaction (p=0.052) indicated that the reduction in yield from increasing N was greatest when using SuperU. The reason for this is unclear. None of the other site/years detected a significant main effect of product or an interaction between product and N fertility rate. For sites where added N significantly increased yield, the responses were highly variable. As soil + fertilizer N was increased from 80 to 120 lb/ac, responses were relatively low at 5.7% and 7.2% for Yorkton (2024) and Indian Head (2024), respectively. In contrast, Melfort (2024) had a very strong yield response to increasing N of 36.1%. For Indian Head, Melfort and Yorkton in 2025, the responses were moderate ranging from 13 to 18%. It should be noted that the yield responses to added N are much larger for most site/years when compared to their no N checks. The exceptions to this would be Prince Albert (2025) and Yorkton (2024) as the background level of soil N was high at these locations, testing 78 lb N/ac and 63 lb N/ac in the top 24 inches of soil, respectively.

Table 12. F-test results of mixed-effects models of **grain yield** assessing the presence of Product and N rate interactions at each site individually. Effects are considered significant if P<0.05 and significant effects are bolded for emphasis.

	Indian Head		Melfort		Prince Albert		Scott		Yorkton	
	2024	*2025*	*2024*	*2025*	*2024*	*2025*	*2024*	*2025*	*2024*	*2025*
Fixed effects										
Product (P)	0.748	0.139	0.251	0.392	0.209	0.206	0.166	0.429	0.679	0.272
N rate (N)	**0.022**	**<0.001**	**<0.001**	**<0.001**	0.110	0.558	0.073	**<0.001**	**0.005**	**0.013**
P x N	0.272	0.679	0.863	0.513	0.546	0.549	0.623	**0.052**	0.683	0.607

Table 13a. Means, and LSD separations for the main effects and interactions of product and N rate on **yield** in 2024.					
Product (P)	Indian Head	Melfort	Prince Albert	Scott	Yorkton
A. Urea	4660^{a}	5075^{a}	4825^{a}	4293^{a}	5087^{a}
B. eNtrench	4745^{a}	5080^{a}	4909^{a}	4211^{a}	4995^{a}
C. SuperU	4688^{a}	4957^{a}	4714^{a}	4368^{a}	5018^{a}
S.E.M.	*79.86*	*57.55*	*75.93*	*56.3*	*75.79*
N Rate (lb/ac soil + fert N) (N)					
80	4506^{b}	4212^{c}	4709^{a}	4225^{a}	4815^{b}
120	4756^{a}	5168^{b}	4796^{a}	4401^{a}	5195^{a}
160	4830^{a}	5732^{a}	4943^{a}	4246^{a}	5090^{a}
S.E.M.	*79.86*	*57.55*	*75.93*	*56.3*	*75.79*
P x N					
Urea- 80 lb N/ac	4537^{b}	4262^{c}	4636^{a}	4217^{a}	4827^{bc}
Urea- 120 lb N/ac	4764^{ab}	5222^{b}	4916^{a}	4426^{a}	5350^{a}
Urea- 160 lb N/ac	4679^{ab}	5740^{a}	4923^{a}	4236^{a}	5083^{abc}
eNtrench- 80 lb N/ac	4387^{b}	4256^{c}	4805^{a}	4239^{a}	4830^{bc}
eNtrench- 120 lb N/ac	4771^{ab}	5251^{b}	4782^{a}	4279^{a}	5033^{abc}
eNtrench- 160 lb N/ac	5077^{a}	5735^{a}	5141^{a}	4115^{a}	5123^{abc}
SuperU- 80 lb N/ac	4596^{b}	4120^{c}	4686^{a}	4219^{a}	4789^{c}
SuperU- 120 lb N/ac	4733^{ab}	5031^{b}	4689^{a}	4497^{a}	5202^{ab}
SuperU- 160 lb N/ac	4734^{ab}	5721^{a}	4765^{a}	4387^{a}	5065^{abc}
S.E.M.	*138.32*	*99.68*	*75.93*	*97.51*	*131.28*
No N Check	2639	3278	4220	3799	4716

Table 13b. Means, and LSD separations for the main effects and interactions of product and N rate on **yield** in 2025.					
Product (P)	Indian Head	Melfort	Prince Albert	Scott	Yorkton
A. Urea	4869.9^{a}	5428.5^{a}	3791.5^{a}	3311.1^{a}	4012.8^{a}
B. eNtrench	4940.9^{a}	5362.9^{a}	4161.6^{a}	3395.2^{a}	3768.1^{a}
C. SuperU	4782.5^{a}	5511.5^{a}	3970.8^{a}	3323.1^{a}	3997.7^{a}
S.E.M.	*54.15*	*75.51*	*142.5*	*48.6*	*116.8*
N Rate (lb/ac soil + fert N) (N)					
80	4547.7^{c}	4956.9^{c}	3852.6^{a}	3446.5^{a}	3693.1^{b}
120	4903.7^{b}	5505.4^{b}	4004.4^{a}	3445.7^{a}	3869.9^{b}
160	5141.9^{a}	5840.5^{a}	4066.9^{a}	3137.2^{b}	4215.6^{a}
S.E.M.	*54.15*	*75.51*	*142.5*	*48.6*	*116.8*
P x N					
Urea- 80 lb N/ac	4584.1^{d}	4907.7^{e}	3715.4^{a}	3378.8^{ab}	3639.1^{b}
Urea- 120 lb N/ac	4930.8^{bc}	5474.6^{bc}	3871.5^{a}	3312.7^{ab}	3876.4^{b}
Urea- 160 lb N/ac	5094.7^{ab}	5903.3^{a}	3787.6^{a}	3241.8^{b}	4523.0^{a}

eNtrench- 80 lb N/ac	4572.9[d]	4979.2[de]	3917.7[a]	3448.5[ab]	3610.5[b]
eNtrench- 120 lb N/ac	5038.0[ab]	5322.4[cd]	4402.9[a]	3514.6[a]	3759.3[b]
eNtrench- 160 lb N/ac	5211.8[a]	5787.0[ab]	4164.3[a]	3222.5[b]	3934.7[ab]
SuperU- 80 lb N/ac	4486.0[d]	4983.9[de]	3924.8[a]	3512.2[a]	3829.8[b]
SuperU- 120 lb N/ac	4742.3[cd]	5719.4[ab]	3738.9[a]	3509.8[a]	3974.1[ab]
SuperU- 160 lb N/ac	5119.3[ab]	5831.1[ab]	4248.8[a]	2947.3[c]	4189.3[ab]
S.E.M.	*93.79*	*130.79*	*246.9*	*84.1*	*202.4*
No N Check	3096.4	3826.3	3747.9	3145.6	3322.9

Grain Protein

Increasing the rate of soil + fertilizer N from 80 to 160 lb/ac significantly increased grain protein at all site/years except Prince Albert (2025) (Tables 14, 15a and 15b). Subtle inconsistencies in the rate responses amongst individual N forms resulted in a significant product by N rate interaction at Prince Albert (2025); however, this response was small and not important from a practical perspective.. At Indian Head (2025), using SuperU resulted in significantly less grain protein than using straight Urea or eNtrench. The reason for this is unclear. SuperU delays the conversion of urea to ammonium and in turn ammonium to nitrate. Even if SuperU delayed the availability of N to the crop this would be expected to increase grain protein, not decrease it. Alternatively, higher yields from using SuperU could potentially reduce grain protein through dilution. However, this was not the case as SuperU had the lowest yield at this location. For the remaining site/years there were no significant effects of product on grain protein or interactions between product and nitrogen rate. In other words, there was no evidence to suggest the N supplied to the crop differed between products.

Table 14. F-test results of mixed-effects models of **grain protein** assessing the presence of Product and N rate interactions at each site individually. Effects are considered significant if P<0.05 and significant effects are bolded for emphasis.

	Indian Head		Melfort		Prince Albert		Scott		Yorkton	
	2024	*2025*	*2024*	*2025*	*2024*	*2025*	*2024*	*2025*	*2024*	*2025*
Fixed effects										
Product (P)	0.399	**0.025**	0.309	0.158	0.581	0.328	0.302	0.242	0.712	0.527
N rate (N)	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.255	**<0.001**	**<0.001**	**<0.001**	**<0.001**
P x N	0.227	0.710	0.995	0.243	0.895	**0.033**	0.876	0.084	0.433	0.346

Table 15a. Means, and LSD separations for the main effects and interactions of product and N rate on **grain protein** in 2024.

Product (P)	Indian Head	Melfort	Prince Albert	Scott	Yorkton
A. Urea	12.48[a]	13.41[a]	13.08[a]	14.00[a]	15.04[a]
B. eNtrench	12.37[a]	13.40[a]	12.85[a]	14.29[a]	14.81[a]
C. SuperU	12.38[a]	13.23[a]	13.00[a]	14.07[a]	14.87[a]

S.E.M.	*0.06*	*0.09*	*0.16*	*0.14*	*0.2*
N Rate (lb/ac soil + fert N) (N)					
80	11.07^{c}	12.20^{c}	12.46^{b}	13.28^{c}	13.48^{c}
120	12.47^{b}	13.08^{b}	13.04^{a}	14.26^{b}	15.00^{b}
160	13.68^{a}	14.74^{a}	13.42^{a}	14.83^{a}	16.28^{a}
S.E.M.	*0.06*	*0.09*	*0.16*	*0.14*	*0.2*
P x N					
Urea- 80 lb N/ac	11.10^{d}	12.23^{c}	12.69^{bcd}	13.18^{c}	13.92^{de}
Urea- 120 lb N/ac	12.47^{c}	13.18^{b}	12.98^{abcd}	14.15^{b}	15.14^{bc}
Urea- 160 lb N/ac	13.87^{a}	14.83^{a}	13.59^{a}	14.68^{ab}	16.07^{ab}
eNtrench- 80 lb N/ac	11.15^{d}	12.29^{c}	12.29^{d}	13.33^{c}	13.16^{e}
eNtrench- 120 lb N/ac	12.48^{c}	13.11^{b}	13.04^{abcd}	14.40^{b}	14.69^{cd}
eNtrench- 160 lb N/ac	13.49^{b}	14.79^{a}	13.22^{ab}	15.15^{a}	16.59^{a}
SuperU- 80 lb N/ac	10.97^{d}	12.10^{c}	12.41^{cd}	13.33^{c}	13.35^{e}
SuperU- 120 lb N/ac	12.48^{c}	12.96^{b}	13.11^{abc}	14.23^{b}	15.07^{bc}
SuperU- 160 lb N/ac	13.69^{ab}	14.61^{a}	13.46^{ab}	14.65^{ab}	16.20^{a}
S.E.M.	*0.11*	*0.16*	*0.27*	*0.24*	*0.35*
No N Check	10.43	12.59	12.00	13.20	13.82

Table 15b. Means, and LSD separations for the main effects and interactions of product and N rate on **grain protein** in 2025.

Product (P)	Indian Head	Melfort	Prince Albert	Scott	Yorkton
A. Urea	13.13^{a}	14.53^{a}	13.96^{a}	14.65^{a}	14.12^{a}
B. eNtrench	13.11^{a}	14.85^{a}	13.98^{a}	14.85^{a}	14.36^{a}
C. SuperU	12.85^{b}	14.96^{a}	14.08^{a}	14.85^{a}	14.07^{a}
S.E.M.	*0.07*	*0.16*	*0.06*	*0.09*	*0.19*
N Rate (lb/ac soil + fert N) (N)					
80	11.49^{c}	13.16^{c}	13.95^{a}	13.98^{c}	12.37^{c}
120	13.29^{b}	14.81^{b}	13.99^{a}	14.84^{b}	14.64^{b}
160	14.32^{a}	16.37^{a}	14.08^{a}	15.53^{a}	15.55^{a}
S.E.M.	*0.07*	*0.16*	*0.06*	*0.09*	*0.19*
P x N					
Urea- 80 lb N/ac	11.62^{c}	12.80^{d}	13.90^{bc}	14.11^{c}	12.65^{d}
Urea- 120 lb N/ac	13.48^{b}	14.93^{c}	13.86^{c}	14.69^{b}	14.69^{c}
Urea- 160 lb N/ac	14.32^{a}	15.85^{b}	14.13^{abc}	15.15^{b}	15.03^{abc}
eNtrench- 80 lb N/ac	11.57^{c}	13.28^{d}	13.95^{bc}	14.03^{c}	12.43^{d}
eNtrench- 120 lb N/ac	13.29^{b}	14.53^{c}	13.84^{c}	14.90^{b}	14.73^{bc}
eNtrench- 160 lb N/ac	14.47^{a}	16.75^{a}	14.16^{ab}	15.63^{a}	15.93^{a}
SuperU- 80 lb N/ac	11.27^{c}	13.40^{d}	14.00^{abc}	13.79^{c}	12.01^{d}
SuperU- 120 lb N/ac	13.11^{b}	14.98^{c}	14.27^{a}	14.95^{b}	14.49^{c}
SuperU- 160 lb N/ac	14.19^{a}	16.50^{ab}	13.96^{bc}	15.80^{a}	15.70^{ab}

S.E.M.	*0.13*	*0.28*	*0.1*	*0.16*	*0.34*
No N Check	9.29	12.28	13.82	12.93	12.54

%Tissue N and N Uptake

N uptake by the crop (kg N/ha) was determined by sampling a small amount of plant material from each plot and determining the tissue N content (2 X 0.5m). While N uptake is the measure of interest, small sample sizes can increase variability between plots. Thus, % tissue N was also analyzed for comparison. However, the F-test results were very similar between the tissue N and N uptake data with only a few exceptions (Tables 16a and 16b). At Yorkton in 2024 and 2025, the significance of N rate was lower for the tissue N data compared to N uptake. At Prince Albert 2025, only the main effect of N rate was significant for the tissue N data. For the N uptake data, only the main effect of product was significant. However, since results are so similar between the two data sets, the discussion will be restricted to the N uptake data.

N uptake by the crop (kg N/ha), as determined by the N content of above ground biomass, increased significantly with added N at all site/years except Prince Albert (Tables 16b, 17a and 17b). N uptake did increase numerically with added N at Prince Albert in 2024 but not in 2025. Despite the unresponsiveness to added N at Prince Albert in 2025, significant main effects of product were detected. N uptake was significantly lower when using eNtrench and SuperU compared to using straight urea. The reason is unclear and unanticipated since no differences in N uptake were detected with increasing N. Although unlikely, delayed release of available N with eNtrench and SuperU may have led to reduced uptake. However, this hypothesis is not supported by any associated decreases in yield or grain protein (Tables 13b and 15 b). For all other site/years, there were no significant main effects of product on N uptake or interactions between product and nitrogen rate. Overall, there was no evidence to suggest that side-banded eNtrench or SuperU had improved the nitrogen use efficiency over using straight urea.

Table 16a. F-test results of mixed-effects models of **Tissue N** assessing the presence of Product and N rate interactions at each site individually. Effects are considered significant if P<0.05 and significant effects are bolded for emphasis.

	Indian Head		Melfort		Prince Albert		Scott		Yorkton	
	2024	*2025*	*2024*	*2025*	*2024*	*2025*	*2024*	*2025*	*2024*	*2025*
Fixed effects										
Product (P)	0.550	0.499	0.694	0.536	0.877	0.242	0.100	0.684	0.673	0.737
N rate (N)	**<0.001**	**<0.001**	**0.001**	**0.001**	0.387	**0.023**	**<0.001**	**<0.001**	0.067	**0.03**
P x N	0.716	0.477	0.094	0.645	0.758	0.419	0.483	0.366	0.908	0.215

Table 16b. F-test results of mixed-effects models of **N uptake (kg N/ha)** assessing the presence of Product and N rate interactions at each site individually. Effects are considered significant if P<0.05 and significant effects are bolded for emphasis.

	Indian Head	Melfort	Prince Albert	Scott	Yorkton

	2024	2025	2024	2025	2024	2025	2024	2025	2024	2025
Fixed effects										
Product (P)	0.398	0.593	0.965	0.098	0.578	**0.001**	0.117	0.679	0.668	0.667
N rate (N)	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.427	0.675	**<0.001**	**0.138**	**0.033**	**<0.001**
P x N	0.849	0.705	0.154	0.348	0.372	0.115	0.409	1.000	0.899	0.213

Table 17a. Means, and LSD separations for the main effects and interactions of product and N rate on **N uptake (kg N/ha)** in 2024.

Product (P)	Indian Head	Melfort	Prince Albert	Scott	Yorkton
A. Urea	127.1^{a}	122.7^{a}	210.2^{a}	130.4^{a}	106.0^{a}
B. eNtrench	127.3^{a}	122.2^{a}	196.7^{a}	140.2^{a}	100.3^{a}
C. SuperU	119.9^{a}	120.0^{a}	216.2^{a}	140.8^{a}	110.5^{a}
S.E.M.	*4.35*	*7.48*	*13.32*	*3.81*	*8*
N Rate (lb/ac soil + fert N) (N)					
80	103.4^{c}	89.77^{c}	193.4^{a}	111.4^{b}	89.32^{b}
120	129.1^{b}	120.5^{b}	213.2^{a}	146.7^{a}	106.5^{ab}
160	141.8^{a}	154.7^{a}	216.6^{a}	153.4^{a}	121.0^{a}
S.E.M.	*4.35*	*7.48*	*13.32*	*3.81*	*8*
P x N					
Urea- 80 lb N/ac	106.4^{bc}	85.68^{c}	185.9^{a}	101.8^{c}	80.82^{b}
Urea- 120 lb N/ac	131.3^{a}	142.7^{ab}	199.6^{a}	139.4^{b}	113.5^{ab}
Urea- 160 lb N/ac	143.6^{a}	139.6^{ab}	245.2^{a}	150.1^{ab}	123.5^{a}
eNtrench- 80 lb N/ac	105.3^{c}	99.40^{c}	199.3^{a}	119.1^{c}	89.68^{ab}
eNtrench- 120 lb N/ac	127.5^{ab}	109.1^{bc}	214.1^{a}	153.9^{ab}	98.36^{ab}
eNtrench- 160 lb N/ac	149.2^{a}	158.2^{a}	176.7^{a}	147.7^{ab}	112.9^{ab}
SuperU- 80 lb N/ac	98.63^{c}	84.23^{c}	195.0^{a}	113.2^{c}	97.46^{ab}
SuperU- 120 lb N/ac	128.4^{ab}	109.6^{bc}	225.8^{a}	146.9^{ab}	107.7^{ab}
SuperU- 160 lb N/ac	132.7^{a}	166.2^{a}	277.8^{a}	162.4^{a}	126.4^{a}
S.E.M.	*7.54*	*12.96*	*23.07*	*6.59*	*13.86*
No N Check	64.46	69.75	180.2	93.98	107.5

Table 17b. Means, and LSD separations for the main effects and interactions of product and N rate on **N uptake (kg N/ha)** in 2025.

Product (P)	Indian Head	Melfort	Prince Albert	Scott	Yorkton
A. Urea	100.2^{a}	161.8^{a}	150.2^{a}	62.5^{a}	185.6^{a}
B. eNtrench	104.5^{a}	155.4^{a}	137.7^{b}	64.0^{a}	192.1^{a}
C. SuperU	103.4^{a}	174.9^{a}	135.8^{b}	62.1^{a}	197.2^{a}
S.E.M.	*3.1*	*6.21*	*3.3*	*1.62*	*9.02*
N Rate (lb/ac soil + fert N) (N)					

80	89.6^{c}	136.1^{b}	143.6^{a}	61.0^{a}	162.5^{c}
120	102.7^{b}	173.0^{a}	140.4^{a}	62.0^{a}	191.3^{b}
160	115.8^{a}	183.0^{a}	139.7^{a}	65.5^{a}	221.1^{a}
S.E.M.	*3.1*	*6.21*	*3.3*	*1.62*	*9.02*
P x N					
Urea- 80 lb N/ac	87.5^{c}	145.6^{cd}	148.7^{ab}	60.5^{a}	150.8^{d}
Urea- 120 lb N/ac	95.7^{bc}	168.5^{abc}	147.5^{ab}	61.8^{a}	184.0^{bcd}
Urea- 160 lb N/ac	117.3^{a}	171.1^{abc}	154.4^{a}	65.1^{a}	222.1^{ab}
eNtrench- 80 lb N/ac	89.5^{c}	122.7^{d}	147.6^{ab}	62.0^{a}	157.4^{cd}
eNtrench- 120 lb N/ac	107.3^{ab}	158.2^{bc}	140.0^{abc}	63.1^{a}	179.2^{bcd}
eNtrench- 160 lb N/ac	116.9^{a}	185.3^{ab}	125.5^{c}	66.9^{a}	239.6^{a}
SuperU- 80 lb N/ac	91.7^{bc}	139.8^{cd}	134.5^{bc}	60.4^{a}	179.2^{bcd}
SuperU- 120 lb N/ac	105.2^{ab}	192.3^{a}	133.7^{bc}	61.2^{a}	210.7^{ab}
SuperU- 160 lb N/ac	113.4^{a}	192.5^{a}	139.3^{abc}	64.6^{a}	201.7^{abc}
S.E.M.	*5.37*	*10.75*	*5.72*	*2.8*	*15.62*
No N Check	54.9	111.4	145.8	51.4	137.3

Conclusions and Recommendations *(maximum 500 words)*

Highlight significant conclusions based on the findings of this project, with emphasis on the project objectives specified above. Provide recommendations for the application and adoption of the project findings.

Overall, increasing soil + fertilizer N from 80 to 160 lb/ac significantly increased lodging (one site/year), delayed maturity whileincreasing yield, grain protein concentrations, and N uptake. At Scott, increasing N significantly decreased yield but this may have been related to an associated decrease in plant population. For some site/years, side-banding enhanced efficiency fertilizers delayed crop maturity, suggesting there may have been more N available when using these products. However, this was not supported by any associated increases in yield, grain protein or N uptake. Side-banding with eNtrench to reduce denitrification and leaching losses, or with SuperU to further reduce volatilization losses, did not result in any more yield, grain protein or N uptake benefits relative to using untreated urea. This implies that the N use efficiency of side-banded urea was not improved by using eNtrench or SuperU. It is possible that the urease inhibitor in SuperU reduced the volatilization loss of NH_3 or the nitrification inhibitors in both SuperU and eNtrench reduced the loss of N_2O and N_2 gas. While not directly measured in this study, mitigation of any N loss by either eNtrench or SuperU was too small to impact yield or grain protein and, as such, their use would not have provided any economic benefit to the producer. In this study, side-banding was deep enough to minimize volatilization losses and soil moisture was not high enough to drive substantial denitrification or leaching losses of NO_3. Financial incentives would be necessary to encourage producers to side-band eNtrench or SuperU over untreated urea.

Follow-up Work

Please identify if there is a need to conduct further work. Detail any further projects and/or communication needs arising from this project.

Reductions in N_2O emissions from side-banding enhanced efficiency N fertilizers need to be related to lb N/ac lost to crop production. For example, a 50% reduction in N_2O emissions sounds impressive but it may be agronomically insignificant to the producer if that only represents a couple pounds per acre of actual N. More clarity is needed.

Patents/ IP generated/ Commercialized Products

List any products developed from this project.

None

Sustainable Canadian Agricultural Partnership (Sustainable CAP) Performance Indicators

a) List of performance indicators

Sustainable CAP Indicator	Total Number
Scientific publications from this project (List the publications under section b)	
• Published	None
• Accepted for publication	None
HQPs trained during this project	
• Master's students	None
• PhD students	None
• Post docs	None
Knowledge transfer products developed based on this project (presentations, brochures, factsheets, flyers, guides, extension articles, podcasts, videos)[1]	

[1] Please only include the number of unique knowledge transfer products.

b) List of scientific journal articles published/accepted for publication from this project.

Title	Author(s)	Journal	Date Published or Accepted for Publication	Link (if available)

c) List of knowledge transfer products/activities developed from this project.

Knowledge Transfer Product or Activity	Event/Location Where Knowledge Transfer Was Conducted	Estimated Number of Producers/Processors Participated In Knowledge Transfer	Link (if available)
Video:	Youtube	In progress	
Research Farm Tour 2024 & 2025	Yorkton	200	
IHARF Field Day 2024 &	Indian Head	300	

2025			

Contributions and Support

List any industry contributions or support received.

None

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Appendices

Include any additional materials supporting the previous sections, e.g. detailed data tables, maps, graphs, specifications, literature cited (Use a consistent reference style throughout).