2016 Annual Report for the Agriculture Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Exploring the merits of sulphur fertilization in flax production

Project Number: 20150388

Producer Group Sponsoring the Project: Western Applied Research Corporation

Project Location(s):

- Scott Saskatchewan, R.M. #380 Legal land description: NE 17-39-20 W3

Project start and end dates (month & year): May 2016 and completed January 2016

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Objectives and Rationale

Project objectives:

The objective of this project is to demonstrate the response of three modern, high yielding flax varieties to varying application rates of sulphur (S) fertilizer and assess whether S fertility is a potential limiting factor for regional flax yields.

Project Rationale:

For most crops, including flax, fertilizer is one the largest input costs and typically provides a large return on investment when appropriate rates are applied. Despite flax being widely perceived as a relatively low input crop, sulphur deficiencies can limit the yields of flax due to its heavy reliance on S for seed production. Average flax yields from trials conducted at Scott and Indian Head over the past 5 years were 37 bu/ac (2358 kg/ha) and 36 bu/ac (2264 kg/ha) which means that, on average, the crop has taken up more than 20 lb S/ac (23 kg S/ ha), respectively. On a per bushel basis, flax S requirements are actually higher than those of canola; however, canola yields (and subsequent S requirements) are normally higher. While soil tests do not always show potential for S deficiencies, estimated availability is often marginal and S fertility is known to be highly variable across the landscape which can limit the reliability of soil testing for this nutrient. Furthermore, as S is a mobile nutrient and is subject to leaching below the rooting zone, potential yield loss and/or improved response to S fertilization may be dependent on the timing.

The most commonly used form of S fertilizer is ammonium sulphate (21-0-0-24). This product is widely used throughout western Canada and its efficacy is not disputed; however, yield responses can only be reasonably expected when crop requirements exceed what the soil can supply throughout the growing season without additional fertilization. This trial demonstrated the potential response to applications of varying rates of S fertilizer for 3 high yielding varieties. While the S component of this work is somewhat exploratory, it will help to promote sound agronomic management of flax and simultaneously demonstrate the relative performance of a few top varieties.

Methodology and Results

Methodology:

The demonstration was arranged as a randomized complete block design (RCBD) with four replicates at Scott, SK 2016. The demonstration consisted of four S fertilizer rates (0, 15, 30 and 45 kg S/ha) and three varieties (CDC Bethune, CDC Neela, and CDC Glas), resulting in a total of 12 treatments (Table 1). Prior to seeding, soil samples were collected at three depth increments (0-15 cm, 15-30 cm and 30-60 cm) in order to determine fertilizer rates recommendations (Table A2). The trial was sown on wheat stubble using an R-tech drill with 10-inch row spacing. All N (urea; 46-0-0) and S (ammonium sulphate; 21-0-0-24) was side-banded while P (monoammonium phosphate) was seed-placed. Weeds and disease were controlled using registered herbicide and foliar fungicide applications. The plots will be terminated with pre-harvest glyphosate at maturity (>75% boll colour change). Further details regarding treatment applications can be found in Appendix A.

Table 1. Flax variety and Sulphur application rate for determining the merit of sulphur in flax

Trt #	Variety	Sulphur Rate **kg S/ha**
1	CDC Bethune	0
2	CDC Bethune	15
3	CDC Bethune	30
4	CDC Bethune	45
5	CDC Glas	0
6	CDC Glas	15
7	CDC Glas	30
8	CDC Glas	45
9	CDC Neela	0
10	CDC Neela	15
11	CDC Neela	30
12	CDC Neela	45

Data Collection:

Plant densities were determined by counting numbers of emerged plants on 2 x 1 meter row lengths per plot about a week after the first rows became visible. Days to maturity (DTM) were also determined based on 75% boll colour change. Lodging was assessed by determining lodging severity, intensity and area affected (lodging did not occur within plots). Yields were determined from cleaned harvested grain samples and corrected to 10% moisture content. Weather data was recorded from the online database of Environment Canada weather station.

Growing Conditions:

The 2016 growing season started out very dry in April with only 1.9 mm of precipitation. May, July, and August were far above the long-term average, with 40 %, 21 %, and 50 % increase, respectively. Overall, when looking at the accumulated amount of precipitation in 2016 from April to October, there was 38.5 mm more than the long-term total. Throughout the growing season, the temperature was very similar to the long-term average. Growing degree days were higher than the long-term average for the months of April – July, and lower for the remaining months (Table 2).

Table 2. Mean monthly temperature, precipitation and growing degree day accumulated from April to October 2016 at Scott, SK

Year	April	May	June	July	August	Sept.	Oct.	Average /Total
Temperature (°C)								
2016	5.9	12.4	15.8	17.8	16.2	10.9	1.6	11.5
Long-term[z]	3.8	10.8	14.8	17.3	16.3	11.2	3.4	11.1
Precipitation (mm)								
2016	1.9	64.8	20.8	88.1	98.2	22.2	33.1	329.1
Long-term[z]	24.4	38.9	69.7	69.4	48.7	26.5	13	290.6
Growing Degree Days								
2016	58.9	224.9	303	398.7	343.8	176.2	12.5	1518.0
Long-term[z]	44	170.6	294.5	380.7	350.3	192.3	42.5	1474.9

[z]Long-term average (1985 - 2014)

Analysis:

The data was statistically analysed using the PROC MIXED in SAS 9.4. The residuals were tested for normality and equal variance to meet the assumptions of ANOVA. The means were separated using a Tukey's Honestly Significant Difference (HSD) test with level of significance at 0.05. Replications were treated as random effect factor whiles treatments were fixed effect factors.

Results & Discussion:

Plant densities were collected for treatments of similar sulphur rates of 15 kg S /ha for the three different varieties: CDC Bethune, CDC Glas, CDC Neela. Variety had a significant effect on plant density (P= 0.0132) with CDC Neela resulting in a significantly higher plant density of 70 plants m^{-2} compared to CDC Bethune (Table 3). CDC Glas and CDC Neela resulted in similar plant densities of 226 and 263 plants m^{-2}, respectively. Overall, the plant densities recorded in this study are lower than the targeted plant density of 500 plants m^{-2} used for the seeding rate calculation. This was not unexpected as seedling emergence rates can be reduced up to 60% depending on growing conditions (Saskatchewan Flax Development Commission, N/A). The plant densities of this study were however below the minimum plant density of 300 plants m^{-2}. In most field conditions, plant densities below 300 plants m^{-2} result in a significant seed yield decline due to excessive crop-weed competition (Saskatchewan Flax Development Commission, N/A). However, seed yield losses due to crop-weed competition were not observed as the average yield was 50 bu ac^{-1}, a 26% yield increase compared to the 5 -year yield average at Scott (Agriculture and Agri-Food Canada, 2015). This is likely attributed to the fact that the plots were kept weed-free via in-crop herbicide applications and rigorous hand-weeding.

Table 3. The P values were generated using a One-way Analysis of Variance (P< 0.05) to determine the effect of variety on plant density (plants m^{-2}) at Scott, 2016. Treatment means were generated and separated using Tukey's HSD. Different letters indicate a significant difference (P < 0.05).

	Plant Density (plant m^{-2})	**DTM**	**Yield** bu ac^{-1}
Variety (Vr)	0.013	0.013	0.004
Fertilizer Rate (Rt)	-	0.623	0.891
Vr* Rt	-	0.972	0.974

Flax seed yield was largely influenced (P = 0.004) by varietal selection with CDC Glas and CDC Neela resulting in a 4 bu ac^{-1} seed yield increase compared to CDC Bethune (Table 3; Figure 1). These results correspond with the 2015 yield data collected at Scott, in which CDC Glas and CDC Neela resulted in a 2.5 bu ac^{-1} average yield increase compared to CDC Bethune (Agriculture and Agri-Food Canada, 2015). CDC Bethune also matured 3 days after the days to maturity of CDC Glas and CDC Neela, which matured in 107 days.

Varietal selection plays a large role in seed yield production, however, the effect of S fertilizer is less consequential. S fertilizer did not have a significant effect on overall flax seed yield (P= .891). at Scott, even with a low residual soil S levels (Table A2). S deficiencies have been found to limit yields, yet flax responses to S fertilizer applications in western Canada are rare. However, as continuous canola cropping rotations are largely used on the Prairie, S deficiencies may become more common due to the high S requirements associated with canola production. Consistently high yielding flax crops may have the potential to be a large user of S and therefore may require S fertilization in the future. Although flax did not have a response to S, it is important for producers to continue to apply S to ensure soil residual levels do not become depleted and cause future seed production problems. A management strategy based on soil health rather than on crop sufficiently should be properly utilized to ensure that soils are not depleted.

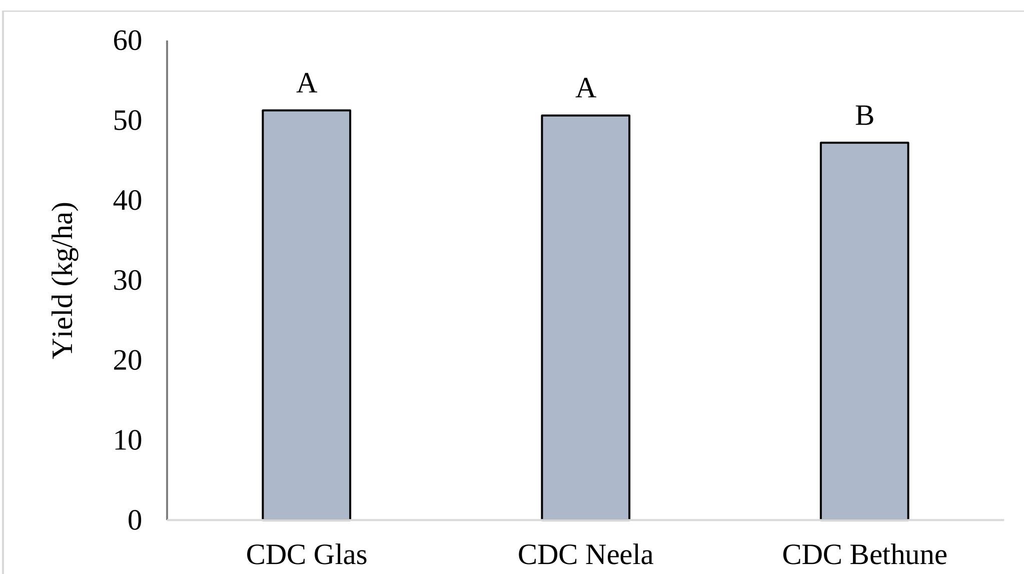

Figure 1. The effect of variety on flax yield (bu/ac) at Scott, SK in 2016 growing season. Different lettering indicates significant difference between treatments, respectively.

Conclusions and Recommendations:

The results of this trial have provided insights to improve flax production by demonstrating the effect of varietal selection on yield production. Varietal selection largely influenced overall plant density, maturity, and seed yield production. CDC Glas and CDC Neela consistently resulted in a 4 bu ac^{-1} yield increase compared to CDC Bethune will having a shorter day to maturity. Sulphur applications had negligible effects on plant density, maturity, and seed yield. Although sulphur deficiencies are not common on the Canadian prairies, the continuous use of high demanding S crops, such as canola, may result in the depletion of S and thus effect of S on flax yields. A conservative fertility management approach should be utilized to ensure that S deficiencies do not impact future yields.

Supporting Information

Acknowledgements

We would like to thank the Ministry of Agriculture for the funding support on this project. We would like to acknowledge Herb Schell and our summer staff for their technical assistance with project development and implementation for the 2016 growing season. This report will be distributed through WARC's website and included in WARC's and Agri-ARM annual reports.

Appendices

Appendix A

Table A1. Agronomic and treatment application information during the growing season at Scott, 2016.

	Product	Rate	Stage
Fertilizer	Trt 1, 5, 9	0 S kg/ha; Urea 97 lb/ac and MAP 48 lb/ac	-
	Trt 2 ,6, 10	15 S kg/ha; Urea 71 lb/ac and MAP 48 lb/ac	-
	Trt 3, 7, 11	30 S kg/ha; Urea 46 lb/ac and MAP 48lb/ac	
	Trt 4, 8, 12	45 S kg/ha; Urea 21 lb/ac and MAP 48 lb/ac	
Variety	CDC Glas	500 seeds/ m2	-
	CDC Neela	500 seeds/ m2	-
	CDC Bethune	500 seeds/ m2	-
Herbicide	Buctril M + Post Ultra + Merge	0.4 L/ac 0.19 L/ac 0.5L/100L	2 - 4 inches tall
Fungicide	Priaxor	180 mL/ac	20 - 50% flower
Desiccation	Reglone Ion	0.69L/ac	maturity

Table A2. Soil test nutrient level results (lb/ ac) from Scott, SK 2016.

	NO_3-N	P	K	SO_4 -S	Cu	Mn	Zn	B	Fe	Cl
0 - 15	11	55	547	9	1.4	43.4	3.4	1.1	211	3
15 - 30	8			5						3
30 - 60	16			13						7

Abstract

For most crops, including flax, fertilizer is one the largest input costs and typically provides a large return on investment when appropriate rates are applied. Despite flax being widely perceived as a relatively low input crop, sulphur deficiencies can limit the yields of flax. On a per bushel basis, flax S requirements are actually higher than those of canola; however, canola yields (and subsequent S requirements) are normally higher. This trial was developed to demonstrated the potential response of three flax varieties to varying rates of S fertilizer applications. The demonstration was arranged as a 2-way factorial, randomized complete block design with four replicates. The demonstration consisted of four S fertilizer rates (0, 15, 30 and 45 kg S/ha) and three varieties (CDC Bethune, CDC Neela, and CDC Glas), resulting in a total of 12 treatments. The results showed that varietal selection largely influenced overall plant density, maturity, and seed yield production. CDC Glas and CDC Neela consistently resulted in a higher plant density, faster maturity and greater seed yield production compared to CDC Bethune. CDC Glas and Neela resulted in a 4 bu ac^{-1} yield increase compared to CDC Bethune. Sulphur applications had a negligible effect on plant density, maturity, and seed yield. Although sulphur deficiencies are not common on the Canadian prairies, the continuous use of high demanding S crops, such as canola, may result in the depletion of S and thus effect of S on flax yields. A conservative fertility management approach should be utilized to ensure that S deficiencies do not impact future yields.

Extension Activities

This project was shown to producers and agronomists at the Scott Field Day in July 2016, with an attendance of approximately 175 people. Rachel Evans, Extension Agronomist with Flax Council of Canada, discussed the effects of fertilizer, seeding rates and popular trends surrounding flax production. Signs stating the objective of this demonstration with acknowledgement of the ADOPT program and the Saskatchewan Ministry of Agriculture were posted in front of the plots. A fact sheet will be generated and distributed on the WARC website as well as all Agri-ARM and WARC events to ensure the information will be transferred to producers.

References

Agriculture and Agri-Food Canada. 2015. Crop Variety Highlights and Insect Pest Updates. https://www.westernappliedresearch.com/research/varietal-testing-pest-forecast/

Saskatchewan Flax Development Commission. N/A. Seed and Seeding Practices. Accessed February 2017. http://www.saskflax.com/growing/seeding.php