AgriInnovation Program Stream B
2015-16 Annual Performance Report

For projects or activities that started in 2015-2016, 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: 2015-04-01 to 2016-03-31
Activity #: A9 **Name of Activity:** Adaptation and establishment of soybean (Glycine max) under no-till in south Saskatchewan	**Principal Investigator:** Chris Holzapfel, Indian Head Agricultural Research Foundation

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 southeast Saskatchewan in recent years, the long-term yield stability of the crop in this province is uncertain and regional agronomic recommendations are lacking. Producers in Saskatchewan require access to information on the overall risks associated with growing soybeans relative to more traditional crops. Furthermore, those who do decide that soybeans have a fit in their rotations require access to regional agronomic recommendations to minimize the risks of poor establishment, delayed maturity and subsequent risk of yield loss due to early frost. 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 was initiated in the spring of 2014 and consisted of three separate field trials (Sub-Activities). Sub-activity #1 was an adaption trial where soybeans, canola, field peas or faba beans were planted at one of three seeding dates which were targeted to range from early -May to the beginning of June. At Indian Head, actual seeding dates ranged from May 7 to May 30 while at Swift Current the dates ranged from May 12 to June 4. Overall, weather conditions at Indian Head were much more favourable for soybeans in 2015 relative to the previous season while at Swift Current this crop was, again, negatively impacted by dry conditions. Unlike the previous season, early frost was not a factor at either location in 2015 and yields were considered above average at Indian Head for this crop. While soybeans seeded in early May took

much longer to germinate than with the later dates, neither final plant stands nor yields were negatively impacted. Overall, yields tended to be highest with mid-May planting at both locations but the specific effects of seeding date varied with crop type. For all crops at Indian Head, the highest yields were observed with mid-May seeding; however, canola and faba bean yields were significantly lower with late seeding but similar for the first two dates while, for field pea, yields were highest at the latter two dates. Soybeans were generally less sensitive to seeding date than the other crop types but tended to yield lower at the latest date at Indian Head. At Swift Current, overall yields for all crops were much lower, especially for field peas. Canola and peas were most sensitive to seeding date with early seeding being preferable for field peas but not canola. In general, canola emergence was slow and highly variable due to the combination of dry soils and shallow seeding. All crops reached maturity at both locations in 2015, regardless of seeding date. At Indian Head, overall average yields were 2725, 4634, 4017 and 2539 kg ha^{-1} for canola, field pea, faba beans and soybeans while at Swift Current overall mean yields for these crops were 1916, 383, 1285 and 1144 kg ha^{-1}. While canola maturity at Swift Current in 2015 was affected by the poor emergence, in most cases maturity has been earliest for field peas followed by canola then faba beans and finally soybeans. In some cases (i.e. Indian Head 2015), the spread in maturity between the earliest and latest treatments has been as high as 30-40 days.

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 for 2015 were 2413 kg ha^{-1} at Indian Head and 791 kg ha^{-1} at Swift Current. Mean seedling mortality was 20% at Indian Head and 43% at Swift Current; however, neither emergence nor seed yield were affected by seeding depth at either location. While neither plant populations nor seed yields were adversely affected by seeding depth in 2015, deep seeding resulted in a slight reduction in pod clearance at Indian Head and a 1.1 day delay in maturity at Swift Current. In 2014, yields at both locations continued to increase with much higher seeding rates than expected. In 2015, yields at Indian Head leveled off at seeding rates of 50-60 seeds m^{-2} while at Swift Current the response was again linear but much shallower, similar to the responses in 2014. There were no interactions between seeding depth and seeding rate for any of the response variables measured at either location in 2015.

Sub-activity #3 evaluated a factorial combination of five row spacing levels (25, 31, 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 2015, overall soybean yields were highest at 25-30 cm row spacing and lower with 36-61 cm; however yields were similar for row spacing ranging from 36-61 cm and adequate canopy closure was still achieved at the widest spacing. Interactions between row spacing and seeding rate were detected for seed yield and seed weight. For yield, there was subtle evidence that soybeans were less sensitive to seeding rate at very wide row spacing (i.e. 61 cm) while, for seed weight, the increase observed with increasing row spacing only occurred at the lowest seeding rate.

These field trials are scheduled to continue for two more seasons.

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).

1) While not specifically relating to the specific project objectives, one noteworthy success story was in confirming the ability of soybeans to recover from substantial hail damage during the vegetative growth stages. During the 3rd week of June at Indian Head, a hail storm resulted in significant damage to all of the crops but particularly the canola, faba beans and soybeans. At this time, the soybeans were mostly at the first trifoliate stage and the hail snapped off many plants either below the first trifoliate or below the unifoliate leaves. Within a matter of days, new shoots were forming and the plants proceeded to become some of the tallest, highest yielding ever observed at this location. It is uncertain what effect this damage had on pod clearance, yield or maturity and damage would likely have been more permanent if it had occurred later in the season; however, our experience showed that soybeans are well equipped to recover from physical damage early in the season provided that temperatures and moisture are adequate. Canola and faba beans also recovered well and there was relatively little damage observed on the field peas which were quite large already at this time.

2) In the adaptation trials of 2015, soybeans performed quite well at Indian Head. In contrast to the previous season which was more favourable for faba beans, the precipitation patterns in 2015 at this location were better suited for soybeans as it was somewhat hot and dry during flowering for the faba beans but moisture was abundant late in the season when the soybeans were entering the reproductive growth stages. While soybeans were less sensitive to delayed seeding than some of the other crops (i.e. canola), yields were slightly reduced and maturity was delayed at the last seeding date, despite a relatively open fall and abundant late season moisture. Although they took much longer to emerge, soybeans seeded early May yielded as well as those seeded in mid-May and there was no negative impact on final plant densities. These results show that there was no benefit to early seeding as there often can be with other pulses and canola and, therefore, producers would be wise to seed other crops first; however they also suggest that seeding soybeans early is a viable option. Despite being seeded 12 days earlier, soybeans seeded on the 7th of May emerged within approximately 1 day of those seeded on May 19, therefore, were not necessarily at a greater risk of injury due to spring frost. While soybeans have not performed particularly well at Swift Current, neither have faba beans or field peas in the current study. Our results to date suggest that, in this environment, producers may be advised to focus on pulse crops with the lowest cost of production and best tolerance to drought. That being said, while more traditional pulses such as peas, lentils or chick peas may be better suited to the Brown soil zone, challenges with these crops have driven some producers in this region to experiment with faba beans and soybeans. Canola has been the most consistent performer at Swift Current; however, producers in this region need other broadleaf crop options to maintain sustainable rotations. Upon conclusion of this study, when costs and revenues have been taken into account, we will be able to provide better recommendations on the potential risks and rewards of growing soybeans and faba beans relative to canola or field peas in contrasting environments.

3) With much higher yield potential and a longer growing season, soybean response to seeding rates at Indian Head in 2015 was considered much more typical than the previous season where yields climbed linearly through seeding rates of 85 seeds m^{-2}. It is worth noting that emergence was actually lower in 2015 so, despite lower overall plant populations, soybean yields levelled off at lower seeding rates than the previous season. At Swift Current, with much lower overall yield potential, the response was shallow but linear. At Indian Head, soybean emergence and yield were not affected by seeding depth but seeding deeper did result in a slight reduction in pod height. At Swift Current, under much drier conditions, soybeans actually yielded higher with deeper seeding despite there being no effect on emergence. Results to date confirm that it is generally preferable to seed soybeans relatively shallow compared to other pulses;

however, there may be merit to increasing seeding depth in dry regions or under dry seeding conditions. Row spacing effects favoured narrower spacing (25-30 cm) in 2015; however, no further reductions in yield were observed with further increases from 36-61 cm and weed control was adequate for all row spacing levels. There may be potential to slightly reduce seeding rates and (although this is not part of the study objectives) inoculant rates when row spacing is increased to 61 cm or wider.

4) While all results are still preliminary, this project was discussed and promoted at several noteworthy extension events in 2015-16. The field trials themselves were shown to approximately 80 Syngenta and FCL sales agronomists in two separate tours and to a sold out crowd (> 200 people) at the IHARF Crop Management Field Day. Several smaller and less informal tours through the site occurred throughout the growing season. As part of a presentation on row spacing effects on various crops, preliminary results from sub-Activity 3 in 2014-15 were shared with over 250 producers and agronomists at the Crop Production Show and IHARF Soil & Crop Management Seminar / AGM. Preliminary results were also contributed to an article in Growing Soybeans Magazine which is freely distributed online and targets western Canadian soybean growers.

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 the release of increasingly early varieties, soybean production has expanded into Saskatchewan with the greatest uptake in the southeast but interest from producers throughout the province. The adoption of this crop in southeast Saskatchewan has coincided with unusually wet weather which has delayed seeding for many growers and made it difficult to grow traditional pulse crops such as field peas or lentils. In Saskatchewan, 2015 soybean acres were estimated at approximately 300,000 acres, up over 11% from the previous year. 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 established in 2014 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 2015 growing season (May-September) was over 2 °C warmer than average at Indian Head and 0.4 °C warmer at Swift Current. Both locations received below normal precipitation; however, the driest months were May and June while July through September had approximately normal to above-average precipitation. At Indian Head, hail damaged the plots in the third week of June and, while the soybeans recovered quickly and thoroughly, certain response variables (primarily pod clearance) may have been affected. Generally speaking, the weather at Indian Head in 2015 was considered favourable for soybeans which prefer warm temperatures and require large quantities of water late in the growing season. At Indian Head, the first frost (≤ 2 °C) occurred on September 28 which was prior to full maturity; however, the pods were turning rapidly at this point and the frost only appeared to affect the uppermost leaves and pods. At Swift Current, the first killing frost did not occur until October 6; however, the combination of coarser soils and drier weather was less favourable overall for soybeans.

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 soybean varieties. The 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. At Indian Head, foliar insecticides were required to control both blister beetles (faba beans) and pea aphids (faba beans and late seeded peas). For a minimum of 2 replicates per location, 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. At Indian Head in 2015, faba beans had to be hand harvested (3 x 1 m rows) because mechanical harvesting was not possible due to plugged seed rows. Yields are expressed in kg ha^{-1} and were corrected for dockage and to uniform 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 for plant density, maturity, seed yield and seed weight were analyzed separately for each site with effects of seeding date and crop/variety treatment considered fixed and replicate considered random. Heterogeneity of variance was permitted for each crop/variety treatment but the more complex model was only utilized when doing so improved the model fit. 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 2)

The actual seeding dates at Indian Head were May 7, May 19 and May 30 while at Swift Current the dates were May 12, May 28 and June 4. At Indian Head, while all crops, especially soybeans, took longer to emerge with early seeding, plant densities were not affected by seeding date for canola, faba bean or soybeans. For peas, however, the highest plant densities were achieved at the last seeding date while the lowest densities were observed with mid-May seeding. While soil moisture was presumably lowest at the end of May, substantial precipitation fell in the 3rd week of June (prior to emergence counts for the final date) which likely resulted in improved emergence. At Swift Current, emergence was more variable and not significantly affected by seeding date; however, in general, higher plant populations tended to be achieved as seeding was delayed at this location. Similar to the previous year, field peas at Indian Head were the earliest to mature and soybeans were last; however, unexpectedly, faba beans matured slightly ahead of the canola (Fig. 1). This was likely due to the hot dry conditions earlier in the season being more detrimental to the faba beans than the canola and it is worth noting that 46H75 is a relatively late maturing canola hybrid. Soybean maturity was most dramatically affected by seeding date at Indian with soybeans seeded on the first two dates at Indian Head emerging and maturing at approximately the same time despite a 12 day difference in seeding date. At Swift Current, the overall effect of seeding date was similar with days from planting to maturity declining as seeding was delayed; however, individual crop responses differed at this site (Fig. 2). Due to delayed and irregular emergence, canola at Swift Current took longer to mature than soybeans for the latter two seeding dates and when averaged across all dates. Field peas were the first to mature at Swift Current in 2015 followed by faba beans and then soybeans and canola.

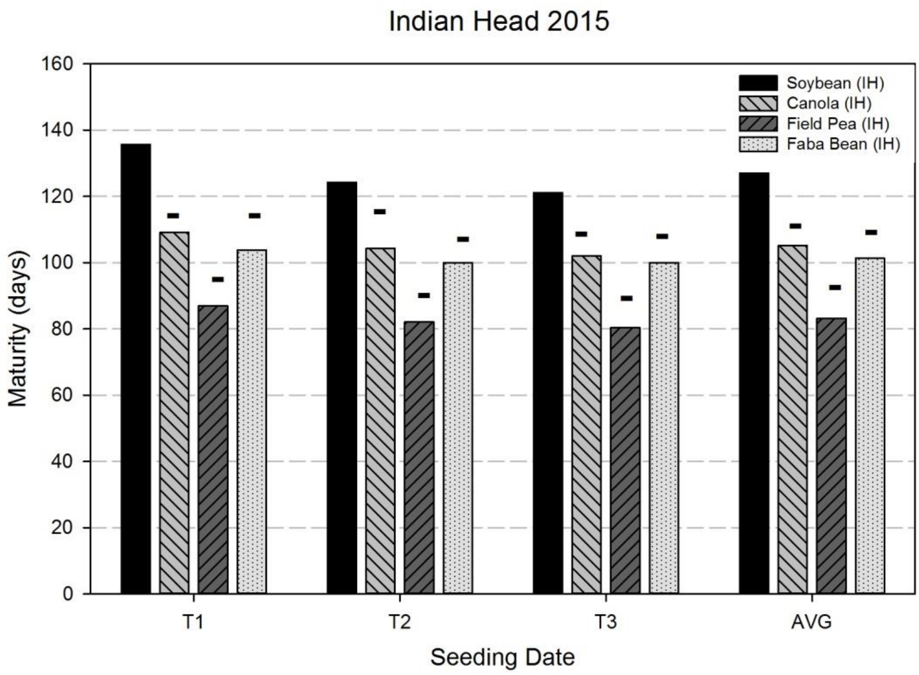

Figure 1. Mean maturity and contrast results for maturity at Indian Head (2015). Soybeans are compared directly to canola, field pea and faba bean. Yields within a group are either below (-), above (+) or equal to soybean (=).

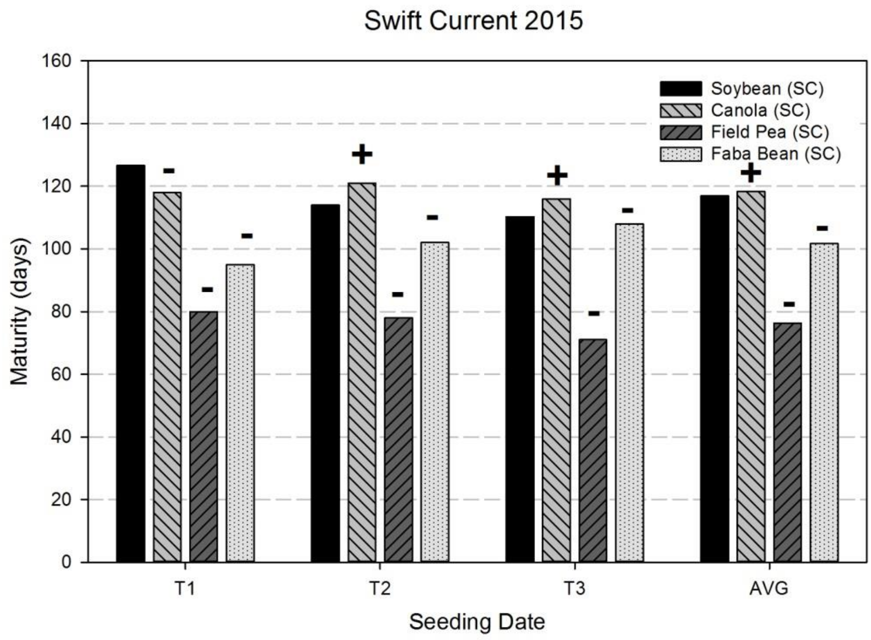

Figure 2. Mean maturity and contrast results for maturity at Indian Head (2015). Soybeans are compared directly to canola, field pea and faba bean. Yields within a group are either below (-), above (+) or equal to soybean (=).

At Indian Head, soybeans yielded well relative to other recent years (including those pre-dating this project); however, yields for all of the crops evaluated were also relatively high (Fig. 3). While this result was not necessarily unexpected or reflective of profitability, yields for field pea and faba beans were significantly higher than soybeans at all three seeding dates and canola was higher yielding for the first two dates but not the third. Crops were seeded into adequate moisture at all dates; however, the late precipitation tended to favour seeding in mid- over early-May. That being said, soybean and especially canola yields declined relative to the first two dates when seeded in late May (May 30). While insecticides were utilized to keep pest damage low, it was also noted that insect pressure (primarily aphids) was more severe for all crops except for soybeans with the latest seeding date.

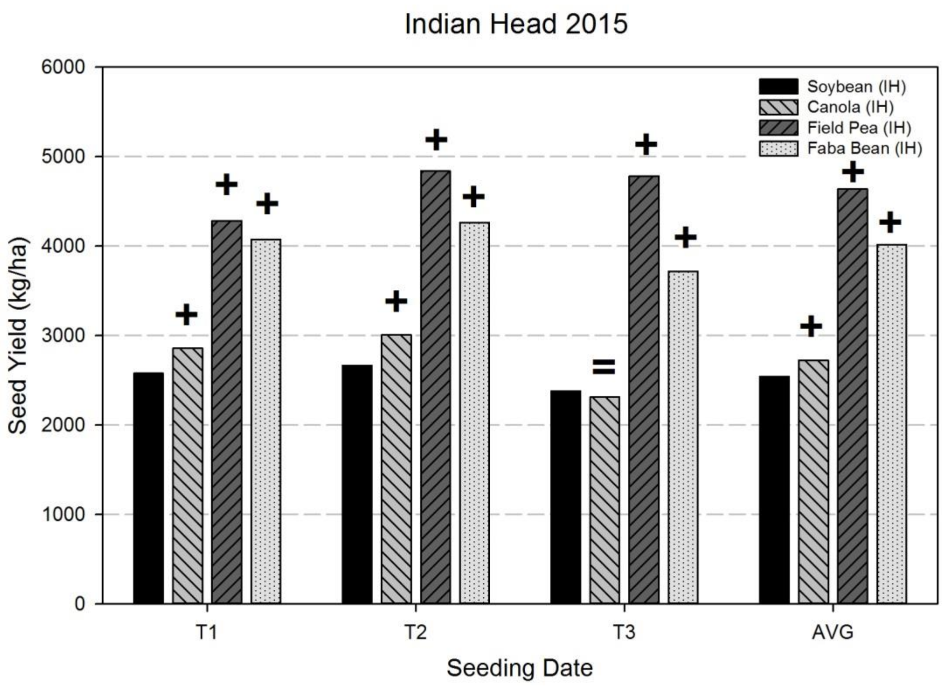

Figure 3. Mean yields and contrast results for seed yield at Indian Head (2015). Soybeans are compared directly to canola, field pea and faba bean. Yields within a group are either below (-), above (+) or equal to soybean (=).

At Swift Current, seeding dates were generally 4-5 days later than at Indian Head and yields for all crops were lower, particularly for the pulse crops. Both canola and field pea yields declined with delays in seeding at this location. Similar to the previous season, field pea yields at Swift Current were extremely low for all three seeding dates and dry conditions, flower abortion and heat stress are suspected to be the primary reasons for the low yields. For individual seeding dates, soybeans yielded lower than canola but higher than field peas in all cases. Soybean and faba bean yields were similar; however, both were likely too low to be profitable and, when averaged across all three dates, faba bean yields were slightly but significantly higher.

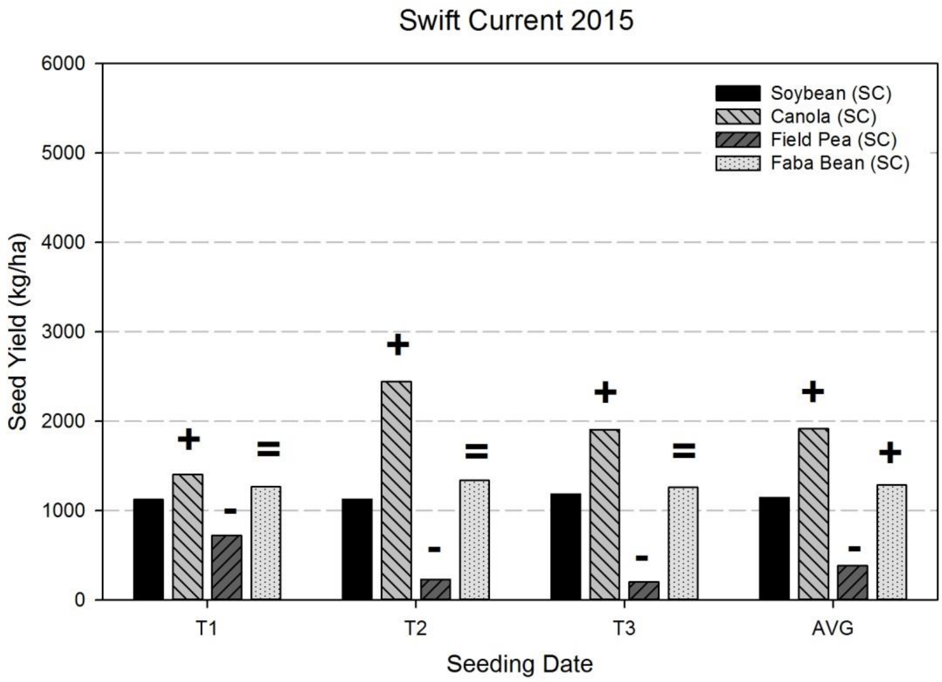

Figure 4. Mean yields and contrast results for seed yield at Swift Current (2015). Soybeans are compared directly to canola, field pea and faba bean. Yields within a group are either below (-), above (+) or equal to soybean (=).

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 until further into the study when more data is available.

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

Methods (Sub-Activity 2 – Year 2)

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 was NSC Moosomin RR2Y, which is one of 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. While light frost occurred prior to full maturity at Indian Head, it only affected the uppermost leaves and pods and the plants matured naturally without being terminated by frost (with the exception of the lowest seeding rate which struggled to reach maturity). Frost did not occur at Swift Current in 2015 until after all of the soybeans had matured. The plots were straight-combined in early October at both locations.

Various data were collected during the growing season and post-harvest. 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 the interaction between these factors (D × 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 seeding rate were linear, quadratic, or not significant. Detailed results tables are not included in this report but are available upon request.

Results (Sub-Activity 2 – Year 1)

Soybean plant densities were affected by seeding rate ($P < 0.001$) but not depth ($P = 0.133$-0.719) at both locations in 2015 but the D × R interaction was not significant at either location ($P = 0.344$-0.789). The commonly recommended minimum final populations of 30-40 plants m^{-2} were achieved with 40-50 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.

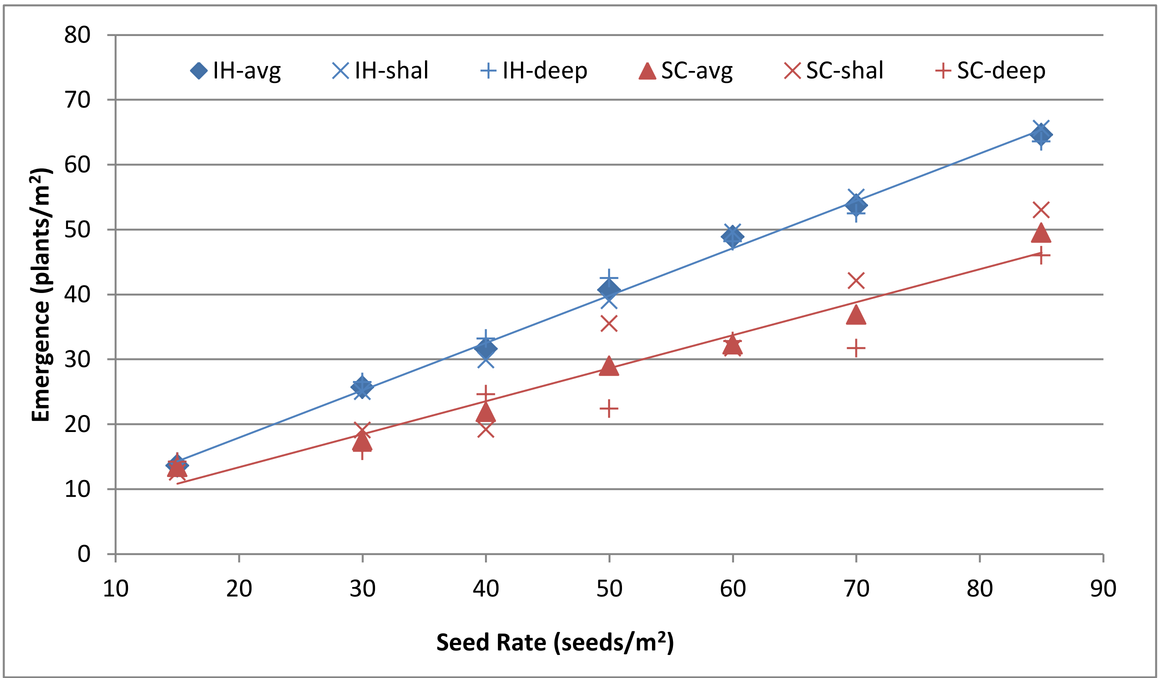

Figure 5. Seeding rate effects on soybean plant density at Indian Head (IH) and Swift Current (SC) in 2015.

Pod height was affect by both seeding rate ($P < 0.001$) and seeding depth ($P = 0.049$) at Indian Head but with no D x R interaction ($P = 0.809$). In general, treatment effects were subtle and pods in all treatments were quite low to the ground, quite possibly due to the hail damage in late June (1st trifoliate stage). The effects were such that pod height was reduced (potentially increasing harvest losses) with deeper seeding (Indian Head only) and suboptimal seeding rates (Fig. 6).With a difference of 0.6 cm between seeding depths but a difference of 3.3 cm between the lowest and highest seeding rates, seeding rate had a much greater overall effect on pod height than seeding depth. At Swift Current, seeding depth did not affect pod height ($P = 0.542$) but, similar to Indian Head, increasing seeding rate did result in higher pods ($P = 0.007$). Similar to Indian Head, there was no interaction between seeding depth and rate for pod height at Swift Current ($P = 0.902$).

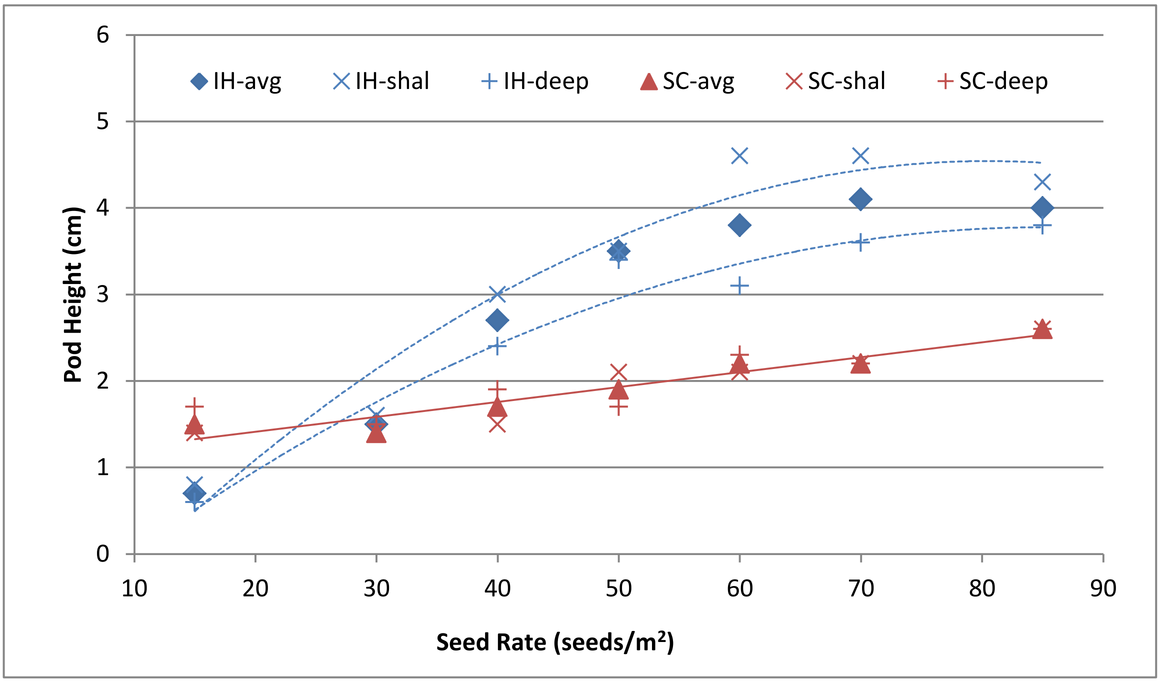

Figure 6. Seeding rate and depth effects on soybean pod height at Indian Head (IH) and Swift Current (SC) in 2015.

Maturity was affect by seeding rate ($P < 0.001$) but not depth ($P = 0.887$) at Indian Head and by both factors at Swift Current ($P \leq 0.001$). The interaction between these factors was not significant at either location in 2015 (P = 0.093-0.782). At Indian Head, with more moisture and higher yielding conditions, the response was linear and substantial with an 11 day delay in maturity at the lowest seeding rate relative to the highest (Fig. 7). At Swift Current, while the response was also linear, the difference in maturity between the lowest and highest seeding rates was only 4.6 days. There was also a 1.1 day delay in maturity with deeper seeding at Swift Current.

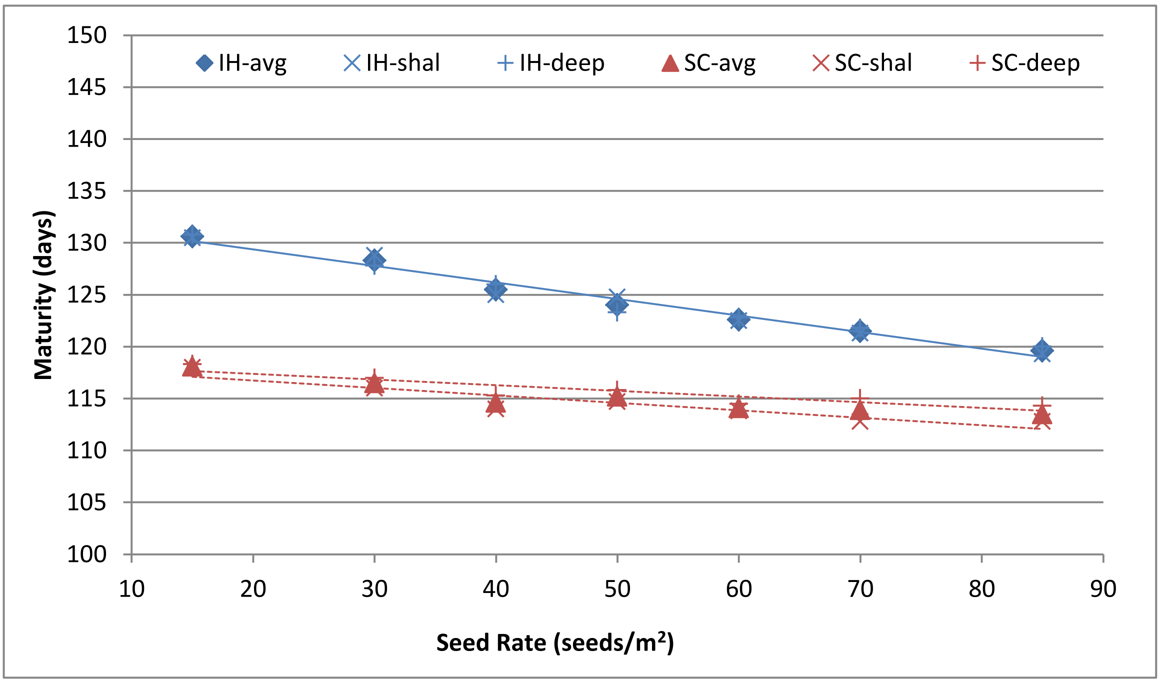

Figure 7. Seeding rate and depth effects on soybean maturity at Indian Head (IH) and Swift Current (SC) in 2015.

At Indian Head, soybean seed yield was affected seeding rate ($P < 0.001$) but not depth ($P = 0.558$) and there was no interaction between factors ($P = 0.879$). At this location, the response to seeding rate was quadratic with yields plateauing at seeding rates of 50-60 seeds m^{-2} and no significant differences amongst the three highest seeding rates (Fig. 8). At Swift Current, yields were much lower relative to Indian Head (790.5 kg ha^{-1} versus 2413 kg ha^{-1} on average) and affected by both seeding depth and rate ($P < 0.001$); however, again, there was no interaction between these two factors. The yield response to seeding rate at Swift current was shallow but linear, suggesting that yields continued to climb through the entire range of seeding rates tested, albeit at a relatively low rate. This is not inconsistent with the results from 2014 (not presented) when yields were much lower due to cool, wet conditions at Indian Head, dry conditions at Swift Current and early frost at both locations. It is worth noting that under such low yielding conditions the response to high seeding rates may be statistically significant but is unlikely to make economic sense. Somewhat unexpectedly, yields were slightly but significantly higher with shallow seeding relative to deep seeding at Swift Current (832 kg ha^{-1} versus 749 kg ha^{-1}). It is normally not recommended that soybeans be seeded deeper than ~25 mm but is possible that the deeper seeding was beneficial under the extremely dry spring/early summer conditions encountered at this location. Recall that emergence was not significantly affected by seeding depth and, numerically, plant populations actually tended to be slightly higher with deeper seeding at Swift Current.

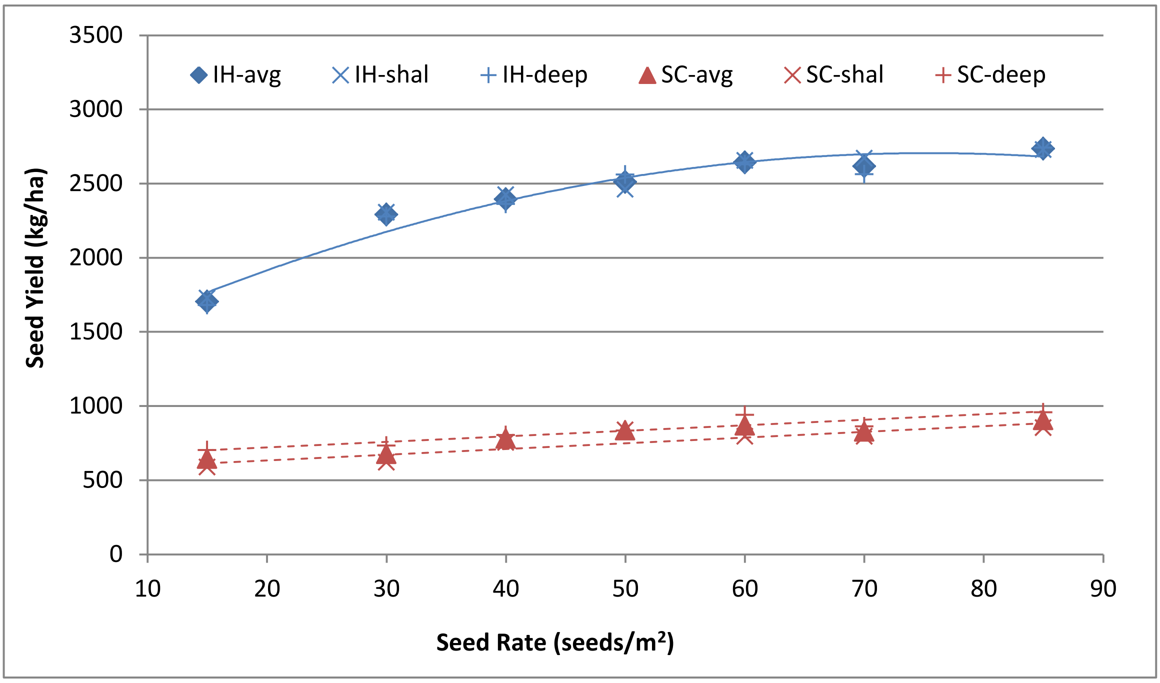

Figure 8. Seeding rate effects on soybean seed yield at Indian Head (IH) and Swift Current (SC) in 2015.

At Indian Head, seed weight was affected by seeding rate ($P < 0.001$) but not depth ($P = 0.865$) and, again, there was no interaction between the two factors ($P = 0.865$). Under relatively favourable conditions for soybeans, seed size declined with increasing seeding rates. The response was quadratic with the sharpest declines going from 15-30 seeds m^{-2} and seed weights levelling off at 50-60 seeds m^{-2}, approximately the same point where yields plateaued. At Swift Current, seed size was not affected by seeding rate but was significantly higher with deep (135 g 1000 seeds^{-1}) relative to shallow seeding (131 g 1000 seeds^{-1}). The previous season, seed size was not affected by seeding rate but reduced slightly with deep seeding at Indian Head while at Swift Current there was positive response to seeding rate for this variable. While not consistent with the other site-years in the current project, the results from Indian Head 2015 are likely quite typical when moisture or early season frost are not major limiting factors.

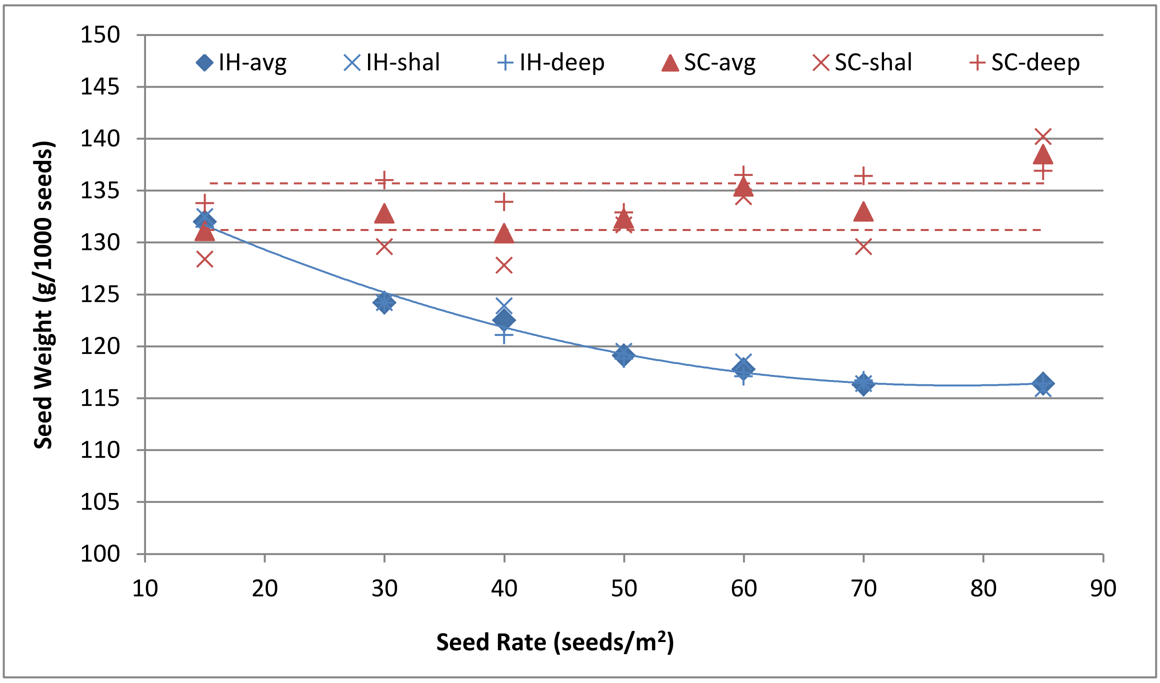

Figure 9. Seeding rate and depth effects on soybean seed weight at Indian Head (IH) and Swift Current (SC) in 2015.

These field trials are scheduled to continue at both locations for two more growing seasons.

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

Methods (Sub-Activity 3)

Sub-activity #3 was only conducted at Indian Head due to the specialized seeding equipment required. 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 was comprised of 8 full seeded rows except for those on 61 cm spacing where only four rows were possible. The variety was P002-T04R, a new (in 2014) very early maturing soybean variety. 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 herbicide applications and no fungicides were applied. Similar to the previously discussed trials, light frost occurred late in September but only affected the upper canopy and the plants were generally able to reach maturity naturally. The plots were straight-combined when mature and dry in early 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 major response variables of interest. Harvest methods were modified slightly from Sub-Activity 2 where a single combine pass (5 rows) was harvested from the centre of each plot. In the current Activity, 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 2)

Spring plant densities were affected by both row spacing (*P* = 0.024) and seeding rate (*P* < 0.001) but no significant SR × RS interaction (*P* = 0.532) was detected. As expected, plant densities increased linearly (*P* < 0.001) with increasing SR and, averaged across row spacing levels, ranged from 32-46 plants m^{-2}. There was a significant decline in plant populations as row spacing was increased with an overall mean of 43 plants m^{-2} at the 25 cm row spacing level and 34 plants m^{-2} at 61 cm row spacing. This has been observed with other crops and is attributed to increased competition amongst seedlings due to higher concentrations of plants within any given length of individual crop row. Overall, plant populations as a whole were slightly lower in 2015 than in 2014 (results not shown) but the treatment effects were consistent for both seasons.

Pod height was measured for each row spacing level at the 50 seeds m^{-2} seeding rate and was not affected by row spacing (*P* = 0.497).

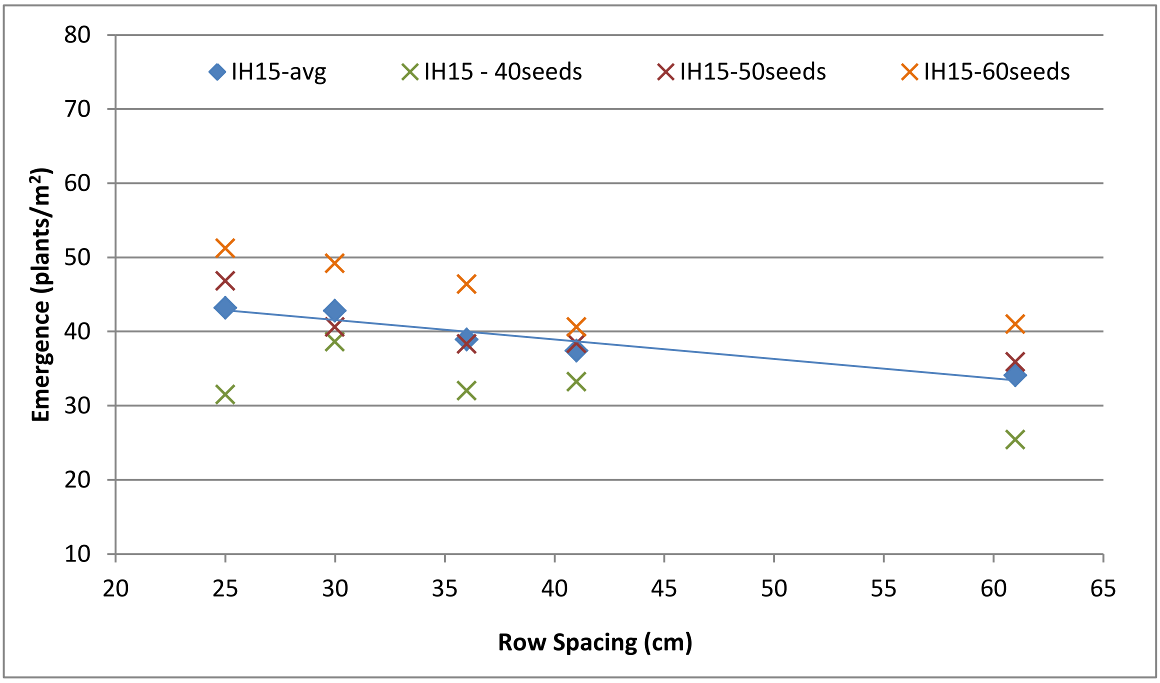

Figure 10. Row spacing effects on soybean plant density at Indian Head (IH) in 2015.

Days to maturity was not affected by row spacing (*P* = 0.148) but was affected by seeding rate (*P* < 0.001) and there was no interaction between these two factors (*P* =0.358). Despite the relative narrow range of seeding rates evaluated, there was 1.4 day spread in maturity between the lowest and highest rates and, with no interaction, the effect was reasonably consistent across row spacing levels.

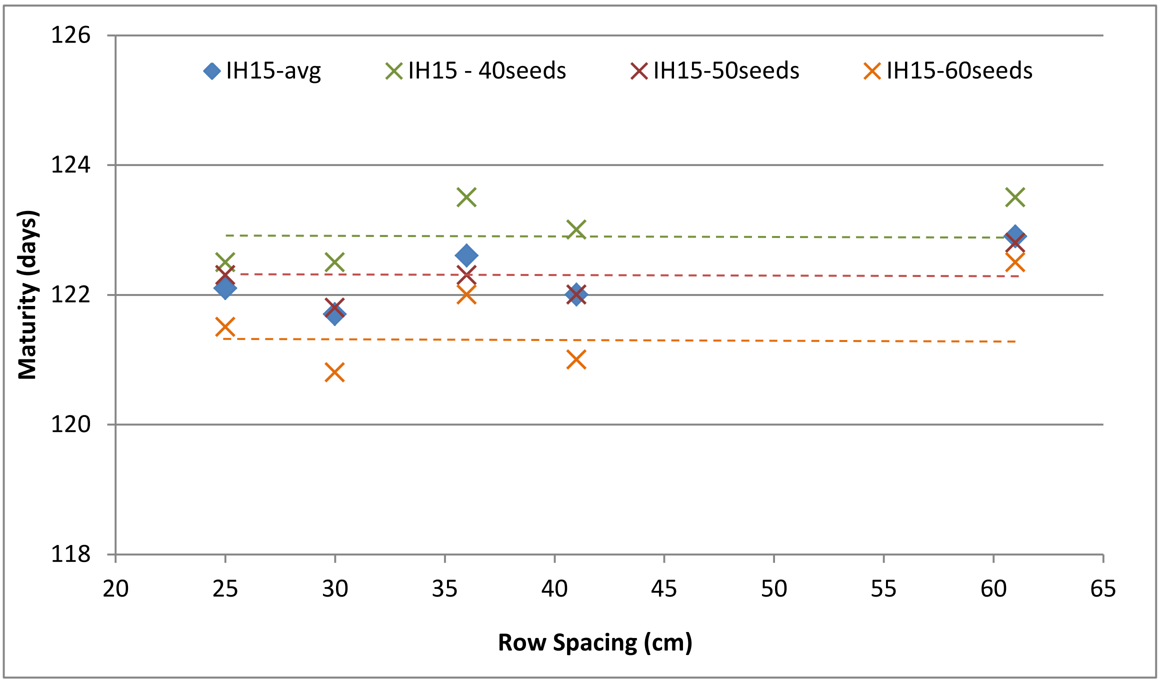

Figure 11. Row spacing and seeding rate effects on soybean maturity at Indian Head (IH) in 2015.

Seed yield was affected by both row spacing and seeding rate ($P \leq 0.001$) in 2015 and the interaction between these factors was also significant ($P = 0.048$). Averaged across row spacing levels, seed yields were lower at 40 seeds m^{-2} (2551 kg ha^{-1}) than at 50-60 seeds m^{-2} (2658-2680 kg ha^{-1}). This was consistent with the results from Sub-Activity 2 at this site. The overall effect of row spacing was such that yields at 25-30 cm were significantly higher than those at 36-61 cm. The response was quadratic with a significant decline when row spacing was increased beyond from 25 cm to 36 cm but then levelling off with no significant differences amongst 36-61 cm row spacing levels. While the SR x RS interaction was significant, the specific nature of this interaction was somewhat inconclusive. The orthogonal contrasts for seeding rate were not significant at 61 cm row spacing ($P = 0.117$-0.121), suggesting that the crop may have been less response to seeding rates (within this range) at wide row spacing. However, the seeding rate response at 30 cm row spacing was also relatively weak with so significant orthogonal contrasts at this RS level either ($P = 0.099$-0.120). In 2014, yields actually increased with increasing row spacing; however, in hind sight we know that the granular inoculant rate used in the first year of the study was not sufficient to maximize yield and most likely introduced biases to these results that favoured wider row spacing. While yields in 2015 were higher at 25-30 cm row spacing, the facts that they did not decline from 36-61 cm row spacing and adequate canopy closure was achieved at all row spacing levels suggest that this crop is still relatively insensitive to row spacing compared to many crops.

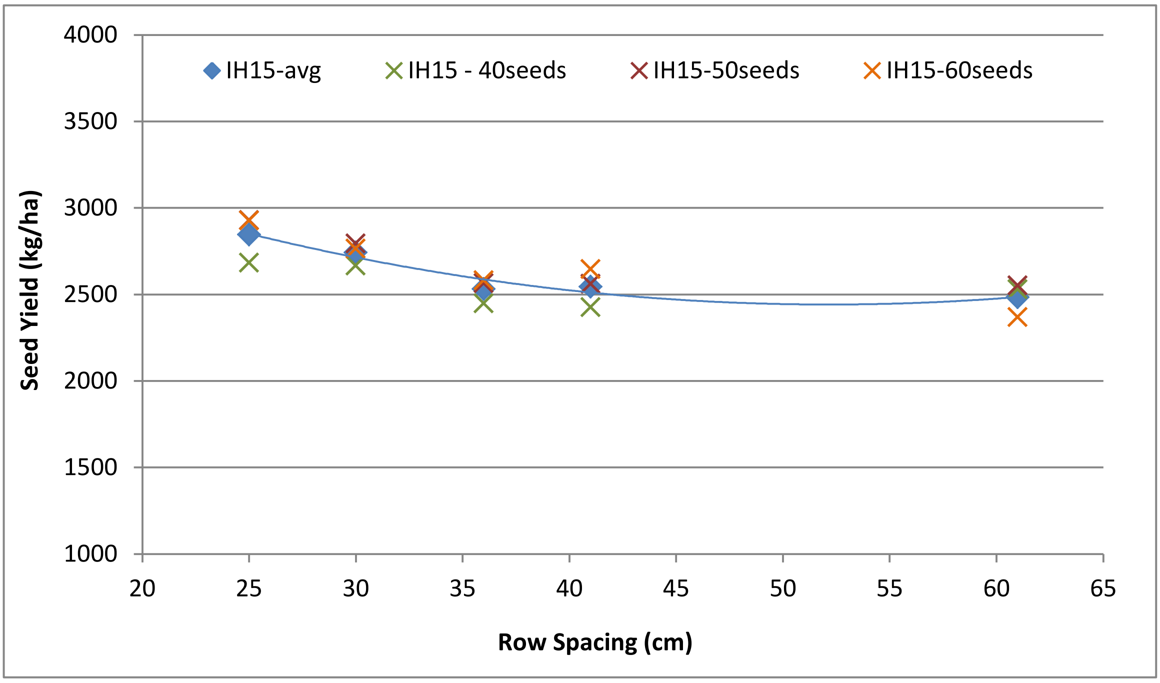

Figure 12. Row spacing and seeding rate effects on soybean seed yield at Indian Head (IH) in 2015.

Finally, seed weight was affected by row spacing (*P* = 0.007) but not seeding rate (*P* = 0.294) but the RS x SR interaction was highly significant (*P* = 0.005). Averaged across all three seeding rates, TKW increased from 113.7-118.3 g 1000 seeds^{-1} when row spacing was increased from 25 cm to 61 cm (Fig. 13). The interaction, however, appeared to be due to this effect being much more prominent at the lower seeding rates of 40-50 seeds m^{-2} and, according to the orthogonal contrasts, this effect was not significant at 60 seeds m^{-2}.

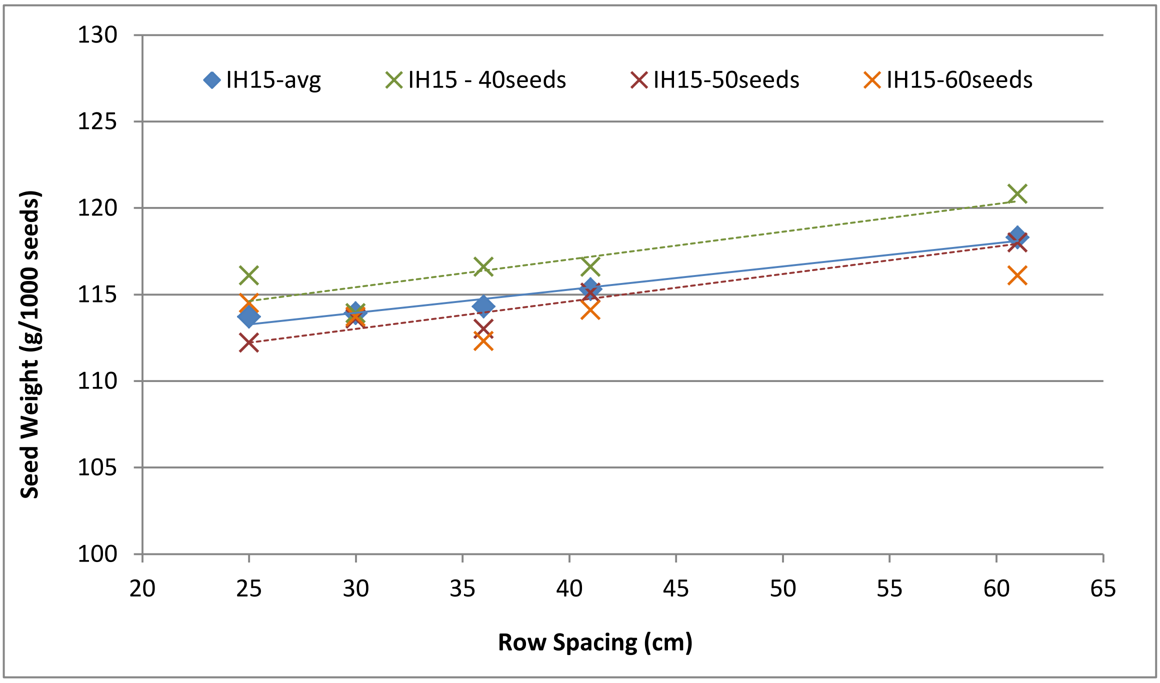

Figure 13. Row spacing and seeding rate effects on soybean seed weight at Indian Head (IH) in 2015.

This project is scheduled to continue at Indian Head for the next two growing seasons.