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

Project Title: Demonstrating 4R Phosphorus in Canola

Project Number: 20160376

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 2017 and completed January 2018

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Objectives and Rationale

Project objectives:

Developing best management practices (BMPs) for nutrient applications has long been focused on the 4R principles which refer to using the: 1) right formulation, 2) right rate, 3) right placement and 4) right timing. These factors are not necessarily independent of each other. For example, depending on the formulation, application timings or placement options that would normally be considered high risk can become viable.

The purpose of this trial is to demonstrate 4R principles for phosphorus (P) in canola with a focus on using the right rate, right placement and right timing of application. Formulations will not be a part of this demonstration because our drills are not equipped for liquid products and the granular alternatives are either not widely utilized or contain multiple nutrients.

Project Rationale:

Canola is known to be a large user of phosphorus and it is well documented that high rates of seed-placed P fertilizer can reduce seedling survival and establishment in canola. Phosphorus is a critical component of the plant metabolism as it plays a role in basic functions such as respiration and photosynthesis. Low phosphorus availability at the early developmental stages of the plant can have detrimental effects on an appropriate crop growth even if adequate levels are supplied at a later stage. While P fertilizer will typically result in higher canola seed yields when residual levels of this nutrient are low, often the response is most evident early in the season when more vigorous growth is frequently observed with P fertilization. This is sometimes referred to as a 'pop-up' effect and is usually attributed specifically to seed-placed P fertilizer; however, yields do not typically differ between commonly recommended placement methods when using safe rates. The dominant form of P is mono-ammonium phosphate (11-52-0); however, other forms are available and effective, albeit generally more expensive. As for rates, relatively low rates of starter P can often be sufficient to optimize yield and, due to limited mobility and availability in cool, spring soils, may be beneficial even when residual nutrient levels are relatively high. Appropriate rates of P fertilizer generally depend on whether the objective is to draw down, maintain or build long-term soil P levels. Due to the large P requirements of canola and limits to how much fertilizer can be safely placed in the seed-row, growers who seed-place P are often forced to choose between applying less than the required amount of P for maintenance purposes or seed-placing rates that will potentially result in crop injury. Alternatively, growers have the option of side-banding P fertilizer and most research has shown that this is an effective practice, despite concerns of reduced availability early in the season relative to seed-placement. Broadcast P is not recommended because it can quickly become insoluble and

unavailable when applied in this manner, particularly in high pH, calcareous soils.

The project is relevant for several reasons. Phosphorus is the second most commonly limiting nutrient throughout most of Saskatchewan and, in many cases, residual P levels are declining over the long-term as a result of continuous cropping, recent high yields, and inadequate application rates. In addition, many growers and agronomists prefer in-furrow placement of P fertilizer versus side-band and, with mid-row band configurations, at least some of the P should be seed-placed to prevent yield loss due to early-season deficiencies. The project is intended to illustrate the potential risks and benefits of seed-placement relative to side-banding while also demonstrating that either of these methods is preferable to broadcast applications.

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 fertilizer P rate and fertilizer placement to result in a total of seven treatments (Table 1). Prior to seeding, soil samples were collected at two depth increments (0-15 cm and 15-60 cm) in order to determine fertilizer rates recommendations (Table A1). The trial was sown on wheat stubble using an R-tech drill with 10-inch row spacing. The canola variety was Liberty Link 140P and was seeded at 115 seeds/m^2. Weeds and disease were controlled using registered herbicides and foliar fungicide.

Table 1: Treatment list representing P_2O_5 rate and placement variety.

Trt #	P_2O_5 Rate (kg/ha)	Application Placement
1	0 control [Z]	-
2	25	Early spring[Y] broadcast (starter)
3	55	Early spring broadcast (replacement)
4	25	Seed-placed (starter)
5	55	Seed-placed (replacement)
6	25	Side-banded (starter)
7	55	Side-banded (replacement)

[Z] All treatments will receive a full rate of N, K and S fertilizer (based on soil test)

[Y] Applied as early as possible, no incorporation other than seeding operation

Data Collection:

Plant densities were determined by counting numbers of emerged plants on 2 spots x 2 rows x 1 m row lengths per plot approximately three weeks after emergence. In-season NDVI was measured on each plot at four to six leaf stage and mid-bolting using a GreenSeeker optical sensor. 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:

Weather data was estimated from the nearest Environment Canada weather station. 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 less than half precipitation compared to the long-term average. Throughout the growing season, the mean monthly temperature was very similar to the long-term average. Growing degree days were higher than the long-term average for the months of May to July and lower for August and September (Table 2).

Table 2. Mean monthly temperature, precipitation and growing degree day accumulated from April to October in 2016 and 2017 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
2017	3.0	11.5	15.1	18.3	16.6	11.5	3.8	11.4
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
2017	30.9	69.0	34.3	22.4	53.0	18.9	20.9	228.5
Long-term[z]	24.4	38.9	69.7	69.4	48.7	26.5	13.0	290.6
----------*Growing Degree Days*----------								
2016	58.9	224.9	303	398.7	343.8	176.2	12.5	1518.0
2017	16.6	202.7	283.3	399.1	348.4	194.8	33.8	1478.7
Long-term[z]	44	170.6	294.5	380.7	350.3	192.3	42.5	1474.9

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

Statistical Analysis:

The data was statistically analysed using the PROC MIXED in SAS 9.4. The residuals were tested for normality using Shapiro-Wilk data were normally distributed, therefore no transformation was required equal variance was tested using Levene's to meet the assumptions of ANOVA. Treatment means were separated using Tukey's Honestly Significant Difference (HSD) with a level of significance at 0.05. Replications were treated as random effect factor while treatments were fixed-effect factors.

Results

Plant emergence

Plant density was assessed to determine the effects of phosphorus rates, application timings, and placement. Although, seed-placed P fertilizers can reduce plant stand, in this study no difference was found between seed-placed P and the other placements. No differences were found regardless of the evaluated factors, irrespective of the phosphorus rates (P= 0.9833) or application time and placement (P= 0.2838) and no interactions between these factors (P= 0.7616) (Table 3). Data from Table 3 shows the average means of every treatment and the standard error (SE) explains the variance of the data and shows the effects of the treatments.

Normalized Difference Vegetation Index (NDVI)

NDVI as a measurement of plant vigour was measured at two developmental stages; at the four-leaf stage and prior to bolting. There were no effects of the phosphorus rates (0.0545) and/or application timing for the first measurement (P=0.1970) and no interactions between these factors existed (P= 0.9175). However, when measurements were done prior to bolting some differences were observed among placement (P=0.0072). The check plots had the lowest NDVI (0.58) and no difference was found with side banded phosphorus (0.6); seed-placed phosphorus had the highest NDVI (0.65) indicating that this placement contributes to plant vigour (Table 4). No interaction between rates or placement were observed at this stage (P= 0.5023).

Grain yield

There were no differences detected among phosphorus rates (P= 0.545), placement (P= 0.8221), or interaction between rates and placement (P= 0.7097). These results suggest that phosphorus is not a limiting factor in the area as yield was not affected. Seed-placed P fertilizer can result in higher yields, especially, when residual P in the soil is under critical values. According to

the canola council, phosphorus levels from 0 to 20 lb/ac are considered very low and from 20 to 35 lb/ac low. Our soil tests results had a P content of 36 lb/ac. It seems that there was a trend towards a higher yield when phosphorus was applied at a rate of 55 kg/ha regardless of the placement or application timing (Table 3 and Figure 1). Brennan and Bolland (2009) found that there is a positive yield response to applied N and P and interaction between these two factors had a positive grain yield response. In this experiment, N was applied according to soil sample recommendations and P residual levels were not considered low. Although, the check plots have very similar results confirming once more that phosphorus was not a limiting factor and could explain why there was not a response to the P application.

Table 3. Phosphorus rates, application timing and placement effects on plant density, yield and normalized vegetation index of canola at Scott, SK in 2017.

P_2O_5 rate (kg/ha)	Application time and placement	Plant density (plants/m^2)	Yield (bu/ac)	NDVI 1	NDVI 2
				Four Leaf Stage	Prior to Bolting
0	-	59 ± 1.0	41 ± 1.5	0.33 ± 0.01	0.58 ± 0.02
25	Early spring broadcast (starter)	51 ± 3.6	39 ± 1.4	0.34 ± 0.01	0.61 ± 0.02
55	Early spring broadcast (replacement)	54 ± 6.9	41 ± 2.3	0.36 ± 0.01	0.65 ± 0.02
25	Seed-placed (starter)	56 ± 5.3	39 ± 0.3	0.35 ± 0.01	0.65 ± 0.02
55	Seed-placed (replacement)	56 ± 5.0	42 ± 2.0	0.37 ± 0.01	0.66 ± 0.01
25	Side-banded (starter)	50 ± 6.8	39 ± 2.3	0.33 ± 0.00	0.58 ± 0.01
55	Side-banded (replacement)	46 ± 4.5	41 ± 1.4	0.34 ± 0.01	0.61 ± 0.01

Table 4. Effect of phosphorus placement on normalized vegetation index of canola at Scott, SK in 2017.

Placement	NDVI 2 Prior to bolting
Check	0.58 ^{c}
Broadcast	0.63 ^{ab}
Seed-placed	0.65 ^{a}
Side-banded	0.60 ^{bc}

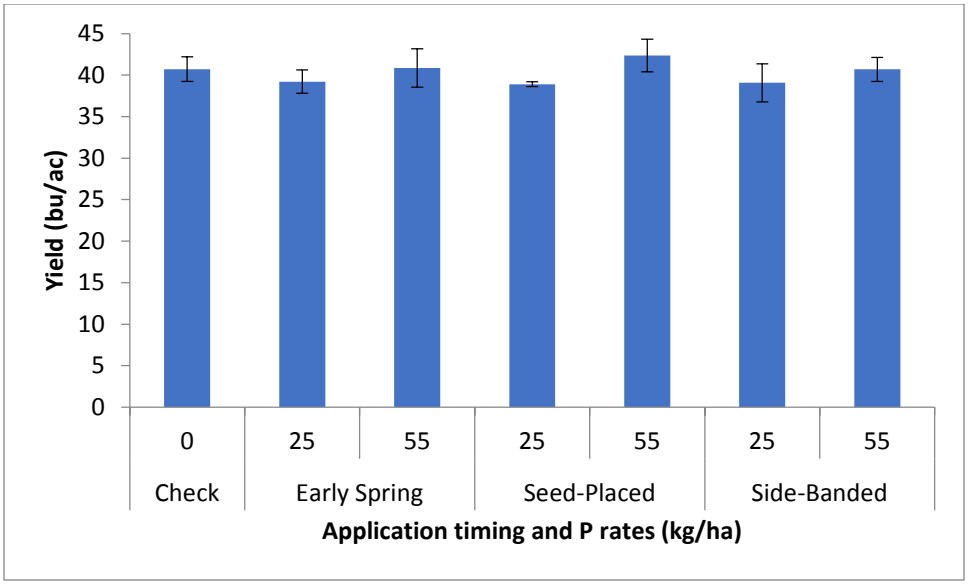

Figure 1. Canola yield (bu/ac) as a response to P placement, application timing and rate.

Conclusions and Recommendations:

The results of this trial have provided some beneficial information regarding P fertilization placement regardless of the lack of response among treatments. The probability of having a lower plant stand due to seed-placed P is minimal and the possible yield benefits are high. The lack of yield response to P can be attributed to the residual P levels in the soil. The second measurement of NDVI shows that the plant is able to utilize P more effectively when this element is close to the seed.

NDVI results are in agreement with the 4R management practices and show that seed-placed P confirms the 'pop-up' effect in terms of plant vigour. We recommend developing a plan to maintain P fertility levels and monitor these to avoid any nutrient deficiency particularly N and P in canola. Seed-placed P can be used with a low rate complemented with a side-band application to avoid any P injury to the plant. Broadcast application is acceptable but is important to take into consideration the potential loses. As P is an immobile nutrient, placement next to the seed is essential.

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

Appendix A

Table A1. Soil test nutrient level results (lb/ ac) from Scott, SK 2017.

	NO_3-N	P	K	SO_4 -S	Zn
0 - 15	9	36	664	14	5.5
15 - 60	2			20	

Abstract

The 4R principles of 1) right formulation, 2) right rate, 3) right placement and 4) right timing have long been the focus of best management practices (BMPs). Phosphorus in Saskatchewan is the second most commonly limiting nutrient and a trend of residual P levels declining is becoming problematic, due to continuous cropping, recent high yields, and inadequate application rates. A common practice is in-furrow placement of P. Although, with in-furrow P placement seed burn can occur if rates are above the recommended safe values. The objective of this project is to illustrate the potential risks and benefits of seed-placement relative to side-banding while also demonstrating that either of these methods is preferable to broadcast applications.

The treatments consisted of P fertilizer rates of 0, 25 and 55 kg ha^{-1}. Three different placements were used; broadcast, seed-placed and side-banded for a total of seven treatments. Plots were seeded with a target of 115 seeds/m^2 using an R-tech drill with a 10-inch row spacing. The results showed no difference in plant stand among treatments. NDVI was measured at two developmental stages and only at the second measurement differences were found among P placement. The check plots had the lowest NDVI (0.58) and no difference was found with side banded phosphorus (0.6); seed-placed phosphorus had the highest NDVI (0.65) indicating that this placement contributes to plant vigour. No differences in grain yield were observed among rates or placement. Soil tests results for the demonstration had a P content of 36 lb/ac and there was a trend towards a higher yield when phosphorus was applied at a rate of 55 kg/ha regardless of the placement or application timing. Our results showed that despite the fact that residual phosphorus was barely above the low values yield was not affected.

Extension Activities

The results of this trial were highlighted by Dr. Rigas Karamanos at the Scott Field Day with approx. 140 people in attendance. The results will also 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 AgriARM and WARC events to ensure the information will be transferred to producers.

Finances

Expenditure Statement

Majority of expenses associated with this project went towards labor ($5,000) required for the establishment of this field trial, including field operations, data collection, extension, data analyses and reporting. An amount of $1,000 was requested for materials and supplies to cover costs of research supplies, fertilizer, fuel, seed, crop inputs etc. There was a request for $250 each was requested for administration costs (see attached expenditure statement for details).

Expenditure information for *Demonstrating 4R phosphorus principles in canola* at Scott, SK in 2017 (ADOPT 20160376).				
	Year 1 ($)	Year 2 ($)	Year 3 ($)	Total ($)
Salaries & Benefits				
Students	1,500			1,500
Postdoctoral / Research Associates				
Technical / Professional Assistants	2,500			2,500
Consultant Fees / Contractual Services				
Rental Costs				
Materials & Supplies	1,000			1,000
Project Travel				
Field Work				
Collaborations / consultations				
Other				
Field Day				
Administration	250			250
Miscellaneous				
Total	**$5,250**			**$5,250**

Agronomic information for 2017 demonstration

Table A.1. Selected agronomic information for the 'Demonstrating 4R phosphorus principles in canola' trial at Scott, SK.

Seeding Information	**2017**
Seeder	R-Tech Drill, 10 inch row spacing, knife openers
Seeding Date	May 10, 2017
Cultivar and Seeding Rates	Canola (L140P) @ 115 seeds/m^2
Fertilizer applied	MAP (11-52-0) @ 25 kg/ha MAP (11-52-0) @ 55 kg/ha Urea @ 97-120 lb/ac + AS @ 104 lb/ac side-banded
Plot Maintenance Information	
Pre-plant herbicide	Roundup RT 540 @ 1 L/ac (May 4, 2017) Bromoxynil @ 0.4 L/ac (May 4, 2017)
In-crop herbicide	Liberty @ 0.81 L/ac (June 7, 2017) Liberty @ 0.61 L/ac (June 21, 2017)
Insecticide	Decis @ 6 mL/ac (May 29, 2017)
Fungicide	Priaxor @ 180 mL/ac (July 4, 2017)
Dessication	Reglone @ 0.8 L/ac (August 23, 2017)
Data Collection	
Emergence Counts	June 8, 2017
Harvest Date	August 30th, 2017

References

Brennan, R.F., Bolland, M.D.A. 2009. Comparing the nitrogen and phosphorus requirements of canola and wheat for grain yield and quality. Crop Pasture Sci. 60: 566-577