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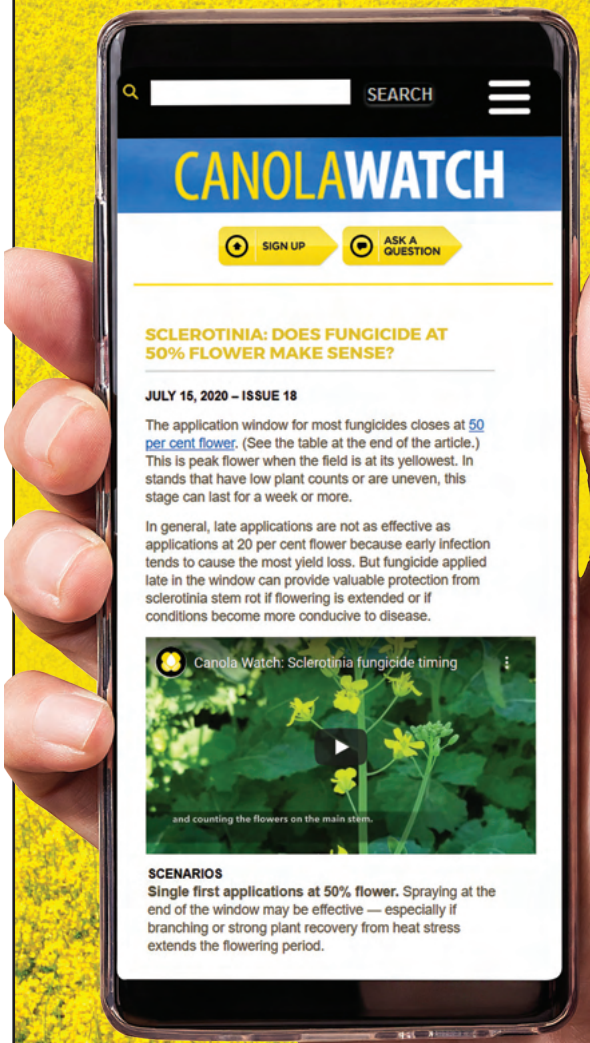
canola DIGEST

The Source For Canada's Canola Growers

SCIENCE EDITION

Open the cover to find a community of experts working to improve canola productivity. Canola Digest Science 2022 includes one-page summaries for 16 recently completed projects, and snapshots of new and ongoing work.

CANOLAWATCH



Your second set of eyes

Canola Watch agronomy tips are timely and research based.

Sign up for email updates at **canolawatch.org**

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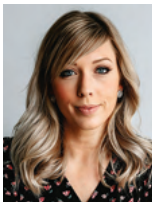
Your provincial research leads



BRITTANY VISSCHER

Alberta Canola
Research Director

As Alberta Canola's first research director, I have enjoyed the opportunity to do a deep dive into all aspects of our research programs and partnerships driven by grower funding.

Beginning with our Grower Engagement Meetings in the fall of 2021, I've been helping growers understand the partnerships and funding that drives Alberta Canola's research program. More importantly, I've been actively listening to growers to hear their immediate research needs and what they see as opportunities or threats for the future.

I am very excited to announce the first annual Alberta Canola Research Symposium, to be held in Lethbridge on January 18, 2023 as part of the new Alberta Canola Conference. The Symposium will include presentations on current research and, more importantly, a chance to hear directly from growers on their current and future research needs. Grower input is essential as we build and strengthen the research program at Alberta Canola.

My first year as research director has given me a lot of ideas on how we, together, can continue to make the research program inclusive for all canola growers in Alberta. I look forward to this upcoming year leveraging grower dollars for leading research success.

brittany@albertacanola.com

DOUG HEATH

SaskCanola
Research Manager

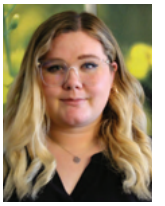
As the global pandemic hit, SaskCanola had to pivot and move events to an online format to stay connected with our growers and other stakeholders. As we get back to hosting in-person events, we've tailored them strategically to best suit the needs of Saskatchewan canola growers.

This past summer, in partnership with IHARF and WARC, we hosted two canola-specific crop walks. These events highlighted SaskCanola-funded research projects and demonstrations. Project leads were available to talk about their work and answer any questions from growers.

As the winter months approach, SaskCanola is planning five regional meetings across Saskatchewan for the end of January to mid-February. We will be partnering with SaskBarley, and other organizations, to bring timely and relevant agronomic, marketing, policy and health information to growers and agronomists. Registration and agenda details are available on our website.

SaskCanola will have videos of extension events available if you can't attend, but it's worthwhile to join us in-person, to learn about the latest canola research findings and to help increase your yields and your prosperity. I look forward to seeing you and reconnecting with each other to discuss your priorities on your farm.

dheath@saskcanola.com



SONIA WILSON

Manitoba Canola Growers
Research Manager (term)

My passion for plants and agriculture has driven me to be where I am today. From studying plant biotech at the University of Manitoba to becoming a Masters' candidate studying excess moisture in canola, I have wanted to learn as much as I can about how plant genetics relate to crop resiliency. During my university studies, I was fortunate to have been the summer student at MCGA and see first-hand how they represent farmers' needs. I stepped in while Amy Delaquis is on parental leave to continue her work of ensuring that the gaps in Manitoba's canola research are being filled and upcoming research aligns with our farmers' priorities.

As the current research manager with the Manitoba Canola Growers Association, I am responsible for prioritizing farmer-identified research needs, managing funding, exploring new research collaborations and growing the on-farm research programs. The 2021 season showed us that even with less revenue due to drought challenges, maximizing and leveraging what we have is key to providing future resilience and yield stability for canola growers. I am focused on ensuring that the investment from canola growers funds research that is timely and innovative to support them in their on-farm decisions and future success.

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canola DIGEST
Science Edition 2022

PROVINCIAL RESEARCH BULLETINS

4 SaskCanola

SaskCanola co-funds important research on the management and study of weed populations, including herbicide-resistant weeds that could cause challenges for canola production. The SaskCanola research bulletin highlights six researchers and their weed surveys and management projects. Find more details on these current or completed weed research projects at SaskCanola's Research Results webpage (search for "weeds" at saskcanola.com/research-results) or on the Canola Research Hub at canolaresearch.ca.

6 ALBERTA CANOLA

Over the last year, Alberta Canola invested over $1.1 million toward 12 new projects representing approximately $3.6 million worth of research. Every $1 of farmer levy invested by Alberta Canola was matched by about $2.50 from research partners and funding programs. Projects examining canola diseases took precedence in 2022. Alberta Canola also committed $50,000 to the $9.4 million Alberta AgriSystems Living Lab (AALL) led by the Alberta Beef Producers and with funding from Agriculture and Agri-Food Canada's Agricultural Climate Solutions Living Lab Initiative.

8 Manitoba Canola Growers

In 2022, Manitoba Canola Growers launched a pilot on-farm research program to help farmers across the province fill the gap between traditional research results and the farm level experience. The program aims to provide applied, transferable research results. Manitoba Canola Growers worked with independent agronomists to conduct trials and work with growers to execute scientifically-sound randomized, replicated trials on their farms using field scale equipment. Trials for 2022 tested seeding rate, nitrogen rate and anti-fungal bio-inoculants.

FEATURES

10 **Canola Encyclopedia: Top 10 hits for 2022**

Clicks and searches are good indicators of interest. The Canola Encyclopedia at **canolaencyclopedia.ca** is the complete guide to growing canola in Canada, and this article has the top 10 most popular Canola Encyclopedia pages for 2022. Flea beetles, cutworms and sclerotinia stem rot are the top three pests on the list, but the growth stages page remains the most popular.

11 **Canola Research Hub has over 200 science summaries**

The Canola Research Hub's comprehensive database and user-friendly interface at **CanolaResearch.ca** make research results easy to find and apply. Explore over 200 plant establishment, genetics, nutrient, harvest and integrated pest management projects. For each study, users can see key findings, short summaries or full reports, along with photos, videos, tables or graphs.

REPORTS FOR RECENTLY COMPLETED PROJECTS

FERTILIZER MANAGEMENT

12 **Fungus *Olpidium brassicae* dominates in canola-only rotations**

Key result: While this study found minimal impacts from crop rotation on root nutrient availability, frequency of canola in the rotation did show differences in the fungal microbiome associated with canola roots. More research is required to show what this means for canola productivity.

13 **Root and rhizosphere microbiota vary by crop and conditions**

Key result: Biodiverse agricultural systems improve agricultural productivity and climate management. This study contributes to a better understanding of canola microbiota, which provide important information to improve canola yields and reduce greenhouse gas emissions by identifying crop rotations that could potentially reduce nitrogen fertilizer use.

14 **Silicon uptake could increase canola stress tolerance**

Key result: If canola could be transformed with two target genes for silicon uptake, the crop could become more tolerant to biotic (pathogen) and abiotic (weather) stress. In the end, this study could transform only one of the two target genes, and resulting stress tolerance to blackleg and drought were not noticeably different from controls. They determined that both genes are necessary, and continue to work toward that goal.

15 **Are we measuring the right soil nitrogen pool?**

Key result: Researchers wanted to see if soil protein, extracted using the ACE/MACE methods, is an appropriate measure of the soil nitrogen that potentially becomes available during the growing season. They found only a weak correlation, and concluded that current soil test recommendations provide an acceptable measure of biologically available nitrogen.

INTEGRATED PEST MANAGEMENT

16 Details on clubroot infection set stage for better resistance

Key result: This is one of the first studies to characterize effector proteins with key roles in clubroot infection and disease progression. Results provide a valuable resource for the identification of new clubroot resistance genes.

17 Diamondback moth thresholds may need adjustment

Key result: Yield reductions at current nominal thresholds of one to two DBM larvae per plant in canola may not be significant. Therefore, the nominal thresholds for DBM in canola may need to be increased to a slightly higher number of larvae per plant. Dynamic action thresholds incorporate the effect of natural enemies on pest control.

18 Testing thresholds and insecticides for pollen beetle

Key result: Pollen beetles were susceptible to three of four insecticides tested. Yield reduction was detected at seven to nine beetles per plant, but not at four beetles per 10 sweeps. Pollen beetles were not detected in the Prairies and no native parasitoids were found attacking pollen beetle larvae in Atlantic Canada.

19 Field studies show dandelion part of aster yellows disease cycle

Key result: This project evaluated several crop and non-crop species commonly found in the Canadian Prairies as possible hosts for aster leafhopper development or phytoplasma infection or both. Alfalfa, sow thistle, stinkweed and dandelion were found to harbour aster yellows phytoplasma and are likely acting as reservoirs for the phytoplasma in Western Canada.

20 Genome analysis of 45 clubroot isolates leads way for ID tests

Key finding: Clubroot continues to spread, but improved monitoring and methodologies allow for more pathotype characterization to better identify, quantify and eventually manage clubroot-causing pathotypes going forward.

21 Predatory nematodes provide biocontrol option for canola pests

Key result: Although impact varied among species, predatory nematodes belonging to the *Steinernema* genus provided significant mortality of diamondback moth, lygus bug, cabbage root maggots and black cutworms.

22 Sign up to help the Prairie Pest Monitoring Network

Key result: The Prairie Pest Monitoring Network (PPMN) provides forecasts, risk maps and monitoring protocols for crop pest insects across Western Canada. It also provides a free weekly update during the growing season. Anyone can subscribe at **prairiepest.ca**.

23 Uniformity of sprayer deposition needs improvement

Key result: The range in on-target spray deposition volume across the width of sprayers was unexpectedly large for this study. With each sprayer pass, some targets only received one third of the intended dose while others received triple the intended dose.

GENETICS

24 Canola lines with corn genes yield more, have stronger stems

Key result: CRISPR technology was used to generate a range of starch branching enzyme (SBE) mutants in canola. *Sbe* quadruple and sextuple mutants were used for expressing maize endosperm SBEI and effects on growth, morphology, flowering and yield determined. Introduction of corn SBEI into quadruple mutants (four canola genes edited) repeatedly led to increased total seed yield of 30 per cent in greenhouse conditions. In the sextuple *sbe* mutant an additional phenotype of a thicker stem conferred improved resistance to drought and high temperature. Additional lines are being generated to test under field conditions and a patent has been granted.

25 A new gene for blackleg resistance

Key result: AAFC researchers completed the genetic mapping of blackleg resistance gene Rlm11. Rlm11 is effective against *L. maculans* isolates carrying the avirulence gene AvrLm11, which is found in 95 per cent of L. maculans isolates collected from Western Canadian canola farms. Canola lines with Rlm11 will enable canola farmers to effectively control the blackleg disease.

26 Researchers expand the spectrum of clubroot resistance

Key result: Canola lines with a broad spectrum of clubroot resistance were developed, which are valuable for developing resistant cultivars by canola breeders. Additional developments can improve the ability to monitor changes in the clubroot pathogen race structure, as the pathogen evolves in canola fields on the Prairies.

OTHER

27 Canola meal a viable protein supplement for beef cattle

Key result: The study showed that canola meal, a high-quality protein source, may be more economically favourable than distillers' grains when used as a feed supplement for beef cattle.

28 NEW AND ONGOING PROJECTS

New projects launched in the past year include research into nitrogen fertilizer sources, updating the critical weed-free period for canola, genetics to increase drought and heat tolerance, and quantifying combine auto settings for their ability to reduce harvest losses. Ongoing projects include research into biologicals for nitrogen fixation and insect management, phenology-based weed control, and new techniques to breed for disease resistance and environmental stress tolerance. Canola growers contribute to these projects through their levy payments to SaskCanola, Alberta Canola and Manitoba Canola Growers. In partnership with the grower groups and Canola Council of Canada, a number of ongoing projects are funded in part by the Government of Canada under the Canadian Agricultural Partnership's AgriScience Program, a federal provincial, territorial initiative. Many projects are also collaborations with other commodity groups and other Prairie-wide funders, including Western Grains Research Foundation.

Photo credit: Jonah Lawley

SaskCanola's recent investments into weed research

Photo credit: iStock.com/vaivirga

Weed survey field at time of kochia surveying.

Photo supplied by Shaun Sharpe, AAFC.

SASKCANOLA CO-FUNDS IMPORTANT RESEARCH on the management and study of weed populations, with a focus on weeds that are important to canola production. Several of these projects involve screening weed populations for baseline levels of resistance to several classes of herbicides.

This screening provides useful knowledge for researchers to compare to future data and determine how quickly herbicide-resistant (HR) weed species are spreading across the Prairies, as well as which herbicide modes of action are most at-risk of becoming ineffective. Herbicide stewardship, with proper herbicide rotation across the entire crop rotation, is key to maintaining a diverse choice of herbicides for a longer period of time.

Shaun Sharpe, research scientist with Agriculture and Agri-Food Canada (AAFC) in Saskatoon, is most concerned with the risk of Group 14 herbicide resistance arising in kochia on the Prairies. "This mode of action has pre-emergence, post-emergence, desiccation, and post-harvest application timings. The later timing, desiccation and post-harvest may mean kochia is a lot larger and harder to kill," Sharpe says.

This poses a risk for developing HR weeds because of increased selection pressure from applying the same herbicide mode of action. This can happen whether it is applied multiple times within one growing season or if the same herbicide is applied year-after-year on the same field. Unfortunately, we are running out of modes of action that are effective against this weed, and that is why herbicide stewardship is so important.

Breanne Tidemann, research scientist at AAFC Lacombe, currently leads a SaskCanola co-funded project to learn more about cleavers populations in Western Canada. Different cleavers biotypes may have early or late emergence, and some winter annual biotypes can overwinter. Biotypes with different emergence times require different management strategies. As well, some biotypes have been observed to have HR, so this project will evaluate the base-level of quinclorac resistance to see if any can be found in Western Canadian cleavers populations.

Robert Gulden, researcher at the University of Manitoba, recently started a project to update the critical weed-free period (CWFP) in canola. The previous CWFP recommendations were done 20 years ago. Since then, modern hybrids have greater seedling vigour and the ability to compete with weed species. Results from this

It is important to scout for herbicide resistant weed populations in your field after herbicide applications. For more best management practices and tips for controlling HR weeds, see manageresistancenow.ca

research could mean that the CWFP will be shortened and potentially give growers the confidence to apply fewer herbicide applications in the canola growing season after the CWFP. However, plant stand densities are also a key factor in the ability of canola hybrids to compete with weeds. For this reason, different canola establishment rates, including rates below the recommended five to eight plants per square foot, will be evaluated for their ability to compete with weed populations.

Charles Geddes, research scientist at AAFC Lethbridge, is evaluating the economic thresholds for glyphosate-resistant kochia in canola in Western Canada. Specifically, Geddes and his team are looking at the threshold for using a two-pass herbicide system for canola varieties that have stacked glyphosate and glufosinate tolerance traits to control HR kochia. This threshold will depend on the density of kochia in the field and whether the second herbicide pass occurs after the CWFP. This project also evaluates whether the cost savings of reduced canola seeding rates causes a greater economic loss due to lost competitiveness against weeds, as well as the higher risk of evolving HR weeds.

Julia Leeson, research scientist at AAFC Saskatoon, is researching the composition of general weed populations in different regions and crops over time. The first iteration of the general weed survey began in the 1970s. The current survey, which began in 2019, is the sixth iteration on the Prairies. Each iteration of the survey spans several years and looks at the weed population dynamics of which weeds are becoming more prevalent and which species may become greater issues. This current survey sampled 2,277 Saskatchewan fields during 2019 and 2021 with similar numbers of fields to be surveyed across the three Prairie provinces by the end of the six-year cycle. In 2019, the top three weeds in Saskatchewan were green foxtail, canola and wild oats. With extreme drought conditions in 2021, this changed to green foxtail, wild oats and kochia. Full results for the Prairies will be available in 2024.

Above: Kochia seed collected in field surveys was seeded in the greenhouse and then treated with Dicamba to evaluate the level of resistance. Approximately 10 per cent of this population survived and resumed a normal growth habit.

Photo supplied by Shaun Sharpe, AAFC.

Shaun Sharpe leads another Prairie weed survey focused specifically on identifying populations of kochia and Russian thistle with HR to glyphosate or dicamba. The rate of increase in HR kochia over the last decade has been shocking, so it is advisable to use multiple modes of action to control kochia.

Sally Vail, research scientist with AAFC Saskatoon, is looking at causes and potential solutions to secondary dormancy in canola seed in a Canola AgriScience Cluster project. Secondary dormancy in canola seed causes germination to be delayed to the following crop season, triggering canola volunteers to be a dominant weed issue in many fields. Vail's research aims to identify genes controlling this trait, with the goal of breeding canola with lower secondary dormancy, and lower numbers of volunteers in following crops.

Other resources

SaskCanola avoids funding duplicate projects, so we encourage you to look at other weed research projects by these and other researchers that are funded by other organizations. You can find other current or completed weed research projects at SaskCanola's Research Results (search for "weeds" at saskcanola.com/research-results) or at the Canola Council of Canada's Canola Research Hub (canolaresearch.ca). General information on weeds that impact canola production can be found in the Weeds section at canolaencyclopedia.ca.

Alberta Canola invests $1.1 million in research

Rasha Salih and Priyavashini Prakash, summer undergraduate supported by MITACS.
Photo credit: Edel Pérez-López

OVER THE LAST YEAR, ALBERTA CANOLA INVESTED OVER $1.1 MILLION TOWARD 12 NEW PROJECTS REPRESENTING APPROXIMATELY $3.6 MILLION WORTH OF RESEARCH. Every $1 of farmer levy invested by Alberta Canola was matched by about $2.50 of investment by research partners and funding programs.

Projects examining canola diseases took precedence in 2022. Clubroot continues to be a challenging disease, with resistance-breaking pathotypes threatening canola cultivar resistance – which is the most effective management tool. At the University of Alberta, Stephen Strelkov is efficiently identifying *Plasmodiophora brassicae* pathotypes through metabarcoding, and Gavin Chen is enhancing clubroot resistance in canola through regulating a transcription factory AIL7. Meanwhile, Hossein Borhan at Agriculture and Agri-Food Canada (AAFC) in Saskatoon is dissecting the genetics of *Brassica napus* resistance to clubroot.

Photo credit: Brittany Visscher

Gary Peng continues to work on blackleg disease at AAFC Saskatoon by monitoring changes in *Leptosphaeria maculans* races and blackleg's impact on canola after the introduction of the new R genes Rlm2, Rlm4 and Rlm7. Jacqueline Monaghan at Queen's University will examine non-disease-specific impacts following the deployment of calcium-dependant protein kinases.

With the extreme drought in 2021, Alberta Canola found it especially necessary to support Shelley Hoover's research at the University of Lethbridge where she's examining the effects of heat and drought on canola-pollinator interactions and crop yield. Following the climate and environment theme, Reynald Lemke at AAFC Saskatoon will look at how fall-applied nitrogen fertilizer influences soil-emitted nitrous oxide emissions over the winter and during the spring thaw period in the semi-arid Prairies. Melissa Arcand at the University of Saskatchewan will analyze the quantification of soil- and fertilizer-derived nitrogen sources and greenhouse gas emissions under canola hybrids.

Weeds continue to threaten the successful production of canola. Breanne Tidemann at AAFC Lacombe is screening false cleavers from the Prairie herbicide resistance surveys for quinclorac and glyphosate resistance, while Rob Gulden and his team will update the critical weed free period in canola out of the University of Manitoba.

Emerging potential threats are important to understand, which is why Alberta Canola funded Christine Noronha at AAFC Charlottetown, who is developing and assessing different strategies to reduce the impact of pollen beetle, *Brassicogethes viridescens* (Coleoptra: Nitidulidae).

In addition to agronomy-related research projects, Alberta Canola recognizes the importance of investing in market development. Catherine Chan at the University of Alberta is comparing saturated and unsaturated fat sources of the ketogenic diet along with their metabolic and inflammatory outcomes.

Beyond these research projects, Alberta Canola has committed $50,000 to the $9.4 million Alberta AgriSystems Living Lab (AALL) led by the Alberta Beef Producers. The AALL is focused on measuring the impacts of beneficial management practices (BMPs) in the real world. Results from this project will be used to help direct government policy makers and help to demonstrate the value of the work producers do every day. Funding of this initiative is provided by AAFC through the Agricultural Climate Solutions Living Lab Initiative, as well as contributions from partner organizations.

RESEARCHER	PROJECT TITLE	Alberta Canola Funding	Total Project Cost	Partners
Stephen Strelkov University of Alberta	Efficient identification of *Plasmodiophora brassicae* pathotypes by metabarcoding	$42,694	$387,750	RDAR, WGRF
Reynald Lemke AAFC Saskatoon	How does fall-applied N fertilizer influence soil-emitted nitrous oxide emissions during the over-winter and spring thaw period in the semi-arid Prairies	$88,440	$88,440	CCC
Rob Gulden University of Manitoba	Updating the critical weed free period in canola	$87,477	$262,432	CCC, SaskCanola, MCGA, RDAR
Jacqueline Monaghan Queen's University	Deploying calcium-dependent protein kinases to fight canola pathogens	$131,404	$304,175	CCC, SaskCanola, MCGA
Breanne Tidemann AAFC Lacombe	Screening false cleavers from the Prairie Herbicide Resistance Surveys for quinclorac and glyphosate resistance	$40,013	$40,013	CCC
Gary Peng AAFC Saskatoon	Monitoring changes in *Leptosphaeria maculans* races and blackleg impact on canola after the introduction of the new R genes Rlm2, Rlm4 and Rlm7	$93,750	$187,500	CCC, SaskCanola
Melissa Arcand University of Saskatchewan	Climate-smart canola: quantifying soil- and fertilizer-derived nitrogen sources and greenhouse gas emissions under Canola hybrids	$62,038	$148,076	CCC, SaskCanola, MCGA, WGRF
Gavin Chen University of Alberta	Enhancing clubroot resistance in canola through regulating a transcription factor AIL7	$49,247	$245,870	RDAR, WGRF
Shelley Hoover University of Lethbridge	Effects of heat and drought on canola–pollinator interactions and crop yield	$109,900	$271,200	CCC, RDAR
Hossein Borhan AAFC Saskatoon	Dissecting the genetics of *B. napus* resistance to clubroot	$20,000	$648,860	RDAR, WGRF
Christine Noronha AAFC Charlottetown	Develop and assess different strategies to reduce the impact of pollen beetle *Brassicogethes viridescens (Coleoptera: Nitidulidae)*, a new invasive insect pest on canola	$30,012	$230,000	CCC, MCGA
Catherine Chan University of Alberta	Metabolic and inflammatory outcomes of the ketogenic diet comparing saturated and unsaturated fat sources	$391,681	$783,361	RDAR
	2022 PROJECT TOTAL	**$1,146,656**	**$3,597,677**	

Alberta AgriSystems Living Lab Initiative, led by the Alberta Beef Producers: Integrating beef, forage and cropping systems to improve soil carbon sequestration and reduce greenhouse gas emissions

PARTNERS: Alberta Wheat Commission, Alberta Barley, Beef Cattle Research Council, Ducks Unlimited Canada, Alberta Pulse Growers, Alberta Cattle Feeders Association, Corteva Agriscience, Canfax Research Services, Canola Council of Canada, Alberta Beekeepers Commission, Verified Beef Production Plus, nu nenne Advisian Environmental LP, Alberta Conservation Association, University of Alberta, and Agriculture and Agri-Food Canada

AALL TOTAL	**$50,000**	**$9,416,474**
2022 TOTAL	**$1,196,656**	**$13,014,151**

AAFC = Agriculture and Agri-Food Canada
CCC = Canola Council of Canada
MCGA = Manitoba Canola Growers Association
RDAR = Results Driven Agriculture Research
WGRF = Western Grains Research Foundation

MCGA launches on-farm research program

IN 2022, Manitoba Canola Growers launched a pilot on-farm research program to help farmers across the province fill the gap between traditional research results and the farm level experience. The program aims to provide applied, transferable research results to farmers to allow for the adoption of new and improved production practices by evaluating performance across a wide range of growing regions and farm operations in Manitoba.

Manitoba Canola Growers worked with independent agronomists located in various regions across the province to conduct trials and work with growers to execute scientifically-sound randomized, replicated trials on their farms using field scale equipment. In 2022 we focused on three trial types: seeding rate, nitrogen rate and anti-fungal bioinoculant.

Result reports with individual trials and combined analysis for the complete data sets and all trials were provided directly back to farmers that participated. They are also available for all MCGA members on our website CanolaGrowers.com.

SEEDING RATE TRIAL

Research Objective:

Identify economic and agronomic optimal seeding rates for Manitoba canola production and the major factors influencing this relationship.

Treatments:

Farmer's standard seeding rate compared to reduced rate (75 per cent) and high rate (125 per cent)

Data Collected:

Spring and fall plant counts, emergence percentage, survival percentage, plant stand uniformity, grain yield

NITROGEN RATE TRIAL

Research Objective:

Identify optimal nitrogen fertilizer rate based on return on investment and nitrogen use efficiency.

Treatments:

Farmer's standard nitrogen rate compared to reduced rate (75 per cent) and high rate (125 per cent)

Data Collected:

Plant counts, nitrogen tissue content at bolting, grain yield, nitrogen use efficiency, protein and oil percentages in harvested seed

ANTI-FUNGAL BIOINOCULANT TRIAL

Research Objective:

Determine the level of disease control and yield response of canola treated with a foliar application of KGS-3 anti-fungal bioinoculant (Paenibacillus sp.).

Treatments:

Untreated, KGS-3 foliar-applied at approximately the four-leaf stage

Data Collected:

Blackleg ratings, verticillium stripe ratings, grain yield

2022 Agronomists:

Tone Ag Consulting,
St. Pierre, MB

New Era Ag Research,
Swan River, MB

A1 Agronomy,
Melita, MB

Antara Agronomy,
St. Jean, MB

360 Ag Consulting,
Roblin, MB

Scan QR code for full 2022 research results.

If you are interested in participating in MCGA on-farm trials for the 2023 growing season, please contact Sonia@CanolaGrowers.ca

Participants speak out

We asked three participants in our pilot on-farm research program to answer the question, *What value do the on-farm research trials bring to your farm?*

"Trying new products and ideas has allowed me to gather first-hand information. This helps with future decisions on keeping my farm profitable."

Leon Mykula
L&R Farms
Swan River, MB

"In an environment where we are bombarded with information, the on-farm research network has been an extremely valuable tool to help us assess new products or agronomic strategies. The trials are at arms-length, unbiased, and the replication and statistical analysis provides us with tremendous confidence in the results, an aspect that is missing from much of the information presented to us as farmers these days. We not only benefit on our own farm from participating in the on-farm network but also share a great deal of their findings with the farmers we interact with in our seed business."

Mark Sloane
Sloane AgriVentures Ltd.
Crystal City, MB

"We love doing the on-farm research trials. We are always trying to learn something new and innovative to try and maximize yield and minimize costs. We have a saying here 'we are in it to win it'."

Chris Grenier
Altamont, MB

Clicks and searches are good indicators of interest. The Canola Encyclopedia at **canolaencyclopedia.ca** is the complete guide to growing canola in Canada, and this article has the top 10 most popular Canola Encyclopedia pages for 2022.

CANOLA ENCYCLOPEDIA:

HITS FOR 2022

Who has the A-Z on canola production? The Canola Encyclopedia, that's who. Farmers and agronomy providers with questions go to **canolaencyclopedia.ca** for science-based answers on weeds, insects and diseases, plant establishment, nutrient management, and on harvest loss and storage. Here are the top 10 most-viewed encyclopedia pages for first nine months of 2022.

1. GROWTH STAGES. This chapter describes all stages of canola plant growth from germination to senescence. A great feature is the graphic on canola growth stages, posted in the overview section. It shows clearly what four-leaf, rosette and bolting stages look like.

2. FLEA BEETLES. Flea beetles were out and looking for food when a lot of late-seeded canola was emerging. Canola Watch, which drives a lot of traffic to the Canola Encyclopedia, started talking about flea beetles in early May and ramped up in June with headlines like "Slow-starting spring = buffet for flea beetles" and "Seedling canola's #1 threat: flea beetles."

3. CUTWORMS. These big eaters are always lurking in the soils, ready to chomp. Cutworm chapter page views were up nine per cent over 2021 and average time on page, at just under eight minutes, was the most of any other topic in the top 10. People really dig their cutworm reading.

4. HISTORY OF CANOLA SEED DEVELOPMENT. This chapter sees steady traffic throughout the entire year. It starts with the ancient history of brassica oilseeds and moves quickly to the main feature: the Canadian researchers who developed canola with its low erucic acid and low glucosinolate levels. The chapter has sections on herbicide-tolerant canola, hybrid canola and fatty acid profiles.

5. SCLEROTINIA STEM ROT. With better yield potential in 2022, sclerotinia stem rot had a 20 per cent increase in page views over 2021. This perennial pest moved up two spots on the top 10 list, luring people with its visuals on sclerotinia identification, best management practices and a detailed table of fungicide products.

Explore the Canola Encyclopedia at **canolaencyclopedia.ca**.

6. LYGUS BUGS. Lygus ate and ate through August, with most of the concern in Alberta. Should I spray?! Economic thresholds, now 20-30 per 10 sweeps, were revised recently and the Canola Encyclopedia describes in adequate detail the new thresholds as well as scouting tips and insect identification.

7. CLUBROOT. Information gathering on now-familiar clubroot tends to ramp up in late summer when galls and sick plants are most obvious. Around that time, farmers with clubroot will start seed shopping. As usual, Canola Encyclopedia delivers, giving shoppers a complete list of clubroot-resistant canola cultivars.

8. DIAMONDBACK MOTH. Prairie Pest Monitoring Network in mid August predicted that diamondback moth development would be marginally greater in 2022, and that warm conditions during August resulted in rapid development of populations. Canola Watch also talked about diamondback moth more than usual in 2021. The search for BMPs pushed DBM into the T10 for '22.

9. BLACKLEG. With the increase in sclerotinia stem rot and arrival of verticillium stripe, farmers and agronomists were checking Canola Encyclopedia to brush up on their disease identification skills. The blackleg chapter has information on testing for races and on R-gene rotation for those close scouters seeing a rise in blackleg severity.

10. HARVEST MANAGEMENT. Greased by better yields, this chapter slid into the 10-spot for 2022. Straight combining continues to gain in popularity, and the Canola Encyclopedia chapter has lots of tips. Swath timing was another hot topic in 2022 because a high number of people are still cutting too early – before 60 per cent seed colour change – and Canola Council of Canada agronomy specialists talked a lot about it.

Canola Watch quizzes always drive a lot of traffic to the Encyclopedia. To test your knowledge on a year's worth of quick quizzes, go to **canolawatch.org** and click on "Quizzes" in the Quick Links box.

The Hub provides the science behind current best management practices. Explore over 200 plant establishment, genetics, nutrient, harvest management and integrated pest management projects at **canolaresearch.ca**.

Canola Research Hub has over 200 science summaries

By Taryn Dickson

As a one-stop spot for Canadian canola science, the Canola Research Hub provides applicable agronomic insights on subjects and challenges that impact farmers.

The Hub's comprehensive database and user-friendly interface at **CanolaResearch.ca** make research results easy to find and apply. For studies, users can see key findings, short summaries or full reports, and easily share results with colleagues or customers. Photos, videos, tables and graphs help relay key explanations and conclusions from the experiments and studies highlighted on the Hub.

Explore the 200+ plant establishment, genetics, nutrient, harvest and integrated pest management projects to catch up on the latest research and increase your knowledge of canola production topics. The Hub provides the science behind current best management practices for sustainable and profitable canola production in Canada. It also initiates the adoption of new practices and stimulates further innovation and discovery.

BLOG POSTS

Monthly blogs posted on the Hub and shared on its LinkedIn account (linkedin.com/showcase/the-canola-research-hub) showcase new content and topics relevant throughout the growing season.

Here are titles and short introductions for three of my favourite blog posts from 2022:

Dive into the database at **CanolaResearch.ca** today and put findings into action next growing season.

–Check more than just temperature for safe canola storage

Maintaining seed quality and avoiding spoilage are key goals of canola storage. To achieve these goals, growers need to know how seed parameters (such as oil content, quality, temperature and moisture), bin factors (bin size, fan type and size, quantity, etc.) and environmental considerations (air temperature, humidity, etc.) affect safe storage.

–Check twice for improved long-term sclerotinia management

Sclerotinia stem rot is a challenge to predict and manage every year. Implementing a late summer (at 30 to 60 per cent seed colour change) field visit to rate the sclerotinia disease severity (in addition to assessing sclerotinia risk at 20 to 50 per cent flower, to make that tough spray decision) could provide a huge benefit to growers over time.

–Ensure proper growth stage when lygus scouting and using thresholds

Only at certain life stages can the lygus bugs potentially cause economic damage when using their piercing and sucking mouthparts to feed on certain stages of canola crops. So it is recommended to use the new threshold of 20-30 late instar or adult lygus bugs per 10 sweeps in canola fields at the early to mid-pod stage to best manage this insect.

Find all blog posts at CanolaCouncil.org/Research-Blog/.

The Canola Research Hub is funded through the Canadian Agricultural Partnership with support from industry members like Alberta Canola, SaskCanola, Manitoba Canola Growers and the Canola Council of Canada. The site features many projects funded or administered by these organizations and is positioned to help achieve the industry goal of an average yield of 52 bu./ac. by 2025.

—Taryn Dickson is resource manager for Crop Production and Innovation with the Canola Council of Canada. Taryn also manages the Canola Research Hub.

Fungus *Olpidium brassicae* dominates in canola-only rotations

KEY RESULT:

While this study found minimal impacts from crop rotation on root nutrient availability, frequency of canola in the rotation did show differences in the fungal microbiome associated with canola roots. More research is required to show what this means for canola productivity.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Canola frequency effects on nutrient turnover and root-microbe interactions" Tim Dumonceaux, AAFC Saskatoon, and Bobbi Helgason, University of Saskatchewan

FUNDING:
SaskCanola, Alberta Canola

FULL REPORT:
To find the full report, go to the Canola Research Hub at canolaresearch.ca and search for the project title.

The fungal microbiome responded more strongly to crop rotation than did bacterial communities, this study found, and researchers identified a fungus, *Olpidium brassicae*, that was particularly dominant in the canola-only rotations.

Study objectives were to determine the effect of crop rotation on the nutrient fluxes experienced by canola roots during flowering, examine the organic acids produced by canola that shape the composition of the root-associated microbial communities, and characterize the resulting microbial communities.

This project leveraged a long-established crop rotation study comparing continuous canola, canola-wheat and canola-pea-barley at Scott, Saskatchewan (Dark Brown soil zone), Swift Current, Saskatchewan (Brown soil zone) and Lacombe, Alberta (Black soil zone). Samples were taken from the canola years of these well-established rotations. Researchers used commercially available Plant Root Simulator probes from WesternAg to examine the flux of nutrients available to canola roots, and ion exchange chromatography to examine the organic acids produced by canola plants. Bacterial and fungal communities were characterized using DNA sequencing of the soil, rhizosphere and roots. In this way, researchers examined the long-term impact of crop rotation on soil processes and the canola microbiome to better understand how canola cropping frequency impacts crop performance.

RESULTS

Researchers found minimal impact of rotation on root nutrient availability. Any rotation effects on nutrient availability were transient and site-dependent, likely due to the use of soil-test-based fertilization according to normal agronomic practices, which provided adequate nutrients for crop growth.

Crop rotation strategy had a stronger impact on the fungal microbiota at all sites and years. Crop rotation affected the abundance of fungi associated with both detrimental and beneficial effects on crop production, and this effect was most pronounced in and near canola roots. In particular, continuous canola resulted in a predominance of a fungus identified as *Olpidium brassicae*, a poorly understood root colonizer with a life cycle that is similar to that of the clubroot pathogen, *Plasmodiophora brassicae*. This fungus was present in and near the roots at all sites, and was particularly dominant in short-rotation and continuous canola. This provides a direction for future studies.

These findings highlight the importance of considering the impacts of crop rotation strategies on the microbiota associated with canola roots, and demonstrate that the fungal biome is more affected by continuous canola than the bacterial community.

Tim Dumonceaux, research scientist with Agriculture and Agri-Food Canada, discussed the results of this study in a presentation at Canola Week 2021. Find the video in the "Canola Week 2021" playlist at youtube.com/canolacouncil. Dumonceaux also joined fellow AAFC research scientist Susan Boyetchko on episode 66 of the Canola Watch podcast. They talk about plants and microbes, and how the massive microbe community can help in crop production. Subscribe to the Canola Watch podcast through Apple and Android sources.

Root and rhizosphere microbiota vary by crop and conditions

KEY RESULT:

Biodiverse agricultural systems improve agricultural productivity and climate management. This study contributes to a better understanding of canola microbiota, which provide important information to improve canola yields and reduce greenhouse gas emissions by identifying crop rotations that could potentially reduce nitrogen fertilizer use.

This project demonstrated that biodiverse agricultural systems improve agricultural productivity and climate management. The challenge in employing microbiome technologies for improving agricultural systems is the pre-requisite of understanding how soil microbial communities are structured. The study contributed to a better understanding of canola microbiota, providing information to improve canola yields and reduce greenhouse gas emission by identifying the best rotation system that could potentially reduce nitrogen fertilizer use.

The objective of this project was to assess the consistency and variability in the composition of the canola core rhizospheric and root microbiota, and determine crop rotation systems that best favour a beneficial root microbiome in canola. Researchers also investigated crop rotation systems that possibly increase canola productivity while allowing the reduction of fertilizer and pesticide use.

Researchers tested two parameters of this process: the role of soil history in environmental filtering, and the selection pressure created by host plants. They also described the impact of five Brassicaceae plants and their soil history on the structure of bacterial communities in their rhizosphere and roots. It was determined that soil history was significant in structuring the bacterial communities when soil chemistry was highly significant under possible drought conditions. Second, that the Brassicaceae host plants (*Brassica napus, B. carinata, B. juncea, Sinapis alba* and *Camelina sativa*) were consistently significant in structuring the bacterial communities.

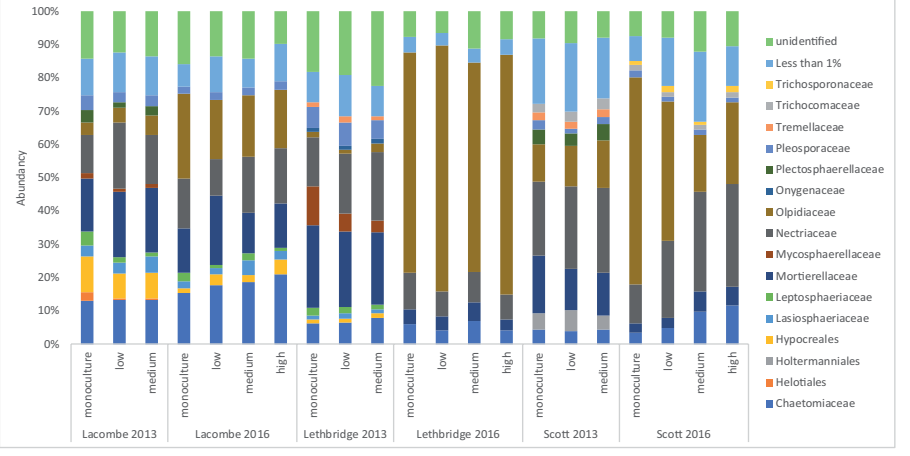
RESULTS

- Canola microbiomes were documented for three communities of microorganisms: bacteria, fungi and archaea.
- Canola root and rhizosphere microbiomes were significantly different from those of wheat and pea.
- The research team highlighted the potential PGPR (plant growth-promoting rhizobacteria) among those microorganisms by correlating the core microbiome members in the Canadian Prairies with canola yield.
- Fertilization and seeding rates seem to influence certain taxa forming the core and eco microbiomes of canola based on the relative abundances profiles, notably the parasite *Olpidium brassicae*, which was less abundant at the higher seeding rate.
- Certain archaea showed some specificity to crops and treatments. Furthermore, the putative interactions between members of bacterial and fungal core microbiomes were weaker with higher fertilization and seeding than with the recommended treatments in canola rhizospheres.
- Lentil substantially increased biological nitrogen fixation and reduced denitrification in the following oilseed crops.
- Most nitrogen-cycling gene transcripts are more abundant in the microbiomes associated with roots than with the rhizosphere.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Enhancing the beneficial root microbiome in canola"
Chantal Hamel, AAFC Swift Current

FUNDING: SaskCanola, Alberta Canola, Manitoba Canola Growers, Natural Sciences and Engineering Research Council of Canada

FULL REPORT: To find the full report and list of peer-reviewed publications with articles on this work, go to the Canola Research Hub at canolaresearch.ca and search for the project title.



Variation in taxonomic profiles is characterized by an increase in the abundance of the Olpidiaeae in the phylum Chytridiomycota in 2016. Fungal families also varied with site, crop diversification level, and year, with an overall increase in the relative abundance of the Olpidiaceae in 2016 in all crop diversification levels. (See the browns bars.) Monocultures were continuous canola, either Liberty Link or Roundup Ready. Low is canola-wheat. Medium is canola-wheat-peas. High has lentils, wheat, peas, barley, wheat and both canola systems, with two canola crops in a nine-year period. Researchers were given access to samples from years 2013 and 2016. Olpidiaeae was the most abundant fungus in the rhizosphere microbiome of canola in both years, however, wet conditions in July 2016 were favourable for Olpidium zoospore production. | Source: Floc'h, JB., Hamel, C., Harker, K.N. et al. Fungal Communities of the Canola Rhizosphere: Keystone Species and Substantial Between-Year Variation of the Rhizosphere Microbiome. Microb Ecol 80, 762–777 (2020).

Silicon uptake could increase canola stress tolerance

KEY RESULT:

If canola could be transformed with two target genes for silicon uptake, the crop could become more tolerant to biotic (pathogen) and abiotic (weather) stress. In the end, this study could transform only one of the two target genes, and resulting stress tolerance to blackleg and drought were not noticeably different from controls. They determined that both genes are necessary, and continue to work toward that goal.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"A simple and holistic approach to alleviate biotic and abiotic stresses in canola through silicon (Si) uptake" Richard Belanger, Laval University

FUNDING:
SaskCanola, Natural Sciences and Engineering Research

FULL REPORT:
To find the full report, go to SaskCanola.com and search for the project title.

If canola could be transformed with silicon-uptake genes, say from adzuki bean and soybean, the crop could become more tolerant to biotic (pathogen) and abiotic (weather) stress.

Plants absorb silicon (Si) from soils in the form of silicic acid ($Si(OH)_4$) through root influx channels termed Lsi1 and efflux transporters termed Lsi2. Prior to this project, all low-silicon-accumulating species under investigation were found to lack one or both determinants.

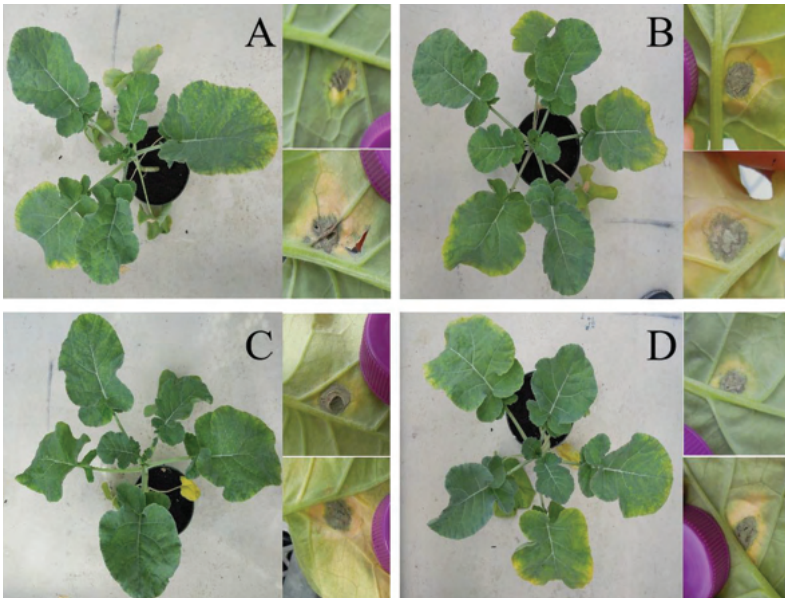
A unique exception is tobacco (*Nicotiana sylvestris*), a species which possesses both molecular determinants in its Lsi1 and yet does not accumulate Si in its tissues. Researchers used this discovery to identify genetic substitutions that gave tobacco a heightened silicon-uptake capabilities. The discovery improved the researchers' understanding of silicon accumulation in plants, contributing to bioengineering efforts to improve silicon accumulation in crops, including canola.

Belanger and his group also took major strides in improving the understanding of the Lsi2 transporter processes. They found differences among *Lsi2* alleles in soybeans (*Glycine max*) that could explain the differential silicon content observed across contrasting soybean varieties. This is the first identification of a rare *Lsi2* allele that dictates superior silicon absorption in plants. This could be exploited for bioengineering purposes to increase plant stress resilience.

Another objective of this study was to characterize canola (*Brassica napus*) plants transformed with high-capacity silicon transporters for their ability to accumulate silicon. Plants in the Brassicaceae family are considered low silicon accumulators. Researchers aimed to introgress canola with both determinants – genes encoding high-capacity silicon influx channels (Lsi1) and efflux transporters (Lsi2) – in an attempt to improve silicon accumulation and, ultimately, environmental stress resilience. They selected *VaLsi1* gene from adzuki bean (*Vigna angularis*) and *GmLsi2Hi* gene from soybean cv. Hikmok for canola transformations based on their high silicon-transport capacity.

The *VaLsi1* gene from adzuki bean was successfully incorporated into canola. *GmLsi2Hi* from soybean was not. However, researchers were successful in transforming two genes into model species thale cress (*Arabidopsis thaliana*; also a member of the Brassicaceae). To the researchers' knowledge, this would be the first such demonstration of a double-transformant and would be an important step toward testing the viability of this technology as a means to improve silicon accumulation in plants.

Even though researchers were only able to produce *VaLsi1* single-transformants of canola, they proceeded to test these canola plants against blackleg disease. The single transformants did not fare any better than controls, concluding that double transformants are indeed necessary. Having both determinants seems to be necessary to increase silicon accumulation in plants. Ongoing efforts to test double-transformed thale cress plants should directly test this hypothesis.



Control plants without the silicon-uptake gene (A,B) and plants transformed to carry the *VaLsi1* silicon-uptake gene from adzuki beans (C,D) were soil-grown for five weeks then inoculated with *Leptosphaeria maculans*, the pathogen that causes blackleg. Differences in lesion size were not significantly different. Researchers conclude that double-transformants – canola bioengineered with two genes for silicon uptake – are indeed necessary.

Are we measuring the right soil nitrogen pool?

KEY RESULT:

Researchers wanted to see if soil protein, extracted using the ACE/MACE methods, is an appropriate measure of the soil nitrogen that potentially becomes available during the growing season. They found only a weak correlation, and concluded that current soil test recommendations provide an acceptable measure of biologically available nitrogen.

PROJECT TITLE, PRINCIPAL INVESTIGATORS:
"Revisiting nitrogen fertilizer recommendations for Saskatchewan: Are we measuring the right soil nitrogen pool?" Richard Farrell and Fran Walley, University of Saskatchewan

FUNDING: SaskCanola, SaskWheat, Western Grains Research Foundation, Alberta Wheat Commission

FULL REPORT:
To find the full report, go to SaskCanola's research page at saskcanola.com/research-results and search for the project title.

With nitrogen being so important to crop production, lack of appropriate soil nitrogen tests have been criticized as being a limitation to developing sound fertilizer recommendations. Soil testing is meant to measure how much nitrogen is in the soil that will supply the crop during the growing season. However, what is typically measured is the soil inorganic nitrogen (a product of mineralization), and then predictions are used to estimate how much additional nitrogen will be released depending on the soil zone. Although measuring mineralization during a growing season could determine actual nitrogen release, it is a matter of too little too late – so an estimate of potentially mineralizable nitrogen is required.

Research has been done in the past but no test developed through past projects has been widely adopted. There needs to be an affordable, easily reproducible, and chemically defensible test that measures the substrate for nitrogen mineralization (soil protein), and not the product (inorganic nitrogen). Soil proteins are the key substrate that contributes to the plant-available nitrogen pool – a pool that contains both organic monomers, which are not measured by typical soil N tests, as well as inorganic nitrogen.

Soil nitrogen tests currently used in Saskatchewan usually involve the use of a chemical extractant that determines the amount of plant available nitrate nitrogen in the soil or short-term incubation release. This provides only a snapshot of the amount of inorganic nitrogen (nitrate and/or ammonium) either in the inorganic pool or entering this pool. Mineralizable nitrogen and proteins could be a better measure.

Researchers have found a soil protein pool that is believed to represent potentially mineralizable nitrogen and that can be rapidly tested in a lab. The standard method for testing soil protein is referred to as Autoclaved citrate extractable (ACE) protein, however this method is not regularly used for commercial soil tests as it is time consuming. Most labs are equipped with microwave systems that can provide the high temperature and pressure needed for soil protein extraction. The researchers wanted to determine whether microwave-assisted extraction of soil protein yields the same results as the standard ACE method. They would then optimize the method, and demonstrate that this soil protein pool is directly related to potentially mineralizable nitrogen and can provide a basis for improved fertilizer recommendations.

RESULTS

Researchers started by assessing the ACE soil protein concentration in 55 different soils in Saskatchewan. Microwave-assisted citrate extractable (MACE) soil protein was determined on a sub-set of these samples and compared to ACE protein levels. Soil protein concentration was not affected by extraction method. Moreover, MACE soil protein extraction can be performed in half the time of the ACE method, without affecting protein recovery. Results showed strong correlations between soil protein nitrogen, total soil nitrogen and soil organic carbon, but only a weak correlation between soil protein nitrogen and inorganic nitrogen.

This research found the soil protein pool extracted using the ACE/MACE methods are not an appropriate measure of the nitrogen that potentially becomes available during the growing season. Researchers concluded that the ACE/MACE methods of soil protein are not suitable as a seasonal nitrogen availability index. Since statistically significant yield increases often were not observed above the soil-test recommended rate of nitrogen, this suggests that current soil test recommendations provide an acceptable measure of available nitrogen, with the understanding that weather strongly influences nitrogen responses. Researchers have also indicated that more research is needed to develop a rapid chemical test to determine biologicially-available soil nitrogen.

Details on clubroot infection set stage for better resistance

Photo credit: Dan Orchard

KEY RESULT:

This is one of the first studies to characterize effector proteins with key roles in clubroot infection and disease progression. Results provide a valuable resource for the identification of new clubroot resistance genes.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Genome wide functional analysis of *Plasmodiophora brassicae* effectors and the management of clubroot disease" Peta Bonham-Smith, University of Saskatchewan

FUNDING: SaskCanola, Saskatchewan's Agriculture Development Fund

FULL REPORT: To find the full report and list of peer-reviewed publications with articles on this work, go to SaskCanola's research page at saskcanola.com/research-results and search for the project title.

The pathogen *Plasmodiophora brassicae* causes clubroot disease in canola and other brassicas. Successful infection relies on effector proteins that are able to suppress the host immune system as well as induce morphological changes in the plant that can increase infection rate. Although effector proteins have a high potential to play an important role in *P. brassicae* infection and clubroot development, and are therefore potential targets for future breeding strategies, their function and roles in clubroot pathogenicity are not well understood.

Researchers at the University of Saskatchewan initiated a five-year study in 2016 to develop a genome-wide identification and *in planta* expression profiling of the *Plasmodiophora brassicae* secretome, a set of proteins expressed and secreted by the pathogen. Other objectives were to conduct a functional analysis of *P. brassicae* effectors, and analysis of virulence mechanisms of *P. brassicae* on host plants. Effector proteins are mostly secretory proteins that enable plant infection by manipulating the host response. They may also activate defense strategies in resistant plant genotypes. Researchers also explored the genetic diversity of some of the genes that encode these small secreted effector proteins.

The model plant *Arabidopsis thaliana* ecotype Columbia, which is susceptible to clubroot disease, was used in this study for most of the experiments. The *Brassica napus* canola cultivar Westar was used to generate resting spores of *P. brassicae*. Canola plants were inoculated at the four-leaf stage, and at 35 days post inoculation (dpi) fresh galls were processed to collect the resting spores. For species comparisons, several Brassica species were used, including arugula, broccoli, cabbage and wild mustard.

Researchers used RNA analysis to identify genes coding small, secreted *P. brassicae* proteins that were up-regulated during infection of the model plant *Arabidopsis thaliana* at 17, 20 and 24 days dpi and from a 35 dpi canola root gall. Researchers identified and partially characterized 32 (from Arabidopsis) and 52 (from canola) P. *brassicae* effectors, with a more in-depth functional characterization of some effectors, identifying important roles in the *P. brassicae* infection process that may prove to be potential targets for future breeding strategies. Researchers were able to successfully establish the probable function and role in *P. brassicae* infection and disease progression for a select number of effectors. Very little variability of some of these candidate effectors was described among pathotypes.

Overall, this study is one of the first to characterize effector proteins with key roles in clubroot pathogenicity. Researchers have produced a substantial annotation of *P. brassicae* effector proteins and their functions. They have also identified some host targets of *P. brassicae* effectors that has allowed an initial characterization of the molecular and cellular mechanisms underlying *P. brassicae* virulence and host resistance. These effectors and their host targets characterized in this study provide a valuable resource for the identification of new R-genes that will benefit both breeders and producers of canola and other crops in Canada.

Diamondback moth thresholds may need adjustment

KEY RESULT:

Yield reductions at current nominal thresholds of one to two DBM larvae per plant in canola may not be significant. Therefore, the nominal thresholds for DBM in canola may need to be increased to a slightly higher number of larvae per plant. Dynamic action thresholds incorporate the effect of natural enemies on pest control.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:

"Identification and assessment of the role of natural enemies in pest suppression in canola with specific reference to diamondback moth management" Maya Evenden and Sharavari Kulkarni, University of Alberta

FUNDING: SaskCanola, Alberta Canola

FULL REPORT:

To find the full report, go to the Canola Research Hub at canolaresearch.ca and search for the project title.

Researchers investigated natural enemies of diamondback moth (DBM) in the canola cropping system with the aim to bolster biological control of the pest. Another objective was to understand and quantify the effects of varying larval densities of DBM on foliar damage and yield in canola.

DBM populations and moth influx were consistently low in all study years (2018-2020), resulting in minimal captures of DBM life stages. Across all years surveyed, *Diadegma insulare* was the most abundant DBM parasitoid species. Predators included ladybird beetles (lady bugs), lacewings and nabid bugs.

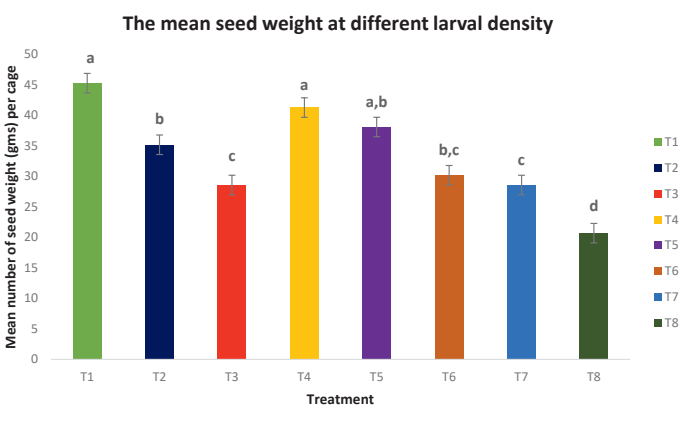
Researchers conducted laboratory bioassays to estimate rates of feeding on eggs and larvae of DBM to calculate functional responses for these beneficial parasitoids and predators. They concluded that combined action of members in the natural enemy guild of DBM may reduce pest populations substantially, particularly in high infestation years.

THRESHOLDS

Field cage studies indicated that the foliar damage and yield reductions linearly increased with DBM larval densities. At eight larvae per plant, yield was reduced around twofold, with four times more defoliation compared to controls. Further, high larval density at the podding stage is more detrimental to canola yield compared to that at the flowering stage. Under field conditions, foliar damage to plants with eight larvae per plant was around fourfold higher than at the action threshold with two larvae per plant at the podding stage in both 2019 and 2020.

These studies indicate that nominal thresholds should be adjusted based on moth influx, natural enemy presence, and field population dynamics when making spraying decisions. Recommendations arising from the study include:

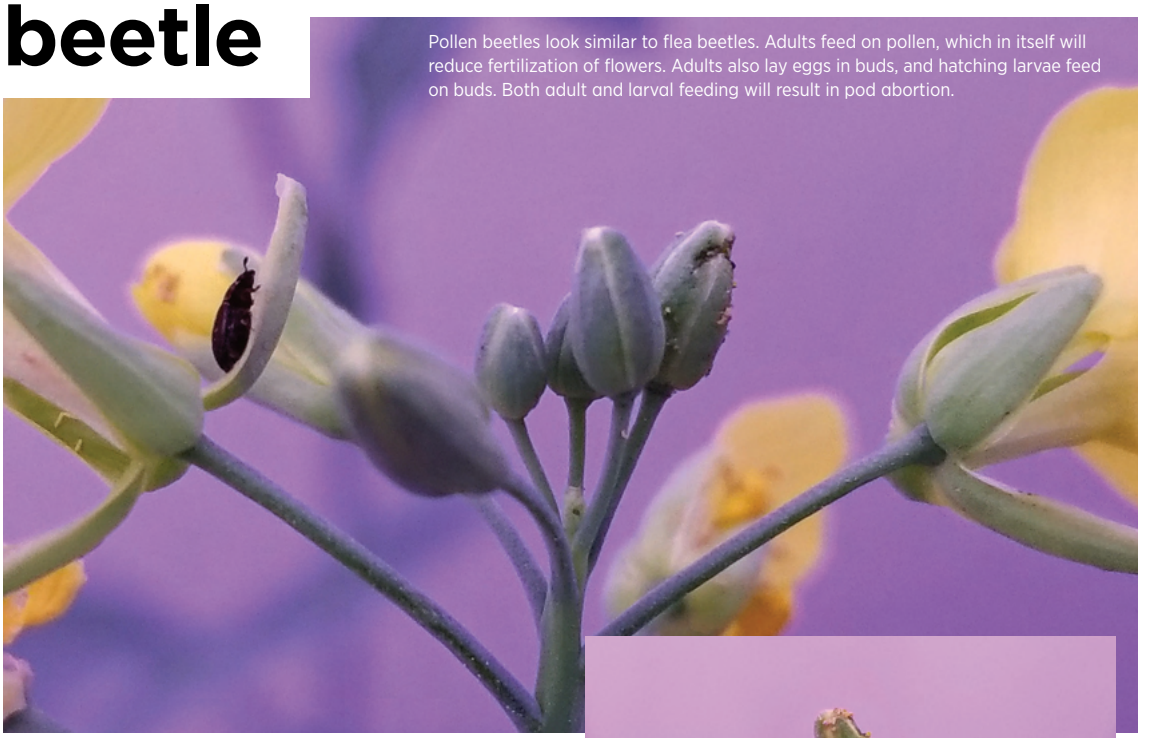
- Yield reductions at current nominal thresholds of one to two DBM larvae per plant in canola may not be significant. Therefore, the nominal thresholds for DBM in canola may need to be increased to a slightly higher number of larvae per plant.
- DBM management should focus on pest monitoring and forecasts, estimates of pest density, commodity value, and the consideration to the role of natural enemies in the cropping systems in addition to insecticide utilization.
- Natural enemies and strategies to augment or conserve natural enemy populations should be integrated into pest management plans for mitigating DBM damage.
- Dynamic action thresholds incorporate the effect of natural enemies on pest control to provide realistic estimates of pest population densities to trigger management activities.



Effects of different DBM larval densities on canola yield (g) in cage study conducted in a growth room. Bars marked with different letters are significantly different at $p < 0.05$.

T1= caged control, T2= 2 larvae per plant at early flowering stage, T3= 4 larvae per plant at early flowering stage, T4= 2 larvae per plant at early flowering stage, larval feeding discontinued, and larvae removed once they neared pupation, T5= 4 larvae per plant at early flowering stage, larval feeding discontinued, and larvae removed once they neared pupation, T5= 2 larvae per plant at late flowering/early pod stage, T6= 2 larvae per plant at late flowering/early pod plant, T7=4 larvae per plant at late flowering/early pod plant, T8= 8 larvae per plant at late flowering/early pod plant. Read more in the final report at canolaresearch.ca.

Testing thresholds and insecticides for pollen beetle



Pollen beetles look similar to flea beetles. Adults feed on pollen, which in itself will reduce fertilization of flowers. Adults also lay eggs in buds, and hatching larvae feed on buds. Both adult and larval feeding will result in pod abortion.

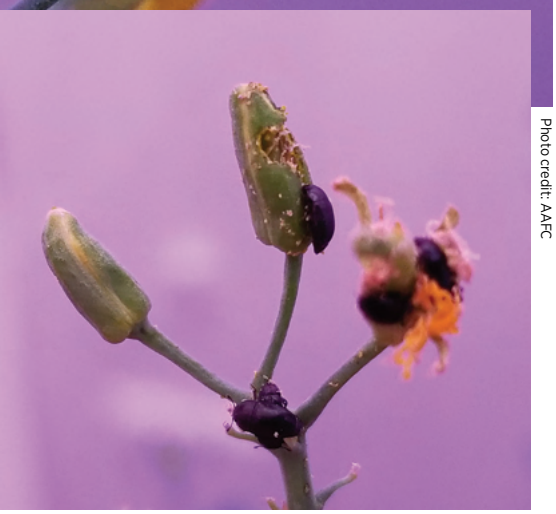


Photo credit: AAFC

KEY RESULT:

Pollen beetles were susceptible to three of four insecticides tested. Yield reduction was detected at seven to nine beetles per plant, but not at four beetles per 10 sweeps. Pollen beetles were not detected in the Prairies and no native parasitoids were found attacking pollen beetle larvae in Atlantic Canada.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:

"Generate knowledge and control strategies for the pollen beetle *Brassicogethes viridescens (Coleoptera: Nitidulidae)*, a new invasive pest of canola" Christine Noronha, AAFC Charlottetown

FUNDING: SaskCanola, Alberta Canola, Manitoba Canola Growers

FULL REPORT:

To find the full report, go to the Canola Research Hub at canolaresearch.ca and search for the project title.

Pollen beetles are an invasive pest of canola. Originally from Europe, the beetle is found in Atlantic Canada and Quebec. Climate models show a high potential for it to migrate to Western Canada where canola is a major crop.

Pollen beetles look similar to flea beetles. Adults feed on pollen, which in itself will reduce fertilization of flowers. Adults also lay eggs in buds, and hatching larvae feed on buds. Both adult and larval feeding will result in pod abortion. They have only one generation per year.

The lack of basic management information about this invasive pest prompted this research project. The main objectives were to determine an economic threshold and to evaluate the efficacy of insecticides less toxic to bees, since this pest is found feeding and laying eggs when the crop is in bloom. The canola crop in Alberta, Saskatchewan and Manitoba was monitored for presence of this pest.

To determine the economic threshold, researchers conducted trials within field cages to eliminate the influence of other insect pests on yield. Wild bees were placed in the cage for pollination. Plant samples were also collected from outside the cages to compare the influence of other pests on yield. Researchers also conducted sweep net sampling, a common method used for sampling canola, to determine population levels in 2021. They related sweep net counts to damage.

RESULTS

Researchers found that a threshold of seven to nine beetles per plant can cause significant yield loss in the absence of other pests. Sweep net sampling in 2021 showed that in the presence of other pests an average of four beetles per sweep gave 18 per cent pod loss.

This project also showed that three insecticides with reduced risk to bees were efficacious at the low rate. This makes the two or more applications generally required to control pollen beetles a more feasible option. The lack of native parasitoids indicates that evaluation of biocontrol agents from Europe should be considered.

Although pollen beetles were not discovered on the Prairies, continued vigilance is recommended.

Field studies show dandelion part of aster yellows disease cycle

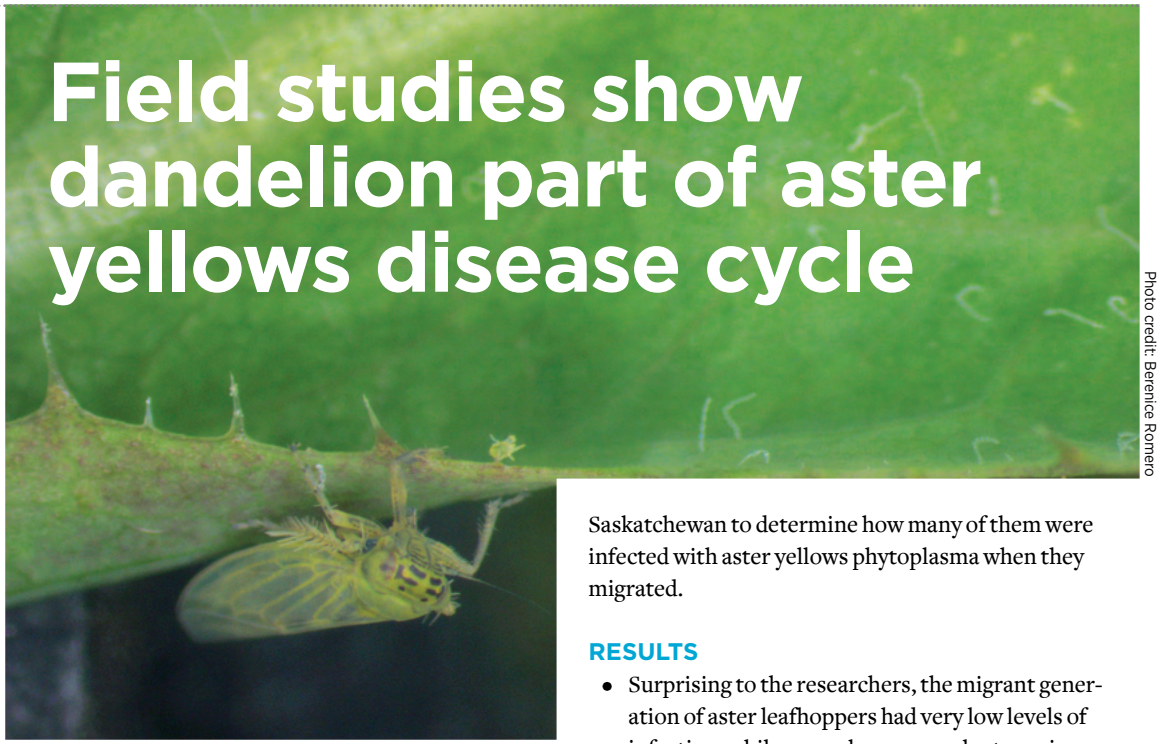


Photo credit: Berenice Romero

KEY RESULT:

This project evaluated several crop and non-crop species commonly found in the Canadian Prairies as possible hosts for aster leafhopper development or phytoplasma infection or both. Alfalfa, sow thistle, stinkweed and dandelion were found to harbour aster yellows phytoplasma and are likely acting as reservoirs for the phytoplasma in Western Canada.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Investigating the role of plant hosts in the outbreaks of the aster leafhopper vectored aster yellows" Sean Prager, University of Saskatchewan

FUNDING: SaskCanola

FULL REPORT:
To find the full report, go to the Canola Research Hub at canolaresearch.ca and search for the project title.

Aster leafhoppers are the main vector of aster yellows phytoplasma in the Canadian Prairies. Aster yellows phytoplasma causes aster yellows disease in over 300 plant species, but is especially problematic in canola. Aster leafhoppers are migratory and almost every spring arrive on the Prairies. However, their arrival date typically precedes suitable staging of host crops. Researchers wanted to identify likely plants that sustain them prior to moving into crops.

Disease dynamics of aster yellows are also poorly understood. For example, the source of the phytoplasma-carrying leafhoppers each year is unknown. Aster yellows phytoplasma could originate from plants in the source areas of the leafhopper migration, which would be the case if the aster leafhoppers migrated with a high percentage of individuals infected. The alternative hypothesis is that the aster leafhoppers migrate into Saskatchewan and acquire the phytoplasma infection from local plants. A combination of these hypotheses is also possible.

Researchers evaluated several crop and non-crop species commonly found on the Canadian Prairies as food and reproductive hosts for aster leafhoppers through no-choice bioassays. To study possible effects of pathogen infection on host choice, uninfected and infected insects were used. Host choice selection behaviour accounting for both feeding and reproductive choices by aster leafhoppers was evaluated through two-choice bioassays, using domesticated and wild plants species commonly found in the Canadian Prairies.

The research team also captured and tested early-season migrant leafhoppers as they arrived in Saskatchewan to determine how many of them were infected with aster yellows phytoplasma when they migrated.

RESULTS

- Surprising to the researchers, the migrant generation of aster leafhoppers had very low levels of infection, while several common plant species – alfalfa, sowthistle, stinkweed and dandelion – were harbouring aster yellows phytoplasma infections in the early spring and summer and are likely acting as reservoirs for the phytoplasma in Western Canada.
- When given a choice between a crop (including canola and three cereals) and a non-crop (weedy plants common in field margins), aster leafhoppers preferred crop plants over weedy plants and this preference likely drives their movement into crops from field margins.
- Aster yellows phytoplasma infection status of aster leafhoppers only influenced one of the studied preferences, indicating that infection with the phytoplasma likely does not have a strong effect on the behaviour or reproductive potential of the vector insect on the tested plants. The only preference shown was for uninfected leafhoppers to preferentially settle on non-crop hosts, which may indicate a preference for plants where aster yellows phytoplasma infection can be acquired.
- Canola and sowthistle were poor reproductive hosts for aster leafhoppers, yet sowthistle was one of the plants identified as an aster yellows phytoplasma reservoir. Cereal plants and fleabane were very suitable for aster leafhopper oviposition and nymphal development. This suggests that prior to crop emergence, a plant species such as fleabane could act as a suitable reproductive and food choice for aster leafhoppers. However, in the presence of an additional plant species, fleabane and other weedy species are less preferred (for settling, probing, and ovipositing), indicating that little reproduction is happening on the dicotyledonous weeds in the field margins.

Genome analysis of 45 clubroot isolates leads way for ID tests

KEY RESULT:

Clubroot continues to spread, but improved monitoring and methodologies allow for more pathotype characterization to better identify, quantify and eventually manage clubroot-causing pathotypes going forward.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Canadian canola clubroot cluster pillar 4: Surveillance and pathotype monitoring" Stephen Strelkov, University of Alberta

FUNDING:
Alberta Canola

FULL REPORT:
To find the full report, go to the Canola Research Hub at canolaresearch.ca and search for the project title.

As the appearance of new clubroot pathotypes capable of overcoming resistance is one of the most important threats facing canola production in clubroot-infested regions of the Prairies, this research led by Steve Strelkov focused on tracking and responding to changes in the clubroot pathogen.

Surveillance in Alberta: In addition to clubroot being found in 79 of the 543 canola crops surveyed in 2018, another 221 cases were found by municipal personnel. These cases are distributed across 40 counties and municipal districts, plus Edmonton, Medicine Hat and the town of Stettler. Disease identification in new locations suggested that clubroot is spreading in the Peace Country of northwestern Alberta and in southern Alberta.

In most cases, clubroot severity was mild or moderate, although five crops were heavily infested – two of which had included clubroot-resistant canola cultivars – and pathogen populations from these fields were collected for further evaluation in the lab.

Surveillance in Saskatchewan: Of the 1,800 fields surveyed, 37 canola crops were found with visible clubroot symptoms. A subset of 10 samples was sent for pathotype characterization and nine samples were sent for pathotyping.

Surveillance in Manitoba: Of the 100+ fields in 2018, 17 cases of clubroot were identified, bringing the cumulative total to 33 confirmed infestations since 2009. A subset of six clubroot samples was sent for pathotype characterization, while three collections were sent for pathotyping.

Characterization of single-spore and field isolates: Thirteen pathotypes were identified amongst the 39 single-spore isolates (populations) obtained and characterized for their virulence on a suite of CR canola cultivars and on the Canadian Clubroot Differential Set.

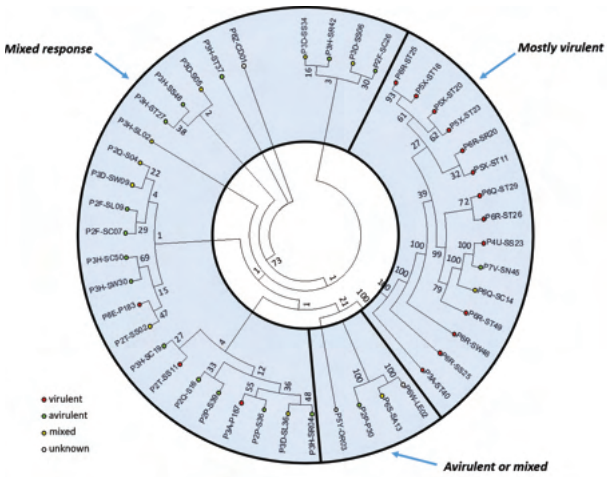
A total of 119 *Plasmodiophora brassicae* populations, including 103 from Alberta, 10 from Saskatchewan and six from Manitoba were tested.

Eighty-seven of the 103 field isolates collected from Alberta could overcome clubroot resistance, bringing the total number of confirmed fields with resistance issues to 191 in the province.

Of the 10 samples from Saskatchewan and the six field isolates from Manitoba tested, only one isolate from Manitoba could overcome clubroot resistance in CR canola, while the rest did not. This was the first confirmed case of a clubroot resistance-breaking pathotype detected on canola outside of Alberta.

Refinement of the clubroot differential set: Collectively, the results identified 19 *Brassica* accessions that had good 'differential capability' and potential as differential hosts. These included two *B. napus*, eight *B. rapa* and nine *B. nigra* accessions.

Examination of the genetic and virulence relationships between pathotypes and their interactions: Resting spores representing 45 isolates of *P. brassicae,* including the 39 single-spore isolates described earlier in this report plus an additional six field isolates, were selected for genomic analysis. This allowed for the development of a binary matrix to construct a dendrogram showing relationship between 45 *P. brassicae* field and single-spore isolates.



This circular dendrogram shows the relationship between 45 *Plasmodiophora brassicae* field and single-spore isolates. The dendrogram represents a bootstrap consensus tree built using PhyloSNP with 100 bootstrap replications. The colour-coded dots indicate whether an isolate is virulent (red), avirulent (green) or gives a mixed reaction (yellow) on a suite of clubroot resistant (CR) canola cultivars. Those isolates that were not tested for virulence on CR canola are denoted as 'unknown' (white circles).

Development of molecular tests to distinguish between pathotypes: Successful analysis involving 45 *P. brassicae* genomes initiated the development of molecular markers for the identification of *P. brassicae* pathotypes using the genome sequence information (which is highly specific and more accurate than standard PCR). This can be used to identify and quantify clubroot-causing pathotypes from plant, soil and water samples.

Predatory nematodes provide biocontrol option for canola pests

KEY RESULT:

Although impact varied among species, predatory nematodes belonging to the *Steinernema* genus provided significant mortality of diamondback moth, lygus bug, cabbage root maggots and black cutworms.

PROJECT TITLE, PRINCIPAL INVESTIGATORS:

"Biocontrol potential of entomopathogenic nematodes (EPNs) against selected key insect pests of canola in Alberta" Shabeg Briar and Paul Tiege, Olds College

FUNDING:
Alberta Canola

Crop losses and the economic impact caused by canola insect pests can be substantial. The resistance to chemical control is also a growing problem - as the number of options are shrinking over time. A commercially available biocontrol agent that is largely unexplored in the Canadian Prairies is the use of entomopathogenic nematodes (EPNs). These predatory nematodes are soil-dwelling round worms that specialize in parasitizing insects.

Entomopathogenic nematodes (EPNs) emerging from dead waxworm larva.

Researchers Paul Tiege and Shabeg Briar produced base line information on the biocontrol potential of four predatory nematode species: *Heterorhabditis bacteriophora*, *Steinernema carpocapsae*, *S. kraussei* and *S. feltiae*. Four concentrations of nematodes were examined against foliar insect pests (flea beetles, diamondback moth larvae and lygus bugs) using Petri dishes and below ground pests (cabbage root maggots and black cutworms) using sandy soil in plastic cups, in controlled laboratory conditions. Insect mortality was assessed after 72 hours of exposure to the nematodes and observed under the microscope to confirm nematode infection.

In general, mortality rates of most insects increased with increasing nematode concentrations. Specific impacts on different insect pest species are outlined below.

Diamondback moth: Mortality rates for larval diamondback moth ranged from 33-63 per cent at low nematode concentrations and 60-90 per cent at high concentrations. Mortality of diamondback moth pupae was generally lower than larvae, with rates across species ranging from 30-40 per cent at low nematode concentrations to 50-70 per cent at high nematode concentrations.

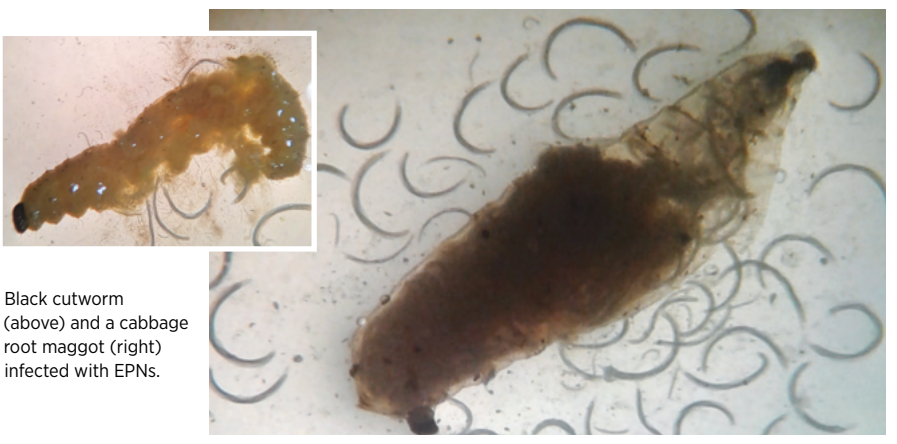
Lygus bugs: Of the three *Steniernema* species tested against lygus bug nymphs, *S. kraussei* generally produced the highest mortality rates, followed by *S. carpocapsae* and then *S. feltiae*. Mortality rates for lygus bugs were 39-50 per cent at low nematode concentrations and 62-87 per cent at higher concentrations.

Flea beetles: Unfortunately, very low mortality rates (10 per cent or less) were reported for adult flea beetles, even at the highest concentration of nematodes.

Black cutworm larvae: Mortality rates for black cutworms were 10-80 per cent for low nematode concentrations, 85-100 per cent for high concentrations. *H. bacteriophora* provided a high average mortality of 95 per cent at the highest concentration, but resulted in much lower mortality rates than the other species at all other concentrations. At the 95 per cent confidence interval, the LC50 value of all *Steniernema* species were significantly lower than those of *H. bacteriophora*.

Cabbage root maggots: The *H. bacteriophora* and *S. carpocapsae* species resulted in no to low mortality to cabbage root maggot larvae, at any concentrations. The other two species tested (*S. feltiae* and *S. krausse*) produced progressively higher mortality rates with increasing nematode concentrations, ranging from 8-17 per cent at low concentrations and up to 83 per cent at high concentrations. Pupal stage of root maggots appeared to be resistant to all EPN species and showed no host penetration of the pupal stage.

Further studies on the exploration of locally adapted strains is already underway in the follow up project funded by RDAR and Alberta Canola.



Black cutworm (above) and a cabbage root maggot (right) infected with EPNs.

Sign up to help the Prairie Pest Monitoring Network

KEY RESULT:

The Prairie Pest Monitoring Network (PPMN) provides forecasts, risk maps and monitoring protocols for crop pest insects across Western Canada. It also provides a free weekly update during the growing season. Anyone can subscribe at prairiepest.ca.

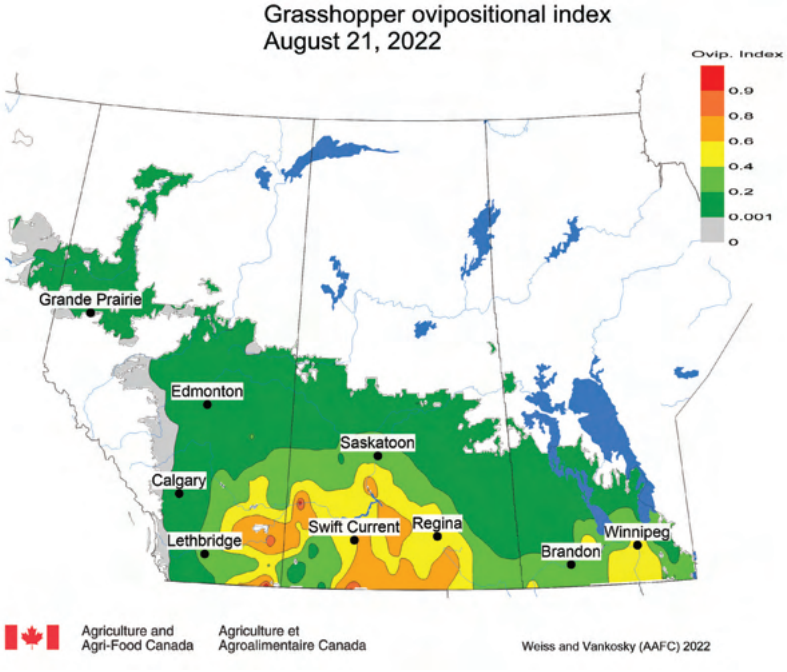
PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Coordinated monitoring of field crop insect pests in the Prairie Ecosystem" Meghan Vankosky, AAFC Saskatoon

FUNDING: SaskCanola, Manitoba Canola Growers, Western Grains Research Foundation

Saskatchewan farmers who want to give permission for pest monitoring can use the QR code, which takes them to *"Pest monitoring in Saskatchewan: Why it is important and how you can get involved"* at saskatchewan.ca.

This project provides funding support for the Prairie Pest Monitoring Network (PPMN).

The PPMN is comprised of field crop entomologists who conduct research and actively monitor insect pest populations. It includes researchers from Agriculture and Agri-Food Canada, Manitoba Agriculture, Saskatchewan Ministry of Agriculture, Alberta Agriculture Forestry and Rural Economic Development, and university researchers. Industry stakeholders provide regular input including monitoring data in the summer and valuable insight at annual PPMN working group meetings.



Grasshopper (*Melanoplus sanguinipes*) oviposition – egg-laying – index across the Canadian prairies as of August 21, 2022. Higher ovipositional index values indicate greater potential for oviposition. Map courtesy of Ross Weiss and Meghan Vankosky, Agriculture and Agri-Food Canada.

A coordinated insect surveillance program for the Prairies first took shape in 1997. Since then, the PPMN has been involved in coordinating and conducting population monitoring of insect pests of field crops.

The PPMN conducts annual insect pest monitoring in oilseed, pulse and cereal crops to generate maps of regional pest distribution and relative abundance. It also develops and uses predictive models to help farmers and agronomists time pest scouting activities during the growing season. The PPMN communicates this information through weekly updates. These updates and other information are available online at prairiepest.ca. People can also sign up to receive weekly updates by email.

FARMER COOPERATION

Annual monitoring, especially of pests like cabbage seedpod weevil, pea leaf weevil and wheat midge, for example, requires in-field sampling. The PPMN relies on farmers to volunteer access to their properties for monitoring. Without volunteered field sites, the PPMN cannot collect enough samples across the Prairie region to estimate, with reasonable accuracy, changes in pest distribution and population density. In Manitoba and Alberta, farmers can volunteer their land for monitoring by contacting John Gavloski (john.gavloski@gov.mb.ca) and Shelley Barkley (shelley.barkley@gov.ab.ca), respectively. In Saskatchewan, farmers can sign up to volunteer their land online. Use the QR code on this page to find the sign up page.

2023 CANOLA PEST PLANNING

The PPMN monitors several important pests of canola, including diamondback moth. Diamondback moth were quite low for most of the spring and summer, but populations grew quickly in August because of high daily temperatures. Diamondback moth is a migratory pest that does not survive winter conditions in Western Canada, so monitoring will begin again in spring 2023 for the arrival and growth of diamondback moth populations.

The final weekly update of 2022, posted August 26, included an update on grasshoppers, which can be an important pest of canola, especially as their densities increase. Grasshopper populations were quite high in some parts of the Prairies in 2022, with weather conditions optimal for fast grasshopper development and egg laying. Earlier egg laying (oviposition) can result in above-average production of eggs and increased overwintering survival of eggs. In 2022, model outputs indicate that oviposition rates were high across a large part of southern Prairies, extending from east of Lethbridge to Regina and north to Saskatoon (see the map). Farmers should scout early and often for grasshopper development in spring 2023, especially in areas where grasshoppers were plentiful in summer 2022.

Uniformity of sprayer deposition needs improvement

KEY RESULT:

The range in on-target spray deposition volume across the width of sprayers was unexpectedly large for this study. With each sprayer pass, some targets only received one third of the intended dose while others received triple the intended dose.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Characterizing turbulent spray deposition from self-propelled sprayers" Tom Wolf, Agrimetrix

FUNDING: SaskCanola, Alberta Canola

FULL REPORT:
To find the full report, go to SaskCanola's research page at saskcanola.com/research-results and search for the project title.

Spray deposition across the width of a boom, based on results from this study, was not as uniform as principal investigator Tom Wolf would have hoped to see, and the path to effective improvement is not clear.

The "best" configuration of low boom height, slow travel speed and coarser spray was only somewhat more uniform compared to the alternative of higher boom height, faster travel speed and finer spray.

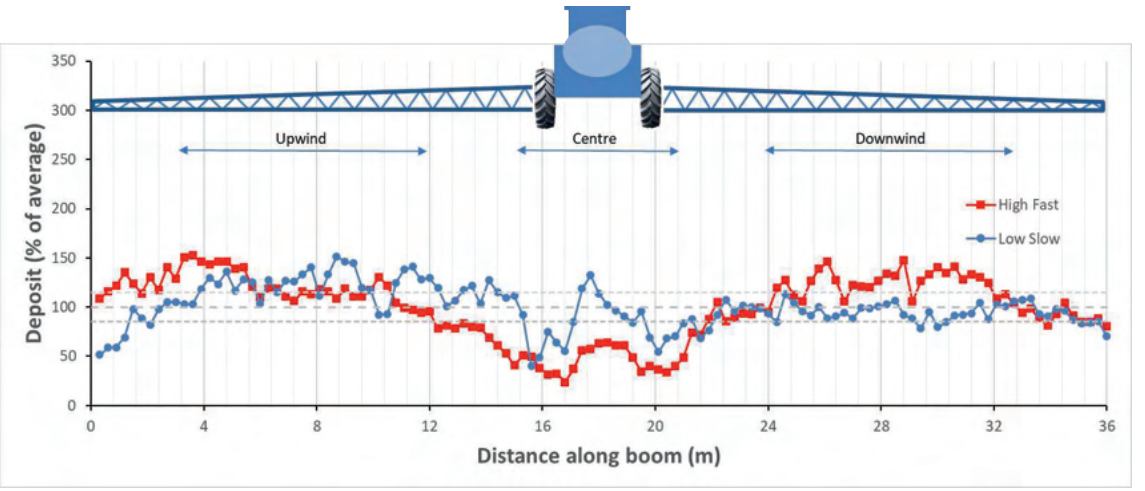
Trials compared various configurations of boom height, travel speeds, boom widths and spray qualities (coarse, medium, etc.) on Rogator RG1100B, John Deere R4045 and John Deere 4830 sprayers. Data collected came from field trials and computer modelling.

RESULTS

Higher wind speeds increased variability, as did a combination of higher booms and faster travel speeds. Finer sprays also tended to deposit less uniformly. Deposit patterns, and the magnitude of the associated variability, were only moderately repeatable, but some similar trends were apparent. The first was the down-wind displacement of the edges of the spray swath. The second was the overall lower deposition in the wake of the sprayer wheel tracks. The final common observation was the greater variability of the deposit in the centre of the spray boom, behind the tractor unit, than for the boom wings.

Computational fluid dynamics studies showed that disturbances in the flow field were increased with travel speed and boom height. In computer modelled data, both upward and lateral components were increased similarly, increasing the potential for spray droplets to be directed off target. Tire width had an impact on flow field disturbances. Not only was greater turbulence observed in the wake of the wider tires, the width of the tire-induced wake was several tire widths more than the width of the tractor unit.

This study demonstrated that the uniformity of spray deposits from modern self-propelled sprayers is lower than predicted in existing lab and field studies. Efforts to reduce the variability using lower booms, lower speeds, and coarser sprays was met with some success. However, even the "best" configuration (low boom, slow travel speed, and coarser spray) was only somewhat more uniform compared to the alternative (high boom, fast speed, and finer sprays). Although the overall effect of slower speeds and lower booms were not as large as hoped, they nonetheless represent the single best tool available to applicators at this time.



Average of replicate lines for "High & Fast" and "Low & Slow", 2019

Low boom height and slow ground speed has somewhat better uniformity than high boom height and fast ground speed. This graph is based on 2019 results. It compares a medium spray quality operated at a 40" boom height and a speed of 18 mph (high and fast) to thesame nozzle operated at a 24" and 7.3 mph (low and slow). However, the improvement was not a great or as consistent as the researchers might have expected.

Canola lines with corn genes yield more, have stronger stems

KEY RESULT:

CRISPR technology was used to generate a range of starch branching enzyme (SBE) mutants in canola. *Sbe* quadruple and sextuple mutants were used for expressing maize endosperm SBEI and effects on growth, morphology, flowering and yield determined. Introduction of corn SBEI into quadruple mutants (four canola genes edited) repeatedly led to increased total seed yield of 30 per cent in greenhouse conditions. In the sextuple *sbe* mutant an additional phenotype of a thicker stem conferred improved resistance to drought and high temperature. Additional lines are being generated to test under field conditions and a patent has been granted.

PROJECT TITLE, PRINCIPAL INVESTIGATOR: "Enhancing yield and biomass in canola by modifying carbohydrate metabolism" Michael Emes, University of Guelph

FUNDING: SaskCanola, Alberta Canola, Manitoba Canola Growers, Canadian Agricultural Partnership

FULL REPORT: To find the full report and articles published in peer-reviewed journals, go to the Canola Research Hub at canolaresearch.ca and search for the project title.

Carbohydrates such as starch provide the stored energy reserves of plants. The research team previously developed a novel technology that caused a remarkable boost in seed yield in Arabidopsis by modifying starch metabolism. When the Arabidopsis endogenous leaf starch branching enzymes (SBEs) were replaced with corn SBEs, the Arabidopsis plants demonstrated significant increases in starch biosynthesis and a dramatic increase in seed production that led to a 250 per cent increase in total seed oil produced per plant. The increase in seed production was associated with an increase in the numbers of flowers and siliques per plant, while the fatty acid profile of the seed oil remained unaffected.

Canola (*Brassica napus*) is genetically close to Arabidopsis. This provided a feasible strategy to apply the above technology to canola. Canola has a more complicated genetic background and, since no SBE knockout mutants are so far publicly available, the strategy for replication of this effect in canola has been divided into two stages: (1) deletion of canola SBEs through gene editing and (2) expression of maize SBEs.

RESULTS

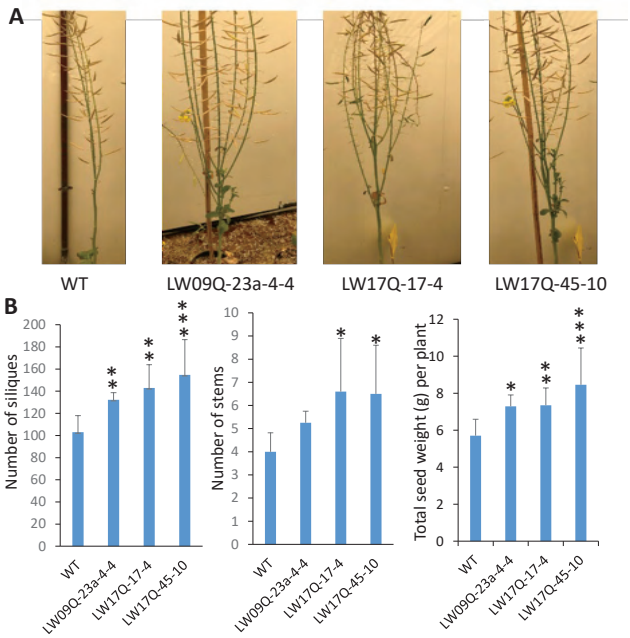
Using the CRISPR-Cas9 gene editing system, the researchers successfully produced homozygous mutant canola lines targeting all six SBE genes. They evaluated homozygous lines expressing the corn SBE in both quadruple and sextuple *sbe* mutants. The number of stems, flowers, and siliques were increased in the quadruple mutant expressing corn SBEI, yielding a highly statistically significant 30 per cent average increase in total seed weight per plant, compared to WT (Figure 1). Primary transformants expressing the corn SBE gene in the *sbe* sextuple mutant showed similar increases in productivity and are currently being taken through to homozygosity. Phenotypes of all the lines will be further evaluated in greenhouse and field.

While phenotyping the *sbe* sextuple mutant and WT plants, the research team noticed that at the maturation stage, the main stem in the sextuple mutant was 21-50 per cent thicker than WT when measuring the perimeter of internodes. Transgenic lines expressing corn SBEI in the sextuple mutant produce a similarly thickened stem as well as increased yield compared to WT, suggesting a double benefit from these genetic changes. The *sbe* sextuple genotype, possessing the thick stem, exhibited significantly improved tolerance to realistic exposure to drought and elevated temperature in controlled environment conditions.

Previous reports have shown that high temperature at flowering causes a deterioration in stem mechanical properties in canola, resulting in increased risk of crop lodging and accompanied yield loss. The research team will test whether the thickened stems can minimize yield loss under high temperature or drought stress in field conditions.

US patent 11,028,483 "Methods of increasing plant biomass and oilseed production" has been granted.

Figure 1



Effects on silique (pod) and stem numbers and total seed weight for canola lines over-expressing the corn starch-branching-enzyme (SBE) gene in the quadruple *sbe* mutant background. These are compared to the wild-type (WT) check. (A) The three transgenic lines and control line maintained in growth chambers (16h light, 21°C then 8h dark, 18°C). (B) Statistical analysis of the number of siliques, stems and total seed weight for each line. Values are means plus or minus standard deviation from five plants. Single, double and triple asterisks indicate the differences are significant at P<0.05, P<0.01 and P<0.001 (t-test).

A new gene for blackleg resistance

KEY RESULT:

AAFC researchers completed the genetic mapping of blackleg resistance gene Rlm11. Rlm11 is effective against *L. maculans* isolates carrying the avirulence gene AvrLm11, which is found in 95 per cent of *L. maculans* isolates collected from Western Canadian canola farms. Canola lines with Rlm11 will enable canola farmers to effectively control the blackleg disease.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Introgression of the highly effective *Brassica rapa* blackleg resistance gene Rlm11 into spring-type *Brassica napus*" Hossein Borhan, AAFC Saskatoon

FUNDING: SaskCanola, Saskatchewan's Agriculture Development Fund, Western Grains Research Foundation

FULL REPORT:
To find the full report, go to SaskCanola's research page at saskcanola.com/research-results and search for the project title.

Genetic resistance is the most cost-effective, efficient and environmentally safe approach for protecting crops such as canola against various pathogens, particularly for blackleg fungus *L. maculans* that does not respond to late applied – after cotyledon or early true leaves – foliar fungicides. To date, 19 resistance (R) genes in Brassica have been identified (named as Rlm or LepR) that confer resistance to various isolates of *L. maculans* with matching avirulence (Avr) genes.

However, tight crop rotations and the rapid emergence of new virulent isolates of *L. maculans* have led to resistance breakdown, forcing researchers to search for new sources of R genes. Field surveys across Western Canadian canola farms found that blackleg races with the avirulence (Avr) gene AvrLm11 were highly prevalent at greater than 95 per cent of fields across the Prairies. This makes the matching R gene, Rlm11, a highly relevant and effective gene used in canola cultivars in Western Canada. Rlm11 was identified in a *Brassica rapa* accession; however, the genome location of the gene and associated markers were unknown, and incorporation of Rlm11 from *B. rapa* is challenging and time-consuming for canola breeders.

Researchers with Agriculture and Agri-Food Canada (AAFC) have recently addressed these issues in a four-year project initiated in 2016. Objectives were to complete the genetic mapping of the blackleg resistance gene Rlm11, to incorporate Rlm11 from the winter-type *B. rapa* to a spring-type *B. napus* and to generate molecular markers linked to Rlm11.

Researchers first identified a *B. rapa* line that contained the race-specific resistance gene Rlm11. This homozygous Rlm11 line named BR-11 was used to generate inter-species (*B. napus* x *B. rapa*) mapping populations by crossing BR-11 to the double haploid, blackleg susceptible *B. napus* line Topas DH16516. DNA from 96 F2 lines was applied to the Brassica 60K Illumina single nucleotide polymorphism (SNP) genotyping marker array and a genome scale SNP map was generated. Rlm11 was found to be positioned on the lower arm of chromosome A07 in a region between the previously mapped Rlm1 and the Rlm3-4-7-9 gene cluster.

To generate the spring type *B. napus* Rlm11 introgression lines, the *B. napus* susceptible line Topas DH16516 was chosen as the recipient parent. Several resistant individuals were selected for successive backcrossing to the susceptible Topas DH16516 parental line. Plants with a normal spring-type growth habit and good seed set were selected at each back-cross generation. Researchers advanced the generation of Topas-Rlm11 introgression lines through further back-crossing to produce and phenotype advanced back-cross populations. These advanced populations were screened to generate and identify further recombination in the Rlm11 region. In the fall of 2021, advanced generations of Topas-Rlm11 introgression lines were harvested. These lines will be used to produce bulk seeds for distribution among canola breeders and agronomists.

As a result of the project, researchers have completed the genetic mapping of the blackleg resistance gene Rlm11 and successfully developed Topas-Rlm11 introgression lines. Researchers also generated molecular markers linked to Rlm11. These markers will be shared with the industry and canola breeders. Rlm11 markers and Topas-Rlm11 introgression lines will allow canola breeders to offer a new and effective resistance gene to farmers. Canola cultivars with Rlm11 combined with the blackleg race determination markers developed in this project will enable canola farmers to continue to effectively control blackleg disease in the future when new varieties incorporate Rlm11 resistance.

Researchers expand the spectrum of clubroot resistance

Photo credit: Liwen Liu

KEY RESULT:

Canola lines with a broad spectrum of clubroot resistance were developed, which are valuable for developing resistant cultivars by canola breeders. Additional developments can improve the ability to monitor changes in the clubroot pathogen race structure, as the pathogen evolves in canola fields on the Prairies.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Defining populations of *P. brassicae* with near isogenic B. napus lines" Fengqun Yu, AAFC Saskatoon

FUNDING: SaskCanola, Saskatchewan's Agriculture Development Fund

FULL REPORT:
To find the full report, go to the Canola Research Hub at canolaresearch.ca and search for the project title.

Clubroot disease caused by *Plasmodiophora brassicae* continues to pose a serious threat to canola production. Genetic resistance can be an effective strategy for clubroot management, but the sources available for resistance to clubroot in *Brassica napus* are limited.

This study aimed to develop a set of near isogenic *B. napus* lines containing single clubroot-resistance genes, and to define the populations of *P. brassicae* with the newly developed near isogenic lines.

OBJECTIVES OF THIS PROJECT WERE TO:

- Complete the development of the doubled haploid (DH) lines initiated in a previous project
- Develop a set of near isogenic spring type *B. napus* lines carrying resistance and define populations of *P. brassicae* collected in Western Canada.

Researchers used conventional breeding methods such as crossing and backcrossing, and molecular marker-assisted selection. Next-generation sequencing technologies were used for genetic mapping of clubroot-resistance (CR) genes, which has greatly accelerated CR gene identification.

RESULTS

Clubroot strains for the study were collected in canola fields in Alberta, Saskatchewan and Manitoba to define populations of *P. brassicae* in Western Canada. The research group also developed a highly efficient method for testing plants for resistance to clubroot.

Genetic mapping in several DH populations with introgressed CR genes from *B. rapa* turnips identified five novel genes. Researchers identified another gene from two mapping populations, one from European canola cv. Mendel and a second from introgressed *B. napus* lines originating from turnip cv. Siloga. This led to the development of canola DH lines with a broad spectrum of clubroot resistance derived from three sources of turnips.

The DH lines, which were distributed to AAFC Clubroot Consortium members in April 2021, showed a high level of resistance to the majority of Canadian races of the clubroot pathogen identified in this study. These lines are valuable for developing resistant cultivars by canola breeders and for more robust strategies for disease management.

Researchers also developed a set of *B. napus* near-isogenic lines (NILs) containing single CR genes, which is ideal for differentiating races of the clubroot pathogen. This first set of NILs containing eight single CR genes in brassica crops could replace the current Canadian Clubroot Differential set and monitor race change in the pathogen race structure, potentially revolutionizing current clubroot pathotyping systems. The NILs can be used for genetic studies on the pathogen such as identification and cloning of the potential Avr genes, developing SNP markers associated with each of the Avr genes and providing information concerning the effectiveness of resistance.

Overall, the project resulted in the development of canola lines with a broad spectrum of clubroot resistance derived from three sources of turnips. Researchers also developed more than 1,200 DH lines for identification of novel resistant genes. Several breeding lines have been distributed to AAFC Clubroot Consortium members for development of future clubroot-resistant canola cultivars.

Canola meal a viable protein supplement for beef cattle

KEY RESULT:

The study showed that canola meal, a high-quality protein source, may be more economically favourable than distillers' grains when used as a feed supplement for beef cattle.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Comparing the protein source and frequency of supplementation of forage intake, competitive feeding interactions, and nutrient utilization for beef cattle fed low-quality forages" Gregory Penner, University of Saskatchewan

FUNDING: SaskCanola, Saskatchewan Stock Growers Association, Natural Sciences and Engineering Research Council of Canada

FULL REPORT: To find the full report, go to SaskCanola's research page at saskcanola.com/research-results and search for the project title.

Forages in Western Canada may not contain sufficient protein to meet nutrient requirements for beef cattle. Therefore, producers may need protein supplements to augment the dietary protein level in cattle rations. Researchers at the University of Saskatchewan and from industry wanted to determine if canola meal could be a suitable protein source for beef cattle.

Main objectives of this two-year study were to compare use and digestion kinetics for low-oil dry distillers' grains, a high protein byproduct from the ethanol industry, and canola meal, a major high protein byproduct of canola oil production, as protein supplements for beef cattle consuming low-quality forage. Researchers also wanted to determine whether the source of protein and the frequency of protein supplementation affected nutrient utilization and feeding behaviour of cattle.

The study was conducted at the University of Saskatchewan's Livestock Research Building using yearling heifers. The control treatment group were fed a mature grass hay-based diet and no protein supplements for 21 days. The other treatments included the mature grass hay-based diet with either canola meal or low-oil dry distillers' grain supplements as pellets, either daily or every second day, for 21 days. Researchers assessed heifer performance and behavior, forage dry matter intake (DMI), heifer average daily gain (ADG), total ruminal short-chain fatty acids (SCFA) concentration and ruminal ammonia concentration.

Photo credit: iStock.com/Jeremy Stenuit

RESULTS

The study confirmed that providing supplemental protein to beef heifers fed a protein-deficient diet increased feed intake and daily gain. Beef heifers fed low quality forage supplemented with either canola meal or distillers' grains showed increased forage DMI, heifer ADG, total ruminal SCFA concentration and ruminal ammonia concentration than those without protein supplementation.

Groups fed a protein supplement showed gains of more than 0.8 pounds per day over the control. This shows that control cattle were limited on protein.

Although performance results of feeding canola meal or distillers' grains were similar, the study showed that canola meal is a high-quality protein source and may be more economically favourable than distillers' grains. Canola meal protein was degraded to a greater extent in the rumen than low-oil dry distillers' grain protein, resulting in greater levels of ruminal ammonia-nitrogen. The supplement frequency did not affect forage or pellet DMI, but alternate-day supplementation led to increased competitive behavior between heifers and faster eating rate of the supplement provided due to increased motivation to feed when feed is offered less frequently.

Overall, the study showed a clear need for protein supplementation of heifers fed low-quality forages, and that canola meal can be a suitable and economically-favourable option. The study also showed feeding double the amount of protein supplements every second day was sufficient, saving producers time, labor and machinery costs. Overall, the study results highlight that cattle can up-cycle byproducts such as canola meal and convert them into a high-quality meat source.

NEW AND ONGOING PROJECTS

New projects launched in the past year include research into nitrogen fertilizer sources, updating the critical weed-free period for canola, genetics to increase drought and heat tolerance, and quantifying combine auto settings for their ability to reduce harvest losses. Ongoing projects include research into biologicals for nitrogen fixation and insect management, phenology-based weed control, and new techniques to breed for disease resistance and environmental stress tolerance. Canola growers contribute to these projects through their levy payments to SaskCanola, Alberta Canola and Manitoba Canola Growers. In partnership with the grower groups and Canola Council of Canada, a number of ongoing projects are funded in part by the Government of Canada under the Canadian Agricultural Partnership's AgriScience Program, a federal provincial, territorial initiative. Many projects are also collaborations with other commodity groups and other Prairie-wide funders, including Western Grains Research Foundation.

NEW PROJECTS

PLANT ESTABLISHMENT

A META-ANALYSIS OF SMALL-PLOT TRIAL DATA TO EXAMINE THE RELATIONSHIP BETWEEN CROP DEVELOPMENT AND ENVIRONMENTAL CONDITIONS IN CANOLA

PRINCIPAL INVESTIGATOR:
Christiane Catellier, Indian Head Agriculture Research Foundation
FUNDING: SaskCanola, Western Grains Research Foundation
OBJECTIVES: Researchers will use archived small-plot canola agronomic trial data from across the canola production region and regional weather data to conduct a meta-analysis to examine the relationship between environmental conditions, canola emergence, and other crop development factors such as maturity and survivability. They will quantify the effect of specific environmental variables on canola emergence and subsequent crop development.

CLIMATE CHANGE RESILIENCE OF PRAIRIE OILSEED CROPS AND THEIR BELOW-GROUND MICROBIOTA UNDER DROUGHT STRESS IN CONTROLLED AND FIELD ENVIRONMENTS

PRINCIPAL INVESTIGATOR:
Tim Dumonceaux, AAFC Saskatoon
FUNDING: SaskCanola
OBJECTIVES: This project will examine the soil, rhizosphere, and root microorganisms that canola plants recruit under stress conditions. It will also isolate microbes (or groups of microbes) that could help plants adapt to changing conditions experienced on the Canadian Prairies.

OPTIMIZING CROP ROTATIONS TO ENHANCE AGRONOMIC, ECONOMIC AND ENVIRONMENTAL PERFORMANCE

PRINCIPAL INVESTIGATOR:
Ramona Mohr, AAFC Brandon
FUNDING: Manitoba Canola Growers
OBJECTIVES: To determine the agronomic, economic and environmental performance of a range of crop rotations under Manitoba conditions, with a focus on wheat, canola, soybean and pea. Specifically, researchers will examine the effect of crop rotation (crop choice, crop sequence, and rotation duration) on crop yield and quality, disease incidence and severity, profitability and economic risk, soil health and nutrient cycling. The goal is to generate a reliable, research-based dataset of production and economic information for a range of climate smart cropping systems and crop rotations.

UNDERSTANDING THE EFFECTS OF CROP ROTATION ON SOIL ORGANIC CARBON STABILIZATION

PRINCIPAL INVESTIGATOR: Bobbi Helgason, University of Saskatchewan
FUNDING: SaskCanola, Saskatchewan's Agriculture Development Fund, Western Grains Research Foundation, Sask Wheat
OBJECTIVES: To obtain new knowledge of the impact of crop rotation diversity on soil organic matter stability and functional pools, how long-term crop rotation diversity affects microbial abundance and activity, and the relationships between microbial community dynamics and functionally important pools of soil organic matter. The study will quantify carbon storage in different soil functional pools.

FERTILITY MANAGEMENT

USING A 4RS PLUS APPROACH TO IMPROVE GROWTH AND SUSTAINABILITY OF ANNUAL CROPPING SYSTEMS IN SASKATCHEWAN

PRINCIPAL INVESTIGATOR:
Blake Weiseth, Discovery Farm
FUNDING: SaskCanola, Sask Wheat
OBJECTIVES: This study will assess the impact of 4R Nutrient Stewardship practices on nitrogen and phosphorus crop uptake and nutrient load in run-off water. It will also assess the impact of topography on nitrogen and phosphorus load in run-off water. Researchers will run a cost-benefit analysis of 4R and associated practices.

Photo credit: D&M Images for SaskCanola

CLIMATE-SMART CANOLA: QUANTIFYING SOIL- AND FERTILIZER-DERIVED NITROGEN SOURCES AND GREENHOUSE GAS EMISSIONS UNDER CANOLA HYBRIDS

PRINCIPAL INVESTIGATOR:
Melissa Arcand, University of Saskatchewan
FUNDING: SaskCanola, Alberta Canola, Manitoba Canola Growers
OBJECTIVES: This project will bring together physiological (plant-based; e.g. nitrogen harvest index) and agronomic (fertilizer-based; e.g. yield per unit nitrogen fertilizer) understanding of canola nitrogen use efficiency (NUE). Researchers will examine soil contributions to canola nitrogen fertility using 15N stable isotope tracing to paint a more complete picture of canola NUE. They will build on previous and current NUE research using a diverse set of canola genotypes to understand the range in NUE and the mechanisms underpinning NUE to identify breeding targets.

TRACING C AND N DURING CROP RESIDUE DECOMPOSITION TO OPTIMIZE C SEQUESTRATION AND PREDICT N TRANSFER CREDIT

PRINCIPAL INVESTIGATOR: Bobbi Helgason, University of Saskatchewan
FUNDING: SaskCanola, Sask Wheat, SaskBarley
OBJECTIVES: Researchers aim to characterize the chemical composition of crop root and shoot tissues in wheat, barley, canola, lentil, field pea and soybean. The goal is to better understand plant residue factors—and residue by environment interactions —controlling decomposition. The result will be better assessment of the potential contribution of residue-nitrogen to the next crop. This could help to predict carbon and nitrogen transformations in the soil and develop farmer-friendly strategies to optimize soil carbon sequestration, organic matter accumulation and mitigate against nitrogen losses.

Richard Farrell (left) from the University of Saskatchewan works with Agriculture and Agri-Food Canada research scientist Reynald Lemke (right) on a number of fertilizer projects, including a new one called "Discovering the optimal rate of a dual-inhibitor N-fertilizer for maximum N_2O emissions reduction."

HOW DOES FALL-APPLIED NITROGEN FERTILIZER INFLUENCE SOIL-EMITTED NITROUS OXIDE EMISSIONS DURING THE OVER-WINTER AND SPRING THAW PERIOD IN THE SEMI-ARID PRAIRIES?

PRINCIPAL INVESTIGATOR:
Reynald Lemke, AAFC Saskatoon
FUNDING: Alberta Canola
OBJECTIVES: Since N_2O emissions are often a symptom of denitrification where nitrogen fertilizer is biologically converted to N_2 gas, reducing N_2O emissions also means a costs savings through greater nitrogen retention for crop use. This study will quantify soil-emitted N_2O from soil receiving urea, dual-inhibitor urea or no nitrogen fertilizer during the non-growing season period under semi-arid conditions. It will examine factors driving the timing and magnitude of soil-emitted N_2O during the non-growing season period and examine the impact of a dual-inhibitor urea product on soil microbial nitrifier and denitrifier dynamics.

DISCOVERING THE OPTIMAL RATE OF A DUAL-INHIBITOR N-FERTILIZER FOR MAXIMUM N2O EMISSIONS REDUCTION

PRINCIPAL INVESTIGATOR:
Reynald Lemke, AAFC Saskatoon
FUNDING: SaskCanola, Saskatchewan's Agriculture Development Fund, Western Grains Research Foundation, Sask Wheat
OBJECTIVES: Researchers will study how a dual inhibitor product applied at a reduced nitrogen-rate compares to urea. They will compare yields, and dig into the maximum N_2O reduction that can be achieved with an DI fertilizer product while maintaining crop yields equivalent to a standard application rate of urea.

EVALUATION OF VARIABLE RATE APPLIED ENHANCED EFFICIENCY N FERTILIZERS ON WHEAT AND CANOLA- FIELD SCALE MANAGEMENT ZONES COMPARISON

PRINCIPAL INVESTIGATOR:
Haben Tedla, AAFC Saskatoon
FUNDING: SaskCanola, Sask Wheat
OBJECTIVES: To evaluate the agronomic potential of variable-rate application and performance of enhanced efficiency nitrogen fertilizer. Researchers will compare the performance of SuperU, ESN-Urea blend and eNtrench to urea. They will conduct economic feasibility and risk assessment on sources of nitrogen fertilizer and on variable rate application by management zones.

INTEGRATED PEST MANAGEMENT

DEVELOP AND ASSESS DIFFERENT STRATEGIES TO REDUCE THE IMPACT OF POLLEN BEETLE *BRASSICOGETHES VIRIDESCENS (COLEOPTERA: NITIDULIDAE)*, A NEW INVASIVE INSECT PEST ON CANOLA

PRINCIPAL INVESTIGATOR:
Christine Noronha, AAFC Charlottetown
FUNDING: Alberta Canola, Manitoba Canola Growers
OBJECTIVES: Pollen beetle, an invasive species, is a pest of rapeseed in Europe and has been found in canola in Eastern Canada. This project will evaluate the efficiency of different monitoring techniques to predict damage, evaluate canola cultivar preference by pollen beetles, survey fields in Alberta, Saskatchewan and Manitoba for pollen beetles, and survey for parasitoids in the Maritimes.

DEPLOYING CALCIUM-DEPENDENT PROTEIN KINASES TO FIGHT CANOLA PATHOGENS

PRINCIPAL INVESTIGATOR:
Jacqueline Monaghan, Queen's University
FUNDING: Alberta Canola, Manitoba Canola Growers, SaskCanola, Western Grains Research Foundation
OBJECTIVES: This project will use precision gene editing to enhance the function of single genes that could provide canola plants with enhanced, durable, broad-spectrum resistance to disease without any growth tradeoff. It will first select candidate *Brassica napus* calcium-dependent protein kinases (BnCPKs), then precision-engineer BnCPK alleles for enhanced disease resistance in canola.

SCREENING FALSE CLEAVERS FROM THE PRAIRIE HERBICIDE RESISTANCE SURVEYS FOR QUINCLORAC AND GLYPHOSATE RESISTANCE

PRINCIPAL INVESTIGATOR:
Breanne Tidemann, AAFC Lacombe
FUNDING: Alberta Canola
OBJECTIVES: This project will provide an indication of how quickly quinclorac and glyphosate resistance in cleavers may be increasing or spreading on the

Prairies. This will contribute to the development of technologies, strategies and recommendations that help growers mitigate or reduce selection pressure for weed resistance.

Breanne Tidemann, weed scientist with Agriculture and Agri-Food Canada in Lacombe, Alberta, collects buckwheat samples this fall for one of her many projects. She has a new canola research project screening false cleavers for quinclorac and glyphosate resistance.

EFFECTS OF HEAT AND DROUGHT ON CANOLA – POLLINATOR INTERACTIONS AND CROP YIELD

PRINCIPAL INVESTIGATOR:
Shelley Hoover, University of Lethbridge
FUNDING: Alberta Canola
OBJECTIVES: Can pollinators improve canola yield when the crop is under heat and drought stress? Researchers will analyze the effects of heat and drought on seed yield and quality, with and without supplemental pollination by bees, for five varieties of canola. They will also examine the benefits of supplemental pollination prior to heat and drought stress versus at the time of the stress event (i.e. can yield be 'rescued' by bees?). Beekeepers will get information on independent and combined effects of drought and heat on nectar and pollen production in canola, across five varieties.

BIOCONTROL OF BLACKLEG USING CARNIVOROUS BACTERIA

PRINCIPAL INVESTIGATOR:
Paul Holloway, University of Winnipeg
FUNDING: Manitoba Canola Growers
OBJECTIVES: This project will isolate various myxobacterial and mycophagous bacteria from soil, sediment, and plant material from Manitoba sources, then identify specific myxobacterial and mycophagous isolates. Researchers will determine whether the isolates can kill or inhibit the growth of filamentous fungi in general, then test them on *Leptosphaeria maculans*, the pathogen that causes blackleg in canola.

UPDATING THE CRITICAL WEED FREE PERIOD IN CANOLA

PRINCIPAL INVESTIGATOR:
Rob Gulden, University of Manitoba
FUNDING: SaskCanola, Alberta Canola, Manitoba Canola Growers, Alberta's Results Driven Agriculture Research
OBJECTIVES: Herbicide labels indicate when it is biologically safe to apply the product but do not indicate when it is biologically necessary to prevent yield losses. Weed management thresholds and critical periods provide that information. This study will update the critical weed-free period (CWFP) for canola using modern canola hybrids, and determine how the crop's plant density affects the CWFP. The goal is to collect data from sufficient locations and years to be able to make sound recommendations regarding the CWFP under various scenarios.

BALANCING ECONOMIC, ACTION, AND SEED PRODUCTION THRESHOLDS FOR GLYPHOSATE-RESISTANT KOCHIA IN CANOLA

PRINCIPAL INVESTIGATOR:
Charles Geddes, AAFC Lethbridge
FUNDING: SaskCanola, Western Grains Research Foundation
OBJECTIVES: In Western Canada, glyphosate-resistant kochia is now more common than glyphosate-susceptible. Canola with stacked traits for both glyphosate and glufosinate tolerance can provide a management option. This project aims to determine the economic, action, and seed production thresholds for glyphosate-resistant kochia in canola planted at five versus 10 plants per square foot. Understanding these thresholds will aid in management decisions regarding a two-pass herbicide strategy in canola with stacked resistance to glyphosate and glufosinate, and further our understanding of the weed management implications of current canola stand density recommendations.

CONTINUE MONITORING LEPTOSPHAERIA MACULANS POPULATIONS FOLLOWING THE INTRODUCTION OF RESISTANT GENES RLM2, RLM4 AND RLM7 FOR EFFECTIVE RESISTANCE DEPLOYMENT ON THE CANADIAN PRAIRIES

PRINCIPAL INVESTIGATOR:
Gary Peng, AAFC Saskatoon
FUNDING: SaskCanola, Alberta Canola, Western Grains Research Foundation
OBJECTIVES: It is generally believed that the blackleg pathogen population will adapt to the newly-introduced R genes, resulting in erosion in resistance over time. The proposed project is intended to provide updated information on pathogen race changes (Avr profile). Information on the prevalence and distribution of *L. maculans* races can help breeders determine effective regimes of R genes for new canola varieties. For agronomists, the information will help recommendations for optimal rotation of resistant canola cultivars. The study may also identify the emergence of virulent pathogen races, providing breeders and industry early warning before significant resistance erosion resulting from the defeat of Rlm2, Rlm4 or Rlm7. The study will also assess the impact of newly introduced R genes on blackleg in relation to the Avr profile of the pathogen at different locations.

COVER CROPS FOR FLEA BEETLE MANAGEMENT

PRINCIPAL INVESTIGATOR:
Yvonne Lawley, University of Manitoba
FUNDING: Manitoba Canola Growers
OBJECTIVES: This study will evaluate the impact of overwintering and spring-planted cover crops on flea beetle damage of canola. These preliminary experiments will not answer all questions but will verify previous observations under controlled conditions and identify the important questions, treatments, and measurements for expanded future research in this area. Analysis will consider trade-offs between the potential benefits of using cover crops to mitigate the risk of flea beetle damage and the practice's possible impact on canola yield.

Photo credit: JonahLawley

Yvonne Lawley, research scientist at the University of Manitoba, leads a new project to evaluate the impact of overwintering and spring-planted cover crops on flea beetle damage of canola.

COMPREHENSIVE INVESTIGATION OF PESTICIDES IN HONEY, POLLEN, BEES AND SOIL COLLECTED FROM CANOLA FIELDS

PRINCIPAL INVESTIGATOR: Elemir Simko, University of Saskatchewan
FUNDING: SaskCanola, Saskatchewan's Agriculture Development Fund, MITACS
OBJECTIVES: This study will accurately document residues of 93 pesticides (including all neonicotinoids and their metabolites) in honey, pollen, bees and soil samples collected from canola fields and boreal regions across Saskatchewan. Honey, pollen, bees and soil will be collected before, during and after canola flowering. In addition, comparable samples will be collected from apiaries in northern Saskatchewan. Each sample will be subjected to a multi-residue analysis for 93 pesticide compounds. The evidence-based data will be useful for policy makers, canola producers, beekeepers, honeypackers and exporters, and consumers.

HARVEST MANAGEMENT

QUANTIFYING COMBINE AUTO-ADJUST CAPABILITIES IN CANOLA

PRINCIPAL INVESTIGATOR: Lorne Grieger, Prairie Agricultural Machinery Institute
FUNDING: SaskCanola, Western Grains Research Foundation
OBJECTIVES: Data from this project will help identify differences in combine loss due to changes in ambient conditions and influenced by canola variety and harvest method. Researchers will measure the performance potential of combines with auto adjusting settings while harvesting canola. The goal is to understand the ability of using advanced control systems to reduce losses through changing conditions, and compare that to manually-set combines.

GENETICS

DROUGHT TOLERANCE IN CANOLA THROUGH MODULATING THE KANGHAN GENE FAMILY

PRINCIPAL INVESTIGATOR:
Zou Jitao, National Research Council
FUNDING: SaskCanola, Manitoba Canola Growers, Western Grains Research Foundation
OBJECTIVES: A gene family, Kanghan, which influences drought tolerance, was discovered though analysis of Arabidopsis ecotypes. This gene family was then identified in *Brassica napus*. Growth chamber assessment demonstrated that RNAi suppression of the Kanghan gene family in canola leads to drastically improved drought tolerance. This project will conduct CRISPR gene editing of the Kanghan genes in canola to generate knockout lines with improved drought tolerance. The primary objective is to demonstrate the Kanghan technology under field conditions so it could be adopted by industry programs for drought tolerance trait breeding.

GENERATION OF CANOLA LINES WITH INCREASED HEAT AND DROUGHT TOLERANCE BY REGULATING PHOSPHOLIPID: DIACYLGLYCEROL ACYLTRANSFERASE ACTIVITY

PRINCIPAL INVESTIGATOR: Guanqun (Gavin) Chen, University of Alberta
FUNDING: SaskCanola, Western Grains Research Foundation
OBJECTIVES: Recent extreme heat waves and arid conditions in Western Canada have led to catastrophic yield losses of canola in some areas. Phospholipid: diacylglycerol acyltransferase (PDAT1) catalyzes a terminal step of seed oil formation, and recent studies indicate that PDAT1 over-expression can effectively increase heat tolerance in the model plant Arabidopsis. This project will evaluate canola lines with distinct modifications of PDAT1 under heat and drought stress. It will also identify additional candidate genes related to heat and drought stress. Resulting characterized canola lines and genes could be used in breeding canola cultivars with improved heat and drought tolerance, as well as seed quality.

FUNCTIONAL VALIDATION OF *BRASSICA NAPUS* GENES RELATED TO CLUBROOT RESISTANCE THROUGH HIGH-THROUGHPUT CRISPR/CAS9 GENOME EDITING

PRINCIPAL INVESTIGATOR:
Wei Xiao, University of Saskatchewan
FUNDING: SaskCanola, Natural Sciences and Engineering Research Council
OBJECTIVES: Researchers will validate functions of clubroot resistance (CR) related genes and understand molecular mechanisms of clubroot resistance and susceptibility. They will establish a high-throughput CRISPR-Cas9-based gene editing platform in *B. napus*.

MODIFICATION OF SURFACE WAXES FOR IMPROVED WATER RETENTION IN CANOLA

PRINCIPAL INVESTIGATOR:
Mark Smith, AAFC Saskatoon
FUNDING: SaskCanola, Saskatchewan's Agriculture Development Fund, Western Grains Research Foundation
OBJECTIVES: Surface wax functions as a barrier to water loss in plants. Researchers will study the positive or negative role of wax components in maintaining the cuticular water barrier of canola, and to identify DNA regions conferring epidermal transcription of genes. The ultimate goal will be to use a technique like genome editing to specifically prevent expression of target genes in the epidermis, without disrupting wax in other parts of the plant such as pollen.

DEVELOPING ALLELE SPECIFIC MOLECULAR MARKERS FOR THE *B. NAPUS* BLACKLEG RESISTANCE (RLM) GENES

PRINCIPAL INVESTIGATOR:
Hossein Borhan, Agriculture and Agri-Food Canada Saskatoon
FUNDING: SaskCanola, Western Grains Research Foundation
OBJECTIVES: To sequence information for blackleg resistance genes Rlm1 and Rlm11 and PCR-based markers for these genes as well as Rlm2. This information will be publicly available for use by all seed companies, public and private research labs and private diagnostic labs.

UNDERSTANDING THE MOLECULAR BASIS OF NLR-MEDIATED CLUBROOT RESISTANCE IN *BRASSICA NAPUS*

PRINCIPAL INVESTIGATOR:
Edel Pérez López, Université Laval
FUNDING: SaskCanola, Western Grains Research Foundation
OBJECTIVES: The goal is to identify clubroot-resistance genes of the nucleotide-binding leucine-rich repeat (NLR) family and characterize their mechanisms in existing commercial canola germplasm. Having identified candidate clubroot resistance genes, canola breeders will be able to incorporate such genes into their germplasm to test their function in combination with traditional marker-assisted breeding.

ONGOING PROJECTS

PLANT ESTABLISHMENT

UNDERSTANDING GRAIN PNEUMATIC CONVEYING IN SEEDING EQUIPMENT

PRINCIPAL INVESTIGATOR: Lorne Grieger, Prairie Agricultural Machinery Institute
FUNDING: SaskCanola, Ag Action Manitoba
OBJECTIVES: To look at factors in air seeder components that affect small seed distribution and viability, both in the field and in computer simulations.

HOW DOES IN-ROW SEED SPACING AND SPATIAL PATTERN AFFECT CANOLA YIELD?

PRINCIPAL INVESTIGATOR:
Steve Shirtliffe, University of Saskatchewan
FUNDING: SaskCanola
OBJECTIVES: To determine the optimum distance canola plants should have from their neighbour, both within rows and between rows, so they can survive to produce maximum yield at existing seeding rates.

MANIPULATING AGRONOMIC FACTORS FOR OPTIMUM CANOLA HARVEST TIMING, PRODUCTIVITY AND CROP SEQUENCING

PRINCIPAL INVESTIGATOR:
Brian Beres, AAFC Lethbridge
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To look at the canola yield effect of seeding rates, hybrid maturity and harvest method.

FERTILITY MANAGEMENT

BIOLOGICAL NITROGEN FIXATION IN CANOLA

PRINCIPAL INVESTIGATOR:
Alicia Ziemienowicz, Agriculture and Agri-Food Canada Lethbridge
FUNDING: Alberta Canola, Alberta Innovates, Western Grains Research Foundation, Alberta's Results Driven Agriculture Research
OBJECTIVES: To generate canola with the trait of "biological nitrogen fixation." This trait would allow crops to grow more efficiently in nitrogen-deficient soil, making them independent of nitrogen fertilizers.

Photo credit: Warren Taylor

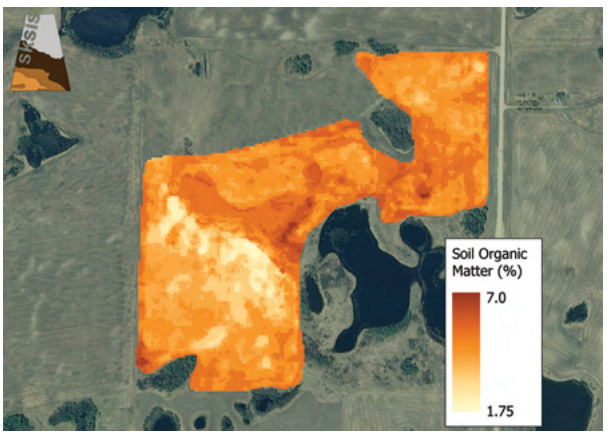
This image is from field work for Brian Beres's study, "Manipulating agronomic factors for optimum canola harvest timing, productivity and crop sequencing." Agriculture and Agri-Food Canada technician Warren Taylor, who took the photos, says these are two side by side plots. At left is an earlier-maturing cultivar, which has lost most of its flowers and is podded out. At right is a later maturing variety, still in flower. Agriculture and Agri-Food Canada researchers also harvested the plots with two different swathing and straight cut timings.

UNDERSTANDING CANOLA ROOT MORPHOLOGY AND MICROBIOMES IN RESPONSE TO SOIL PHOSPHORUS FERTILITY

PRINCIPAL INVESTIGATOR:
Bobbi Helgason, University of Saskatchewan
FUNDING: SaskCanola
OBJECTIVES: To determine how canola root architecture and the root-associated microbiome impact the plant's ability to forage for phosphorus. This can help to develop strategies for overcoming phosphorus deficiency in canola production.

SKSIS-3: SYNERGIES AND SUSTAINABILITY FOR THE SASKATCHEWAN SOIL INFORMATION SYSTEM

PRINCIPAL INVESTIGATOR: Angela Bedard-Haughn, University of Saskatchewan
FUNDING: SaskCanola, Western Grains Research Foundation, Growing Forward 2
OBJECTIVES: To enhance Saskatchewan Soil Information System (SKSIS) by developing and integrating predictive soil mapping tools into SKSIS, and by creating a standalone SKSIS feature for efficient use in internet-deficient areas.



SKSIS Predictive Soil Mapping Service generated this predicted map of soil organic matter. SaskCanola is a funder for the project "To enhance SKSIS by developing and integrating predictive soil mapping tools into SKSIS, and by creating a standalone SKSIS feature for efficient use in internet-deficient areas." For a video description of the platform, find the YouTube channel for SKSIS - Saskatchewan Soil Information System.
Photo credit: Jeremy Kiss, project manager

REVISING THE CROP NUTRIENT UPTAKE AND REMOVAL GUIDELINES FOR WESTERN CANADA

PRINCIPAL INVESTIGATOR:
Fran Walley, University of Saskatchewan
FUNDING: SaskCanola, Western Grains Research Foundation, other commodity groups
OBJECTIVES: To determine and revise estimates of the nutrient uptake and removal of crops commonly grown in Western Canada, and to develop a user-friendly online and mobile app for determining nutrient uptake and removal estimates.

USING MODULATED ON-FARM RESPONSE SURFACE EXPERIMENTS (MORSE) TO DEVELOP EVIDENCE BASED, AGRONOMIC RECOMMENDATIONS

PRINCIPAL INVESTIGATOR: Steve Shirtliffe, University of Saskatchewan
FUNDING: SaskCanola, Sask Wheat, Western Grains Research Foundation
OBJECTIVES: To develop methodology that will allow crop input experiments to be performed using Modulated On-farm Response Surface Experiments, to refine image-based technology as a tool to assess crop response variables, including yield.

ENHANCING THE SASKATCHEWAN SOIL HEALTH ASSESSMENT PROTOCOL – PHASE 2

PRINCIPAL INVESTIGATOR: Kate Congreves, University of Saskatchewan
FUNDING: SaskCanola, Sask Wheat
OBJECTIVES: To build on the Saskatchewan Soil Health Testing Protocol so that it outputs soil zone-specific scores; to incorporate novel microbial measurements of soil health into the testing protocol; and to explore early-indicators of soil health change.

SHINING A LIGHT ON DIGITAL AGRICULTURE: LINKING SOIL NIR MEASUREMENTS, FERTILITY AND CROP YIELDS

PRINCIPAL INVESTIGATOR:
Derek Peak, University of Saskatchewan
FUNDING: SaskCanola, Sask Wheat, Saskatchewan's Agriculture Development Fund
OBJECTIVES: To use spectral sensing to produce spatially-resolved soil based yield potential maps; and develop methodology to link field near infrared (NIR) data and laboratory analyses.

IMPACT OF PHOSPHORUS FERTILIZER FORMS ON NUTRITION OF WHEAT, PEA AND CANOLA, SOIL FATE AND LOSSES IN RUN-OFF WATER

PRINCIPAL INVESTIGATOR: Jeff Schoenau, University of Saskatchewan
FUNDING: SaskCanola, Sask Wheat, SaskPulse, Western Grains Research Foundation
OBJECTIVES: To assess how phosphorus fertilizer forms, placement, and rate affect crop responses, fate in the soil, and run-off losses in Saskatchewan soils.

IMPROVING NITROGEN USE EFFICIENCY AND SOIL SUSTAINABILITY IN CANOLA PRODUCTION ACROSS CANADA

PRINCIPAL INVESTIGATOR:
Bao-luo Ma, AAFC Ottawa
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To assess and improve nitrogen use efficiency (NUE); to identify root architecture traits for efficient nitrogen acquisition; and to investigate how the soil microbiome responds to nitrogen management.

COLLECTING THE CARBON DATA NEEDED FOR CLIMATE-SMART AGRICULTURE IN SASKATCHEWAN

PRINCIPAL INVESTIGATOR: Kate Congreves, University of Saskatchewan
FUNDING: SaskCanola, Sask Wheat, SaskOats, Saskatchewan's Agriculture Development Fund
OBJECTIVES: To provide year-round measurements of greenhouse gas emissions from a representative cropping system in Saskatchewan; to assess 4R practices to minimize carbon footprints; to test if Saskatchewan cropping systems are a net carbon sink.

Some clubroot pathotypes can infect at higher soil pH. University of Alberta researcher Stephen Strelkov leads a study called "Influence of pH on the clubroot pathogen: are there pH-insensitive strains?" to look into these differences. The photo shows symptoms caused by clubroot pathotype 5X at pH 6 (susceptible host reaction) and pH 7.5 (susceptible host reaction), and symptoms caused by clubroot pathotype 6B at pH 6 (susceptible host reaction) and pH 7.5 (partially resistant host reaction). The isolate representing pathotype 6B is more sensitive to higher pH than the isolate representing 5X. Photo credit: Yoann Aigu

INTEGRATED PEST MANAGEMENT – DISEASE

THE ROLE OF INSECT FEEDING AND PLANT DEFENSE RESPONSES IN ASTER YELLOWS DISEASE EPIDEMIOLOGY

PRINCIPAL INVESTIGATOR:
Sean Prager, University of Saskatchewan
FUNDING: Alberta Canola, Manitoba Canola Growers
OBJECTIVES: To quantify the feeding behaviour of aster leafhoppers on different host plants and examine the relationship between feeding time and aster yellows phytoplasma.

INVESTIGATING INTERACTIONS OF ASCOSPORES AND PYCIDIOSPORES WITH BLACKLEG RESISTANCE IN CANOLA AND EFFICACY OF SEED APPLIED FUNGICIDES

PRINCIPAL INVESTIGATOR:
Dilantha Fernando, University of Manitoba
FUNDING: SaskCanola
OBJECTIVES: To develop a protocol to efficiently produce ascospore and pycnidiospore inoculum with defined Avr profile for resistance screening. To assess interactions of inoculum types with blackleg resistance. To evaluate seed-applied fungicides.

PURIFYING GENOTYPES OF *P. BRASSICAE* AND DEVELOPING MARKERS LINKED TO RACES OF *P. BRASSICAE* COLLECTED IN WESTERN CANADA

PRINCIPAL INVESTIGATOR:
Fengqun Yu, AAFC Saskatoon
FUNDING: SaskCanola, Manitoba Canola Growers, Western Grains Research Foundation
OBJECTIVES: To develop markers linked to races of *P. brassicae* (the pathogen that causes clubroot), similar to the technology used for blackleg. First step is an efficient method to produce near pure genotype isolates (NPGI).

INFLUENCE OF pH ON THE CLUBROOT PATHOGEN: ARE THERE pH-INSENSITIVE STRAINS?

PRINCIPAL INVESTIGATOR:
Stephen Strelkov, University of Alberta
FUNDING: Alberta Canola, SaskCanola, Manitoba Canola Growers
OBJECTIVES: To determine whether strains of the clubroot pathogen respond differentially to soil pH and whether pathogen strains can become adapted to high pH conditions.

CLUBROOT INOCULUM MANAGEMENT FOR SUSTAINABLE CANOLA PRODUCTION

PRINCIPAL INVESTIGATOR:
Stephen Strelkov, University of Alberta
FUNDING: Alberta Canola, Alberta Agriculture, Forestry and Rural Economic Development
OBJECTIVES: To determine the spore population levels that are safe for the use of clubroot-resistant cultivars and develop a knowledge-based resistance deployment strategy.

A RAPID MOLECULAR ASSAY TO IDENTIFY *PLASMODIOPHORA BRASSICAE* PATHOTYPES FROM PLANT AND SOIL SAMPLES

PRINCIPAL INVESTIGATOR:
Stephen Strelkov, University of Alberta
FUNDING: Alberta Canola, Alberta Agriculture, Forestry and Rural Economic Development
OBJECTIVES: To generate an effective rapid molecular assay (PCR-based) to identify abundance and diversity of *P. brassicae* pathotypes in soil and plant samples; and to use genetic variability among pathotypes to identify genes of interest related to infection.

STUDY OF THE EFFECTS OF BRASSICA ROOT ARCHITECTURE AND FERTILIZER APPLICATION ON CLUBROOT DISEASE SEVERITY

PRINCIPAL INVESTIGATOR:
Stephen Strelkov, University of Alberta
FUNDING: Alberta Canola, Western Grains Research Foundation, Results Driven Agriculture Research
OBJECTIVES: To investigate the association between Brassica root architecture and nitrogen treatments on clubroot severity and crop yield.

Verticillium-infected canola stems in Dilantha Fernando's nursery. Fernando, researcher at the University of Manitoba, leads a study called "Verticillium disease etiology and nursery" to learn more about the disease.
Photo credit: Aria Dolotabadian

FINE-TUNING OF THE BLACKLEG YIELD LOSS MODEL IN CANOLA

PRINCIPAL INVESTIGATOR:
Stephen Strelkov, University of Alberta
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To refine and improve on an earlier yield loss model by using modern hybrid cultivars.

UNDERSTANDING FUSARIUM WILT AND ROOT ROT OF HYBRID CANOLA

PRINCIPAL INVESTIGATOR:
Sheau-Fang Hwang, University of Alberta
FUNDING: Alberta Canola, Results Driven Agriculture Research
OBJECTIVES: To optimize cultural methods to control the fusarium pathogens causing seedling blight and root rot and wilt of canola.

EXPLORING NOVEL SEED-TREATMENT OPTIONS TO MITIGATE THE IMPACT OF BLACKLEG ON CANOLA

PRINCIPAL INVESTIGATOR:
Gary Peng, AAFC Saskatoon
FUNDING: SaskCanola, Alberta Canola, Manitoba Canola Growers
OBJECTIVES: To assess the importance of blackleg infection from the soil, and investigate the conditions that affect the success of infection. The information will help understand the potential value of fungicide seed treatment for blackleg.

MONITORING THE RACE DYNAMICS OF *LEPTOSPHAERIA MACULANS* FOR EFFECTIVE DEPLOYMENT AND ROTATION OF RESISTANCE GENES FOR SUSTAINABLE MANAGEMENT OF BLACKLEG

PRINCIPAL INVESTIGATOR:
Gary Peng, AAFC Saskatoon
FUNDING: SaskCanola, Alberta Canola, Manitoba Canola Growers
OBJECTIVES: To provide an up-to-date *L. maculans* race profile, which can be used to guide the deployment or rotation of canola cultivars carrying different *R* genes. To see how pathogen race changes in response to resistant cultivars over the years.

IMPROVING MANAGEMENT OF BLACKLEG ON CANOLA VIA BETTER FLEA BEETLE CONTROL AND EFFECTIVE FUNGICIDE SEED TREATMENT IN WESTERN CANADA

PRINCIPAL INVESTIGATOR:
Gary Peng, AAFC Saskatoon
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To assess potential connection between flea beetle feeding and blackleg infection, and whether foliar insecticide, blackleg-resistant cultivar and fungicide seed treatment can alleviate blackleg infection under different flea beetle feeding pressure.

DEVELOPING A ROBUST SYSTEM FOR EFFICIENT ASSESSMENT OF QUANTITATIVE RESISTANCE (QR) IN COMMERCIAL CANOLA VARIETIES FOR BLACKLEG MANAGEMENT

PRINCIPAL INVESTIGATOR:
Gary Peng, AAFC Saskatoon
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To explore a ddPCR-based protocol to measure quantitative resistance (QR) to blackleg in canola. Once developed and validated, this can quantify QR in canola cultivars and help screen QR traits in commercial canola breeding lines.

UNDERSTANDING THE CRITICAL INFECTION WINDOW THAT CAUSES BLACKLEG OF CANOLA IN WESTERN CANADA

PRINCIPAL INVESTIGATOR:
Gary Peng, AAFC Saskatoon
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To understand how quantitative resistance (QR) affects the success of stem infection via cotyledons or lower true leaves. The information may help fine-tune the timing of fungicide, including use of seed treatment.

MANAGING SMALL PATCHES OF CLUBROOT INFESTATION IN CANOLA FIELDS

PRINCIPAL INVESTIGATOR:
Bruce Gossen, AAFC Saskatoon
FUNDING: Alberta Canola, SaskCanola, Manitoba Canola Growers
OBJECTIVES: To develop practical recommendations to manage small patches of clubroot. Includes lab studies of rotation crops and grass cover crops, field studies of liming and grasses, and tests to estimate resting spore numbers in soil.

DEVELOPING SINGLE-SPORE ISOLATES OF PATHOTYPES OF *PLASMODIOPHORA BRASSICAE*

PRINCIPAL INVESTIGATOR:
Bruce Gossen, AAFC Saskatoon
FUNDING: SaskCanola, Saskatchewan's Agriculture Development Fund
OBJECTIVES: To develop techniques for whole-genome sequencing of single spores of *P. brassicae*, the pathogen that causes clubroot.

CLUBROOT PILLAR 3: HOST-PATHOGEN BIOLOGY AND INTERACTION

PRINCIPAL INVESTIGATOR:
Bruce Gossen, AAFC Saskatoon
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To examine factors that affect resting spore survival, germination and infection; to examine quantitative resistance to see if it might increase the durability of resistance genes; and to evaluate strategies to maximize the durability of resistance.

APPLICATION OF HYPERSPECTRAL IMAGING FOR DETECTION AND MAPPING OF SMALL PATCH CLUBROOT INFESTATIONS IN COMMERCAIAL CANOLA FIELDS

PRINCIPAL INVESTIGATOR:
David Halstead, Saskatchewan Polytechnic
FUNDING: SaskCanola, Saskatchewan's Agriculture Development Fund
OBJECTIVES: To identify readily applied diagnostic features for mapping small clubroot patches and develop a diagnostic tool; to refine and validate diagnostic tool for identifying small patch clubroot infestations.

A PROTEOMICS-BASED APPROACH TOWARDS IDENTIFYING HOST AND PATHOGEN PROTEINS CRITICAL TO CLUBROOT ESTABLISHMENT IN CANOLA

PRINCIPAL INVESTIGATOR:
Chris Todd, University of Saskatchewan
FUNDING: SaskCanola, Western Grains Research Foundation
OBJECTIVES: To identify *P. brassicae* effector proteins and to identify differentially expressed proteins in clubroot-susceptible and clubroot-resistant canola lines.

BIOPESTICIDES AS A NOVEL MANAGEMENT STRATEGY FOR SCLEROTINIA IN CANOLA

PRINCIPAL INVESTIGATOR:
Susan Boyetchko, AAFC Saskatoon
FUNDING: SaskCanola, Manitoba Canola Growers
OBJECTIVES: To screen and evaluate the biopesticide potential of selected bacterial strains that are indigenous to the Canadian Prairies and determine their ability to control disease development and growth of *Sclerotinia sclerotiorum* in canola.

RESISTANCE TO *SCLEROTINIA SCLEROTIORUM* EFFECTORS IN CANOLA

PRINCIPAL INVESTIGATOR:
Dwayne Hegedus, AAFC Saskatoon
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To simplify the identification of *Brassica napus* canola lines with tolerance to sclerotinia stem rot.

DEVELOPMENT OF A BIOSENSOR FOR SCLEROTINIA STEM ROT DISEASE FORECASTING IN CANOLA

PRINCIPAL INVESTIGATOR:
Xiujie (Susie) Li, InnoTech Alberta
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To develop an in-field real-time sensor to monitor plant disease pathogens, specifically the sclerotinia stem rot pathogens. The sensor would notify the farmer, via cell phone, when a disease outbreak is imminent.

David Halstead, research chair at Saskatchewan Polytechnic's School of Natural Resources and Built Environment, leads a study called "Application of hyperspectral imaging for detection and mapping of small patch clubroot infestations in commercial canola fields." The drone carries the hyperspectral camera that provides the imaging.

Photo credit: Leila Benmerrouche

IMPROVING THE MANAGEMENT OF SCLEROTINIA STEM ROT OF CANOLA USING FUNGICIDES AND BETTER RISK ASSESSMENT TOOLS

PRINCIPAL INVESTIGATOR:
Kelly Turkington, AAFC Lacombe
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To study how the relationship between inoculum availability and environmental conditions before and during flowering impacts stem rot risk and fungicide response; to study how crop development and variability in flowering impact fungicide efficacy; and to test fungicide application timing.

VERTICILLIUM STRIPE - THE DISEASE MANAGEMENT

PRINCIPAL INVESTIGATOR:
Sheau-Fang Hwang and Stephen Strelkov, University of Alberta
FUNDING: Alberta Canola, SaskCanola, Manitoba Canola Growers
OBJECTIVES: To determine the effects of growth stage and inoculation techniques on host infection, and to evaluate the effects of disease severity on plant growth and yield at different inoculum concentrations.

VERTICILLIUM DISEASE ETIOLOGY AND NURSERY

PRINCIPAL INVESTIGATOR:
Dilantha Fernando, University of Manitoba
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To identify and characterize *Verticillium longisporum* isolates from across the Prairies; to investigate the longevity of micro-sclerotia in canola stems, and monitor pathogen movement in soil or through space; and to look for resistant canola lines.

GENETICS AND GENOMICS OF BRASSICA-VERTICILLIUM INTERACTION

PRINCIPAL INVESTIGATOR:
Hossein Borhan, Agriculture and Agri-Food Canada Saskatoon
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To identify verticillium-resistant *B. napus* (canola) lines and to develop pathogen diagnostic tools.

PROTECTION OF CANOLA FROM PATHOGENIC FUNGI USING RNA INTERFERENCE TECHNOLOGIES

PRINCIPAL INVESTIGATOR:
Steve Whyard, University of Manitoba
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To synthesize double-stranded RNA (dsRNA) and screen for fungicidal activity on sclerotinia stem rot and non-target effects, develop and test topical formulations, and assess the persistence of dsRNAs in the soil.

INTEGRATED PEST MANAGEMENT – INSECTS

INSECTICIDE SUSCEPTIBILITY AND RESISTANCE MONITORING OF FLEA BEETLES IN CANOLA

PRINCIPAL INVESTIGATOR:
Boyd Mori, University of Alberta
FUNDING: Alberta Canola, Western Grains Research Foundation, Results Driven Agriculture Research
OBJECTIVES: To determine the susceptibility of the striped and crucifer flea beetle to various registered insecticides and investigate the mechanisms of insecticide tolerance.

MONITORING THE CANOLA FLOWER MIDGE WITHIN PHEROMONE-BAITED TRAPS

PRINCIPAL INVESTIGATOR:
Boyd Mori, University of Alberta
FUNDING: Western Grains Research Foundation, Alberta Canola, SaskCanola, Manitoba Canola Growers
OBJECTIVES: To develop a pheromone-monitoring tool for the canola flower midge and enhance our knowledge of the factors that contribute to its pest status.

IDENTIFYING KEY PREDATORS AND THEIR ROLE IN CANOLA INSECT PEST SUPPRESSION

PRINCIPAL INVESTIGATOR:
Boyd Mori, University of Alberta
FUNDING: Alberta Canola, Manitoba Canola Growers, Western Grains Research Foundation
OBJECTIVES: To identify the key natural enemies in the canola agroecosystem by detecting pest insect DNA in guts of predators, and to begin quantifying their pest suppression ability.

A carabid beetle *(Pterostichus melanarius)* attempts to catch a flea beetle. Study of natural enemies is part of Alejandro Costamagna's project to improve flea beetle management. He and his team are studying the effect of plant density in flea beetle management, the effect of stem feeding damage, the role of natural enemies on flea beetle management, and regional predictive models for flea beetle abundance. Photo credit: Shayla Woodland

EVALUATING THE EFFECT OF CANOLA SEEDING RATE AND SEED SIZE SEEDED INTO WHEAT STUBBLE ON FLEA BEETLE DAMAGE AND POPULATION

PRINCIPAL INVESTIGATOR:
María Angélica Ouellette, North Peace Applied Research Association
FUNDING: Alberta Canola
OBJECTIVES: To evaluate the impact of seeding rate, seed size, and seeding date on flea beetle damage - specifically for the North Peace region.

CONTINUING TO WATCH THE WINDS: THE ORIGIN AND ARRIVAL OF MIGRANT ASTER LEAFHOPPERS AND DIAMONDBACK MOTHS

PRINCIPAL INVESTIGATOR:
Tyler Wist, AAFC Saskatoon
FUNDING: SaskCanola, Western Grains Research Foundation
OBJECTIVES: To pinpoint the southern origins of diamondback moth and aster leafhopper; to see if alfalfa could be a "green bridge" for aster yellows phytoplasma in Saskatchewan; to develop aster yellows risk index.

SURVEILLANCE NETWORKS FOR BENEFICIAL INSECTS II

PRINCIPAL INVESTIGATOR:
Paul Galpern, University of Calgary
FUNDING: Alberta Canola, Manitoba Canola Growers
OBJECTIVES: To determine how far services extend from beneficial anthropod reservoirs and how much beneficial anthropod reservoirs contribute to canola yield by using precision agriculture.

INTEGRATED APPROACHES FOR FLEA BEETLE CONTROL II

PRINCIPAL INVESTIGATOR: Alejandro Costamagna, University of Manitoba
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To improve flea beetle management in general by studying the effect of plant density in flea beetle management, the effect of stem feeding damage, the role of natural enemies on flea beetle management, and regional predictive models for flea beetle abundance.

GENETIC RESOURCES FOR FLEA BEETLE RESISTANCE IN CANOLA

PRINCIPAL INVESTIGATOR:
Dwayne Hegedus, AAFC Saskatoon
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To investigate the complexity of the "hairy" trait and will provide canola breeders with hairy lines, and associated genetic markers, to allow its introduction into canola varieties.

BIOLOGICAL CONTROL OF CABBAGE SEEDPOD WEEVIL IN THE PRAIRIES

PRINCIPAL INVESTIGATOR:
Hector Carcamo, AAFC Lethbridge
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To assess the efficacy of *T. perfectus* in managing seedpod weevil in Quebec and its non-target effects in Eastern Canada. To document the species of weevils and parasitoids in cultivated and uncultivated habitats that could be affected directly or indirectly in the Prairies.

EXPLORING FURTHER POSSIBILITIES AND ADVANCEMENTS OF USING BIO-CONTROL ENTOMOPATHOGENIC NEMATODES (EPNS)

PRINCIPAL INVESTIGATOR:
Shabeg Briar, Olds College
FUNDING: Alberta Canola, Results Driven Agriculture Research
OBJECTIVES: To assess the management of root maggots and cutworms using commercially available entomopathogenic nematodes (EPNs); to identify and explore locally adapted virulent strains of EPNs.

This image shows entomopathogenic nematodes (EPNs) emerging from a dead waxworm larva. Shabeg Briar at Olds College is the lead on a study called "Exploring further possibilities and advancements of using bio-control entomopathogenic nematodes (EPNs)," looking at EPNs for the management of root maggots and cutworms.
Photo credit: Peggy Greb, USDA

INCORPORATION OF ABIOTIC AND BIOTIC FACTORS FOR DEVELOPMENT OF STAGE-STRUCTURED PREDICTIVE MODELS OF FLEA BEETLES

PRINCIPAL INVESTIGATOR:
Maya Evenden, University of Alberta
FUNDING: Alberta Canola, Results Driven Agriculture Research
OBJECTIVES: To develop a weather-dependent, stage-structured deterministic developmental model for both flea beetle species and evaluate appropriate base temperature thresholds for predictions of flea beetles in canola.

INTEGRATED PEST MANAGEMENT – WEEDS

HERBICIDE RESISTANT KOCHIA AND RUSSIAN THISTLE PRAIRIE SURVEYS

PRINCIPAL INVESTIGATOR: Julia Leeson, AAFC Saskatoon; Andrew Sharpe, Global Institute for Food Security
FUNDING: Western Grains Research Foundation, SaskCanola and other commodity groups
OBJECTIVES: To complete the sixth set of weed surveys in the Prairie Provinces since the series of provincial surveys began in the mid-1970s. To summarize existing weed survey information and conduct a new series of general weed surveys.

PRAIRIE WEED SURVEYS

PRINCIPAL INVESTIGATOR:
Julia Leeson, AAFC Saskatoon; Andrew Sharpe, Global Institute for Food Security
FUNDING: Western Grains Research Foundation, SaskCanola and other commodity groups
OBJECTIVES: To determine the distribution and abundance of glyphosate-resistant or auxinic-resistant kochia and other targeted weeds, including Russian thistle, waterhemp, and ragweed species in Manitoba, Saskatchewan and Alberta.

ENHANCE UNDERSTANDING OF CLEAVERS POPULATIONS IN WESTERN CANADA

PRINCIPAL INVESTIGATOR:
Breanne Tidemann, Agriculture and Agri-Food Canada Lacombe
FUNDING: Alberta Canola, SaskCanola, Western Grains Research Foundation
OBJECTIVES: To look for cleavers biotypes on the Prairies based on emergence

phenology, whorl/branch number, seed production, and seed weight. Evaluate emergence timing of cleavers populations. Screen for quinclorac resistance.

MANIPULATING WEED SEED PRODUCTION THROUGH PHENOLOGY-BASED WEED CONTROL

PRINCIPAL INVESTIGATOR:
Charles Geddes, AAFC Lethbridge
FUNDING: Alberta Canola, Alberta Wheat Commission, Sask Wheat, Western Grains Research Foundation
OBJECTIVES: To improve our understanding of weed phenology in Western Canada, and use that information to develop strategies to reduce the amount of weed seed returned to the soil. This will help with herbicide-resistant weed management.

INTEGRATED PEST MANAGEMENT – OTHER

IMPACT OF DROUGHT AND HEAT DURING FLOWERING ON CANOLA YIELD

PRINCIPAL INVESTIGATOR:
Raju Soolanayakanahally, Agriculture and Agri-Food Canada Saskatoon
FUNDING: SaskCanola, Saskatchewan's Agriculture Development Fund
OBJECTIVES: To see how drought, heat and a combination of the two can affect canola seed yield, oil composition and carbon assimilation.

PROMOTION OF WETLAND STEWARDSHIP BEST MANAGEMENT PRACTICES THROUGH A TARGETED WATER MONITORING PROJECT

PRINCIPAL INVESTIGATOR:
Tony Ciarla, Millenium EMS Solutions
FUNDING: Alberta Canola and various other public and private funders
OBJECTIVES: To evaluate wetland management practices in mitigating the movement of crop protection products into wetlands and aquatic ecosystems. This will help ensure that farmers have access to crop protection tools by continuing to follow sound environmental stewardship.

These cleavers biotypes were planted the same day and at the same rate. As part of the study "Enhance understanding of cleavers populations in Western Canada," Agriculture and Agri-Food Canada research scientist Breanne Tidemann will study cleavers biotypes with different growth characteristics to see what these differences could mean for management. Photo credit: AAFC

GENETICS

CONTRIBUTION OF INDIVIDUAL DEFENCE GENES TO SCLEROTINIA RESISTANCE IN CANOLA

PRINCIPAL INVESTIGATOR:
Lone Buchwaldt, AAFC Saskatoon
FUNDING: SaskCanola, Saskatchewan's Agriculture Development Fund
OBJECTIVES: To determine the contribution of lectin genes to sclerotinia resistance in canola, to determine the contributio of penetration-resistance genes to sclerotinia resistance in canola, and to determine the contribution of other candidate defense genes to sclerotinia resistance in canola.

PRESERVING HYBRID VIGOUR THROUGH A NOVEL APOMIXIS BREEDING STRATEGY IN BRASSICA CROPS

PRINCIPAL INVESTIGATOR:
Tim Sharbel, University of Saskatchewan
FUNDING: SaskCanola, Saskatchewan's Agriculture Development Fund
OBJECTIVES: To generate diploid, hybrid unbalanced apomictic boechera backcrosses; to transfer apomixis from these lines into sexual bridging species; and to generate apomictic brassica crops via intergeneric crosses.

MODIFIED LIPID METABOLISM TO DELIVER IMPROVED LOW TEMPERATURE TOLERANCE IN BRASSICA NAPUS

PRINCIPAL INVESTIGATOR:
Mark Smith, AAFC Saskatoon
FUNDING: SaskCanola, Saskatchewan's Agriculture Development Fund
OBJECTIVES: To apply a targeted approach to identify new traits to confer improved low temperature tolerance in seedling canola.

ESTABLISHING TRANSGENE-FREE CRISPR/CAS9 BASED GENOME EDITING PLATFORM TO IMPROVE CANOLA RESISTANCE TO CLUBROOT

PRINCIPAL INVESTIGATOR:
Wei Xiao, University of Saskatchewan
FUNDING: SaskCanola, Saskatchewan's Agriculture Development Fund
OBJECTIVES: To establish transgene-free CRISPR/Cas9 based genome editing platform to support canola breeding programs, to identify novel clubroot resistance genes and create novel resistance allelic variants in elite canola germplasms.

INCREASING ABIOTIC (DROUGHT) AND BIOTIC (CLUBROOT) RESISTANCE IN BRASSICA SPECIES BY MODIFYING AUXIN RESPONSE

PRINCIPAL INVESTIGATOR:
Jocelyn Ozga, University of Alberta
FUNDING: SaskCanola, Alberta Canola, Natural Sciences and Engineering Research Council
OBJECTIVES: To develop novel genetically-improved canola, using a biotechnological approach, that is more resistant to both biotic (clubroot disease) and abiotic (drought) stress.

IMPROVING HEAT AND DROUGHT RESISTANCE IN CANOLA THROUGH REGULATING DGAT1 ACTIVITY

PRINCIPAL INVESTIGATOR:
Gavin Chen, University of Alberta
FUNDING: Alberta Canola

OBJECTIVES: To generate and evaluate canola lines with distinct modifications of DGAT1 enzyme under heat and drought stress and to identify additional candidate genes related to heat and drought stress. Diacylglycerol acyltransferase 1 (DGAT1) can increase tolerance to drought, heat or freezing stress in arabidopsis.

IDENTIFICATION AND EXPLOITATION OF GENOME STRUCTURAL VARIANTS FOR TRAIT IMPROVEMENT IN PRAIRIE CROPS

PRINCIPAL INVESTIGATOR: Andrew Sharpe, Global Institute for Food Security
FUNDING: SaskCanola, Sask Wheat, Alberta Wheat, Western Grains Research Foundation
OBJECTIVES: To develop canola and wheat pan-genome structural variant (PanSV) atlases; to develop high-throughput structural variant (SV) genotyping pipeline; to associate SVs with important agronomic traits.

EXPLORING *BRASSICA OLERACEA* FOR RESISTANCE TO THE NEWLY EMERGED *P. BRASSICAE* PATHOTYPES

PRINCIPAL INVESTIGATOR:
Habibur Rahman, University of Alberta
FUNDING: Alberta Canola, Alberta Agriculture & Forestry
OBJECTIVES: To introgress clubroot resistance genes from the cabbage/cauliflower-type plant species (*B. oleracea*) into Canadian canola, and develop molecular markers for these genes.

Isobel Parkin, research scientist with Agriculture and Agri-Food Canada in Saskatoon, is the principal investigator for genetics projects, including one to develop constructs for gene knock-outs using CRISPR technology and another to identify optimal root system architecture for improved nitrogen efficiency.
D&M Images for SaskCanola

IMPROVEMENT OF THE CLUBROOT-RESISTANT CANOLA GERMPLASM OF CANOLA × RUTABAGA CROSS, AND FINE MAPPING OF THE RESISTANCE GENE

PRINCIPAL INVESTIGATOR:
Habibur Rahman, University of Alberta
FUNDING: Alberta Canola, Alberta Innovates, Alberta Agriculture & Forestry
OBJECTIVES: To develop canola lines that carry the clubroot resistance gene of rutabaga, resulting in clubroot-resistant hybrid canola cultivars.

INTROGRESSION OF CLUBROOT RESISTANCE FROM *B. RAPA* INTO *B. NAPUS* CANOLA AND IDENTIFICATION OF MOLECULAR MARKERS FOR RESISTANCE

PRINCIPAL INVESTIGATOR:
Habibur Rahman, University of Alberta
FUNDING: Alberta Canola, SaskCanola
OBJECTIVES: To introgress clubroot resistance (CR) from *B. rapa* to canola. The *B. rapa* germplasm used in this research carries resistance to pathotypes 3 and 3A. This could be a new source of resistance.

RE-SYNTHESIZING *BRASSICA NAPUS* WITH CLUBROOT RESISTANCE FROM C-GENOME

PRINCIPAL INVESTIGATOR:
Fengqun Yu, AAFC Saskatoon
FUNDING: Alberta Canola, Alberta Innovates
OBJECTIVES: To generate new and unique germplasm and make it available to canola breeders to develop cultivars with broad spectrum of resistance to clubroot in Western Canada.

GENETIC DISSECTION OF THE RLM3-4-7-9 BLACKLEG R GENE CLUSTER AND KASP MARKER IMPROVEMENT

PRINCIPAL INVESTIGATOR:
Hossein Borhan, AAFC Saskatoon
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To identify the *Rlm3, 4, 7, 9* genes for resistance against blackleg, develop allele specific markers *B. napus* donor lines for canola breeding and understand the function of these genes.

FROM FIELD TO THE GENOME. APPLICATION OF 3RD GENERATION SEQUENCING TO DIRECT GENOTYPING OF CANOLA PATHOGENS

PRINCIPAL INVESTIGATOR:
Hossein Borhan, AAFC Saskatoon
FUNDING: Alberta Canola, SaskCanola
OBJECTIVES: To help canola growers with management of clubroot disease, researchers propose to develop a sensitive and rapid diagnostic tool to detect the presence of pathogen and determine the pathotypes present and the relative abundance.

OVERCOMING BLACKLEG DISEASE IN CANOLA THROUGH ESTABLISHMENT OF QUANTITATIVE RESISTANCE

PRINCIPAL INVESTIGATOR:
Hossein Borhan, AAFC Saskatoon
FUNDING: SaskCanola
OBJECTIVES: To clone adult plant resistance (APR) genes against blackleg disease, to characterize the host pathways triggered by these genes, and to incorporate APR genes into commercial canola cultivars by marker-assisted breeding and gene editing.

DEVELOPING TOOLS FOR THE RAPID SCREENING OF CANOLA GERMPLASM FOR QUANTITATIVE RESISTANCE TO BLACKLEG DISEASE

PRINCIPAL INVESTIGATOR:
Hossein Borhan, AAFC Saskatoon
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To optimize a protocol for identifying adult plant resistance (APR) to blackleg disease under controlled conditions and validate results in the field; to develop molecular markers associated with APR genes.

TO STANDARDIZE THE NOMENCLATURE OF BLACKLEG RESISTANCE GENES

PRINCIPAL INVESTIGATOR:
Hossein Borhan, AAFC Saskatoon
FUNDING: Alberta Canola, SaskCanola
OBJECTIVES: To help in the international effort to locate new blackleg resistance genes, researchers need a universal protocol so they're not finding the same gene multiple times but giving it different names – which is happening.

DEVELOPING TOOLS FOR THE RAPID SCREENING OF CANOLA GERMPLASM FOR QUANTITATIVE RESISTANCE TO DISEASE

PRINCIPAL INVESTIGATOR:
Hossein Borhan, AAFC Saskatoon
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To develop a protocol to screen for quantitative resistance to blackleg in canola germplasm under controlled environmental conditions in growth chambers.

WEEDING OUT SECONDARY DORMANCY POTENTIAL FROM VOLUNTEER CANOLA

PRINCIPAL INVESTIGATOR:
Sally Vail, AAFC Saskatoon
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To look for the genomic regions harbouring the genes controlling secondary dormancy in *Brassica napus;* to identify molecular markers to facilitate selection; to scan *B. napus* lines for lower secondary dormancy, perhaps identifying parent lines less likely to become volunteers.

PRE-BREEDING LINES COMBINING CANOLA QUALITY WITH SCLEROTINIA RESISTANCE, GOOD AGRONOMY AND GENOMIC DIVERSITY FROM PAK93

PRINCIPAL INVESTIGATOR:
Sally Vail, AAFC Saskatoon
FUNDING: Western Grains Research Foundation, Alberta Canola, Manitoba Canola Growers, SaskCanola
OBJECTIVES: To develop resistant pre-breeding lines that combine desirable traits in PAK93 with canola seed quality and shatter resistance from Agriculture and Agri-Food Canada's elite lines; to form a consortium of breeding companies interested in funding final selection of pre-breeding lines.

Sally Vail, research scientist with Agriculture and Agri-Food Canada in Saskatoon, is the principal investigator on three ongoing genetics projects. Topics are weeding out secondary dormancy in volunteer canola, genetic resistance to sclerotinia stem rot, and identification of yield stability drivers.
Photo credit: D&M Images for SaskCanola

ADDRESSING YIELD STABILITY DRIVERS OF CANOLA IN A CHANGING CLIMATE USING HIGH THROUGHPUT PHENOTYPING

PRINCIPAL INVESTIGATOR:
Sally Vail, AAFC Saskatoon
FUNDING: Western Grains Research Foundation, Manitoba Canola Growers, SaskCanola
OBJECTIVES: To fund field trials of the *B. napus* nested association mapping (NAM) germplasm resource in contrasting climatic environments. This will provide a sufficient datatset to test and apply phenotyping and selection techniques to improve canola yield stability.

MANIPULATING RECOMBINATION IN CROP POLYPLOIDS

PRINCIPAL INVESTIGATOR:
Isobel Parkin, AAFC Saskatoon
FUNDING: SaskCanola, Sask Wheat, National Research Council, Agriculture and Agri-Food Canada
OBJECTIVES: To identify homologues of gene candidates controlling homoeologous recombination in wheat and *Camelina sativa*, to develop constructs for gene knock-outs using CRISPR technology.

IDENTIFYING THE OPTIMAL ROOT SYSTEM ARCHITECTURE (RSA) FOR *BRASSICA* CROPS

PRINCIPAL INVESTIGATOR:
Isobel Parkin, AAFC Saskatoon
FUNDING: SaskCanola, Saskatchewan's Agriculture Development Fund
OBJECTIVES: To understand the level of natural variation of root system architecture (RSA) for *Brassica napus*, to identify the regions of the genome contributing to variation in RSA and to assess the variation for improving nitrogen-use efficiency.

IDENTIFICATION AND GENETIC MAPPING OF NOVEL GENES FOR RESISTANCE TO BLACKLEG

PRINCIPAL INVESTIGATOR: Dilantha Fernando, University of Manitoba
FUNDING: SaskCanola, Alberta Canola
OBJECTIVES: To identify and map new sources of blackleg resistance.

IMPROVING BLACKLEG RESISTANCE DURABILITY THROUGH R-GENE ROTATION IN COMMERCIAL FIELDS

PRINCIPAL INVESTIGATOR:
Dilantha Fernando, University of Manitoba
FUNDING: Canadian Agricultural Partnership
OBJECTIVES: To monitor blackleg incidence and severity in selected commercial fields with different R-gene rotations. This will develop empirical data of blackleg avirulence gene changes in the growers' fields in response to *R*-gene rotations.

USING AVIRULENCE MARKERS TO PREDICT THE PHENOTYPES OF CLUBROOT PATHOTYPES

PRINCIPAL INVESTIGATOR:
Edel Pérez-López, Université Laval
FUNDING: Alberta Canola, Manitoba Canola Growers, Western Grains Research Foundation
OBJECTIVES: To optimize a hydroponic bioassay to phenotype the interaction between canola and *P. brassicae*; to identify *P. brassicae* avirulence markers; to design and implement a multiplex PCR assay able to differentiate *P. brassicae i*solates.

BUILDING BRIDGES TO SUCCESS - ACCESSING BRASSICA DIPLOID VARIATION FOR CANOLA IMPROVEMENT

PRINCIPAL INVESTIGATOR:
Steve Robinson, AAFC Saskatoon
FUNDING: Alberta Canola, Manitoba Canola Growers, SaskCanola
OBJECTIVES: To test new technology for blackleg resistance breeding. Domesticated diploid bridging species in combination with targeted diploid germplasm will increase the efficiency to introduce and evaluate new resistance alleles into *B. napus*.

NEW CLUBROOT PATHOTYPES AND SECOND GENERATION RESISTANCE

PRINCIPAL INVESTIGATOR:
Stephen StWestern Grains Research Foundation
OBJECTIVES: To evaluate the infectivity of the most important *P. brassicae* pathotypes on a suite of canola cultivars with second-generation resistance.

Blackleg Disease Cycle

Leptosphaeria maculans

1 Spores Released

In the spring, ascospores are released from the infected stubble and infect plants through stomata and wounds.

2 Primary Infection

Cotyledons and young leaves exhibit lesions with pycnidia. *See* A *below.*

3 Secondary Infection

The pycnidia release pycnidiospores which spread disease to other leaves and plants via rain splash and wind. Secondary infection has less impact on blackleg severity.

4 Fungal Growth Towards Stem

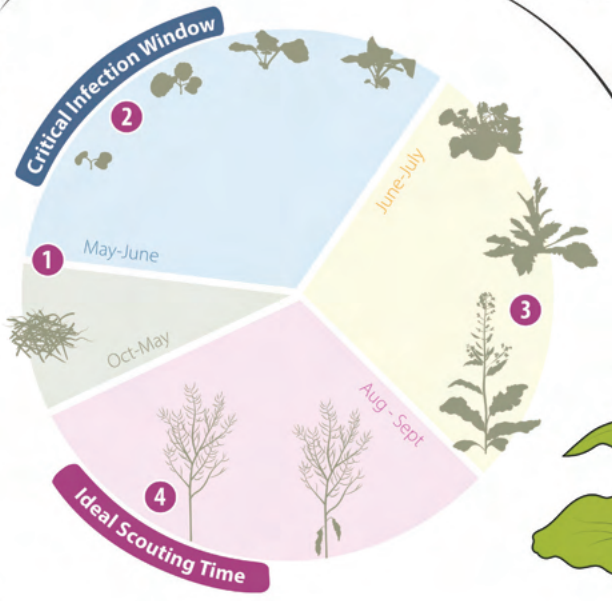
During mid-season flowering, infection from cotyledons/ lower leaves spreads internally to the stem base. *See* B *below.*

5 Stem Cankers and Plant Lodging

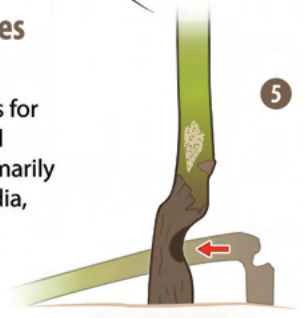
Lesions can cause root and stem cankers, which lead to lodging under severe infection. *See* C *below.*

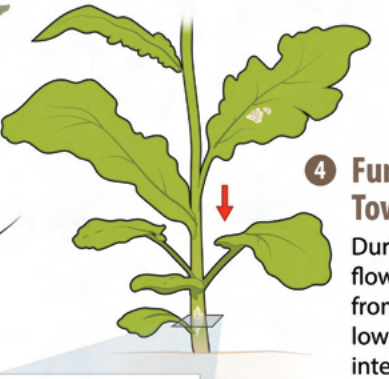
6 Blackleg Survives on Residue

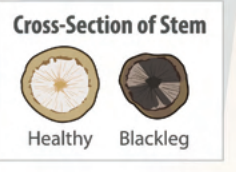
Fungus overwinters for 2⁺ years on infected canola stubble, primarily as mycelium pycnidia, and pseudothecia. *See* D *below.*



Crop rotation allows residue to decompose, reducing the inoculum available to infect the next crop. 2⁺ years





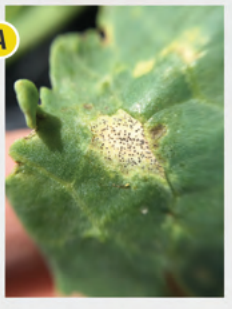


Scouting

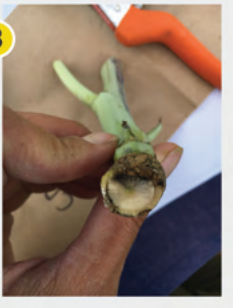
The main blackleg disease scouting periods are:

1. prior to planting
2. cotyledon to two-leaf stage
3. flowering stage
4. ripening stage to post-harvest

Symptoms of blackleg disease in canola plants:

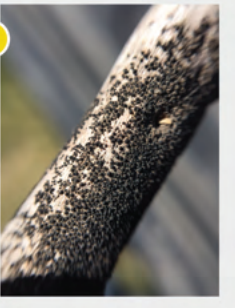


Early stages present as lesions with pycnidia (black specks) on the leaves.



The stem displays varying degrees of black, as seen in cross-section.

Late stages present with root and stem cankering (shrunken, pinched areas).



Pseudothecia and pycnidia can be seen on old canola stubble.

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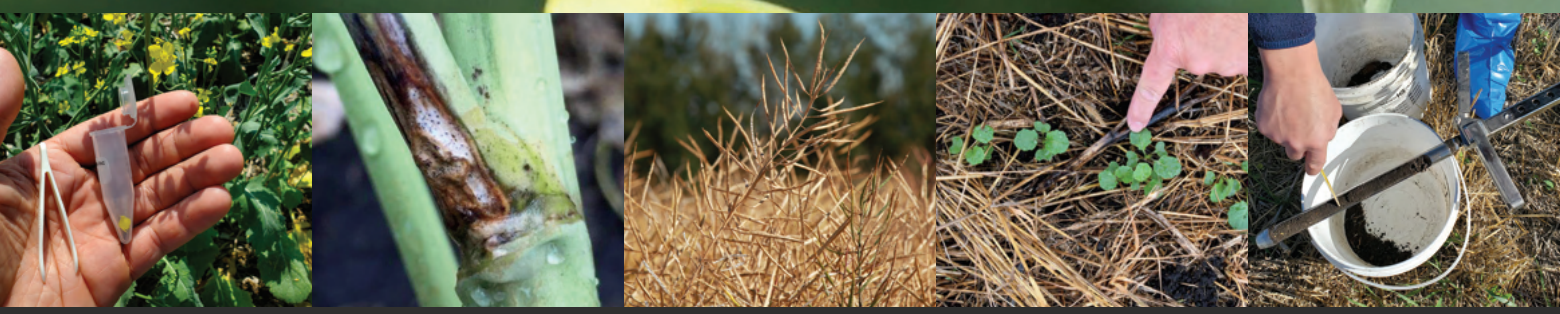

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