Agriculture et Agroalimentaire Canada | Agriculture and Agri-Food Canada

AgriInnovation Program Stream B

2016-17 Annual Performance Report

For projects or activities that started late, it is expected that answers may be brief for some questions and not applicable or premature for other questions. Indicate "Not applicable" if the question is not relevant at this time.

Name of Recipient: **Pulse Canada / Saskatchewan Pulse Growers**	
Project Title: **Pulse Science Cluster Two**	
Project Number: **AIP-CL03**	Period Covered by Report: 2016-04-01 to 2017-03-31
Activity #: AAFC Activity 6.v10 (A9) Name of Activity: Adaptation and establishment of soybean (Glycine max) under no-till in southern Saskatchewan	Principal Investigator: Chris Holzapfel, Indian Head Agricultural Research Foundation

1. Performance Measures. See Annex A for an explanation of each measure.

Innovation Items	Results Achieved	Provide a description (2-3 paragraphs) for each item produced and describe its importance to the target group or sector. Explain any variance between results achieved and targets. Use plain language.
# of Intellectual property items flowing from the project	0	N/A
# of new/improved products	0	N/A
# of new/improved processes or systems	0	N/A
# of new/improved practices	0	N/A
# of new varieties	0	N/A
# of new/improved genetic materials	0	N/A
# of new/ improved gene sequences	0	N/A
# of improved knowledge	0	N/A

Information Items	Results Achieved	Provide the complete citation for each item. Please see Annex A for examples.
# of peer reviewed publications	0	N/A
# of information items	3	Summaries of the project objectives and 2016 results from each of the three individual sub-activities will be publicly

		available from the IHARF website as soon as possible. Results summaries from 2014 and 2015 are included in the respective IHARF Annual Reports. Online: Available (www.iharf.ca/iharf-annual-reports)
# of media reports	1	Donna Fleury, Top Crop Manager (West). Studying Row Spacing Effects. March 2017, Page 22.
# of information events		1) Indian Head Crop Management Field Day - Indian Head, SK; July 19, 2016; Presenters – Chris Holzapfel and Corey Loessin (SPG) 2) Arysta LifeScience/IHARF Agronomy Tour - Indian Head, SK; July 26, 2016; Presenter – Chris Holzapfel 3) Richardson Pioneer Agronomy Tour - Indian Head, SK; July 27, 2016; Presenter – Chris Holzapfel 4) WCA Swift Current; - The trials were not specifically shown during any of the major tours at Swift Current; however, they were visited during several informal tours for farmer directors and crop consultants with clients
		Provide the # of attendees
# of individuals attending information events		1) 212 (producers and agronomists) 2) 45 (producers and agronomists) 3) 33 (producers and agronomists) 4) 25 (producers and agronomists)
		Provide the # of attendees who intended to adopt new information or technology
# of individuals attending information event who intend to adopt new innovation	unknown	We are not able to accurately estimate commercial uptake of the information that has been derived specifically from this project. Results from this project were presented alongside those from other applicable projects and multiple speakers participated in each event. Attendees were not formally surveyed regarding either their current practices or intentions to adopt new practices in any cases.
		Provide the name, degree completed and date of completion
# of persons who completed a M.Sc. or Ph.D. during project	0	N/A

2. Executive Summary

The Executive summary contains two parts: Key highlights of activities and scientific results and Success story. Information may be used for internal and external communication purposes. Write for a general audience using plain language. Do not include sensitive or confidential information.

Key Highlights - This section describes the key activities and final scientific results of an activity/ project in such a way that readers can rapidly become acquainted with a large body of material without having to read it all. Include a brief statement of the problem(s), background information, concise analysis and main conclusions. Suggested length – maximum 1 page.

While soybean production has expanded from western Manitoba into Saskatchewan in recent years, the long-term yield stability of the crop in this province is considered uncertain by many and regional agronomic recommendations are lacking. Producers in Saskatchewan require access to information on the overall risks associated with growing soybeans compared to more traditional crops. Furthermore, those who decide that soybeans are a good fit require access to regional agronomic recommendations to optimize yields and minimize the risks of poor establishment and subsequently delayed maturity and potential yield loss due to fall frost or other factors. A four-year project was initiated with field trials at two contrasting locations in southern Saskatchewan (Indian Head and Swift Current) to evaluate the adaptation of soybeans compared to canola, field pea and faba bean and to improve regional soybean seeding rate, seeding depth and row spacing recommendations. This project began in the spring of 2014 and consists of three separate field trials (Sub-Activities).

Sub-activity #1 was a crop adaption trial where soybeans, canola, field peas or faba beans were planted at three seeding dates targeted to range from early-mid May to early June. At Indian Head in 2016 actual seeding dates ranged from May 6 to June 2 while at Swift Current the dates ranged from May 18 to June 7. Overall weather at both locations was favourable for soybeans in 2016 with remarkably high yield potential at Swift Current relative to the previous two seasons. While soybeans seeded in early May took longer to emerge than with the later dates, final plant stands were not negatively impacted. At Indian Head, days to maturity declined as seeding was delayed for all crops but most prominently with soybeans. This is attributable to planting into warmer soils and more rapid accumulation of heat units during the vegetative growth stages with later planting. Somewhat unexpectedly, maturity was not affected by planting date at Swift Current. For all crops at Indian Head, including soybeans, yields tended to be highest at the first seeding date; however, observed differences were not always significant for individual crops. At Swift Current, yields tended to be highest at the second seeding date; however, the extent to which they were affected by seeding date varied with crop type. At both locations, canola was the least sensitive to seeding date; however, yield differences across dates were not generally significant for soybeans either. Consistent with most literature and agronomic recommendations, peas and faba beans performed best with early seeding at Indian Head; however, at Swift Current, field pea yields in particular were higher at the latter two seeding dates. This was presumably a result of conditions at planting and timing of precipitation combined with the late warm fall which allowed the late seeded long-season crops to fully mature and benefit from the abundant precipitation. At Indian Head, overall average yields (across seeding dates) were 2100, 2219, 2756, and 1454 kg ha^{-1} for canola, field pea, faba beans and soybeans while at Swift Current overall mean yields for these crops were 3226, 2766, 3197, and 2200 kg ha^{-1}. It is important to remember that yields alone are not reflective of profitability which must take both the relative cost of production and grain values into consideration.

Sub-activity #2 evaluated a factorial combination of two seeding depths (~20 mm versus ~40 mm) and seven seeding rates ranging from 15-85 seeds m^{-2}. Overall mean yields in this trial were 2112 kg ha^{-1} at Indian Head and 2871 kg ha^{-1} at Swift Current for 2016. Mean seedling mortality was essentially nil at Indian Head (average target seeding rate of 50 seeds m^{-2} with observed density of 55 seeds m^{-2}) and 30% at Swift Current; however, plant densities were not affected by seeding depth at either location. The only observed effects of seeding depth at Indian Head were a slight (1 day) delay in maturity and slightly smaller seeds with deeper seed placement. At Swift Current, deeper seeding led to a 0.8-day delay in maturity and 378 kg ha^{-1} (12%) yield reduction but there was no impact on seed size. While important differences in agronomic performance to date have not always occurred for the range of seeding depths evaluated, when detected they have always favoured the shallower depth. This supports the recommendation that soybeans should not be seeded deeper than approximately 20-25 mm. Focussing on seed rate, yields levelled off at approximately 60 seeds m^{-2} at Indian Head, relatively high rates considering the excellent emergence that was achieved. No interactions between seeding depth and rate were detected for any response variables at Indian Head in 2016. At Swift Current, yields increased to even higher rates peaking at 70 seeds m^{-2} when averaged across depths; however, a significant seeding depth by rate interaction suggested that yields started levelling off at only 50 seeds m^{-2} with shallow seeding and 70 seeds m^{-2} with the deeper seed placement.

Sub-activity #3 evaluated a factorial combination of five row spacing levels (25, 30, 36, 41 and 61 cm) and three seeding rates (40, 50 and 60 seeds m^{-2}). Due to the specialized seeding equipment required, this experiment is only being conducted at Indian Head. In 2016, overall average soybean yields were 2115 kg ha^{-1} and yields were not affected by row spacing, regardless of seeding rate. Yields increased linearly, albeit slightly, from 2009-2212 kg ha^{-1} as the seeding rate was increased from 40-60 seeds m^{-2}. Seeding rate also affected maturity with a 1.2 day spread between the lowest and highest seeding rates while row spacing had no effect on soybean maturity in 2016. Row spacing did affect seed weight, with thousand kernel weights increasing from approximately 114-120 g 1000 $seeds^{-1}$ as row spacing was increased from 25-61 cm. Seed size was not affected by seeding rate.

These field trials are scheduled to continue for one more season.

Success Story - A success story presents a significant result or an important milestone achieved. It is intended to showcases achievements in applied research. Focus on research results, successful technology transfer, potential for pre-commercialization, and/or potential impact. A Success Story is not a progress report for each activity (suggested length 2 – 3 paragraphs).

Despite challenges, primarily weather related, 2016 was considered a successful year for the project. Most notable was just how successful soybeans and faba beans were at Swift Current; however, we must emphasize that 2016 was a highly unusual year with a total of 438 mm of growing season (May-September) precipitation combined with warm but not extreme temperatures and a late fall. The more traditional crops for the region also performed extremely well at Swift Current with overall average yields of 3226, 2766, 3197, and 2200 kg for canola, field pea, faba bean and soybean in Sub-Activity #1. In Sub-Activity #2, with a single variety and optimal seeding date, soybean yields averaged 2871 kg ha^{-1} compared to less than 1000 kg ha^{-1} the previous two seasons.

At both locations, with approximately average to above-average yield potential and low variability, conditions were optimal for evaluating seeding rate, depth and row spacing effects on soybean establishment, maturity and yield. Although there was hail damage at Indian Head, the damage was uniform, overall yields were still approximately average, and the results were still considered perfectly viable with low experimental error and good treatment separation.

2016 was also considered another successful year for project extension, particularly at Indian Head where the trials were shown during 3 separate tours to a total of nearly 300 participants (farmers and agronomists) with representation from both IHARF and the Saskatchewan Pulse Growers. Additionally, the trials were shown during several smaller, informal site visits at both locations and results to date from Sub-Activity #3 were discussed along with those from other row spacing trials in the March 2017 issue of Top Crop Manager.

3. Objectives/Outcomes (technical language is acceptable for this section)

Provide a brief summary that includes introduction, objectives, approach/methodology, deliverables/outputs, results and discussion, and any Ph.D or Master students recruited to work on the project.

Introduction and Objectives

Southern Manitoba has seen a rapid increase in soybean production over the past decade, with the rate of uptake increasing in recent years. With increasing selection and availability of early maturing varieties, soybean production has expanded into Saskatchewan with the greatest uptake in the southeast but interest and experimentation from producers throughout the province. The adoption of this crop in southeast Saskatchewan has mostly coincided with wet weather which has delayed seeding for many growers and made it difficult to grow more traditional pulse crops such as field peas or lentils. In Saskatchewan, 2016 soybean acres were estimated at approximately 240,000 acres compared to 170,000 in 2013. While varying factors may have driven soybean adoption in Saskatchewan, there is still uncertainty regarding the crop's long-term yield stability and adaption relative to other crops, particularly as we move north and west into cooler and/or drier parts of the province.

The broad objectives of this Activity are: 1) to assess the risks associated with growing modern, early maturing soybean varieties under no-till in Saskatchewan compared to more traditional broadleaf crops and 2) to improve recommendations for the successful establishment of soybeans in southern Saskatchewan. More specifically, the Sub-Activities were designed to: 1) evaluate the performance of soybeans planted at varying seeding dates and in contrasting environments relative to canola, field pea and faba beans, 2) evaluate soybean response to seeding rates and depths and 3) to evaluate soybean response to varying row spacing levels that are common amongst modern no-till drills. Three separate field trials were initiated in 2014 with locations at Indian Head (thin Black soil zone) and Swift Current (Brown soil zone) to achieve these objectives.

Site Information and Weather

Indian Head (50˚33'N, 103˚39'W) lies in the thin Black soil zone of southeast Saskatchewan and the soil is an Indian Head heavy clay (Rego Black Chernozem). The mean annual temperature is 2.7˚C with a frost free period of 113 days and an average of 428 mm of annual precipitation. Swift Current is considerably warmer and drier, located in the Brown soil zone of southwest Saskatchewan (50˚16'N, 107˚44'W) with a Cypress light loam (Rego Brown Chernozem) soil. The mean annual temperature at Swift Current is 4.3˚C with a frost free period of 122 days and an average of 275 mm annual precipitation. Overall, the 2016 growing season (May-September) was over 1.3 °C warmer than average at Indian Head and 0.2 °C warmer at Swift Current; however, May and June were considerably (~1-3°C) warmer than average. Both locations received above average precipitation, especially Swift Current were a total of 438 mm was received relative to the long-term (5 month) average of 250 mm. At Indian Head, hail damaged the plots late in July and, while the damage was generally considered uniform across the study area, this may have compromised the data in Sub-Activity 1 to some extent to differences in crop stage at the time when the damage occurred and also differences amongst the crop types in their susceptibility to hail damage. Generally speaking, the weather at both locations was considered favourable for soybeans which prefer warm temperatures and require large quantities of water late in the growing season. At both locations, the first killing frost (≤ 2 °C) occurred on October 6-7 which was after the soybeans had reached full physiological maturity.

Sub-Activity 1: Adaptation of Soybean Relative to Traditional Broadleaf Crops

Methods (Sub-Activity 1)

Sub-activity #1 was conducted at both Indian Head and Swift Current. The treatments were a factorial combination of three seeding dates and 6 crop/variety treatments. The targeted seeding dates were 1) Early (first two weeks of May), 2) Normal (10-14 days after the 1st seeding date and 3) Late (10-14 days after the 2nd date). The crop/variety treatments were 1) Canola – 46H75 CL, 2) Field pea – CDC Golden, 3) Faba bean - Snowbird, 4) Soybean1 – NSC Tilston RR2Y, 5) Soybean2 – TH33003R2Y and 6) Soybean3 – P002T04R. The intent of including multiple soybean treatments was not to compare varieties but rather to ensure that results would be robust and applicable to a range of early maturing genotypes. Consequently, for ease of interpretation, response data for individual soybean varieties may be averaged prior to final analyses. Treatments were arranged in a four replicate split plot design with seeding dates as the main plots.

Crop management was tailored for each location, crop type and seeding date with respect to selection of crop protection products and timing of applications. Weeds were controlled using registered pre-emergent and in-crop herbicide applications. Foliar fungicide was applied to all canola, field peas and faba beans at Indian Head but no fungicides were applied at Swift Current. No foliar insecticides were required for any crops at either location in 2016. For each plot, days to emergence (visible rows), the start of flowering (10% of flowers open) and physiological maturity were recorded along with weekly BBCH universal growth stage measurements. Crop establishment was evaluated by counting seedlings in 2 x 1 m sections of crop row per plot approximately 3-4 weeks after planting for each date. The plots were mechanically harvested as soon as possible after they were fit to combine, with the specific harvest dates tailored to each treatment. Yields are expressed in kg ha^{-1} and corrected for dockage and to seed moisture contents of 10% for canola, 16% for field pea / faba bean and 14% for soybean. Seed weight (g 1000 seeds^{-1}) was determined by either automatically counting approximately 1000 seeds per plot.

Response data were analyzed separately for each location with effects of seeding date and crop type considered fixed and replicate considered random. Fisher's protected LSD test was used to separate treatment means ($P \leq 0.05$) and single degree of freedom contrasts were used to simultaneously compare all three soybean varieties to canola, field pea and faba bean. Detailed results tables are not included in this report but are available upon request.

Results (Sub-Activity 1 – Year 3)

The actual seeding dates at Indian Head were May 6, May 19 and June 2 while at Swift Current the dates were May 18, May 30 and June 7. Seed was unintentionally placed deeper than desired at Indian Head for soybeans and canola which delayed emergence and likely had a negative impact on plant densities, yield and maturity. At Indian Head, while all crops, especially soybeans, took longer to emerge with early seeding, final plant densities were not affected by seeding date for canola, faba bean or soybeans; however, with peas, emergence was best at 1st seeding date, worst at the 2nd and intermediate at the final date. The specific reasons for this variation are unclear and likely attributable to variable conditions during planting, rolling and the emergence period. At the later dates, moisture was considerably higher during planting and excessive for field peas at times later in the season. At Swift Current, emergence was not affected by planting date. Similar to previous years, field peas were the earliest to mature, soybeans were latest and faba beans and canola were intermediate (Fig. 1). It should be noted that 46H75 is a relatively late maturing canola hybrid and maturity was further delayed by slow and variable emergence at Indian Head. At Indian Head where the seeding date effect was significant, soybean maturity was affected most by planting date to a greater extent than the other crop types falling from 132 days with early planting down to 111 days at the final planting date.

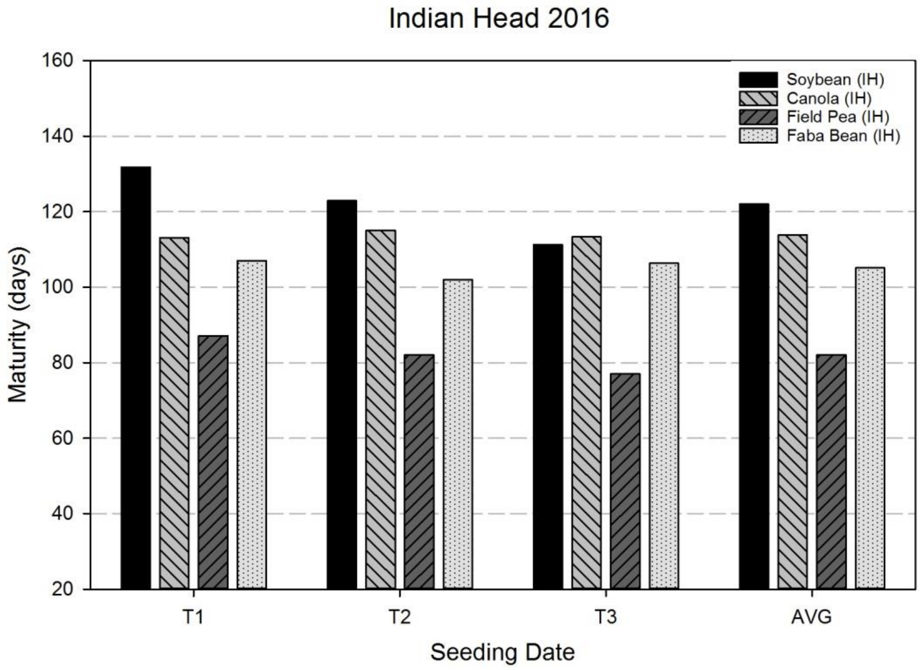

Figure 1. Mean maturity and contrast results for maturity at Indian Head (2016). Soybeans are compared directly to canola, field pea and faba bean. Yields within a group are either below (-), above (+) or equal (=) to soybean.

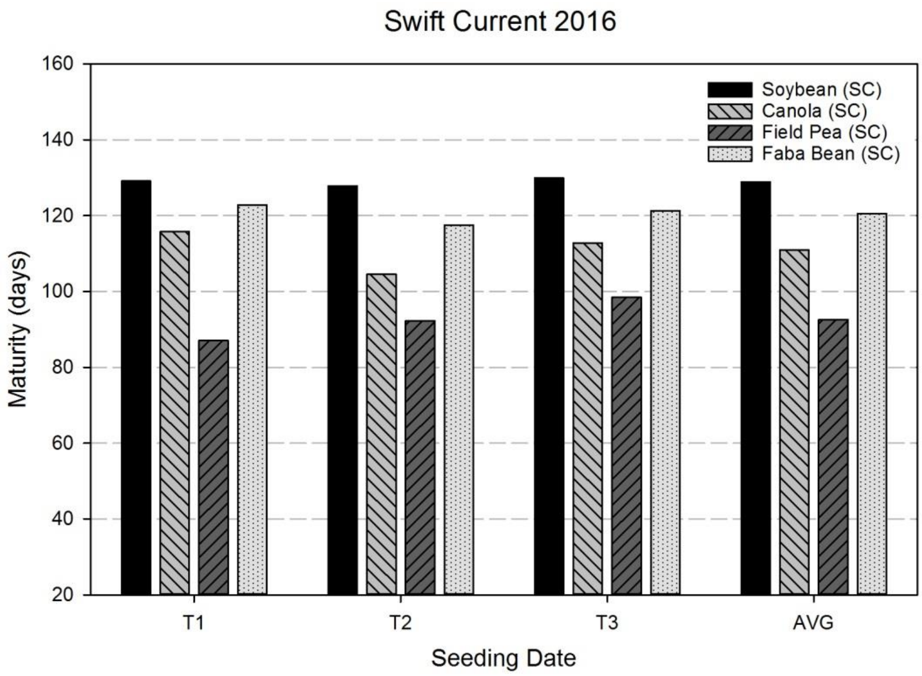

Figure 2. Mean maturity and contrast results for maturity at Indian Head (2016). Soybeans are compared directly to canola, field pea and faba bean. Yields within a group are either below (-), above (+) or equal to (=) soybean.

At Indian Head, yields generally declined as seeding was delayed for all crops but especially for field peas and faba beans. Soybeans yielded significantly lower than the other crops evaluated; however, the unintentionally deep seeding slowed emergence and are believed to have reduced yield based to some extent. Furthermore, yields alone are not necessarily reflective of profitability across the different crop types. As seeding was delayed, the yield gap between soybeans and field peas in particular was reduced.

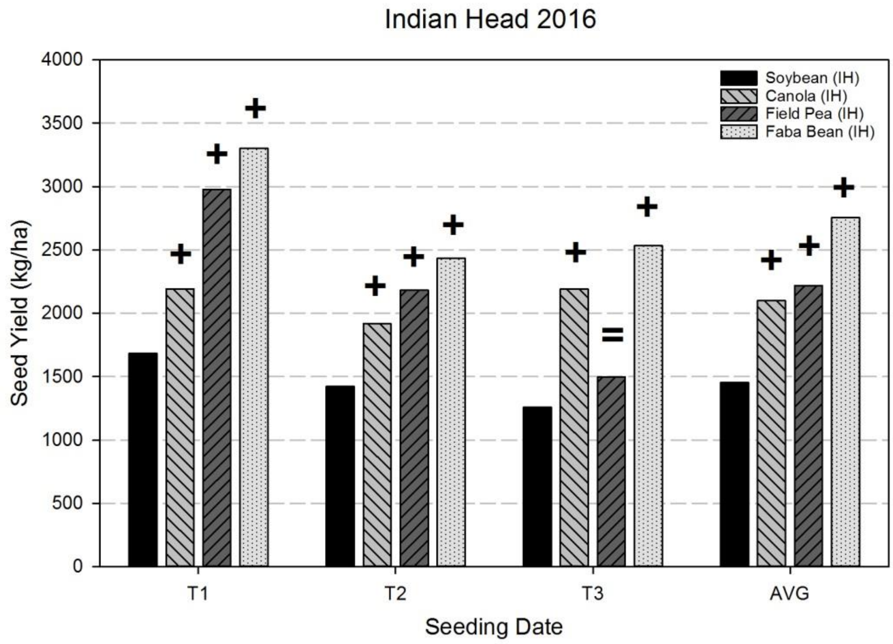

Figure 3. Mean yields and contrast results for seed yield at Indian Head (2016). Soybeans are compared directly to canola, field pea and faba bean. Yields within a group are either below (-), above (+) or equal to (=) soybean.

At Swift Current, yields for all crops were remarkably high for the region and largely unaffected by planting date. All crops yielded higher than soybeans with the exception of field peas at the early planting date; however, even soybean yields were considered well above-average and the higher yields of other crops will not necessarily mean increased profits once production costs and grain prices are accounted for.

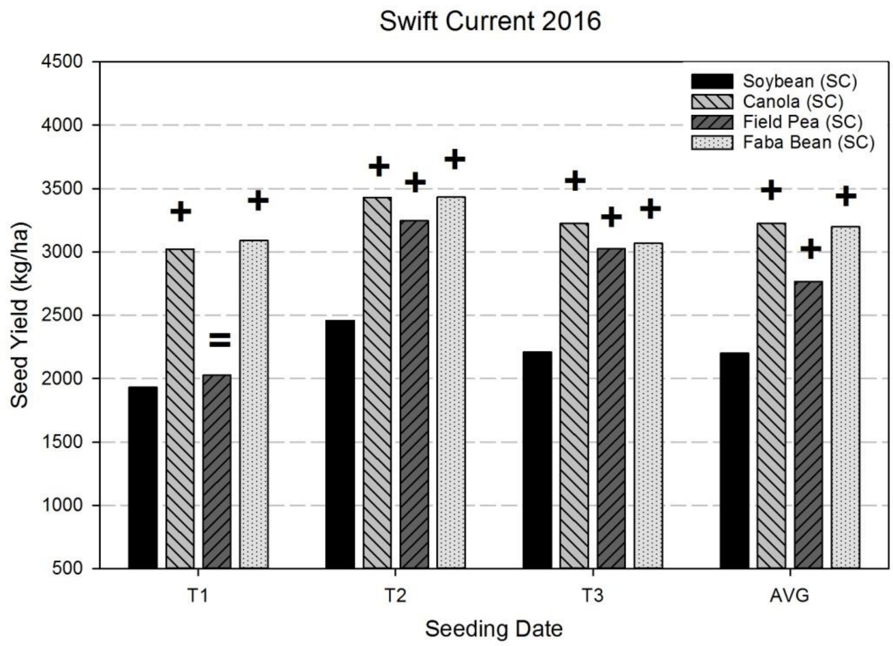

Figure 4. Mean yields and contrast results for seed yield at Swift Current (2016). Soybeans are compared directly to canola, field pea and faba bean. Yields within a group are either below (-), above (+) or equal to (=) soybean.

Again, an important component to this sub-activity will be basic economic analyses of the marginal profitability of each crop as a function of seeding date and environment (location-year); however, these analyses will be deferred to the final year of the study when all data is available. The field trials associated with Sub-Activity 1 will be conducted for one more growing season.

Sub-Activity 2: Seeding rate and seeding depth effects on soybean establishment, maturity and yield

Methods (Sub-Activity 2 – Year 3)

Sub-activity #2 was also conducted at both Indian Head and Swift Current. The treatments were a factorial combination of two seeding depths and seven seeding rates. The targeted seeding depths were defined as shallow (1.25-1.9 cm) or deep (3.8-5 cm) and the target seeding rates were 15, 30, 40, 50, 60, 70 or 85 viable seeds m^{-2}. All treatments were arranged in an RCBD with four replicates. The same seed was used at both locations and the variety in 2016 was NSC Watson RR2Y, which is one of the earliest maturing varieties currently available. All seed was pre-treated with a liquid inoculant / seed-applied fungicide and granular inoculant was placed in-furrow at 2x the label recommended rate. Weeds were controlled using registered pre-emergent and in-crop herbicide applications and no fungicides were applied at either location. Fall frost did not occur until early October, after full maturity, and was not a yield limiting factor at either location. The plots were straight-combined in late September at Indian Head and late October at Swift Current where wet weather delayed harvest progress.

Various data were collected during the growing season and from the harvested grain samples. Spring plant densities were determined by counting the number of plants in 2 x 1 m sections of crop row at approximately 3-4 weeks after planting and converting the values to mean plants m^{-2}. The mean distance from the bottom of the lowest pod to the soil surface (referred to as pod height or pod clearance) was determined by measuring 10 plants per plot after the lowest pods were fully formed. Maturity was defined as the Julian date where 95% of the pods had turned colour and was expressed as days from planting. Grain yields were determined by mechanically harvesting the centre rows of each plot (five rows at Indian Head and seven at Swift Current) and are corrected for dockage and to a uniform seed moisture content of 14%. Seed weight was determined by mechanically counting and subsequently weighing approximately 1000 seeds per plot and converting the values to g 1000 $seeds^{-1}$

Data from each location was analyzed separately using the Mixed procedure of SAS 9.3 with the effects of seeding depth (D), seeding rate (R) and their interaction (D × R) considered fixed and replicate effects considered random. Means were separated using Fisher's protected LSD test and orthogonal contrasts were used to determine whether crop responses to seeding rate were linear, quadratic, or insignificant. Detailed results tables are not included in this report but are available upon request.

Results (Sub-Activity 2 – Year 3)

The overall F-tests for soybean plant densities were significant at Indian Head ($P < 0.001$) but not Swift Current ($P = 0.129$) and seeding depth did not affect final plant populations at either location (P = 0.141-0.675). There was no D × R interaction for plant density at either location (P = 0.418-0.917). At Indian Head, the response to seeding rate was linear ($P < 0.001$) with actual populations of 16-93 plants m^{-2} at the targeted rates of 15-85 seeds m^{-2}. Despite the lack of a significant F-test at Swift Current, the orthogonal contrasts did show an overall linear increase in plant density, from 24-48 plants m^{-2} with increasing seeding rates. The commonly recommended minimum final populations of 30-40 plants m^{-2} were achieved with 30-40 seeds m^{-2} at Indian Head and 50-60 seeds m^{-2} at Swift Current. The main effects of seeding rate are plotted for both locations in Figure 5.

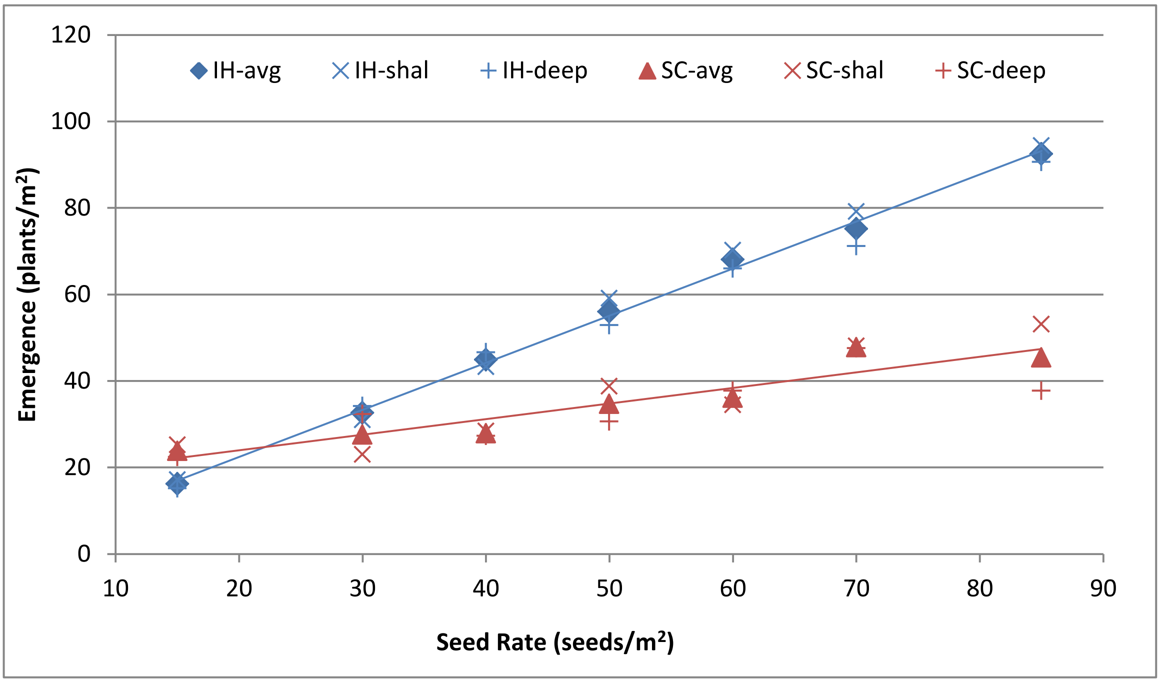

Figure 5. Seeding rate effects on soybean plant density at Indian Head (IH) and Swift Current (SC) in 2016.

Pod height was affect by seeding rate ($P < 0.001$) but not depth ($P = 0.174$-0.835) at both locations and no D x R interactions were detected ($P = 0.809$). At both locations, pod height increased with increasing seeding rate; however, the response was quadratic at Indian Head ($P < 0.001$), leveling off at approximately 50 seeds m^{-2}, and linear at Swift Current ($P < 0.001$) increasing through the highest seeding rates. The observed difference in response may have been due to the lower overall plant densities at Swift Current. At Indian Head, pod height increased from a minimum of 4.0 cm at the lowest seeding rate to 6.4-6.8 cm at seeding rates of 50 seeds m^{-2} or higher. At Swift Current, the observed range was from 2.0-5.2 cm from the lowest to highest seeding rates.

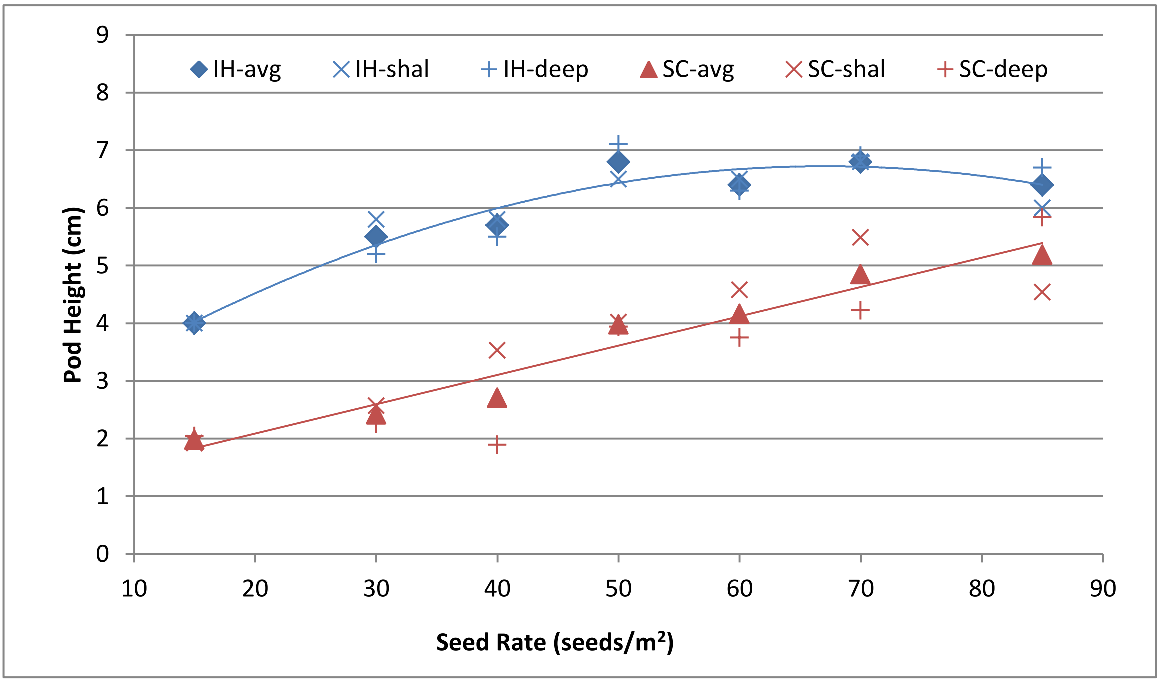

Figure 6. Seeding rate and depth effects on soybean pod height at Indian Head (IH) and Swift Current (SC) in 2016.

Maturity was affected by seeding depth ($P < 0.001$-0.033) and seeding rate ($P < 0.001$-0.003) at both locations ($P \leq 0.001$). The interaction between these factors was significant at Swift Current ($P = 0.043$) but not Indian Head ($P = 0.100$). At both locations, maturity was delayed slightly (0.8-1 day) with deeper seed placement and days to maturity was reduced as plant populations increased. At Indian Head, the response was quadratic with no further effects on maturity past seeding rates of approximately 50-60 seeds m^{-2}. At Swift Current, the response was linear and at both locations the maximum spread between the lowest seeding and more optimal rates was 3.0-3.3 days.

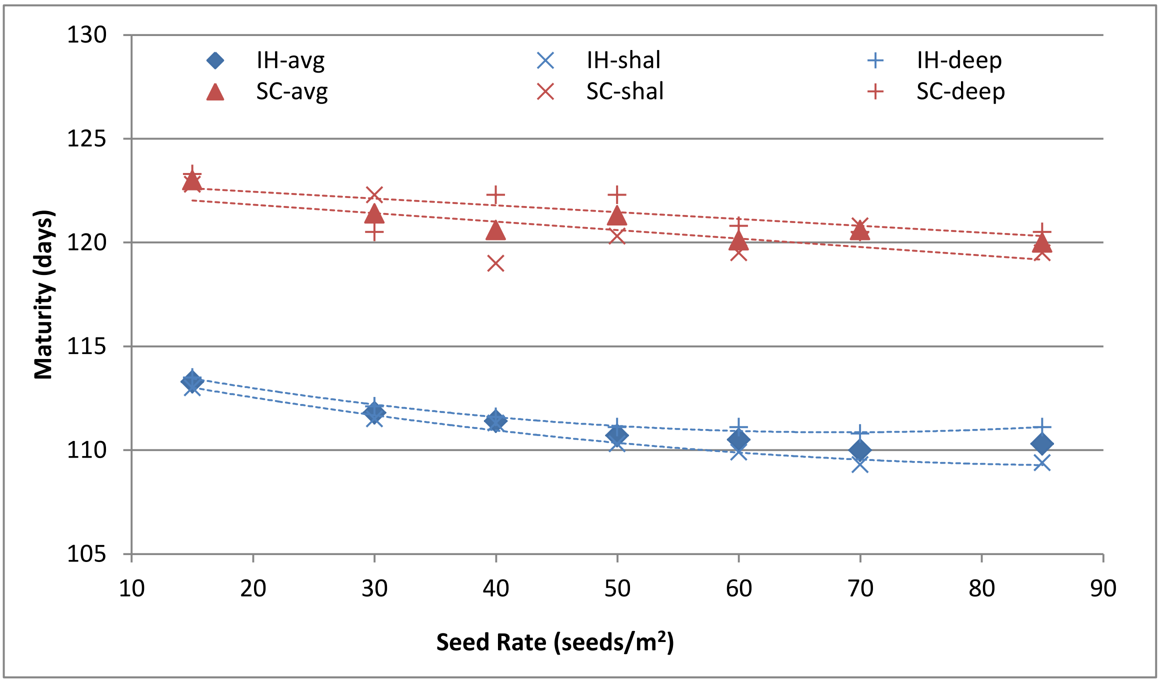

Figure 7. Seeding rate and depth effects on soybean maturity at Indian Head (IH) and Swift Current (SC) in 2016.

At Indian Head, soybean seed yield was affected seeding rate ($P < 0.001$) but not depth ($P = 0.317$) while at Swift Current both factors were significant ($P < 0.001$) and a D × R interaction was also detected ($P = 0.017$). At Indian Head, yields were consistent between the two depths and increased quadratically ($P < 0.001$) from 1531 kg ha^{-1} at the lowest rate to 2281-2362 kg ha^{-1} at rates of 60 seeds m^{-2} or higher. At Swift Current, yields were 14% higher overall with shallow seeding compared to deep seeding and the response to seeding rate also differed somewhat depending on seeding depth. With shallow seeding, yields did not statistically differ from 50 seeds m^{-2} onwards while, with deep seeding, optimal yields were not reached until rates of approximately 70 seeds m^{-2}. Yields at the lowest and highest seeding rates did not statistically differ between seeding depths while the yield increase associated with increased seeding rates was relatively large at approximately 115%.

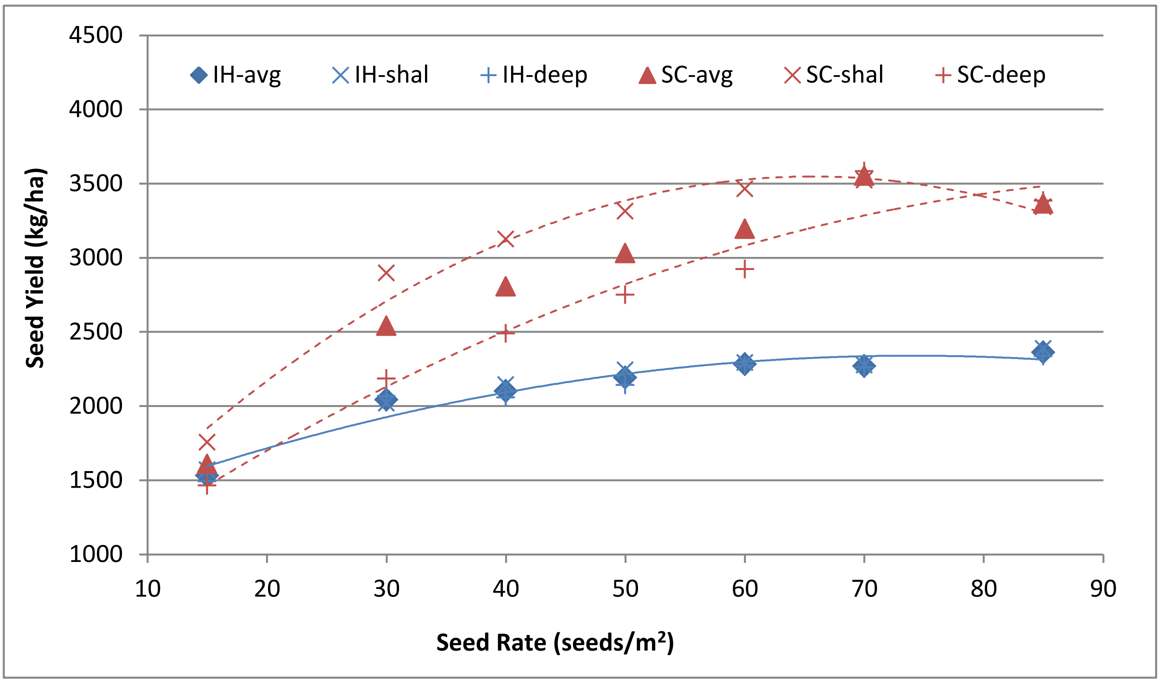

Figure 8. Seeding rate effects on soybean seed yield at Indian Head (IH) and Swift Current (SC) in 2016.

At Indian Head, seed weight was affected by seeding depth (*P* = 0.041) but not rate (*P* = 0.240) while at Swift Current neither factor had an effect (*P* – 0.555-0.903). There was no D × R interaction at either location (*P* = 0.280-0.903). Overall, seed size was much larger at Swift Current than at Indian Head, averaging 163 g 1000 seeds^{-1} compared to 132 g 1000 seeds^{-1}, respectively. At Indian Head, seed weight was 1.5% higher on average with shallow seed placement compared to when seed was placed approximately 40 mm deep.

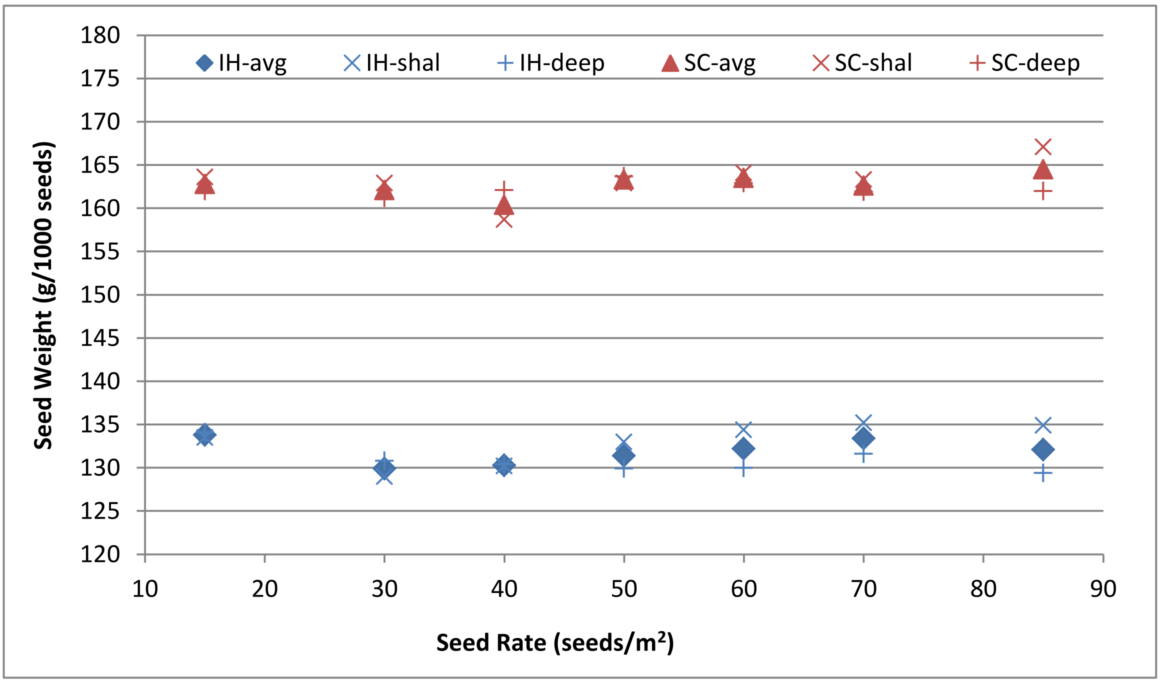

Figure 9. Seeding rate and depth effects on soybean seed weight at Indian Head (IH) and Swift Current (SC) in 2016.

The field trials associated with Sub-Activity 2 are scheduled to continue at both locations for one more growing season.

Sub-Activity 3: Seeding rate and row spacing effects on soybean establishment, maturity and yield

Methods (Sub-Activity 3 – Year 3)

Sub-activity #3 was only conducted at Indian Head due to the specialized seeding equipment required to vary the spacing between crop rows. The treatments were a factorial combination of three seeding rates (SR) and five row spacing (RS) levels. The seeding rates were 40, 50 or 60 seeds m^{-2} and the row spacing levels were 25, 30, 36, 41 or 61 cm. Treatments were arranged in a four replicate split plot design with row spacing levels as the main plots and seeding rates as the sub-plots. Each plot consisted of eight seeded rows except for those on 61 cm spacing which were comprised of four rows. The variety was P002-T04R, a very early maturing soybean variety released in 2014, the year the study was initiated. All seed was pre-treated with liquid inoculant and seed-applied fungicide while granular inoculant was applied in-furrow at 2x the label recommended rates for all treatments. Weeds were controlled using registered pre-emergent and in-crop herbicides and no fungicides or insecticides were applied. Similar to the previously discussed trials, the first killing frost did not occur until early October, after all of the soybeans had reached physiological maturity. The plots were straight-combined in early November, delayed due to wet weather in October.

The data collected and methodology used in Sub-Activity 3 were identical to Sub-Activity 2 with spring plant density, pod height, maturity and seed yield being the primary variables of interest. To minimize edge effects and potential biases across row spacing treatments, all except the outside crop rows were harvested from each plot. Consequently, six rows were harvested for all but the 61 cm row spacing treatments where only two rows were harvested.

All response data were analyzed using the Mixed procedure of SAS 9.3 with the effects of row spacing (S) and seeding rate (R) considered fixed and the effects of replicate considered random. Means were separated using Fisher's protected LSD test and orthogonal contrasts were used to determine whether crop responses to row spacing and seeding rate were linear, quadratic, or not significant. Detailed results tables are not provided in this report but are available upon request. Basic graphical representations of the results are provided in Figures 10-13.

Results (Sub-Activity 3 – Year 3)

Spring plant densities were affected by seeding rate ($P < 0.001$) but not row spacing ($P = 0.957$) and there was no interaction between the two factors ($P = 0.607$). As expected, plant densities increased linearly ($P < 0.001$) with increasing SR and, averaged across row spacing levels, ranged from 41-63 plants m^{-2}. It is not uncommon for plant densities to decline as row spacing is increased; however, this was not observed under the optimal conditions for emergence and seeding rates evaluated at Indian Head in 2016.

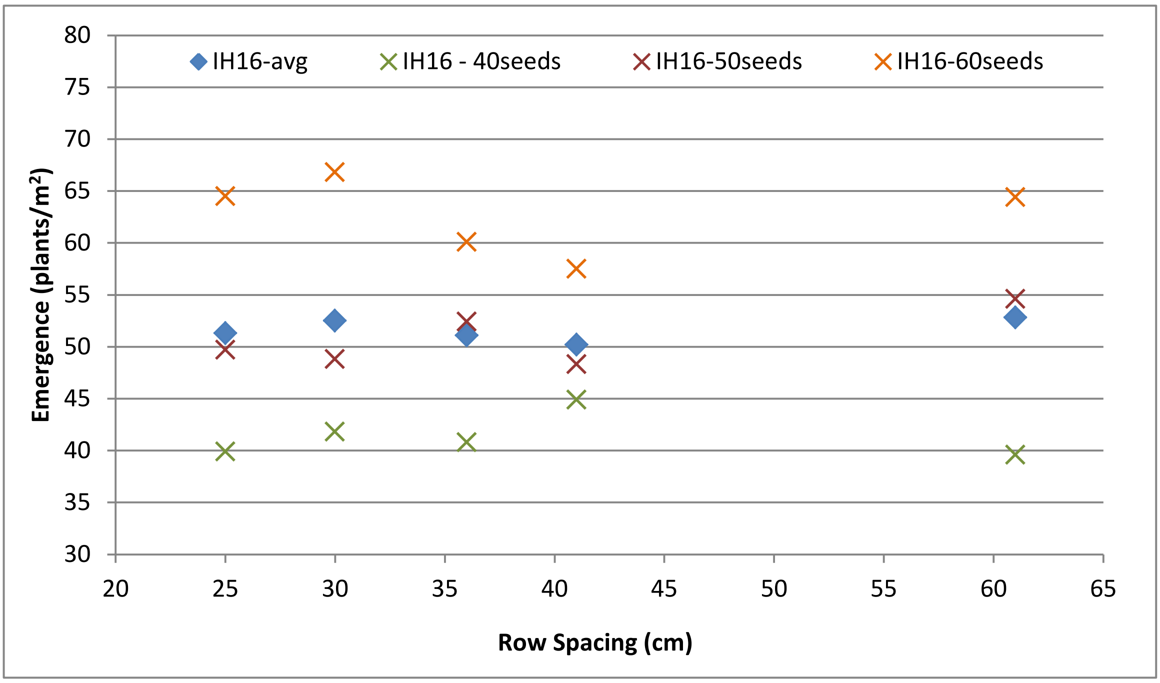

Figure 10. Row spacing effects on soybean plant density at Indian Head (IH) in 2016.

Pod clearance was measured at the 50 seeds m^{-2} seeding rate only and was not affected by row spacing (P = 0.683). The overall average distance from the soil surface to the bottom of the lowest pod was 6 cm.

Row spacing had no effect on maturity (P = 0.674) but seeding rate did (P < 0.001) and there was no interaction between these two factors (P =0.497). Despite the relatively narrow range of seeding rates evaluated there was a linear, 1.2 day spread in maturity between the lowest and highest seeding rates and, with no interaction, the seeding rate effect was consistent across row spacing levels.

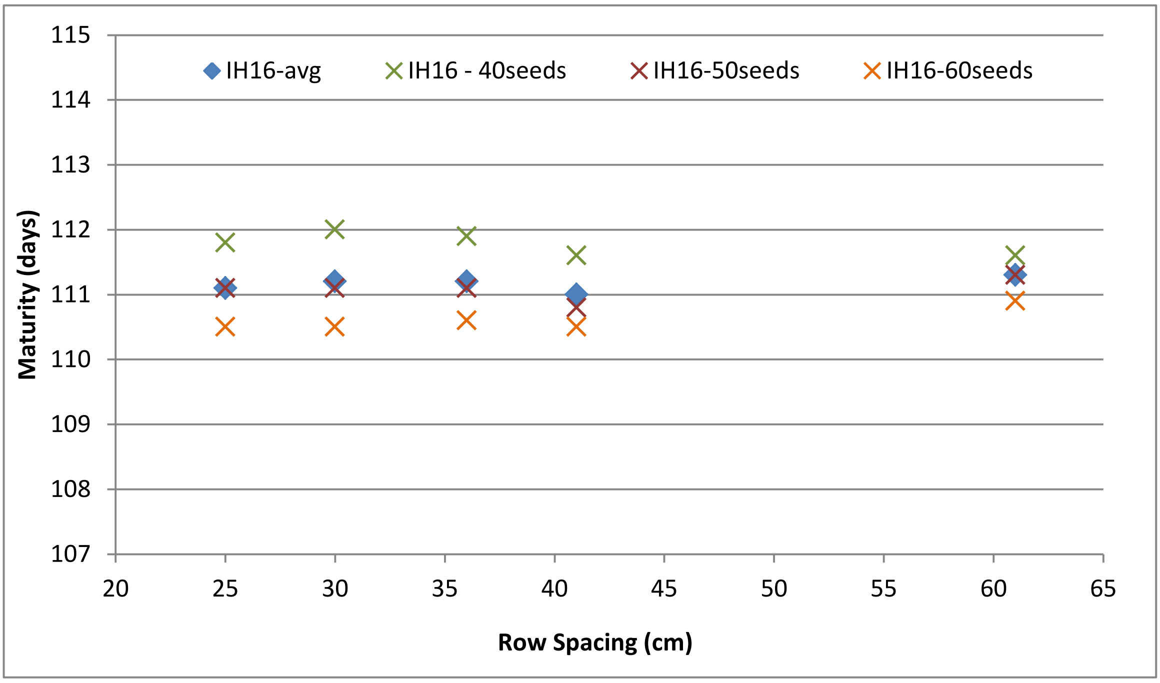

Figure 11. Row spacing and seeding rate effects on soybean maturity at Indian Head (IH) in 2016.

Seed yield was affected by seeding rate ($P \leq 0.001$) but not row spacing (P = 0.204) and no RS x SR interaction was detected (P = 0.763). Averaged across row spacing treatments (and despite excellent emergence), soybean yields increased linearly ($P < 0.001$) with each incremental increase in seeding rate. Furthermore, with no RS × SR interaction, the seeding rate effects were consistent at each row spacing level. On average, the yield spread between seeding rates of 40-60 seeds m^{-2} was 203 kg ha^{-1}. Over the past three years, row spacing effects on seeding rate have been variable. In 2014, yields increased with increasing row spacing until levelling off at 46 cm; however, in hind sight, this was largely attributed to granular inoculant effects that favoured wider row spacing. Granular inoculant rates are held constant across all treatments and, under the environmental conditions encountered in 2014, the applied rate was not sufficient to maximize yield, particularly at the narrower row spacing levels. In 2015, soybean yields were slightly but significantly higher at 25-30 cm row spacing but then constant for row spacing ranging from 36-61 cm. Adequate canopy closure was achieved in all treatments suggesting that this crop is still relatively insensitive to row spacing compared to many crops.

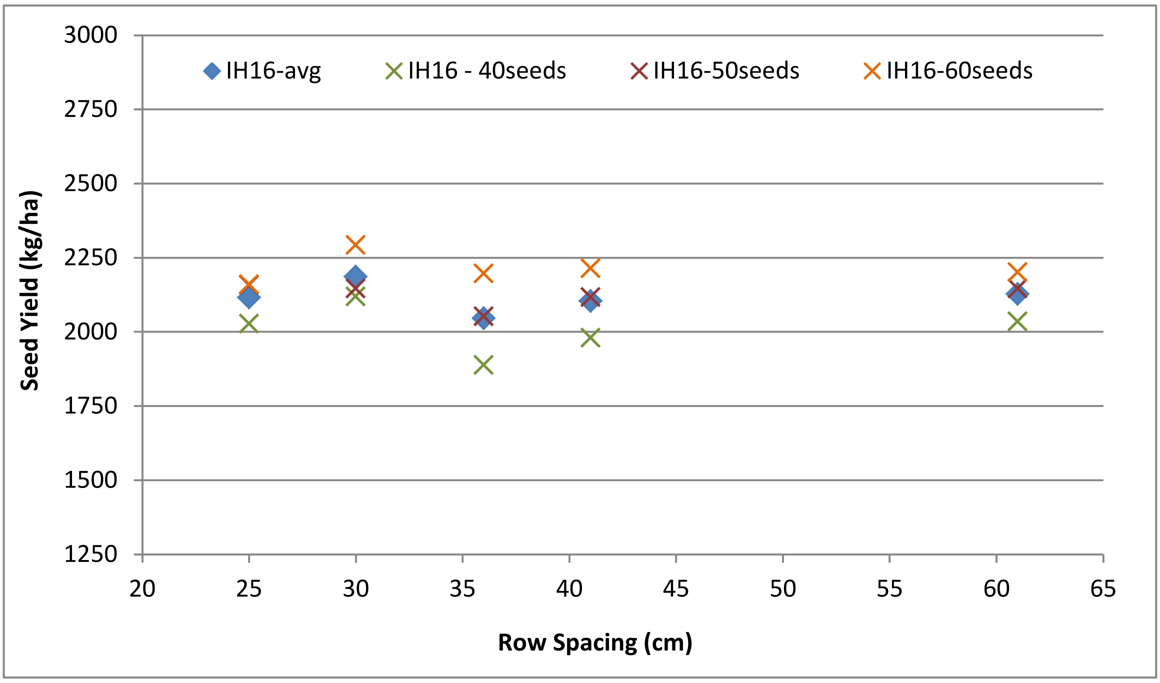

Figure 12. Row spacing and seeding rate effects on soybean seed yield at Indian Head (IH) in 2016.

Seed weight was affected by row spacing ($P = 0.015$) but not seeding rate ($P = 0.419$) and the RS x SR interaction was not significant ($P = 0.858$). Averaged across all three seeding rates, TKW increased from 113.6-119.5 g 1000 $seeds^{-1}$ when row spacing was increased from 25 cm to 61 cm (Fig. 13). With no significant interaction and similar orthogonal contrast results, the row spacing effect was consistent across the range of seeding rates evaluated.

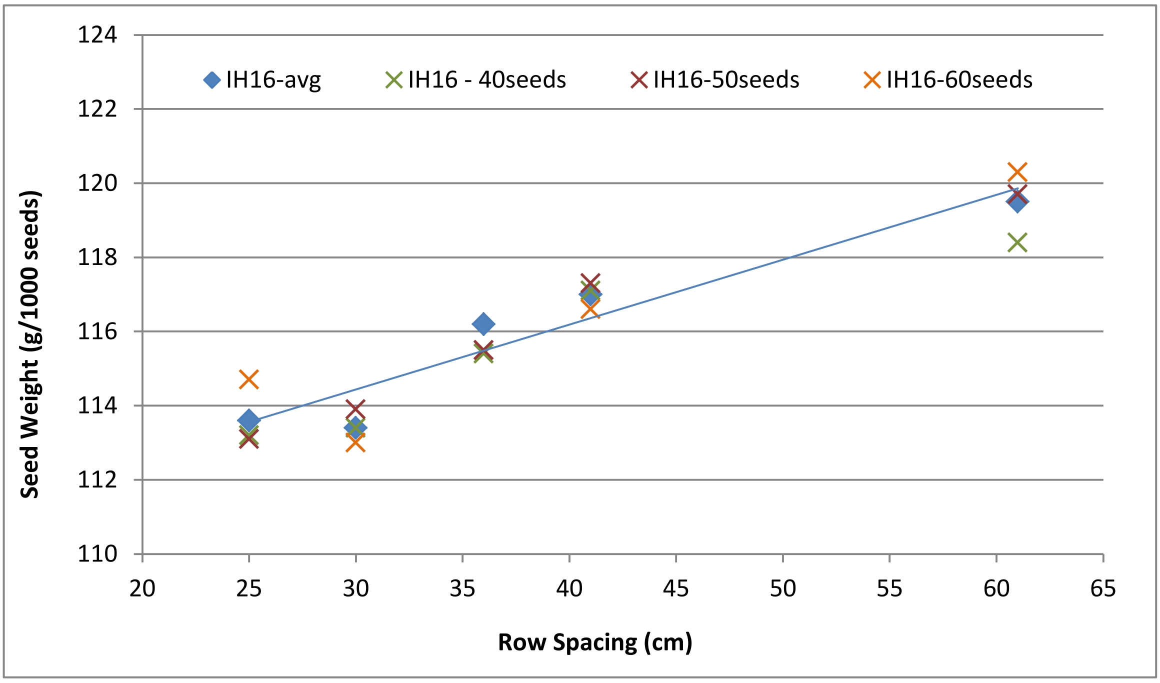

Figure 13. Row spacing and seeding rate effects on soybean seed weight at Indian Head (IH) in 2016.

This field trial is scheduled to continue at Indian Head for one more growing season.

4. Issues

- Describe any challenges or concerns faced during the project. How were they overcome or how do you plan to overcome?
- Describe any potential changes to the work plan and the budget. How were or how will they be managed?

There were no major challenges or concerns that will impact either the work plan or budget. For Sub-Activity 1 at Indian Head in 2016, soybeans and canola were seeded deeper than desired which affected emergence, maturity and potentially yield. Hail late in July also damaged the plots at Indian Head in 2016. While the impacts of the hail were uniform within individual study areas, the extent of the damage and magnitude of yield loss presumably varied across crop types and growth stages in Sub-Activity 1. Consequently, results from this sub-Activity at Indian Head in 2016 will need to be interpreted cautiously.

5. Lessons Learned:

Describe the key lessons learned gained as a result of executing the project (e.g., a more efficient approach to performing a specific task for activity / project).

There were no specific new lessons learned regarding execution of the trials themselves in 2016, the third year of a four year trial. Aside from challenges with seeding depth for the canola and soybeans in Sub-Activity 1 (partly attributed to environmental conditions) all aspects of the trials went well in 2016 at both locations and the methods were unchanged from previous years.

6. Future Related Opportunities:

Describe the next steps for the innovation items produced by the activity/project. Is additional research required? Is there potential for commercialization or adoption?

Since the study is a work in progress and conclusive innovation items have not yet been developed, we have not firmly identified next steps or additional research requirements stemming specifically from the current project.

While optimal seeding rates have varied with environment to some extent, under normal conditions, the responses have been reasonably consistent and generally in line with industry recommendations. While some such comparisons have been made in more traditional regions, there may be value to exploring how plant populations interaction with plant distribution to verify the potential benefits of more uniform distribution (i.e. seeded with a planter) as populations/seeding rates are reduced.

As identified last year, there may be value to exploring row spacing interactions with soybean genotypes. Specifically, it should be verified whether the optimal row spacing differs between more upright versus branching varieties with the hypotheses being that branching types will less sensitive to increasing row spacing than more upright varieties. This information would be of considerable value to growers using no-till drills configured with row spacing greater than 30 cm along with those using planters (traditionally on 45-76 cm row spacing).

Annex A

Innovation Items	
Performance Measures	**Description**
# of Intellectual property items flowing from the project	These include: declaration of invention, patent application, patents, trademarks, copyrights, trade secrets, signed license agreements, and royalties generated. This does not include IP for plant varieties; those should be reported under "# of new varieties" below.
# of new/improved products	New products could include: a new commercial product, bacterial strain, cartographic product, cell culture, analysis certificate, computer software, database, enzyme, equipment/instrument, fertilizer, hormone, methodology, model, monoclonal antibody, pest control product, polyclonal antibody, standard reference-chemical, standard reference-biological, standard reference-plant, etc.
# of new/improved processes or systems	This is the set of operations performed by equipment in which variables are monitored or controlled to produce an output. A combination of inter-related components or processes is arranged to perform a specific function and generate a given outcome.
# of new/improved practices	This is for a research that generated new knowledge that can be applied directly on the ground by the sector. This is mostly for new agronomic practices but can also cover new practices by processors.
# of new varieties	This includes registered varieties, cultivars, or breeds. This includes invention disclosure, protection and license for new plant varieties. For each new variety, please provide the registration number and the variety name.
# of new/improved genetic materials	This could include genetic map and gene probes. Include new varieties, cultivars or breeds in category "New varieties."
# of new/ improved gene sequences	The discovery of order of bases of a DNA [segment] making up a gene.
# of improved knowledge	This category is for reporting results following completion of the final year of the activity, or results against an activity's improved knowledge target. It is intended for results that do not fit in any of the above categories.
Information Items	
Performance Measures	**Description**
# of peer reviewed publications	These are published items such as: research papers published in scientific journals, books, book chapters, review articles, conference proceedings, research notes, or other that receive peer-review. Items that are not yet published (ex. manuscripts in development or review) should not be reported. For each reported item, please provide the following: author(s), year of publication, article title, title of journal, volume (issue), and page number(s). If the item is a book or a book chapter, add name of publisher. If the item is an article for conference proceedings, add title of published proceedings, location, and year/month/day.
# of information items	Information items include: posters, abstracts, pieces in publications such as trade journals, articles in industry magazines or press, industrial reports (confidential or not), technical bulletins, brochures, guides, flyers, newsletters, other technical transfer publications. If an item is published in a medium whose audience is the general public, it should be reported in the # of media reports category below. For each reported item, please provide the following: author(s), article title, title of magazine/trade publication etc., page number(s), type of information item such as poster or abstract or guide etc., and year/month/day.

# of media reports	Examples include articles or interviews about project results in media such as newspaper, tv, radio, and internet (announcements about project funding are excluded). (These are items prepared by a third party, usually with input by the project). If an item is published in an industry journal, newspaper, or magazine, it should be reported in the # of information items category above. For each reported item, please provide the following: author(s), article title, name of interviewee(s), source of reports (TV or radio interview etc.), and year/month/day.
# of information events	These are events such as a scientific meeting, symposium, conference, industry meeting, or field day where a project participant has been invited to present a talk or presentation directly related to the activity. For each reported item, please provide the following: name of presenter, title of presentation, name of the event, location, and year/month/day.
# of individuals attending information events	Please provide the number of attendees per event.
# of individuals attending information event who intend to adopt new innovation	Please provide the number of attendees intending to adopt the new innovation per event.
# of persons who completed a MSc or PhD during project	Only students who completed their MSc or PhD in the last year should be included in this category. For each reported graduate, please provide the following: the name of the student, degree completed and date of completion.