2015 Annual Report
for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Safe Rates of Side-Banded and Seed-Placed Phosphorus in Canola

(Project #20140427)

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Project Identification

1. **Project Title:** Safe rates of side-banded and seed-placed phosphorus in canola
2. **Project Number:** 20140427
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 2015 to January 2016
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **Project objectives:**

The objectives of this project were to demonstrate the effects of increasing rates of phosphorus fertilizer on canola establishment and seed yield for both side-band and seed-row placement.

8. **Project Rationale:**

Most farmers in western Canada apply their phosphorus (P) fertilizer either directly in the seed-row or in a side-band due to both the efficiency of banded P fertilizer and convenience of single pass seeding-fertilization. While canola is considered sensitive to seed-placed P fertilizer, this crop requires large amounts of this nutrient to reach maximum yield potential and replace what is removed from the soil compared to cereals. Most growers run a P deficit with canola, particularly when relying on seed-placed P. The reason this occurs is that, in order to satisfy canola's P requirements in the year of application and maintain long-term soil fertility, farmers must apply P at rates that greatly exceed the maximum recommended safe rates for seed placement. For example, a 2000 kg ha^{-1} canola crop (35 bu ac^{-1}) requires a total of 52-64 kg P_2O_5 ha^{-1} and exports 37-45 kg P_2O_5 ha^{-1} in the seed; however, the maximum recommended rate of seed-placed P in Saskatchewan is 28 kg P_2O_5 ha^{-1}. In southeast Saskatchewan, canola yields well beyond 3000 kg ha^{-1} (53 bu ac^{-1}) are becoming increasingly common.

High rates of seed-placed P fertilizer may result in delayed emergence and reduced plant densities, potentially leading to lower seed yield and/or quality and increased weed competition. On the other hand, repeatedly under applying P fertilizer while achieving high yields results in an overall decline in residual P fertility. Although higher seeding rates might be used to offset reductions in plant stand caused by fertilizer toxicity to a certain extent, many farmers are reducing seeding rates to manage input costs for canola. While actual results often vary depending on factors such as soil characteristics (i.e. texture, organic matter), moisture and seeding equipment, a growing number of field trials and producer testimonials suggest that current seed-safety recommendations may be somewhat conservative with modern drills and hybrids combined with no-till management. Side-banding P with other fertilizer products is considered by most experts to be a safe and effective method of applying P fertilizer, particularly when higher rates are required; however, questions on the overall efficacy of this practice remain out of concern that side-banded P is less available early in the season. This demonstration was intended to evaluate the risks and benefits of a range of side-banded and seed-placed monoammonium phosphate rates for canola with a focus on plant emergence / survival, early season growth and seed yield.

Methodology and Results

9. Methodology:

A field trial with canola was established on a clay soil east of Indian Head, Saskatchewan (R.M. #156; -103.560 W 50.556 N). Eleven P fertilizer treatments were arranged in a Randomized Complete Block Design and replicated four times. The treatments were a control (no P fertilizer) and five P rates (20, 40, 60, 80 and 100 kg P_2O_5 ha^{-1}) which were either side-banded or placed in the seed-row. The P fertilizer source was mono-ammonium phosphate (11-52-0) and the drill was a SeedMaster plot drill with eight openers (1.6 cm opener width) on 30 cm spacing and a seed-bed utilization of approximately 6%. The targeted seed depth was 1.9 cm and, for the side-banded treatments, all fertilizer was placed 1.9 cm (0.75”) below and 3.8 cm (1.5”) beside the seed-row (www.seedmaster.ca/openers.php).

A two depth (0-15 cm, 15-60 cm) composite soil sample was collected on May 5 and submitted to ALS laboratory group for various analyses. InVigor L140P canola was direct-seeded into heavy-harrowed spring wheat stubble at 115 seeds m^{-2} (5.4 kg ha^{-1}) on May 11. Due to significant pressure in the plots and surrounding fill crop, flea beetles were sprayed with 124 ml Decis 5EC ha^{-1} on May 27. Weeds were controlled using a pre-emergent application of 890 g glyphosate ha^{-1} combined with 74 ml ha^{-1} of Aim (May 9) plus an in-crop application of 4.0 l Liberty 150 SN ha^{-1} combined with 124 ml Centurion ha^{-1} (June 15). To reduce the likelihood of sclerotinia stem rot becoming a potential yield limiting factor, 350 g Lance WDG ha^{-1} was applied on July 3. The plots were terminated with 890 g glyphosate ha^{-1} (August 25) and the centre five rows of each plot were straight-combined using a Wintersteiger plot combine on September 2.

Various data were collected over the course of the growing season and from the harvested grain samples. Emergence was assessed by marking four separate 1 m sections of crop row (from the same four rows of each plot) and counting the plants within the marked areas at approximately 2 (May 27), 3 (June 3) and 4 (June 10) weeks after planting. At 4 weeks past planting, canola from the marked sections of crop row were harvested at ground level, dried and weighed to determine early season biomass yield. The maturity date (60% seed colour change) was recorded for each plot to determine the average number of days from planting to maturity. Seed yields were corrected for dockage and to a uniform moisture content of 10%. Seed size was determined by mechanically counting and weighing approximately 4000-5000 seeds and converting the values to g 1000 $seeds^{-1}$. Percent green seed was determined for each plot by counting the number of distinctly green seeds in a 500 seed crush.

Response data were analysed using the Mixed procedure of SAS 9.3. Individual treatment means were separated using Tukey’s studentized range test and orthogonal contrasts were used to determine whether the responses were linear or quadratic (curvilinear) in shape. Additional contrasts were utilized to compare the control to all fertilized plots and to compare side-banded to seed-placed P across rates. All treatment effects and differences between means were considered significant at $P \leq 0.05$.

10. Results:

Soil test results for the trial site are presented in Table 1. All macronutrients except for K were considered deficient to marginal with strong potential for a yield response to P fertilization. The pH was 7.9 for the 0-15 cm soil profile and organic matter was lower than normal for these particular soils at an estimated 2.8%.

Table 1. Soil test results for the ADOPT canola phosphorus demonstration at Indian Head in 2015. Samples were collected on May 5 and submitted to ALS Laboratory Group for analyses.

Soil Depth	Nitrogen (NO_3)	Phosphorus (Olsen-P)	Potassium (K)	Sulphur (SO_4)	pH	Organic Matter
	------------------------------ kg ha^{-1} ------------------------------				—	----- % -----
0-15 cm	12	10	> 605	6	7.9	2.8
15-60 cm	20	—	—	12	8.3	—
Total [Z]	32	10	> 605	18	—	—

[Z] 0-60 cm for N and S; 0-15 cm for P and K

Mean monthly temperatures and precipitation amounts for the 2015 growing season at Indian Head are presented relative to the long-term averages in Table 2. Temperatures were slightly above average overall in May-June, close to normal in July and slightly below average in August. While seed and fertilizer were placed into adequate, but not excessive moisture, the spring as whole was dry with no significant precipitation events until late in the third week of June when the canola was nearly ready to bolt. From this point on, moisture conditions improved substantially and the weather as a whole was conducive to above-average canola yields.

Table 2. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) averages for the 2015 growing season at Indian Head, SK.

Year	May	June	July	August	Avg. / Total
	------------------------------------- Mean Temperature (°C) -------------------------------------				
2015	10.3	16.2	18.1	17.0	15.4
Long-term	10.8	15.8	18.2	17.4	15.6
	--- Precipitation (mm) ---				
2015	15.6	38.3	94.6	58.8	207
Long-term	51.8	77.4	63.8	51.2	244

Mean plant densities at 2, 3 and 4 weeks after planting and tests of significance are presented in Table 3. Canola emergence was not affected by P fertilizer rate or placement at any of the three dates (P = 0.57-0.81). Furthermore, emergence in the control did not differ from that in the combined fertilized treatments or between side-band versus seed-row placement and neither the linear or quadratic orthogonal contrasts were significant in any cases.

Table 3. Treatment means and tests of significance for canola plant density at 2, 3 and 4 weeks after planting at Indian Head (2015). Values followed by the same letter do not significantly differ.

Treatment	Emergence 1 (16 DAP[Z]) Side-Band	Emergence 1 (16 DAP[Z]) Seed-Row	Emergence 2 (23 DAP) Side-Band	Emergence 2 (23 DAP) Seed-Row	Emergence 3 (30 DAP) Side-Band	Emergence 3 (30 DAP) Seed-Row
	plants/m²					
Control (0P)	69.1 a		88.4 a		91.5 a	
20 kg P_2O_5	69.5 a	83.7 a	84.1 a	95.2 a	88.6 a	99.7 a
40 kg P_2O_5	75.9 a	66.5 a	92.7 a	79.2 a	97.0 a	85.5 a
60 kg P_2O_5	73.4 a	70.7 a	90.9 a	90.2 a	98.4 a	96.6 a
80 kg P_2O_5	71.6 a	73.8 a	89.8 a	88.0 a	95.6 a	91.7 a
100 kg P_2O_5	66.1 a	72.8 a	79.2 a	98.4 a	84.3 a	103.0 a
S.E.M.	6.35		6.47		6.52	
	p-value					
Pr. > *F*	0.807		0.568		0.596	
Linear	0.828	0.899	0.575	0.468	0.804	0.422
Quadratic	0.292	0.955	0.244	0.225	0.156	0.387
0 P vs. rest	0.626		0.957		0.713	
SB vs. SR	0.588		0.489		0.549	

[Z] DAP – days after planting

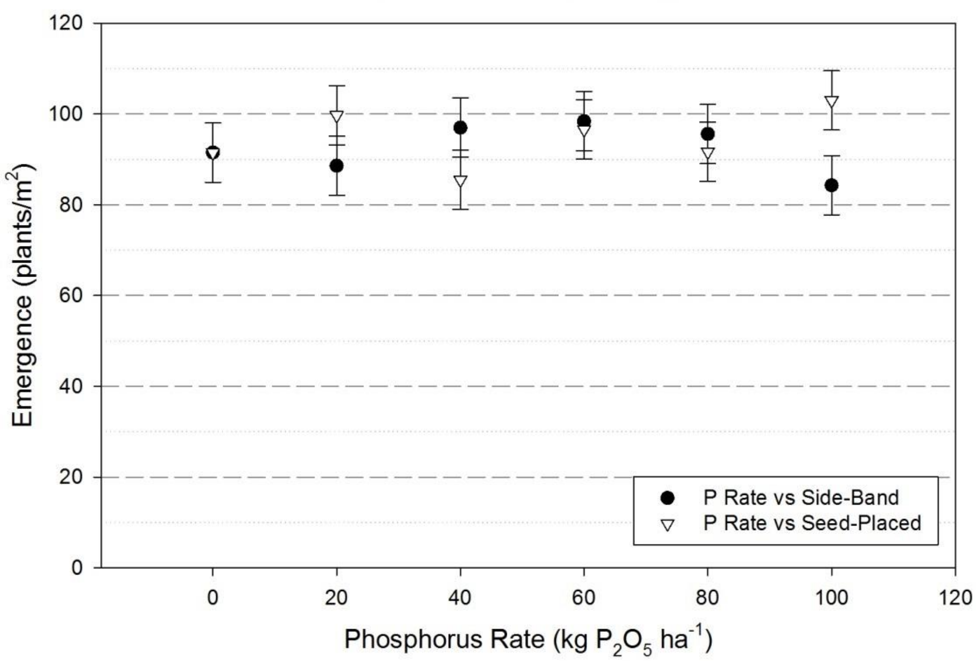

Figure 1. Phosphorus rate effects on canola emergence (4 weeks after planting) for side-banded versus seed-row placed monoammonium phosphate.

Treatment effects on canola early-season biomass yield, maturity and yield are presented in Table 4. While the observed biomass was lowest for the control (67 kg ha^{-1}), only the treatments that received

60-100 kg P_2O_5 ha^{-1} in the seed-row were significantly higher at 146-152 kg ha^{-1} and no differences amongst the individual fertilized treatments were statistically significant. However, contrasts comparing the control to the combined fertilized treatments (P = 0.001) and side-band to seed-row placement (P < 0.001) indicated an overall increase in early-season biomass yield with P fertilization and an advantage to seed-row placement versus side-banding. Averaged across rates, early season biomass yields were 99 kg ha^{-1} with side-banding and 142 kg ha^{-1} with seed-row placement. For side-banding, none of the orthogonal contrasts were significant at the desired probability; however the quadratic effect was notable at P = 0.081. In contrast, for seed-row placement both the linear and quadratic responses to P rate were significant (P < 0.001-0.021) with a stronger overall response and a tendency for increasing biomass with increasing rates which was not evident with side-banded P.

Table 4. Treatment means and tests of significance for canola early-season biomass, maturity and seed yield at Indian Head (2015). Values followed by the same letter do not significantly differ.

	Early-Season Biomass		Maturity		Seed Yield	
Treatment	Side-Band	Seed-Row	Side-Band	Seed-Row	Side-Band	Seed-Row
	------------- kg/ha -------------		----- days from planting -----		------------- kg/ha -------------	
Control (0P)	67.0 b		99.8 a		2773 c	
20 kg P_2O_5	94.4 ab	129.9 ab	99.1 ab	98.6 b	2963 bc	2990 b
40 kg P_2O_5	105.3 ab	131.5 ab	99.0 ab	98.4 b	3068 ab	3093 ab
60 kg P_2O_5	99.9 ab	146.2 a	98.8 ab	98.3 b	3108 ab	3086 ab
80 kg P_2O_5	106.2 ab	151.8 a	98.9 ab	98.5 b	3015 ab	3090 ab
100 kg P_2O_5	90.3 ab	147.9 a	98.8 ab	98.6 b	3156 ab	3195 a
S.E.M.	14.3		0.22		58.7	
	---------------- p-value ----------------					
Pr. > *F*	0.002		0.001		< 0.001	
Linear	0.228	0.000	0.001	0.001	< 0.001	< 0.001
Quadratic	0.081	0.021	0.070	0.000	0.010	0.017
0 P vs. rest	0.001		< 0.001		< 0.001	
SB vs. SR	< 0.001		0.003		0.275	

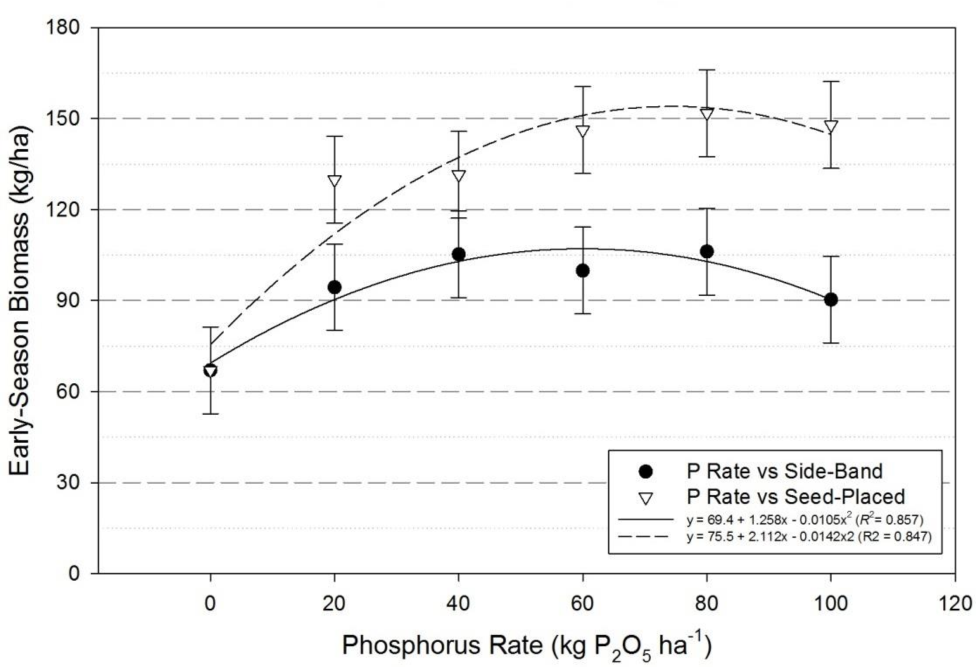

Figure 2. Phosphorus rate effects on canola above-ground biomass (4 weeks after planting) for side-banded versus seed-row placed monoammonium phosphate.

The overall F-test for days to maturity was also significant ($P = 0.001$) and was due to a significant reduction (by approximately 1 day) with seed-row placed P relative to the control and intermediate values with side-band placement. Both the control versus fertilized ($P < 0.001$) and side-band versus seed-row ($P = 0.003$) contrasts were significant and due to earlier maturity with P fertilization and a slight, further reduction with seed-row placement relative to side-banding. For side-banding, only the linear orthogonal contrast was significant ($P < 0.001$) while for, seed-row placement, the response was more quadratic with similar maturity observed across all P rates (Table 4).

Canola seed yield was also affected by the treatments ($P < 0.001$). At 2773 kg ha^{-1}, the 0 P control was significantly lower yielding than all fertilized treatments except for 20 kg side-banded P_2O_5 ha^{-1} (2963 kg ha^{-1}). While the contrast comparing the control to the combined fertilized treatments was highly significant ($P < 0.001$), the side-band versus seed-row placement contrast indicated that yields were the same for the two placement methods. The overall average yield with side-banding was 3062 kg ha^{-1} and, for seed-row placement, the average was 3091 kg ha^{-1}. While there were no statistically significant yield differences amongst fertilized treatments according to the multiple comparisons test, there was a tendency for lower yields at 20 kg P_2O_5 relative to the higher rates with both placement methods. Furthermore, for both placement methods, the linear and quadratic orthogonal contrasts were significant ($P < 0.001$-0.018).

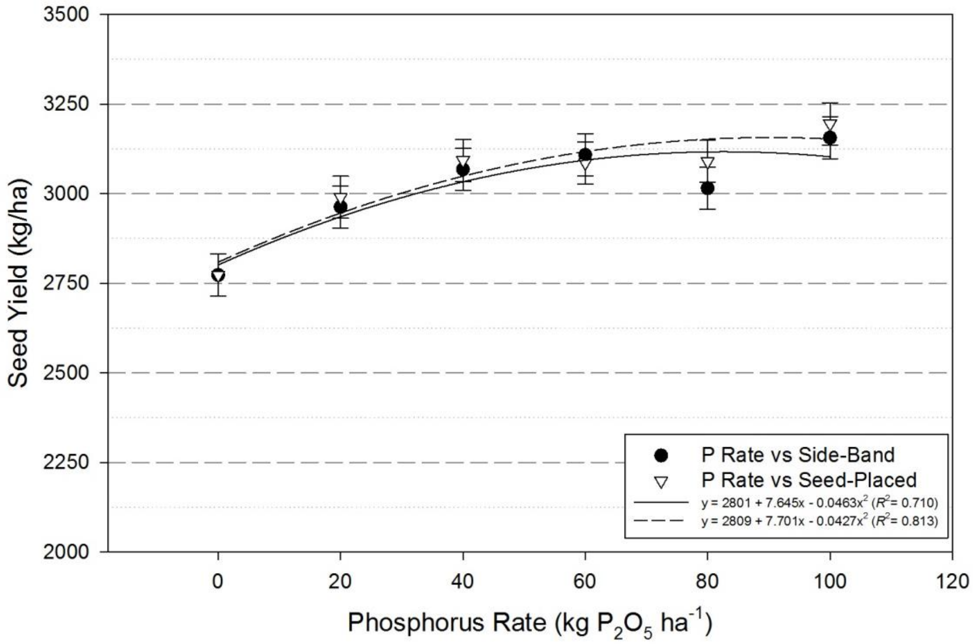

Figure 3. Phosphorus rate effects on canola seed yield for side-banded versus seed-row placed monoammonium phosphate.

Treatment means and tests of significance for seed size and percent green seed are provided in Table 5. For seed size, the overall F-test was significant ($P < 0.001$) as a result of larger seeds in the control (3.00 g 1000 seeds^{-1}) than for the fertilized treatments which averaged 2.88 g 1000 seeds ($P < 0.001$). Seed size did not significantly differ between placement methods when averaged across rates ($P = 0.075$); however seeds tended to be slightly larger with side-banding. While seed size can be an important yield component and larger seeds contribute to higher yields, there was an inverse relationship between seed size and yield. It is not uncommon to see smaller seeds with fertilizer applications and this effect was more than offset by improvements in other yield parameters (i.e. more seeds per pod and/or more pods per plant) with P fertilization. While the overall F-test for percent green seed was significant ($P = 0.050$), there were no detectable differences between individual treatments and none of the contrasts identified any trends in the data. Green seed was always well below the allowable level of 2%.

Table 5. Treatment means and tests of significance for canola early-season biomass, maturity and seed yield at Indian Head (2015). Values followed by the same letter do not significantly differ.

	Seed Size		Green Seed	
Treatment	Side-Band	Seed-Row	Side-Band	Seed-Row
	------------------ g/1000 seeds ------------------		------------------------ % ------------------------	
Control (0P)	3.00 a		0.4 a	
20 kg P_2O_5	2.91 ab	2.88 b	0.1 a	0.3 a
40 kg P_2O_5	2.90 b	2.85 b	0.4 a	0.1 a
60 kg P_2O_5	2.85 b	2.84 b	0.4 a	0.4 a
80 kg P_2O_5	2.87 b	2.89 b	0.0 a	0.2 a
100 kg P_2O_5	2.92 ab	2.88 b	0.1 a	0.3 a
S.E.M.	0.020		0.09	
	-- p-value --			
Pr. > *F*	< 0.001		0.050	
Linear	< 0.001	0.001	0.081	0.701
Quadratic	< 0.001	< 0.001	0.485	0.225
0 P vs. rest	< 0.001		0.133	
SB vs. SR	0.074		0.313	

Extension and Acknowledgement

This demonstration was a formal stop during the 2015 IHARF Crop Management Field held on July 21. The tour was attended by over 200 registered guests and signs were in place to acknowledge the support of the Agricultural Demonstrations of Technologies and Practices (ADOPT) program. Chris Holzapfel led the discussion during this segment of the field day with the assistance of Barbara Ziesman (Saskatchewan Ministry of Agriculture – Oilseed Specialist) and John Heard (Manitoba Agriculture, Food and Rural Initiatives – Soil Fertility Specialist). Results from this project will be made available in the 2015 IHARF Annual Report (available online) and also through a variety of other media (i.e. oral presentations, popular agriculture press, fact sheets, etc.) as opportunities arise.

11. Conclusions and Recommendations

This project has demonstrated, and perhaps challenged, some important aspects of phosphorus (P) fertilization in canola. The site was in the thin-Black soil zone of southeast Saskatchewan and soil tests indicated low residual P levels and relatively low organic matter for the region. While there was adequate initial soil moisture, the weather was dry over the first 5-6 weeks of the growing season; however, conditions improved dramatically late in June and yields in this demonstration were considered above average for the region at approximately 3,000 kg ha^{-1} (54 bu ac^{-1}). At this yield, canola requires a total of 79-98 kg P_2O_5 ha^{-1} and exports 57-69 kg ha^{-1} in the harvested seed. Additionally, the dry conditions for the first half of the season provided a good opportunity to assess early-season effects of P fertilizer placement.

One of the most significant observations was the lack of any negative impact on canola establishment, despite having several rates of seed-row placed monoammonium phosphate (11-52-0) that were well beyond the maximum recommended rate of 28 kg P_2O_5 ha^{-1}. While the relatively fine soil texture and good initial soil moisture certainly reduced the potential for injury, this particular site also had relatively low organic matter and there was no precipitation for nearly 6 weeks following planting. In addition, with an opener width only 1.6 cm (5/8") and 30 cm (12") row spacing, the drill used in this demonstration had a seed-bed utilization (SBU) of less than 6% which is another important factor affecting the safety of seed-row placed fertilizer. While there was no evidence of reduced emergence or seeding injury with high rates of seed-row placed P under the specific conditions encountered, more extensive research is required before formal recommendations to increase the maximum safe rates of seed-row placed P fertilizer could be made. If growers choose to use rates exceeding the current recommendations they are accepting a certain amount of risk; however, this risk may be reduced by using adequate seeding rates and taking factors such as soil texture, organic matter and moisture conditions at planting into consideration.

Another key observation was that there was a significant advantage to seed-row placement relative to side-banding early in the season but it did not carry through to yield. Averaged across rates, early season biomass yields were 43% higher with seed-row placement than for side-banded P; however, seed yields were within less than 1% of each other. While more vigorous early season growth might provide economic advantages under certain conditions (i.e. better resilience under heavy flea beetle pressure, more competitive with weeds), the benefits were much less apparent as the crop went into bloom and the data shows that side-banding was also effective for meeting the P requirements of canola in the year of application. It is also plausible that the observed placement effect on early season biomass yield would be less prominent under wetter spring conditions where the fertilizer bands, particularly N, could dissolve and disperse more quickly after seeding. While seed-placement can have advantages over side-banding under certain conditions, particularly when residual P is low and soils are cool, our experience has been that these advantages rarely translate into yield benefits and the most important thing from a soil fertility perspective is for growers to ensure that they are meeting the P requirements of their crops over the long-term.

Supporting Information

12. Acknowledgements:

This project was financially supported by the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canada-Saskatchewan Growing Forward 2 bi-lateral agreement. 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 seed and crop protection products evaluated in this demonstration were provided in-kind by Bayer CropScience, BASF and Syngenta. The support and contributions of Christiane Catellier, Dan Walker, Carly Miller and Danny Petty are greatly appreciated.

13. Appendices

Abstract

14. Abstract/Summary:

A canola field trial was initiated to demonstrate the response to side-banded versus seed-row placed phosphorus (P) fertilizer rates. The treatments were a control plus five rates (20-100 kg P_2O_5 ha^{-1}) of monoammonium-phosphate (11-52-0) either side-banded or seed-placed. Importantly, there were no treatment effects on emergence or final plant density, despite having evaluated seed-row P rates of more than 3x the maximum recommended amounts. Seed-row placement resulted in greater early season growth relative to side-banding; however, yields for the two placement methods were equal despite low residual P levels and strong response to fertilization. There was a slight reduction in seed size with P

fertilization but seed sizes did not significantly differ between placement methods or fertilizer rates. These results showed that, while seed-row placement can be advantageous for early-season uptake under some conditions, side-banding is also effective for meeting P requirements of canola and ensuring that yields are not limited by this nutrient.