2018 Annual Report

Soybean and Pulse Agronomy Lab
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About the Soybean and Pulse Agronomy Lab

The Soybean and Pulse Agronomy Lab led by Kristen P. MacMillan focuses on soybean, dry bean and pea agronomy and cropping systems. Our Mission is to study and develop best management practices for soybean and pulse cropping systems that optimize agronomy, profitability and sustainability for farmers in Manitoba and western Canada through applied agronomic research, extension and training. Established in 2017, this program represents a unique collaboration between the Manitoba Pulse & Soybean Growers and the University of Manitoba that arose in response to the growth of soybean acres, steady dry bean production and re-emerging interest in pulse production. The Manitoba Pulse & Soybean Growers initiated and provided funding for a 5-year research program focused specifically on soybean and pulse crop agronomy that would address production questions, extend knowledge and bring an applied professional to the classroom. This annual report is a summary of the Soybean and Pulse Agronomy lab's research trials in Manitoba in 2018. It has been developed as a reference for farmers and industry members and is meant to provide a concise summary of each project.

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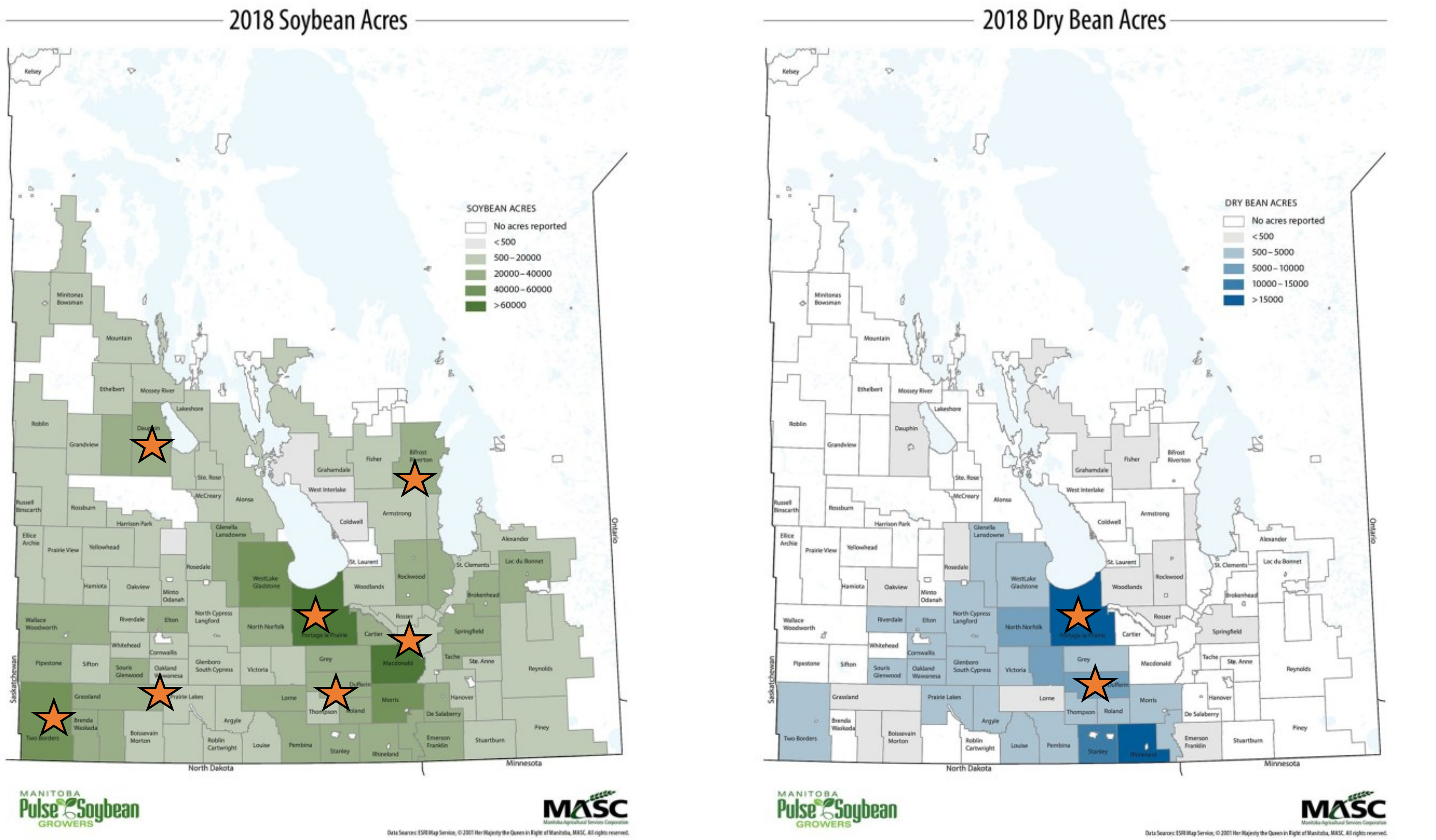

Figure A. Soybean and dry bean acre distribution by municipality in Manitoba and locations of research trials in the Soybean and Pulse Agronomy research lab (Maps developed by Manitoba Pulse & Soybean Growers with data from Manitoba Agricultural Services Corporation).

Soybean seeding depth evaluation

(Carman and Arborg, 2017-ongoing)

The objective of this study is to identify the optimum seeding depth for soybeans in Manitoba. The current recommendation is to seed soybeans between 0.75 and 1.5 inches based on guidelines from other regions. However, dry spring soil conditions often lead agronomists and farmers to 'chase moisture' and seed soybeans at 1.75 inches or deeper as has occurred in 2017 and 2018. Observations on the success of this practice have been mixed - delayed emergence is a frequent observation and reduced emergence has occurred in some but not all cases. On the other hand, very wet soil conditions in spring have led some farmers to broadcast and incorporate their seed. The potential yield impact of shallow and deep seeding is currently unknown in Manitoba and western Canada.

Soybean seeding depths between 0.25 and 2.25 inches were tested at Arborg (clay soil) and Carman (loam soil) in 2017 and 2018 in a randomized complete block design (RCBD) experiment. Trials were seeded with a double disc plot seeder between May 14 and May 24. At the time of seeding, moist soil was at 1.25" in 2018 and an accumulated 25mm of rain took about 14 and 21 days in 2017 and 2018, respectively. All trials were seeded into tilled stubble, except Arborg 2017 which was seeded into tilled fallow. Also at Arborg 2017, the plot seeder could only reach a depth of 1.75". For those reasons, Arborg17 was excluded from the combined analysis. Data was analyzed using Proc Mixed in SAS 9.4 with environment, treatment and their interaction as fixed effects and block within environment as a random effect.

At Arborg17, soybean seeding depth from 0.25 to 1.75" did not affect soybean plant density or yield (28.4 to 30.8 bu/ac; data not shown). This is not necessarily surprising as the depth range was narrower and the trial was seeded into tilled fallow land, which promotes loose soil that may not elicit potential impacts of deep seeding. In the combined analysis of Arborg18, Carman17 and Carman18, soybean plant density was significantly affected by seeding depth (Figure 1a). Soybean yield was affected by both main effects (environment and seeding depth) and their interaction (Figure 1b). At Carman17, soybean yield was reduced by 25% when seeded at 2.25" compared to 0.5 and 0.75". The other seed depths produced yields similar to all other treatments. At Carman18, soybean yield was reduced by 20% with shallow seeding (0.25") compared to seeding at 1.25 and 1.5". The other depths were statistically similar to all others. At Arborg18, seeding depth did not affect soybean yield. When looking at the overall effect of seed depth on yield, the same trend exists at each environment - although to different degrees, which leads to the interaction. Yield loss with very shallow or deep seeding is not consistent, however, when it does occur (2 out of 4 environments thus far), it is substantial (20-25%).

Delayed and reduced plant establishment and reduced seedling vigour are potential factors contributing to yield loss with non-optimal seeding depth. Shallow seeded soybeans (0.25") are more prone to moisture fluctuations, resulting in wetting and drying of the seed which can lead to poor germination and establishment. Deep seeded soybean seedlings (2.25") show hypocotyl swelling, loss of cotyledons and chlorosis. To identify other mechanisms potentially contributing to yield differences, we measured the effect of seed depth on pod height in 2018 and we plan to measure nodulation and root rot in 2019, which will be the last year of the study. In 2018, seed depth did not affect pod height.

Based on the first 2 years of study, farmers should choose seeding depths between 0.5 and 1.5 inches depending on their soil type, management practices, equipment and rain forecast. Measuring seed depth during seeding and making adjustments by field may also be necessary. A post-emergent assessment to measure actual seeding depth at the cotyledon or unifoliate stage should be adopted to ensure that the target seeding depth was achieved.

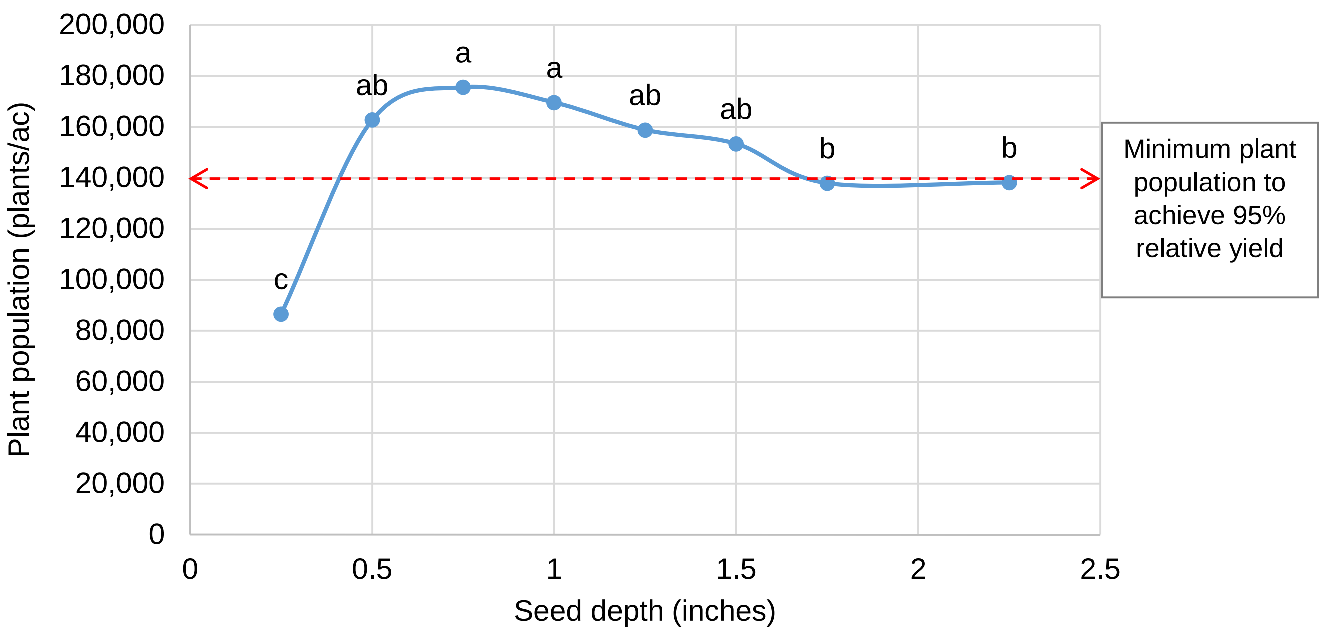

Figure 1a. Effect of seeding depth on established plant population among environments. Means that contain the same letter are not statistically different at P = 0.05.

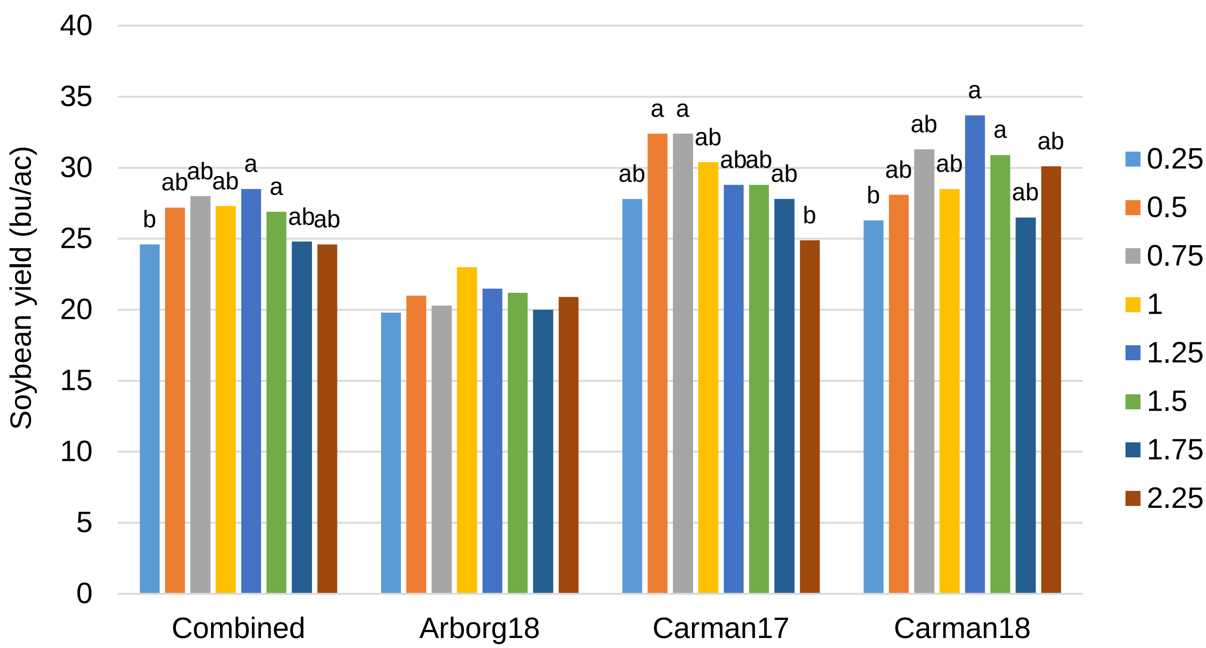

Figure 1b. Effect of soybean seeding depth on yield among environments (combined) and by environment. Means that contain the same letter are not statistically different at P = 0.05.

Soybean seeding window

(Arborg, Carman, Dauphin, Melita, 2017-ongoing)

Traditional recommendations are to plant soybeans when soil temperature has warmed to at least 10°C, which is typically May 15-25 in Manitoba (Manitoba Agriculture). However, farmers have started to seed soybeans earlier and recent work by Dr. Yvonne Lawley and Cassandra Tkachuk (2017) supports this trend. They evaluated seeding dates across a range of soil temperatures from 6 to 14°C in 2014 and 2015; the earliest seeding dates maximized yield regardless of soil temperature and it was concluded that calendar date is a superior indicator. To update seeding date recommendations across a wider range of environments and using defined calendar dates, this study was initiated at Arborg, Carman, Dauphin and Melita in 2017 and will continue through 2019. **The objective of this study is to determine the optimum seeding window for soybeans across Manitoba growing regions.**

The experimental design is a split plot RCBD, with seeding window as the main plot and variety as the split plot. The four seeding windows tested were "very early" (April 28 to May 4), "early" (May 8 to 14), "normal" (May 16 to 24) and "late" (May 31 to June 4). The short season variety S007Y4 and mid season variety NSC Richer were seeded within each seeding window.

The preliminary combined analysis from 2017 to 2018 indicates that soybean yield was affected by the main effects of environment (E) and seeding date (D), and their interaction (E x D). Overall, soybean yields were below average to average in these dry growing environments, ranging from 21-40 bu/ac, with the exception of Dauphin18 which yielded 64 bu/ac. Looking at individual environments (data not shown), yield maximization occurred in the first seeding window (very early; April 28-May 4) for 3 out 7 environments, out yielding the second and third dates by 2-12%. In the other 4 out of 7 environments, yield maximization occurred in the second seeding window (early; May 8-14) by 1-14% compared to the first and third dates. In 2 out of those 4 environments (Carman17 and Melita17), soybeans in the first seeding date were beginning to emerge and were exposed to spring frost which is an important consideration for very early seeding. Yield differences among the first three seeding dates were statistically similar in 5 out of 7 environments and reduced yield with late seeding was consistent across all environments contributing to a meaningful overall effect of seeding date. Overall, soybean yield was statistically similar when seeded between April 28 and May 24, seeding beyond which reduced soybean yield by 20% on average. At Arborg18, soybean yield was statistically higher at the second seeding date compared to the first and last date. Due to this occurrence and associated frost risk observed at two other environments, farmers may want to consider waiting until the 2nd week of May to seed soybeans in Manitoba. Other measurements being collected include emergence, crop phenology, maturity and seed quality.

Table 1a. Summary of analysis of variance for main effects and their interactions on soybean yield.

Effect	Significant?
Environment (E)	*******
Seeding Date (D)	***
Variety (V)	ns
E x D	*******
E x V	******
D x V	ns
E x D x V	ns

* Significant at 0.05 probability level, ** Significant at 0.01 probability level
*** Significant at 0.001 probability level, ns = not significant

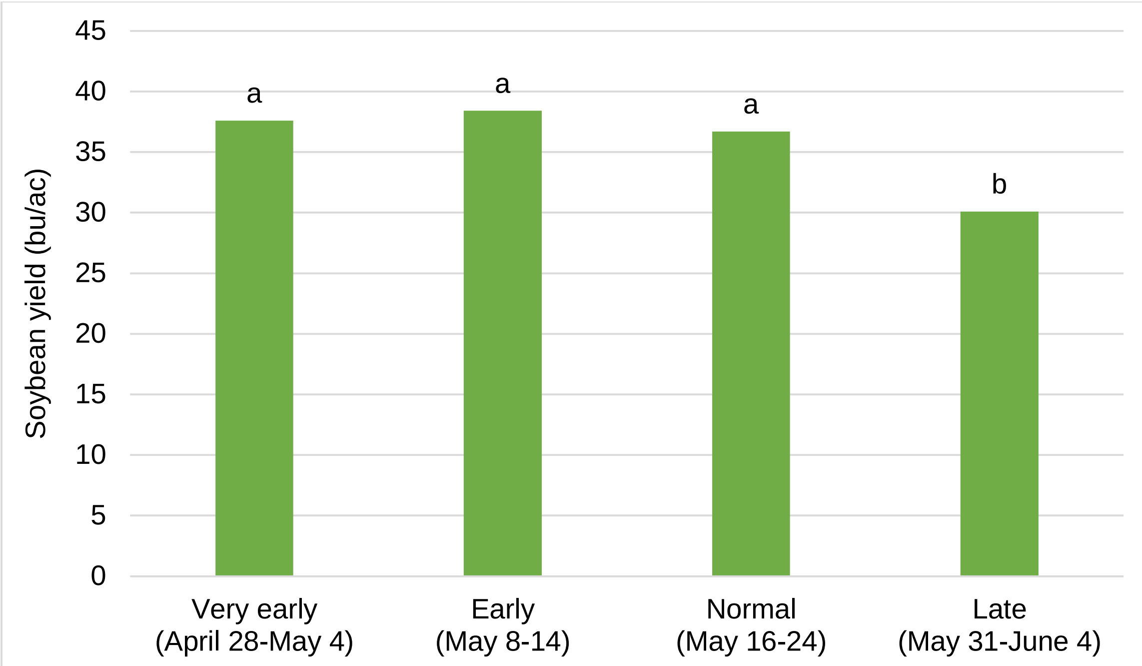

Figure 2a. Soybean yield by seeding window among 7 site-years in Manitoba from 2017-2018. Means followed by the same letter are not statistically different at $P = 0.05$.

Figure 2b. Soybean seedlings in the first seeding window (April 28 to May 4) were emerging and exposed to the last spring frost in 2 out of 7 environments, making frost exposure a risk with very early seeding.

Soybean fungicide product and timing evaluation

(Carman 2017-ongoing)

The most common soybean diseases found in Manitoba soybeans are foliar leaf diseases; Septoria brown spot, bacterial blight and downy mildew which are typically present at low severity (<2 out of 5) in the majority (39-100%) of soybean fields surveyed annually from 2014 to 2018[†]. Frogeye leaf spot was also confirmed in Manitoba in 2016 and was found in 8-44% of fields in 2017 and 2018 at low incidence. White mould is found in 3-33% of surveyed fields annually at an average incidence level of ≤10% and root rot is found in 18-59% of surveyed fields annually at an average incidence level of ≤12%. Foliar fungicides are one management tool available to farmers to protect soybeans from some of those diseases; brown spot, frogeye leaf spot and white mould. In the Manitoba Pulse & Soybean Growers On-Farm Network, the frequency of yield response to foliar fungicide application is currently 22% (11 out of 50 trials conducted from 2014 to 2018) and the overall average yield response is 0.77 bu/ac.

The objective of this experiment is to conduct an annual assessment of fungicide product and timing in soybeans at Carman, MB. Treatments are comprised of Cotegra and Acapela single fungicide application at R2 and R4 plus a sequential application of the products applied at both R2 and R4 (~14 days after R2). Cotegra is a dual action fungicide product from BASF containing boscalid (group 7) and prothioconazole (group 3). Acapela is a picoxystrobin (group 11) fungicide from DuPont. Inoculated soybeans (24-10RY) were seeded mid-May with a disc drill on 7.5" row spacing at 200,000 seeds/ac. Foliar leaf disease and white mould ratings were taken at R2, R4 and R6. Foliar leaf diseases are rated for severity along a 1m length of row in the front and back of each plot using a scale from 0 to 5. Incidence (% of plants affected) of white mould was determined along the same 1m length of row, if present. The experimental design is a randomized complete block design with four replicates.

There was no yield response to any foliar fungicide treatment in 2017 or 2018 and there was no treatment x year interaction (Table 3a). All foliar leaf disease ratings were low (<1.6 out of 5), except bacterial blight during R4 in 2018 which was rated as moderate (2.5 out of 5). White mould was only detected at trace levels in some plots. Very dry conditions in both years likely contributed to low disease pressure. This experiment will be repeated in 2019.

Table 3a. Effect of fungicide treatment on soybean yield (bu/ac) at Carman 2017 and 2018.

Treatment	Carman17	Carman18	Combined
1. Untreated	39.1	36.6	37.9
2. Cotegra 280 ml/ac at R2	40.1	36.6	38.3
3. Cotegra 280 ml/ac at R4	36.8	34.9	35.9
4. Acapela 350 ml/ac at R2, Cotegra at R4	34.5	34.2	34.4
5. Cotegra 280 ml/ac at R2, Acapela at R4	35.7	35.5	35.6
6. Acapela 350 ml/ac at R2	40.2	37.6	38.9
7. Acapela 350 ml/ac at R4	35.2	34.8	35.0
CV%	35.4	11.1	26.6
Significant at *P* = 0.05?	ns	ns	ns

[†] Soybean disease survey information is a compilation of data available from Manitoba Pulse & Soybean Growers and the Western Forum on Pest Management and is a coordinated effort Manitoba Agriculture, Manitoba Pulse & Soybean Growers, Agriculture and Agri-Food Canada, Brandon University and the University of Manitoba.

Thank you to BASF and DowDuPont for providing fungicide products for testing.

Evaluating the effect of simulated hail damage on soybeans

(Portage la Prairie and Minto, 2015-2018)

Hail accounts for 7% of historical post-seeding causes of crop losses (Manitoba Agricultural Services Corporation, 1966-2016), making crop insurance an important risk management tool for farmers. Current crop loss data for hail damage to soybeans is derived from the US mid-west and observations suggest that soybean recovery from hail is different in our cooler, shorter growing season. Over the past 4 years (2015-2018), we have been working on the development of local crop-loss data to determine the effect of simulated hail damage on soybean yield, maturity and quality. This is the first investigation of hail damage on soybeans in western Canada.

This study is comprised of two experiments; 1) stem breakage/node removal and 2) leaf defoliation (Figure 1d). Each experiment was repeated at Minto and Portage la Prairie from 2015 to 2018. The experimental design is a split plot arrangement of an RCBD with a shared control where hail simulation timing is the main plot and severity is the split plot.

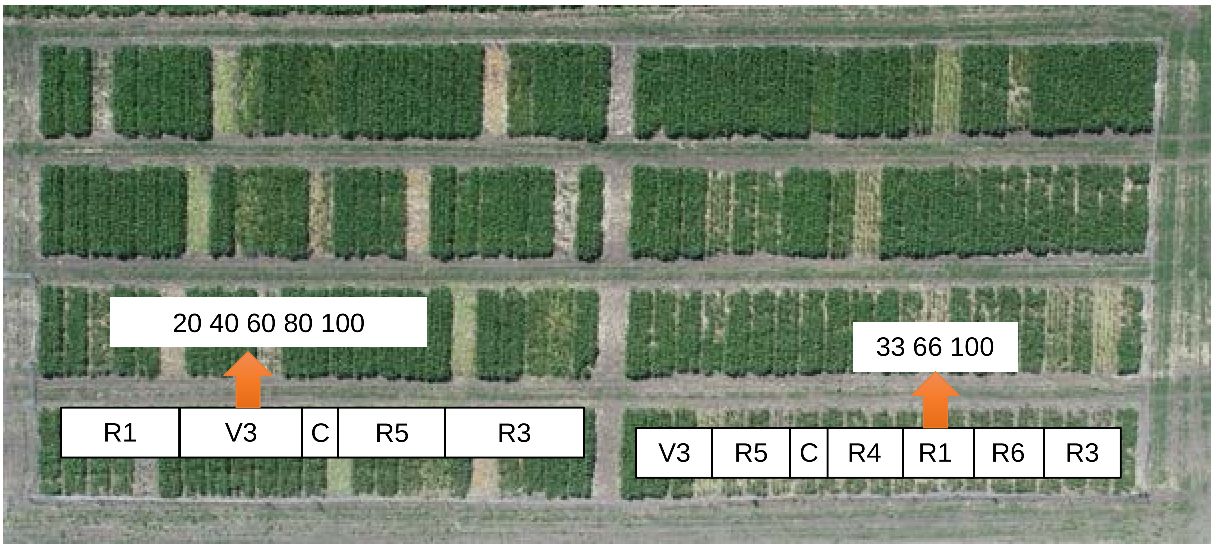

Figure 4a. Aerial image of the soybean hail experiment at Portage la Prairie, MB in 2018.

Preliminary results indicate that the effect of hail on soybean depends on the type of damage, timing and severity. The relationship between yield loss and severity for each type of damage and growth stage will be determined. Upon completion of data analysis, results will be provided to the National Crop Insurance Services and Canadian Crop Hail Association. They are the insurance advisory organizations that review and develop crop loss adjusting procedures for crop insurance agencies such as Manitoba Agricultural Services Corporation and other private insurance groups.

“Evaluating the effect of hail damage on soybean maturity, yield and quality”
- Top Crop Manager 2017

“Preliminary summary of soybean yield loss from hail at V2 to V3 in Manitoba”
- Written for the Manitoba Pulse & Soybean Growers *Bean Report* June 2019

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Yield Impact of Yellow Soybeans and Management Strategies

Kristen P. MacMillan, MSc, PAg, Research Agronomist, University of Manitoba

Figure 5a. Over 80 varieties are rated for iron deficiency chlorosis (IDC) annually at an IDC prone site near Winnipeg.

THE YELLOWING OVER of soybean fi lds, caused by iron deficiency chlorosis, during June in Manitoba is a mystery that continues to be investigated. It hits close to home for me – over half the soil tests on our farm come back at a "high" risk for IDC. We choose varieties carefully and continue to grow great soybeans, but a look into the literature describing this unique soil-plant interaction offe s more insight into how we could manage it in the future.

UNDERSTANDING THE SOIL-PLANT-WATER INTERACTION

To manage a problem, you must first understand the system. Iron deficiency chlorosis (IDC) is a challenge unique to high pH soils (often called calcareous due to the presence of calcium carbonates), which is why we don't hear about it from all soybean growing regions. Manitoba soils are calcareous by nature; calcium carbonates in our soil are derived from the weathering of limestone parent material, particularly in the Interlake and Red River Valley. In wet soil, carbon dioxide builds up and reacts with these carbonates, leading to bicarbonate which impedes iron uptake in soybeans. Despite iron being abundant in most of our soils, soybeans need to convert it to an available form for uptake by acidifying the area around their roots. Bicarbonate neutralizes that acidification process, reducing the availability of iron, leading to IDC. In addition to wet, calcareous soils, high nitrate levels are also thought to be involved with bicarbonate presence in the soil and salinity and is another soil factor that contributes to IDC. Good news though – the ability of soybean to acidify their root zone and take up iron diffe s among cultivars, which is why variety selection is the best management tool for IDC prone environments.

HOW ARE VARIETIES EVALUATED FOR IDC AND HOW MUCH DOES IT IMPACT YIELD?

The susceptibility of soybean varieties to IDC is tested annually at an IDC prone site near Winnipeg (Figure 5a). Each variety is grown in single rows over three replicates and a visual rating from 1 to 5 is assigned based on its reaction, with 1 being tolerant and 5 being highly susceptible. This information is then used to choose varieties when growing soybeans in fi lds prone to IDC. The IDC test site was taken to yield in 2017 for the first time in order to demonstrate the effect of IDC rating on yield. In Figure 5b, soybean yield decrease in response to IDC rating is shown through regression using the 2017 data. The results may surprise you. Based on last year's trial, soybean yield was reduced by 20 bu/ac with each 1-unit increase in IDC rating at V5/R1. For example, varieties with an IDC rating of 1.7 produced an average soybean yield of 43 bu/ac compared to 23 bu/ac for soybean varieties with an IDC rating of 2.7, in an IDC prone environment. These results may represent the extremity of yield impact due to IDC as symptoms in 2017 persisted for several weeks; in other years, chlorosis comes and goes within a week and may have less of an impact on yield. However, these results are in line with previous data from North Dakota, where Goos (1998–2000) reported 9–19 bu/ac yield decrease per chlorosis unit at

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▼ *Figure 5b. Soybean yield decrease with increasing IDC rating as collected from the 2017 IDC trial.*

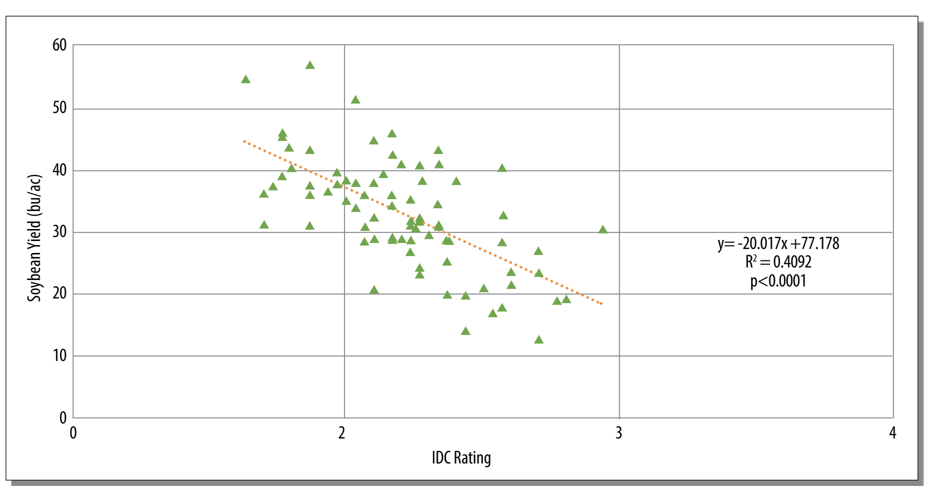

Figure 5c. The pattern of IDC in a field varies by soil and topography. In nearly level fields of the Red River Valley and Interlake, carbonates are often widespread in the soil (pictured left is a field planted to tolerant and susceptible variety). While areas where topography and salinity are at play, IDC may occur in only certain parts of the field, often low areas and headlands (pictured right). In other cases, the pattern may be unpredictable from year to year, making site specific management an even greater challenge.

V5–6. So if you were skeptical of variety selection as a management tool for iron chlorosis, I hope this convinces you otherwise.

BUT WHAT IF WE ARE DEALING WITH IDC PRONE AREAS, NOT ENTIRE FIELDS?

This past winter, I spoke of this topic to farmer audiences in Brandon and Clandeboye – and I surveyed the groups on their experiences with iron chlorosis. The majority indicated that IDC occurs every year, and that when IDC occurs, 10–25% of their acres are aff cted. The reason I asked these questions is because Helms et al. (2010) found that in North Dakota and South Dakota, varieties suited for IDC aff cted areas did not maximize yield in non-IDC parts of the fi ld, although in Kansas they did. In other words, varieties can perform diffe ently depending on the environment, but also potentially by site within environment or fi ld. To optimize yield across the whole fi ld, we could be planting multiple varieties or planting the overall best variety. But what varieties and where? Does this yield drag with IDC score exist in Manitoba? What is the overall best variety? The answers are not readily available.

MOVING TOWARDS SITE-SPECIFIC MANAGEMENT OF IDC

Currently, soil test values for calcium carbonates and soluble salts are used as predictors to evaluate fi ld risk for IDC; this index was developed by AgVise and was able to predict IDC occurrence 73–81% of the time. The best management strategy begins with soil testing, using this index to assess fi ld risk, and then choosing varieties based on fi ld risk in order to prevent the yield loss previously discussed. Another approach is using those soil layers for site-specific management – however, temporal and spatial variability in the occurrence of IDC across years and within fi lds remains a challenge. This is likely due to the interaction of soil factors with moisture and the heterogeneity of soil properties at a fine scale. Mapping the occurrence of IDC when it's actually happening, and letting the plants tell the story, is something I encourage you to start doing – it may provide the foundation for future site-specific management.

To move forward and address some of these questions, future work in Manitoba aims to evaluate soybean yield performance on both IDC and non-IDC sites within the same fi ld, potentially expand to multiple fi lds and attempt to characterize where IDC occurs in fi lds by building on previous literature. Stay tuned as more clues are unveiled. ■

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YIELD & QUALITY

Yield and Maturity of Late-Seeded Soybeans in Manitoba

Soybeans grown in Portage and Morden demonstrated good yield potential and little risk for seeding soybeans as late as June 9 to 12. Seeding between May 31 and June 6 at Arborg reduced yield potential and/or increased risk for not reaching maturity.

NEARLY HALF OF the 95+ soybean varieties evaluated in 2018 fell within the short-season category. These early-maturing varieties require less than 115 frost-free days to reach maturity.

In situations where spring planting is delayed, and farmers are presented with a shorter growing season, could early-maturing varieties be used to achieve acceptable yields and mature before the typical fall frost date?

Soybean seeding deadlines for full insurance coverage are May 30 for Area 2 (Portage), 3 (Arborg, Melita) and 4 (Roblin, Swan River), and June 6 for Area 1 (Morden). These deadlines have not been reviewed since 2005.

This project evaluated the potential of late-seeded soybeans in Manitoba and determined the feasibility of extending current crop insurance deadlines.

From 2015 to 2017, three soybean varieties (very early, early and mid-season) were planted in three seeding windows (late May, early June, mid-June) in Arborg, Portage and Morden. These locations vary in growing season length and latitude, but also represent three distinct Manitoba Agricultural Services Corporation (MASC) insurance areas. To evaluate the potential of late-seeded soybeans, data was collected on plant population, plant height, plant productivity, maturity, yield and seed quality. Regarding decision-making, yield and maturity are the most important variables.

MATURITY

At both Portage site-years, soybeans matured within at least one day of the normal frost date (Sep 25) regardless of seeding date. At Morden in 2017, all soybeans matured prior to the normal frost date (Sep 25), but in 2016, late- and very late-seeded soybeans matured beyond the normal frost date. As expected, Arborg showed the highest risk associated with seeding soybeans late. Soybeans at Arborg matured five days or more after the normal frost date (Sep 22) when seeded May 31 or later. In addition, two of the varieties at the very late seeding date did not mature in 2016.

YIELD

Soybean yields ranged from 24–53 bu/ac, depending on the site-year. Overall, the very early variety and very late seeding date tended to reduce yield.

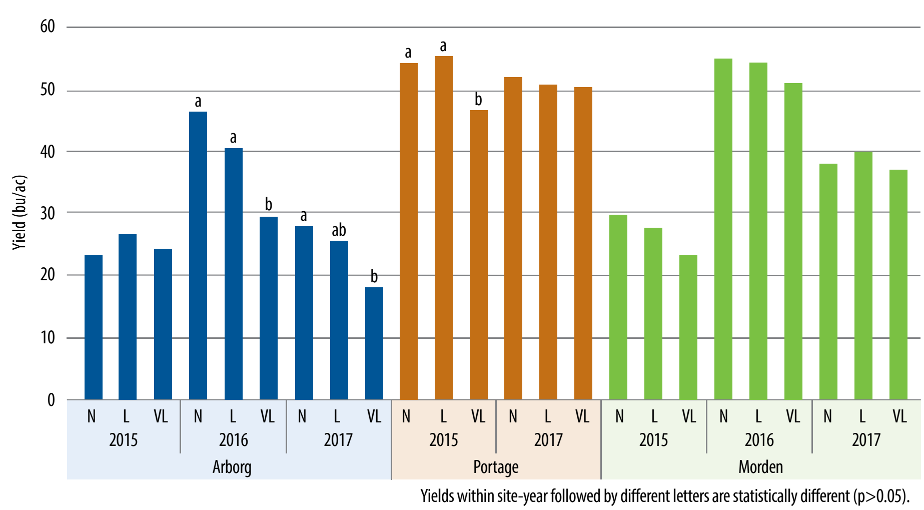
Historically, seeding dates and deadlines have considered 80% yield potential to be an acceptable benchmark. In other words, can late-seeded soybeans maintain 80% yield potential compared to a normal seeding date? To answer this question, the effect of seeding date within site-years was explored (Figure 6a).

Soybean yield across seeding dates was statistically similar at most site-years, except at Arborg, where soybean yield at the very late planting date was reduced to 65–67% of the normal planting date. Yield was reduced due to very late seeding at Portage in 2015, as well, but maintained 84% yield potential compared to the normal seeding date. All seeding dates were delayed at Morden in 2015, which contributed to reduced yields overall.

In summary, based on soybean maturity and yield potential, Portage and Morden site-years demonstrated good yield potential and little risk for seeding soybeans as late as June 12. At Arborg, seeding soybeans beyond June 6 typically resulted in a decline in yield potential and increased risk of not reaching maturity. When soybeans are seeded late, risk may be mitigated with appropriate variety selection.

The results of this research project are being reviewed in consultation with Manitoba Agriculture and MASC to support a review of soybean seeding deadlines for Areas 1–3.

Figure 6a. Soybean yield by seeding date (N = normal, L = late, VL = very late) within site-year.



PRINCIPAL INVESTIGATOR Kristen P. MacMillan, University of Manitoba,

MPSG INVESTMENT $17,610

CO-FUNDERS *Growing Forward 2* Growing Innovation: Agri-Food Research and Development Initiative

Effect of preceding crop and residue management on dry bean

(Carman and Portage la Prairie, 2017-ongoing)

Crop sequence within a rotation can influence yield through various agronomic factors, such as disease. There is currently no data available for Manitoba or the Northern Great Plains on the effect of preceding crop on dry bean yield and productivity. Currently, farmers in Manitoba are seeding dry beans most commonly following wheat, corn, canola, dry bean and oat (MPSG Survey 2014-2015). Long term data from Manitoba crop insurance demonstrates that crop yield response varies by previous crop type. From 2010-2016, 25% of navy bean acres were planted into spring or winter wheat stubble, 35% into canola stubble, 13% into navy bean stubble and 8% into corn stubble. Relative navy bean yield produced by those previous crop types was 109-112%, 93%, 86% and 103%, respectively. Crop residue management may also influence yield through soil moisture, seed placement and weed dynamics.

The objective of this experiment is to determine the effect of preceding crop type and residue management on dry bean productivity. In 2017 and 2018, four test crops were seeded in a sandy loam soil at Carman, MB and a clay soil at Portage la Prairie, MB. After harvest, each test crop plot was split into a tilled and direct seed treatment. Tillage was performed after harvest and the following spring. In 2018, Windbreaker pinto beans were seeded into each crop-residue management combination using a disc drill on 15" spacing. Both site-years (environments) are characterized as dry. Preliminary yield results of the 2018 pinto bean crop are summarized here and the trial is being repeated in 2019.

Pinto bean yield was affected by environment and the effect of preceding crop type and residue management (tillage vs. direct seed) varied by environment (Table 5a). Yields at Portage18 were higher than Carman18. At Carman18, pinto bean yield was greatest following pinto beans and was statistically higher than beans following canola. Pinto beans following corn and wheat were statistically similar to all other crop types. At Portage18, the effect of preceding crop type was not significant but showed the opposite trend to Carman (Figure 5a). Pinto bean yield was not affected by crop residue management (tilled vs direct seed) at Portage18 and at Carman18, direct seeded pinto beans yielded higher (2900 lbs/ac) than beans seeded into tilled residue (2300 lbs/ac). The effect of residue management was consistent among crop types (no interaction). Other data collected includes weed community (Figure 5b), root rot, nodulation and maturity to help further explain yield differences and identify agronomic factors that may influence crop sequence decisions.

Table 7a. Summary of analysis of variance for the effect of preceding crop type, residue management (tillage), environment and their interactions on pinto bean yield at Carman and Portage la Prairie in 2018.

Effect	Significant?
Environment	***
Crop type	ns
Tillage	ns
Environment x Crop	**
Environment x Tillage	*
Preceding crop x Tillage	ns
Environment x Crop x Tillage	ns

* Significant at 0.05 probability level
** Significant at 0.01 probability level
*** Significant at 0.001 probability level
ns = not significant

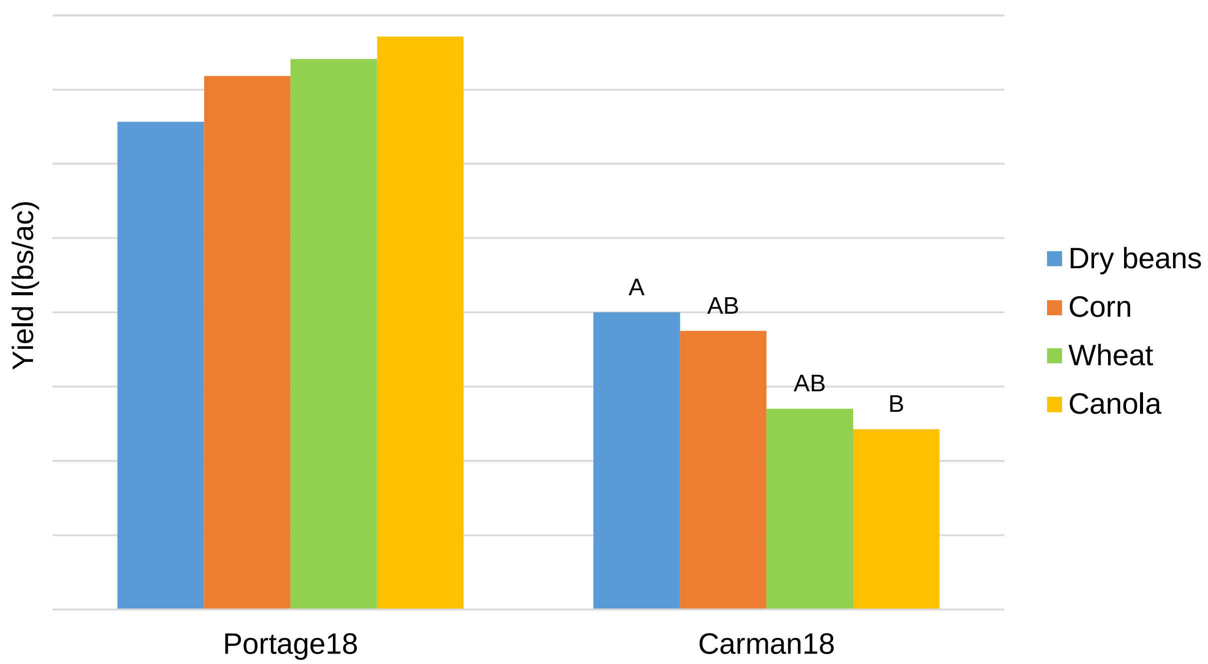


Figure 7a. Effect of preceding crop/stubble type on pinto bean yield varied by environment: yields were statistically different among stubble type at Carman18 only (*P* < 0.05).

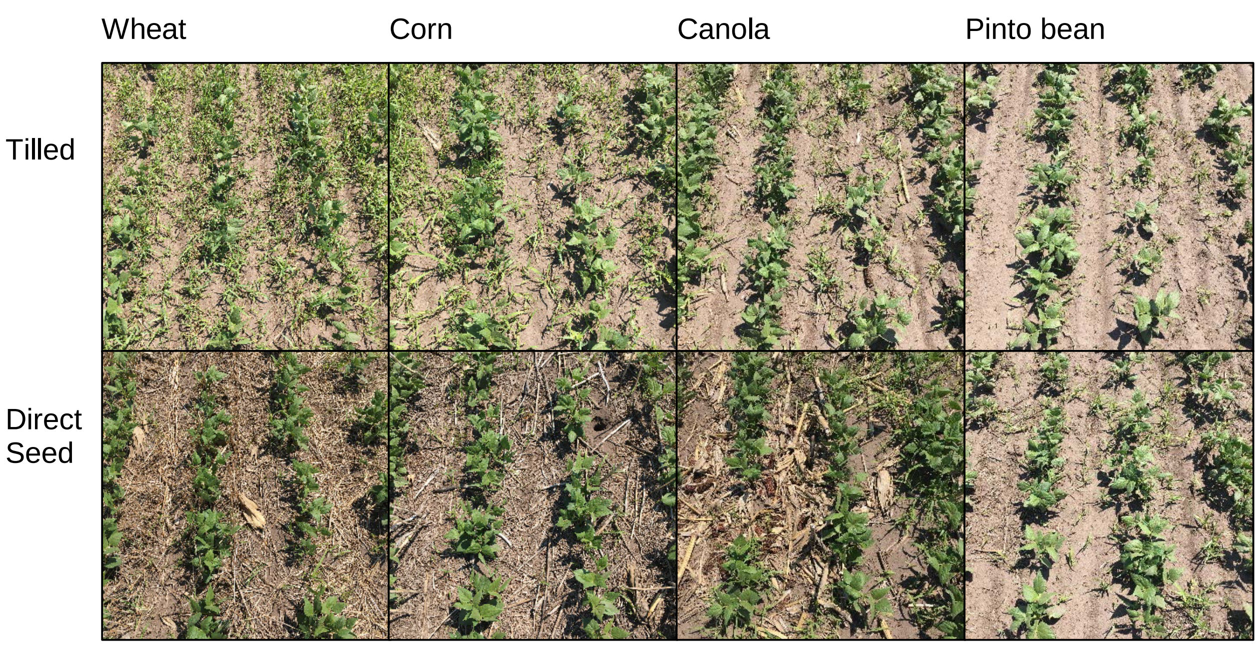


Figure 7b. Pinto beans were seeded May 23, 2018 into split plots of tilled and direct-seeded wheat, corn, canola and bean stubble at Carman, MB. Grass weed density was higher in tilled vs. direct seed plots and in pinto beans following wheat compared to all other stubble types.

Nitrogen rates for pinto and navy bean production in Manitoba

(Carman and Portage la Prairie, 2017-ongoing)

Despite being a legume, dry beans (*Phaseolus vulgaris*) are relatively poor N-fixers compared to soybean or field pea, for example. They produce less than 50% of their N requirements through symbiotic nitrogen fixation and their efficiency can be highly variable depending on cultivar and environment. Application of nitrogen fertilizer is standard practice in dry bean production systems in Canada and the United States, although recommendations vary by region. Currently, N recommendations in Manitoba are to achieve 70-120 lbs N/ac total N supply (soil + fertilizer N) depending on fall soil N level and production system (wide or narrow row) for a yield goal of 2,400 lbs/ac. This equates to 2.9-5 lbs applied N/cwt. Inoculation is not a standard practice in Manitoba since bean response to inoculation has been inconsistent in previous literature and inoculants for dry beans are not widely available. Since the last investigation of dry bean nitrogen fertility rates in Manitoba, cultivars have changed and yields have increased, providing justification to re-visit N recommendations. Further, N fertilization practices vary widely among dry bean farmers in Manitoba.

This study aims to compare five rates of N fertilizer (0, 35, 70, 105 and 140 lbs N/ac) in Windbreaker pinto beans and T9905 navy beans in Carman and Portage la Prairie, MB. Results of this study will contribute to 4R nutrient management practices by attempting to identify the agronomic and economic optimum N rate for dry beans in Manitoba.

The experimental design is a factorial arrangement of a split plot RCBD with 4 blocks (main plot = bean type, split plot = N rate). The method of fertilization is spring broadcast and incorporation of urea prior to planting dry beans on 15" row spacing. Non-inoculated beans were seeded into tilled wheat stubble with background N levels of 12-56 lbs N/ac from May 20-30 and were hand harvested September 10-20. The 2017 and 2018 growing seasons at Carman and Portage la Prairie were dry; precipitation from May through August was only 42-69% of normal. Data collection included plant population, days to flowering, nodulation score, disease ratings, maturity, pod height and yield. The Portage17 trial was discarded due to poor bean establishment (<40% of target population achieved) and non-uniformity. Data was analyzed using PROC Glimmix in SAS 9.4 with nitrogen rate, bean type, environment and their interactions as fixed effects, and block nested within environment as a random effect.

Preliminary results (2017-2018)

Preliminary analysis of the 2017 and 2018 combined site-years (environments) shows that bean yield was affected by environment, bean type and nitrogen rate, with no interactions among those fixed effects. Pinto beans yielded 2950 lbs/ac on average and navy beans yielded 2600 lbs/ac. The Carman17 and Portage18 environments both produced combined yields over 3500 lbs/ac compared to the lower yielding environment at Carman18 which yielded 1800 lbs/ac. Bean yield was maximized with the highest N rate of 140 lbs N/ac producing 3007 lbs/ac compared to 2536 lbs/ac in the control (Figure 8b). It is possible that variability masked other treatment effects. However, when investigating economic return to nitrogen, there were no statistical differences among N treatments (Figure 8c), ranging from $809-$900/ac [return to N ($/ac) = (yield x price) – (N rate x N price)]. The prices used were $0.31/lb for pinto beans, $0.33/lb for navy beans and $0.43/lb for N fertilizer. The effect of nitrogen rate and bean type on nodulation score varied by environment. Generally speaking, nodulation was reduced with increasing N rates at Portage18 and Carman17 with poor to fair nodulation scores overall (mean scores of <2 out of 4). There was virtually no nodulation at Carman18.

Total N supply (soil + fertilizer N) for bean yield in the control varied from 0.7-3.5 lbs N/cwt compared to 4.3-9.3 lbs N/cwt at the yield maximizing rate of 140 lbs N/ac. However, if we exclude the low yielding environment (Carman18), the mean value is 4.4 lbs N/cwt which is similar to the current estimate of 4.5 lbs N uptake/cwt identified by Heard and Brolley (2008) in Manitoba. With spring soil N levels of 23-56 lbs N/ac and estimated total N uptake values of 72-153 lbs N/ac in the control, 16-126 lbs N/ac was acquired through other processes, such as mineralization, biological N fixation (BNF) or root exploration > 24 inches. With some effective nodulation in the high-yielding environments (up to 10 nodules/plant) and periods of dryness, it is possible that these three processes each contributed to N availability. Measurements were not taken to allow consideration of nitrate-N from deeper depths, nitrogen derived from BNF or residual N at harvest.

White mould was only present at Carman17. In order to evaluate nitrogen rates in environments with a wider range of environmental and edaphic conditions, this experiment will be repeated at both locations in 2019 and will expand to include on-farm trials. Further, recently available inoculants will be tested in a new experiment.

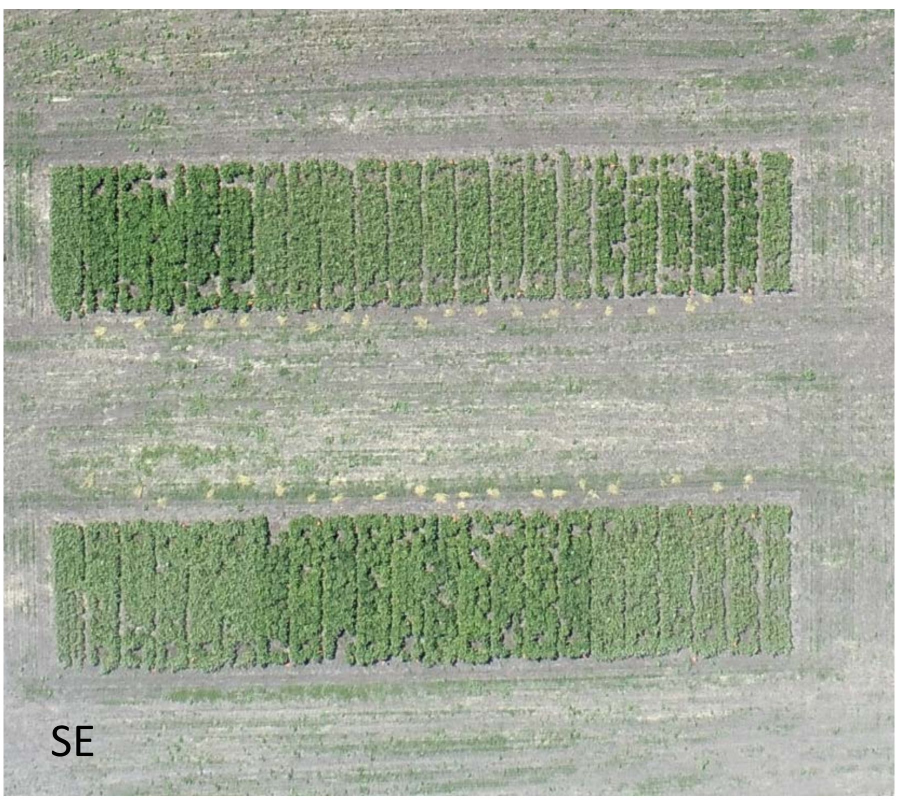


Figure 8a. Dry bean fertility experiment on July 27, 2018 in Portage la Prairie after plants were removed from the front and back of each plot for root rot and nodulation ratings.

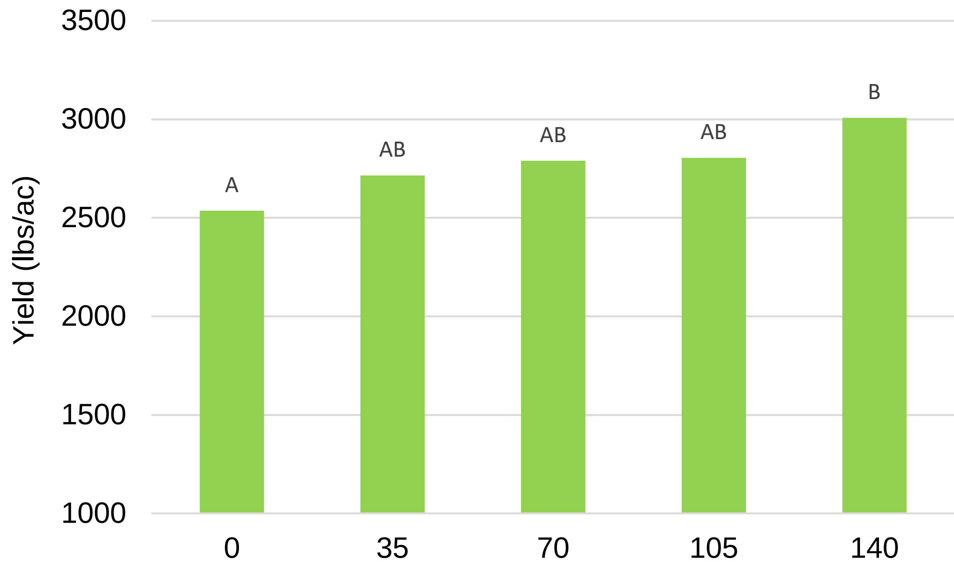


Figure 8b. Bean yield (lbs/ac) response to nitrogen rate (lbs/ac). Means followed by different letters are statistically different at $P < 0.05$.

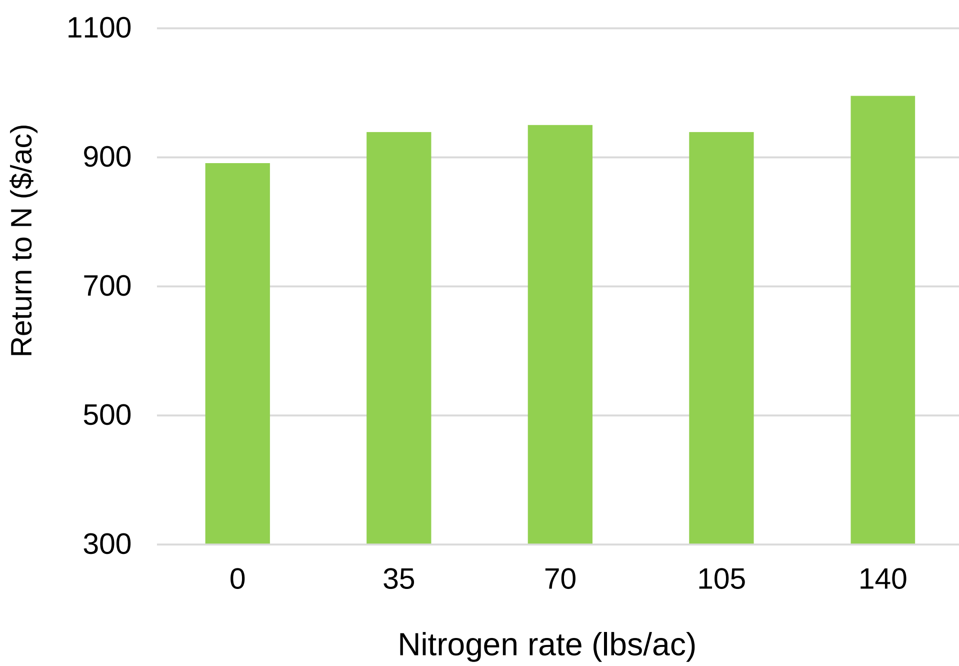


Figure 8c. Return to N ($/ac) was not statistically different among nitrogen rates ($P > 0.05$).

Novel pulse cropping systems – intercropping and relay cropping

(Carman 2017-ongoing)

Intercropping is the practice of seeding, growing and harvesting 2 or more crops together in the same field. Relay cropping is the practice of seeding one crop, usually a winter crop, and then direct seeding another crop into the existing crop so that their growing periods overlap. Harvest may take place separately or together. These cropping practices mimic the diversity found in nature and aim to increase system productivity by identifying crops that complement one another in one or more ways. At Carman, we established a demonstration of various intercropping and relay cropping treatments to explore this opportunity. Treatments were replicated three times and direct seeded into canola stubble with a plot seeder (except pea-oat, chickpea-flax, pea-canola, and monocrop peas and soybeans which were tilled before seeding). In 2018, no intercrop or relay crop combinations improved gross return or Land Equivalency Ratio (LER) compared to monocrop peas and soybeans. Drought was a limiting factor in addition to non-optimal seeding densities and weed competition in some treatments. This work continues and we will be comparing seeding rates in 2019.

Soybean-Flax intercrop

Soybean (S007Y4) and flax (CDC Bethune) were seeded in alternate 7.5" rows at full seeding rates; soybeans at 200,000 seeds/ac and flax at 55 plants/ft^2. Research from the Western Agricultural Diversification Organization (WADO) in Melita observed that alternating rows were superior to mixed rows (Scott Chalmers, personal communication). Seed depth was 1.5" for both crops. Soybeans were inoculated and no additional fertility was added for the soybeans or flax. Assure II grassy herbicide was sprayed and plots were hand weeded. There are other pre and in crop herbicide options that will be utilized in 2019. Emergence was recorded on May 31 and established plant densities were 157,000 soybean plants/ac (80% est.) and 25 flax plants/ft^2 (45% est.). Our observations indicate that soybean staging was delayed in intercrop and relay treatments compared to the monocrop and that soybeans matured early compared to the monocrop, likely due to moisture stress. On Aug 14, soybeans were rated at R7 with only 5-9 nodes, 3-5 pods/plant and many aborted pods. Flax bolls were brown and green. Soybean and flax were hand harvested on Aug 24. Canopy height of soybean was 30-40cm and flax was 50-60cm. Average soybean yield was 6.9 bu/ac and flax yield was 6.3 bu/ac (gross revenue = $156), compared to the soybean monocrop which yielded 23.6 bu/ac (gross revenue = $260). Yield potential was limited by drought and weed competition in 2018. Future studies aim to evaluate seeding rates, preceding crop, weed management options and fertility. Research at WADO is evaluating N fertilizer placement.

Pea-Oat intercrop

Peas (CDC Amarillo) and oats (Souris) were seeded May 3, 2018 in mixed 7.5" rows at a depth of 1.25". A full seeding rate for peas (100 seeds/m2) and low rate of oats (5 seeds/ft2) was used. Our aim was to seed a half rate of oats but an error was made. Granular pea inoculant and 25 lbs actual P/ac (MAP) were put down with the seed and 40 lbs actual N/ac (urea) was broadcast and incorporated prior to seeding. Ideally, N application would be directed to the oats only but this is not possible in a mixed row system. No herbicides were used for weed control as there are no in crop options. Oats generally provided good weed competition - pea-oat is a common green manure crop used in organic crop rotations - however, wild oats were a problem and some hand rogueing was done. Established plant densities were 38 plants/m^2 for peas (38% est.) and 1 plant/ft^2 for oats (21% est.). Peas and oats were harvested together on Aug 1, 2018 with yields of 15.8 bu/ac for peas and 11 bu/ac for oats (gross revenue = $147/ac) compared to 34.5 bu/ac monocrop peas (gross revenue = $242/ac).

Pea-Canola intercrop

Peas (Amarillo) and canola (5545 CL) were seeded in the same mixed rows on 7.5" spacing using a full rate of peas (100 seeds/m^2) and half rate of canola (7 seeds/ft^2). Urea was broadcast and incorporated to provide 50 lbs N/ac (urea) ahead of seeding and 25 lbs actual P/ac (MAP) was placed with the seed. The seeding depth was 1-1.25" which proved to be too deep for the canola as it did not emerge (<1 plant/ft^2) and this treatment behaved as a pea monocrop. Pea-canola is one of the most well researched intercrops and comprises a large share of commercially grown intercrops in western Canada. We learned from this demonstration that seed depth is a very important consideration.

Winter wheat - Pinto bean relay crop

Winter wheat (Falcon) was seeded in 15" rows using a plot seeder in fall 2017 into canola stubble. A full seeding rate of 4.7 bu/ac targeting 30 plants/ft^2 was seeded at a depth of 0.75". Additional fertility included 30 lbs P/ac seed placed (MAP) and 100 lbs N/ac spring broadcast urea. Pinto beans (Windbreaker) were seeded on 15" rows in between the already emerged rows of winter wheat on May 24 when the winter wheat was 6-8" tall with 1 tiller. Seeding depth was 1.25" at a full seeding rate of 100,000 seeds/ac targeting 70,000 plants/ac. Established plant densities were 8.6 plants/ft^2 winter wheat (24% est.) and 37,000 bean plants/ac (37% est.). Buctril M was applied for the control of broadleaf weed a few days after bean seeding. Fields with a history of grass problems are not recommended for this system, as it will be difficult to treat these weeds before wheat harvest. At winter wheat harvest, canopy height of the wheat was 50-60cm and 30-40 cm for the pinto beans which were at seed fill, with few pods. Winter wheat yielded 16.8 bu/ac on Aug 2 and pinto beans yielded 274 lbs/ac on Aug 30. Poor winter wheat establishment, lack of moisture and grasshopper infestation negatively impacted yield. Previous research has also shown that winter wheat extract negatively affects navy bean germination compared to rye and triticale (Flood and Entz 2000), although in our demonstration pinto beans established better in winter wheat than fall rye. This may have been due to higher moisture use by the fall rye crop which induced the more severe drought symptoms we observed in the pinto bean-fall rye system.

Fall rye-Pinto bean relay crop

Fall rye (Hazlet) was seeded on 15" rows Sept 21, 2017 at a full seeding rate of 4 bu/ac targeting 24 plants/ft2 and seed depth of 1.25-1.5". Fertility included 30 lbs P/ac seed placed and broadcast urea in spring 2018 at 100 lbs N/ac. On May 23, 2018 Windbreaker pinto beans were seeded between the established rows of fall rye (15" center) which was 12-18" tall with 1-2 tillers. A full seeding rate of 100,000 seeds/ac was seeded at 1.25-1.5". Established plant densities of fall rye and pinto beans was 23 plants/ft2 (71% est.) and 24,000 plants/ac (24% est.), respectively. No herbicide applications were made as fall rye suppressed most weeds. The beans showed severe drought symptoms beginning early June (not evident in winter wheat relay crop). On July 13, the fall rye was at the hard dough stage and the pinto beans had yet to flower. Fall rye was hand harvested on July 24 and yielded 40 bu/ac. At the time of harvest, canopy height of the fall rye was 30-40cm and the pinto beans were at V5. Plots were sprayed due to grasshopper infestation but damage was sustained. Pinto beans were harvested Aug 30 producing 33 lbs/ac. Lack of moisture and grasshopper infestation negatively affected the yield of pinto bean.

Winter wheat-Soybean relay crop

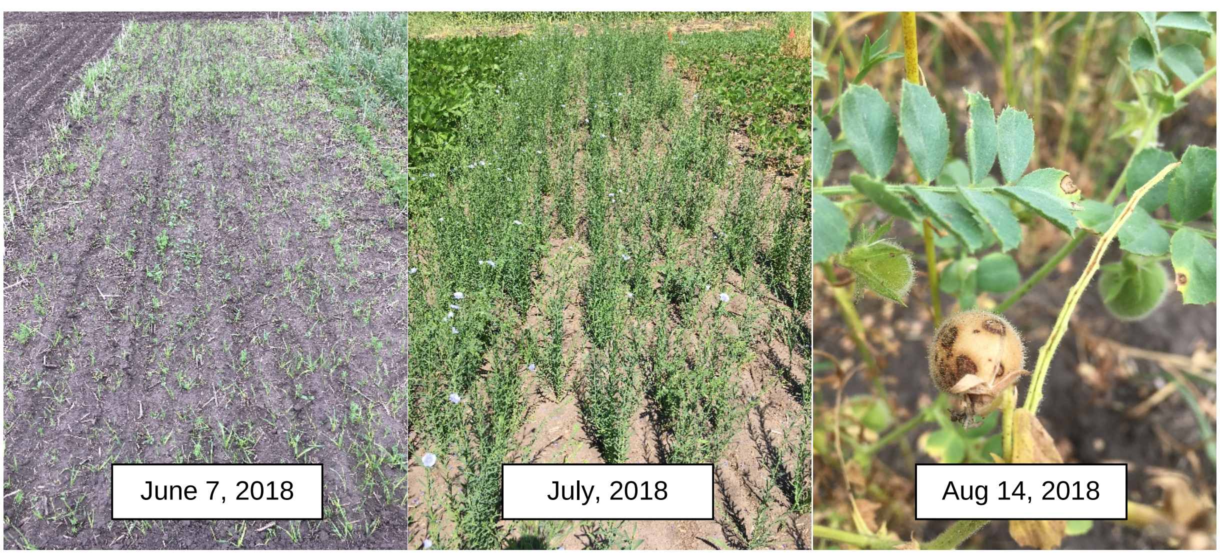
Winter wheat (Falcon) was seeded on 15" rows Sept 21, 2017 at a full seeding rate of 4.7 bu/ac at a depth of 0.75". Fertility included 30 lbs P/ac (MAP) seed placed and spring broadcast urea at 100 lbs N/ac prior to rain. Soybeans (S007Y4) were seeded May 23, 2018 between the emerged rows of winter wheat which were 6-8" tall with 4-5 leaves and 1 tiller. A full seeding rate of 200,000 seeds/ac was seeded at 1.25". Established plant densities of winter wheat and soybeans were 7 plants/ft2 (19% est.) and 89,000 plants/ac (44% est.), respectively. Buctril M was applied for the control of broadleaf weeds prior to soybean emergence. Dicamba tolerant soybeans could be used in this system which would allow for broadleaf control in crop. On July 13, winter wheat was at the soft dough stage and soybeans were at V4/R1. Winter wheat was hand harvested Aug 2 yielding 15.5 bu/ac. At time of cereal harvest, canopy height of winter wheat was 45-55cm and soybeans were 30-50cm and staged at V9/R5. Plots were sprayed for grasshoppers. oybeans were harvested Aug 30 and yielded 3.7 bu/ac. Poor winter wheat establishment, lack of moisture and grasshopper infestation reduced yield potential.

Fall rye-Soybean relay crop

Fall rye (Hazlet) was seeded on 15" rows at a full rate of 4 bu/ac at 1.25-1.5" in fall 2017. Fertility included 30 lbs P/ac seed placed (MAP) and 100 lbs N/ac spring broadcast urea. On May 23, 2018 soybeans (S007Y4) were seeded between the established rows of fall rye (12-18" tall, 1-2 tillers) at 200,000 seeds/ac at a 1.5" depth. Established plant densities were 21 wheat plants/ft2 (66% est.) and 58,000 soybean plants/ac (29% est.). No herbicide applications were made as the fall rye suppressed most weeds. On July 13, fall rye was at hard dough and soybeans were at V4/R1. Fall rye was hand harvested July 24 yielding 33 bu/ac. Canopy height of fall rye was 35-40cm compared to 25-40cm for soybeans. Plots were sprayed with Coragen to control grasshoppers. Intercrop soybeans were harvested on Aug 30 yielding 1.6 bu/ac. Monocrop soybeans were harvested Oct 1 and yielded 23.6 bu/ac.

Chickpea-Flax intercrop

Chickpea and flax (CDC Bethune) were seeded in the same mixed 7.5" rows on May 25, 2018 at 1-1.25" depth. Full seeding rates were used for both crops (chickpeas: 4 seeds/ft^2 and flax: 55 plants/ft^2). Authority and glyphosate was sprayed a few days after seeding and Assure II was sprayed in-crop for grassy weed control. Established plant densities were very poor for both crops: 5 plants/ft^2 for flax (10% est.) and <1 plant/ft^2 for chickpea (<25% est.). Chickpeas did not emerge well and is attributed to poor seed quality based on observations following a low score germination test due to fungal infection. There are no in crop broadleaf herbicide options, making weed pressure a challenge especially with poor crop establishment in our plots and volunteer canola was also present. Hand weeding was done. Maturity of the chickpeas and flax seemed complementary but an additional challenge was ascochyta blight that was evident on the chickpea leaves and pods despite dry conditions. Flax and chickpea were hand harvested on Aug 24 and allowed to dry down, producing 13 bu/ac of flax and 4 bu/ac of chickpeas. Canopy height was 40-60 cm for flax and 35-40cm for chickpeas.



Winter camelina

Spring-type camelina is currently grown on limited acreage in Saskatchewan and winter-type camelina, while not commercially produced has been grown successfully in research trials in Minnesota. We seeded winter camelina (Joelle) on Sept 18, 2017 at 8 lbs/ac (~65 seeds/ft^2) on 7.5" rows at 0.5" with 16 lbs P_20_5/ac seed-placed and 60 lbs N/ac broadcast prior to rain. Spring plant density was 3.4 plants/ft^2 which is <4% establishment. Camelina seed is very small and requires very shallow seeding. Assure II was used for grassy weed control but no broadleaf herbicides are registered in crop so hand weeding was also done. Camelina was hand harvested July 24, 2018 and yielded 13.8 bu/ac. Plant establishment (seed depth, winter hardiness), weed control and drought were challenges for this crop.

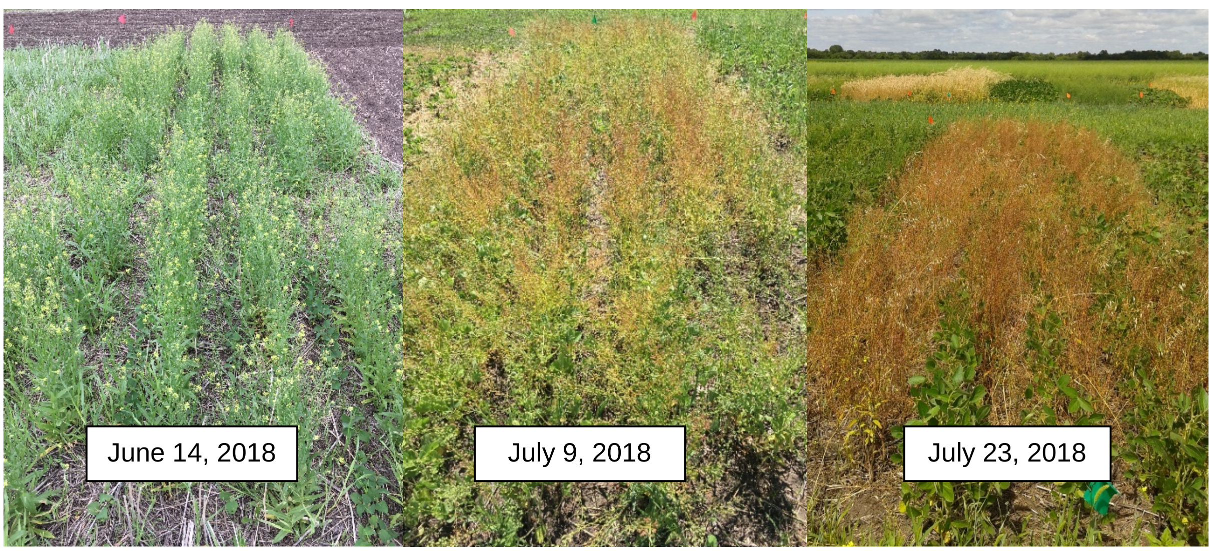
Winter camelina-Pea relay crop

Winter camelina (Joelle) was seeded in fall 2017 at 6 lbs/ac on 7.5" rows with 30 lbs MAP/ac seed placed at a depth of 0.5". Winter peas (Windham) were also seeded in the same row and reached 4-5 nodes prior to freeze up but did not overwinter. Therefore, inoculated spring pea (Amarillo) was seeded between the winter camelina rows in spring 2018 at 100 seeds/m^2 at 1.5" with 25 lbs MAP/ac. Established camelina and pea populations were 1 plant/ft^2 (2% est.) and 33 plants/m2 (33% est.), respectively. Assure

II was sprayed for grass control but there are no in-crop herbicide broadleaf options so some hand weeding was done. Winter camelina is an early maturing crop – it was flowering in mid-June and ready for harvest by mid-July when the peas were starting to mature. Seed retention was good and both crops were hand harvested on July 24, producing 1.0 bu/ac of camelina and 22.4 bu/ac of peas compared to 34.5 bu/ac in the pea monocrop and 13.8 bu/ac in the winter camelina monocrop. Winter camelina shows potential as relay/intercrop but crop establishment and weed control is a challenge as there are no registered herbicides for broadleaf control in crop.

Winter camelina-Soybean relay crop

Winter camelina (Joelle) was seeded in fall 2017 at 6 lbs/ac on 15" rows with 30 lbs MAP/ac with the seed at a depth of 0.5". Inoculated soybean (S007-Y4) was relay cropped between the rows of camelina on May 23, 2018 at a full seeding rate of 200,000 seeds/ac at a depth of 1.25". Established plant densities were 104,000 plants/ac for soybeans (52% est.) and 1 plant/ft^2 for camelina (1.5% est.). Winter camelina was hand harvested on July 24 when the soybeans were at pod fill, producing 8.9 bu/ac. Soybeans were harvested Aug 30 and produced 5.8 bu/ac. The land equivalency ratio (LER) for the relay crop was 1.2 and 0.6 compared to the monocrop camelina and soybean, respectively. Thus, the relay crop out-performed the monocrop of camelina (LER >1) but not the soybean monocrop (LER <1). Winter hardiness and weed control will remain challenges for this relay crop. This relay crop was first tested near Morden in 2017 by Manitoba Pulse & Soybean Growers in collaboration with Smart Earth Seeds.



Growing Season Weather Summary

	Soil type	May	June	July	Aug	M-A	May	June	July	Aug	M-A
		Mean daily temperature (°C)					Precipitation, mm				
Arborg17	Clay	10.1	16.2	18.9	16.9	15.5	23	54	76	56	209 ↓
Arborg18	Heavy Clay	13.3	18.4	19.8	17.9	17.4	34	37	58	61	190 ↓
LTA-Arborg		10.0	15.8	18.6	17.5	15.5	55	81	70	69	276
Carman17	Fine Loam	12.1	17.1	19.4	17.7	16.6	25	64	23	23	135 ↓
Carman18	Sandy Clay Loam	14.7	18.8	19.9	19.1	18.1	48	97	43	31	219 ↓
LTA-Carman		11.6	17.2	19.4	18.5	16.7	70	96	79	75	319
Melita17	Loam	12.2	16.8	21.6	18.7	17.4	6	64	45	39	154 ↓
Melita18		15.3	19.1	19.4	18.8	18.1	11	98	54	23	187 ↓
LTA-Melita		11.2	16.5	19.2	18.5	16.3	65	88	62	46	260
Dauphin18	Silty clay loam	13.6	18.8	19.1	17.3	17.2	38	104	91	3	236 ↓
LTA-Dauphin		10.5	15.7	18.7	17.7	15.7	55	82	73	61	271

LTA = long term average, ↑ ↓ = +/- 10% of normal, data sources: Manitoba Agriculture and Environment Canada

Collaborating Partners

The soybean and pulse agronomy research lab would like to thank the following teams for their contribution to our research in 2018 and for making province-wide research possible.

- Curtis Cavers, Danny Bouchard and team at the Canada-Manitoba Crop Diversification Centre (CMCDC) in Portage la Prairie for hosting multiple soybean and dry bean trials.
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- Nirmal Hari, Britney Gilson and team at the Prairies East Sustainable Agriculture Initiative (PESAI) in Arborg for hosting multiple soybean trials.
- Ag Quest for hosting soybean trials at Minto and Dauphin.
- Dr. Bob Connor and Waldo Penner of Agriculture and Agri-Food Canada (AAFC) at Morden for collaborating on data collection in dry beans.
- Dennis Lange of Manitoba Agriculture for collaborating on the soybean iron deficiency chlorosis variety evaluation trial.

CMCDC PESAI WADO Agriculture and Agri-Food Canada AG-QUEST Celebrating 35 Years of Research You Can Trust