2016 Annual Report

for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Seed-Placed vs Side-Banded Phosphorus Effects on Faba Bean Establishment and Yield

(Project #20150389)

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Project Identification

1. **Project Title:** Seed-placed versus side-banded phosphorus fertilizer effects on faba bean establishment and yield
2. **Project Number:** 20150389
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):** Apr-2016 to Feb-2017
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **Project objectives:**

The objective of this project was to demonstrate the effects of increasing rates of phosphorus fertilizer on faba bean establishment and seed yield for both side-banded and seed-row placement.

8. **Project Rationale:**

Faba beans have been grown in limited acres on the Prairies for decades and have long been considered well adapted to the moister, cooler regions of Saskatchewan such the Black soil zone. While acres continue to be small, interest in this crop continues to strong due to its high yield potential, resistance to root diseases and ability to withstand prolonged wet periods much better than field peas and lentils. With the potential for increased production of this crop, farmers need increased exposure to some of the management factors that should be considered when growing this crop. Separate field trials are in progress to evaluate faba bean response to seeding date, seeding rate, inoculation and disease management; however, P fertilization is an important aspect of production that is not currently being addressed elsewhere for this crop.

While phosphorus (P) fertilizer response in faba beans has not been thoroughly researched in Saskatchewan, the basic principles of P fertility in crop production are generally understood. Field trials at 6 locations in Alberta over a three year period did not show a significant response to P, K or S fertilization when all sites were combined, but there was an overall tendency for higher yields with P fertilizer and the response to P was significant at two sites when looked at individually. It is worth noting that the P source used in these studies was triple super phosphate (0-45-0) which is generally considered less available to crops than monoammonium phosphate (11-52-0) which is also the most commonly used formulation. While most research suggests that crops respond similarly to safe rates of side-banded versus seed-placed P fertilizer, many growers prefer seed-placement and the early-season (pop-up) response can be superior under cool, dry conditions or extremely low residual P levels. That said, there are limits to how much P fertilizer can be placed in the seedrow before the risk of crop injury becomes unacceptably high. Provincial recommendations for this crop specify that faba bean is a relatively large user of P fertilizer but also recommend that seed-placed P should not exceed 25 kg/ha

when planting with drills using narrow openers. While the response to fertilizer applications may vary, it is known that high yielding faba beans remove large amounts of P in the grain. For example, a relatively modest 50 bu/ac crop removes 55-67 lbs P_2O_5/ac and takes up a total 89-108 lbs/ac. This crop is also generally seen as being sensitive to seed-placed fertilizer and therefore it is not recommended that more than 25 kg/ha P_2O_5 (22 lb P_2O_5/ac) be applied when using narrow openers as most modern no-till drills do.

This project was initiated to demonstration and gather information on faba bean response to varying rates of seeded-placed versus side-banded monoammonium phosphate and to provide information on the sensitivity of seed-placed P fertilizer when seeded into clay soils using a hoe drill with low seed-bed utilization.

Methodology and Results

9. Methodology:

A field demonstration with faba beans was established on spring wheat stubble near Indian Head, Saskatchewan (50.556º N, -103.608º W) in the spring of 2016. The treatments were arranged in a Randomized Complete Block Design (RCBD) with four replications and included two placement methods, four rates of monoammonium phosphate and an unfertilized control:

1. Control – 0 P_2O_5
2. Seed-Placed – 20 kg P_2O_5 ha^{-1} (18 lb P_2O_5 ac^{-1})
3. Seed-Placed – 40 kg P_2O_5 ha^{-1} (36 lb P_2O_5 ac^{-1})
4. Seed-Placed – 60 kg P_2O_5 ha^{-1} (53 lb P_2O_5 ac^{-1})
5. Seed-Placed – 80 kg P_2O_5 ha^{-1} (71 lb P_2O_5 ac^{-1})
6. Side-Banded – 20 kg P_2O_5 ha^{-1} (18 lb P_2O_5 ac^{-1})
7. Side-Banded – 40 kg P_2O_5 ha^{-1} (36 lb P_2O_5 ac^{-1})
8. Side-Banded – 60 kg P_2O_5 ha^{-1} (53 lb P_2O_5 ac^{-1})
9. Seed-Banded – 80 kg P_2O_5 ha^{-1} (71 lb P_2O_5 ac^{-1})

Pertinent agronomic information is provided in Table 1. Snowbird (zero-tannin) faba beans were direct-seeded into spring wheat stubble on May 1 using a SeedMaster plot drill with eight openers on 30 cm row spacing. With an opener width of 16 mm (5/8”), the theoretical seed-bed utilization with this drill is less than 6%. The seed was inoculated with Nodulator (BASF) self-adhering peat based inoculant applied at two times the label recommended rate. No supplemental nitrogen was applied (i.e. N was not balanced across P treatments) and monoammonium phosphate (11-52-0) was applied as per protocol. For the side-band treatments, fertilizer was placed 38 mm (1.5”) beside and 19 mm (3/4”) below the seed. The target depth was approximately 38 mm (1.5”) and, although the spring was relatively dry, seed was placed into moisture. Weeds were controlled using registered pre-emergent and in-crop herbicide applications and fungicide was applied preventatively during mid-bloom. Pre-harvest glyphosate was applied for weed control at physiological maturity (Aug-28) and the plots were straight-combined as soon after it was fit to do so as possible (Sep-19).

Emergence was measured at two pre-determined intervals by counting the number of seedlings two

separate 1 m sections of crop row per plot. Counts were targeted for two and four weeks after planting but the actual dates were May 17 and June 2. On the first date, the counted rows were marked so that the same sections of crop could be returned to when emergence was complete. Yields were determined from the harvested grain samples which were corrected for dockage and to 16% seed moisture content. Seed size was determined by mechanically counting and weighing a minimum of 200 seeds and calculating g 1000 seeds^{-1} (TKW). Weather data were estimated from a privately-owned weather station located approximately 2 km from the field trial site.

All response data were analysed using the Mixed procedure of SAS with P treatment and replicate effects considered fixed and random, respectively. Tukey's studentized range test, which controls experiment-wise error and is relatively conservative, was used to separate individual treatment means and contrasts were used to compare the control to all fertilized plots simultaneously and to seed-placed to side-banded P. Orthogonal contrasts were used to determine whether the responses to seed-placed and side-banded P were insignificant, linear or curvilinear (quadratic). All treatment effects and comparisons were considered statistically significant at $P \leq 0.05$.

Table 1. Selected agronomic information for ADOPT faba bean response to P rate and placement demonstration at Indian Head in 2016.

Factor / Field Operation	Indian Head 2015
Pre-emergent herbicide	894 g glyphosate/ha + 140 g sulfentrazone/ha (7-May-2016)
Fertility	N as provided w/11-52-0 (not balanced), 164 g Nodulator seed-applied inoculant/100 kg seed
Seeding Date	1-May
Cultivar	Snowbird (zero tannin)
Seeding Rate	50 seeds/m^2 (adjusted for 70% germination)
Row spacing	30 cm
In-crop herbicide	15 g imazomox/ha + 15 g imazethapyr/ha + 40 g tepraloxydim (4-Jun)
Fungicide	74 g fluxapyroxad/ha + 140 g pyraclostrobin /ha (28-Jun)
Insecticide	none applied
Pre-harvest herbicide	890 g glyphosate/ha (28-Aug)
Harvest date	19-Sep (centre 5 rows)

10. Results:

Growing Season Weather & Soil Test Information

Mean monthly temperatures and precipitation amounts for the 2016 growing season at Indian Head along with the long-term averages for Indian Head (1981-2000) are presented in Table 2. Overall conditions in the early spring were relatively dry but soil conditions were excellent for planting the faba beans were seeded early and into moisture. While May was initially warm and dry, precipitation received late in the month amounted to 140% of the long-term average. Total precipitation for June was 81% of the average while July was wet (177%) while August was relatively dry (58%) compared to the long-term average. The total amount of precipitation from April 1 through August 31 was 292 mm (11.7"), approximately 9% above the long-term average. Temperatures were substantially higher than normal for May and June and then approximately normal in July and August. Although faba beans generally prefer cool conditions, they respond well to abundant moisture and the crop was in exceptional condition for much of the growing season. Unfortunately, the plots were severely damaged by hail on July 18 (mid-late bloom) resulting in most upper stems being broken off, many damaged pods and flowering being terminated prematurely. While quite severe, the damage was considered uniform across the study area and therefore all trials were still considered viable despite the negative impacts on potential yield.

Table 2. Mean monthly temperatures and precipitation amounts along with long-term averages (LT; 1981-2010) averages for the 2016 growing season at Indian Head, Saskatchewan.

Year	April	May	June	July	August	Avg/Tot
	---------- Mean Temperature (°C) ----------					
2016	3.8	14.0	17.5	18.5	17.2	14.2
LT [z]	4.2	10.8	15.8	18.2	17.4	13.3
	---------- Precipitation (mm) ----------					
2016	13.9	72.6	63	112.8	29.8	292
LT [z]	22.6	51.8	77.4	63.8	51.2	267

A composite soil sample for the study area was collected prior to seeding and submitted to AgVise Laboratories for various analyses (Table 3). Soil pH for the upper 15 cm was 7.4 with 6.0% organic matter and a relative high cation exchange capacity of 39.1 Meq. Residual soil P was relatively low at 9 ppm Olsen P, or approximately 16 kg/ha extractable P while K, as expected at this location, was extremely high (725 ppm or 1294 kg/ha for the 0-15 cm soil profile).

Table 3. Soil test results for the 2016 phosphorus rate and placement demonstration with faba beans at Indian Head, Saskatchewan.

Soil Depth	pH	O.M.	NO_3-N	Olsen-P	K	S	C.E.C.
(cm)		---- % ----	- ppm [Z] -	-- ppm --	-- ppm --	-- ppm --	-- Meq --
0-15	7.4	6.0	6.5	9	725	6	39.1
15-60	7.9	–	2.0	–	–	6	–
kg/ha	–	–	23.6	16.1	1294	46.7	–

[Z] Based on estimated soil bulk density and observed soil test ppm values

Crop Response to Phosphorus Rate & Placement

Results for faba bean emergence at approximately 14 and 28 days after planting are presented in Table 4. The overall F-test was not significant for either counting date, indicating that emergence was not affected by P fertilizer rate or placement method. At 16 days after planting (targeted 14 days), approximately half of the plants had emerged and individual treatment means ranged from 19-31 plants/m^2 and there was no evidence to suggest that emergence was reduced by high rates of seed-applied P fertilizer based on the both contrast comparisons (i.e. SP vs SB) and the linear and quadratic orthogonal contrasts. At the second date, 32 days after planting (targeted 28 days), the range of observed densities was 59-86 plants/m^2, with neither a significant overall F-test and or SP vs SB contrast, there was again no evidence to suggest that emergence was negatively impacted by high rates of seed-placed P fertilizer. The only significant result for final plant density was a quadratic response to seed-placed P whereby the lowest densities occurred at 40 kg P_2O_5 while the highest occurred with either no fertilizer or the highest rate of seed-applied fertilizer. Consequently, this result cannot readily be attributed to seedling toxicity caused by high rates of fertilizer applied in-furrow and, in fact, the highest populations in the trial were measured at 80 kg seed-placed P_2O_5/ha. Phosphorus treatment effects on faba bean emergence are also presented graphically in Figures 1 and 2.

Table 4. Treatment means for monoammonium phosphate (11-52-0) rate and placement effects on faba bean emergence at approximately 2 and 4 weeks after planting (Indian Head, 2016). Means followed by the same letter do not significantly differ ($P \leq 0.05$) and contrast p-values below 0.05 are considered significant.

	Emergence – 14 DAP [Z]		Emergence – 28 DAP	
Phosphorus Rate	Seed-Placed (SP)	Side-Band (SB)	Seed-Placed (SP)	Side-Band (SB)
kg P_2O_5/ha	---------- plants/m^2 ----------		---------- plants/m^2 ----------	
0	29 a		85 a	
20	34 a	19 a	85 a	59 a
40	20 a	23 a	64 a	77 a
60	21 a	26 a	72 a	80 a
80	24 a	35 a	86 a	79 a
S.E.M.	5.7		6.9	
L.S.D.	24.7		33.0	
	---------- p-value ----------			
Pr > *F*	0.314		0.109	
Check vs rest	0.474		0.198	
SP vs SB	0.797		0.532	
P-Rate – lin	0.184	0.276	0.641	0.722
P-Rate – quad	0.527	0.073	0.036	0.197

[Z] DAP – days after planting

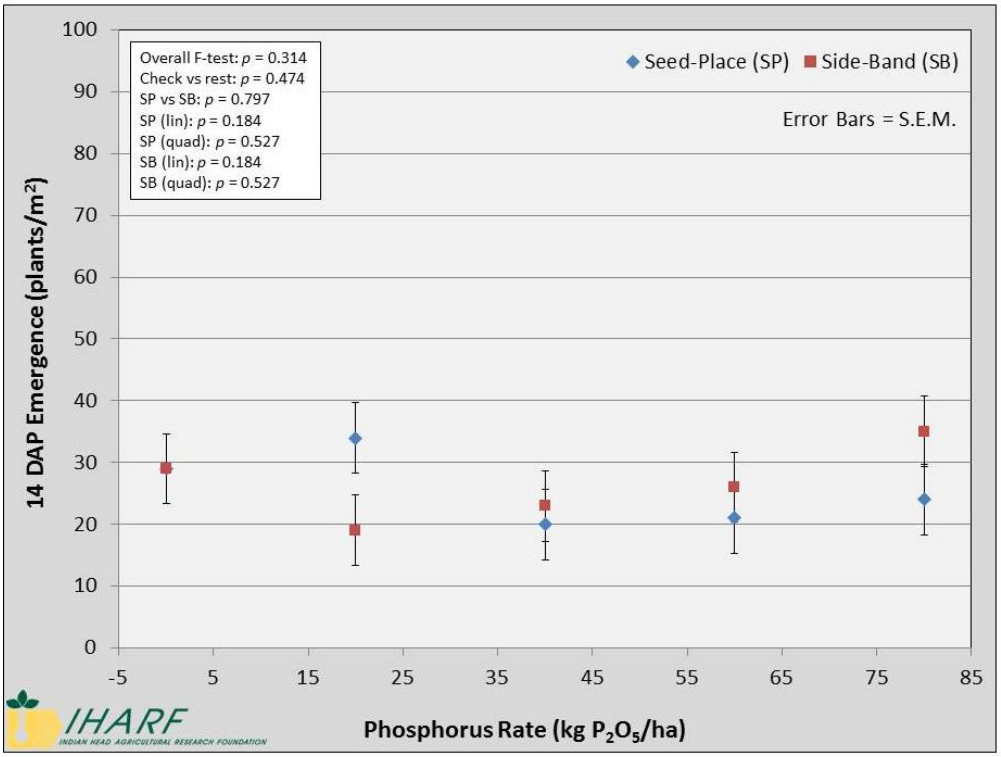

Figure 1. Rate and placement effects of monoammonium phosphate rate and placement effects on faba bean emergence at approximately 14 days after planting (DAP) at Indian Head, 2016.

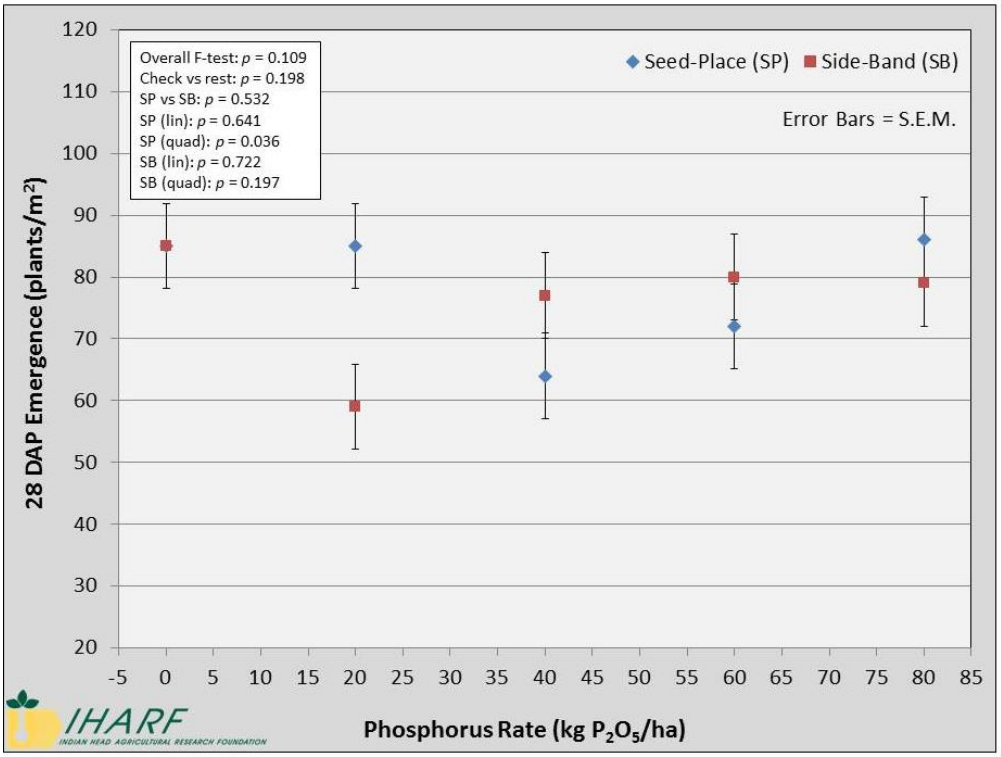

Figure 2. Rate and placement effects of monoammonium phosphate rate and placement effects on faba bean emergence at approximately 28 days after planting (DAP) at Indian Head, 2016.

Results for both seed yield and seed size, or thousand kernel weight are presented in Table 5. The overall F-test for seed yield was highly significant ($P = 0.003$) which indicated that yield differences existed amongst the treatments. Overall yields ranged from a minimum of 3997 kg/ha (59 bu/ac) in the control to as high as 4588-4605 kg/ha (68 bu/ac) at the highest, 80 kg P_2O_5/ha (71 lb/ac) rate, regardless of placement method. Despite the observed differences, the results of 'check vs rest' comparison was not significant at the desired probability; however, at $P = 0.058$, it was still noteworthy and indicates that we can be 94% confident that yields were higher with P fertilization. At all P rates, yields were similar for both placement options and the overall average yields (across rates) were 4249 kg/ha and 4230 kg/ha (63.0 bu/ac and 62.8 bu/ac) for seed-placed and side-banded P, respectively ($P = 0.820$). The linear orthogonal contrasts were highly significant ($P < 0.001$-0.002) indicating a strong overall response to P fertilizer rate within the range evaluated.

Treatment effects on thousand kernel weight were relatively weak; however, there was an overall tendency for lighter seeds with P fertilizer application (Check vs rest; $p = 0.038$). In the control, a value of 430 g/1000 seeds was observed while, averaged across all fertilized treatments, the TKW was 421 g/1000 seeds. The linear response was significant for side-banded but not seed-placed P; however, the overall TKW was numerically lower for seed-placed P (420.8 g/1000 than side-banded P (421.3 g/1000 seeds) an averaged across rates the two placement methods did not statistically differ (SP vs SB; $P = 0.842$). Graphical representations of the treatment effects on seed yield and TKW are presented graphically in Figures 3 and 4.

Table 5. Treatment means for monoammonium phosphate (11-52-0) rate and placement effects on faba bean yield and seed size (Indian Head, 2016). Means followed by the same letter do not significantly differ ($P \leq 0.05$) and contrast p-values below 0.05 are considered significant.

	Seed Yield		Thousand Kernel Weight	
Phosphorus Rate	Seed-Placed (SP)	Side-Band (SB)	Seed-Placed (SP)	Side-Band (SB)
kg P_2O_5/ha	---------- kg/ha ----------		---------- g/1000 seeds ----------	
0	3997 c		430 a	
20	4041 bc	4107 abc	417 a	429 a
40	4066 abc	4068 abc	419 a	420 a
60	4302 abc	4142 abc	425 a	422 a
80	4588 ab	4605 a	422 a	414 a
S.E.M.	122.1		5.5	
L.S.D.	551.8		19.2	
	---------- p-value ----------			
Pr > *F*	0.003		0.133	
Check vs rest	0.058		0.038	
SP vs SB	0.820		0.842	
P-Rate – lin	< 0.001	0.002	0.452	0.005
P-Rate – quad	0.118	0.068	0.125	0.909

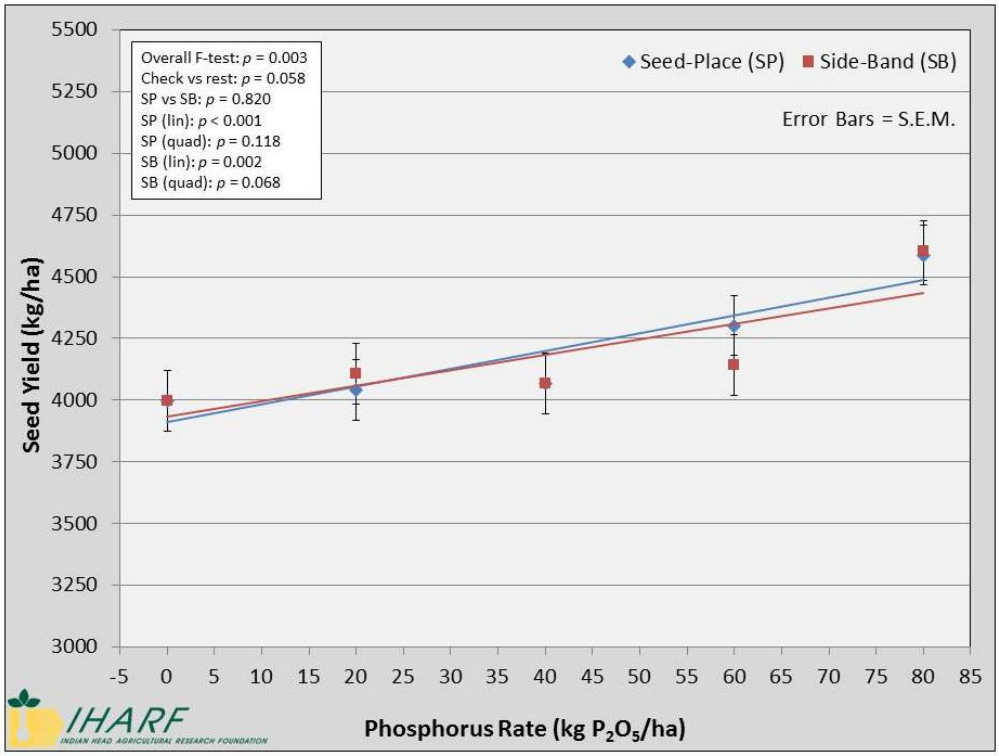

Figure 3. Rate and placement effects of monoammonium phosphate rate and placement effects on faba bean seed yield at Indian Head, 2016.

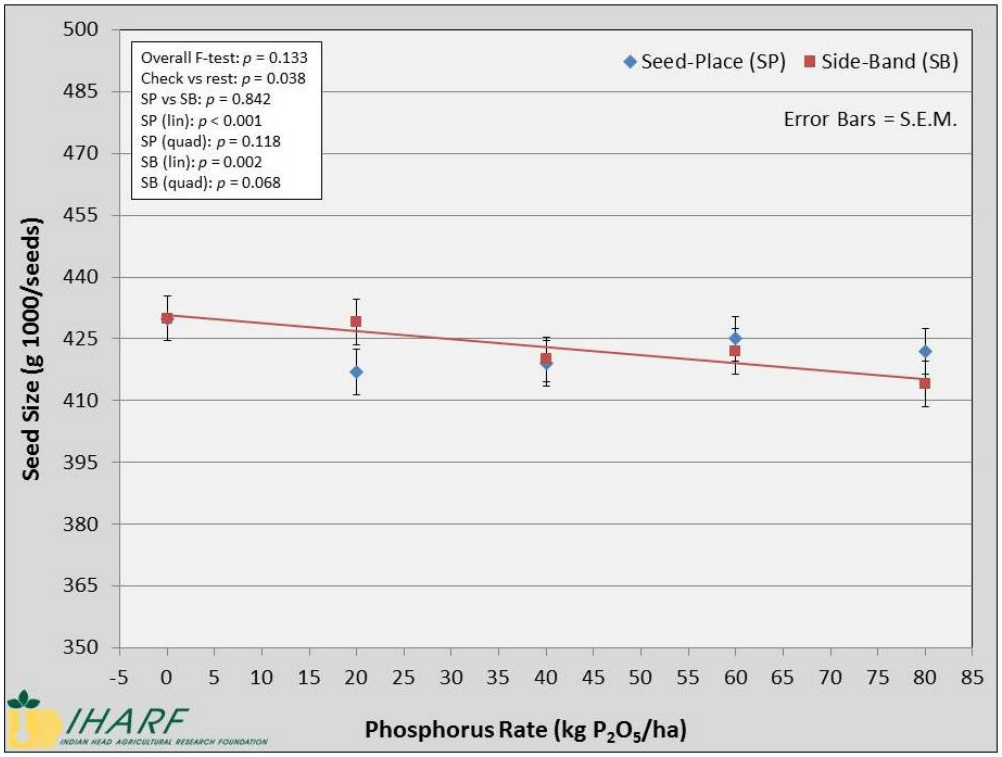

Figure 4. Rate and placement effects of monoammonium phosphate rate and placement effects on faba bean seed size at Indian Head, 2016.

Extension and Acknowledgement

This demonstration was again part of the Crop Management Field Day in 2016 (July 19, 219 registered guests) where Chris Holzapfel (IHARF) and Corey Loessin (Saskatchewan Pulse Growers Association & Pulse Canada) led the pulse crop segment of the tour and discussed research objectives and activities of SPG for faba beans and soybeans. The faba bean segment of the tour focussed on P fertility, inoculation, establishment and disease management for this relatively new crop. The trial was also highlighted on tours co-hosted with Arysta Lifesciences (July 26, 2016, 45 guests) and for Richardson Pioneer (July 27, 33 guests). In addition to these more formal tours, the site was visited by numerous growers, agronomists and researchers over the season. A summary of this work will be included in the 2016 IHARF Annual Report which, in addition to the full report, will be available online. Results will also be made available through a variety of other media (i.e. oral presentations, popular agriculture press, social media, fact sheets, etc.) as opportunities arise.

11. Conclusions and Recommendations

Overall, this project has demonstrated that faba beans can respond well to phosphorus (P) fertilizer application in low P soils and that they even respond to rates that are higher than those typically used by most producers. Considering that this is only a single site-years' worth of data, results cannot be considered conclusive, but in 2016 at Indian Head (on a soil with 9 ppm Olsen-P) the highest yields were achieved at the top rate of 80 kg P_2O_5/ha (71 lb/ac). The response was equal and linear regardless of application method whereby, at the top rate, faba bean yields were 600 kg/ha (9 bu/ac) higher than for the control (15% yield increase). Effects on thousand kernel weight were small; however, there was an overall tendency for smaller seeds with P application therefore the observed yield increase was presumably due to more pods/plant and/or seeds/pod as opposed to larger seeds. Interestingly, and perhaps unexpectedly, there was no apparent impact on emergence observed with high rates of seed-placed P. Again, the yield response to P was identical for the two application methods. While the lack of seedling toxicity at high rates of seed-placed has been observed at our location with other sensitive crops (i.e. canola), extreme caution is recommended if considering seed-placing fertilizer at rates exceeding the traditionally recommended limits. Potential seedling injury is a complex issue that can potentially be affected by many different factors including opener type (i.e. hoe vs disc), seedbed utilization, soil texture/chemistry, seeding depth, crop rotation/tillage system and weather. For growers looking to maintain or build soil P levels, at an average yield of 4213 kg/ha (63 bu/ac), the estimated P removal of this particular crop was 77-94 kg P_2O_5/ha (69-84 lb/ac); therefore, fertilizing to match removal or build soil P may not be practical with high yielding faba beans. While the protocols were not identical, IHARF conducted a similar demonstration in 2015 (ADOPT 2014036) and the P response results were consistent with the current project (Table 6, Appendices).

Supporting Information

12. Acknowledgements:

This project was 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 crop protection products

evaluated in this demonstration were provided in-kind by BASF and FMC of Canada. The technical, administrative and professional support of Danny Petty, Dan Walker, Karter Kattler, Carly Miller, Andrea De Roo and Christiane Catellier is greatly appreciated.

13. Appendices

Table 6. Predetermined contrast comparisons results for phosphorus fertilization effects on faba bean establishment, yield and seed size at Indian Head (2015). Soil tests indicated 12 ppm Olsen-P residual phosphorus and soil pH of 8.0 (0-15 cm). Data were analyzed using the mixed procedure of SAS.

Contrast Comparison	Plant Density	Seed Yield	Seed Size
	--------- plants m^{-2} ---------	---------- kg ha^{-1} ----------	------ g 1000 $seeds^{-1}$ ------
Control (0P) vs.	41.8 a	2896 a	401.7 a
Fertilized	38.6 b	3188 a	408.0 a
Pr > F (p-value)	0.047	0.110	0.221
Control (0P) vs.	41.8 a	2896 a	401.7 a
25 kg P_2O_5	38.7 a	2888 a	398.9 a
Pr > F (p-value)	0.069	0.968	0.608
Control (0P) vs.	41.8 a	2896 b	401.7 b
50 kg P_2O_5	38.6 a	3489 a	417.2 a
Pr > F (p-value)	0.067	0.005	0.010
25 kg P_2O_5 vs.	38.7 a	2888 b	398.9 b
50 kg P_2O_5	38.6 a	3489 a	417.2 a
Pr > F (p-value)	0.989	< 0.001	0.000
Seed-Row vs.	39.9 a	3267 a	410.0 a
Side-Band	37.4 a	3110 a	406.1 a
Pr > F (p-value)	0.071	0.327	0.392

Abstract

14. Abstract/Summary:

A field trial was established in the spring of 2016 near Indian Head, Saskatchewan to demonstrate faba bean response to varying rates of seed-placed and side-banded monoammonium phosphate (11-52-0) under field conditions. Snowbird faba beans were direct-seeded into spring wheat stubble using a SeedMaster drill on 30 cm row spacing (<6% seedbed utilization) and P fertilizer was applied at 0, 20, 40, 60 and 80 kg P_2O_5/ha for each placement option. With measurements completed at approximately two and four weeks after planting, emergence was not affected by any of the P fertilizer treatments, even at 80 kg P_2O_5/ha placed in the seedrow. The yield response was linear, the same for both placement methods and, at the highest P rates, yields were increased by 600 kg/ha (9 bu/ac), or 15%. Effects on thousand kernel weight were small, but there was an overall reduction in seed weight with P fertilization suggesting that the yield response was due to more pods/plant and/or seeds/pod as opposed to larger

seeds. At the observed average yield of 4213 kg/ha (63 bu/ac), the estimated P removal of this specific faba bean crop was 77-94 kg P_2O_5/ha (69-84 lb/ac), therefore fertilizing to match P removal or build soil P may not be practical for this crop.
