2017 Annual Report

for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Demonstrating 4R Phosphorus Principles in Canola

(Project #20160396)

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Project Identification

1. **Project Title:** Demonstrating 4R Phosphorus Principles in Canola
2. **Project Number:** 20160396
3. **Producer Group Sponsoring the Project:** Indian Head Agricultural Research Foundation
4. **Project Location(s):** Indian Head, Saskatchewan, R.M. #156
5. **Project start and end dates (month & year):** April-2017 to February-2018
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **Project objectives:**

Developing Best Management Practices (BMPs) for nutrient applications has long been focussed on the 4R principles which refer to using the: 1) right source, 2) right rate, 3) right time and 4) right place. The purpose of this trial was to demonstrate 4R principles for monoammonium phosphate fertilizer in canola with a focus on using the right rate, right placement and right timing of application. Phosphorus (P) formulations were not varied as part of this demonstration because our equipment is not fitted for liquid products and the granular alternatives are either not widely utilized or contain multiple nutrients.

8. **Project Rationale:**

Phosphorus is the second most commonly limiting nutrient throughout 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. A 2015 survey of soil testing lab results by the International Plant Nutrition Institute showed that 81% of Saskatchewan soil tests fell below the critical levels for P. Canola is known to be a large user of phosphorus but it is also generally accepted that high rates of seed-placed P fertilizer can reduce seedling survival and establishment in this crop. While P fertilization will typically result in higher canola seed yields when soil residual levels of this nutrient are low, often the response is most evident early when more vigorous growth is frequently observed with P fertilization. This is sometimes referred to as a 'pop-up' effect and is usually attributed to seed-placed P fertilizer; however, early season response can also occur with side-banded P and yields do not typically differ between these two recommended placement methods (seed-placed versus side-banded) when using safe rates. The dominant form of P is mono-ammonium phosphate (MAP; 11-52-0); however, other forms are available and effective, albeit generally more expensive. Based on 2014-15 surveys (Stratus Ag Research), 71-76% of the P applied to canola is MAP and 40-43% is seed-placed. As for rates, relatively low rates of starter P are often sufficient to optimize yield in any given year and, due to limited mobility and availability in cool, spring soils, can be beneficial even when residual P levels are relatively high. Appropriate rates of P fertilizer generally depend on whether the objective is to draw down, maintain or build soil P levels over the long-term. Due to the large requirements of canola and limits to how much fertilizer can be safely placed in the seed-row, growers who seed-place P must often choose between applying less than the optimal amount of P or seed-placing rates that will potentially

result in crop injury. The most popular alternative to placing P in the seedrow is side-banding 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 quickly becomes insoluble and unavailable when applied in this manner, particularly in high pH, calcareous soils (common in southeast Saskatchewan). Broadcast P can also be more prone to surface runoff losses, particularly if applied to frozen soil or prior to heavy precipitation events without incorporation. This project was initiated to demonstrate the potential risks and benefits of seed-placement relative to side-banding while also showing that either of these methods is preferable to broadcast applications.

Methodology and Results

9. Methodology:

A field trial was initiated in the spring of 2017 near Indian Head, Saskatchewan (50.550 N, 103.568 W) to evaluate the response of canola to various P rates and placement/timing options. Indian Head is situated in the thin-Black soil zone of southeast Saskatchewan and the soil is classified as an Indian Head clay with typical organic matter concentrations of 4.5-5.5%. The treatments were a combination of two P fertilizer rates (25 or 55 kg P_2O_5/ha), three placement/timing options (pre-seed broadcast, seed-placed or side-banded) and a control (no P fertilizer). Application rates were intended to represent typical starter versus replacement rates and the form in all treatments was commercial grade monoammonium phosphate (11-52-0). The treatments were arranged in Randomized Complete Block Design (RBCD) with four replicates and are described in Table 1. Unfortunately, an error at seeding resulted in the loss of five plots including all of Treatment #5 (55 kg P_2O_5/ha – seed-placed).

Table 1. Phosphorus management treatments in ADOPT 4R Phosphorus demonstration with canola at Indian Head in 2017.

#	Formulation	Timing / Placement	Fertilizer Rate
1	N/A	N/A	0 kg P_2O_5/ha
2	Monoammonium Phosphate (11-52-0)	Pre-seed broadcast	25 kg P_2O_5/ha
3	Monoammonium Phosphate (11-52-0)	Pre-seed broadcast	55 kg P_2O_5/ha
4	Monoammonium Phosphate (11-52-0)	Side-banded	25 kg P_2O_5/ha
5	Monoammonium Phosphate (11-52-0)	Side-banded	55 kg P_2O_5/ha
6	Monoammonium Phosphate (11-52-0)	Seed-placed	25 kg P_2O_5/ha
7	Monoammonium Phosphate (11-52-0)	Seed-placed	55 kg P_2O_5/ha

Selected agronomic information is provided in Table 2. A composite soil sample (0-15, 15-60 cm) was collected on May 11 (prior to seeding or any fertilizer applications) and analysed for select quality parameters and residual nutrients at AgVise Laboratories. To simplify logistics and avoid potential effects on emergence while ensuring that sulphur was not limiting, K_2SO_4 was broadcast across all plots prior to seeding. Nitrogen was supplied as side-banded urea with the rate balanced across treatments (i.e. rates adjusted for N provided by 11-52-0) to provide 140 kg N/ha as side-banded urea. Phosphate fertilizer rates and timing/placement varied as per protocol. InVigor® 233P, a high yielding shatter resistant canola variety, was direct-seeded into wheat stubble on May 13 at a target rate of 115 seeds/m^2.

Weeds were controlled using registered pre-emergent and in-crop herbicide applications while fungicides were applied at mid-bloom to ensure that disease did not become a yield limiting factor. Pre-harvest glyphosate was applied at approximately 70-80% seed colour change and the centre five rows of each plot were straight-combined when fit to do so.

Table 2. Selected agronomic information for the 4R Phosphorus demonstration with canola at Indian Head (2017).

Factor / Field Operation	Indian Head 2017
Previous Crop	CWRS Wheat
Pre-emergent herbicide	894 g glyphosate/ha (May-10-2017)
Soil Nutrient Sampling	May-11-2017
Pre-seed K_2SO_4 application	May-13-2017
Pre-seed P applications	May-12-2017 (as per protocol)
Variety / Seeding Rate	InVigor® L233P 115 seeds/m^2
Seed Treatment	Prosper plus Lumiderm
Seeding Date	May 13-2017
Row spacing	30 cm
kg N-P_2O_5-K_2O-S ha^{-1}	140-x-15-15
Plant density	Jun-5-2018
In-crop herbicide	202 g clopyralid/ha (Jun-6-2017) 600 g glufonsinate/ha + 30 g clethodim/ha (Jun-18-2017)
NDVI measurements	Jun-19-2017 Jun-23-2017 Jul-1-2017
Foliar fungicide	245 g boscalid/ha + 81 g pyraclostrobin/ha (Jul-5-2017)
Pre-harvest herbicide	894 g glyphosate/ha (Aug-20-2017)
Harvest date	Sep-2-2017

Various data were collected throughout the growing season. To assess treatment effects on emergence, the number of plants in four separate 1 m sections of crop row were recorded approximately 2 weeks after emergence was first noted. Early season growth response to P fertilizer was assessed by measuring

the NDVI of each plot at three stages ranging from 4-6 leaves to late-bolting using a handheld Trimble GreenSeeker sensor. Grain yields were determined from the harvested grain samples and are corrected for dockage and to a uniform moisture content of 10%. Daily temperatures and precipitation were recorded at the Environment Canada weather station located approximately 6 km from the field site.

Response data were analysed using the GLM procedure of SAS with the treatment effects considered fixed and replicate effects treated as random. Treatment means were separated using Fisher's protected LSD test and orthogonal contrasts were used to determine whether the responses to broadcast and side-banded P rate were linear or quadratic (curvilinear). Additional contrasts were utilized to compare the control to all fertilized plots, broadcast P, or side-banded P and broadcast to side-banded P (across both rates). All treatment effects and differences between means were considered significant at $P \leq 0.05$.

10. Results:

Growing season weather

Weather data for 2017 growing season at Indian Head is presented with the long-term (1981-2010) averages in Table 3. Despite less than normal precipitation through the winter months (60% of average from November 2016 through April 2017), with the wet fall, initial soil moisture conditions in 2017 were considered excellent. However, less than half of the long-term average precipitation was received during the growing season (May through August 2017). Nonetheless, crop establishment was adequate and stored soil moisture along with timely and substantial rainfall in mid-June (10 mm on June 9 and 50 mm on June 14) prevented drought from becoming a major limiting factor leading to high overall yields. Averaged across the four month period, temperatures were normal; however, May was warmer than the long-term average while August was cooler. Temperatures were approximately normal in June and July and conditions were such that disease pressure was negligible throughout the season.

Table 3. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) averages for the 2017 growing season at Indian Head, SK.

Year	May	June	July	August	Avg. / Total
	---------- Mean Temperature (°C) ----------				
IH-2017	11.6	15.5	18.4	16.7	15.6
IH-LT	10.8	15.8	18.2	17.4	15.6
	---------- Precipitation (mm) ----------				
IH-2017	10.4	65.6	15.4	25.2	117
IH-LT	51.8	77.4	63.8	51.2	244

Field Trial Results

Residual soil test nutrient levels are presented for the site in Table 4. Soil pH and percent organic matter were considered typical for the region at 7.7 and 5.0%, respectively. Residual NO_3-N was low, estimated at 29 kg/ha (0-60 cm). Residual phosphorus levels were considered very low with only 6 ppm Olsen-P. Both potassium and sulphur appeared to be sufficient. All nutrients other than P were intended to be non-limiting to canola yield in the current trial. Calcium, which reacts with phosphate to form increasingly insoluble compounds, is typically high on these sites (>6000 ppm).

Table 4. Selected soil test results for 4R Phosphorus demonstration with canola at Indian Head, Saskatchewan (2017).

Attribute/Nutrient	0-15 cm	15-60 cm	0-60 cm
pH	7.7	–	–
S.O.M. (%)	5.0	–	–
C.E.C. (meq)	42.7	–	–
NO_3-N (kg/ha)[Z]	12	17	29
Olsen-P (ppm)	6	–	–
K (ppm)	632	–	–
S (kg/ha)	13	34	47
Ca (ppm)	6139	–	–

Individual treatment means, overall F-test results and measures of variability are presented in Table 5 while results of the orthogonal controls and group comparisons appear in Table 6 of the Appendices. Overall emergence was somewhat variable under the dry conditions and the overall average plant density was 63 plants/m^2; however, plant density was not affected by any of the P treatments (P = 0.166). This was anticipated as neither broadcast nor side-banded P were expected to affect emergence and the starter P rate (25 kg P_2O_5/ha) was low enough to be considered safe for seed-row placement. Specifically for emergence, the treatment of greatest interest was the replacement rate (55 kg P_2O_5/ha) placed in the seedrow as this is more than double the typically recommended maximum rate of seed-placed P; however, as previously mentioned, this treatment was lost due to a seeding error. While measurements in early June suggested an overall average seedling mortality of 45%, most of the un-germinated seeds eventually emerged after mid-June rains.

Normalized difference vegetation index (NDVI) is an indirect measure of above-ground biomass / plant health that takes in to account both overall vegetative cover and chlorophyll status (i.e. greenness) of the canopy being measured. Earlier in the season it is a good objective indicator of overall crop vigor. Measurements were completed three separate times ranging from 5-6 leaves at the earliest date to late-bolting at the final date. At the first date (Jun-19), NDVI values were low due to the small plants (overall average of 0.315) but inspection of individual treatment means revealed slight improvements in early-season growth with seed-placed and side-banded but not broadcast P. This was also evident in the contrasts which detected significant NDVI differences between the control and side-banded P (P = 0.037), broadcast and side-banded P (P = 0.003) but not between the control and broadcast P (P = 0.574). NDVI values at the second date (Jun-23) were higher (0.407 across treatments) but otherwise consistent with the first measurements. Results at this time again showed higher NDVI with side-banded P relative to both the control (P = 0.040) and broadcast P (P = 0.001) but no difference between broadcast P and the control when averaged across rates (P = 0.338). Contrasts could not be utilized for seed-placed P due to the missing treatment but individual treatment means suggested comparable responses to seed-placed and side-banded P at the lower rate. By the final NDVI measurements, values were considerable higher (overall average of 0.674) but there were no longer any significant differences amongst the treatments (P = 0.180; Table 5) and none of the contrasts comparing timing/placement

options to the control or each other were significant (*P* = 0.223-0.662). It is not uncommon for early season growth effects of P fertilization to diminish as the growing season progresses.

Table 5. Individual treatment means for selected response variables in the ADOPT 4R Phosphorus Principles Demonstration with canola at Indian Head, 2017. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Entry	Plant Density	NDVI (Jun-19)	NDVI (Jun-23)	NDVI (Jul-1)	Seed Yield
	-- plants/m^2 --	---------- 0-1 ----------			---- kg/ha ----
1) Check (0 P)	63.6 a	0.303 bc	0.390 bc	0.660	3299 a
2) 25 kg P_2O_5/ha - BC	59.9 a	0.283 c	0.358 c	0.653	3307 a
3) 55 kg P_2O_5/ha - BC	66.4 a	0.308 abc	0.388 bc	0.685	3254 a
4) 25 kg P_2O_5/ha - SP	53.0 a	0.332 ab	0.449 a	0.674	3450 a
5) 55 kg P_2O_5/ha - SP	–	–	–	_	–
6) 25 kg P_2O_5/ha - SB	66.4 a	0.338 a	0.438 a	0.698	3449 a
7) 55 kg P_2O_5/ha - SB	69.9 a	0.328 ab	0.423 ab	0.673	3439 a
S.E.M.	4.14	0.0110	0.0148	0.0165	64.5
Pr > *F* (*p*-value)	0.166	0.023	0.053	0.180	0.436
C.V. (%)	12.6	6.8	7.1	4.7	3.7

Timing/placement: BC = pre-seed broadcast; SP = seed-placed; SB = side-banded

Phosphorus supplied as commercial grade monoammonium phosphate (11-52-0)

Considering the dry conditions, overall seed yields were quite high averaging 3366 kg/ha or 60 bu/ac across treatments. The overall F-test was not significant (*P* = 0.436) suggesting that no differences between individual treatment means were large enough to be considered significant; however, there was an overall tendency for higher yields with seed-placed and side-banded P relative to broadcast P and the unfertilized control. This was evident in the contrasts which detected higher yields with side-banding than with broadcast P (*P* = 0.021) and, although not significant at the desired probability level, a notable difference between side-banded P and the control (*P* = 0.081). The magnitude of the difference was modest with an advantage of 163 kg/ha (2.9 bu/ac), or 5%, to side-banded over broadcast P. Despite the low residual levels, small responses to P fertilization are not atypical for this site and presumably due to considered amounts of P becoming available through mineralization or chemical processes over the course of the season. While soil tests are valuable tools for predicting the potential response to P fertilization, extractable P is typically only a small percentage of the total P in soils.

Extension Activities and Dissemination of Results

This project was discussed and the plots were toured by approximately 200 guests at the Indian Head Crop Management Field Day on July 18, 2017 with a detailed discussion on 4R P management principles and contributions from Chris Holzapfel (IHARF), Stewart Brandt (NARF) and Rigas Karamanos (Koch Agronomic Services). Additionally, the site was shown on two smaller guided tours

for Federated Co-Op (July 13) and Richardson-Pioneer (July 21) agronomists. The full project report will be made available online (www.iharf.ca) and potentially elsewhere in the winter of 2017-18. Results will also be made available through a variety of other media (i.e. oral presentations, popular agriculture press, fact sheets, etc.) as opportunities arise. Data may be combined with that from other sites in the future for extension purposes.

11. Conclusions and Recommendations

This project has demonstrated the overall response of canola to contrasting rates and timing/placement options for monoammonium phosphate (11-52-0) fertilizer. While we could not demonstrate the potential risks associated with higher than recommended rates of seed-placed P on emergence, it is advised that growers exercise utmost caution if considering doing so. Negative effects associated with high rates of seed-placed P can be variable and difficult to predict as they are affected by many factors including soil physical and chemical properties (i.e. pH, texture, organic matter), seeding practices (i.e. opener type, seeding depth, seeding rate) and environmental conditions (i.e. soil moisture and temperature). Based on the NDVI measurements completed prior to bolting, early season growth/vigor was improved slightly but significantly over the control with side-banded but not broadcast P fertilizer. The improved growth also appeared to occur with seed-placed P but the same tests of significance could not be applied to this placement method. This positive early-season response was no longer evident at the late-bolting stage. When it came to yield, the overall response was relatively weak; however, there was a slight yield increase (approximately 5%) with side-banded monoammonium phosphate when compared to the pre-seed broadcast P or the control. Despite the missing treatment, yields with seed-placed P appeared similar to those achieved with side-banding. Overall, the results of this project support the current recommendations of side-banding or seed-placing P fertilizer during the seeding operation. In most cases, low rates of P fertilizer are sufficient to mitigate yield loss within the year of application; however, rates should be based on long-term fertility objectives which, for most, involve maintaining or building residual soil P levels.

Supporting Information

12. Acknowledgements:

This project was supported by the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canada-Saskatchewan Growing. Seed and crop protection products were provided in-kind by Bayer CropScience and BASF. The many contributions of IHARF staff Danny Petty, Christiane Catellier, Dan Walker, Karter Kattler, and Shaelyn Stadnyk are greatly appreciated.

13. Appendices

Table 6. Orthogonal contrast and group comparison results for selected response variables in the ADOPT 4R Phosphorus Principles in Canola demonstration at Indian Head, 2017.

Entry	Plant Density	NDVI (Jun-19)	NDVI (Jun-23)	NDVI (Jul-1)	Seed Yield
	---------- p-value ----------				
BC – linear	0.585	0.679	0.977	0.267	0.604
BC – quadratic	0.328	0.110	0.097	0.353	0.717
SB – linear	0.282	0.139	0.156	0.647	0.152
SB –quadratic	0.997	0.092	0.085	0.128	0.281
Check vs Rest	0.924	0.228	0.211	0.374	0.264
Check vs BC	0.935	0.574	0.338	0.662	0.811
Check vs SB	0.365	0.037	0.040	0.223	0.081
BC vs SB	0.232	0.003	0.001	0.327	0.021

Timing/placement: Check = 0P; BC = pre-seed broadcast; SP = seed-placed; SB = side-banded

Phosphorus supplied as commercial grade monoammonium phosphate (11-52-0)

Abstract

14. Abstract/Summary:

A field trial with canola was conducted on a low P site near Indian Head, Saskatchewan in 2017 to demonstrate the response to contrasting rates (0, 25 or 50 kg P_2O_5/ha) and various timing/placement options (pre-seed broadcast, seed-placed or side-banded) for monoammonium phosphate fertilizer (11-52-0). An error during seeding resulted in the loss of the 55 kg P_2O_5/ha seed-placed P treatment. InVigor® L233P canola was seeded in early May, side-banded urea was balanced across treatments to supply 140 kg N/ha, and K_2SO_4 was broadcast prior to seeding to ensure that nutrients other than P were not limiting. Overall it was a dry season with less than half the long-term average precipitation; however, initial soil moisture and yield potential were high. Seedling mortality was relatively high (~45%) under the dry conditions and emergence was somewhat variable but not affected by the treatments. This was not unexpected as the treatment most likely to impact emergence was the high rate of seed-placed P which was lost. Early-season assessments of vegetative growth using NDVI detected slight increases with side-banded P relative to broadcast P and the control but the differences were no longer evident by late bolting. The overall F-test for individual treatment effects on yield was not significant; however, across rates, yields with side-banded P were approximately 5% higher than those achieved with broadcast P or in the control. While the same comparisons could not be made due to the missing treatment, seed-placed P appeared to perform similarly to side-banded P with respect to both early season growth and yield. Yields were high despite the dry conditions, averaging 3366 kg/ha (60 bu/ac) across P treatments. The trial was toured on multiple occasions to over 300 people in total and discussed in detail at the annual IHARF/AAFC Indian Head Crop Management tour. Overall, these results support the recommendation of banding or seed-placing P during the seeding operation as opposed to broadcasting.