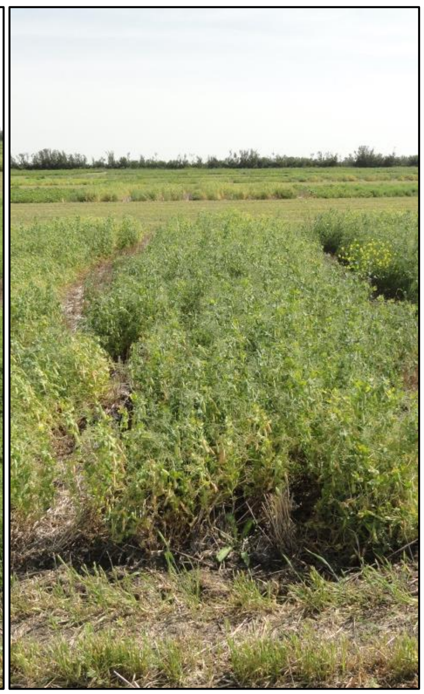
2014 Annual Report

for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Field Pea, Lentil and Soybean Response to Rhizobial and Mycorrhizal Inoculation

(Project #201300392)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Project Identification

1. **Project Title:** Field pea, lentil and soybean response to rhizobial and mycorrhizal inoculation
2. **Project Number:** 20130392
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 effects of traditional granular rhizobial inoculant and a relatively new mycorrhizal inoculant, alone and in combination, on the seed yield of field peas, lentils and soybeans.

8. **Project Rationale:**

Field peas and lentils have been grown in the thin-Black Soil Zone for several decades and are recognized for their rotational benefits. Benefits associated with the inclusion of pulses in crop rotations are primarily due to their ability to form symbiotic relationships with Rhizobium bacteria (*Rhizobium leguminosarum*) and utilize nitrogen from the soil air, which is normally not available to plants. To ensure adequate root nodulation, growers are advised to use rhizobial inoculants that are either applied directly to the seed or in the seed furrow as a granular or peat-based product. For soybeans, which are a new crop for most growers in Saskatchewan, inoculation is especially critical since the bacteria that infect soybean roots are of a different strain (*Bradyrhizobium japonicum*) than field pea or lentil, therefore native populations in the soil will be very low in most Saskatchewan fields. While the economic returns that are realized with rhizobial inoculation may vary from field-to-field and year-to-year, inoculating remains a generally recommended and accepted practice for ensuring that pulse yields and rotational benefits are maximized.

Arbuscular mycorrhizal inoculants (*Glomus intraradices*), are relatively new to western Canadian farmers and are not specific to pulse crops. The benefits of arbuscular mycorrhizal fungi in agricultural systems are well recognized. These organisms form symbiotic relationships with most plants and effectively increase their root areas thereby enhancing their ability to utilize soil resources. While an appreciable number of growers are aware of the overall importance of arbuscular mycorrhizal fungi, growers have limited experience with the inoculants and may be hesitant to invest in this technology. Current research funded by the Saskatchewan Pulse Growers is assessing arbuscular mycorrhizal fungal inoculants for pulse production systems and the proposed demonstration will help to validate this emerging research while increasing producer knowledge of the potential benefits and/or limitations of these products. Including the rhizobial inoculant provides an opportunity to explain the important differences between these two types of products while providing a familiar benchmark for which to compare the effects of the mycorrhizal inoculants on seed yield.

Methodology and Results

9. Methodology:

Replicated field trials with field pea, lentil and soybean were conducted in both 2013 (50°34’05” N, 103°38’06” W) and 2014 (50°32’58” N, 103°34’18” W) near Indian Head, Saskatchewan with treatments arranged in a randomized complete block design (RCBD) with four replicates. Four inoculant treatments were evaluated for three crops and the treatments are described in Table 1.

Table 1. Treatment evaluation in a pulse inoculant demonstration conducted at Indian Head in 2013 and 2014.

#	Crop	Inoculant Treatment
1	Field Pea	Nil (no inoculant)
2	Field Pea	Rhizobial [Z]
3	Field Pea	Mycorrhizal [Y]
4	Field Pea	Rhizobial [Z] + Mycorrhizal [Y]
5	Lentil	Nil (no inoculant)
6	Lentil	Rhizobial [Z]
7	Lentil	Mycorrhizal [Y]
8	Lentil	Rhizobial [Z] + Mycorrhizal [Y]
9	Soybean	Nil (no inoculant)
10	Soybean	Rhizobial [X]
11	Soybean	Mycorrhizal [Y]
12	Soybean	Rhizobial [X] + Mycorrhizal [Y]

[Z] 3 kg ha^{-1} granular Nodulator XL for pea and lentil
[Y] 5.5 kg ha^{-1} granular MykePro inoculant
[X] 7.5 kg ha^{-1} granular Nodulator in 2013; 4 kg ha^{-1} Cell Tech granular in 2014

In both years, the field pea variety CDC Golden, lentil variety CDC Maxim CL and soybean variety NSC Reston RR2Y were direct-seeded into cereal stubble 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. Targeted seeding rates were 100 viable seeds m^{-2} for field pea, 150 seeds m^{-2} for lentil and 55 seeds m^{-2} for soybean. The targeted seeding depth was approximately 20 mm for lentil and soybeans and 30 mm for field pea. Soil moisture conditions at seeding were considered excellent with adequate but not excessive surface moisture; however, some issues with straw / residue clearance were encountered in 2014. In 2013, a blend of mono-ammonium phosphate (11-52-0), potassium chloride (0-0-60) and ammonium sulphate (21-0-0-24) was side-banded to all plots to supply 21-30-15-15 kg ha^{-1} of N, P_2O_5, K_2O and S, respectively. In 2014, mono-ammonium phosphate was side-banded to supply 30 kg P_2O_5 ha^{-1}. All inoculants were placed in the seed-row and the products are provided in Table 1. Weeds were controlled using registered pre-emergent and in-crop herbicide applications. Due to the RCBD arrangement of the treatments in 2013, we were unable to spray glyphosate on the soybeans during the growing season; however, a split-plot design was used in 2014 to correct this. Pre-harvest glyphosate was applied to terminate the field peas and lentils in both years and for late-season weed control in the soybeans in 2013. All plots were direct-combined when fit to do so using a Wintersteiger plot combine. Selected agronomic information and dates of all pertinent field operations are provided in Table 2.

Table 2. Selected agronomic information for seeding rate and fungicide demonstration for field pea and lentil at Indian Head, Saskatchewan in 2013 and 2014.

Factor / operation	Indian Head (2013)	Indian Head (2014)
Previous Crop	CWRS Wheat	2-Row Barley
Pre-emergent herbicide	590 g glyphosate ha^{-1} (May-17-2013)	890 g glyphosate ha^{-1} (May-18-2014)
Seeding Date	May-19-2013	May-22-2014
Row spacing	30.5 cm	30.5 cm
Plant Density	Jun-11-2013	Jun-13-2014
kg $N-P_2O_5-K_2O-S$ ha^{-1}	21-30-15-15	6-30-0-0
In-crop herbicide 1	42.7 g Odyssey ha^{-1} + 166 ml Equinox ha^{-1} + 0.5% Merge (Jun-7-2013)	42.7 g Odyssey ha^{-1} + 166 ml Equinox ha^{-1} + 0.5% Merge (Jun-11-2013)
In-crop herbicide 2	0.185 l Equinox ha^{-1} + 0.5% Merge (Jun-29-2013)	0.46 l Poast Ultra ha^{-1} (Jul-7-2014)
In-crop herbicide 3	n/a	890 g glypl
Fungicide T1	0.4 l Headline EC ha^{-1} (Jul-4-2013)	0.4 l Priaxor DS ha^{-1} (Jul-12-2014) ^{Z}
Pre-harvest herbicide 1	890 g glyphosate ha^{-1} (Aug-20-2013)	890 g glyphosate ha^{-1} (Jul-14-2014) ^{Y}
Field Pea harvest date	Aug-30-2013	Aug-31-2014
Lentil harvest date	Sep-9-2013	Sep-2-2014
Soybean harvest date	Oct-1-2013	Oct-10-2014

^{Z} field pea and lentil only; ^{Y} soybeans only

Spring crop establishment was assessed by counting the number of plants in 2 x 1 m sections of crop row per plot and converting the values to plants m^{-2}. Grain yields were determined by cleaning and weighing the entire harvest sample, determining moisture content and converting the weights to kg ha^{-1} of clean seed corrected to a uniform moisture content of 16% for field pea, 13% for lentils and 14% for soybeans. Growing season weather data were estimated using data from an Environment Canada weather station located within approximately 2 km of the site in 2013 and 6 km in 2014.

Response data were analyzed separately for each crop type using the Mixed procedure of SAS 9.3 with the effects of year (Y), inoculant treatment (I) and Y × R considered fixed and the effect of replicate considered random. Fisher's protect LSD test was used to separate treatment means and contrasts were used to compare the various inoculants to the control individually for each of the two years and averaged across years. All treatment effects and differences between means were considered significant at $P \leq 0.05$.

10. Results:

Mean monthly average temperatures and precipitation totals for the 2013 and 2014 growing seasons are provided in Table 3. While spring arrived late both years with snow persisting into the first week in May, drier than normal weather in May allowed for seeding to progress reasonably well both seasons. June was wetter than normal both years with precipitation levels that were 134% and 258% of the long-term average in 2013 and 2014, respectively (Table 3). Precipitation in July was 79% of the long-term average in 2013 and only 12% of average in 2014. While August was extremely dry with only 6.1 mm of rain in 2013, this month was wet in 2014 with 278% of the long term average amounts. It is well recognized that field peas and lentils are sensitive to prolonged wet conditions, especially on clay soils. While the crops recovered quite well from the excess moisture in June 2013 and yields were quite high, 2014 was much wetter and, despite the plots being located on a relatively well drained site, significant crop damage and yield loss occurred to field peas and lentils on the site. Frost occurred on both September 9 and 10, at which time the earliest soybean pods were just starting to turn colour and this was thought to be a significant yield limiting factor for this crop.

Table 3. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) averages for the 2013 and 2014 growing seasons 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
2013	11.9	15.3	16.3	17.1	15.2
Long-term	10.8	15.8	18.2	17.4	15.6
	--------------------------------- Precipitation (mm) ---------------------------------				
2014	36.0	199.2	7.8	142.2	385
2013	17.1	103.8	50.4	6.1	177
Long-term	51.8	77.4	63.8	51.2	244

Field Pea

Tests of fixed effects and predetermined contrasts for field pea are provided in Table 4 while the mean plant densities and seed yields appear in Table 5. Field pea plant densities were affected by year (P = 0.001) but not inoculant (P = 0.680) and the Y × I effect was not significant (P = 0.806). This is an indication that the treatment effects (or lack thereof) were consistent from year to year. Similar results were observed for seed yield with a significant year effect (P < 0.001) but no inoculant effect (P = 0.891) and no interaction (P = 0.866). None of the contrasts were significant for field pea plant density (P = 0.225-0.902) or seed yield (P = 0.350-0.915), which is consistent with the multiple comparison results. Overall, field pea plant densities and yields were significantly higher in 2013 than 2014. There were no statistical results or trends to suggest that field pea yields were increased with any inoculants.

Table 4. Tests of fixed effects year, inoculant and year x inoculant on field pea plant populations and seed yield at Indian Head, SK (2013).		
Tests of Fixed Effects	Plant Density	Seed Yield
Source	------------------------ p-value ------------------------	
Year	0.001	<0.001
Inoculant	0.680	0.810
Year × Inoculant	0.806	0.866
Contrast	------------------------ p-value ------------------------	
Check vs rhiz	0.264	0.350
Check vs myc	0.487	0.573
Check vs dual	0.794	0.712
2013 – Check vs rhiz	0.225	0.468
2013 – Check vs myc	0.248	0.605
2013 – Check vs dual	0.623	0.915
2014 – Check vs rhiz	0.712	0.550
2014 – Check vs myc	0.853	0.792
2014 – Check vs dual	0.902	0.494

Table 5. Mean field pea plant densities and seed yields as affected by year and inoculant treatment at Indian Head in 2013 and 2014. Standard errors of the treatment means are enclosed in parentheses.

	Plant Density (plants m^{-2})			**Seed Yield (kg ha^{-1})**		
Treatment	**2013**	**2014**	**Average**	**2013**	**2014**	**Average**
Control	99.7 (4.6)	82.8 (4.6)	91.2 A (3.3)	4538 (704)	2814 (639)	3676 A (565)
Rhizobial	91.5 (4.6)	80.4 (4.6)	85.9 A (3.3)	5108 (704)	3219 (639)	4163 A (565)
Mycorrhizal	91.9 (4.6)	84.1 (4.6)	88.0 A (3.3)	4943 (704)	2992 (639)	3967 A (565)
Dual	96.4 (4.6)	83.7 (4.6)	90.0 A (3.3)	4454 (704)	3279 (639)	3867 A (565)
Average	94.8 A (2.3)	82.7 B (2.3)	—	4761 A (524)	3075 B (492)	—

<u>*Lentil*</u>

The results of the tests of fixed effects and contrast for lentil are provided in Table 6 with mean plant densities and seed yields reported in Table 7. Similar to field pea, lentil plant densities were affected by year (P < 0.001) but not inoculant (P = 0.158) and the Y × I effect was not significant (P = 0.694). Similarly, lentil yields were affected by year (P < 0.001) but not inoculant (P = 0.387) with no significant interaction (P = 0.328). While the check versus dual inoculant contrast was significant for plant density (P = 0.026) and the check versus rhizobial inoculant contrast was significant for seed yield in 2013 (P = 0.037), no other contrasts were significant for either variable; thus these results were somewhat inconsistent. Similar to field pea, lentil plant densities and seed yields were higher in 2013 than in 2014. In 2013, there was an overall trend of higher lentil yields with rhizobial inoculant (as indicated by the contrasts) but this was not the case in 2014 where yields were lower and other factors (i.e. excess precipitation) were more limiting.

Table 6. Tests of fixed effects year, inoculant and year x inoculant on lentil plant populations and seed yield at Indian Head, SK (2013).

Tests of Fixed Effects	Plant Density	Seed Yield
Source	------------------------ p-value ------------------------	
Year	<0.001	<0.001
Inoculant	0.158	0.387
Year × Inoculant	0.694	0.328
Contrast	------------------------ p-value ------------------------	
Check vs rhiz	0.213	0.137
Check vs myc	0.288	0.660
Check vs dual	0.026	0.204
2013 – Check vs rhiz	0.138	0.037
2013 – Check vs myc	0.411	0.461
2013 – Check vs dual	0.144	0.118
2014 – Check vs rhiz	0.788	0.819
2014 – Check vs myc	0.490	0.854
2014 – Check vs dual	0.077	0.909

Table 7. Mean lentil plant densities and seed yields as affected by year and inoculant treatment at Indian Head in 2013 and 2014. Standard errors of the treatment means are enclosed in parentheses.

	Plant Density (plants m^{-2})			**Seed Yield (kg ha^{-1})**		
Treatment	**2013**	**2014**	**Average**	**2013**	**2014**	**Average**
Control	114 (12.8)	164 (12.8)	139 A (9.0)	4345 (346.9)	1842 (327.0)	3093 A (306.4)
Rhizobial	141 (12.8)	169 (12.8)	155 A (9.0)	5015 (346.9)	1782 (327.0)	3399 A (306.4)
Mycorrhizal	129 (12.8)	177 (12.8)	153 A (9.0)	4568 (346.9)	1794 (327.0)	3181 A (306.4)
Dual	141 (12.8)	198 (12.8)	170 A (9.0)	4832 (346.9)	1872 (327.0)	3352 A (306.4)
Average	177 A (6.4)	131 B (6.4)	—	4690 A (296)	1882 B (287)	—

Soybean

Tests of fixed effects and predetermined contrast results for soybean are provided in Table 8 with mean plant densities and seed yields in Table 9. Soybean plant densities were similar regardless of year (P = 0.544) and inoculant treatment (P = 0.957) and there was no year by treatment interaction (P = 0.901). This was consistent with the contrast results for plant densities whereby none were significant (P = 0.422-0.999). Unlike field pea and lentil at this location, soybean yields were affected by both year and inoculant treatment ($P < 0.001$). Similar to the previous two crops, soybean yields were higher in 2013 than 2014; however soybean yields were relatively low in both years. There was a strong and consistent yield increase with rhizobial inoculant, alone or combined with a mycorrhizal inoculant, with significant increases in both years individually and when averaged across years. There was no evidence of any yield benefits associated specifically with the mycorrhizal inoculant in either the predetermined contrasts or the multiple comparisons tests.

Table 8. Tests of fixed effects year, inoculant and year x inoculant on soybean plant populations and seed yield at Indian Head, SK (2013).

Tests of Fixed Effects	Plant Density	Seed Yield
Source	------------------------ p-value	------------------------
Year	0.544	<0.001
Inoculant	0.957	<0.001
Year × Inoculant	0.901	0.340
Contrast	------------------------ p-value	------------------------
Check vs rhiz	0.637	0.003
Check vs myc	0.999	0.858
Check vs dual	0.926	<0.001
2013 – Check vs rhiz	0.889	0.048
2013 – Check vs myc	0.688	0.907
2013 – Check vs dual	0.734	0.033
2014 – Check vs rhiz	0.422	0.013
2014 – Check vs myc	0.686	0.712
2014 – Check vs dual	0.638	<0.001

Table 9. Mean soybean plant densities and seed yields as affected by year and inoculant treatment at Indian Head in 2013 and 2014. Standard errors of the treatment means are enclosed in parentheses.

	Plant Density (plants m^{-2})			**Seed Yield (kg ha^{-1})**		
Treatment	**2013**	**2014**	**Average**	**2013**	**2014**	**Average**
Control	55.0 (4.3)	57.0 (4.3)	55.9 A (3.0)	1061 (107.8)	368 (107.8)	715 B (80.7)
Rhizobial	55.8 (4.3)	52.1 (4.3)	53.9 A (3.0)	1362 (107.8)	758 (107.8)	1060 A (80.7)
Mycorrhizal	57.4 (4.3)	54.5 (4.3)	56.0 A (3.0)	1078 (107.8)	314 (107.8)	696 B (80.7)
Dual	57.0 (4.3)	54.1 (4.3)	55.6 A (3.0)	1388 (107.8)	983 (107.8)	1185 A (80.7)
Average	56.3 A (2.1)	54.4 A (2.1)	—	1222 A (63.0)	606 B (63.0)	—

Extension and Acknowledgement

In 2013, this field demonstration was shown to an estimated 194 attendees at the IHARF Crop Management Field Day on July 23 and field signs were in place to acknowledge the support of the ADOPT program for the tour. In addition to the annual field day which is geared towards Saskatchewan producers and agronomists, groups of producers from Germany, Kazakhstan and Australia also had formal tours and we estimate that roughly 350-400 producers and agronomists visited over the 2013 growing season. In 2014, the plots were again shown at the annual Crop Management Field Day which was held on July 21 and attended by over 200 producers and industry representatives. 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

Although this demonstration did not show conclusive agronomic benefits or crop response to the inoculant treatments field peas or lentils, rhizobial inoculation is recommended for these crops to ensure that both potential N fixation and seed yields are maximized. It is important to recognize, however, that these fields have a rich history of field peas in rotation and as such, native populations of rhizobium may have been largely sufficient to ensure adequate nodulation. For soybeans, which have not historically been grown in the region and require a different strain of bacteria, there were substantial benefits to rhizobial inoculation in both years. Whether or not mycorrhizal inoculation is likely to provide tangible agronomic benefits under normal field conditions is less well understood; however, this demonstration failed to show any benefits to mycorrhizal inoculation for field pea, lentil or soybean. The benefits of mycorrhizal fungi and, potentially under some circumstances, mycorrhizal inoculation are not exclusive to pulse crops and the product used in this demonstration may also be used with cereals and oilseeds such as flax. It is possible that the potential benefits of mycorrhizal inoculants are affected by management factors such as crop rotation, tillage practices and seeding equipment. Benefits to inoculation would be most likely following non-host crops such as canola and when tillage or high-disturbance seeding equipment damages existing mycorrhizal networks and hyphae. This demonstration was conducted following a host crop (spring wheat or barley) and in long-term no-till fields and these factors may have contributed to the lack of response to the mycorrhizal inoculant product. Growers who do choose to try mycorrhizal inoculants for themselves are advised to use check strips to evaluate the effects and assess where and when there is an adequate return on investment in order to inform future management decisions.

<u>Supporting Information</u>

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. The mycorrhizal inoculant product used was provided in-kind by Premier Tech Biotechnologies. In-crop herbicide products and fungicides used in this demonstration were provided in-kind by BASF while soybean seed was provided in-kind by Northstar Genetics.

13. Appendices

No additional appendices are included in this report.

Abstract

14. Abstract/Summary

Field demonstrations were conducted at Indian Head, Saskatchewan in both 2013 and 2014 to demonstration the effects of rhizobial and mycorrhizal inoculants on the yields of field pea, lentil and soybeans. Seeding was completed in mid-May and excellent plant stands were established for all crops in both years. Growing season conditions were drier and generally more optimal for most crops in 2013 and, as such, yields were higher for all three crops than they were in 2014. Not unexpectedly, the inoculant treatments evaluated did not affect plant density in any cases. There was no evidence to suggest a yield benefit to any of the inoculant treatments for field pea; however, there was a tendency towards higher yields with rhizobial inoculants in lentils in 2013 and a strong response to rhizobial inoculant for soybeans in both years. No significant advantages to mycorrhizal inoculation were detected for field pea, lentil or soybean in either of the two years or when averaged across years.

While the yield benefits that are realized with rhizobial inoculation for pulse crops can be inconsistent depending on field history and environmental conditions, growers are still advised to inoculate in order to ensure that N fixation and yield potential are maximized. This was quite evident in this demonstration whereby no significant benefits to rhizobial inoculation were detected for field peas or lentils (which are well established crops in the region) but the observed yield increases were highly significant for soybean which had never previously been grown on the sites. The agronomic benefits and probability of responses for mycorrhizal inoculation are not well understood; however, this demonstration failed to show any practical benefits to the product evaluated under the specific circumstances encountered. This demonstration was part of the IHARF Crop Management Field Day which was attended by approximately 200 producers and agronomists each year. Results will be presented at winter meetings when there are opportunities to do so and in written reports such the 2013 and 2014 IHARF Annual Reports.