


Project Identification

1. **Project Title:** Influence of Potassium Fertilizer on Yield and Seed Quality of Malt Barley and Spring Wheat
2. **Project Number:** 20200481
3. **Producer Group Sponsoring the Project:** Saskatchewan Conservation Learning Centre
4. **Project Location(s):** Project was located at the Conservation Learning Centre located 18 km south of Prince Albert (SW 20 46 26 W2, RM 461). Lana Shaw (SERF), Mike Hall (ECRF), Bryan Nybo (WCA), Brianne McInnes (NARF), Chris Holzapfel (IHARF), and Erin Karppinen & Garry Hnatowich (ICDC) are all co-investigators in this project.
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:**

The objectives of this project were to conduct trials with typical soil testing potassium (K) levels to evaluate the effects of K fertilizer rate and placement on yield of malt barley and spring wheat;

evaluate the influence of K fertilization on seed quality characteristics, and; assess the impact of K fertilization on crop lodging.

8. **Project Rationale:**

Recently, the Saskatchewan Wheat and Barley Development Commissions have both expressed an interest in conducting Potassium (K) fertilization studies. Anecdotal claims of crop benefits to potash are not infrequent and retail fertilizer representatives often promote K applications as “cheap insurance”. Often these claims allude to the possible chloride (Cl) influence on disease management. Research trials from Oregon, Washington, and South Dakota have shown that the presence of chloride in Potassium fertilizer can inadvertently increase crop yields through the suppression of disease (McKenzie and Pauly, 2013). Trials to ascertain the “Cl effect” have been inconclusive in Saskatchewan and throughout the prairies. Saskatchewan producers have been showing a growing concern regarding root rot. The possibility that an application of K fertilizer could alleviate some of the impacts of root rot warrants an investigation. However, it was not the intent of this demonstration to determine the potential benefit of either K or Cl, but rather to evaluate the general response of both wheat and barley to potassium fertilizer.

Generally, Saskatchewan soils tend to have abundant soil potassium. However, within the province, sandy loam, loamy sand, and peat soils are often deficient in potassium. It has been estimated that about one million acres of land in Saskatchewan are K deficient (“Potassium Fertilization in Crop Production” Government of Saskatchewan, n.d.). Many Saskatchewan studies on the effects of potassium have failed to provide a grain yield response. Yield responses tend to be limited when K is applied to soils with high or adequate potassium levels (Karamanos et al., 2013; Holzapfel, C, 2016). However, yield responses can and have occurred. A summary of 124 barley trials conducted by Westco from 1989 to 1998 suggests that the probability of observing a yield response in barley to seed-placed K could be expected in 2 of 5 years (PowerPoint data summary presentation in possession of G. Hnatowich). In wheat trials (52 sites), the probability of observing a yield response to seed-placed K was 1 in 5 years.

Although yield responses can be variable on typical soils in western Canada, K fertilization may provide other agronomic and market-enhancing attributes. Potassium applications have been shown to increase crop response on average 5-10%, and studies have found that K applications have improved grain quality and plumpness (“Potassium Fertilization in Crop Production” Government of Saskatchewan). Vasey & Soper (1966) found that K fertilization increased the plumpness of malting barley on soils with high available K. In North Dakota, low levels of K fertilization elevated the percentage of plump kernels in malt barley grown on soils testing from 248 to 1060 kg K/ha (Zubriski et.al., 1970). As 2-row malt barley varieties require ≥ 80% plump kernels to meet grading criteria, the potential to increase plumpness with K fertilizer additions is highly desirable and would provide a direct monetary benefit to producers.

In plants, potassium regulates cellulose production and adequate uptake can reduce lodging; which is critical for high-yielding wheat and barley varieties. Lodging is a concern for high-yielding varieties, particularly under irrigation. Lodging reduces yield, influences seed quality, and can create logistical challenges at harvest. Increased stem strength and enhanced lodging resistance have been attributed to sufficient K availability (Yuan et. al., 2010). However, McKenzie et. al. (2005) conducted field trials in southern Alberta and failed to relate barley lodging resistance with potassium fertilization. Lodging only occurred at one of fourteen sites over a three-year period. In high-yielding or irrigated environments where lodging is more prevalent, additional K fertilizer supplementation might be beneficial.

Potassium is a significant macronutrient. It acts to regulate water balances, nutrient, and sugar movement, and drives starch and protein synthesis in plants ("Potassium Fertilization in Crop Production" Government of Saskatchewan). Plant uptake of potassium can be limited if the K supply rate of soils is restricted by temperature, compaction, or poor drainage. Potassium has been shown to be fairly immobile in the soil. For example, research from Montana showed that potassium deficiency can occur in fields with high soil test K. This is due to the slow diffusion of potassium within cold, dense soils (McKenzie and Pauly, 2013). Compaction has been an increasing concern in no-till production systems across Saskatchewan. Moreover, soil drainage can be a concern in regions with heavy textured soils or high groundwater tables. Although this demonstration did not directly address these issues, conversations and discussions were had with producers on the likelihood of potassium fertilizer benefits to malt barley and spring wheat. Considerable research effort has targeted 4R nutrient management with respect to N & P additions in cereals. This demonstration incorporated the rate and placement of K in assessing a 4R strategy.

References:

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Methodology and Results

9. Methodology:

In this project, the malt barley and spring wheat were seeded in separate trials located beside each other. Both trials had randomized complete block designs and plots were replicated four times. Eight treatments of varying potassium fertilizer rates and placements were compared to evaluate the effects of K fertilizer on the yield of malt barley and spring wheat. The trial also evaluated the influence of potassium fertilization on the quality characteristics of seed, and on crop lodging. Treatment descriptions can be found in Table 1.

Table 1. Description of treatments evaluated in "Influence of Potassium fertilizer on Yield and Seed Quality of Malt Barley and Spring Wheat"

Treatment #	Fertilizer Rate	Fertilizer Placement
1	0 kg K_2O/ha	Seed placed
2	10 kg K_2O/ha	Seed placed
3	20 kg K_2O/ha	Seed placed
4	30 kg K_2O/ha	Seed placed
5	10 kg K_2O/ha	Side banded
6	20 kg K_2O/ha	Side banded
7	30 kg K_2O/ha	Side banded
8	20 + 40 kg K_2O/ha	20 kg K_2O/ha seed placed + 40 kg K_2O/ha side banded

Plots measured two meters wide and seven meters long, with 10in row spacing. On May 27th, both trials were seeded with the CLC's Fabro Plot Seeder. An agronomic summary is located in Table 2.

Table 2. Agronomic summary

	Wheat	Barley
Seeding Date:	May 27th, 2021	
Seeding Method:	Fabro Plot Seeder with double disc openers and 10-inch row spacing	
Seeding Rate:	AAC Cameron VB wheat: 108.4 kg/ha, target 300 plants/m^2	CDC Churchill barley: 144.5 kg/ha, target 300 plants/m^2
Stubble	Canola	
Seed Depth:	1.25 inches	
Fertilizer:	Potash @ rates of K as per protocol (Table 3) Urea @ 126 kg N/ha MAP @ 39 kg P/ha MAP and urea were side-banded 2.5 in deep.	Potash @ rates of K as per protocol (Table 3) Urea @ 98 kg N/ha MAP @ 45 kg P/ha MAP and urea were side-banded 2.5 in deep.
Yield Goal:	68.2 bu/ac	113 bu/ac
Emergence:	June 8th, 2021	
Post-Emergent Herbicide:	Dyvel at 510 mL/ac with 40L of water/ac on June 15th	
Fungicide:	Folicur at 202 mL/ac (250g ae/L) with 60L of water/ac on July 13th	
Spring Plant Density:	2 x 1m rows were counted per plot on June 21st	2 x 1m rows were counted per plot on June 18th
Lodging:	No lodging was observed.	
Plant Heights:	Plant heights were mistakenly not recorded prior to harvest.	
Harvest Date:	September 22nd, 2021	September 9th, 2021
Days to Maturity:	118	105
Harvest Method:	Entire plots harvested with a Wintersteiger Quantum Plot Combine	
Harvest Moisture:	Yields corrected to 14.5% moisture content	Yields corrected to 13.5% moisture content
Coordinates of Corners:	N53˚01.285' W105˚50.428' N53˚01.284' W105˚50.392' N53˚01.275' W105˚50.428' N53˚01.274' W105˚50.392'	N53˚01.283' W105˚50.380' N53˚01.284' W105˚50.344' N53˚01.274' W105˚50.379' N53˚01.275' W105˚50.343'
Soil Zone and Texture	Black Clay loam	

Composite soil samples were taken from the trial areas in the spring of 2021 and sent to Western Ag Laboratories for analysis. Western Ag soil sample results can be found in Tables 6 and 7. Additional soil samples were also sent to Agvise Laboratories. Agvise soil sample results can be found in Table 5. Fertilizer recommendations were based on the soil test results from Western Ag. A summary of KCl fertilizer rates and placement can be found in Table 3.

Table 3. Rates and placement of potash in the barley and wheat trials.

Trt #	Potash Applied (kg/ha)
1	0
2	16.67 (seed placed)
3	33.33 (seed-placed)
4	50.00 (seed-placed)
5	16.67 (side-banded)
6	33.33 (side-banded)
7	50.00 (side-banded)
8	33.33 (seed-placed) and 66.67 (side-banded)

Data collection included recording lodging, disease, yield, protein, test weight and thousand kernel weight (TKW). No disease or lodging was observed throughout the growing season. Plant height at maturity and days to maturity of the various treatments were supposed to be recorded but were missed. Data collection methods are presented in Table 2. Scouting occurred periodically throughout the growing season.

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

<u>Weather</u>

The 2021 growing season at the CLC was very hot and dry compared to past years (Table 4). The 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. Precipitation was very low in May, which led to poor emergence in the wheat and barley. 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. Precipitation was slightly higher than average in August, which likely prevented more severe drought related losses in the wheat and barley. The first fall frost occurred on October 2 (-0.9˚C). The complete monthly weather summaries can be downloaded from src.sk.ca/download-weather-summaries.

Table 4. 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 Tests

Soil samples were collected with a Dutch soil auger on May 15, 2021 and sent to Agvise Laboratories for analysis. Results showed that nitrogen levels were low in the top 30 cm of soil with 27 lb/ac present (Table 5). Phosphorus was low at 5 ppm and potassium was high at 245 ppm. Sulfur was low in the top 30 cm with 28 lb/ac available. Zinc was high with 1.67 ppm. The level of organic matter in the soil was 5.4%. Soluble salts were very low in the top 30 cm with 0.37 mmho/cm. Agvise soil testing recommended potash application at a rate of 10 lb K/ac.

Table 5. Spring 2021 composite soil sample results from the barley and wheat trials sent to Agvise Laboratories

Depth (cm)	N (lb/ac)	P (ppm)	K (ppm)	S (lb/ac)	Z (ppm)	OM (%)	pH	Sol. Salts (mmho/cm)
0 to 15	17	5	245	16	1.67	5.4	6.0	0.18
15 to 30	10			12			6.7	0.19
0 to 30	27							

Additional soil samples were also collected for wheat (Table 6) and barley (Table 7) and sent to Western Ag Laboratories for analysis. For the wheat, the Western Ag soil tests recommended the application of potash at 25 lb K/ac, notably higher than the Agvise recommendation of 10 lb K/ac. The Western Ag soil test results for spring wheat also indicated higher levels of soil N and lower levels of K than the Agvise soil test.

Table 6. Spring 2021 soil sample results from spring wheat trial sent to Western Ag Laboratories

Depth (cm)	N	P	K	S	Z	pH	Soil EC (1:1)
	Standard supply rate (lb/ac)						
0 to 15	40.8	3.4	47.6	12.5	0.29	6.08	0.16

For the barley, Western Ag soil tests recommended an application of potash at a rate of 60 lb

K/ac, once again much higher than the Agvise soil test recommendation (Table 7). Additionally, the barley soil test results from Western Ag demonstrated even higher levels of soil N and once again lower levels of K than the Agvise test.

Table 7. Spring 2021 composite soil sample results from barley sent to Western Ag Laboratories

Depth (cm)	N	P	K	S	Z	pH	Soil EC (1:1)
	Standard supply rate (lb/ac)						
0 to 15	53.9	5.6	60.6	16.5	0.38	6.08	0.16

Data Analysis - Wheat

Wheat spring plant density averaged at 189 plants/m^2, well below the target of 300 plants/m^2 (Table 8, p>0.05). Poor emergence can likely be attributed to extremely dry soil conditions at seeding.

Thousand kernel weight (TKW) was on the lower end of normal, ranging between 30.9-32.7 g/1000 grains (Table 8, p>0.05). TKW for hard red spring wheat is typically between 31-38 g/1000 grains according to the 2021 SaskSeed Guide. Test weight varied from 374.3-379.8 g/0.5 L (Table 8, p>0.05).

Yields fell short of the target of 68.2 bu/ac in all treatments, averaging at 51.3 bu/ac (Table 8, p>0.05). Poor yields may be due to extremely hot and dry conditions during seed set and low plant densities.

Wheat protein was higher when no potash was applied and lowest for treatments that received the highest amount of potash.

Table 8. Summary of means of wheat in potassium fertilizer trial.

TRT #	Fertilizer Rate	Fertilizer Placement	**Mean Plant Density** (# plants/m^2)	**Mean TKW** (g/1000 grains)	**Mean Test Weight** (g/0.5 L)	**Mean Yield** (bu/ac)	**Protein** (%)
1	0 kg K_2O/ha	Seed placed	192	31.0	374.3	55.2	15.1 a
2	10 kg K_2O/ha	Seed placed	191	32.4	376.9	48.3	14.3 bc
3	20 kg K_2O/ha	Seed placed	188	31.6	377.8	52.9	14.4 bc
4	30 kg K_2O/ha	Seed placed	189	30.9	377.5	50.6	14.2 c
5	10 kg K_2O/ha	Side banded	186	31.3	378.3	48.2	14.7 ab
6	20 kg K_2O/ha	Side banded	199	31.0	376.5	51.3	14.5 bc
7	30 kg K_2O/ha	Side banded	183	31.3	375.9	50.9	14.5 bc
8	20 + 40 kg K_2O/ha	Seed placed + Side banded	187	32.7	379.8	52.7	14.2 c
	p value		0.9221	0.2446	0.5976	0.8393	0.0054

Data Analysis - Barley

Overall barley plant density averaged at 199 plants/m^2, falling short of the target of 300 plants/m^2 (Table 9, $p>0.05$). Very hot and dry spring conditions likely contributed to poor emergence.

Barley thousand kernel weight (TKW) is typically between 40-50 g/1000 grains according to the 2021 SaskSeed Guide. TKW was normal in all treatments, ranging between 40.9-43.0 g/1000 kernels (Table 9, $p>0.05$). Test weight averaged at 286.1 g/0.5 L overall (Table 9, $p>0.05$).

Barley yields were extremely low, achieving on average only 65% of the target of 113 bu/ac (Table 9). Yields varied between 65.6-81.6 bu/ac ($p>0.05$). Once again, poor emergence and high heats combined with poor soil moisture during flowering and seed set likely resulted in significant yield losses.

Table 9. Summary of means of barley in potassium fertilizer trial.

TRT #	Fertilizer Rate	Fertilizer Placement	Mean Plant Density (# plants/m^2)	Mean TKW (g/1000 grains)	Mean Test Weight (g/0.5 L)	Mean Yield (bu/ac)	Protein (%)
1	0 kg K_2O/ha	Seed placed	177	43.0	286.0	66.5	12.7
2	10 kg K_2O/ha	Seed placed	191	42.1	287.7	81.6	12.5
3	20 kg K_2O/ha	Seed placed	213	42.4	283.3	77.6	12.1
4	30 kg K_2O/ha	Seed placed	196	40.9	281.8	78.4	12.5
5	10 kg K_2O/ha	Side banded	190	41.7	294.3	70.3	13.0
6	20 kg K_2O/ha	Side banded	207	42.0	285.8	76.5	12.5
7	30 kg K_2O/ha	Side banded	207	42.3	285.6	72.5	12.5
8	20 + 40 kg K_2O/ha	Seed placed + Side banded	209	42.9	284.2	65.6	12.1
	p value		0.1311	0.9249	0.1765	0.4223	0.8319

11. Conclusions and Recommendations

It is difficult to discern meaningful conclusions from these results due to the extremely hot and dry growing conditions experienced in 2021. Low emergence combined with heat and drought stress resulted in very poor yields in the wheat and barley. It is unlikely that the crops were able to benefit from the addition of potassium fertilizer under hot and dry conditions that limited plant performance. It would be beneficial to repeat this trial under more typical, cooler, wetter, growing conditions in order to assess whether different rates and placements of potassium fertilizer could benefit spring wheat and malt barley crops. This project had been resubmitted for funding for the 2022 growing season. Funding results have yet to be announced.

A virtual field day video featuring this trial was posted to the CLC's YouTube channel and has 19 views to date.

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 also thanks Nutrien Ag Solutions for donations of crop inputs.

Abstract

13. Abstract/Summary

This trial aimed to demonstrate the effects of potassium fertilizer at different rates and placements on yield, seed quality and lodging of spring wheat and malt barley. The trial was set up with 1 control that received no K fertilizer and 7 fertilized treatments that received K fertilizer in the form of potash at rates of 10, 20, 30 and 60 kg K_2O/ha either seed placed, side banded, or a combination of seed placed and side banded. AAC Cameron VB wheat and CDC Churchill barley were seeded on May 27, 2021 at the Conservation Learning Centre located 18 km south of Prince Albert, SK. The barley was harvested on September 9 and the wheat on September 22. The 2021 growing season was unusually hot and dry. Wheat and barley plant densities both fell short of the target 300 plants/m^2, with barley averaging at 199 plants/m^2 and wheat at 189 plants/m^2. Poor emergence and extremely hot and dry conditions during flowering and seed set contributed to very low yields in both crops. Barley yields ranged between 65.6-81.6 bu/ac, well below the target 113 bu/ac. Wheat yields were targeted for 68.2 bu/ac, instead achieving only 48.2-55.2 bu/ac. No lodging was observed. There were no apparent differences in seed quality between treatments. Extremely hot conditions and poor soil moisture throughout the growing season limited plant performance, which likely prevented the crops from benefiting from the additional potassium fertilizer. Repeating this trial in a cooler, wetter year would be beneficial in order to assess whether different rates and placements of K fertilizer could benefit spring wheat and malt barley crops under more typical growing conditions. A virtual field day video featuring this trial was posted to the CLC's YouTube channel and has 19 views to date.
