SFP interim report

1. **Project Title:** Top Dressing Nitrogen Fertilizer on Frozen or Snow Covered Soils in Saskatchewan

2. **Project Number:** #20200439

3. **Contractor undertaking the project:**
   Northeast Agriculture Research Foundation
   Brianne McInnes, Research Associate
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4. **Project locations:**
   This project will be conducted at eight AgriARM locations:
   Wheatland Conservation Area (WCA) – Swift Current, SK
   Northeast Agriculture Research Foundation (NARF) – Melfort, SK
   Indian Head Agricultural Research Foundation (IHARF) – Indian Head, SK
   South East Research Farm (SERF) – Redvers, SK
   Irrigation Crop Diversification Corporation (ICDC) – Outlook, SK
   Conservation Learning Centre (CLC) – Prince Albert, SK
   East Central Research Foundation (ECRF) – Yorkton, SK

5. **Project start and end dates (month & year):**
   Start: November/2020
   Completion: December/2022

6. **Project contact person & contact details:**
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   Crops Extension Specialist, Tisdale
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7. **Project objectives:**
   The objectives of the project are to develop Saskatchewan specific data showing the loss of production and economic risks associated with broadcast applications of nitrogen fertilizers on frozen and snow covered soils.

8. **Project Rationale:**
   The use of nitrogen fertilizers has a large impact on crop production in western Canada. It is often the largest single bulk nutrient that is applied annually to crops such as wheat, barley, canola, etc. High rates of nitrogen being applied at seeding can significantly slow down operations due to the extra time required to haul and fill seeder tanks. As well, there are added labour requirements and increased capital investment for trucks to haul the product and seeders capable of banding. In response to these logistical issues, producers have looked at ways to apply nitrogen fertilizer at different times of the year. One of these practices involves

the broadcasting granular nitrogen fertilizer onto cold or frozen soils often covered with snow. This practice has started to be utilized more in many regions across the province. Some producers have opted to use products that can help to reduce losses associated with broadcasting nitrogen fertilizers such as urease inhibiters (Agrotain) and/or nitrification inhibitors (Super U) while other do not.

To date there is very little Saskatchewan specific independent information or research available to agronomist or producers that directly measures the potential losses (crop yield and economic cost) for nitrogen broadcast onto frozen or snow covered ground with or without the use of a nitrification and/or urease inhibitors. Furthermore, there is potential to have regional differences in nutrient losses within the province of Saskatchewan, due to significant differences in soil type and growing season moisture. In order to account for some of the regional variability this project will be conducted on multiple sites across the province to determine if nitrogen losses and crop responses are different due to environmental factors as well as soil types.

9. Methodology:

The test was a Randomized Complete Block Design (RCBD) with 4 replicates. Plots were to be at least 3 m by 9 m in size. All plots received nitrogen applications based on soil test recommendations. The method of application and timing for nitrogen was based on treatments. All plots received a seed placed phosphorus application at a rate of 34 kg P_2O_5/ha. The plots were seeded to hard red spring wheat.

All applications of pesticides were done on an as required basis.

Treatments:

1. 1x Urea broadcast mid-November
2. 1x Super U (urease + nitrification inhibitor) broadcast mid-November
3. 1X Anvol (urease inhibitor) treated Urea mid-November
4. 1x Urea broadcast early February
5. 1x Super U broadcast early February
6. 1X Anvol treated Urea early February
7. 1x Urea broadcast early April
8. 1x Super U broadcast early April
9. 1X Anvol treated Urea early April
10. Spring side band 1x urea at seeding

Data collection:

Fall soil test/recommendations
Fertility rate
Application dates
Soil temperature at application
Depth of frozen soil at application
Snow depth at application
Meteorological data Nov – April

Seeding rate and date
Crop Variety
Seed and nitrogen costs
Grain yield
Grain protein

10. Progress:

Operations:
Six sites (CLC, ECRF, IHARF, NARF, SERF and WCA) were established in November, 2020 under dryland conditions and one site (ICDC) conducted the project under irrigated conditions. Locations of these sites were: Prince Albert, Yorkton, Indian Head, Melfort, Redvers, Swift Current and Outlook, Saskatchewan. Research was commenced and completed for all seven sites in 2021.

At the time of reporting, six of the seven sites had submitted data. The only site not reporting (IHARF) has indicated that the project had been completed but due to other commitments the data will be submitted at a later date.

Target application dates for the broadcast nitrogen fertilizers was the middle of November, early February, and early April, with a comparison side band treatment that was applied during seeding. All applications were completed within the month specified in the protocol but there were some deviations from the targeted date (Table 1). The reason for these deviations was not known at the time of this report.

Table 1. 2020-21 Broadcast application dates.

Timing	CLC	ECRF	ICDC	NARF	WCA	SERF	IHARF
1st	16-Nov-20	10-Nov-20	17-Nov-20	16-Nov-20	19-Nov-20	14-Nov-20	16-Nov-20
2nd	2-Feb-21	9-Feb-21	16-Feb-21	16-Feb-20	1-Feb-21	15-Feb-21	19-Feb-21
3rd	1-Apr-21	22-Apr-21	15-Apr-21	8-Apr-20	7-Apr-21	6-Apr-21	9-Apr-21
Seeding	13-May-21	14-May-21	5-May-21	10-May-21	5-May-21	6-May-21	6-May-21

Environmental conditions such as soil temperature and snow depth were recorded for each of the broadcast application timings and precipitation was recorded for the May to August growing season (Tables 2, 3 & 4). These recordings indicate that at ICDC, NARF and WCA the soils were not frozen at the time of the first application and as expected all were frozen by the second application timing. As well, all sites had snow cover to a varying degree for the first and second application timings but only the CLC had snow cover during the third. All sites, with the exception of SERF and IHARF, received below average precipitation throughout the 2021 growing season.

Table 2. Soil temperature at broadcast application date (°C).

Timing	CLC	ECRF	ICDC	NARF	WCA	SERF	IHARF
1st	-7	-4	1.8	1	2.4	-1	-2
2nd	-5.5	-12	-10.5	-10	-5.2	-25.6	-18
3rd	2.5	0	4	1	3.8	11.5	5

Table 3. Snow cover depth at broadcast application date (cm).

Timing	CLC	ECRF	ICDC	NARF	WCA	SERF	IHARF
1st	28	1.5	26	19	30	2	9
2nd	39	20	24	26	11	20.5	9.5
3rd	6	0	0	0	0	0	0

Table 4. May - August precipitation (mm).

	CLC	ECRF	ICDC	NARF	WCA	SERF	IHARF
2021	151.8	147.6	Irrigated	146	159.3	247.1	295.1
Long-term avg.	251.5	272.0	-	265	213.7	N/A	244.1

Soil tests were conducted for all sites and residual nitrogen was recorded as well as the application rate for all timings (Table 5). The SERF soil test data and IHARF application rates were unavailable at the time of the report. With the exception of ECRF, most soil tests indicated a low residual nitrogen level.

Table 5. Soil residual nitrogen and application rates (kg/ha).

	CLC	ECRF	ICDC	NARF	WCA	SERF	IHARF
Residual (0-15)	9	76	3	15	25	76*	5.6
Residual (15-30)	7	13	3	12	6	N/A	10.1
Applied	144	78	155	172	112	78	N/A

* Soil test for 0-30 cm

Yield:
Grain yield was measured for each plot and adjusted to 14.5% moisture content. Mean yields are reported in Table 6 for the six sites that submitted for this report. The results were statistically compared through analysis of variance with multiple comparisons of means. The Coefficient of Variance (CV), Least Significant Difference (LSD) for the 95% and 99% confidence intervals and indication of significance are also reported in Table 6.

Table 6. 2021 Mean grain yields adjusted to 14.5% moisture content (kg/ha).

Treatment	CLC	ECRF	ICDC	NARF	WCA	SERF
Urea mid-Nov	3427	2678	4939	3273	949	2924
Super U mid-Nov	3685	2748	5561	3312	1030	2889
Anvol mid-Nov	3718	2731	5488	3086	898	3021
Urea early Feb	3560	2831	5182	2985	1044	3027
Super U early Feb	3487	2765	5466	2906	982	3183
Anvol early Feb	3153	2816	5031	2972	1006	2834
Urea early April	3679	2589	5795	2798	1023	3064
Super U early April	3604	2858	5895	3019	989	3097
Anvol early April	3571	2835	5811	2892	1132	3136
Side band	3723	2758	6020	2996	1088	3445
CV (%)	11.7	8.6	8.3	10.9	11.2	6
LSD (0.05)	900	400	659	578	171	265
LSD (0.01)	1211	539	868	780	231	357
Significance	NS	NS	**	NS	**	**

Three sites (CLC, ECRF and NARF) showed no significant differences between treatments (Table 6). There are a number of reasons that contributed to these sites showing no significant differences. Firstly, each of these sites received more than 100 mm of precipitation less than the long-term average during the growing season (Table 4). In the case of the CLC and NARF the high target yields led to increased nitrogen application rates (Table 5). These high rates were likely able to supply the crop with highest yield potential for all treatments regardless of losses, given the reduced precipitation. In the case of ECRF, the target yields were also high but the maximum yield potential was met with the high soil residual nitrogen rather than the amount that was applied (Table 5).

While the WCA site also received less than the long-term average precipitation (Table 4), the data showed there were some significant differences (Table 6). The greatest yields were achieved where the nitrogen was broadcast in early April with the use of a urease inhibitor (Anvol) or side banded at seeding (Figure 1). Significant differences were few but in this case the trend showed that broadcasting nitrogen in early April with the use of a urease inhibitor (Anvol) or side banded at seeding had better yield potential than broadcasting nitrogen on snow covered soils, frozen or not.

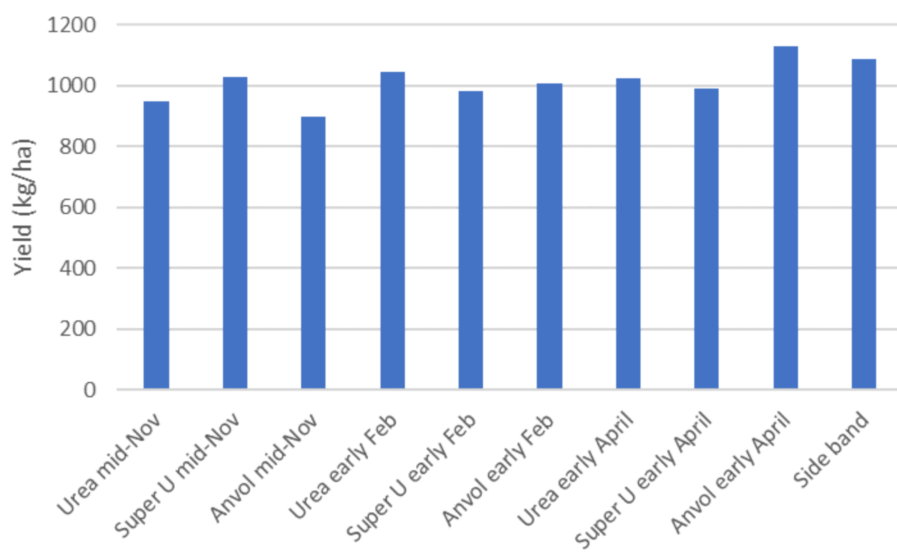

Figure 1. 2021 WCA mean yield by treatment.

The SERF site had the second highest precipitation over the growing season of all the dryland sites (Table 4). This gave it a higher yield potential than the sites that had much lower than the long-term average precipitation. Data indicated that the treatment where nitrogen was applied in the side band had a higher yield than any of the broadcast applications (Figure 2). As well, the yield of the side band treatment was significantly better than all other treatments except where the nitrogen was broadcast in early February with a nitrification and urease inhibitor.

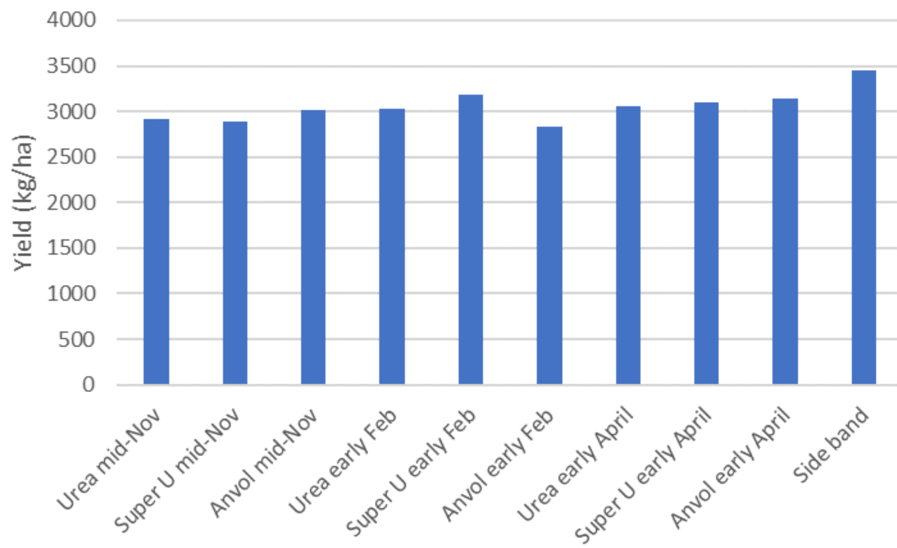

Figure 2. 2021 SERF mean yield by treatment.

Moisture was not a limiting factor at ICDC since it was supplied through irrigation. This led to the highest yield potential of all the locations. The greatest yield was again achieved when the nitrogen was applied at seeding as a side band treatment (Figure 3). Early April broadcast applications showed similar yield responses to the side band application and were greater than applications made in mid-November and early February when the ground was covered with snow.

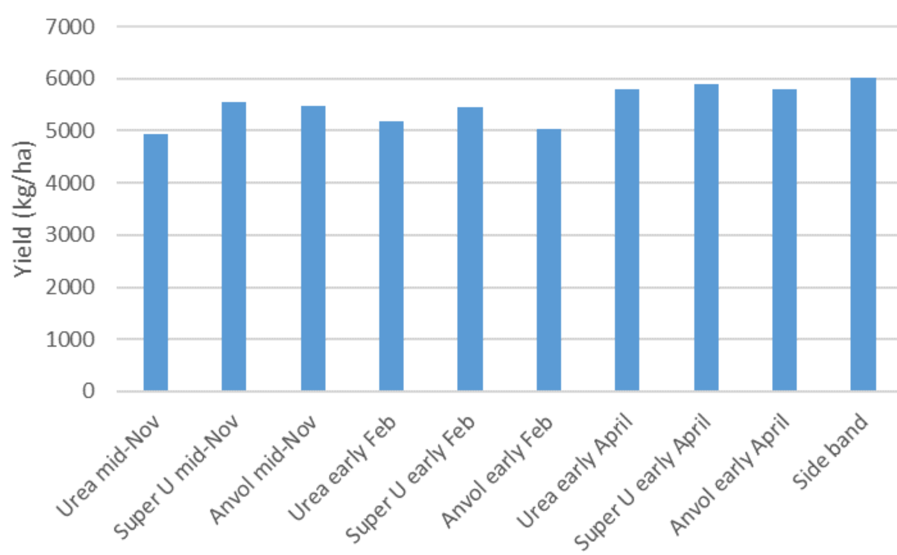

Figure 3. 2021 ICDC mean yield by treatment.

Protein:

The percent protein was assessed for each grain sample that was harvested from each plot. The mean protein percentages are reported for each site in Table 7. At the time of reporting the protein data was not available for two of the seven sites (IHARF and SERF) but will be analyzed at a later date.

Table 7. 2021 Mean grain protein (%).

	CLC	ECRF	ICDC	NARF	WCA
Urea mid-Nov	12.5	15.3	10.6	14.6	19.2
Super U mid-Nov	13.4	15.4	12.6	14.6	19.3
Anvol mid-Nov	13.4	15.1	11.3	14.8	19.7
Urea early Feb	12.8	15.2	11.1	13.1	17.9
Super U early Feb	12.5	15.5	11.0	13.7	18.3
Anvol early Feb	13.1	15.2	10.9	13.2	17.9
Urea early April	12.1	15.5	12.0	13.5	19.3
Super U early April	13.3	15.2	12.4	13.7	19.1
Anvol early April	13.1	15.3	12.5	13.6	19.0
Side band	14.3	15.2	13.6	15.4	19.2
CV (%)	5.5	1.8	8.3	4.5	2.4
LSD (0.05)	1.57	0.47	1.39	1	0.64
LSD (0.01)	2.12	0.63	1.88	1.34	0.86
Significance	**	NS	**	**	**

Four of the five sites reporting (CLC, ICDC, NARF and WCA), showed highly significant differences in protein levels (Table 7). As well, there was a significant range in protein levels from site to site (10.6 to 19.7 %). This is likely reflective of the available moisture during the growing season.

Three of the four sites showing significant differences indicated that the highest grain protein was achieved where the nitrogen fertilizer was side banded at seeding. Data from the CLC site (Figure 4) indicates that the grain protein level of the side band treatment was significantly greater than all broadcast treatments that used bare urea and the February broadcast application of Super U. There were no significant differences between any of the broadcast treatments. This would seem to indicate that there is a trend for nitrogen products treated with urease and/or nitrification inhibitors to help to improve grain protein levels of broadcast urea but, not significantly and not to the level that can be achieved through side banding untreated urea.

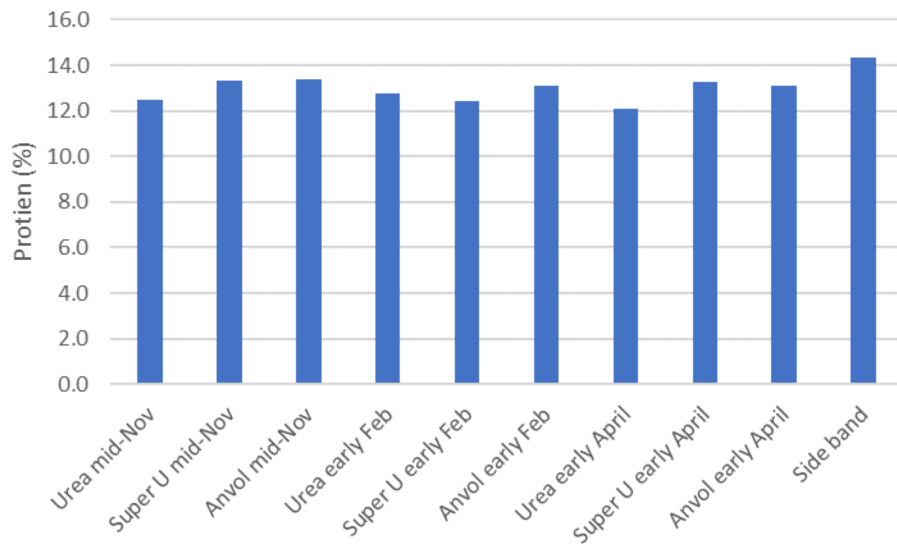

Figure 4. 2021 CLC mean protein by treatment.

While adequate moisture at the ICDC site due to irrigation produced the highest yields, it also produced the lowest grain protein. This is likely due to a limitation of available nitrogen during the growing period where the plants were building grain protein. Data from the ICDC site (Figure 5) indicates that the grain protein level of the side band treatment was greater than all of the broadcast treatments. As well, the analysis of variance showed that this difference was significantly greater seven out of nine times. In this case the addition of urease and/or nitrification inhibitors did not appear to have any consistent benefit for building grain protein.

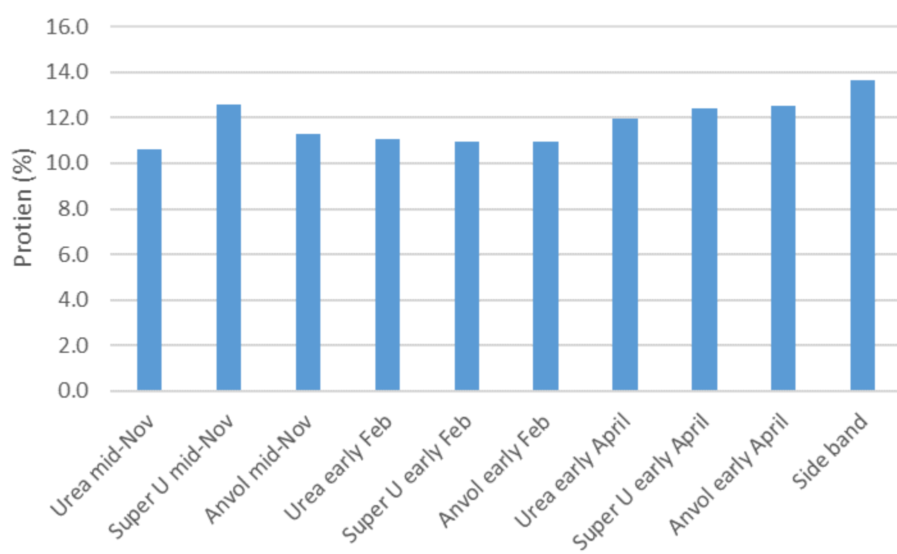

Figure 5. 2021 ICDC mean protein by treatment.

Data from the NARF site also showed that maximum grain protein was reached with the side band treatment (Figure 6). The analysis of variance indicated that the increase in grain protein achieved with the side band treatment was significantly greater than the all broadcast applications made in early February and early April. The difference was not significant when comparing the mid-November applications to the side band treatment. Again, the addition of urease and/or nitrification inhibitors did not appear to have any consistent benefit for building grain protein at the NARF site.

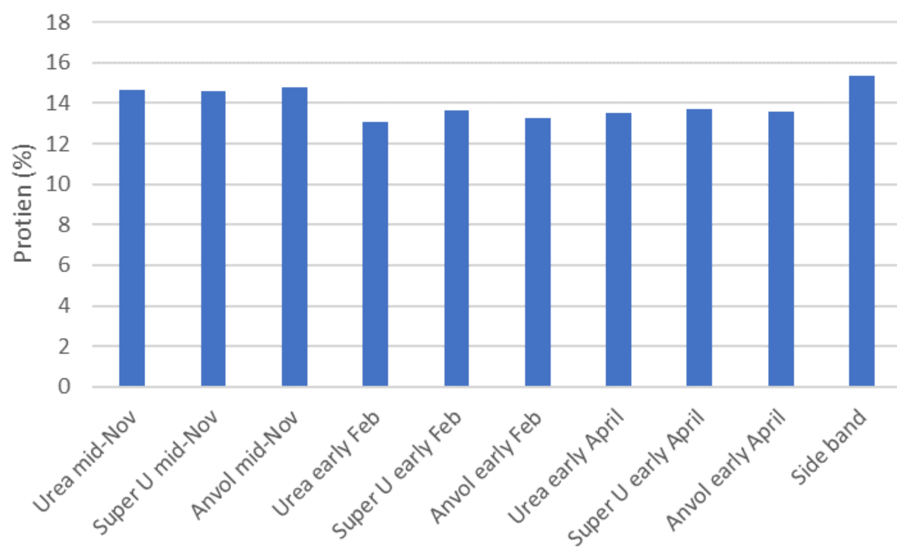

Figure 6. 2021 NARF mean protein by treatment.

Overall the WCA site recorded the highest grain protein of all the sites reporting. The average grain protein for the WCA site was 18.9% compared to 15.3% (ECRF), 14.0% (NARF), 13.0% (CLC) and 11.8% (ICDC). This is not surprising since the WCA also recorded the lowest yield and low wheat yields are generally characterized by reduced starch content. Thus, the relative amount of protein to starch is higher.

There was no significant difference in grain protein at the WCA site for any treatments where nitrogen was broadcast in mid-November, early April or side banded at seeding (Figure 7). There was however, a significant reduction in grain protein content for the treatments where nitrogen was broadcast in early February compared to all other applications. Again, the addition of urease and/or nitrification inhibitors did not show any positive or negative benefits for building grain protein at the WCA site.

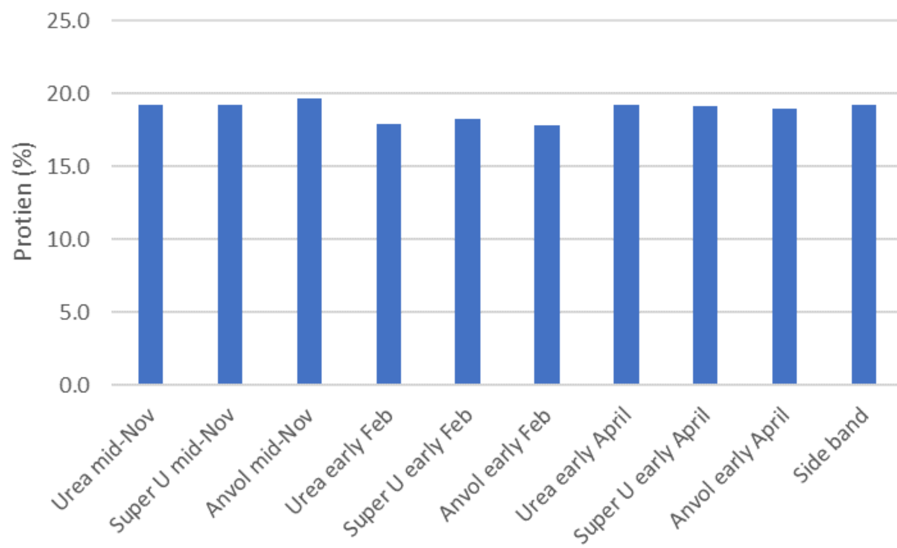

Figure 7. 2021 WCA mean protein by treatment.

Economics:
The economics will be considered in the final report.

Preliminary Conclusions:
Hot and dry growing conditions in 2021 and high nitrogen availability (either applied or residual) at three locations (CLC, ECRF and NARF) reduced the yield potential to the point where there was sufficient nitrogen available to supply the crop needs regardless of runoff or leaching losses. Therefore, no significant differences in yields were recorded at these sites.

At the WCA site the low yields indicated that moisture was somewhat limiting. However, some significant differences were found. Here the greatest yields were found on treatments where nitrogen was broadcast in early April with the use of a urease inhibitor (Anvol) or side banded at seeding.

At sites where moisture was more adequate (ICDC and SERF) significant yield differences were recorded. These two sites showed that maximum yield was only achieved when the nitrogen was side banded.

Significant grain protein differences were recorded at four of the five sites reporting grain protein. Three of these four sites (CLC, ICDC and NARF) found that grain protein was highest for the side banding treatment. The fourth site (WCA) indicated that a significant reduction in grain protein happened when nitrogen was broadcast on frozen/snow covered soils.