Project Identification

1. **Project Title:** Lentil Phosphorus Response in the North-Central Region
2. **Project Number:** 20200504
3. **Producer Group Sponsoring the Project:** Saskatchewan Conservation Learning Centre
4. **Project Location(s):** Conservation Learning Centre – Prince Albert, SK
   SW 20 46 26 W2 RM #461
   Coordinates of corners: N53˚01.732' W105˚45.678'
   N53˚01.733' W105˚45.649'
   N53˚01.686' W105˚45.677'
   N53˚01.689' W105˚45.650'
5. **Project start and end dates (month & year):** April 2021 to February 2022
6. **Project contact person & contact details:**

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Objectives and Rationale

7. Project objectives:

This project was intended to demonstrate how lentils respond to the application of P fertilizer in the north-central region of Saskatchewan. The project also determined if starter N fertilizer would positively impact lentil yields.

8. Project Rationale:

Lentil production in Saskatchewan began in the 1970s with 600 hectares being grown. In 2016, the production of lentils in Saskatchewan increased to 2.1 million ha. Lentils are a cold-season crop. They are best adapted to brown and dark brown soil zones, and can also be grown in the thin black soil zones of Saskatchewan (McVicar et al., 2017). In the last few years, the production of lentils in the north-central region of the province has been increasing. Between 2018 and 2019, the total seeded acres of lentils in the north-central crop district increased from 8,587 to 9,462 (Government of Saskatchewan, 2018; Government of Saskatchewan, 2019). Lentils are grown primarily for human consumption as they are high in protein and fibre (McVicar et al., 2017). Canadian producers exported an estimated 3.19 million tonnes of lentils in 2020-2021 (Franz-Warkentin, 2021). Lentils are a valuable addition to crop rotations in the region. Lentils reduce the need for high rates of nitrogen fertilizer and help improve the economic returns of following crops via N-fixation (McVicar et al., 2017).

Strategies that address some of the challenges associated with growing lentils in a more northern environment could greatly benefit local producers that want to incorporate this crop into their rotation. Lentils have a relatively high phosphorus requirement. Phosphorus helps to develop and promote extensive root systems and vigorous seedlings (McVicar et al., 2017). P application has the potential to increase protein content, increasing grain quality and market value (Singh and Singh, 2016). Low spring soil temperatures in the north-central region slow down early plant development and root growth which can make immobile P more difficult for plants to access, hindering early root development and proper formation of nodules (Dona et al., 2019). Mitigating the impacts of cold soil temperatures by adding seed placed P fertilizer may make growing lentils more feasible for producers in the region.

Additionally, small amounts of nitrogen fertilizer applied at seeding can help support lentil seedlings for the first couple of weeks prior to nodule development and nitrogen fixation (Dona et al., 2019). Placing a small amount of N in the seed row allows the crop to benefit from the nitrogen sooner than if it were side-banded.

High rates of seed-placed fertilizer can lead to seed damage and desiccation. Finding the right rate of fertilizer to apply is crucial to maximize yields and minimize crop damage. As the demand for lentils continues to grow, finding the optimal rates of starter fertilizer for this crop across several different field sites, soils and climate regions in Saskatchewan will help farmers across the province maximize yield and quality, which will improve returns.

A field study was conducted in Saskatchewan in 2019 investigating how lentils and soybeans responded to a starter blend of N-P fertilizer, a 28-26-0 blend of 50% MAP and 50% urea (Dona et al., 2019). The researchers found that a rate of 10 kg N and P_2O_5/ha maximized yield for both crops and did not significantly reduce plant emergence. Reproducing this study using 28-26-0 fertilizer in the Prince Albert area would provide local lentil producers with good insights into safe rates of seed placed fertilizer in the black soil zone and under different climatic conditions. Additionally, adding treatments of starter MAP alone would help determine if urea application is necessary to maximise yields in lentils, as MAP already contains small amounts of nitrogen.

Methodology and Results

9. Methodology:

This 1-year trial was set up with a randomized complete block design. To demonstrate how lentils respond to the application of phosphorus fertilizer and to determine if starter nitrogen fertilizer would positively impact lentil yields, seven different fertilizer applications were used as treatments. A description of all the treatments can be found in Table 1. The treatments were replicated 4 times and plots measured approximately 2 meters wide by 7 meters in length. CDC Proclaim lentils were seeded with a Fabro plot seeder with double disk openers on May 14th into oat stubble at a rate of 44.3 kg/ha for a target plant stand of 130 plants/m^2. The seeding rate was determined based on the Saskatchewan Pulse Growers' recommended seeding rate. Soil temperature at seeding was 12.6°C. Lentils were seeded to a depth of 1.5-1.75 inches and rows were spaced 10 inches apart.

Table 1. Treatments in the "Lentil Phosphorus Response in the North-Central Region" project.

Trt #	Treatment Description
1	0 kg/ha
2	10 kg P/ha MAP
3	20 kg P/ha MAP
4	30 kg P/ha MAP
5	10 kg N/ha 28-26-0 blend (50% urea:50% MAP)
6	20 kg N/ha 28-26-0 blend (50% urea:50% MAP)
7	30 kg N/ha 28-26-0 blend (50% urea:50% MAP)

Verdesian Primo Pulse liquid inoculant was applied at a slightly higher rate than the label suggested to ensure proper inoculation. Inoculant was applied at a rate of 63.3 mL/22.7 kg of seed. Poast Ultra and Merge was applied as a post-emergent herbicide on June 22nd at a rate of 0.3 L Poast Ultra/ac and 0.75 L Merge/100 L of spray solution. On July 12th, Miravis Neo 300 SE fungicide was applied at a rate of 505 mL Miravis/ac. No insecticides were used in the trial.

On August 5th, a harvest aid was applied to all treatments. Plots received an application of 1.11 L Reglone/ac to 125 L water/ac. However, the aerial sprayer rate was mistakenly used instead of the ground sprayer rate, resulting in a higher than the recommended application of the harvest aid. There were no apparent negative effects from the higher application rate of Reglone. A full agronomic summary can be found in Table 2.

Table 2. Agronomic summary

Seeding Date	May 14th
Seeding Method	Fabro plot seeder with double disc openers and 10 in row spacing
Seeding Rate	CDC Proclaim Lentils seeded at 44.3 kg/ha
Soil Temp at Seeding	12.6°C
Stubble	Oat
Seed Depth	1.5-1.75 in
Fertilizer Rates	Nitrogen (Urea 46-0-0) and Phosphorus (MAP 11-52-0) rates: · Trt 2: 39 kg urea/ha and 19 kg MAP/ha · Trt 3: 37 kg urea/ha and 38 kg MAP/ha · Trt 4: 35 kg urea/ha and 58 kg MAP/ha 28-26-0 blend (made by Nutrien at 50% Urea:50% MAP) rates: · Trt 5: 36 kg blend/ha · Trt 6: 71 kg blend/ha · Trt 7: 107 kg blend/ha
Inoculation Method	Liquid inoculant on-seed prior to seeding
Inoculation Rate	Verdesian Primo Pulse at 63.3 mL/22.7 kg of seed
Plant Density Counts	Number of plants in 2 x 1 m rows on June 16th
Post-Emergent Herbicide	Poast Ultra at 0.3 L/ac and Merge at 0.75 L/100 L spray solution on June 22nd
Fungicide	Miravis Neo 300 SE at 505 mL/ac on July 12th
Nodulation	Assessed using the methods outlined in the Saskatchewan Pulse Growers Nodulation and Nitrogen Fixation Guide on July 13th
Harvest Aid	Reglone @ 1.11 L/ac to 125 L water/ac on August 5th NB: The aerial sprayer rate was mistakenly used instead of the ground sprayer rate.
Harvest Date	August 13th
Harvest Method	Wintersteiger Quantum plot combine
Soil Type	Clay loam
Soil Zone	Black

To determine how lentils would respond to different phosphorus (MAP 11-52-0) fertilization rates, P fertilizer was applied to treatments at varying rates. Composite soil samples from the trial area were submitted to Agvise Laboratories who provided the fertilizer recommendations for a lentil yield goal of 2491 lbs/ac. For treatments 2-4, nitrogen (Urea 46-0-0) was applied based on rates recommended from soil test results. Soil test results can be found in Table 4. Treatments 5, 6, and 7 received an application of a custom Nutrien blended fertilizer (28-26-0), comprised of 50% phosphorus and 50% nitrogen. The fertilizer rates applied in each treatment can be found in the Agronomic summary (Table 2). All fertilizer was seed-placed in order to examine the effects of different rates of seed placed fertilizer on early root development, nodulation and yield in lentils.

Data collection for this project included plant density counts, assessment of nodulation and plant vigour, assessment of the average number of pods per plant and the average number of grains per pod, thousand kernel weights, and yields. On June 16th, spring plant densities were counted in 2 x 1-meter rows at the front and back of each plot. Nodulation was assessed on July 13th based on the methods outlined in the Saskatchewan Pulse Growers Nodulation and Nitrogen Fixation Guide. Lentil harvest occurred on August 13th with the CLC's Wintersteiger Quantum plot combine. Lentil yields were determined by combining all 6 rows of each plot and correcting to 13% moisture. Just prior to harvest, 10 randomly selected plants per plot were collected. The pods were then collected, and seeds were counted. Thousand kernel weights were determined based on standard practices.

Data analysis was completed by ANOVA using Statistix 10 software. Any non-parametric data was analyzed using the Kruskal-Wallis test. Post-hoc tests used were LSD for parametric data and Dunn's multiple comparisons test for non-parametric data.

10. Results

Weather

The 2021 growing season at the CLC was very hot and dry compared to past years (Table 3). Average temperature for the entire growing season was nearly 1˚C warmer than the long-term average. Total precipitation in the 2021 growing season was 97.1 mm lower than the long-term average. Heat and drought conditions likely contributed to very poor yields observed in the lentils in the 2021 growing season. Precipitation was very low in May. July was also exceptionally dry (9.6 mm) when compared to the long-term average of 84.6 mm, and hot with 10 days above 30°C. Lentil yields likely suffered from high heats and minimal soil moisture during flowering-pod fill. Higher than average precipitation in August may have mitigated some drought related losses were it not for the accelerated maturity in the lentils in the hot and dry conditions, resulting in an early harvest on August 13. The first fall frost occurred on October 2 (-0.9˚C), long after the lentils had been harvested. The complete monthly weather summaries can be downloaded from src.sk.ca/download-weather-summaries .

Table 3. Weather conditions in the 2021 growing season at the Conservation Learning Centre from the onsite SRC weather station.

	May	June	July	August	September	October	Average/Total
				--- Mean Temperature (°C) ---			
2021	10.1	18.3	20.3	17.0	13.5	4.9	14.0
2012-2020	11.4	15.9	18.5	17.1	11.4	2.9	12.9
				--- Precipitation (mm) ---			
2021	29.8	84.0	9.6	57.0	9.5	13.9	202.3
2012-2020	40.4	79.6	84.6	42.9	31.2	20.7	299.4

Soil Test Results

Soil samples were collected using a Dutch soil auger on May 6, 2021 and sent to Agvise Laboratories for analysis. Soil test results indicated nitrogen and phosphorus were low, with 18 lb/ac N available in the top 30 cm and 6 ppm of P (Table 4). Potassium and Sulphur were high at 329 ppm K available and 42 lb/ac S available in the top 15 cm.

While it was not originally planned to apply urea in the 10, 20 and 30 kg P/ha MAP treatments (treatments 2-4), due to low soil N urea was applied at a rate of 19 kg N/ha in those treatments based on soil test recommendations. The soil test results indicated that the 20 kg/ha rate of fertilizer (treatments 3 and 6) corresponded to the recommended maximum safe rate of seed-placed N and P fertilizer for lentils. Based on these results, it was anticipated that the 10 kg/ha rate (treatments 2 and 5) would be low, and the 30 kg/ha rate (treatments 4 and 7) would be high. Unfortunately, due to the high temperatures and low precipitation throughout the growing season, even the maximum safe rate of seed placed fertilizer may have been too high and resulted in negative impacts on lentil growth and yield.

Table 4. Soil test results from May 6, 2021.

Depth (cm)	N (lb/ac)	P (ppm)	K (ppm)	S (lb/ac)	Zn (ppm)	OM (%)	pH	Salts (mmho/cm)
0 to 15	13	6	329	42	0.99	3.8	5.6	0.23
15 to 30	5			20			6.4	0.23
0 to 30	18							

Data Analysis

Plant stands were lower than the desired targeted plant stand of 130 plants/m^2. Seeding rates could have been increased to account for greater seed mortality, but similar seeding rates were used on site to achieve desired lentil plant stands in 2020. While it is anticipated seed placed fertilizer had a detrimental effect on all treatments under dry conditions, even treatment 1, which received no fertilizer, performed poorly.

Nodulation score did not vary significantly between treatments (Table 5). Nodulation in all treatments varied between 7.4-9.3, below the threshold for effective nodulation (11-13) as outlined in the Saskatchewan Pulse Growers Nodulation and Nitrogen Fixation Guide (Saskatchewan Pulse Growers, n.d.a.). Nodulation may have been poor because plants were stressed by heat and drought. As well, the high rates of seed placed fertilizer used in this trial may have negatively impacted lentil nodulation

under the hot and dry conditions of the 2021 growing season. Another consideration is that it is difficult to remove lentil seedlings from hard, dry, clay soil without losing roots or nodules, which could have contributed to low scores on the nodulation assessment. Nodulation score was lowest in the control with no fertilizer applied.

Plant vigour, pods per plant, grains per pod and TKW did not vary significantly between treatments ($p>0.5$) (Table 5). Vigour was good in all treatments, ranging between 4.2-4.8 on a scale of 0-5. As anticipated, the control had the lowest vigour. The control also had fewer pods/plant than the fertilized treatments. The number of grains/pods ranged between 1.31-1.44. TKW ranged from between 44.0-45.5 g/1000 grains, which is slightly higher than the average of 40 g/1000 grains for CDC Proclaim small red lentils (Saskatchewan Pulse Growers, n.d.b.).

There were no significant differences in lentil yields between treatments (Table 5). Overall, yields ranged between 284.7-490.2 lb/ac (4.75-8.17 bu/ac), much lower than the target yield of 2491 lb/ac identified in the 2021 Crop Planning Guide for the black soil zone (Government of Saskatchewan, 2021b). Due to hot and dry growing conditions, lentil yields were poor throughout the province. In Saskatchewan in 2021, average lentil yields are estimated at 870 lb/ac (Government of Saskatchewan, 2021a). The lowest yielding treatments were the control with no added fertilizer and treatment 3 – 20 kg P/ha (MAP) with 20 kg N/ha (urea).

Table 5. Summary of means in the "Lentil Phosphorus Response in the North-Central Region" trial.

Trt #	**Description**	**Plant Density** (plants/m^2)	**Nodulation Score** (0-13)	**Vigour Score** (0-5)	**# Pods/ Plant**	**# of Grains/ Pod**	**TKW** (g/1000 grains)	**Yield** (lb/ac)
1	0 kg/ha	74	7.4	4.2	17.0	1.33	45.0	305.9
2	10 kg P/ha MAP	68	7.9	4.8	23.1	1.38	45.5	432.5
3	20 kg P/ha MAP	53	8.5	4.6	24.5	1.31	45.0	284.7
4	30 kg P/ha MAP	67	9.0	4.8	34.6	1.44	44.8	437.5
5	10 kg N/ha 28-26-0 blend	63	8.1	4.4	29.7	1.42	44.0	490.2
6	20 kg N/ha 28-26-0 blend	58	8.7	4.8	30.4	1.40	45.5	398.8
7	30 kg N/ha 28-26-0 blend	66	9.3	4.7	30.6	1.34	44.5	467.3
p-value		0.5299	0.5392	0.3851	0.2166	0.4287	0.6160	0.8174

11. Conclusions and Recommendations

It is difficult to discern meaningful conclusions from this trial about the effectiveness of increasing rates of starter seed placed MAP versus a 50:50 MAP: urea fertilizer blend, due to poor lentil yields and the hot and dry growing conditions of the 2021 growing season. Overall, nodulation score was below the threshold for effective nodulation. Additionally, the mean number of pods per plant was lowest in the control where no starter fertilizer was applied, and highest in the treatment where 28-26-0 was applied at 30 kg N/ha. This also suggests that higher rates of a MAP/urea fertilizer blend could improve lentil pod growth. Lentil yields ranged between 284.7-490.2 lb/ac, well below the yield goal of 2491 lb/ac. Yields were highest when 28-26-0 was applied at a rate of 10 kg N/ha, similar to the 2019 study conducted in the brown soil zone of southern Saskatchewan (Dona et al., 2019). This suggests that low rates of seed-placed starter fertilizer may also be preferable in the black soil zone, especially under poor growing conditions. Poor yields in the lentils can likely be attributed to unusually hot and dry conditions between flowering to pod fill, and potential seed damage resulting from high rates of seed placed fertilizer under dry conditions. This trial would likely produce different results under cooler, wetter growing conditions. Dry conditions have persisted at the CLC for several years now, and so it is recommended that future projects involving seed placed fertilizer reduce the application rate below the recommended maximum safe rate to minimize the risk of damage under poor soil moisture conditions.

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Supporting Information

12. 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. The CLC would also like to thank sales representatives from Verdesian for donating the inoculant used in the trial.

Abstract

13. Abstract/Summary

This trial aimed to demonstrate how lentils respond to the application of increasing rates of seed placed starter phosphorus and nitrogen fertilizer in the north-central region of Saskatchewan. CDC Proclaim small red lentils were seeded at a rate of 44.3 kg/ha on May 14, 2021 at the Conservation Learning Centre located 18 km south of Prince Albert, SK. The lentils were harvested on August 13, 2021. There were six fertilizer treatments and one control where no fertilizer was applied. MAP was applied at rates of 10, 20 and 30 kg P/ha and a custom blend of 50% MAP and 50% urea (28-26-0) was applied at rates of 10, 20 and 30 kg N/ha. The 2021 growing season was unusually hot and dry. Total precipitation was 97.1 mm lower than the long-term average, and the entire growing season was nearly 1°C warmer than the long-term average. Lentil yields were well below the target of 2491 lb/ac, ranging between 284.7-490.2 lb/ac. Yields were highest when the 50% MAP and 50% urea blend was applied at 10 kg N/ha, similar to a 2019 study using the same fertilizer blend on lentils conducted in the brown soil zone of southern Saskatchewan (Dona et al., 2019). This indicates that lower rates of seed-placed starter fertilizer should be used in Saskatchewan, especially under drought growing conditions. Yields likely suffered from hot and dry conditions throughout flowering to pod fill, and potentially seed damage resulting from the application of high rates of seed placed fertilizer under poor soil moisture conditions. The mean number of pods per plant was higher in the 30 kg N/ha 28-26-0 treatment than in the unfertilized control, which may suggest that higher rates of MAP and urea could improve lentil pod production. Ultimately, it is difficult to discern meaningful conclusions from this trial given the difficult growing season and poor lentil performance. The CLC has now experienced several dry growing seasons in a row, and future trials involving seed placed fertilizer should reduce the application rates to well below the recommended maximum safe rate to minimize the risk of crop damage occurring under poor soil moisture conditions. This trial was featured in the CLC's 2021 Field Day and was also visited by the CLC's board of directors in July of 2021. Nearly 3 dozen people attended across both days, including local producers and commodity group representatives.
