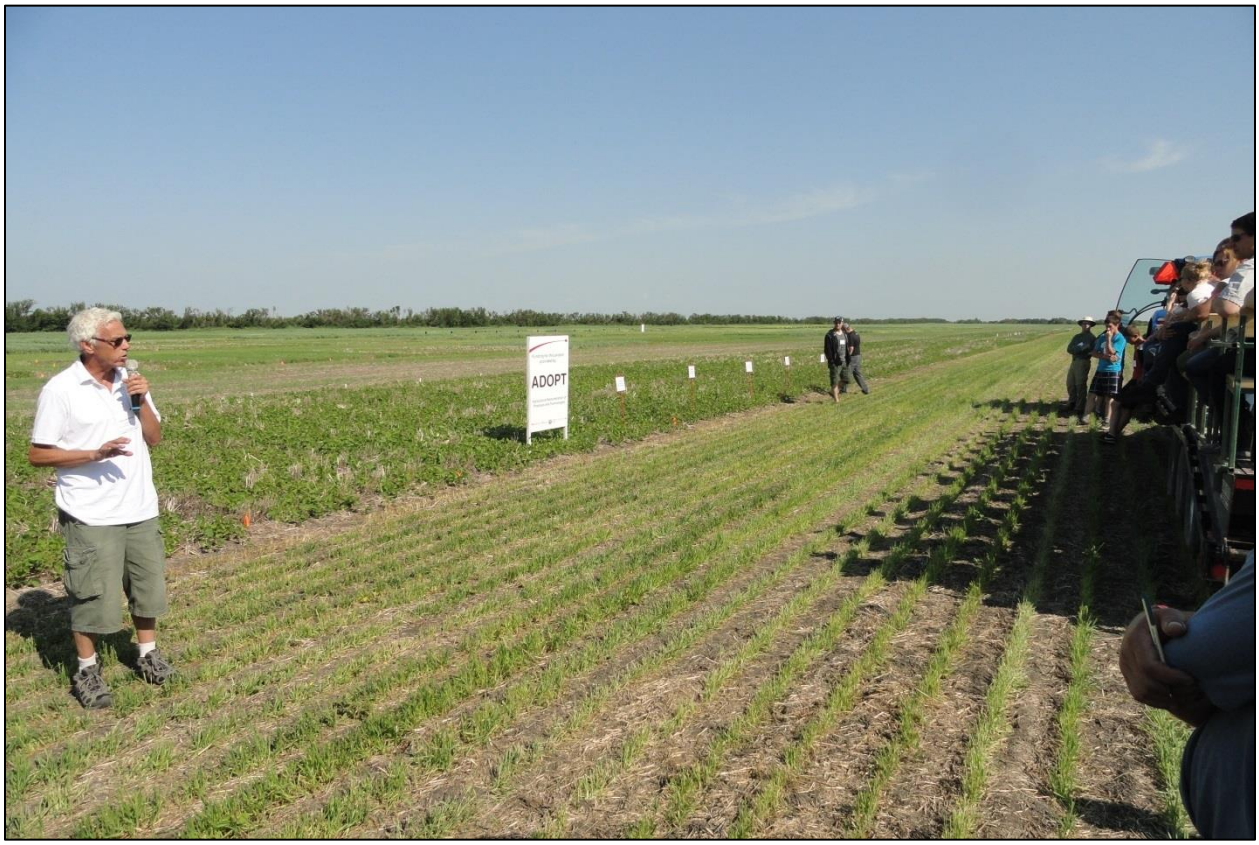
2014 Annual Report

for the

**Agricultural Demonstration of Practices and Technologies (ADOPT) Program**

**Project Title:** Soybean Response to Starter Nitrogen and Phosphorus Fertilizer Application

(Project #201300390)

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## Project Identification

1. **Project Title:** Soybean response to starter nitrogen and phosphorus fertilizer application
2. **Project Number:** 20130390
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):** September 2012-January 2014
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 yield response of soybean to side-banded urea and side-banded versus seed-placed phosphorus fertilizer applications near Indian Head, Saskatchewan.

8. **Project Rationale:**

While both interest and acres in soybeans have recently seen rapid growth in Saskatchewan, growers and agronomists alike have relatively little experience with this crop in our environment. Soybeans are large nutrient user and, while they are legumes and as such can fix atmospheric N, often require more N than they can produce through biological fixation. Most research in more traditional soybean regions has shown that N responses are most likely when either yield potential is high or under stressful conditions such as when nodulation is poor or the soils are cool, dry and/or low in residual N. While data from Saskatchewan and Manitoba on the subject are limited, N fertilizer application is not recommended for soybeans in Saskatchewan under most circumstances. With respect to phosphorus, soybeans prefer soils with high levels of residual P; however, response to fertilizer applications can be inconsistent. In many parts of the United States, broadcasting P is common and frequently recommended but in the cool calcareous soils of southeast Saskatchewan, side-banded or seed-placed P may be more effective. While soybeans will likely benefit from P fertilizer application when soil residual levels are low, they are sensitive to fertilizer placed in close proximity to the seed and therefore in-furrow placement is not generally recommended unless relatively low rates are used. This project is intended to benefit producers by demonstrating the potential response to starter N for soybeans in Saskatchewan and by providing regionally relevant data on this subject. It will also allow for the discussion of P fertilizer considerations for soybeans while demonstrating the potential response to varying rates of P fertilizer applied in either the seed-row or in a side-band, the two most common placement methods in Saskatchewan.

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## Methodology and Results

### 9. Methodology:

A replicated soybean demonstration was conducted in 2014 2014 (50°32'58" N, 103°34'18" W) near Indian Head, Saskatchewan with twelve fertilizer treatments arranged in a randomized complete block design (RCBD) with four replicates. The fertilizer treatments were a combination of different N, P rate and granular inoculant rates that were selected to evaluate potential benefits to starter N (with adequate and poor nodulation) and to demonstrate soybean response to P fertilizer placed either in a sand-band or in the seed-row. The specific treatments are provided in Table 1.

**Table 1. Treatment evaluation in a soybean N and P fertility demonstration at Indian Head, Saskatchewan in 2014.**

| # | N-$P_2O_5$ Rate (kg/$ha^{-1}$) | Phosphorus Placement | Granular Inoculant |
|---|---|---|---|
| 1 | 0-0 | n/a | 4.1 kg Cell-Tech $ha^{-1}$ |
| 2 | 55-0 | n/a | 4.1 kg Cell-Tech $ha^{-1}$ |
| 3 | 2-20 | side-banded | 4.1 kg Cell-Tech $ha^{-1}$ |
| 4 | 2-20 | seed-placed | 4.1 kg Cell-Tech $ha^{-1}$ |
| 5 | 4-40 | side-banded | 4.1 kg Cell-Tech $ha^{-1}$ |
| 6 | 4-40 | seed-placed | 4.1 kg Cell-Tech $ha^{-1}$ |
| 7 | 55-20 | side-banded | 4.1 kg Cell-Tech $ha^{-1}$ |
| 8 | 55-20 | seed-placed | 4.1 kg Cell-Tech $ha^{-1}$ |
| 9 | 55-20 | side-banded | none |
| 10 | 55-20 | seed-placed | none |
| 11 | 55-40 | side-banded | 4.1 kg Cell-Tech $ha^{-1}$ |
| 12 | 55-40 | seed-placed | 4.1 kg Cell-Tech $ha^{-1}$ |

The soybean variety LS002R23 (Legend Seeds)was direct-seeded into barley stubble on May 27 using a SeedMaster drill with 8 openers spaced 30 cm apart (2.4 m total seeded width) and a trimmed plot length of 10.5 m. The width of the seed knife is approximately 20 mm; therefore the seed-bed utilization (SBU) is 6.3%. With this particular drill, the side-band is located approximately 19 mm beside and 38 mm below the seed-row. Soil moisture at seeding was abundant and conditions were considered excellent for emergence; however, some issues with straw / residue clearance were encountered on the site. Granular fertilizer was applied as per protocol and the forms were urea (46-0-0), which was always side-banded, and mono-ammonium phosphate (11-52-0), which was either side-banded or placed in the seed-row. The seed for all entries was treated with Cruizer Maxx Beans and Primo CL liquid inoculant. Unless prohibited by the protocol, the granular inoculant Cell-tech soybean (Monsanto BioAg) was applied in the seed-row at the recommended (30 cm row spacing) of 4.1 kg $ha^{-1}$. Weeds were controlled using two in-crop herbicide applications of 890 g glyphosate $ha^{-1}$ during the vegetative stage (V2-V3) on June 26 and at early flowering (R1) on July 17. The centre five rows of all plots were direct-combined on October 12 using a Wintersteiger plot combine.

Spring crop establishment was assessed by counting the number of plants in 4 x 1 m sections of crop row per plot on June 25 and converting the values to plants $m^{-2}$. The minimum pod height was estimated by measuring and averaging the distance from the soil surface to the bottom of the lowest

hanging pod on 10 plants per plot. Maturity was defined as days from planting to when 95% of the pods had changed colour but was not recorded because the plots were terminated by frost (September 10-11) before any of the pods had started to turn colour. Grain yields are expressed in kg $ha^{-1}$ and were determined by weighing the entire harvest sample and adjusting the values for dockage and to a uniform moisture content of 14%. Growing season weather for the site was estimated using online data from the nearest Environment Canada weather station which was located approximately 5 km west of the site.

Response data were analyzed using the GLM procedure of SAS 9.3 with Tukey's studentized range test used to separate treatment means. Several predetermined contrasts were used to compare various combinations of N, P, placement and inoculant treatments. All treatment effects and differences between means were considered significant at $P \leq 0.05$.

## 10. Results:

*Weather and Soil Information*

Mean monthly average temperatures and precipitation totals for 2014 growing seasons are provided in Table 3. While May was slightly cooler than average, it was relatively warm at the time of seeding with daytime highs of 24-28 °C and night time lows of 6-8 °C during the 24 hour period following seeding. June was much wetter than normal with 199 mm of precipitation (258% of the long-term average) and therefore, while precipitation in July was extremely low, the soils remained wet until the latter half of the month. August was wet with approximately normal temperatures and 142 mm of precipitation (278% of the long term average) with was good for seed filling in the soybeans; however, as indicated earlier, the plots were terminated by frost on September 9-10, at which time no pods had started to turn colour.

**Table 2. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) averages for the 2014 growing season at Indian Head, Saskatchewan.**

| Year | May | June | July | August | Avg. / Total |
|---|---|---|---|---|---|
| | ---------- Mean Temperature (°C) ---------- | | | | |
| 2014 | 10.2 | 14.4 | 17.3 | 17.4 | 14.8 |
| Long-term | 10.8 | 15.8 | 18.2 | 17.4 | 15.6 |
| | ---------- Precipitation (mm) ---------- | | | | |
| 2014 | 36.0 | 199.2 | 7.8 | 142.2 | 385 |
| Long-term | 51.8 | 77.4 | 63.8 | 51.2 | 244 |

A three-depth (0-15 cm, 15-30 cm and 30-60 cm) composite soil sample was collected from plot area on May 22 and submitted to ALS Laboratories (Saskatoon, SK) for residual nutrient analyses and fertilizer recommendations along with determination of other soil properties. Results from these analyses are provided in Table 3. The soil was classified as a clay-loam with a pH of 8.0 and soil organic matter (SOM) content of 3.9% in upper 15 cm profile. While N and P levels were not especially low, both were considered potentially limiting depending on environmental conditions and soybean yield potential. Percent SOM was considered slightly below the typical levels for these soils and pH was considered moderately alkaline.

**Table 3. Residual soil nutrient and recommended fertilizer rates for soybean nitrogen and phosphorus fertility trial at Indian Head, Saskatchewan (2014). The previous crop was canola and the soil at this site is an Indian Head Heavy Clay (Rego Black Chernozem).**

| Soil Property / Recommendation | Residual | Recommended [z] |
|---|---|---|
| | ---------- kg/ha ---------- | |
| N (60 cm) | 29 | 22-34 |
| P (15 cm) | 30.2 | 28-34 |
| K (15 cm) | >605 | 0-17 |
| S (60 cm) | 39 | 11-17 |
| pH (15 cm) | 8.0 | — |
| S.O.M. (%) | 3.9 | |

[z] ALS Laboratories - 2822 kg $ha^{-1}$ (42 bu $ac^{-1}$) yield target

*Soybean Response to Fertilizer Treatments*

Individual treatment means and type 3 tests of fixed effects along the means separations (Tukey's studentized ranged test; $P \leq 0.05$) are provided for emergence, minimum pod height and seed yield in Table 4. The *F*-tests were significant for emergence ($P = 0.002$), pod height ($P = 0.021$) and seed yield ($P < 0.001$), indicating significant treatment effects in all cases.

**Table 4. Treatment means and tests of fixed effects for N and P fertility treatment effects on soybean emergence, pod height and seed yield at Indian Head in 2014.**

| Treatment | Emergence | Pod Height | Seed Yield |
|---|---|---|---|
| kg N-$P_2O_5$ $ha^{-1}$ | --- plants/$m^2$ --- | ------ cm ------ | ----- kg/ha ----- |
| 1) 0N-0P | 45.6 ab | 3.6 b | 937 e |
| 2) 55N-0P | 50.1 ab | 4.9 ab | 1498 abc |
| 3) 2N-20P (side-band) | 49.4 ab | 4.3 ab | 1178 cde |
| 4) 2N-20P (seed-placed) | 52.1 a | 4.0 ab | 1290 abcd |
| 5) 4N-40P (side-band) | 52.5 a | 4.2 ab | 1207 cde |
| 6) 4N-40P (seed-placed) | 52.3 a | 4.1 ab | 1282 bcde |
| 7) 55N-20P (side-band) | 46.3 ab | 4.7 ab | 1598 ab |
| 8) 55N-20P (seed-placed) | 48.4 ab | 4.2 ab | 1640 a |
| 9) 55N-40P (side-band – uninoculated) | 46.0 ab | 5.4 a | 1053 de |
| 10) 55N-40P (seed-placed – uninoculated) | 50.2 ab | 4.9 ab | 1213 cde |
| 11) 55N-40P (side-band) | 43.5 ab | 4.3 ab | 1606 ab |
| 12) 55N-40P (seed-placed) | 41.4 b | 4.3 ab | 1599 ab |
| S.E.M | 1.90 | 0.31 | 70.9 |
| Overall F-test (p-value) | 0.002 | 0.021 | <0.001 |
| Coefficient of Variation (%) | 7.9 | 14.0 | 10.6 |

The results of the predetermined, single degree of freedom contrast comparisons are presented for emergence in Table 5. Overall, excellent establishment was achieved for all treatments with 46-50 plants $m^{-2}$ established, or 88-96% emergence. There were relatively few significant differences amongst the selected groups of treatments with the only cases being slightly higher plant populations with 20-40 kg $P_2O_5$ (averaged across placements) relative to no MAP and a slight reduction in emergence with N fertilizer (averaged across P rates and placement methods). One of the key project objectives was to demonstrate potential risks of seed-placing P fertilizer; however, there were no effects of P placement on emergence detected at the rates that were evaluated and environmental conditions encountered during this demonstration.

**Table 5. Predetermined contrasts comparing the effects of selected groups of N, P and inoculant treatments on soybean emergence at Indian Head in 2014.**

| Predetermined Contrast | Emergence (plants/$m^2$) | | |
|---|---|---|---|
| (Group A vs Group B) | -- Group A -- | -- Group B -- | --- Pr. > *F* --- |
| Check vs Rest | 45.6 a | 48.4 a | 0.157 |
| Side-banded P vs Seed-placed P (all rates) | 47.5 a | 48.9 a | 0.263 |
| Side-banded vs Seed-placed (20 kg $P_2O_5$ $ha^{-1}$) [Z] | 47.9 a | 50.3 a | 0.214 |
| Side-banded vs Seed-placed (40 kg $P_2O_5$ $ha^{-1}$) | 48.0 a | 46.9 a | 0.557 |
| 0 $P_2O_5$ vs 20 $P_2O_5$ | 47.8 a | 49.1 a | 0.452 |
| 0 $P_2O_5$ vs 40 $P_2O_5$ | 47.8 a | 47.4 a | 0.809 |
| 20 $P_2O_5$ vs 40 $P_2O_5$ | 49.1 a | 47.4 a | 0.227 |
| 0 N-0 $P_2O_5$ vs 2 N-20 $P_2O_5$ | 45.6 b | 50.8 a | 0.032 |
| 0 N-0 $P_2O_5$ vs 4 N-40 $P_2O_5$ | 45.6 b | 52.4 a | 0.006 |
| 2 N-20 $P_2O_5$ vs 4 N-40 $P_2O_5$ | 50.8 a | 52.4 a | 0.390 |
| 55 N-0 $P_2O_5$ vs 55 N-20 $P_2O_5$ | 50.1 a | 47.4 a | 0.253 |
| 55 N-0 $P_2O_5$ vs 55 N-40 $P_2O_5$ | 50.1 a | 42.4 b | 0.002 |
| 55 N-20 $P_2O_5$ vs 55 N-40 $P_2O_5$ | 47.4 a | 42.4 b | 0.013 |
| 0 N vs 55 N | 50.4 a | 45.9 b | 0.001 |
| 55 N inoculated vs 55 N uninoculated | 47.4 a | 48.1 a | 0.709 |

[Z] Inoculated treatments only; [Y] uninoculated treatments (9 & 10) did not receive granular inoculant

The contrast results for comparisons of treatment effects on minimum pod height, or pod clearance, are presented in Table 6. There was a small but significant overall increase in pod height with fertilizer ($P = 0.039$); however this was primarily due to the effect of N fertilizer as P fertilizer rate or placement did not have a significant effect in any cases. Somewhat unexpectedly, there was an overall reduction in minimum pod height observed with granular inoculant when combined with N fertilizer. While any observed effects on pod clearance were small, it should be noted that these measurements were highly variable because of the unevenness in the soil surface and do not reflect differences in total plant height which also affected overall harvestability. While detailed measurements were not completed, the treatments that received fertilizer N were generally slightly taller than those that did not and there was also a visible reduction in height when granular inoculant was not applied.

**Table 6. Predetermined contrasts comparing the effects of selected groups of N, P and inoculant treatments on soybean pod height at Indian Head in 2014.**

| Predetermined Contrast | Pod Height (cm) | | |
|---|---|---|---|
| (Group A vs Group B) | -- Group A -- | -- Group B -- | --- Pr. > *F* --- |
| Check vs Rest | 3.60 b | 4.29 a | 0.039 |
| Side-banded P vs Seed-placed P (all rates) | 4.33 a | 4.12 a | 0.158 |
| Side-banded vs Seed-placed (20 kg $P_2O_5$ $ha^{-1}$) [Z] | 4.45 a | 4.01 a | 0.230 |
| Side-banded vs Seed-placed (40 kg $P_2O_5$ $ha^{-1}$) | 4.21 a | 4.16 a | 0.871 |
| 0 $P_2O_5$ vs 20 $P_2O_5$ | 4.23 a | 4.26 a | 0.889 |
| 0 $P_2O_5$ vs 40 $P_2O_5$ | 4.23 a | 4.19 a | 0.889 |
| 20 $P_2O_5$ vs 40 $P_2O_5$ | 4.26 a | 4.19 a | 0.731 |
| 0 N-0 $P_2O_5$ vs 2 N-20 $P_2O_5$ | 3.60 a | 4.10 a | 0.192 |
| 0 N-0 $P_2O_5$ vs 4 N-40 $P_2O_5$ | 3.60 a | 4.11 a | 0.181 |
| 2 N-20 $P_2O_5$ vs 4 N-40 $P_2O_5$ | 4.10 a | 4.11 a | 0.968 |
| 55 N-0 $P_2O_5$ vs 55 N-20 $P_2O_5$ | 4.85 a | 4.43 a | 0.266 |
| 55 N-0 $P_2O_5$ vs 55 N-40 $P_2O_5$ | 4.85 a | 4.26 a | 0.127 |
| 55 N-20 $P_2O_5$ vs 55 N-40 $P_2O_5$ | 4.43 a | 4.26 a | 0.599 |
| 0 N vs 55 N | 4.01 b | 4.45 a | 0.030 |
| 55 N inoculated vs 55 N uninoculated | 4.43 b | 5.12 a | 0.029 |

[Z] Inoculated treatments only; [Y] uninoculated treatments (9 & 10) did not receive granular inoculant

Contrast results for soybean seed yield are presented in Table 7. There was an overall seed yield increase of 53% with fertilizer when averaged across all products, placements and rates. There was also a slight tendency for higher yields with seed-placement when averaged across P rates and N levels; however, the observed difference was not significant at the desired probability level ($P$ = 0.099). This tendency was not observed at either of the individual P levels when considered separately ($P$ = 0.288-0.637) and, as such, it is fair to conclude that the responses to the two placement methods were similar. Averaged across N rates and P placement methods, both P rates (20 and 40 kg $P_2O_5$ $ha^{-1}$) resulted in a significant yield increase over the 0 P treatments ($P$ = 0.002) but yields were similar between the two rates ($P$ = 0.947). Further inspection of the contrast results suggests that the response to P fertilizer was most evident without starter N (32%; $P$ = 0.002) compared when 55 kg N was applied as side-banded urea (7.5%; $P$ = 0.174-0.241). Nitrogen fertilizer application resulted in a 35% yield increase on average ($P$ < 0.001) but did not negate the value of granular inoculant which further increased yields by 43% ($P$ < 0.001). in general, yields were somewhat lower than expected, presumably due to the early frost, and this may have impacted the results to some extent if any of the treatments delayed maturity; however, no noticeable differences in crop development were observed amongst treatments at any point during the season.

**Table 7. Predetermined contrasts comparing the effects of selected groups of N, P and inoculant treatments on soybean seed yield at Indian Head in 2014.**

| Predetermined Contrast | Seed Yield (kg/ha) | | |
|---|---|---|---|
| (Group A vs Group B) | -- Group A -- | -- Group B -- | --- Pr. > *F* --- |
| Check vs Rest [Z] | 937 b | 1433 a | <0.001 |
| Side-banded P vs Seed-placed P (all rates) | 1328 a | 1405 a | 0.099 |
| Side-banded vs Seed-placed (20 kg $P_2O_5$ $ha^{-1}$) [Z] | 1388 a | 1465 a | 0.288 |
| Side-banded vs Seed-placed (40 kg $P_2O_5$ $ha^{-1}$) | 1406 a | 1440 a | 0.637 |
| 0 $P_2O_5$ vs 20 $P_2O_5$ | 937 b | 1427 a | 0.002 |
| 0 $P_2O_5$ vs 40 $P_2O_5$ | 937 b | 1423 a | 0.002 |
| 20 $P_2O_5$ vs 40 $P_2O_5$ | 1427 a | 1423 a | 0.947 |
| 0 N-0 $P_2O_5$ vs 2 N-20 $P_2O_5$ | 937 b | 1234 a | 0.002 |
| 0 N-0 $P_2O_5$ vs 4 N-40 $P_2O_5$ | 937 a | 1244 a | 0.001 |
| 2 N-20 $P_2O_5$ vs 4 N-40 $P_2O_5$ | 1234 a | 1244 a | 0.886 |
| 55 N-0 $P_2O_5$ vs 55 N-20 $P_2O_5$ | 1498 a | 1619 a | 0.174 |
| 55 N-0 $P_2O_5$ vs 55 N-40 $P_2O_5$ | 1498 a | 1602 a | 0.241 |
| 55 N-20 $P_2O_5$ vs 55 N-40 $P_2O_5$ | 1619 a | 1602 a | 0.811 |
| 0 N vs 55 N | 1179 b | 1588 a | <0.001 |
| 55 N inoculated vs 55 N uninoculated | 1619 a | 1133 b | <0.001 |

[Z] Inoculated treatments only; [Y] uninoculated treatments (9 & 10) did not receive granular inoculant

*Extension and Acknowledgement*

The demonstration was featured at the annual IHARF Crop Management Field Day which was held on July 21 and attended by over 200 producers and industry representatives. Garry Hnatowich from the Irrigation Crop Diversification Corporation (ICDC) was invited to discuss soybean agronomy in Saskatchewan and Chris Holzapfel led the attendants through the individual treatments for an interactive discussion on soybean fertility considerations. Results from this project will be made available in the 2014 IHARF Annual Report (available online) and through a variety of other media as opportunities arise (i.e. oral presentations, popular agriculture press, fact sheets, etc.).

## 11. Conclusions and Recommendations

Overall, this project demonstrated that side-banded and seed-placed phosphorus fertilizer provided similar yield benefits and there were no significant effects on emergence at the rates evaluated. There was a strong overall response to P fertilizer, but no yield benefit to applying more than 20 kg $P_2O_5$ under these conditions. Further research would be required to evaluate the effects of P placement at higher application rates and under a broader range of soil and environmental conditions. Contrary to our expectations, there was also a strong response to side-banded N fertilizer. While high mineral N levels can reduce nodulation by *Bradyrhizobium*, there was still a strong response to granular inoculant even when combined with starter N. While we are hesitant to recommend N fertilizer applications on N fixing crops such as soybeans, these results justify a more in-depth evaluation of

interactions between granular inoculant rates and N fertilizer applications for soybeans in Saskatchewan. Again, previous research has shown that responses to N are not uncommon when soil residual levels are extremely low or when cool or dry conditions reduce nodulation and N fixation early in the season.

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## Supporting Information

### 12. Acknowledgements

This project was supported by the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canada-Saskatchewan Growing Forward 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. Granular inoculant was provided in-kind by Monsanto BioAg and soybean seed was provided by Delmar Commodities / Legend Seeds.

### 13. Appendices


55N-20P (Sb)
no gran. inoculant


55N-20P (Sb)
plus gran. inoculant


4N-40P (Sp)
plus gran. inoculant


55N-40P (Sp)
plus gran. inoculant

## Abstract

**14. Abstract/Summary**

A field demonstration was conducted near Indian Head, Saskatchewan in 2014 to demonstrate the effects of various nitrogen (N) and phosphorus (P) fertilizer treatments on soybean establishment and seed yield. Seeding was completed in late-May and excellent plant stands were established for all treatments. There was a strong overall seed yield response to P fertilizer (20% yield increase on average), starter N fertilizer (35% yield increase on average) and granular inoculant (43% yield increase on average). While the response to N was certainly of interest and warrants further investigation, the observed response to granular inoculant suggests that starter N alone cannot fully compensate for poor nodulation and biological N fixation. In the majority, N fertilizer will not be recommended for soybeans but these results show that there can be benefits to starter N under certain circumstances, particularly if residual N is extremely low or if soil conditions early in the spring are dry and/or cool. There were no effects of P fertilizer placement (side-band versus seed-row) on emergence at any of the rates evaluated and under the environmental conditions encountered. Furthermore, equivalent yields were achieved with side-banded and seed-placed P fertilizer suggesting that both methods of fertilization performed similarly. This demonstration was shown at the 2014 IHARF Crop Management Field Day which was attended by over 200 producers and agronomists. Garry Hnatowich was invited to discuss soybean agronomy with the attendants and signs were in-place to identify the individual treatments. Results will be presented at winter meetings when there are opportunities to do so and in written reports such the 2014 IHARF Annual Report.