Date Received	April 15 2016
For Administrative Use Only	

FULL RESEARCH PROJECT FINAL REPORT

Instructions:

- This report must be a stand-alone report, i.e., must be complete in and of itself. Scientific articles or other publications cannot be substituted for the report.

- One electronic copy and one signed original copy are to be forwarded to the lead funding agency on or before the due date as per the investment agreement.

- A detailed, signed income and expenditure statement incurred during the entire funding period of the project must be submitted along with this report. Revenues should be identified by funder, if applicable. Expenditures should be classified into the following categories: personnel; travel; capital assets; supplies; communication, dissemination and linkage; and overhead (if applicable).

- For any questions regarding the preparation and submission of this report, please contact ACIDF

Section A: Project overview

1. Project Number: 2013F142R

2. Project Title: Aster yellows and swede midge – new threats to prairie canola

3. Research Team Leader:	**4. Affiliation**	**Title/Role**
Chrystel Olivier	AAFC Saskatoon	Research scientist, AY diseases

Abbreviations: AAFC: Agriculture and Agri-Food Canada AY : Aster yellows

5. Project Start Date: April 1, 2013 **6. Project Completion Date:** March 31, 2016

7. This is the final report for this three year project. **DATE:** April 15, 2016

Section B: Non-technical summary (max one page)

Overall, excellent results were obtained from laboratory experiments in the AY study, with the development of an AY rating scale and a preliminary estimation of an economic threshold under dry and moist conditions for AY leafhoppers on canola. However, AY incidence in the field was very low in 2013-2015, and many of the observations of tolerant/resistant germplasm observed in the 2012 canola nursery could not be confirmed. Leafhopper populations were surveyed in AB and SK during the three years of the project.

Bioassays utilizing AY inoculation of canola plants allowed the differentiation of typical/atypical symptoms based on leafhopper density and soil moisture. An AY five-point rating scale, based on virescence, phyllody and presence of bladder-like pods, was developed to assess the incidence and severity of AY symptoms during seedling, bolting, flowering and pod formation. The AY rating scale was instrumental in the first estimation of an economic threshold of four AY leafhoppers per plant at

the seedling, 1st and 2nd true-leaf stage in moist soil, and 12 AY leafhoppers per plant at the seedling, 1st and 2nd true-leaf stage in dry soil. Results of experiments aimed at estimating the production losses at other canola plant stages are being analyzed and will be published in 2016 and 2017.

During the summers 2013, 2014 and 2015 leafhopper population and AY incidence in plants and insects were monitored in the *B. napus* germplasm nursery at the AAFC- Saskatoon research farm, as well as in Canola Performance Trials (CPT) located in AB and SK. In the nursery, the AY incidence in plants and leafhoppers were very low: 2% and 0.01% in 2013 and 2014, respectively for leafhoppers and <1% in canola plants for the three years of the project. The very low AY incidence in the nursery did not allow us to confirm the resistance/tolerance of germplasm lines that appeared to be AY-free in the outbreak of 2012. The same low AY incidence was observed in commercial crops and in the CPT trials during the three years of the project. No AY-infected aster leafhopper adults were found in the emergence traps set up in AB, MB and SK for the past three years, suggesting that most of the AY inoculation in spring comes from migratory leafhoppers.

Section C: Project details

1. Project team

a. Chrystel Olivier	AAFC Saskatoon	Team leader, Research scientist, Aster yellows diseases
b. Julie Soroka	AAFC Saskatoon	Co-PI, Research scientist, swede midge distribution
c. Owen Olfert	AAFC Saskatoon	Research scientist, Entomology, forecasting
d. Jennifer Otani	AAFC Beaverlodge	Biologist, insect surveys

2. Background (max 1 page)

Describe the project background and include the related scientific and development work that has been completed to date by your team and/or others.

Two new yield-limiting pests of canola are becoming prevalent on the Canadian prairies. Aster yellows (AY) is an insect-vectored disease that affects many crops, including canola. Aster yellows epidemics in canola crops in western Canada have increased in occurrence and severity over the past 15 years. Significant yield loss was observed in 2012 with aster yellows incidence as high as 80% in some fields. Similarly, the swede midge *Contarinia nasturtii* (Keiffer), native to Europe, is an insect pest of crucifer crop first reported from ON cole crops in the year 2000. While some damage was seen in canola in ON since 2000, the insect was first found in SK in 2007 and MB in 2008, and it was only in 2012 that damage was found in commercial spring canola on the Prairies. The distribution of swede midge on the Prairies and specifically AB was unknown.

3. Objectives and deliverables (max 1 page)

State what the original objective(s) and expected deliverable(s) of the project were. Also describe any modifications to the objective(s) and deliverable(s) which occurred over the course of the project.

The objectives of the project were to determine the extent of infestation, evaluate the yield losses, develop economic thresholds and forecast warnings, and identify resistant canola lines for AY and swede midge on the Prairies. Key results expected were knowledge of factors influencing aster yellows and swede midge biology in canola, determination of factors affecting the occurrence of aster yellows/leafhoppers and swede midge in western Canada that will provide the canola industry with a reliable means of assessing the economic impact of

the pests, and delivery to producers of appropriate management strategies for the pests, such as development of an economic threshold, development of an early warning system and identification of AY-resistant cultivars.

Because much of the investigation involved natural infestations and because insect occurrence is notoriously unpredictable, the project combined work in the field and the laboratory. Also, because there are many parameters involved in insect pest epidemiology and investigation of resistance/ tolerance in canola, several funding agencies were involved in the research on AY epidemiology and control, and swede midge distribution. For instance, the evaluation of yield losses estimated with bioassays involving infection of canola plants at different growth stages with various leafhopper densities necessitated accessing funds from several sources. The results specific to the ACIDF funds were the AY survey conducted in commercial fields in AB and in canola performance trials located in AB and SK, the hunt for overwintering AY-infected leafhopper adults, as well as the technology developed to determine the origin of the leafhopper migrants and the EPG experiments on leafhoppers. Likewise, some of the monitoring of swede midge populations was undertaken through funds from other agencies and AAFC. Because our research contains data generated from multiple related research projects and because we tried to present the greatest information possible on aster yellow and swede midge to the audience, most of the oral presentation and publications mentioned in this report will also be mentioned in reports to other agencies. Financial contributions of all funding agencies involved in the research were acknowledged in the presentations.

4. Research design and methodology (max 4 pages)

Describe and summarise the project design, methodology and methods of laboratory and statistical analysis that were actually used to carry out the project. Please provide sufficient detail to determine the experimental and statistical validity of the work and give reference to relevant literature where appropriate. For ease of evaluation, please structure this section according to the objectives cited above.

5. Results, discussion and conclusions (max 8 pages)

Present the project results and discuss their implications. Discuss any variance between expected targets and those achieved. Highlight the innovative, unique nature of the new knowledge generated. Describe implications of this knowledge for the advancement of agricultural science. For ease of evaluation, please structure this section according to the objectives cited above.
NB: Tables, graphs, manuscripts, etc., may be included as appendices to this report.

i) Aster yellows

Economic thresholds: Aster yellows inoculation conducted in bioassays allowed the differentiation of typical/atypical symptoms based on leafhopper density and soil moisture. An aster yellows five-point rating scale, based on virescence, phyllody and presence of bladder-like pods, was developed to assess the incidence and severity of aster yellows symptoms during bolting, flowering and pod formation. The rating scale with photographs illustrating each rating and the progression of aster yellows symptoms in flowers and seeds was published in the Canadian Plant Disease Survey [1]. The rating scale and the developed bioassay were used extensively to study the parameters leading to symptom expression in canola.

Soil moisture during infection had a pronounced effect on phytoplasma titres, incidence and severity of AY symptoms and subsequent seed yield of hybrid canola. Plants in the two to four leaf stage infected in dry soil had lower titres, fewer symptoms, less severe symptoms (AY rating 0-1) and higher seed yield than plants infected in wet soil. Titres, symptoms and yield in dry soil were not affected ($P \geq 0.05$) by leafhopper feeding densities [2]. In contrast, phytoplasma titres and frequency/severity of AY symptoms in wet soil increased as leafhopper feeding densities increased. The majority of plants exposed to feeding densities above four leafhoppers/plant had elevated phytoplasma titres in leaves, petioles and roots, along with severe AY symptoms (AY rating 3-5) and little or no seed [3].

AY incidence in plants and leafhoppers: During the three years of the project, AY incidence in leafhopper and plants were surveyed in Canola Performance Trials (CPT) set up by the Canola Council in Saskatchewan and Alberta, as well as in the canola germplasm nurseries set up by Dr. S. Vail at the AAFC-Saskatoon research farm. The goal was to correlate the % of infection in leafhopper populations with the % of plants expressing symptoms. Because of the potential impact of destructive sampling on subsequent seed yields, no PCR tests were carried out on plants in the CPT trials. PCR tests were conducted on plants from the AAFC canola germplasm nurseries as well as on all leafhoppers collected. A new PCR test revealed that canola can be infected by two different strains of AY simultaneously, although the majority of AY-infected canola plants are infected by only one strain or the other [4].

In 2013 and 2014, aster leafhopper, *M. quadrilineatus,* constituted 93% (2571/2737) and 97% (102/105) of the leafhoppers collected. In the CPT and AAFC nurseries, the % of aster leafhoppers infected by AY was 1.4% in 2013 and nil in 2014 and in the AAFC nurseries visual assessment showed that the % of plants expressing AY symptoms was less than 1% in both 2013 and 2014. However, PCR tests of the plants sampled in the canola germplasm nurseries revealed that 7% and less than 1% of the plants were infected with AY in 2013 and 2014, respectively, indicating that visual assessment of AY infection may underestimate actual infection rates. In an attempt to find infected overwintering adults in spring, emergence traps were set in early spring at five locations in AB and five locations in SK in 2013-2015. Although one infected female adult *M. quadrilineatus* had been found in an emergence trap in Saskatoon in 2004, no aster leafhopper adults were found in the spring emergence traps set out in this study. Thus, it is unlikely that adults of *M. quadrilineatus* can overwinter in Canada.

Resistance/tolerance to AY: The low level of AY seen in the field in the study did not allow confirmation of the results on AY-resistant lines of *B. napus* found in 2012. Indeed, statistical analyses showed that rates of visual incidence in 2013 and 2014 and incidence detected in the PCR assay were not correlated. In fact, visual inspection of ranking showed that just as many lines were ranked on opposite spectrums as were ranked consistently between field seasons. Interestingly, in 2013, one line consistently showed more symptoms across replications than other entries with the same cultivar name, but derived from different seed sources. These results suggest that seed infection initiated in development on the maternal plant could be a source of infection. Exploration of this hypothesis is being investigated.

Feeding behaviour studies: Aster leafhopper aggregation was observed during the bioassays on plants grown in wet soil as compared to plants grown in dry soil [1]. As well, among plants belonging to the same cultivar and grown under the same conditions, aster leafhoppers tend to aggregate on the same plant [3]. To understand this behaviour, feeding behaviour studies were started using an olfactometer located at the University of Alberta. Preliminary experiments suggested an aggregation phenomenon of leafhoppers on plants (Fig. 1). In the bioassays canola alone was less attractive than barley but when leafhoppers were present on canola the plant became as attractive as barley alone or barley with other leafhoppers. Leafhoppers alone did not have this attractive effect (Appendix Fig. 1). These results suggest that leafhopper feeding causes a change in the volatile organic compounds emitted from canola, and this change in smell attracts more aster leafhoppers.

To further investigate this phenomenon, a four-armed olfactometer was purchased for AAFC-Saskatoon, but due to late delivery of the olfactometer and restriction of further travel to the University of Alberta, no further olfactometer experiments were performed within the scope of this project.

Origin of the migrant leafhoppers: Studies are ongoing to determine the origin of migrant *M. quadrilineatus* using DNA barcoding. LeRoux and Rubinoff [6] showed that the North American origin of *Macrosteles* spp. can be localized to specific populations in the United States using slight differences among the mitochondrial genes cytochrome oxidase subunit 1and NADH 1 (DNA barcoding genes).

Another method of determining approximate latitude of origin is to examine deuterium content in ametabolic tissue. Research by Dr. K. Hobson of the National Hydrology Research Centre, Saskatoon, SK, has shown that deuterium content in ametabolic tissue varies inversely with latitude in a technique called "stable isotope analysis". Dr. Hobson is currently looking at deuterium in wings of *M. quadrilineatus* and *Athysanus argentarius* collected during the surveys done in 2014 and 2015 as an indicator of the approximate latitude of origin. These two techniques are being correlated with wind trajectory data to produce a more accurate model of the origin of the migratory aster leafhopper. Results to date have correlated a southerly wind from California in August 2014 that arrived in Saskatchewan with an increase in the numbers of adult *M. quadrilineatus* caught near that time via sweep sampling and sticky cards. The DNA barcoding technique also placed the origin of these leafhoppers in California as a proof of concept that this technique can be a valuable addition to the diagnosis and prediction of leafhopper outbreaks. Leafhoppers caught throughout 2015 are being tested using both the DNA barcode and the stable isotope analysis, and historical populations of leafhoppers (2012, 2013, 2014) collected in sweep surveys are being DNA barcoded.

Data compilation and early warning system: In an attempt to develop an early warning system for leafhopper invasion/aster yellows infection, data are being compiled about leafhopper populations and AY incidence in crops on the Prairies since 2001. However, leafhopper populations in canola in some years (2010, 2011, 2012) were not surveyed, and insect and plants samples done by other institutes or research groups are being collected and processed. Therefore, the data from all years (2001-2015) are only now being compiled and analyzed. A series of publications are planned for 2016 and 2017, with the first being submitted in March 2016[5]. Leafhopper and plant samples from 2015 are still being analyzed and should be complete by the end of June 2016.

ii) Swede midge

With funding from ACIDF and Canola Cluster, swede midge pheromone traps were distributed to co-operating agronomists in 2014 and 2105 to monitor locations across the four western provinces. Traps from 113 locations were returned to our laboratory for determination of the presence of swede midges out of a total of 150 locations, a 75% return rate. Data were obtained from nine locations in the Peace River District in BC, 24 locations across AB, 66 locations in SK, and 14 locations in MB. Swede midge males were found in low numbers on pheromone traps from three locations in MB and 21 locations in SK. No swede midges were found on traps from AB or BC.

Two of the three MB locations positive for the presence of swede midge in 2014 and 11 of the 21 SK locations are outside the known distribution area of the pest, indicating substantial expansion of its range, and suggesting that swede midge has been present but undetected in at least some of these new areas for a considerable time. Along with monitoring with pheromone traps, co-operators were asked to observe canola growth for evidence of abnormalities cause by swede midge larvae. Through detection of swede midge larvae in canola, swede midge presence has been confirmed as far north as Meadow Lake, SK and Swan River, MB. The present boundaries of swede midge distribution on the Prairies are to the northern limit of canola production in MB and SK, within 100 km of the American border in southern MB, and 150 km from the AB border in western SK.

An analysis of swede midge population development indicated that there were likely two generations of swede midge larvae that fed on canola on the Prairies in 2014. The emergence of adult flies from overwintering larvae

had a split peak, suggestive of an early and a late emergence phenology as is seen in Ontario swede midge populations. Unlike the Ontario situation, however, emergence of the first adults did not occur until well into July, and this late emergence, plus low overall midge numbers as evidenced by the low numbers in pheromone traps, rendered economic impact from the midge negligible on the Prairies in 2014.

Map by Olfert –predicted distribution appears to be becoming reality.

6. Literature cited

Provide complete reference information for all literature cited throughout the report.

1. Olivier, C. et al. (2014) Development of a rating scale for Aster yellow in canola. Canadian Plant Disease Survey 94: 162-176.
2. Bahar, M.H. et al. (2014) Phytoplasma dynamics in Aster yellow infested Brassica plants as determined by droplet digital PCR (ddPCR). Canadian Journal of Plant Pathology 36: 287.
3. Olivier, C. Dumonceaux, T., and Perez-Lopez, E. (2015) Management of insect vector of pathogens in economically important crops in Canada: Aster yellow disease in canola crops. Oral presentation at First International Congress of Molecular Diagnostics for Integrated Pest and Disease Management in Agricultural Production. Trujillo, Peru, November 26-28, 2015.
4. Dumonceaux, T. et al. (2015) Molecular Diagnostic Tools for Detection and Differentiation of Phytoplasmas Based on Chaperonin-60 Reveal Differences in Host Plant Infection Patterns. PLoS ONE 2015. 9(12).
5. Olivier, C. et al. (2016) Detection, symptomatology and management of aster yellows in canola, in G. Reddy, Editor. Integrated Management of Insect Pests on Canola and Other Brassica Oilseed Crops. CABI.
6. LeRoux, J.J. and Rubinoff, D. (2009) Molecular data reveals California as the potential source of an invasive leafhopper species, *Macrosteles* sp. nr. *severini*, transmitting the aster yellows phytoplasma in Hawaii. Ann. Appl. Biol. 154: 429-439.
7. Olfert, O., Hallett, R., Weiss, R., Soroka, J. and Goodfellow, S. (2006) Potential distribution and relative abundance of swede midge, *Contarinia nasturtii*, an invasive pest in Canada. Entomol. Exp. Appl. 120: 221-228.

7. Benefits to the industry (max 1 page; respond to sections *a)* and *b)* separately)

a) Describe the impact of the project results on Alberta's agriculture and food industry (results achieved and potential short-term, medium-term and long-term outcomes).

b) Quantify the potential economic impact of the project results (*e.g.*, cost-benefit analysis, potential size of market, improvement in efficiency, etc.).

a.

8. Contribution to training of highly qualified personnel (max ½ page)

Specify the number of highly qualified personnel (*e.g.*, students, post-doctoral fellows, technicians, research associates, etc.) who were involved in the project.

Tyler Wist	AAFC Saskatoon	Postdoctoral fellow, Aster yellows diseases and leafhopper population biology and distribution
Lars Andreassen	AAFC Saskatoon	Postdoctoral fellow, swede midge biology, distribution

Postdoctoral fellows Tyler Wist and Lars Andreassen played seminal roles in the undertaking of this project.

9. Knowledge transfer/technology transfer/commercialisation (max 1 page)

Describe how the project results were communicated to the scientific community, to industry stakeholders, and to the general public. Organise according to the following categories as applicable:

There was keen interest in information generated on both pest problems in the course of this project, as evidenced by the large number of invited oral presentations to producer groups and agrology meetings, and the requests for media interviews and reports to agro-industry listed below.

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a) Scientific publications:
No scientific publications have been submitted to date on the research conducted in this project, although several are in preparation, including one on spread of swede midge across western Canada and factors affecting the utility of trapping methods for swede midge detection.

b) Industry-oriented publications – 11, itemized in Appendix ZZ

c) Scientific presentations (*e.g.*, posters, talks, seminars, workshops, etc.) – 13

i) Olivier, C., and T. Dumonceaux. (2013) Detection and symptomatology of Aster yellow in canola crops in Saskatchewan, Canada. Oral presentation at and Proceedings of the 61st Entomological Society of America Annual Meeting, Austin, TX, Nov 10-13, 2013.
ii) Bahar, M.H., Olivier, C., Bekkaoui, D., Hegedus, D., and Soroka, J. (2013) Detection, quantification and within-plant distribution of Aster yellows phytoplasmas through digital PCR (ddPCR). Poster and Proceedings of the 32nd New Phytologist Symposium, 20 – 22 Nov. 2013, Universidad Católica, Puerto Madero Campus, Buenos Aires, Argentina. P53.
iii) Bahar, M.H., Olivier, C, Bekkaoui, D., Hegedus, D., and Soroka, J. (2013) Phytoplasma dynamics in Aster yellow infested Brassica plants as determined by droplet digital PCR (ddPCR). Oral presentation at Saskatchewan Regional meeting of the Canadian Phytopathology Society, Saskatoon, Dec 9, 2013. Canadian Journal of Plant Pathology, 36: 287.
iv) Bahar, M.H., Olivier, C., Bekkaoui, D., Soroka, J., and Hegedus, D. (2014) Phytoplasma-leafhopper-plant interactions in a changing climate. Poster at Joint Annual Meeting of the Entomological Societies of Canada and Saskatchewan, Saskatoon, SK, Sept 28th – Oct 1st, 2014.
v) Olivier, C. (2014) Update on aster yellow epidemiology and control in canola. Oral presentation and videoconference seminar at the University of Minnesota, Minneapolis, MN, USA, Dec 8, 2014.
vi) Dumonceaux, Perez-Lopez, E., & Olivier, C. (2015) Molecular diagnostics for phytoplasma infections based on the chaperonin-60 universal target. Videoconference presentation to First International Congress of Molecular Diagnostics for integrated Pest and Disease Management in Agricultural Production. Trujillo, Peru, November 26-28, 2015.
vii) Olivier, Dumonceaux, T., and Pereze-Lopez, E. (2015) Management of insect vector of pathogens in economically important crops in Canada: Aster yellow disease in canola crops. Oral presentation at First International Congress of molecular diagnostics for integrated pest and disease management in agricultural production. Trujillo, Peru, November 26-28, 2015.
viii) Olivier, C., Elliott, B., Bahar, M., Mann, L., and Nordin, D. (2015) Influence of soil moisture and leafhopper feeding densities on phytoplasma titres, AY symptoms and seed yield of hybrid canola. Oral presentation at the 14th International Rapeseed Congress, Saskatoon, Jul 7, 2015.
viii) 17. Soroka, J.J., Andreassen, L, Olfert, O., and Weiss, R. (2014) Distribution of swede midge on the prairies. Oral presentation at Joint Annual Meeting of the Entomological Societies of Canada and Saskatchewan, Saskatoon, SK, Sept 30, 2014.
ix) Andreassen, L. and Soroka, J. (2014) Swede midge injury as influenced by crucifer species, and canola planting date and cultivar. Oral presentation at Joint Annual Meeting of the Entomological Societies of Canada and Saskatchewan, Saskatoon, SK, Sept 30, 2014.

x) Soroka, J. and Andreassen, L. (2015) Swede midge, Contarinia nasturtii (Diptera: Cecidomyiidae) distribution across Prairie Canada. Poster at 14th International Rapeseed Congress, Saskatoon, SK, Jul 5-8, 2015.
xi) Andreassen, L. and Soroka, J. (2015) Parasitoids of swede midge in Saskatchewan. Oral presentation at 14th International Rapeseed Congress, Saskatoon, SK, Jul 7, 2015.
xii) Soroka, J., Andreassen, L., and Wist, T. (2105) Insect research at SRC. Four talks given at four field tours to attendees of the 14th International Rapeseed Congress, Saskatoon, SK, Jul 9, 2015.
xiii) Andreassen, L. and Soroka, J. (2015) Prairie swede midge parasitoids as potential biological control agents in eastern North America. Oral presentation at Joint Annual Meeting of the Entomological Societies of Canada and Quebec, Montreal, PQ, Nov 8, 2015.

d) Industry-oriented presentations (*e.g.*, posters, talks, seminars, workshops, etc.) 35 talks, lectures, and demonstrations to agro-industry across western Canada. Itemized in Appendix zz

e) Media activities: 4 media items, ranging from interviews to weekly newspapers and monthly trade journals, to radio and television interviews. Itemized in Appendix ZZZ.

f) No commercialisation activities or patents were generated in this project.

N.B.: Any publications and/or presentations should acknowledge the contribution of each of the funders of the project.

11. Technology Transfer Plan (max. 1 page)

Future technology transfers: several peer-reviewed manuscripts are in progress, but conference/meeting participations are pending AAFC approval.

Section D: Project resources

1. Statement of revenues and expenditures:

Year	Source	Type	Personnel	Travel	Capital Assets	Supplies	CDL*	Overhead	Total/year
1 (enter year)	ACIDF	Cash	15,500	2,500		12,000			30,000
	Gov't	Cash							
		In-kind	75,200	13,160		5,640			94,000
	Industry	Cash	19,000	1,500		39,500		9,000	69,000
		In-kind							
Total Year 1			109,700	17,160		57,140		9,000	193,000
Carry Over for year 1									
2 (enter year)	ACIDF	Cash	23,231	3,500		8,000			34,731
	Gov't	Cash							
		In-kind	75,200	13,160		5,640			94,000
	Industry	Cash	45,730	7,000		14,731		10,419	77,880

	In-kind							
Total Year 2		144,161	23,660		28,371		10,419	206,611
Carry Over for Year 2								

3 (enter year)	ACIDF	Cash	25,692	3,500		5,000			34,192
	Gov't	Cash							
		In-kind	75,200	13,160		5,640			94,000
	Industry	Cash	47,392	7,000		14,000		10,257	78,639
		In-kind							
Total Year 3									**206,831**
Carry Over for Year 3									
4 (enter year)	ACIDF	Cash							
	Gov't	Cash							
		In-kind							
	Industry	Cash							
		In-kind							
Total Year 4									
Carry Over for Year 4									
5 (enter year)	ACIDF	Cash							
	Gov't	Cash							
		In-kind							
	Industry	Cash							
		In-kind							
Total Year 5									
Unspent Funds									
Grand Total									

*Communication, Dissemination, and Linkage

Details and Justification *(please provide complete details and justification for the budget for each of the following components:*

	Amount Requested for calendar year (2014-2015)	Details and Justification
Personnel	68,960	Post-doc stipend (50K) and part-time casual worker (18K)
Travel	10,500	Field work (6.5K) and meeting/conference attendance (4K)
Capital Assets		
CDL		
Supplies	22,731	Molecular & entomology supplies
Publication fees	2,000	Two peer-reviewed articles
Overhead	10,419	

13. Funding Contribution

Estimated Total Funds Requested for the Entire Duration of the Project		
Source	**Amount**	**Percentage of Total Project Cost**
ACIDF	98,923	16.3%

Other Government sources: Cash	0	0
Other Government sources: In-kind	279,000	46.1
Industry: Cash	227,720	37.6
Industry: In-kind		
Total Project Cost	605,643	100

Sources of Funding Contributions

Government Sources			
Name (no abbreviations please)	*Amount Cash*	*Amount In-Kind*	*Confirmed (Y/N)*
Agriculture and Agri-Food Canada	0	279,000	

Industry Sources			
Name (no abbreviations please)	*Amount Cash*	*Amount In-Kind*	*Confirmed (Y/N)*
Alberta Canola Producers Commission	113,760		
Alberta Crop Industry Development Fund	98,923		
Western Grain Research Foundation	113,760		

Section E: The next steps (max 2 pages)

Describe what further work if any needs to be done.

a) Is new research required to deal with issues and opportunities that the project raised or discovered but were not dealt with within the current project?
b) Is there related work that needs to be undertaken to continue advancement of the project technology or practice?
c) Did the project identify any new technology or practice that needs to be developed?
d) What suggestions do you have that increase commercial use of results by farmers and/or companies. These may be:
   1. commercial uptake.
   2. further research toward commercial use.
   3. extension and information disbursement.

Section F: Research Team Signatures and Employers' Approval

The team leader and an authorised representative from his/her organisation of employment MUST sign this form.

Research team members and an authorised representative from their organisation(s) of employment MUST also sign this form.

By signing as representatives of the research team leader's employing organisation and/or the research team member's(s') employing organisation(s), the undersigned hereby acknowledge submission of the information contained in this final report to the funder(s).

Team Leader's Organization

Please print or type name on the first line and sign in blue ink

Team Leader

Name:	**Title/Organization:**
Signature:	**Date:**

Team Leader's Employer Approval

Name:	**Title/Organization:**
Signature:	**Date:**

Research Team Members' Organizations (add more lines as needed)

1. Research Team Member:	
Name:	**Title/Organization:**
Signature:	**Date:**

Research Team Member's (Employer Approval)	
Name:	**Title/Organization:**
Signature:	**Date:**

2. Research Team Member:	
Name:	**Title/Organization:**
Signature:	**Date:**

Research Team Member's (Employer Approval)	
Name:	**Title/Organization:**
Signature:	**Date:**

3. Research Team Member:	
Name:	**Title/Organization:**
Signature:	**Date:**

Research Team Member's (Employer Approval)	
Name:	**Title/Organization:**
Signature:	**Date:**

4. Research Team Member:	
Name:	**Title/Organization:**
Signature:	**Date:**

Research Team Member's (Employer Approval)	
Name:	**Title/Organization:**
Signature:	**Date:**

APPENDIX

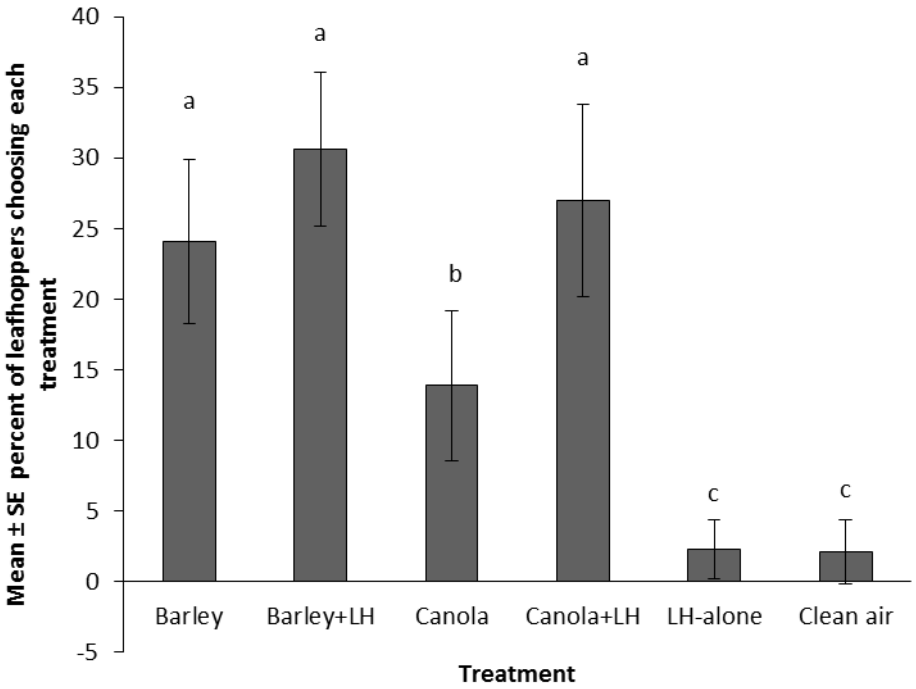
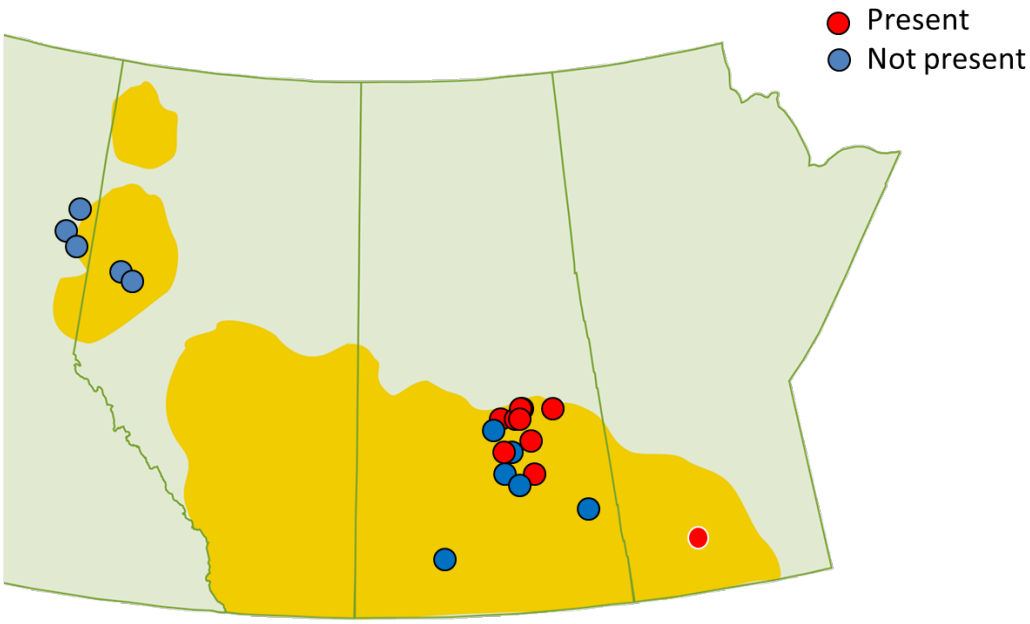


Figure 1. Percentage of leafhoppers choosing plant treatments in a six-armed olfactometer. Lower-case letters represent statistically significant differences (at $\alpha = 0.05$) among treatments with a generalized linear model (Poisson) followed by a Tukey's HSD test.

1. 2013



2. 2104

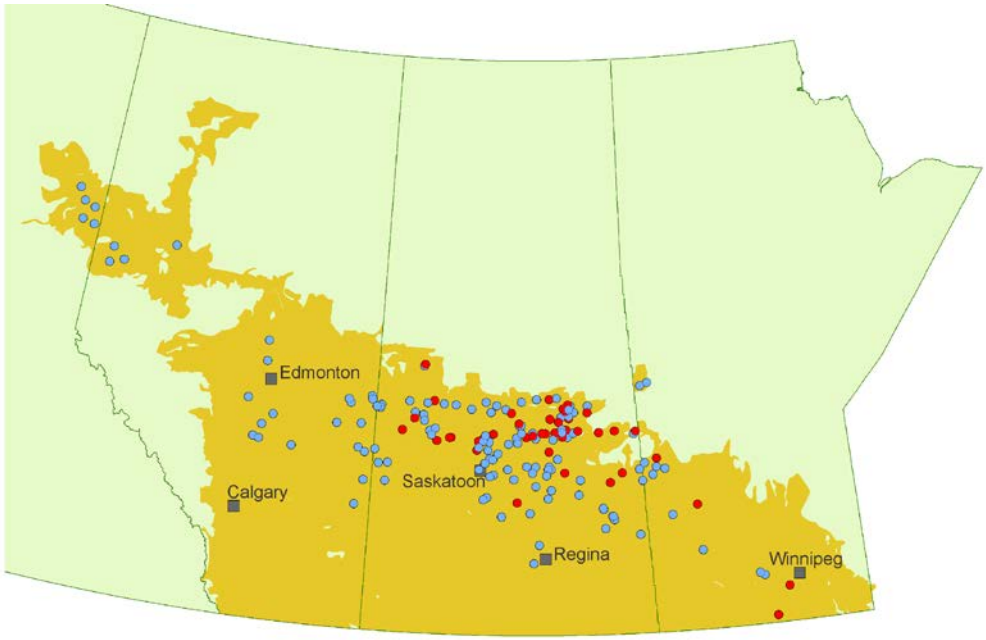


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Figure 2. Swede midge occurrence across the Prairies as determined by pheromone traps and canola plant sampling, 2013-14. A. 2013 - twenty-two locations, 10 with swede midge; B. 2104 – 148 locations, 25 with swede midge.

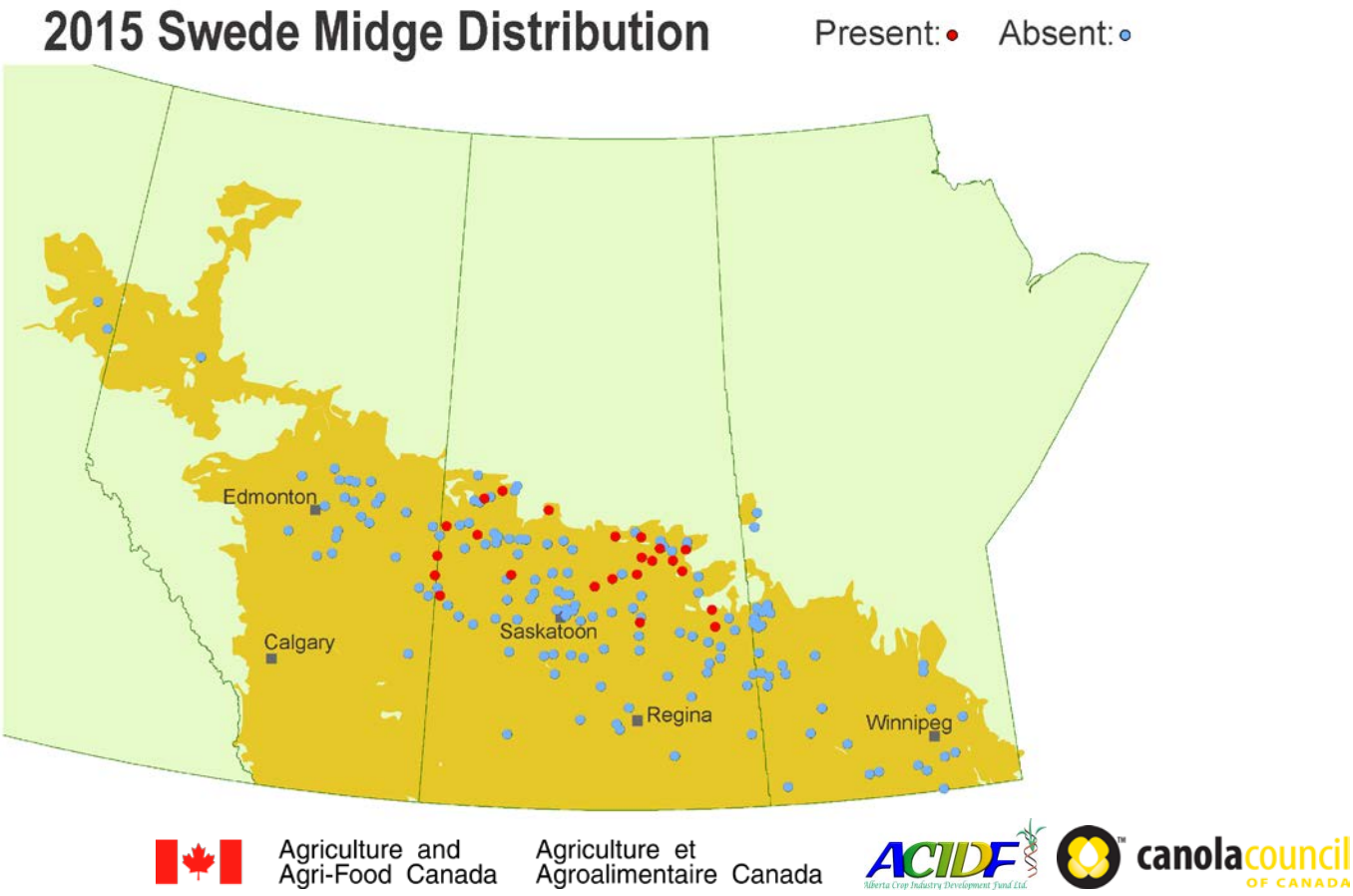

Figure 3. Swede midge occurrence across the Prairies on the Prairies as determined by pheromone traps and canola plant sampling, 2015. 177 locations, 25 with swede midge.

Appendix z

Dumonceaux TJ, Green M, Hammond C, Perez E, Olivier C (2014) Molecular Diagnostic Tools for Detection and Differentiation of Phytoplasmas Based on Chaperonin-60 Reveal Differences in Host Plant Infection Patterns. PLoS ONE 9(12): e116039. doi: 10.1371/journal.pone.0116039

Appendix zz

9. Technology transfer:

b) Industry-oriented publications – 10

1) Canola Watch issue 4, April, 4, 2013: Leafhopper arrival (http://www.canolawatch.org/). Interview by J. Whetter (communication specialist JWMedia)

2) Newsletter Back Forty February 2013 issue. Interviewed by S. Gerbig (Extension, SARDA)

3) Aster yellow outbreak biggest in years, interviewed by B. Barker for the February 2013 issue of Top Crop Manager

4) King, C. 2015. DNA diagnosis in a back of a truck. Top Crop Manager 41, p 16-18.

5) Kuropatwa, R. (2013) Mysterious swede midge increasing on prairies. Western Producer. November 21, 2013.

6) Winter, D. (2014) Swede midge threat looms over Manitoba. Manitoba Co-operator, 20 March, 2014. Interview to weekly industry newspaper. http://www.manitobacooperator.ca/news-opinion/news/swede-midge-threat-looms-over-manitoba-canola-crops/

7) Hilderman, T. (2014) Swede Midge; a potential perfect storm. GrainNews. June 4, 2014. Interview to weekly industry newspaper.

8) Dickson, T (2014) Swede midge moves in. Canola Digest November 2014, pp 38-40. http://www.canolacouncil.org/media/560399/CanolaDigest-Nov14/Canola%20Digest%20November%202014/index.html#/38/

9) Fleury, D. (2014) Keeping an eye on swede midge. Top Crop Manager, December 2014. http://www.agannex.com/field-crops/keeping-an-eye-on-swede-midge. Interview to monthly industry magazine.

10) Fleury, D (2015) Keeping an eye on swede midge. Top Crop Manager. Eastern Edition. Feb 2015. pp 28-29. http://www.mydigitalpublication.com/publication/index.php?i=0&m=1251&l=1&p=3&pre=#{"page":2,"issue_id":245162}

11) Swede midge and its parasitoids on the Prairies. Telephone interview with Peter Reschke, Ontario Farmer Newspaper, April 29, 2105, for monthly newspaper.

d) Industry-oriented presentations -35

1. Olivier, C. (2013) Healthy and AY-infected leafhopper rearing. AAFC- Saskatoon, SK, June 17 & June 26, 2013. Tours for private companies.

2. Olivier, C. (2103) Emerging canola pests. (2013) AAFC & NARF Crop Field Day, Melfort, July 24, 2013 (3 oral presentations and tours).

3. Olivier, C. (2014) Aster yellow symptomology, detection and identification in canola. Invited oral presentation at the Annual Meeting of the SK Institute of Agrologists, Saskatoon, SK, January 13, 2014.

4. Olivier, C, and Elliott, B. (2014) Aster yellow symptoms and rating scale. Invited oral presentation at the Prairie Pest Monitoring Network meeting, Saskatoon, SK, March 25, 2014.

8. Olivier, C. (2014) Aster yellow diseases research update. Invited oral presentation at the AAFC-London Research and Development Centre, London, ON, April 9, 2014.

9. Elliott, R.H., Mann, L.W., Olivier, C.Y., Olfert, O.O., and Soroka, J.J. (2015) Evaluation of new technologies and management practices for flea beetles and leafhoppers in canola. Oral presentation at Industry Update. Saskatoon. February 9, 2015.

10. Elliott, R.H., Mann, L.W., Olivier, C.Y., Olfert, O.O., and Soroka, J.J. (2015) Evaluation of new technologies and management practices for flea beetles and leafhoppers in canola., Invited webinar presentations to Canola Council of Canada agronomists, Saskatoon, Canada, April 10 and 24, 2015.

11. Soroka, J. (2013) Insect Update 2013. Invited oral presentation at AAFC Scott Research Farm Field Day, Jul 17, 2013, Scott, SK - two presentations of talk.

12. Soroka, J. (2013) Swede midge in prairie canola: potential distribution and damage. Invited oral presentation to Western Committee on Crop Protection. Winnipeg, MB, Oct 8, 2013.

13. Soroka, J. (2013) Swede midge on the prairies: potential distribution and damage. Invited oral presentation to Saskatchewan Insect Management Council. Saskatoon, SK, Nov 19, 2013.

14. Soroka, J. (2013) Integrated Pest Management - with Two Canola Pest Examples. Invited oral presentation to Plant Science Class, University of Saskatchewan, Saskatoon, SK, Nov 20, 2013.

15. Soroka, J. (2013) Insect pests on the prairies - what's bugging you? Invited oral presentation at Saskatchewan Bee Keepers' Annual Meeting, Waskesiu Lake, SK, Nov 27, 2013.

16. Hallett, R. and Soroka, J. (2013) Swede midge: Ontario situation, Saskatchewan potential. Invited oral presentation at Annual Canola Industry Meeting, Saskatoon, SK, Dec 4, 2013.

17. Soroka, J. (2013) Swede midge and other canola insects - what's bugging you? Invited oral presentation at Pioneer Agology Meeting, Tisdale, SK, Dec 5, 2013.

18. Soroka, J. (2013) Swede midge damage and potential distribution. Invited oral presentation at Saskatchewan Ministry of Agriculture Agronomy Update. Saskatoon, SK, Dec 12, 2013.

19. Soroka, J., Hartley, S., Wist, T., Elliott, B., Olivier, O., Bahar, H., and Erlandson, M. (2014) What's in my Sweep Net? Invited presentation at CANOLAB 2014 Saskatoon, SK, Mar 5 and 6, 2014, Eight presentations.

20. Soroka, J., Gavloski, J, and Braun, J. (2014) Recurring and New Insect Pests of Canola. Invited presentation at CANOLAB 2014 Brandon, MB, Mar 12 and 13, 2014, Eight presentations.

21. Soroka, J. (2014) Swede midge on the move. Invited oral presentation at Prairie Pest Monitoring Network Annual Meeting, Saskatoon, SK, Mar 25, 2014.

22. Soroka, J. (2014) Swede midge and cabbage seedpod weevil – will they close the vice on canola production? Invited oral presentation at Top Notch Farming Symposium, Melfort, SK, Mar 27, 2014.

23. Soroka, J. and Andreassen, L. (2014) Swede midge biology, symptoms, and outlook in Saskatchewan. Invited oral presentation at Agri-Trend Field Day, Shellbrook, SK, Jul 17, 2014.

24. Andreassen, L. and Soroka, J. (2014) Swede midge research update. Invited oral presentation at Melfort Research Farm Field Day, Melfort, SK, Jul 23, 2014.

25. Soroka, J. and Andreassen, L. (2014) Swede midge in Saskatchewan canola. Invited presentation at Saskatchewan Ministry of Agriculture Crop Diagnostic School, Scott Research Farm, Scott, SK, Jul 22 & 23,, 2014, eight presentations.

26. Andreassen, L., Soroka, J. (2014) Swede midge in Saskatchewan canola. Invited presentation at Saskatchewan Ministry of Agriculture Crop Diagnostic School, Melfort Research Farm, Melfort, SK, Jul 28 & 29, 2014, eight presentations.

27. Hartley, S., Soroka, J., and Andreassen, L. (2014) 2014 Insects in SK canola. Invited oral presentation to Canola Industry Days, Saskatoon, SK, Dec 2, 2014. 225 attendees.

28. Andreassen, L. and Soroka, J. (2014) Swede midge on the prairies 2014. Invited oral presentation at Saskatchewan Ministry of Agriculture Agronomy Update, Saskatoon, SK, Dec 9, 2014.

29. Soroka, J, and Andreassen, L. (2015) Everything you ever wanted to know about swede midge – and more. Invited presentation at Manitoba Agriculture AgDays, Brandon, MB, Jan 21, 2015.

30. Andreassen, L. and Soroka, J. (2015) Update on swede midge on the prairies. Prairie Pest Monitoring Network Annual Meeting, Saskatoon, SK, Mar 24, 2015.

31. Soroka, J. and Andreassen, L. (2015) Everything you ever wanted to know about swede midge - abridged version. Oral presentation at SK Ministry of Agriculture Survey Committee Meeting, Regina, SK. Apr 23, 2015.

32. Soroka, J., Andreassen, L. (2105) Research on swede midge at the Melfort Research Farm. Invited oral presentation at Melfort Research Farm Field Day, Melfort, SK, Jul 22, 2015.

33. Soroka, J., Andreassen, L., and Olfert, O. 2015. Swede midge –canola nemesis or flash in the pan – an update. Invited oral presentation to 2015 Regional SaskCanola Workshop, North Battleford, SK., Nov 18, 2015.

34. Soroka, J., Andreassen, L., and Olfert, O. (2016) Swede midge – new canola scourge or flash in the pan. Oral presentation to 2016 Agronomy Update. Alberta Agriculture Food and Rural Development, Red Deer, AB, Jan 20, 2016.

35. Andreassen, L., Soroka, J., and Olfert, O. (2106) Swede midge update 2016. Invited oral presentation at Prairie Pest Monitoring Network Annual Meeting, Saskatoon, SK, Mar 22, 2016.

Appendix zzz

Media:

1) Video interview by D. Murphy (Field Editor, Real Agriculture) in AAFC-Saskatoon greenhouses on July 26, 2013, http://www.realagriculture.com/2013/08/canola-school-assessing-aster-yellows-late-in-the-season-plus-a-research-update/

2) Real Agriculture web posting October 11, 2013: Canola School: Getting to Know Swede Midge. http://www.realagriculture.com/2013/10/canola-school-getting-to-know-swede-midge/

3) Swede midge on the Prairies. Farm Report December 5, 2013. CTV News, Saskatoon, SK. Interviewed by Bob Simpson.

4) McFarlane, A. (2014) Swede midge potential on the prairies. CJVR Radio interview aired March 7, 2014.

Section F: Research Team Signatures and Employers' Approval

The team leader and an authorised representative from his/her organisation of employment MUST sign this form.

Research team members and an authorised representative from their organisation(s) of employment MUST also sign this form.

By signing as representatives of the research team leader's employing organisation and/or the research team member's(s') employing organisation(s), the undersigned hereby acknowledge submission of the information contained in this final report to the funder(s).

Team Leader's Organization

Please print or type name on the first line and sign in blue ink

Team Leader

Name: Chrystel Olivier Currently on leave	**Title/Organization:** : Research Scientist, AAFC Saskatoon Research and Development Centre
Signature: unavailable	**Date: 15 April 2105**

Team Leader's Employer Approval

Name: Felicitas Katepa-Mupondwa	**Title/Organization:** D/RDT, AAFC Saskatoon Research and Development Centre
Signature: F M K Ld	**Date:** APR 14 2016

1. Research Team Member:	
Name: Juliana Soroka	Title/Organization: Research Scientist, AAFC Saskatoon Research and Development Centre
Signature: Juliana J Soroka	Date: April 13, 2016

Research Team Member's (Employer Approval)	
Name: Felicitas Katepa-Mupondwa	**Title/Organization:** D/RDT, AAFC Saskatoon Research and Development Centre
Signature: F M K Ld	**Date:** APR 14 2016

2. Research Team Member:	
Name: Owen Olfert	**Title/Organization:** Research Scientist, AAFC Saskatoon Research and Development Centre
Signature: Owen Olfert	**Date:** 13-04-2016

Research Team Member's (Employer Approval)	
Name: Felicitas Katepa-Mupondwa	**Title/Organization:** DRDT, AAFC SASKATCHEWAN
Signature: F M K Ld	**Date:** APR 15 2016

3. Research Team Member:

Name: Jennifer Otani	**Title/Organization:** Biologist, AAFC Beaverlodge Research Farm
Signature:	**Date:**

Research Team Member's (Employer Approval)	
Name:	**Title/Organization:**
Signature:	**Date:**