MANITOBA PULSE & SOYBEAN GROWERS

pulsebeat

The Science Edition

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On-Farm Network ‣ Agronomy ‣ Breeding

Nutrition & End-Use

Developing production tools and market demand for profitable and sustainable farms through local research.

PM40016070

Welcome to the second edition of *Pulse Beat – The Science Edition*.

Look anywhere and science and innovation are driving improvements to agriculture. In our corner of the globe, Manitoba Pulse & Soybean Growers (MPSG) invests in research that specifically supports Manitoba farmers. That means aligning MPSG's research investments with its member-mandated mission to support profitable and sustainable pulse and soybean production. It also means focusing on things that matter to farmers' bottom line: crop yield and quality; pest control costs; driving demand from end-users: and soil quality. As a result, most of the funds awarded for research support projects in agronomy, plant breeding and end-use attributes.

Central to MPSG's mandate is the transfer of research results to farmers. This effort begins with MPSG's On-Farm Network, where with the help of MPSG staff, farmers subject research findings to a final test under actual farm conditions. The effort extends to summarizing virtually all research results into reports and fact sheets posted to www.manitobapulse.ca. MPSG agronomists also walk-the-talk by speaking in-person with farmers across the province and retracing those steps through in-season surveys of crop health. Of course, there's the popular magazine *Pulse Beat*. This science-oriented version of *Pulse Beat* reveals the breadth and depth of MPSG's research program including details from projects conducted in laboratories, field trials and the On-Farm Network.

By reporting the full story behind research projects, we hope members gain a sense of where their MPSG dollars are invested. We also hope *The Science Edition* ignites and informs practical comparisons among research results. Ultimately, it's the prospect of stimulating critical thinking among members that drives MPSG to seek new production insights through research. We hope you find this edition to be the start of new ideas for your farm.

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On-Farm Evaluation of Soybean Seed Treatment

Applying seed treatments as a form of self-insurance prevented yield loss 14% of the time. Managing soil-borne pests will become more deliberate and precise only when the risk of loss is easier to estimate.

WHILE THERE ARE proven scouting techniques and economic thresholds for several foliar pests, farmers have very few tools to estimate risk from soil-borne pests. As a result, seed treatments are frequently applied on a just-in-case basis with little knowledge of the risk soil-borne pests actually pose to a given crop. With the cost of common seed treatments ranging from $6–18/ac, optimizing the seed treatment decision would be a positive step toward profitable and sustainable soybean production.

The objective of this project was to examine the decision to treat seed versus planting untreated seed when armed with minimal knowledge of the risk from soil-borne pests.

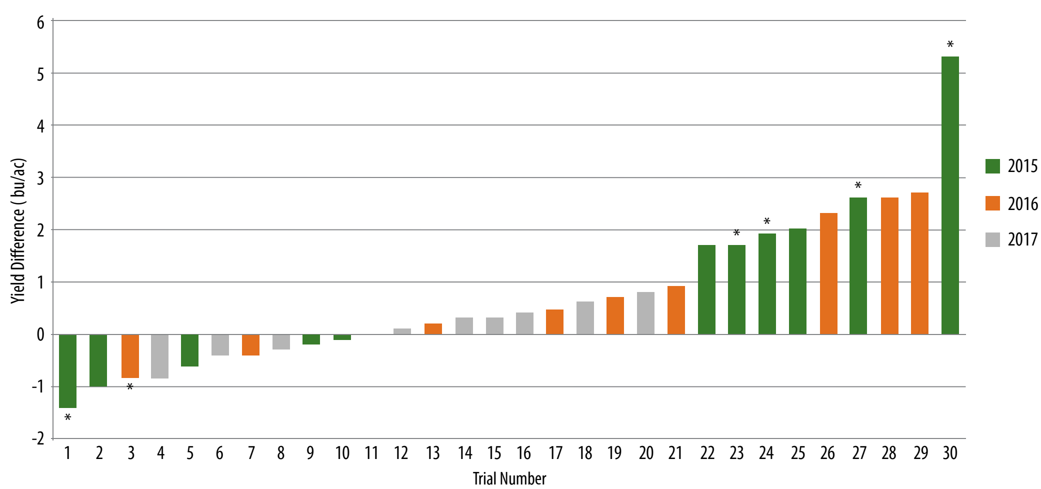
Thirty On-Farm Network soybean field trials were established in eastern Manitoba comparing treated versus untreated seed. Seed treatments consisted of fungicide + insecticide (Cruiser Maxx Vibrance Beans or EverGol Energy + Stress Shield) or fungicide alone (EverGol Energy). In addition, one on-farm trial was conducted in the south Interlake that included the above treatments plus a seed treatment of the fungicide Vibrance Max RFC. Each treatment was replicated three to six times per trial and planted at the host farmer's normal seeding rate (190,000 seeds/ac on average). The south Interlake trial was planted at 220,000 seeds/ac. Field histories varied from more than six previous soybean crops to first-time soybeans. Other than field cropping history no attempt was made to identify soil-borne pests prior to seeding.

Overall growing conditions were very good resulting in robust crop growth. The average soybean yield across eastern sites was about 43 bu/ac with the south Interlake site producing 47 bu/ac. Ten trials yielded more than 45 bu/ac while only two trails yielded less than 30 bu/ac.

Within individual trials, the decision to treat seed resulted in a yield benefit four out of 30 times (14%) (Figure 1). There were no differences in yield among the seed treatment products in any trial. In two trials, the treated plots yielded less than untreated checks. The extent of testing necessary to reveal reasons for this effect was outside the scope of this study. In the four cases where yields were higher with treated seed, it is assumed the products protected the crops from yield-reducing soil-borne pests. However, no attempt was made to measure pest incidence across treatments.

These trials focused on the decision to incur the cost of treating seed when it is not possible to accurately gauge risk – where the choice to treat seed is taken as a means of self-insurance. The suitability of this approach depends on a farmer's perspective on risk. However, it is likely that this approach is not sustainable. The imperative lies with producer groups to encourage the development of pest scouting tools that enable the responsible and profitable use of crop-protection chemicals. To view individual reports for these trials, visit manitobapulse.ca/on-farm-network. The use of seed treatments should be evaluated on a field basis, considering the risk factors that would warrant a seed treatment. To learn more about these risk factors, consult the *Soybean Seed Treatment Risk Assessment* fact sheet at manitobapulse.ca.

Figure 1. Yield difference between soybean seed with and without seed treatment at 30 On-Farm Network trials in eastern Manitoba from 2015–2017.



*Denotes statistically significant yield response at 95% confidence level.

PRINCIPAL INVESTIGATOR Manitoba Pulse & Soybean Growers and Tone Ag Consulting

MPSG INVESTMENT $11,775

ACKNOWLEDGEMENT Seed donated by Syngenta Canada and Bayer CropScience

DURATION 3 years

on-farm network
PARTICIPATORY • PRECISE • PROACTIVE

AGRONOMY

Evaluation of Seeding Rate and Fungicide Use in Field Peas

Single and sometimes multiple foliar fungicide applications are needed to maximize pea yields at the recommended target plant density.

WITH RENEWED INTEREST in growing field peas in our province, farmers need refined, local agronomic recommendations. A multi-input trial conducted in Saskatchewan found that a higher seeding rate (120 seeds/m^2), granular inoculant and two foliar fungicide applications increased yields and economic return compared to a low seeding rate (60 seeds/m^2), liquid inoculant and no fungicide. This study, however, did not assess intermediary seeding rates or a single fungicide application. To further investigate the interaction between these inputs, a range of seeding rates (60, 80, 100, 120 and 140 seeds/m^2), in combination with no fungicide, one (Headline EC at 10% flower) or two applications of fungicide (Headline EC at 10% flower + Priaxor 12–13 days later) were evaluated.

Though the target plant density for peas is well established (75–85 plants/m^2), there is evidence that higher plant populations are required to maximize yields when weed or root rot pressure is high. Foliar fungicide is usually applied to control Manitoba's most prevalent foliar disease, Mycospharella blight; however, it is unclear if multiple applications are required for effective disease control. A thicker crop canopy caused by higher plant stands may increase disease pressure, so it is appropriate to investigate the effect of these inputs on pea yield.

Small plot trials were conducted at Minto (2015 and 2016) and Hamiota (2016). The variety CDC Meadow was direct-seeded into wheat stubble on 8–9 inch rows from May 9–12. Fungicide seed treatment and liquid inoculant were applied on-seed and granular inoculant was applied in-furrow.

As expected, both seeding rate and foliar fungicide had a significant effect on pea yield in each site-year. Yields ranged from exceptionally high (95 bu/ac) to low (17 bu/ac). Yields were maximized at plant densities of 74, 78 and 96 plants/m^2 at Minto (2016), Hamiota and Minto (2015), respectively (Figure 1). In addition, seeding above the recommended density may result in higher yields but the additional seed cost may not pay every year (e.g. Minto 2016).

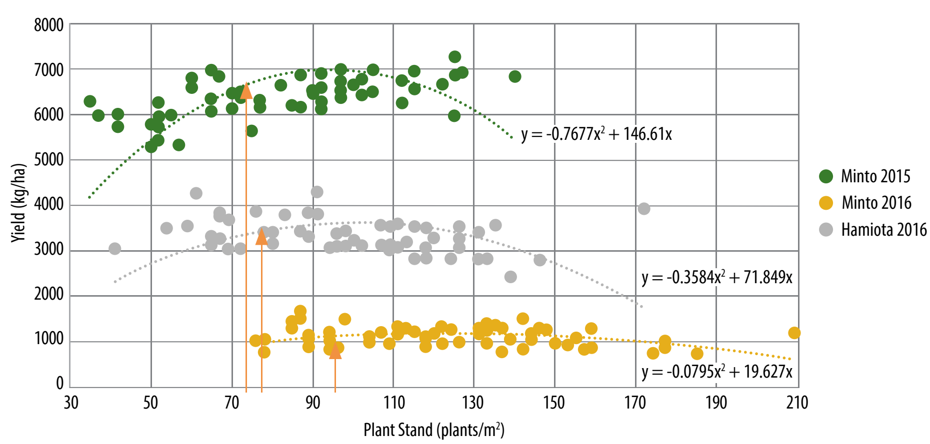
Although there was a response to foliar fungicide in each site-year, the results were not consistent (Table 1). In 2015, one and two fungicide applications yielded 4.2 and 5.6 bu/ac more than the no-fungicide treatment. At Minto in 2016, both single and double application increased yields by 1.5 and 5.2 bu/ac compared to the control. At Hamiota (2016), only the double applications increased yield (7.0 bu/ac) compared to the control. Yield increases due to fungicide were reflected by a reduction in Mycosphaerella blight disease ratings taken 7–20 days after the second fungicide application (data not shown). Manitoba Pulse & Soybean Growers On-Farm Network trials initiated in 2017 will continue to validate single and double foliar fungicide applications in field peas.

Table 1. Field pea yield at Minto (2015 and 2016) and Hamiota (2016) for no fungicide, one application and two applications of fungicide.

Foliar Fungicide Treatment	Minto		Hamiota
	2015	2016	2016
	bu/ac		
No Fungicide	91.4 b	14.7 c	46.8 b
One Application	95.6 a	16.2 b	48.9 b
Two Applications	97.1 a	19.9 a	53.8 a
Average Yield	**95.3**	**17.1**	**50.2**

Different letters within site-years indicate statistically significant differences among treatments.

Figure 1. Field pea plant stand and yield at Minto (2015 and 2016) and Hamiota (2016). Arrows indicate plant density that achieved 95% of maximum yield at each site-year.



PRINCIPAL INVESTIGATOR Manitoba Pulse & Soybean Growers

MPSG INVESTMENT $23,813

ACKNOWLEDGEMENT AgQuest

DURATION 2 years

AGRONOMY

Research and Technical Support for On-Farm Transition to Organic Soybean Production

Organic, non-GM soybean yields are heavily influenced by the growing environment and weed pressure. Co-designed farming systems that integrated researchers and farmers aided the transition to organic soybean production.

DEMAND FOR ORGANIC soybeans is growing, although technical knowledge and suitable varieties are barriers to farmer uptake. This project addressed those barriers by evaluating varieties on-farm under organic conditions and by offering a *farming system co-design* process of technical support for farms seeking to transition a portion of their land to organic production.

ON-FARM VARIETY EVALUATION

Most non-GM soybean varieties are developed under weed-free conventional conditions. In this experiment, twelve non-GM soybean varieties were evaluated on five organic farms and one transition-to-organic farm in southern Manitoba in 2014 and 2015. On each organic farm, variety performance was compared with a weed-free sub-plot. Weed management under organic conditions consisted of pre-emergence harrowing and inter-row cultivation at V1–V2.

Growing environment contributed more to soybean yield than variety choice. Factors that encouraged weed growth, such as high soil nitrogen (N) at seeding, soil organic matter and soil potassium level had a greater impact on yield than variety choice. It is, therefore, recommended that organic soybeans be grown on land with very low soil N, where adequate weed control options are available.

Based on expected organic soybean yield for the area and recent organic prices, this study found that soybeans were profitable even with a 20% yield loss to weeds. However, with better weed control tools now available, a 20% yield loss can be avoided. The effect of variety choice on weed biomass at soybean maturity was insignificant. Moreover, early-and late-maturing soybeans suffered similar yield loss due to weeds. Additional variety traits deemed important were rapid and efficient nitrogen fixation and tolerance to weed competition.

FARMING SYSTEM CO-DESIGN

The *farm system co-design* process is a new approach to farm planning, bringing farmers and researchers together, easing the transition for farmers entering the organic soybean market.

In co-designed systems, researchers bring their knowledge of theories and research results to complement farmers knowledge of soils, equipment, labour and markets. Together, the farmer and researcher come up with several scenarios that could help meet the farmer's goals. Then, with the support of the researcher, the farmer executes a scenario, making adjustments along the way. The farmer-researcher team observe, learn and adapt the plan accordingly.

Twelve farms participated in the co-design. Scenarios tested by conventional and transitional farmers focused on green manures and establishing an organic rotation. Established organic farmers tested row spacing, in-crop tillage, seeding rates and variety choices. One-on-one interactions with researchers provided valuable knowledge to aid the transition process. This program also enabled farmers to connect, creating a community of farmer learning and support. Visit umanitoba.ca/outreach/naturalagriculture to connect with the researchers in this program.

Table 1. Non-GM soybean varieties tested under organic conditions.

Variety	Relative Maturity	Soybean Yield (bu/ac)	Soybean Yield Loss Due to Weeds (%)
Tundra	000.5	21.8 b	37
SK0007	000.7	21.7 b	32
OAC Prudence	00.7	21.1 b	30
Toma	00.7	23.6 ab	28
OAC Petrel	00.5	22.3 b	36
DH 863	00.6	24.3 ab	28
DH 401	00	20.6 b	28
Jari	0.5	21.2 b	27
Auriga	0.5	24.1 ab	36
SVX14T0053	0	23.3 b	34
Savanna	0.4	26.9 a	31
Krios	0	23.4 ab	32

Different letters within columns indicate statistically significant differences among treatments.

PRINCIPAL INVESTIGATOR Dr. Martin Entz, University of Manitoba

MPSG INVESTMENT $20,000 | DURATION 3 years

CO-FUNDERS *Growing Forward 2*: Agri-Food Research and Development Initiative, Organic Science Cluster II, Organic Valley Co-op, Western Grains Research Foundation

2016 Manitoba General and Herbicide Resistant Weed Survey

Volunteer canola was the most abundant weed in soybeans and 68% of surveyed fields had Group 1 and/or 2 herbicide-resistant weeds.

PROVINCIAL WEED SURVEYS help us understand changes in weed populations both geographically and over time. Identified trends inform industry, research and extension efforts in weed management and highlight new threats that farmers may need to manage.

The fifth general weed survey was conducted in 2016, 14 years since the previous. The eight most common annual crops were surveyed: canola, spring wheat, soybeans, oats, barley, corn, flax and sunflowers. Soybeans, corn and sunflowers were included for the first time, representing an enormous change to our crop rotations and production practices. A minimum of 20 fields per crop and a total of 658 fields were randomly selected and sampled. Weeds were counted within a 0.25m^2 quadrat at 20 locations in each field. Counts were taken between July 18–Sept. 2, identifying the extent of troublesome weeds that escaped control measures.

A total of 139 weed species were identified. The 10 most abundant weeds (a function of weed frequency, field density and field uniformity) are listed in Table 1. A notable change from past surveys was wild oats, which fell from second most abundant weed to fourth, surpassed by wild buckwheat and barnyard grass. Spiny annual sow thistle increased the most in abundance since 1970 (now ranked 15th), but levels had not increased from 2002 to 2016. Yellow foxtail, broadleaved plantain and biennial wormwood appeared in the top 20 most abundant weeds for the first time in 2016. The densities of annual grass and broadleaved weeds were the lowest ever recorded, while the abundance of perennials and facultative winter annuals were the highest on record.

The Frequency of Volunteer Canola Across Manitoba

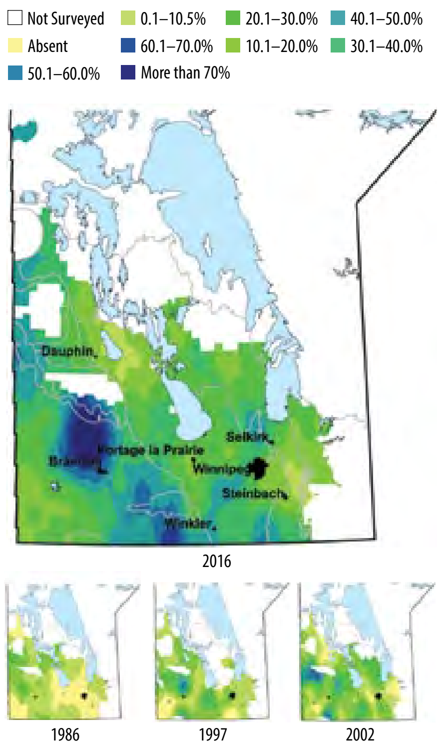


Table 1. Top 10 most abundant weeds in 2016 across Manitoba.

Ranking	All Crops (658 fields)	Soybeans (118 fields)
1	Green foxtail	Canola
2	Wild buckwheat	Wild buckwheat
3	Barnyard grass	Barnyard grass
4	Wild oats	Dandelion
5	Canola	Redroot pigweed
6	Yellow foxtail	Wheat
7	Dandelion	Green foxtail
8	Redroot pigweed	Yellow foxtail
9	Wheat	Wild oats
10	Round-leaved mallow	Broadleaved plantain

Soybeans had the lowest weed density of all crops (9.2 weeds/m^2), were among the least diverse (4.5 weed species/field) and had a relatively high proportion of weed-free quadrats (44.6%). The most abundant weed was volunteer canola, followed closely by wild buckwheat. These results are not surprising, as these weeds are both resistant and somewhat tolerant to glyphosate, respectively. Grassy weeds, such as foxtails and wild oats were relatively less abundant than in other crops.

A subset of 151 fields was also surveyed for Group (Gr) 1 and 2 herbicide-resistant (HR) weeds. All weeds with mature seeds were sampled prior to harvest. Four grass and ten broadleaved weeds were screened in pot assays in the greenhouse.

Overall, 68% of surveyed fields had HR weeds compared to 48% in 2008 and 32% in 2002. Most wild oat populations sampled (79%) were HR (78% Gr 1, 43% Gr 2, 42% Gr 1+2) and 48% green foxtail were HR (44% Gr 1, 6% Gr 2, 2% Gr 1+2). This was the first survey to document HR in yellow foxtail where 42% were HR (32% Gr 1, 17% Gr 2, 8% Gr 1+2). Group 2 resistant barnyard grass was found in 27% of fields, which was also the first occurrence of this biotype.

Four broadleaved species had Gr 2 resistance. The proportion of surveyed fields with HR was 11% for cleavers, 25% for wild mustard, 5% for redroot pigweed and 2% for shepherd's purse. This was the first survey to document HR shepherd's purse.

Based on this survey, an estimated 5.4 million acres in Manitoba are infested with HR weeds and the additional cost to manage HR weeds is estimated at $74 million annually.

PRINCIPAL INVESTIGATOR Dr. Julia Leeson and Dr. Hugh Beckie, Agriculture and Agri-Food Canada – Saskatoon and Dr. Jeanette Gaultier, Manitoba Agriculture

MPSG INVESTMENT $8,078 | DURATION 1.5 years

CO-FUNDERS *Growing Forward 2* Growing Innovation: Agri-Food Research and Development Initiative, Western Grains Research Foundation, Manitoba Wheat and Barley Growers Association, Manitoba Canola Growers, Manitoba Oat Growers Association, Manitoba Corn Growers Association, Manitoba Seed Growers Association, Manitoba Flax Growers Association, National Sunflower Association of Canada

AGRONOMY

Action Thresholds for Volunteer Canola in Soybeans

Action thresholds for volunteer canola in soybeans are low (2–3 plants/m^2). Early season image analysis shows promise as a potential decision-making tool for managing volunteer canola.

ACTION THRESHOLDS DEFINE the densities of pests at which control measures should be taken to preserve yield. To date, no studies have assessed volunteer canola competition in soybeans nor determined its action threshold. Although the approach is in its infancy, development of a yield loss model based on digital images of weed density at early crop stages would create a useful decision support tool for farmers.

The objectives for this study were two-fold. The first objective was to determine the effects of volunteer canola density in soybeans planted on narrow (7.5 inches) and wide (30 inches) rows on crop yield, growth and development. Results were used to pinpoint the volunteer canola density at which 5% soybean yield loss was incurred. The second objective was to characterize the relationship between early season total ground cover at increasing densities of volunteer canola and soybean yield loss in narrow or wide rows. Digital image analysis was investigated as a potential predictive tool to estimate yield loss in soybeans from volunteer canola interference.

Field studies were conducted in 2012 and 2013 at Howden, Carman, and Melita and repeated in 2015 at Carman and Portage. Experiments were seeded to achieve a population of 180,000 plants/ac for both narrow- (7.5–10 inches) and wide- (30 inches) row widths. Canola seed was broadcasted evenly over designated plots at six densities ranging from 0–320 seeds/m^2 in 2012, and in following years a density of 640 seeds/m^2 was added. Plots were assessed at V1, V3–V4, R8 and canola maturity. The rectangular hyperbola yield loss model was used to describe percent crop yield loss in response to increasing densities of canola, compared with yields in weed-free treatments. The action threshold was found by determining the density of volunteer canola that resulted in soybean yield loss of 5%, according to the model.

Volunteer canola is very competitive with soybean, which led to significant yield losses at five of six site-years in this study. The action threshold for 5% soybean yield loss in narrow-row soybeans was 3.2 plants/m^2, while the wide-row soybean action threshold was 2.5 plants/m^2. When differences between row widths were observed, narrow-row soybeans were more competitive and had higher action thresholds before 5% yield loss was observed. This study is the first to describe the relationship between yield loss in soybeans and volunteer canola density.

Early season digital images captured total ground cover over a range of volunteer canola densities during V3–V4. To evaluate the relationship between canola ground cover and soybean yield loss, ground cover for the weed-free treatments was subtracted from the ground cover obtained from each other treatment to provide an estimate of the percentage of ground cover occupied by volunteer canola alone.

Linear regression was used to relate ground cover to soybean yield loss. For every percent increase in total ground cover, soybean yield loss ranged from 0.26%–2.79% for both narrow- and wide-row soybean. A difference in slopes between narrow- and wide-row spacing suggested separate models would be required for different row widths. While still early, this method shows promise relating soybean yield loss to total ground cover and could be developed to serve as a decision-making tool for managing volunteer canola in soybeans in the future.

Table 1. Action threshold (density of volunteer canola causing 5% yield loss) in narrow- and wide-row soybeans.

Year	Location	Soybean Row Spacing 7.5 inches	Soybean Row Spacing 30 inches
		Volunteer Canola plants/m^2	
2012	Carman	ns	ns
	Kelburn	5.9	4.1
	Melita*	2.6	1.1
2013	Carman	6.0	12.4
	Kelburn*	5.7	2.5
	Melita	1.2	12.3
2015	Carman	1.5	2.2
	Portage	3.5	2.9
	Combined	**3.2**	**2.5**

* Denotes locations where significant differences between row spacings was observed

ns – Indicates where the model was not significant

PRINCIPAL INVESTIGATOR Dr. Rob Gulden, University of Manitoba

MPSG INVESTMENT $60,000 – *five objectives*

DURATION 4 years

CO-FUNDERS *Growing Forward 2* Growing Innovation: Agri-Food Research and Development Initiative, NSERC, Western Grains Research Foundation, Monsanto

AGRONOMY

Managing the Volunteer Canola Seedbank After Harvest

Timely tillage following canola harvest increases volunteer canola germination prior to winterkill, decreasing seedbank persistence.

LARGE HARVEST LOSSES of canola (5.9% of canola yield) coupled with secondary seed dormancy allows viable volunteer canola seed to exist in the soil for several years as a dominant and abundant weed species. In western Canada, conventional crop rotations often only span two or three years, enabling a continuous re-stocking of volunteer canola in the seedbank.

The soil seedbank is an effective, yet underutilized management target to bring annual weeds under control, especially those with seedbank persistence like canola. However, practical knowledge on preventing seedbank persistence in Canadian cropping systems is lacking.

This field study was designed to assess the timing and type of post-harvest soil disturbance for management of volunteer canola in the seedbank. The first objective was to evaluate soil disturbance timing and tillage implement. The second was to evaluate the effect of establishing a winter-annual cereal following canola harvest on the persistence of the volunteer canola seedbank.

Experiments were established on canola stubble following harvest at Carman, Howden and Melita in 2013, and Carman and Pilot Mound in 2015. Seed losses from the canola crop were supplemented with 7000 seeds/m^2 glyphosate-resistant canola seed, broadcasted evenly. Soil disturbance treatments were conducted either shortly after canola harvest, one month after canola harvest or in early spring prior to seeding. Soil disturbance consisted of two passes of either spring-tooth tine harrow (1 cm depth) or tandem disc (12 cm depth) implements. These treatments were contrasted with an undisturbed zero-tillage control treatment. For two additional treatments, winter wheat was established in early fall using a double disc seeder into lightly-disturbed (tine harrow) or undisturbed (zero-tillage) soil. Canola seedbank density and seedling emergence were quantified before and after treatment implementation.

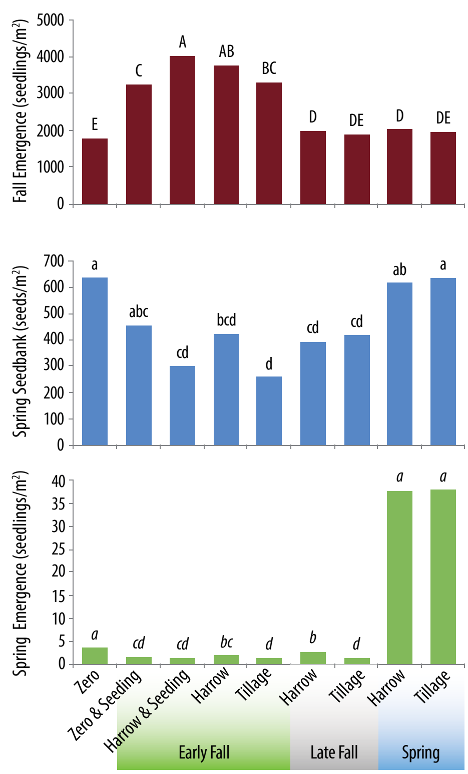
Tillage shortly after canola harvest proved timely in triggering volunteer canola germination and seedling emergence in the fall, thereby decreasing volunteer canola seedbank persistence over winter (Figure 1). Seedlings that germinate in fall should be effectively killed by harsh winter conditions. Encouraging post-harvest emergence in this manner also helped deplete the overall stock of weed seeds in the soil seedbank. Timing of soil disturbance was more important than implement type and degree of disturbance. Even a low disturbance tillage pass (tine harrow) was effective at encouraging fall emergence of volunteer canola.

Although these management practices are effective at reducing volunteer canola seedbank persistence over the first winter, total seed losses at harvest are large enough that 3% population persistence under early fall soil disturbance may still result in large spring seedbank densities. Spring soil disturbance may be used as an additional management tool to stimulate volunteer canola emergence prior to a pre-seed herbicide application.

In early fall, seeding winter wheat into disturbed soil decreased populations of volunteer canola on average by 35% compared with no tillage prior to sowing winter wheat (Figure 1). Soil disturbance during seeding of winter wheat occurred only near the seed row, while tine harrow caused more uniform surface disturbance. This explained the higher fall emergence following early fall tine harrow compared to seeding winter wheat without prior soil disturbance.

Timing of soil disturbance is an effective tool that should be used in addition to other management tactics, as part of a comprehensive integrated program to manage volunteer canola.

Figure 1. Average volunteer canola fall seedling emergence and spring seedbank persistence across five locations established in fall 2013 and 2015.



Different letters above bars indicate statistically significant differences among treatments.

PRINCIPAL INVESTIGATOR Dr. Rob Gulden, University of Manitoba

MPSG INVESTMENT $60,000 – *five objectives*

DURATION 4 years

CO-FUNDERS *Growing Forward 2* Growing Innovation: Agri-Food Research and Development Initiative, NSERC, Western Grains Research Foundation, Monsanto

Herbicide Options for Volunteer Canola in Xtend Soybeans

Faster-acting herbicide modes of action were more effective at preventing soybean yield loss, especially under high volunteer canola pressure.

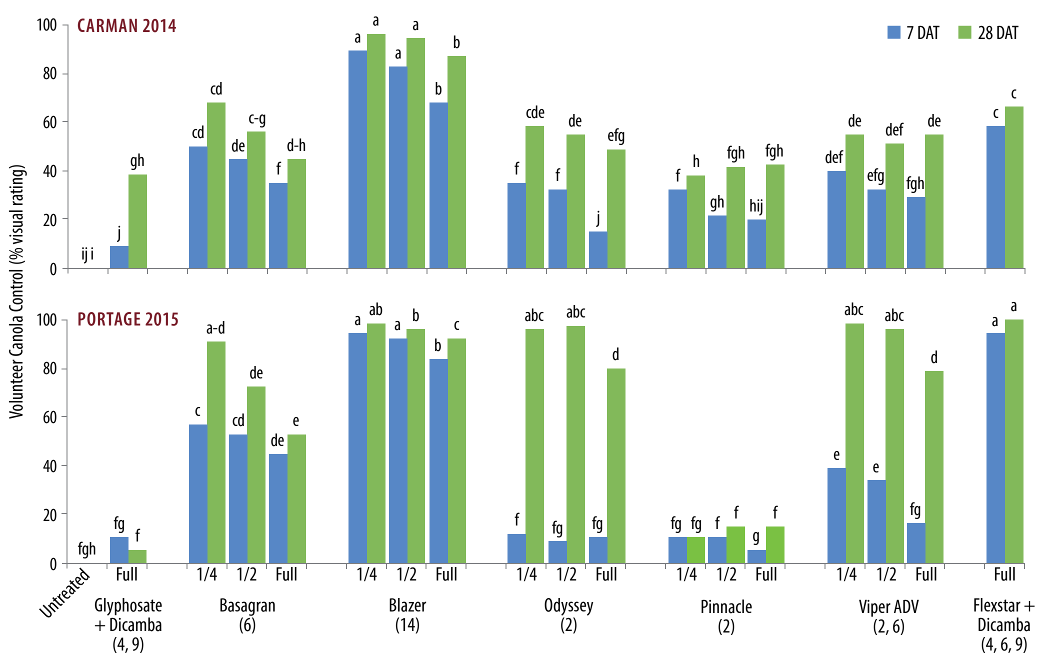
IN 2017, SOYBEAN varieties with resistance to two modes of action first became available in Manitoba. Roundup Ready 2 Xtend® varieties offer glyphosate and dicamba herbicide tolerance. The efficacy of these products against glyphosate-resistant (GR) volunteer canola is not well documented and additional tank-mix herbicides may be necessary to manage volunteers in these systems. Accordingly, this study evaluated the efficacy of in-crop herbicide tank-mix options for Xtend soybean systems.

In 2014 and 2015, an experimental variety of Xtend soybeans were planted in Carman and Portage. GR volunteer canola was planted at the same time as the crop. Glyphosate was applied prior to crop emergence to minimize weed pressure from other species. Several registered post-emergent (post) tank-mix herbicide partners were applied in addition to glyphosate and dicamba. These in-crop applications targeted the 2–4 leaf stage of volunteer canola and the V3 stage of soybeans. Three rates of each product were tested: 1/4, 1/2 and full. As per protocol of the seed suppliers, these experiments were terminated at flowering (R1). Percent volunteer canola control was assessed seven and 28 days after treatment (DAT) and soybean biomass was used as a surrogate for soybean yield.

Dicamba tended to benefit from an in-crop partner for GR volunteer canola control. Active ingredients in Group (Gr) 14 and Gr 6 provided more rapid control than the slow-acting active ingredients in the Gr 2 family (Figure 1). Higher use rates or products known to sometimes cause soybean injury (the "hotter" treatments) were more effective under conditions where volunteer canola growth quickly surpassed the soybean crop, threatening soybean productivity (Carman 2014, Figure 1). However, in 2015, smaller volunteer canola resulted in more herbicide contact with the crop, resulting in delayed soybean growth. Under such conditions, lower rates of tank-mix partners adequately controlled volunteer canola. This was further illustrated in Carman in 2015, where every herbicide treatment resulted in complete control compared with the untreated checks (data not shown).

A number of herbicides with various modes of action were effective for in-crop management of volunteer canola in soybeans. Xtend varieties required an effective in-crop herbicide to maximize volunteer canola control and soybean growth.

Figure 1. Volunteer canola control (seven and 28 days after treatment (DAT)) for post-applied herbicides in Xtend soybean systems applied at 1/4, 1/2 or full rates. Herbicide chemistry groups are indicated in brackets.



Within each rating date and location, different letters above bars indicate statistically significant differences among treatments.

PRINCIPAL INVESTIGATOR Dr. Rob Gulden, University of Manitoba
MPSG INVESTMENT $60,000 – *five objectives*
DURATION 2 years
CO-FUNDERS *Growing Forward 2* Growing Innovation: Agri-Food Research and Development Initiative, NSERC, Western Grains Research Foundation, Dow AgroSciences, Monsanto

AGRONOMY

Herbicide Options for Volunteer Canola in Enlist Soybeans

The combination of glyphosate and 2,4-D applied in-crop consistently provided effective control of volunteer canola.

ENLIST SOYBEAN VARIETIES are resistant to two modes of action, offering tolerance to glyphosate and 2,4-D herbicides. Group (Gr) 4 herbicides, such as dicamba and 2,4-D, do not always provide adequate volunteer canola control, depending on plant stage at the time of application. Additional tank-mix herbicide partners may be required to manage volunteer canola. This study evaluated tank-mix options for Enlist soybeans.

In 2015, once seed became available, Enlist soybeans were planted in Portage. Glyphosate-resistant volunteer canola was planted at the same time as the crop. The efficacy of herbicide tank-mix partners applied as burndown, pre-emergent (pre) or in-crop (post) treatments were evaluated (Figure 1). Glyphosate was applied in each treatment to reduce weed pressure from species other than volunteer canola. Additionally, glyphosate alone and the combination of glyphosate and 2,4-D (Enlist Duo) were tested at both full and reduced (2/3) rates. As per protocol of the seed suppliers, these experiments were terminated at flowering (R1). Percent volunteer canola control was assessed seven and 28 days after treatment (DAT) and soybean biomass was used as a surrogate for soybean yield.

Pre-applied herbicides alone provided relatively poor control of volunteer canola in Enlist soybean (Figure 1). Enlist Duo (2,4-D and glyphosate) applied in-crop as part of the Enlist system showed high efficacy and consistency on volunteer canola. Post-applied, 2,4-D is known to have more activity on volunteer canola than dicamba. These treatments also consistently resulted in the greatest soybean biomass at R1. Other effective post treatments included Odyssey (Gr 2) and Viper ADV (Gr 2, 6). Valour (Gr 14) and Fierce (Gr 14, 15) were the only pre-herbicides with good control of volunteer canola, however, only at Carman. Difference in soil characteristics and precipitation following application likely contributed to efficacy differences between sites.

A number of herbicides with various modes of action are effective for in-crop management of volunteer canola in Enlist soybeans.

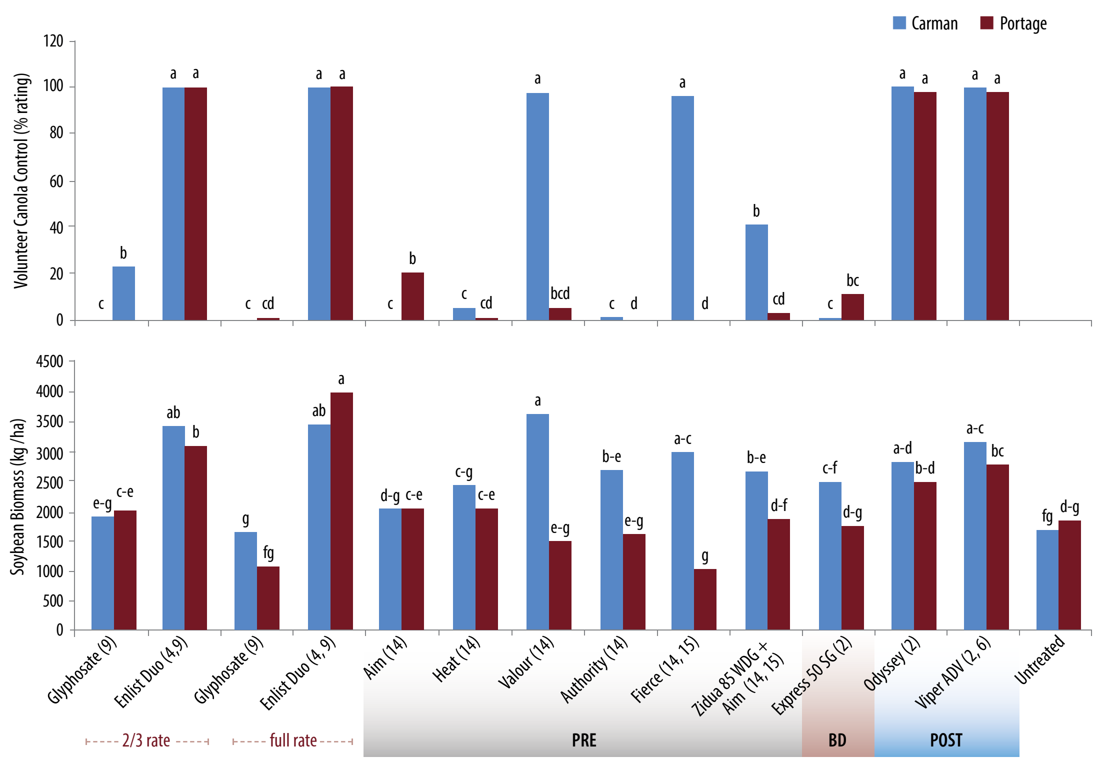


Figure 1. Enlist soybean biomass after competing with GR volunteer canola and percent control in response to a combination of burndown (BD), pre-emergent (PRE) and post-emergent (POST) herbicides at Carman and Portage in 2015. Herbicide chemistry groups are indicated in brackets.

Different letters above bars indicate statistically significant differences among treatments.

PRINCIPAL INVESTIGATOR Dr. Rob Gulden, University of Manitoba

MPSG INVESTMENT $60,000 – *five objectives*

DURATION 1 year

CO-FUNDERS *Growing Forward 2* Growing Innovation: Agri-Food Research and Development Initiative, NSERC, Western Grains Research Foundation, Dow AgroSciences, Monsanto

Making Soybeans More Competitive with Volunteer Canola

Increasing seeding rates and managing residual soil N made soybeans more competitive with volunteer canola. However, these steps worked best when densities of canola were high.

AN ASSORTMENT OF tools are necessary when dealing with herbicide-resistant (HR) volunteer canola. Integrated weed management (IWM) is an approach that applies a set of tools to generate an effect greater than any one weed control tactic alone.

Planting in narrow rows and increasing seeding rates can increase a crop's ability to suppress weeds. In addition, limiting residual soil nitrogen (N), which fuels weed growth, favours the soybean crop that fixes its own N supply.

This study assessed cultural management techniques, evaluating the effects of soybean row spacing, seeding rate, soil N and inter-row tillage on volunteer canola interference in soybeans. Field experiments were established in Carman in 2013 and Carman, Melita and Howden in 2014. Canola was seeded across treatments to simulate volunteers from the seedbank.

Volunteer canola density differed among sites. Low densities occurred at Carman 2013 and Melita 2014 and high densities at Howden and Carman in 2014. This distinction revealed that volunteer canola at low densities appeared to be more adaptable and resilient to weed management strategies than high densities. IWM tools were more effective under high densities of volunteers.

At high canola density sites, increasing seeding rates 1.5x (275,000 plants/ac) led to a 44% yield increase in narrow rows, compared with a standard seeding rate of 185,000 plants/ac, likely due to more rapid canopy closure. However, seeding rate had no influence on volunteer canola seed production.

Surprisingly, row spacing had little impact on the yield of soybeans faced with competition from volunteer canola and had no influence on volunteer canola seed production. This lack of response is likely due to rapid early-season growth of volunteer canola compared to soybeans.

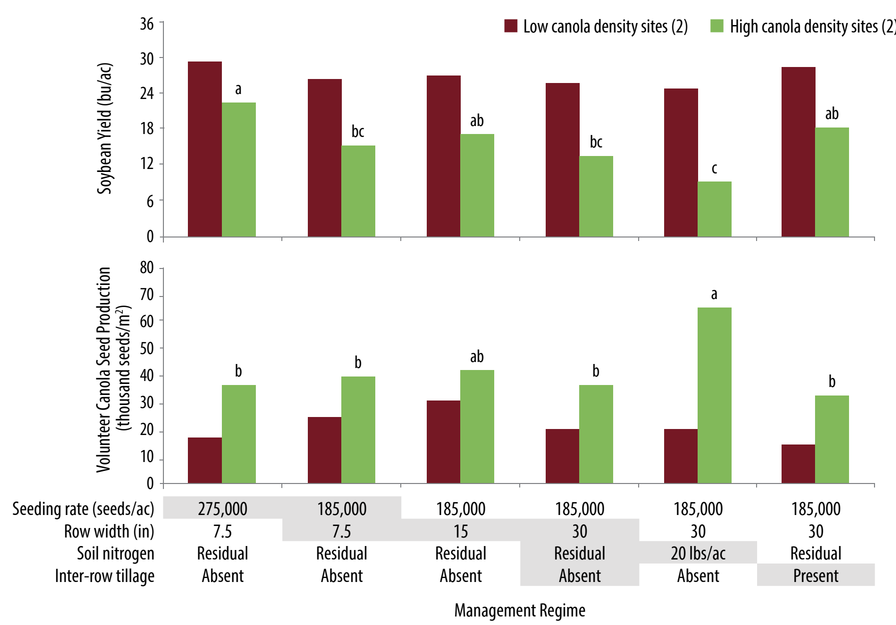
Residual soil N was supplemented in one treatment by adding 20 lbs/ac. Otherwise, these experiments were planted deliberately into soils with low levels of residual soil N (3–13 lbs available N/ac).

Adding to the N supply did not significantly affect soybean yield. Higher residual soil N was expected to tip the competitive balance in favour of volunteer canola. However, while the additional N did increase volunteer seed production at high-density sites, it did not result in significant soybean yield losses. It is possible that a 20 lb N/ac difference in available soil N was insufficient to cause differences in soybean yield.

Inter-row tillage in wide-row soybeans did not reduce volunteer canola seed production and resulted in 37% greater soybean yield at higher density volunteer canola sites, though this difference in yield was not significant.

Volunteer canola can be a highly competitive weed in soybean production and is relatively insensitive to many weed management tactics, especially at lower volunteer densities. An integrated approach to weed management is necessary to manage volunteer populations as soybean production intensifies. This study indicated that reduced soil N, elevated seeding rates and inter-row tillage in wide-row production systems may be the best IWM options for managing volunteer canola. It is likely that these tools will need to be used in combination with herbicides to target this weed.

Figure 1. Soybean yield and number of volunteer canola seeds as affected by soybean management regimes at sites with high (89 plants/m²) and low (39 plants/m²) volunteer canola densities. Highlighted treatments indicate comparisons of interest within each objective.



Different letters above bars indicate statistically significant differences among treatments.

PRINCIPAL INVESTIGATOR Dr. Rob Gulden, University of Manitoba

MPSG INVESTMENT $60,000 – *five objectives*

DURATION 2 years

CO-FUNDERS *Growing Forward 2* Growing Innovation: Agri-Food Research and Development Initiative, NSERC, Western Grains Research Foundation, Monsanto

Agronomic Management of Soybeans in Manitoba: Crop Rotation

Over the short term, crop sequence had limited effect on soybean root rot, crop yield and quality; however, differences among rotations often emerge slowly over time.

SOYBEANS HAVE BECOME a key part of crop rotations on Manitoba farms, but relatively little information is available regarding the effects of preceding crop sequences on soybeans and the effect of soybeans on other crops. In North Dakota, short-term crop sequence research has shown limited effects of preceding crop on soybeans, likely because differences among crop rotations emerge slowly over time. Crop rotation research, however, does provide value over time as the effect of cropping sequence can be measured while keeping environmental factors, such as soil type, constant.

Each crop in a rotation affects the overall economic return by influencing disease levels, weed populations, nutrients and soil conditions. The relative effect of each crop on disease is governed by the frequency and sequence in which it appears. Of particular importance in Manitoba is the root rot complex, including *Fusarium spp*. Surveys have shown root rot to be pervasive to the extent that it has become important to evaluate the impact of various soybean, wheat, canola sequences on managing root rot and its effect on soybean yield and quality.

The objective of this project was to evaluate the impact of soybean included in cropping sequences with wheat and canola on root rot, seed yield and seed quality in Manitoba. From 2011 to 2016, *crop sequence* studies were conducted at Morden (2011–2013) and Brandon (2013–2015) to assess six, three-year crop sequences (Table 1). A second *crop rotation* study was initiated at Brandon (2014–2016) to assess five rotations (soybean-canola, soybean-wheat, soybean-canola-wheat, soybean-wheat-canola and soybean-soybean-wheat). Soybean root rot was evaluated by rating 60 roots per treatment using a scale of 0 (no disease) to 9 (death of plant).

Crop sequence generally had limited effects on soybean root rot, seed yield and quality. Soybean yield was higher following wheat than canola at two of four site-years (Table 1). Root rot ratings, although differing by site and year, were similar across preceding crop treatments. One explanation for the superiority of wheat preceding soybean is the mycorrhizal associations both crops form to assist with nutrient uptake. It is well-known that canola does not form these associations. Therefore, the preceding canola may have reduced mycorrhizae populations prior to the soybean crop. Preceding crop sequence had no influence on the yield of wheat or canola.

In the crop rotation study, root rot severity tended to increase in the soybean-canola rotation compared to the more diverse soybean-wheat-canola rotation. In the final year of the study (2016), wheat and soybean yields were similar regardless of the preceding crop, but canola yields were highest after wheat-soybean and lowest after canola-soybean. Crop sequence also had no effect on oil or protein content for canola and wheat, respectively. Protein levels in soybeans, however, were higher after soybean-wheat (34.3%) and canola-wheat (34.4%) compared to soybean-canola and wheat-soybean (both 33.5%).

To date, this study suggests that manipulating the order of the "big three" crops would not buffer root rot in soybeans. Moreover, if the canola timeline is managed wisely, factors other than crop rotation are likely to be more important to the success of soybeans. Since these studies looked at crop sequence effects over a relatively short duration, it is not surprising that few differences emerged. To better understand the long-term performance of soybean rotations under typical Manitoba conditions, the crop rotation study at Brandon will continue until 2021.

Table 1. Mean yield and root rot ratings for the soybean year of the crop sequence in Brandon (2013–2015) and Morden (2011–2013).

Crop Sequence			Soybean Root Rot Ratings			Soybean Yield (bu/ac)	
			Brandon		Morden	Brandon	Morden
Year 1	Year 2	Year 3	Year 2	Year 3	Year 3		
Canola	**Soybean**	Wheat	2.6	–	–	24.0	22.0
Wheat	**Soybean**	Canola	3.1	–	–	23.4	28.0*
Soybean	Wheat	Canola	–	–	–	–	–
Soybean	Wheat	**Soybean**	–	3.6	2.3	27.3*	41.7
Soybean	Canola	Wheat	–	–	–	–	–
Soybean	Canola	**Soybean**	–	3.9	2.3	15.6	42.0

*Soybean yield following wheat was statistically higher ($p<0.1$) than following canola.

PRINCIPAL INVESTIGATOR Dr. Ramona Mohr, Agriculture and Agri-Food Canada – Brandon

MPSG INVESTMENT $163,900 – *three objectives*

DURATION 4 years

Agronomic Management of Soybeans in Manitoba: Row Spacing and Seeding Rate

The optimal plant population for soybeans in Manitoba is 160,000 plants/ac and narrow-row spacing consistently produced yields equivalent to, or greater than, wide rows.

SOYBEANS IN MANITOBA are often seeded in narrow rows (<15 inches) using an air seeder because row-cropping equipment is unavailable or uncommon in some regions. Questions have begun to arise regarding the relative benefits and disadvantages of narrow- vs. wide-row spacing on soybean establishment and yield. Studies conducted in North Dakota reported narrow-row spacing increased yield and weed competition due to earlier canopy closure. Conversely, wider rows may increase air movement among plants, reducing disease and allowing the use of inter-row cultivation for weed control.

Current Manitoba seeding recommendations are to target 180,000 to 210,000 plants/ac (40 plants/m^2). In North Dakota, previous studies of contrasting seeding rates found higher plant density increased yield in some cases.

The objective of this experiment was to evaluate the effects of seeding rate and row spacing on soybean growth, yield and seed quality in Manitoba.

Eight sites were chosen for this study: Morden, Portage, Melita, Carberry (2011–2013) and Brandon, Roblin, Arborg, Beausejour (2012–2013). Four seeding rates (80,000, 120,000, 160,000 and 200,000 seeds/ac) and two row spacings (narrow 8–12 inches vs. wide 16–30 inches) were established under weed-free conditions. Standard management practices appropriate for each region were applied. Soybeans were typically seeded between mid-May and mid-June, and harvested in September or October, depending upon location.

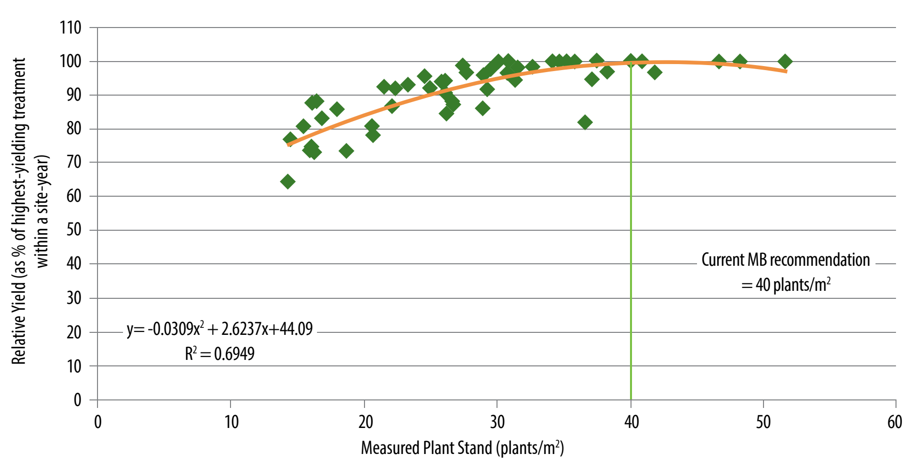
Results showed seeding rate and row spacing were largely independent of each other. Narrow rows produced yields that were equivalent to or greater than wide rows in all site-years. Where narrow rows of 9–10 inches were compared against wide rows ranging from 27–30 inches, narrow rows had a yield advantage in almost all cases (six of seven site-years). In site-years where wide rows ranged from 16–24 inches, yield differences between narrow and wide rows were less frequent (two of 13 site-years).

Increasing seeding rate consistently increased plant stand, but the actual plant stand established frequently ranged from 60 to 100% of that targeted by the seeding rate. This shows the influence of environmental conditions on final crop establishment. These findings demonstrate the importance of stand counts to verify the actual plant stand achieved in a given field.

Increasing seeding rate increased yield in 17 of 20 site-years. Considering relative yield (i.e. yield of a seeding rate as percentage of the highest-yielding seeding rate in each site-year), the results showed yield increased with increasing plant stand then levelled off (Figure 1). Actual plant stands of 120,000, 140,000 and 160,000 plants/ac in the field produced an estimated 95, 98% and 100% of optimum relative yield. This study established seeding recommendations for Manitoba. The *seeding rate calculator* in the MPSG *Bean App* has built in the results of this study, allowing farmers to determine the economic optimum seeding rate with customizable cost of soybean seed, target yield and soybean price.

Information regarding lodging score, plant height and days to maturity was collected; however, no strong nor consistent effects of row spacing and seeding rate were observed. Additionally, both row spacing and seeding rate influenced seed quality in some site-years. However, observed effects were generally not consistent among all site-years, and differences among treatments were often small.

Figure 1. Relationship between actual plant stand and relative yield of soybeans (yield as percent of the highest-yielding treatment within each site-year) based on 13 site-years of data in Manitoba (2011–13). Data presented is averaged across narrow- and wide-row spacing treatments.



PRINCIPAL INVESTIGATOR Dr. Ramona Mohr, Agriculture and Agri-Food Canada – Brandon

MPSG INVESTMENT $163,900 – *three objectives*

DURATION 4 years

AGRONOMY

Agronomic Management of Soybeans in Manitoba: Cultivar Growth Rate and Maturity

In short-season regions, variety selection is a key component to successful soybean production. Among the criteria for selection, maturity groupings are an accurate indicator of variety suitability.

SOYBEAN GROWTH, DEVELOPMENT and maturation are driven by the accumulation of heat units and the progressive reduction in day length over the growing season.

Previously, cumulative crop heat unit (ΣCHU) estimates have been used to rate the suitability of early-maturing varieties for different locations. More recently, the maturity group rating system has been adopted based on differences in photoperiod sensitivity among early varieties. Those varieties designated as being in the 0, 00, and 000 maturity groups are adapted to northern latitudes. Plant breeders have found that in western Canada many early varieties will reach physiological maturity and provide respectable yields at much lower ΣCHU than originally suggested.

Field experiments evaluating the development and agronomic performance of three early-maturing varieties (Table 1) were conducted at eight locations in southern Manitoba (Table 2) from 2011–2013. Trials were planted between May 15 and June 13, once soil temperature reached 10°C. According to the published heat units for each cultivar, five of the eight sites usually receive enough ΣCHU for Cultivar 1 to mature, three of the eight sites receive enough ΣCHU for Cultivar 2, and only one site, Morden, would have the thermal requirements for all three varieties (Table 2).

Table 1. Characteristics of the three soybean varieties grown in 2011–2013.

Soybean Cultivar	Company Heat Units	Maturity Group	Manitoba Variety Zone
Cultivar 1	2325	00.1	Short-season
Cultivar 2	2475	00.7	Long-season
Cultivar 3	2525	0.0	Long-season

Table 2. Characteristics and mean soybean yields at eight different sites from 2011–2013. Sites harvested prior to frost (H) and site harvested after frost (F) are indicated.

Site	Latitude (°N)	ΣCHU	Yield bu/ac 2011	Yield bu/ac 2012	Yield bu/ac 2013
Arborg	50.90	2384	–	28.2 (F)	32.5 (F)
Beausejour	50.08	2496	–	45.1 (F)	44.5 (H)
Brandon	50.02	2316	29.9 (F)	30.9 (F)	58.5 (F)
Carberry	49.90	2316	18.5 (F)	45.0 (H)	55.1 (F)
Melita	49.27	2428	–	27.6 (H)	49.4 (F)
Morden	49.18	2635	50.0 (CT) (H); 33.9 (ZT) (H)	59.0 (H)	54.7 (H)
Portage	49.96	2513	49.7 (F)	24.6 (F)	62.2 (F)
Roblin	51.18	2162	49.5 (F)	54.6 (F)	47.0 (H)

CT = conventional tillage; ZT = zero-tillage

Fourteen out of 22 site-years were harvested after the first killing frost. Morden was the only location harvested prior to frost in all three years. Despite harvesting post-frost, all three varieties advanced to physiological maturity (R7), except at Arborg in 2012. At R7, frost has little effect on seed yield. Seed moisture may be slightly higher and seed size and quality slightly reduced compared to pods that dry down and reach harvest maturity (R8) prior to frost.

Soybean yield and quality were not significantly different between trials harvested post-frost vs. pre-frost. In addition, harvesting after frost had no significant effect on seed weight or protein content. However, the oil content of soybean harvested prior to first fall frost was 1 to 1.5% higher for all three varieties.

The results from this study confirmed that it is possible to achieve reasonable yields with adequate quality under sub-optimal ΣCHU in Manitoba. This strengthens and validates recent moves towards using maturity groupings to assess variety suitability to a region.

Independent evaluations of soybean variety performance are conducted at multiple locations throughout Manitoba every year to help farmers and agronomists select the best varieties for each farm and growing region. Yield, maturity and other important agronomic information are summarized in MPSG's *Pulse and Soybean Variety Guide.*

PRINCIPAL INVESTIGATOR Dr. Aaron Glenn, Agriculture and Agri-Food Canada – Brandon

MPSG INVESTMENT $163,900 – *three objectives*

DURATION 4 years

BREEDING

Soybean Breeding Lines Evaluated for Iron Deficiency Chlorosis Resistance

Sixteen germplasm lines were consistently tolerant to iron deficiency chlorosis (IDC) under field conditions. Further screening under controlled conditions confirmed six varieties to have high IDC resistance.

IRON IS ESSENTIAL for photosynthesis. Not surprisingly, crops deficient in iron frequently show chlorosis (yellowing). Legumes such as soybeans also suffer due to reduced nodulation. The malaise of IDC is common, especially in Manitoba's high carbonate soils. Soil is generally rich in iron; however, iron may be unavailable for plant uptake. Saline, wet and cool soils exacerbate the effects of IDC. Previous research has shown that development of resistant cultivars and breeding lines are the most efficient way to overcome IDC in soybeans. They must, however, also mature early and possess high yield potential. To bring these characteristics together, soybean breeders start by screening large populations of genetically diverse plants in hopes of finding the few that display IDC tolerance. These tolerant breeding lines are crossed with varieties that have established yield and pest resistance characteristics.

Screening of soybean breeding lines for resistance to IDC was done in the field and in the greenhouse.

FIELD EVALUATION

This project evaluated 62 advanced soybean breeding lines developed at Agriculture and Agri-Food Canada (AAFC) Ottawa along with 160 early-maturing germplasm materials selected at AAFC Morden. Field trials were conducted at Emerson, MB in 2012–2015. The site offered optimal conditions for IDC to occur. Each line was rated at the third to eighth trifoliate growth stage on a scale of 1–5: 1 = no chlorosis and 5 = very severe chlorosis or dead plants.

Many lines showed early IDC symptoms, but were able to recover to some degree at later growth stages. Some lines had stunted plant growth, which led to severe yield loss. The advanced breeding lines from Ottawa were generally tolerant to IDC, suggesting genetic improvement through breeding had occurred. In total, 16 germplasm materials were consistently tolerant to IDC.

Due to the heterogeneous field conditions, inconsistency was observed in the soybean materials evaluated at Emerson. Thus, screening of soybean IDC under controlled conditions was initiated.

GREENHOUSE SCREENING

Further screening took place in the greenhouse using hydroponic nutrient solutions. This system enabled researchers to control environmental factors that influence IDC, resulting in more precise resistance ratings. Among other efficiencies, greenhouse trials allowed severe IDC to be induced in order to test the limits of observed resistance. This method has several advantages over field evaluations since a high severity of chlorosis can be induced and confounding effects of environment may be avoided. Additionally, this method of screening may be done year round.

From 2015–2016, 71 selected soybean materials classified as early-, medium- and late-maturing were tested for IDC resistance. Six lines were confirmed to have high levels of IDC tolerance making them suitable donors to variety development programs. Some lines that appeared to be resistant in the field were determined to be false positives and rated as IDC-susceptible in the greenhouse.

From these studies, 10 resistant and susceptible materials are being crossed to generate genetic populations for further genetic analysis of IDC resistance.

IDC susceptible (L) and resistant (R) lines at Emerson, MB in 2013.

Hydroponic system in Morden showing susceptible (L) and resistant (R) lines.

PRINCIPAL INVESTIGATOR Dr. Anfu Hou, Agriculture and Agri-Food Canada – Morden

MPSG INVESTMENT $76,000

DURATION 3 years

Variation in Soybean Seed Quality Across Canada

Food-type soybean varieties grown in Manitoba yielded similarly to those grown in eastern Canada, but protein often fell short of the 42% target for export.

WHILE MANITOBA GROWS soybeans primarily for crushing and meal, farmers may want to take advantage of the lucrative food-type, non-GM soybean export market. However, this market demands specific seed quality targets such as bright yellow colour, large, round seeds and protein concentration of at least 42%.

This project characterized and compared the quality of food-type soybeans grown in Manitoba to those grown in eastern Canada where production is well established. The results show the potential for Manitoba food-type soybeans and identify areas that require improvement. Six varieties (AAC Edward, AAC Mandor, OAC Prudence, AAC Malika, JARI, DH863) suitable for both regions, were grown at seven sites in Manitoba (Roblin, Melita, Carman, Glenlea, Portage la Prairie, Morden, Arborg) and two sites in eastern Canada (Ottawa, ON and Ste. Anne de Bellevue, QC) in 2015 and 2016. Varieties were analyzed for yield and maturity along with appearance (size, roundness, colour, brightness), minerals (iron, zinc, sulfur, cadmium concentration), nutrients (protein, oil, sugar concentration, oil profile) and human health components (isoflavones, lutein, Vitamin E).

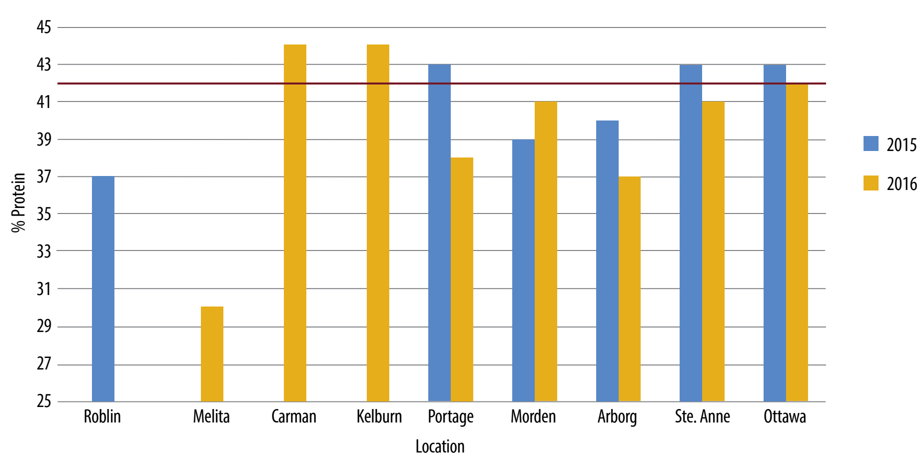
Average soybean yields across Manitoba locations ranged from 24.4 bu/ac to 68.7 bu/ac, which was comparable to or higher than eastern Canadian sites. Varieties took longer to mature in Manitoba than in Ontario. Since soybeans are photoperiod-sensitive, longer days and cooler nights in early summer slow development, delaying the onset of flowering in Manitoba.

Manitoba soybean seed size was generally smaller and seeds were not as bright in colour compared to eastern Canada. This is a disadvantage in the tofu and soymilk markets. However, these markets also prefer round seed and Manitoba soybeans had a distinct advantage in this area. Cooler nights, causing expression of pigments in the seed coat, could have caused the darker colour. Breeders could focus on increasing seed size for Manitoba varieties since this trait is genetically regulated.

Soybeans grown in Manitoba often had greater than 40% protein concentration but rarely exceeded the 42% target for export (Figure 1). Varieties varied in protein, indicating that it is possible to increase protein concentration through breeding. In terms of oil, six out of ten Manitoba locations produced low, two produced medium, and two produced high concentrations. Low to medium oil concentration is an advantage for soymilk. Manitoba soybeans consistently had higher sugar concentrations, likely caused by the slower rate of development. They also contained more polyunsaturated fats, linolenic acid and linoleic acid. But, they contained less monounsaturated fats, oleic acid, saturated fats, palmitic acid and marginally less stearic acid, all of which point to a potential health advantage. Natto soybeans, which require a small, round seed, high sugar concentration and high linolenic acid concentration, may be a very good fit for Manitoba food-type soybean production.

Manitoba soybeans had only one third as much isoflavone, but higher lutein concentrations. There were no regional differences in Vitamin E concentrations. Cadmium concentration in food-type soybeans cannot exceed 200 ppb, a threshold that was exceeded in four of the Manitoba trials. Since varieties differ in their ability to accumulate cadmium, proper screening of varieties for the food-market could remedy this issue. Seed iron concentration was similar across all locations in both years while sulfur and zinc varied by year.

Figure 1. Mean concentration of protein (% dry matter) across six short-season varieties grown in Manitoba, Ontario and Quebec in 2015 and 2016.



PRINCIPAL INVESTIGATOR Dr. Malcolm Morrison, Agriculture and Agri-Food Canada – Ottawa

MPSG INVESTMENT $62,400

DURATION 2 years

Development of Pulse-Based, Gluten-Free, Shelf-Stable and Ready-to-Eat Meals using Retort Technology

Ten pulse-based, gluten-free, meal prototype products packaged in shelf-stable, ready-to-eat retort pouches are ready for commercialization.

Alphonsus Utioh examining retort packaging.

READY-TO-EAT (RTE) MEALS are individually packaged foods that require minimal to no preparation before consumption. These meals are convenient and appeal strongly to consumers with busy lifestyles. It is important that these quick and convenient meals are nutritious. Regular pulse consumption has been shown to have positive health benefits, but it is difficult to incorporate into daily meals due to long cook times. The inclusion of pulses into RTE meals offers consumers a convenient and nutritious choice. Additionally, pulses are gluten-free, making them an excellent choice for people with celiac disease or gluten intolerance. RTE meals are also considered a field ration and an essential nutrient supply in emergency situations.

The most widely used method for preserving food and extending shelf life is thermal processing by the application of heat. Retorting (or canning) has been the technology of choice for commercial sterilization of shelf-stable, low-acid foods, which can be stored for more than twelve months without preservatives. Most of the commercially available low-acid, shelf-stable products in the market are retort processed.

The objective of this project was to develop an innovative, gluten-free, shelf-stable and ready-to-eat meal with a variety of pulses that will deliver a balanced nutritional value, great taste profile, multiple health benefits and convenience to the consumer.

A variety of edible beans, soybeans, chickpeas, quinoa and wild rice were sourced from local growers and suppliers. Non-GMO soybeans, black beans, navy beans, pinto beans and wild rice were deemed suitable ingredients for RTE meal formulations based on their availability and their ability to undergo retort processing while retaining quality. Bean blends, with or without seasonings, wild rice, and water (or tomato juice) were filled into retort pouches and sealed. The pouches were retort processed using high temperatures and pressures to achieve commercial sterility.

Ten prototype products containing a mixture of edible beans, soybeans, and wild rice along with other natural food ingredients were developed through this project (Figures 1 and 2).

Overall, sensory panellists preferred the soybean blends over the black bean blends with respect to colour, flavour, and texture. All the prototype products developed from this project boast excellent nutrient profiles, being high in fibre, protein, vitamins and minerals and low in fat and sodium. These products can be served as a full vegan meal or as a side dish and boast a shelf life greater than twelve months at room temperature.

The technical information developed from this project will allow for scaling up to commercial production. These results suggest that there is great potential in the marketplace if these new products can be commercialized, which would increase local demand for pulses and soybeans.

The appearance of RTE prototype products (left). Packaged RTE prototype products in retort pouch (right).

PRINCIPAL INVESTIGATOR Jiancheng Qi, Food Development Centre

MPSG INVESTMENT $23,000

DURATION 1 year

Post-Prandial Glycaemic Response Health Claims on Dry and Canned Whole Pulses for the Canadian Market

A health claim that states, "one cup (250 ml) of cooked whole pulse food (lentils, beans, peas, and chickpeas) in place of low fibre starchy foods results in a reduced blood sugar [glucose] rise after a meal" can be used in Canada.

DIABETES OR PREDIABETES affects approximately 9 million Canadians. Prevalence has almost doubled since 2000 and will increase by another 1.5 million people by 2020. When combined with undiagnosed diabetes and prediabetes, it is estimated that one in three people in Canada will be affected by 2020.

Foods that help maintain blood sugar levels within the normal range after a meal (the post-prandial glycaemic response) can be part of a dietary strategy to manage diabetes. The pulse industry is well positioned to address these opportunities by substantiating the health claim regarding reduced blood-sugar rise after a meal due to pulse consumption.

According to the Canadian *Food and Drug Act* and the Canadian Food Inspection Agency's *Food Labelling for Industry*, health claims should not be misleading and are required to be supported by scientific evidence. This project sought to establish an evidence-based health claim for the relationship between pulses and favourable post-prandial blood glucose levels, which will, in turn, stimulate food industry and consumer demand for pulse food products.

A systematic literature review was conducted to find scientific evidence supporting the claim for whole pulses and reduced post-prandial glycaemia. This review was conducted according to Health Canada's standards to ensure results and conclusions were aligned with the standards of evidence. Studies published between 1980 and 2012 were included in the literature search to ensure recent data was utilized. Unpublished data was excluded and duplicate studies were removed. After review, eleven studies remained for whole lentils, seven for whole peas, seven for whole beans, and four for whole chickpeas. Health Canada's threshold response to support a health claim is a reduction in post-prandial glycaemic response by 20% compared to controls.

The systematic review of high quality studies demonstrated that, when used to replace highly digestible carbohydrates, whole pulses, regardless of type, elicited a significant decrease in post-prandial glycaemic response at a magnitude that meets or exceeds Health Canada's 20% threshold (Table 1). Therefore, the evidence supports a health claim that communicates the low glycaemic response of canned or conventionally prepared dried whole pulses. After discussion with Health Canada, the following claim reflects the current body of evidence for the attenuation of glycaemic response with pulses.

"One cup (250 ml) of cooked (type of whole pulse) in place of low fibre starchy foods results in a reduced blood sugar [glucose] rise after a meal."

Currently, evidence supports 250 ml as the minimum effective dose of whole pulses for lowering post-prandial glycaemia. As research continues, this dosage may potentially be reduced lower than the one cup (250 ml) threshold in the current claim. This health claim may be extended to products containing processed pulse-based ingredients once data that defines their effects on post-prandial glycaemia becomes available.

Whole Pulse	Percent of Treatments Supporting the Health Claim	Effective Dose of Pulses	Reduction in Glycaemic Response Following a Meal
Lentils	83.3%	250 ml	32 – 73%
Edible Beans	57.1%	~ 250 – 500 ml	37 – 78%
Peas	57.1%	~ 250 – 625 ml	24 – 69%
Chickpeas	75%	~ 325 – 500 ml	35 – 47%
		Health Canada's minimum threshold response	20%

PRINCIPAL INVESTIGATOR Pulse Canada
MPSG INVESTMENT $2,000
CO-FUNDERS Canadian Agricultural Adaptation Program, Saskatchewan Pulse Growers
DURATION 1 year

NUTRITION & END-USE

Recipe Development and Consumer Taste Testing of Recipes Containing Edible Beans

Replacing 25% of flour with bean flour or purée in recipes improves nutritional content while maintaining taste and texture of dishes.

RECIPE DEVELOPMENT

When a chef incorporates new ingredients or develops a new recipe, all senses are employed to assess the final results. The resulting dish must look, smell, feel and taste delicious. Food is more than sustenance; it is an experience. This remains true with adding nutritious ingredients, such as pulses, to recipes. The goal of this project was to maximize the quantity of nutritionally-packed pulse flours and purées in a variety of baked dishes without affecting the taste, texture, or performance of each product.

The challenge with replacing wheat flour is the loss of structure provided by gluten. By blending flours, the chef was able to add extra nutrients found in bean flour to many foods, demonstrating the versatility of dry beans in boosting the nutritional profile of recipes.

Approximately 25–40% of wheat flour can be replaced with bean flour or purée, in a variety of recipes without affecting the taste and/or texture of the resulting dish. Although a single dish alone would not achieve the recommended half-cup serving per day, by combining several dishes throughout the day, people could easily and gradually increase their pulse intake level.

CONSUMER TASTE TESTING

Would consumers notice a 25–30% replacement of wheat flour with bean flour or purées?

Gauging consumer opinions and consumption habits aids in dispelling popular misconceptions that pulses are difficult to incorporate or adversely affect taste.

Consumers were invited to taste test three recipes – navy bean perogies, black bean chocolate cake and pinto bean power balls. Surveys outlined their opinion of sensory attributes and assessed their consumption of pulses. Recipes were evaluated using a 9-point scale for aroma, texture and flavour. All recipes received a 7 to 7.5 (*moderately acceptable* to *like very much*) score. These taste tests revealed that most people do not detect a 25% replacement of wheat flour with pulse flours.

Nutritional analysis was also completed on recipes before and after modifications to the recipe. Protein, fibre and iron levels increased with the addition of pulses. The greatest impact was on gluten-free recipes made with rice flours and starches: a 25% replacement of rice flour with bean flour doubled the protein, fibre and iron.

These results demonstrate the flexibility and acceptance of pulses incorporated into a variety of foods and how easily increasing pulse consumption may be achieved. Most of these recipes could be incorporated into cafeteria menus and restaurants to improve nutrition while serving familiar foods. Readily available flours and purées can help reduce required time to prepare pulse-inclusive products. Although the pulse inclusion could potentially be pushed higher per dish, a 25% inclusion with a high sensory acceptance could change how common food service recipes are prepared. Promotion within food service to make these minor modifications could move pulse consumption from once per week to every day in small amounts.

TEN RECIPES DEVELOPED FROM THIS PROJECT

1. Spinach Linguine with Shitake Mushroom Cream Sauce
2. Exotic Fruit Shortcakes with Key Lime Mousse
3. Garlic Roman Flatbread with Jalapeño Brick Cheese
4. Chicken and Bean Pot Pie with Pinto Pie Crust
5. Gluten-Free Shortbread with Baker's Jam
6. Pulled Chicken, Roasted Garlic and Smoked Gouda Perogies
7. Gluten-Free Padano Grana Soda Crackers with Fresh Thyme
8. Almond Flavoured Chocolate Espresso Cake
9. Orange and Navy Bean Crème Brulée
10. Pinto Bean and Chia Seed Power Balls

PRINCIPAL INVESTIGATOR Mavis McRae, Red River College Culinary Research & Innovation Program

MPSG INVESTMENT $24,730

CO-FUNDERS NSERC

DURATION 2 years

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Photo by Greg Bartley, MPSG