2017 Annual Report for the Agriculture Demonstration of Practices and Technologies (ADOPT) Program

Project Title: PHOSPHOROUS FERTILITY MANAGEMENT IN CAMELINA

Project Number: 20160378

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 demonstration is to investigate camelina responses to monoammonium phosphate (MAP; 11-52-0) rate and placement method and interactions between these two factors.

Project Rationale:

Camelina production in Saskatchewan has risen to 5,000 acres in 2016 and in 2017 estimates from the Saskatchewan Ministry of Agriculture are 8,000 acres. An increase in camelina production is largely associated to an increase in market demand within the aquaculture industry, requiring camelina for fish food. Currently, demands within the aquaculture market can require up to 5,000 tonnes per month, indicating a strong demand for camelina production in the coming years.

In order to reach this growing demand, camelina producers will need to increase production acres and maximize yields on pre-existing production acres. One way to improve yield is through better fertility management. A study conducted in 2008- 2009 indicated that yield increased up to a maximum when 120 kg of N/ ha were applied. Although this study provides producers with an insight into nitrogen requirements, little research is available for phosphorus rate requirements. Furthermore, little is known as the implications of fertilizer placement and its interactive effect with P rates on yield and oil quality. Therefore, in order for producers to maximize production, further information is needed for agronomic recommendations.

Methodology and Results

Methodology:

The demonstration was arranged as a randomized complete block design with four replicates at Scott in 2017. The treatments consisted of a factorial combination of 5 phosphorus (P) fertilizer rates and 3 placement methods to result in 15 treatments (Table 1). Phosphorous was applied as monoammonium phosphate (11-52-0). Nitrogen and sulphur were applied as per soil test recommendation to achieve a 40 bu/ac. Nitrogen was balanced for the N supplied by the monoammonium phosphate (11-52-0) and ammonium sulphate (21-0-24). The nitrogen and ammonium sulphate blends were applied prior to seeding. The seeding rate was targeted to achieve 500 seeds /m2.

Table 1: Treatment list representing treatment numbers, rate of P_2O_5 and fertilizer placement.

Trt #	Rate of P_20_5 (kg/ha)	Fertilizer Placement
1	0	Seed Placed
2	20	Seed Placed
3	40	Seed Placed
4	60	Seed Placed
5	80	Seed Placed
6	0	Side-Band
7	20	Side-Band
8	40	Side-Band
9	60	Side-Band
10	80	Side-Band
11	0	Broadcast
12	20	Broadcast
13	40	Broadcast
14	60	Broadcast
15	80	Broadcast

Data Collection:

Plant densities were determined by counting numbers of emerged plants on 2 x 1-meter row lengths per plot approximately two and four weeks after emergence (WAE). Days to maturity (DTM) were determined based on 75% boll colour change. 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 2017 growing season started with great soil moisture in April and May with 30.9 mm and 69 mm of precipitation, respectively. Midseason growing conditions in June and July were very dry with 51% and 68% less precipitation compared to the long-term average. Throughout the growing season, the temperature was very similar to the long-term average. Frost occurred on several occasions with a nightly low of -0.02 ^{o}C, -1.6 ^{o}C, -2.7 ^{o}C on May 15th, 16th and 18th, respectively. Growing degree days were higher than the long-term average for the months of May and July and lower for the remaining months (Table 2).

Table 2. Mean monthly temperature, precipitation and growing degree day accumulated from April to September in 2016 and 2017 at Scott, SK.

Year	April	May	June	July	August	Sept.	Average /Total
------------------------*Temperature (°C)*------------------------							
2016	5.9	12.4	15.8	17.8	16.2	10.9	13.2
2017	3.0	11.5	15.1	18.3	16.6	11.5	12.7
Long-term[z]	3.8	10.8	14.8	17.3	16.3	11.2	12.4
------------------------*Precipitation (mm)*------------------------							
2016	1.9	64.8	20.8	88.1	98.2	22.2	296
2017	30.9	69.0	34.3	22.4	53	18.9	228.5
Long-term[z]	24.4	38.9	69.7	69.4	48.7	26.5	277.6
------------------------*Growing Degree Days*------------------------							
2016	58.9	224.9	303	398.7	343.8	176.2	1505.5
2017	16.6	202.7	283.3	399.1	348.4	194.8	1444.9
Long-term[z]	44	170.6	294.5	380.7	350.3	192.3	1432.4

[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 using Shapiro-Wilk and equal variance using Levene's to meet the assumptions of ANOVA. The means were separated using a Tukey's Honestly Significant Difference (HSD) test with a level of significance at 0.05. Replications were treated as random effect factor whiles treatments were fixed-effect factors.

Results & Discussion:

Effect of phosphorus on plant establishment

Phosphorus (P_2O_5) rates, along with placement, can have a strong impact on stand establishment under certain soil textures and environmental conditions. Fertilizer placement played a large role in stand establishment in the early growing season. Plant densities measured at two and four WAE indicated a significant response (P=0.0004 and P=0.0083) to fertilizer placement (Table 3).

Table 3. The P values were generated using a One-way Analysis of Variance ($P < 0.05$) to determine the effect of fertilizer placement and rate of P_2O_5 on plant density (plants m^{-2}), days to maturity (DTM), and yield (bu ac^{-1}) at Scott, SK in 2017. Treatment means were generated and separated using Tukey's HSD.

	Plant Density (plant m^{-2})		**DTM**	**Yield**
	2 WAE	**4 WAE**	**-**	**bu ac^{-1}**
Rate (Rt)	0.3467	0.017	0.3342	0.5802
Placement (Pc)	0.0004	0.0083	0.7139	0.4286
Rt x Pc	0.4800	0.4192	0.184	0.8496

Stand establishment tended to decline when phosphorus (P) was placed in close proximity to the seed. Seed-placed P resulted in a 26% decline in plant population compared to the broadcast application and 23% with the side-banded application at two WAE. At four WAE the seed-placed fertilizer had a decline on plant density of 23% compared to the sideband placement and a slight, non-significant decline in plant density of 11% for broadcast applications (Figure 1).

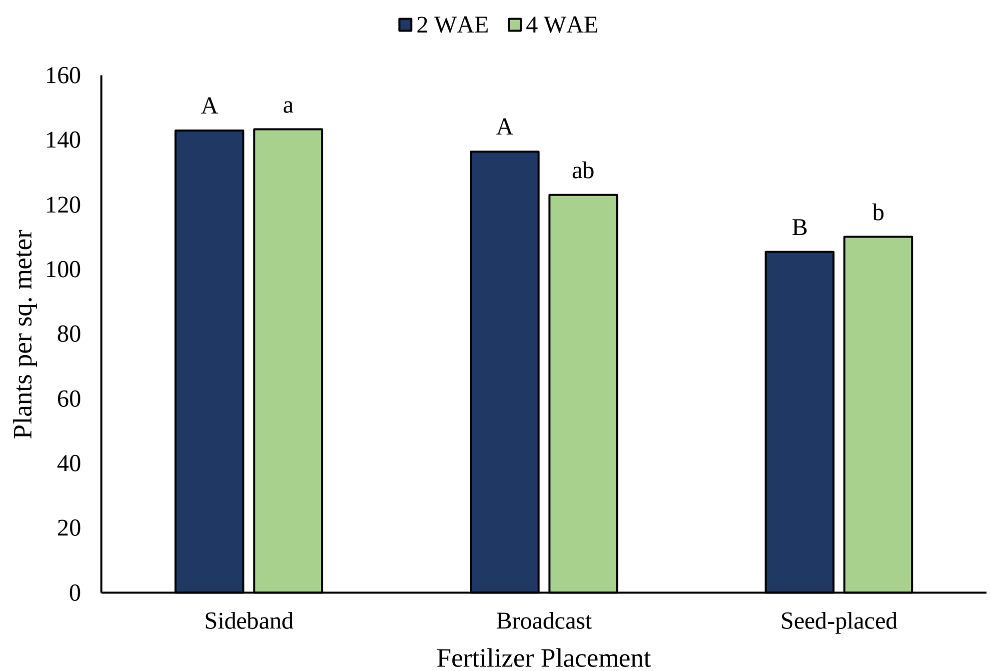

Figure 1. The effect of phosphorus placement (sideband, seed-placed, and broadcast) on camelina plant density at two and four weeks after emergence at Scott, 2017.

P rate did not significantly affect plant density at two WAE (P= 0.3467) while it was significant at four WAE (P=0.17) (Table 3). Although at two WAE there was no significant effect, an underlying trend indicated that plant density decreased on average of 15% when rates exceeded 40 kg of P / ha (Figure 2). A similar trend also occurred at four WAE as plant populations declined with increasing rates of phosphorus. The average plant density for the check was 144.2 plants m^{-2} and when phosphorus rates were 80 kg ha^{-1} plant density declined to 101.62 plants m^{-2} with a reduction of 30% (Figure 2).

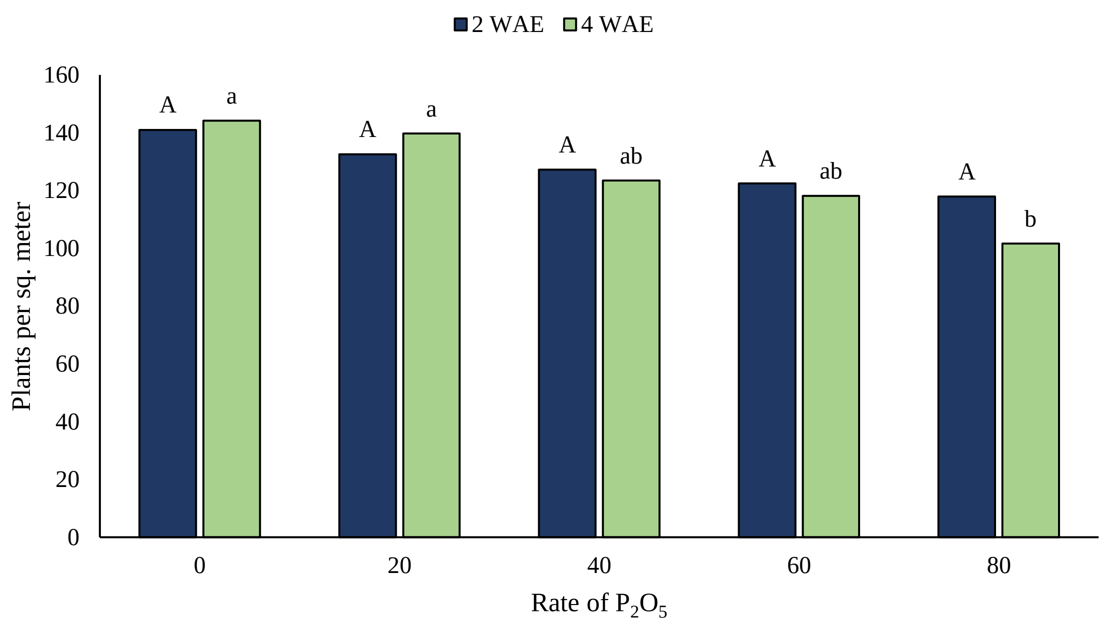

Figure 2. The effect of phosphorus applied at 0, 20, 40, 60, and 80 kg of P_2O_5 / ha on camelina plant density at two and four weeks after emergence at Scott, 2017.

We hypothesized that camelina safe seed-placed P recommendations are close to canola safe rates due to the fact that this species belong to the same botanical family. Safe P rate recommendations are based on seed bed utilization (SBU) factors. SBU takes into consideration crop selection, soil texture, row spacing and opener type among other factors (soil moisture, soil type, air flow, residue levels) (Government of Manitoba, 2016). Appling P in excess of safe rate recommendations can result in seed burn and seedling damage (Henry et al. 1995). Current safe rate P recommendations for a medium texture soil are around 22 kg/ha of monoammonium phosphate. In this demonstration, rates in excess of seed placed 20 kg/ ha resulted in seedling damage and ultimately a reduced plant population. These results indicate that camelina is sensitive to seed placed fertilizer and that safe rate P recommendations for canola should be followed to reduce seedling damage.

Grain yield

Little is known regarding the fertility requirements of camelina. Previous research (Malhi et al. 2013; Gugel and Falk, 2006; Johnson et al. 2009) have indicated that maximum camelina yield can be achieved when high rates (>120 kg/ha) of nitrogen (N) are available. In general, research has indicated that camelina will respond to available N in a similar fashion of other oilseed crops (Johnson et al. 2009). Current recommendations for other nutrient requirements for camelina are similar to those of other *Brassica* species including mustard and flax (Government of Saskatchewan, 2016). Based on the assumption that camelina will responds similarly to P as it does to available N, a yield response was anticipated when grown on nutrient deficient soils. However, grain yield was unaffected by P rate (P=0.5802), placement (0.4286) and any combination of these factors (P=0.8496) (Table 3). There was no yield response detected between the fertilized (20, 40, 60 and 80 kg P_2O_5 /ha) and unfertilized treatments, as yield differences were less than 1 bu per acre. These results indicate that perhaps camelina P nutrient requires are lower than those of its similar oilseed counterparts. This hypothesis is supported by a recent study conducted in Chile by Solis et al. (2013) which concluded that camelina has lower input requirements than canola despite the fact that these species have some similarities. These results allow us to conclude that the low nutrient residuals in the soil and the fertilizer applied were well above the critical values for this plant.

These results also suggest that placement will have little effect on camelina yield due to its low- input nature. However, banding of P fertilizers is still the preferred method due to the immobile nature of P. Banding increases P use-efficiency by placing P in a favourable position for plant uptake as well as minimizing soil-fertilizer contact, reducing P precipitation and adsorption in soil (Havlin et al. 2005). Furthermore, banding may improve availability under dry conditions because the fertilizer is in a moist part of the root zone for a longer period of time. Broadcast-incorporated applications are less effective than when fertilizer is banded with or near the seed of annual crops.

This study also allows us to demonstrate the plasticity of camelina to environmental conditions, as low plant densities caused by seed burn did not result in yield differences. This indicates that a reduction in plant stand does not necessarily translate into a yield loss. Previous research indicates that canola plants are highly plastic and are able to compensate for a reduced plant stand by producing more branching and increased pod retention (Angadi et al., 2003). However, the downsides of a reduced plant stand are an increased weed competition (Johnston et al., 2001), a decrease in oil quality (Grant et al., 2003) and delayed maturity. A decreased oil quality could influence the marketability of the grain, as camelina oil is used for cooking, biofuel and nutritional supplement for animals. Therefore, a uniform plant density is preferable to ensure grain oil quality remains consistent for marketing purposes.

Conclusions and Recommendations:

The results of this trial have provided insights for initial phosphorus requirements for camelina. These results indicated that camelina is sensitive to application rate and placement early in the growing season, as plant densities tended to decline with seed placed P and rate in excess of 20 kg P_2O_5 per ha. This study also demonstrated that camelina has a large capacity to compensate for low plant density by producing more branches and pods per plant. Results also indicated that camelina is a low- P input crop, as yield differences were less than 1 bu per acre between fertilized and unfertilized treatments. Current fertility recommendations for camelina are based on other oilseed crops, however, these results indicate that perhaps camelina P nutrient requires are lower than those of its similar oilseed counterparts. These results also suggest that placement will have little effect on camelina yield due to its low- input nature. However, banding of P fertilizers is still the preferred method over broadcasting due to the immobile nature of P.

We recommend the evaluation of residual soil P contents to improve the decision-making process for P applications. Furthermore, we recommend side-banded P to reduce seedling damaged caused by fertilizer burn. Further research should be conducted to conclusively determine P recommendations of camelina.

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 2017 growing season. This report will be distributed through WARC's website and included in WARC's and Agri-ARM annual reports.

Appendices

Abstract

Camelina production in Saskatchewan has risen to 5,000 acres in 2016 and in 2017 estimates from the Saskatchewan Ministry of Agriculture are 8,000 acres. An increase in camelina production is largely associated to an increase in market demand within the aquaculture industry, requiring camelina for fish food. In order to reach this growing demand, camelina producers will need to increase production acres and maximize yields on pre-existing production acres. One way to improve yield is through better fertility management. The objective of this demonstration is to investigate camelina responses to monoammonium phosphate (MAP; 11-52-0) rate and placement method and interactions between these two factors. The demonstration was arranged as a randomized complete block design with four replicates at Scott in 2017. The treatments consisted of a factorial combination of 5 phosphorus (P) fertilizer rates and 3 placement methods to result in 15 treatments. Phosphorous was applied as monoammonium phosphate (11-52-0). The results of this demonstration indicate that P rates in excess of seed placed 20 kg/ ha will result in seedling damage and thus the current safe rate P recommendations for canola should be followed to reduce seedling damage. We recommend the evaluation of residual soil P contents to improve the decision- making process for P applications. Furthermore, we recommend side-banded P to reduce seedling damaged caused by fertilizer burn. Although there was no yield difference with application method, banding of P fertilizers is still the preferred method over broadcasting due to the immobile nature of P. Lastly, we recommend that further research should be conducted to conclusively determine P recommendations of camelina.

Extension Activities

The results of this trial was highlighted at the Scott Field Day with approx. 140 people in attendance and will be shared at the annual Crop Opportunity event hosted in March with approximately 150 people in attendance. 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.

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