2017 Annual Report
for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Demonstrating the Merits of Potassium and Sulphur Fertilization in Flax Production

(Project #20160407)

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Project Identification

1. **Project Title:** Demonstrating the merits of potassium and sulphur fertilization in flax production
2. **Project Number:** 20160407
3. **Producer Group Sponsoring the Project:** Saskatchewan Flax Development Commission
4. **Project Location(s):** Indian Head, Saskatchewan, R.M. #156
5. **Project start and end dates (month & year):** Apr-2017 to Feb-2018
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **Project objectives:**

The objectives of this project were: 1) to demonstrate the potential response (or lack thereof) to applications of potassium (K) and sulfur (S) fertilizer alone and in combination, 2) to demonstrate the relative performance of three high yielding flax varieties and 3) to explore whether the potential for responses to these important, albeit less commonly limiting, macronutrients differed across varieties.

8. **Project Rationale:**

For most crops, including flax, fertilizer comprises one the largest input costs and typically provides a large return on investment as long as appropriate rates and products are applied. Flax often responds well to nitrogen (N) fertilizer applications with typical rates ranging from approximately 35-80 kg N/ha, depending on past yields, residual N and soil moisture. Flax response to P fertilizer tends to be less consistent than for many other crops; however, utilizing rates that offset crop removal over the long-term is generally seen as important strategy for maintaining soil productivity and small but significant responses frequently occur in deficient soils. With high residual levels, deficiencies of potassium (K) are unlikely in the heavy clay soils northeast of Indian Head; however, responses to potassium chloride (KCl) fertilizer are occasionally reported, sometimes due to a Cl response especially in certain crops like canaryseed. Sulphur availability is frequently marginal on Saskatchewan soils and occasionally limit yields, especially in sensitive crops such as canola. While documented flax responses to K and S fertilizer application are rare in the peer-reviewed literature, demonstrations at Indian Head in 2013 (ADOPT #20120371) showed a 2.2 bu/ac average yield increase (4.5%) with the addition of 12 lb S/ac plus 12 lb K2O as KCl. In 2014 under less favourable conditions (ADOPT #20130375), mean yields with S were 1.4 bu/ac (7%) higher than without; however, the site was more variable and the observed difference was not significant. While it was initially suspected that the observed yield response was due to S (based on residual nutrient levels) these results were not repeated in 2015 (SFDC #15-2424) under low residual S levels and reasonably good yield potential (~35 bu/ac). In 2016, with high yields (~50 bu/ac) and low residual S, flax yields increased quadratically with S; however, the magnitude of the increase was less than 5% and the lowest rate (15 kg S/ha) was sufficient to optimize yields. There was some evidence that the response was stronger with the flax variety CDC Neela relative to the other varieties.

The objective of the current project was to demonstrate the potential response (or lack thereof) to applications of varying combinations of K and S fertilizer for three high yielding varieties. Two sources of K fertilizer (KCl versus K_2SO_4) were utilized to assess whether any observed response was due to the K or Cl component of the dominant K form, potash (0-0-60). While the fertility components of this work are somewhat exploratory, they may be utilized to promote balanced nutrition of flax while simultaneously demonstrating the relative performance of new high yielding varieties relative to the current check, CDC Bethune. This in itself is of interest to flax growers as Bethune continues to be popular; however, those who are looking to purchase certified seed or considering changing varieties will appreciate this regional performance data for top new varieties grown under no-till and relatively intensive management.

Methodology and Results

9. Methodology:

A field trial with flax was established on spring wheat stubble near Indian Head, Saskatchewan (50.548º N, -103.569º W) in the spring of 2017. The treatments were arranged in a four replicate Randomized Complete Block Design (RCBD) and were factorial combination of three varieties (CDC Bethune, CDC Glas and CDC Neela) and five S and K fertilizer combinations for a total of 15 treatments.

Selected agronomic information is provided in Table 1. All plots were direct-seeded into hard red spring wheat stubble on May 11 using a SeedMaster plot drill with eight openers on 30 cm row spacing. The varieties varied as per protocol but all were seeded at target depth of approximately 20 mm (3/4”) and a 52.5 kg/ha seeding rate (not adjusted for seed size or percent germination). Nitrogen was held constant at 100 kg N/ha for all treatments (supplied as side-banded urea) along with 30 kg P_2O_5/ha (supplied as seed-placed monoammonium phosphate). Sulphur and potassium were applied as per protocol as side-banded ammonium sulphate (21-0-0-24), potassium chloride (potash; 0-0-60) and potassium sulphate (0-0-53-18). Weeds were controlled using registered pre-emergent and in-crop herbicide applications and foliar fungicide was applied preventatively at mid-bloom (Jul-10) to prevent Pasmo from developing into a yield limiting factor. Pre-harvest glyphosate was applied for weed control and to assist with crop dry-down at physiological maturity (Aug-20, ~75% boll colour change) and the centre 5 rows of each plot were straight-combined as soon after it was fit to do so as possible (Sep-6).

Table 1. Selected agronomic information for ADOPT flax sulphur and potassium response demonstration at Indian Head in 2017.	
Factor / Field Operation	Details
Pre-emergent herbicide	890 g glyphosate/ha (May-10) 140 g sulfentrazone/ha (May-15)
Fertility (kg N-P_2O_5-K_2O/ha)	100-30-x-x (K and S varied as per protocol)
Seeding Date	11-May
Cultivar	varied as per protocol
Seeding Rate	52.5 kg/ha
Row spacing	30 cm
In-crop herbicide	200 g clopyralid/ha (Jun-6) 280 g bromoxynil/ac + 280 g MCPA/ac (Jun-16)
Fungicide	75 g fluxapyroxad/ha + 150 g pyraclostrobin/ha (July 10)
Insecticide	none applied
Pre-harvest herbicide	890 g glyphosate/ha (Aug-20)
Harvest date	Sep-6 (centre 5 rows)

Emergence was measured at approximately four weeks after planting (Jun-2) by counting the number of seedlings two separate 1 m sections of crop row per plot. The plots were monitored for lodging; however, no lodging occurred in any treatments. Yields were determined from the harvested grain samples, and were corrected for dockage and to 10% seed moisture content. Weather data were estimated from an Environment Canada station located approximately 5 km from the site.

All response data were analysed using the GLM procedure of SAS with the effects of variety (VAR), fertilizer treatment (FERT) and interactions between the two factors (VAR × FERT) considered fixed and replicate effects considered random. Fisher's protected LSD test was used to separate treatment means. Yield data from one replicate were excluded from the analyses as a result of unusually high variability caused primarily by wildlife (deer) damage. Removing the data reduced variability and improved model convergence and substantially reduced the coefficient of variation and standard error of the treatment means. All treatment effects and observed differences between means were considered significant at $P \leq 0.05$.

10. Results:

Growing Season Weather & Soil Test Information

Mean monthly temperatures and precipitation amounts for the 2017 growing season at Indian Head along with the long-term averages (1981-2000) are presented in Table 2. While there was abundant subsoil moisture, the field surfaces in the area dried off and seeding in the area had commenced by late April. Seed was placed into good initial moisture but the weather that followed was hot, windy and dry. The first and essentially only major precipitation event of the growing season occurred in mid-June with only small, isolated showers in May, July and August. Temperatures were average across the entire season (April through August) but above normal in May and slightly below normal in August. Despite the dry weather, the combination of good initial soil moisture, heavy soil texture, and extremely timely precipitation in June allowed for approximately average yield potential to be realized.

Table 2. Mean monthly temperatures and precipitation amounts along with long-term averages (LT; 1981-2010) averages for the 2017 growing season at Indian Head, Saskatchewan.

Year	April	May	June	July	August	Avg/Tot
	---------- Mean Temperature (°C) ----------					
2017	4.2	11.6	15.5	18.4	16.7	13.3
LT ^{z}	4.2	10.8	15.8	18.2	17.4	13.3
	---------- Precipitation (mm) ----------					
2017	18.5	10.4	65.6	15.4	25.2	135
LT ^{z}	22.6	51.8	77.4	63.8	51.2	267

A composite soil sample (0-15 cm, 15-60 cm) for the study area was collected prior to seeding (May-12) and submitted to AgVise Laboratories for analyses (Table 3). Soil pH for the upper 15 cm was 7.9 with 4.9% organic matter and a relative high cation exchange capacity of 46.8 Meq. Nitrate N and phosphorus levels were quite low (25 kg/ha and 7 ppm, respectively); however, these nutrients were intended to be non-limiting in all treatments for the current project. Extractable K was quite high (762 ppm, 0-15 cm) which is quite typical for the region. Residual soil S was not considered particularly low 11 kg/ha detected in the upper 15 cm and an additional 47 kg/ha for the 15-60 cm soil profile. Soil test S levels tend to be variable from year to year and field to field based in the region.

Table 3. Soil test results for the 2017 flax potassium and sulphur response demonstration at Indian Head, Saskatchewan.

Soil Depth	pH	O.M.	NO_3-N	Olsen-P	K	S	C.E.C.
(cm)		---- % ----	-- kg/ha --	-- ppm --	-- ppm --	-- kg/ha --	-- Meq --
0-15	7.9	4.9	12	7	762	11	46.8
15-60	–	–	13	–	–	47	–
0-60	–	–	25	–	–	58	–

^{z} As determined and reported by AgVise Laboratories

Crop Response to Variety and Fertilizer Treatment

Main effect means for both plant density and seed yield are presented with the overall F-test results in Table 4 while fertilizer effects on individual varieties are presented for plant density and seed yield in Tables 5 and 6 of the Appendices, respectively.

Table 4. Flax variety and fertilizer treatment effects on flax plant density and seed yield (Indian Head 2016). Means followed by the same letter do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

Main Effect	Plant Density	Seed Yield
Variety (VAR)	------- *plants/m²* -------	--------- *kg/ha* ---------
1) CDC Bethune	386 a	1848 c
2) CDC Glas	410 a	2026 a
3) CDC Neela	387 a	1968 b
S.E.M.	10.3	19.0
Fertilizer Treatment (FERT)		
1) 0 kg K_2O/ha – 0 kg S/ha	388 a	1988 a
2) 22 kg K_2O/ha – 0 kg S/ha (KCl)	381 a	1923 a
3) 0 kg K_2O/ha – 22 kg S/ha	387 a	1953 a
4) 22 kg K_2O/ha – 22 kg S/ha (KCl)	396 a	1935 a
5) 22 kg K_2O/ha – 22 kg S/ha (K_2SO_4)	420 a	1936 a
S.E.M.	13.39	24.5
C.V. (%)	11.7	3.7
R^2	0.412	0.801
Effect	------------------ *Pr > F (p-value)*	------------------
Variety (VAR)	0.180	< 0.001
K/S Treatment (FERT)	0.271	0.398
VAR × FERT	0.083	0.398

Despite the dry conditions following seeding, emergence was reasonably strong with an overall average of nearly 400 plants/m^2 established. The recommended minimum plant population for flax is 300-400 plants/m^2; therefore, establishment was not considered limiting in the trial. Averaged across fertilizer treatments, plant populations for the individual varieties ranged from 386-410 plants/m^2 with no significant differences detected (Table 4). Across varieties, the range was 381-420 and, again, there were no significant differences amongst the fertilizer treatments. This was not unexpected since all K and S fertilizer products were side-banded; however, even with side-banding, fertilizer effects on establishment can occasionally occur with sensitive crops such as flax. With no VAR × FERT interaction, the lack of a fertilizer effect on crop establishment was consistent for each of the three varieties (Table 5).

The overall mean flax seed yield was 1947 kg/ha (31 bu/ac) which was considered just slightly below average for field trials with this crop in the region. Yields varied across varieties with CDC Glas yielding the highest (2026 kg/ha), followed by CDC Neela (1968 kg/ha) and finally CDC Bethune (1848 kg/ha), the oldest of the varieties included in the evaluation. Although yields were lower, the overall rankings of the varieties were consistent with a similar at this location in 2016 where the yields were 3137, 3209 and 3325 kg/ha for CDC Bethune, CDC Neela and CDC Glas, respectively (ADOPT #20150390).

The effect of the K and S fertilizer treatments was not significant (P = 0.398) and the lack of a VAR × FERT interaction indicates that this was consistent across varieties (Table 4). Averaged across the three varieties, mean yields for individual fertilizer treatments were within 65 kg/ha (1 bu/ac) and, numerically, at 1988 kg/ha the highest yield was observed in the check where only N and P fertilizer were applied. Again, the soil test results for this site did not suggest that a response to either K or S was probable. The previous season, with much higher yields and comparatively low residual S levels, small yield increases with S fertilization were observed (ADOPT #2015039). Unfortunately, soil tests for S can be unreliable due to high spatial variability; therefore S fertilization is often recommended regardless if deficiencies have occurred in the past or when growing sensitive crops such as canola. The previous season, with much higher yields and comparatively low residual levels, small flax yield increases with S fertilization were observed (ADOPT #2015039). Again, the rationale for including K_2SO_4 as a K source was to investigate whether any response was due to K or Cl; however, no response to either form was realized. Based on the actual yields and literature values for flax uptake of various nutrients, the total K_2O and S uptake averaged 50-69 kg/ha and 17-21 kg/ha.

Extension and Acknowledgement
This project was highlighted during the Indian Head Crop Management Field Day in 2017 (July 18, approximately 200 guests). Chris Holzapfel (IHARF) and Rachel Evans (Flax Council of Canada) discussed the results of past fertility work completed in western Canada and other agronomic issues and research priorities for flax. In addition, the trial was shown on smaller tours hosted by IHARF for FCL (July 13) and Richardson-Pioneer (July 21) and was visited by numerous growers, agronomists and researchers over the course of the season. The full report will be made available online (www.iharf.ca) and results will also be made available through a variety of other media (i.e. oral presentations, popular agriculture press, social media, fact sheets, etc.) as opportunities arise.

11. Conclusions and Recommendations

This project has demonstrated both the relative performance of several popular flax varieties and provided a forum for discussion on balanced fertility in flax production.

The varieties showcased were the popular check variety, CDC Bethune, and two newer varieties CDC Glas and CDC Neela. While the differences were modest in absolute terms, the observed variety performance rankings were consistent with those from the previous year showing statistically significant yield advantages to the newer varieties. This supports the recommendation that growing modern, regionally adapted varieties is an important component of achieving top flax yields. Averaged across zones, the provincial variety guide rates the yields of CDC Glas and CDC Neela as 105% and 104% of Bethune which is consistent with the current results where the yields were 110% and 106% of Bethune for CDC Glas and CDC Neela, respectively. Established plant populations were similar across varieties and not considered potentially limiting to yield ranging from 386-410 plants/m^2 – the recommended minimum flax population is 300-400 seeds/m^2.

Focussing on fertility, flax establishment was not affected by the K/S treatments but this was not unexpected given that all K and S fertilizer products were side-banded as opposed to seed-placed. Spring soil tests from the site showed residual levels of 762 ppm of extractable K in the top 15 cm of soil and 57 kg S/ha (0-60 cm); therefore, did not necessarily suggest that applications of these nutrients were likely to improve yields. Consistent with the soil test predictions, neither K nor S fertilization impacted flax yield, regardless of variety, form or combination with other nutrients. While K deficiencies are rate in most Saskatchewan soils, some growers/agronomists see applying some fertilizer as important for maintaining soil productivity over the long-term and, with some crops (i.e. canaryseed) responses specifically to the Cl component of potash have been documented. While S is not commonly limiting for most crops either, deficiencies do occur and challenges arise in that this nutrient is difficult to accurately test for due to high spatial variability and mobility. While low soil test results for S can generally be relied upon, high test values are often suspect and, when growing sensitive crops (i.e. canola) or if deficiencies have been observed in the past, it is often recommended to apply small quantities of S regardless of soil test results. Overall, growers are recommended to take into account soil test results, past experience and long-term fertility objectives when determining whether to apply K and S fertilizer when growing flax.

Supporting Information

12. Acknowledgements:

This project was supported by the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canada-Saskatchewan Growing Forward 2 bi-lateral agreement and was a collaborative effort between the Saskatchewan Flax Development Commission and the Indian Head Agricultural Research Foundation. Acknowledgement of the Saskatchewan Ministry of Agriculture's support for this demonstration will be included as part of all written reports and oral presentations that arise from this work. The crop protection products evaluated in this demonstration were provided in-kind by BASF and FMC of Canada. The many contributions of Danny Petty, Christiane Catellier, Dan Walker, Karter Kattler and Shaelyn Stadnyk are greatly appreciated.

13. Appendices

Table 5. Flax variety and potassium / sulphur fertilizer effects on plant density (Indian Head 2017). Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Fertilizer Treatment	CDC Bethune	CDC Glas	CDC Neela
	Plant Density (plants/m^2)		
1) 0 kg K_2O/ha – 0 kg S/ha	364 a	431 a	369 a
2) 22 kg K_2O/ha – 0 kg S/ha (KCl)	390 a	368 a	384 a
3) 0 kg K_2O/ha – 22 kg S/ha	346 a	403 a	413 a
4) 22 kg K_2O/ha – 22 kg S/ha (KCl)	424 a	384 a	381 a
5) 22 kg K_2O/ha – 22 kg S/ha (K_2SO_4)	405 a	465 a	390 a
S.E.M.		23.0	

Table 6. Flax variety and potassium / sulphur fertilizer effects on seed yield (Indian Head 2017). Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Fertilizer Treatment	CDC Bethune	CDC Glas	CDC Neela
	Seed Yield (kg/ha)		
1) 0 kg K_2O/ha – 0 kg S/ha	1916 a	2051 a	1997 a
2) 22 kg K_2O/ha – 0 kg S/ha (KCl)	1841 a	2023 a	1906 a
3) 0 kg K_2O/ha – 22 kg S/ha	1887 a	1968 a	2003 a
4) 22 kg K_2O/ha – 22 kg S/ha (KCl)	1811 a	2027 a	1968 a
5) 22 kg K_2O/ha – 22 kg S/ha (K_2SO_4)	1783 a	2061 a	1964 a
S.E.M.		42.5	

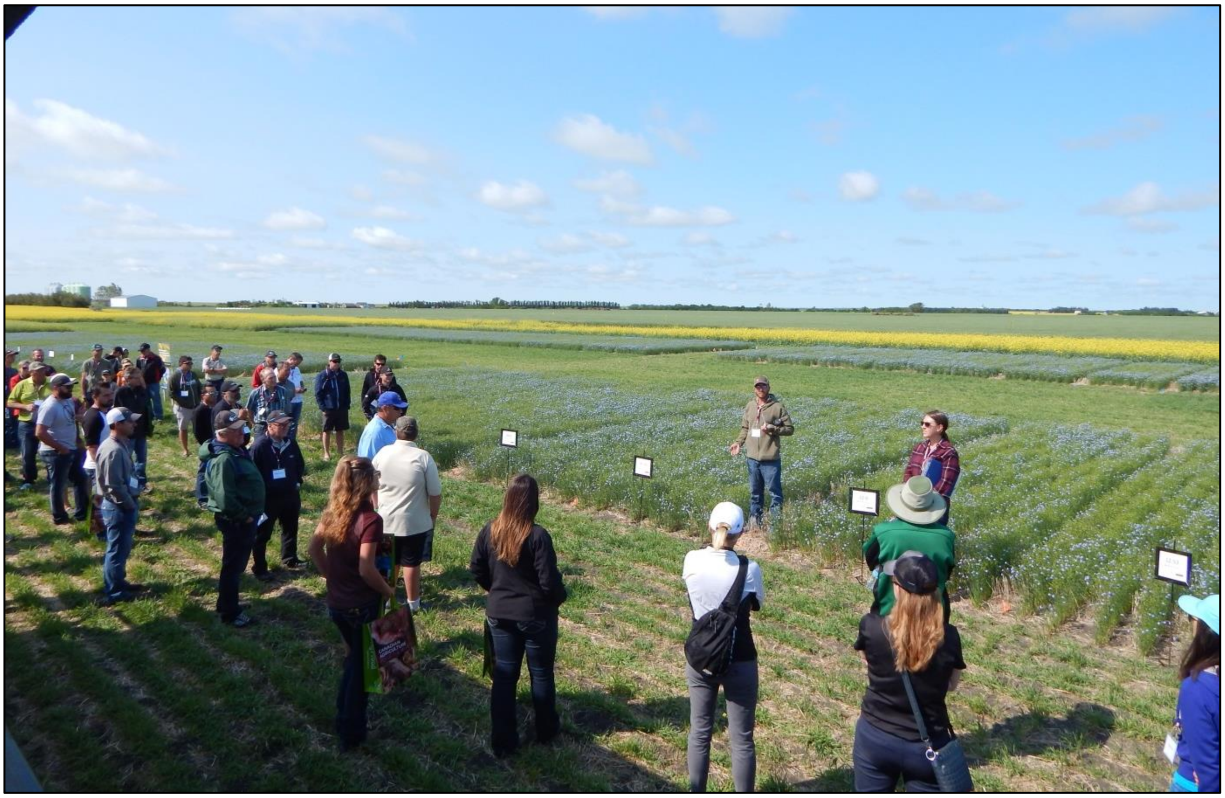

Figure 1. Chris Holzapfel and Rachel Evans discussing flax fertility at the 2017 Indian Head Crop Management Field Day, July 18.

Figure 2. Flax fertility segment of the 2017 Indian Head Crop Management Field Day, July 18.

Figure 3. CDC Bethune flax at Indian Head, Saskatchewan (August 9, 2017)

Figure 4. CDC Glas flax at Indian Head, Saskatchewan (August 9, 2017)

Figure 5. CDC Neela flax at Indian Head, Saskatchewan (August 9, 2017)

Abstract

14. Abstract/Summary:

A field trial was established in 2017 near Indian Head, Saskatchewan to demonstrate the relative performance of modern flax varieties along with the potential for response to potassium (K) and sulphur (S) fertilization. Although the season was drier than normal, with only 51% of the long term average precipitation received (April through August), uniform and adequate plant populations were achieved and yields were approximately average for the region. The varieties evaluated were CDC Bethune, CDC Glas and CDC Neela. Plant populations were similar across varieties (386-410 plants/m^2) while yields differed and were 1848, 2026, and 1968 kg/ha for CDC Bethune, CDC Glas, and CDC Neela, respectively. This supports the recommendation that growing modern, regionally adapted varieties is an important component to achieving top flax yields. The fertility treatments, which included various combinations of K (potash versus potassium sulphate) and S (ammonium sulphate) fertilizer, did not affect either flax establishment or seed yields. The lack of an effect on plant populations was not unexpected since all K and S fertilizer products were side-banded. Regarding yield, while all major crop nutrients can potentially be limiting, K and S deficiencies tend to be soil specific and a spring soil test on the site did not identify either of these elements as likely to be limiting. Overall, these results support the use of soil tests to help guide fertilizer decisions and are in agreement with broader recommendations that flax yield responses to K or S are less likely than for N or P in the majority of Saskatchewan fields. This demonstration was featured at the Indian Head Crop Management Field Day on July 18 (approximately 200 guests) where Chris Holzapfel (IHARF) and Rachel Evans (Flax Council of Canada) discussed flax fertility requirements and other agronomic issues. The site was also visited during multiple smaller tours and visited by several farmers and agronomists over the course of the season. A summary of this work will be available online (www.iharf.ca) and results will also be disseminated through a variety of other media (i.e. oral presentations, agricultural press, social media, fact sheets, etc.) as opportunities arise.