2014 Annual Report

for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Inoculant and Foliar Fungicide Effects on Soybeans

(Project #201300395)

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Project Identification

1. **Project Title:** Inoculant and foliar fungicide effects on soybeans
2. **Project Number:** 20130395
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 high rates of granular inoculant and foliar fungicide applications on both the maturity and seed yield of soybeans.

8. **Project Rationale:**

While both interest and acres in soybeans has grown rapidly in Saskatchewan, growers and agronomists alike have relatively little experience with this crop in our environment. As a legume, soybeans form symbiotic relationships with Rhizobium bacteria (*Bradyrhizobium japonicum*) and can utilize nitrogen (N) from the soil air, which is not available to most plants. Because soybeans have not traditionally been grown in Saskatchewan, proper inoculation is required to ensure adequate nodulation and biological N fixation. There is general acceptance that double inoculating (full rates of both liquid and granular inoculant) is beneficial for land where soybeans have not previously been grown and further evidence that granular inoculant rates exceeding those on the product labels may be warranted. On the other hand, high rates of granular inoculants add considerable costs to seeding soybeans and must be justified with an adequate yield increase to make economic sense.

With regard to fungicide application, it has generally been recommended that soybean growers in Saskatchewan can avoid foliar applications since disease has not typically been a limiting factor in this environment. Furthermore, unnecessary use of fungicide is expensive and could result in unnecessary delays in soybean maturity. However, septoria brown spot and bacterial blight can affect soybeans in our cool environment and therefore growers may be tempted to apply a fungicide. Provided that disease pressure is high enough and moisture or temperatures are not limiting, there may be benefits to foliar fungicide applications for soybeans but the probability of such conditions occurring in Saskatchewan is relatively low.

This project will benefit producers by providing response data and a forum for discussion on the importance of adequate inoculation with soybeans, particularly in Saskatchewan where this crop has not been historically grown. It will also address questions on foliar fungicide application and likely demonstrate that this is not currently a requirement for soybeans in Saskatchewan and should be avoided under most circumstances. When taken into context with other soybean trials and demonstrations, this project will provide both an opportunity to discuss important issues for new soybean growers in Saskatchewan while generating valuable response data to inform future agronomic recommendations.

Methodology and Results

9. Methodology:

A replicated soybean demonstration was conducted near Indian Head, Saskatchewan (50°32’58” N, 103°34’18” W) in 2014. Ten treatments arranged in a split plot design with four separately randomized replicates. The treatments were a factorial combination of two fungicide treatments (main plots) and five granular inoculant rates (sub-plots). The specific treatments are described in Table 1.

Table 1. Treatments evaluated in a soybean inoculant and fungicide demonstration at Indian Head, Saskatchewan in 2014.

#	Granular Inoculant^{Z} Rate^{Y}	Fungicide^{X}
1	0x (no inoculant)	no
2	0.5x (2 kg ha^{-1})	no
3	1.0x (4 kg ha^{-1})	no
4	2.0x (8 kg ha^{-1})	no
5	4.0x (16 kg ha^{-1})	no
6	0x (no inoculant)	yes
7	0.5x (2 kg ha^{-1})	yes
8	1.0x (4 kg ha^{-1})	yes
9	2.0x (8 kg ha^{-1})	yes
10	4.0x (16 kg ha^{-1})	yes

^{Z} Cell-Tech granular inoculant (1.0 x 10^{8} *Bradyrhizobium japonicum* viable cells g^{-1})
^{Y} Label recommended rate for 31 cm row spacing is 4.0 kg ha^{-1}
^{X} 0.4 l Headline E.C. ha^{-1} (100 g pyraclostrobin ha^{-1})

The soybean variety LS002R23 (Legend Seeds) was direct-seeded into barley stubble on May 26 using a Seed Master drill with 8 openers spaced 30 cm apart (2.4 m total seeded width) and a trimmed plot length of 10.5 m. Soil moisture at seeding was abundant and conditions were excellent for emergence; however, heavy residues and generally wet conditions resulted in some issues with straw / residue clearance during seeding. Mono-ammonium phosphate (11-52-0) was side-banded to supply 30 kg P_2O_5 ha^{-1} and no other fertilizer products were applied. The seed for all entries was treated with Cruizer Maxx Vibrance and Primo CL liquid inoculant. Cell-Tech granular inoculant was applied in the seed-row with the rates varied as per protocol. Weeds were controlled using a pre-emergent application (May 24) and 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 11-12 using a Wintersteiger plot combine.

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 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, with values adjusted for dockage and to a uniform moisture content of 14%. Thousand kernel weights were determined by manually counting and weighing 250 seeds per plot and calculating g 1000 $seeds^{-1}$. 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 Fisher's protected LSD test used to separate treatment means. Orthogonal contrasts were used to describe the overall responses to increasing granular inoculant rates. 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 drier and slightly cooler than average, it was reasonably warm at the time of seeding with daytime highs of 24-28 °C and lows of 6-8 °C for the 24 hour period following seeding. June was much wetter than normal with 199 mm of precipitation (258% of the long-term average) and, while precipitation in July was low, the site remained wet until the latter half of the month. August was wet with close to normal temperatures but 142 mm of precipitation (278% of the long term average). While the wet conditions late in the season were desirable for pod filling, frost on September 9-10 terminated the soybeans before any 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 the test area on May 22 and submitted to ALS Laboratories (Saskatoon, SK) for residual nutrient analyses and fertilizer recommendations. 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 somewhat below the typical levels for these soils and pH was considered moderately alkaline.

Table 3. Residual soil nutrient and fertilizer recommendations for soybeans on barley stubble at Indian Head, Saskatchewan (2014). 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 Fungicide and Granular Inoculant

The overall *F*-tests for fungicide (FUNG), granular inoculant rate (INOC) and the FUNG × INOC interaction are presented in Table 4. The minimum pod height was not affected by either FUNG (P = 0.445) or INOC (P = 0.114) but the FUNG × INOC interaction was significant (P = 0.046). Seed yield was affected by INOC (P < 0.001) but not FUNG (P = 0.909) and the interaction was not significant (P = 0.419). Similar to yield, seed size was affected by INOC (P < 0.001) but.not FUNG (P = 0.538) and the interaction was not significant (P = 0.615).

Table 4. Type three tests of fixed effects for fungicide application and granular inoculant effects on soybean pod height, seed yield and seed size. Data were analyzed using the GLM procedure of SAS 9.3.

Source	Pod Height (cm)	Seed Yield (kg/ha)	Seed Size (g 1000 $seeds^{-1}$)
Fungicide (FUNG)	0.445	0.909	0.538
Inoculant (INOC)	0.114	< 0.001	< 0.001
FUNG × INOC	0.046	0.419	0.615
C.V.	11.4	13.0	2.9
R^2	0.707	0.862	0.935

Treatment means for the main effects of foliar fungicide application and granular inoculant effects on soybean pod height, seed yield and seed size are presented in Table 5. Orthogonal contrast results for each variable are also presented to determine whether the observed responses to granular inoculant rate were linear, quadratic or cubic in nature.

Again, pod height was only affected by the FUNG × INOC interaction; however, a significant overall quadratic response (P = 0.037) was due to a slight increase in minimum pod height that levelled off at the 1x rate (Table 5, Fig. 1). While the overall mean treatment differences were small, it is important to note that these measurements were rather variable due to unevenness of the soil surface. Additionally, the pod height measurements do not take into account overall differences in plant height which also affected harvestability.

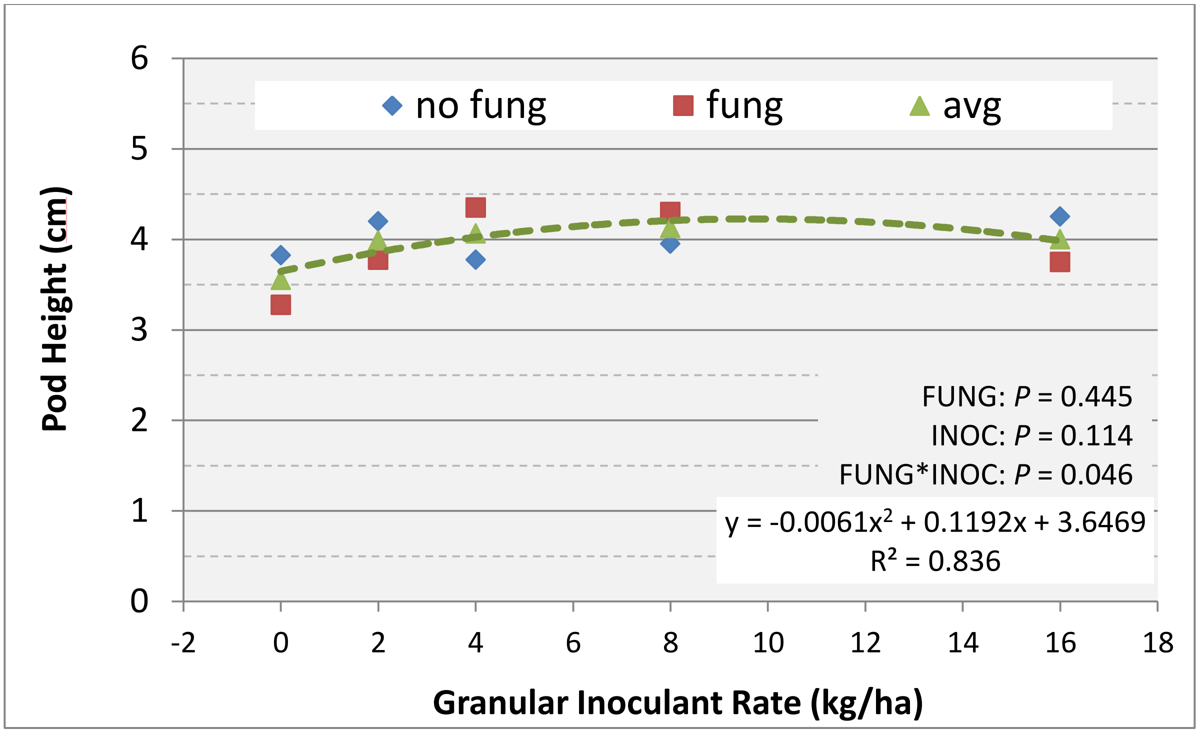

Figure 1. Granular inoculant rate effects on soybean pod height at Indian Head (2014).

Seed yields were relatively low overall on average, largely a result of the early frost on September 10-11 which, again, occurred before any pods had started to turn colour. Yields were similar with and without fungicide (1218-1224 kg ha^{-1}). This was not unexpected considering that very little disease was observed in the untreated plots and other factors (i.e. cool temperatures, frost) were more limiting to yield. Soybean seed yields were increased by up to 116% with granular inoculant and both the linear and quadratic contrasts were significant at $P < 0.001$. The quadratic response was a function of diminishing returns of increase the inoculant rate beyond approximately two times the label recommendation (Figure 2, Table 5). This was reaffirmed by the multiple comparisons test which detected significant yield increases going from 1x to 2x the label recommendation but no significant difference between the 2x and 4x rates.

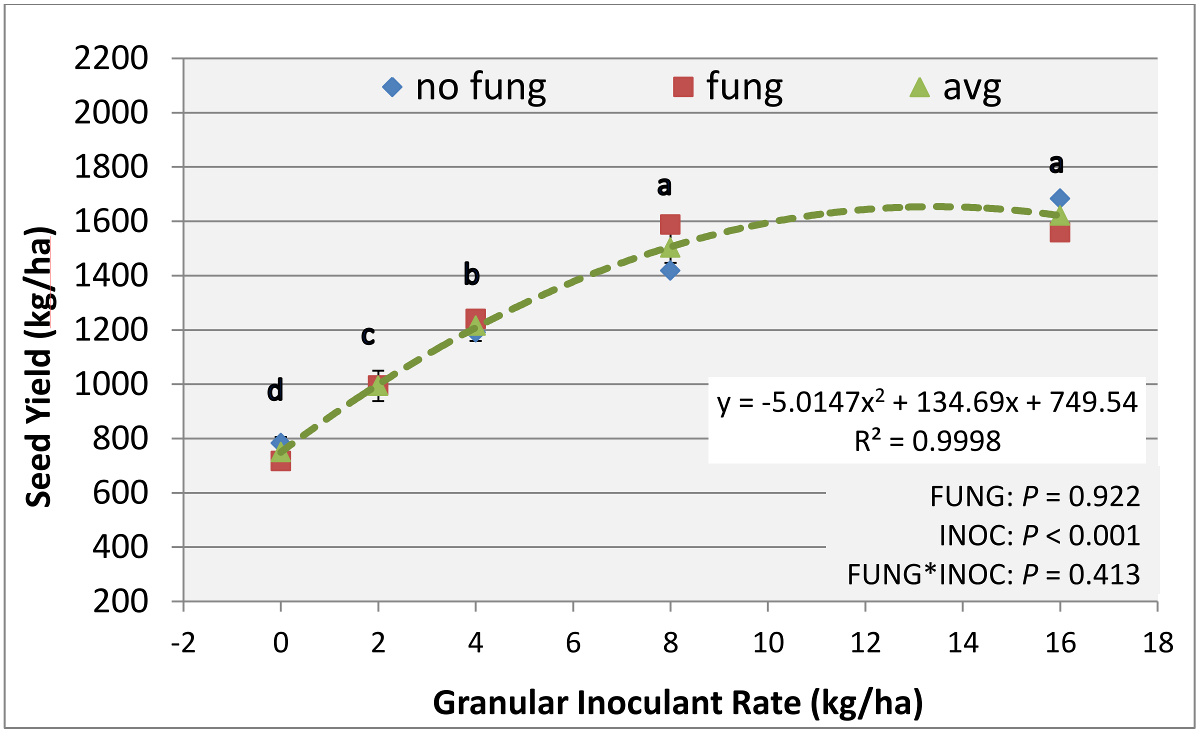

Figure 2. Granular inoculant rate effects on soybean seed yield at Indian Head (2014). Main effect means associated with the same letter do not significantly differ (Fisher's protected LSD test, $P < 0.05$).

Similar to yield, soybean seed size was affected by inoculant but not fungicide and there was no interaction between the two factors. Again, seed size increased both linearly ($P < 0.001$) and quadratically ($P = 0.018$). Seed size continued to increase from the 2x to 4 x rates and, at the highest rate, was 9% larger than when no granular inoculant was applied. While the effect was certainly significant, the mean increases in seed size with granular inoculant were not nearly as large as those for seed yield. This suggests that the yield increases with granular inoculant were are result of improved harvestability, larger seed size and, presumably, more pods per plant and/or seeds per pod.

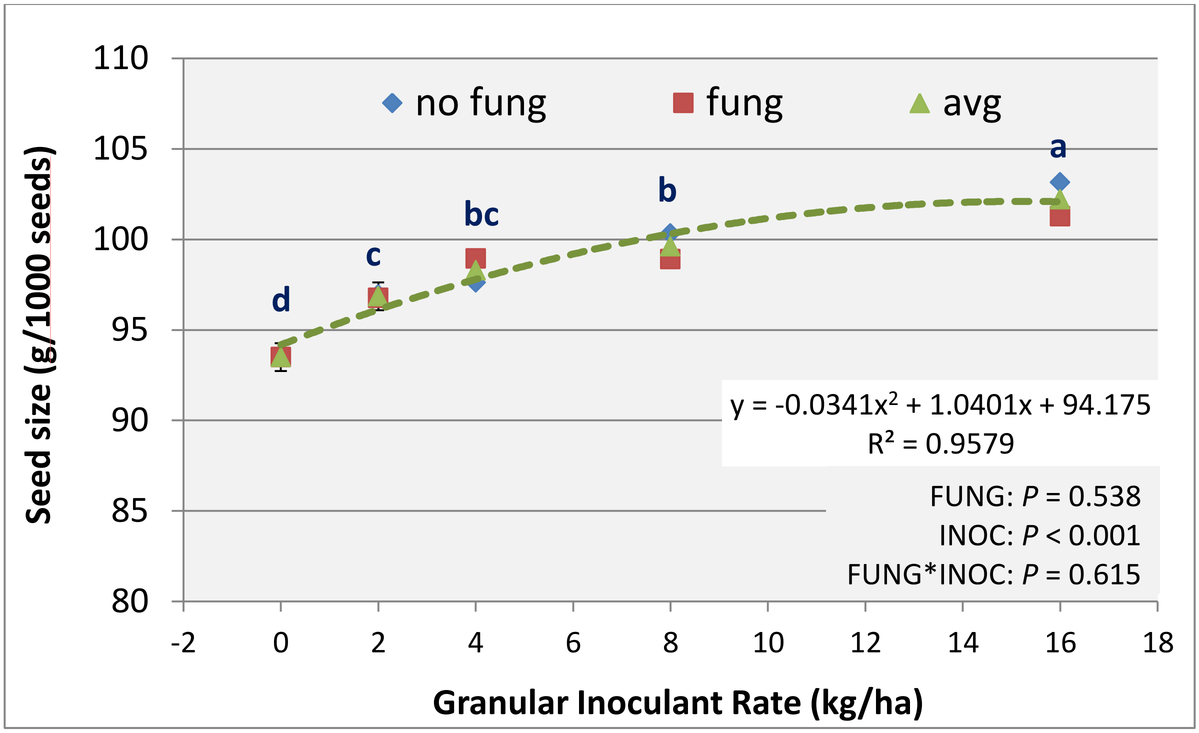

Figure 3. Granular inoculant rate effects on soybean seed size at Indian Head (2014). Main effect means associated with the same letter do not significantly differ (Fisher's protected LSD test, *P* < 0.05).

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

This project demonstrated that, under the soil and weather conditions encountered, soybeans responded extremely well to granular inoculant applications over and above the seed-applied inoculant. Seed yield increases of up to 116% were observed with granular inoculant and, while there was a small further increase at the highest rate, the mean yields at the 2x and 4x rates (8-16 kg ha^{-1}) did not significantly differ. Considering the cost of inoculant and reduced probability of response to increases beyond the 2x rate, the optimum rate in this particular case was 2-2.5x the label recommendation. Inoculant effects on seed size were similar to those on seed yield; however, seed size continued to increase to the highest inoculant rate. The maximum increase in seed size was under 10%, therefore the large yield increase in inoculant was also attributed to improved harvestability and, presumably, more pods $plant^{-1}$ and/or seeds pod^{-1}. For this particular demonstration, the crop was direct seeded into cereal stubble on land which had never previously been seeded to soybeans. While conditions were reasonably warm at planting, it was a cool growing season overall and frost terminated the soybeans prior to maturity. The environmental conditions encountered resulted in relatively low yields; however, the response to inoculant was strong. Recent trials in Manitoba show a lower probability of significant yield increases with dual inoculation in fields where soybean have been previously grown and under higher yielding conditions. However, in Saskatchewan, many soybeans will continue to be planted onto fields where native *Bradyrhizobium* are not present and, it is probably fair to say, under more stressful conditions (i.e. drier, cooler soils) than are typically encountered in southern Manitoba. With this in mind, Saskatchewan soybean growers, particularly under no-till, are advised to apply 2-2.5x the label recommended rate of granular inoculant in furrow, even when using seed that has been treated with a liquid inoculant.

A second objective was to evaluate the potential response of fungicide application on soybeans in Saskatchewan. It is typically recommended that soybean growers in this province need not worry about applying a foliar fungicide because disease has not yet been an issue with this crop and fungicides may cause unnecessary delays in maturity. In the current demonstration, the first killing frost occurred before any pods had started to turn colour and therefore it is unknown whether the fungicide application would have had any effect on maturity. However, despite the strong response to granular inoculant, there was no effect of fungicide on minimum pod height, seed yield or seed size. While some leaf spots were observed later in the season, disease levels were low and these results reaffirm the current recommendation that foliar fungicide applications are not likely to be beneficial for soybeans in the thin Black soil zone of Saskatchewan at this time.

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

Table 5. Least squares means for main effects of fungicide application and granular inoculant rate at Indian Head, Saskatchewan. Means within a group by the same letter do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Effect / Contrast	Pod Height	Seed Yield	Seed Size
Foliar Fungicide	-------- cm --------	----- kg ha^{-1} -----	- g 1000 seeds^{-1} -
check	4.0 a	1218 a	98.3 a
fungicide	3. 9 a	1224 a	97.9 a
S.E.M.	0.10	35.4	0.49
Granular Inoculant			
0x inoculant	3.6 a	753 d	93.5 d
0.5x inoculant	4.0 a	997 c	96.9 c
1x inoculant	4.1 a	1219 b	98.3 bc
2x inoculant	4.1 a	1507 a	99.6 b
4x inoculant	4.0 a	1627 a	102.2 a
S.E.M.	0.16	56.0	0.77
Orthogonal Contrasts			
inoculant - linear	0.163	< 0.001	< 0.001
inoculant - quadratic	0.037	< 0.001	0.018
inoculant - cubic	0.301	0.953	0.103

Table 6. Least squares means for effects of interactions between foliar fungicide applications and granular inoculant rates on pod height, seed yield and seed size. Means within a column followed by the same letter do not significantly differ (Fisher`s protected LSD test, *P* ≤ 0.05).

Effect / Contrast	Pod Height	Seed Yield	Seed Size
Fungicide – Inoculant	-------- cm --------	----- kg ha^{-1} -----	- g 1000 seeds^{-1} -
check - 0x	3.83 ab	785.0 ef	93.5 e
check – 0.5x	4.20 a	997.1 de	97.0 d
check – 1x	3.78 ab	1194.6 cd	97.6 cd
check – 2x	3.95 a	1423.0 bc	100.3 abc
check – 4x	4.25 a	1689.5 a	103.2 abc
fungicide - 0x	3.28 b	721.0 f	93.50 e
fung - 0.5x	3.78 ab	997.3 de	96.78 d
fung - 1x	4.35 a	1244.0 c	99.0 bcd
fung - 2x	4.30 a	1591.8 ab	98.9 bcd
fung - 4x	3.75 ab	1563.8 ab	101.3 ab
S.E.M.	0.22	79.1	1.09

Abstract

14. Abstract/Summary

A field demonstration was conducted near Indian Head, Saskatchewan in 2014 to demonstrate the effects of foliar fungicide applications and granular inoculant rates on soybean development and yield. Seeding was completed in late-May and excellent plant stands were established for all treatments. There was no response to foliar fungicide applications with respect to seed yield or seed size; however, potential impacts on maturity are uncertain since the soybeans froze prior to any pod colour change. In contrast, there was a strong quadratic response to granular inoculant with significant yield increases detected up to at least 2x the label recommended rate and a maximum yield increase of 116% over the control where only a seed-applied inoculant was applied. 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 including the IHARF Soil and Crop Management Seminar (February 2015) and in written reports such the 2014 IHARF Annual Report.