CANADIAN AGRICULTURAL PARTNERSHIP
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ALBERTA CANOLA
Manitoba Canola Growers
SaskCanola
Canada

Science Edition 2020

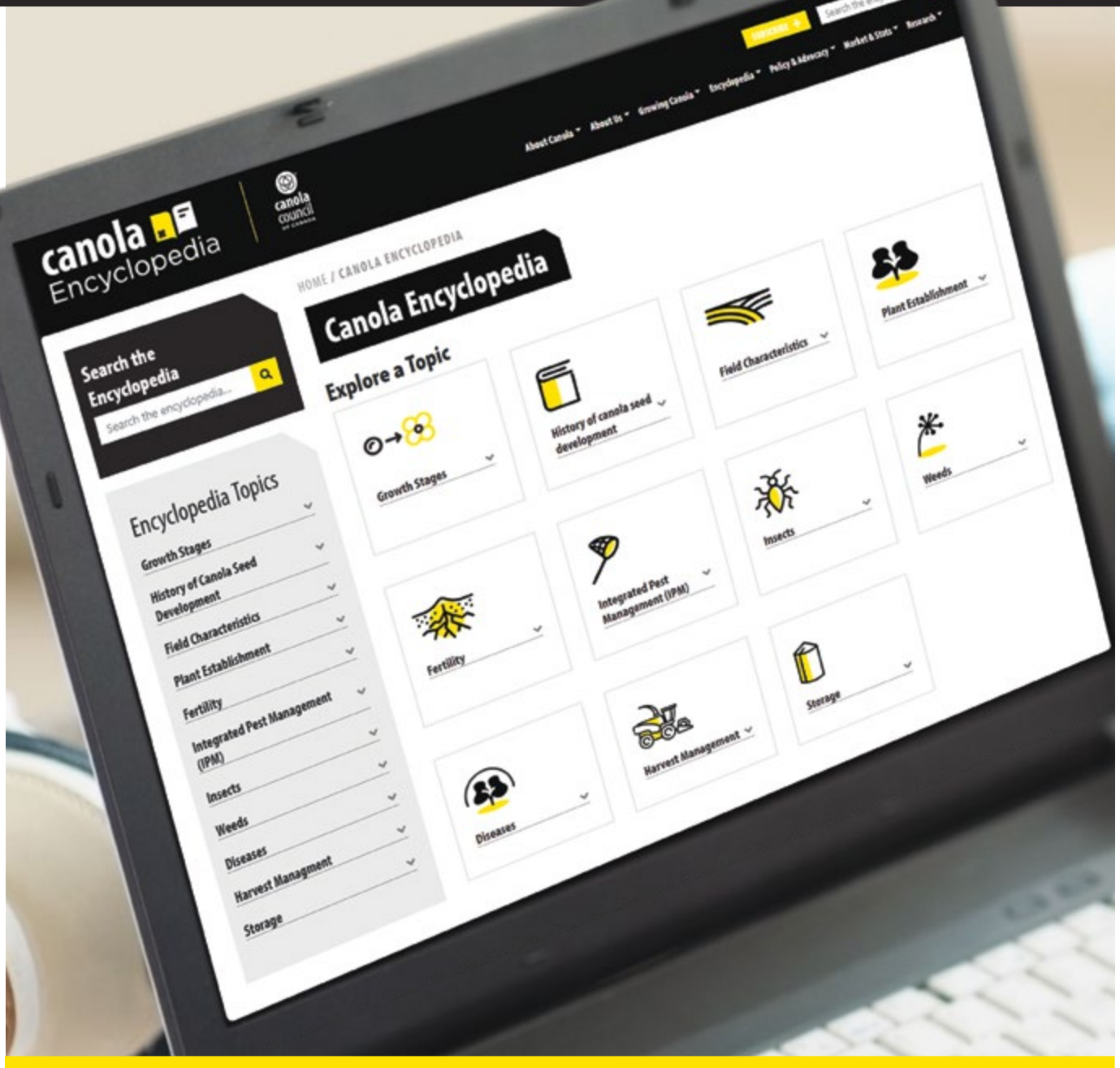
canola DIGEST

The Source For Canada's Canola Growers

SCIENCE EDITION

Verticillium stripe scouting ramped up in 2020

Look inside for updates on verticillium studies and the full range of canola research to reduce risk and improve profitability.



canolaencyclopedia.ca

is your complete guide to growing canola in Canada

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BPA WORLDWIDE

Growers helping growers

Canola growers across the Prairies fund important agronomy research through their annual levy payments to SaskCanola, Alberta Canola and Manitoba Canola Growers. The research committee chairs for each organization explain why they, as growers themselves, support this investment in support of better more profitable canola production.

KEITH FOURNIER
SaskCanola
Lone Rock, Saskatchewan
Research committee chair

Research is essential to maintain our competitive edge. We're in a world market for oilseeds and we are always competing against other countries and alternative crop substitutes. To make sure canola is the first choice for importers, we need a first rate product and we need to grow it efficiently.

By contributing to research, Saskatchewan canola growers can leverage matching provincial and federal government funds. In order to access these funds, we need to put up money and bring proposals forward. If we don't use these funds, other industries will and we will get left behind. By being part of the funding process, growers can make sure to select research projects that help answer situations we encounter in the field.

I am interested in all research that can improve the profitability of my farm. I think of all the research that has gone into each bag of seed. Clubroot, blackleg and sclerotinia resistance genes are all great tools, and they took a lot of research to develop. I look at insect maps to assess risk, and these maps are based on research. Research to bring awareness of combine losses has meant I monitor combines closer in changing conditions.

These are just a few examples. I am using research discoveries in every step of my canola production.

JOHN MAYKO
Alberta Canola
Mundare, Alberta
Research committee chair

Research is the foundation of canola. Through the pioneering work of Drs. Stefansson and Downey, canola was developed from rapeseed into a valuable crop which is the backbone of an industry that contributes over $26 billion to the Canadian economy each year.

For over 30 years, the results of grower-funded research have been instrumental to the success of canola in Western Canada and on my farm. Alberta Canola's main driver for supporting research projects is to solve the challenges that farmers face in their fields and help farmers succeed in growing canola. The importance of proper fertilizer rates in line with yield expectations, methods on managing clubroot, and using proper grain storage and conditioning methods are all results from past research that are making a difference on my farm.

However, this information is of little use if canola growers and their support team of advisors and extension agents never see the results. This is why Alberta Canola has been a strong supporter of the Canola Digest and especially this Science Edition. It is but one way of getting the research results into the hands of the people that can make use of it in the field.
I hope that you will be able to glean some valuable information to make your operation more successful.

CHUCK FOSSAY
Manitoba Canola Growers
Starbuck, Manitoba
Research committee chair

Our committee reviews dozens of proposals each year and we then narrow that down to those projects we feel will provide the greatest benefit to canola producers. When making decisions on what projects to fund, we want to get the best bang for our research buck.

Manitoba Canola Growers invests in research because we, as farmers, expect that it will provide a return many times over in terms of improved farm profitability. By putting our money into research, Manitoba Canola Growers also gets Manitoba-based research results that can validate findings for projects done in other provinces or other countries. That way, we can make sure that research-based recommendations work in our Manitoba growing conditions.

I use research results on my farm all of the time. For example, Manitoba Canola Growers funded research on nitrogen inhibitors – which helped to show the situations where these products can work to reduce losses and improve nitrogen use efficiency. I use research on safe rates for seed-placed fertilizer whenever I make my phosphate and nitrogen plans for canola. When it comes to seeding rates, I use the research on ideal plant populations for canola and the importance of seed size to calibrate the seeder so I can hit my targets.

All Manitoba Canola Growers benefit from farmer-selected and farmer-funded research. I hope you find a few ways to capture a good return from this research while reading through the Canola Digest Science Edition.

PROVINCIAL RESEARCH BULLETINS

4 | SaskCanola

SaskCanola funds research that attempts to solve issues that benefit growers directly, such as yield improvement, sustainable farming practices or greater farm profitability. The commission shares how it gathers research proposals and decides which ones to fund. It encourages growers to communicate on-farm challenges that a research project could investigate.

6 | ALBERTA CANOLA

The provincial government has created an arm's-length research funder called Research Driven Agriculture Research (RDAR). Alberta Canola is on the board, helping to determine the priorities that will guide RDAR's research funding decisions. Alberta Canola also lists new research projects it funded over the past year.

8 | Manitoba Canola Growers

Manitoba Canola Growers has a farmer-directed committee the reviews and funds projects that look for better ways to grow canola, control pests and protect productivity. Grower-funded and directed research often fills gaps not met through private research. Each dollar of grower research investment in 2019-20 leveraged another $8 in funding.

TOP PRACTICES AND THE RESEARCH BEHIND THEM

10 | canola Encyclopedia

Photo: iStock.com/Thatphichai Yodsri

Canola Encyclopedia (**canolaencyclopedia.ca**) has a fresh new look, but the canola best management practices (BMPs) described throughout are – as always – based on research. This article provides a quick glance at the science behind these fundamental canola agronomy practices:

- Target five to eight plants per square foot to balance seed yield potential and cost
- Tailor 4R nutrient plans specifically to each field
- Time herbicide applications to control early, most costly weeds
- Follow insecticide economic thresholds for ROI and biodiversity
- Seed canola once every three (or more) years to reduce clubroot risk
- Rotate major resistance genes to stop blackleg
- Apply sclerotinia fungicides at early flowering
- Swath canola at 60 per cent seed colour change
- Keep canola dry and cool for safe storage

REPORTS FOR RECENTLY COMPLETED RESEARCH

STAND ESTABLISHMENT

12 Good canola establishment with narrow-row planter

KEY RESULT: For this study conducted in southern Alberta on irrigated and dryland plots, the precision planter with 12-inch spacing increased seedling emergence and plant stand density compared to the conventional air drill and precision planter with 20-inch spacing — as long as seeding rates were higher than 20 seeds per square metre.

FERTILIZER MANAGEMENT

13 Flexibility but no added yield for fertigation

KEY RESULT: This study compared nitrogen application through side-banding at seeding and through a split application of side-banding at seeding plus in-season through an irrigation system. It found no yield advantage to the split, but the flexibility of fertigation (for those with irrigation systems) allows farmers to adjust rates based on conditions through the season.

INTEGRATED PEST MANAGEMENT

14 Quest continues for Prairie-wide clubroot map

KEY RESULT: Current clubroot maps produced in each province vary widely in what they show and how they show it. A harmonized clubroot map for the Prairies could reduce confusion and allow for meaningful comparisons between regions. This project resulted in a map for Alberta and Saskatchewan.

16 Canola flower midge found across the Prairies

KEY RESULT: The newly discovered canola flower midge, *C. brassicola*, may be a species native to the Prairies. It is found across the canola-growing region, but population density, for the most part, is low and the midge has not had a significant impact on yield. This midge causes flower galls that result in aborted pods.

17 Pheromone found for trapping canola flower midge

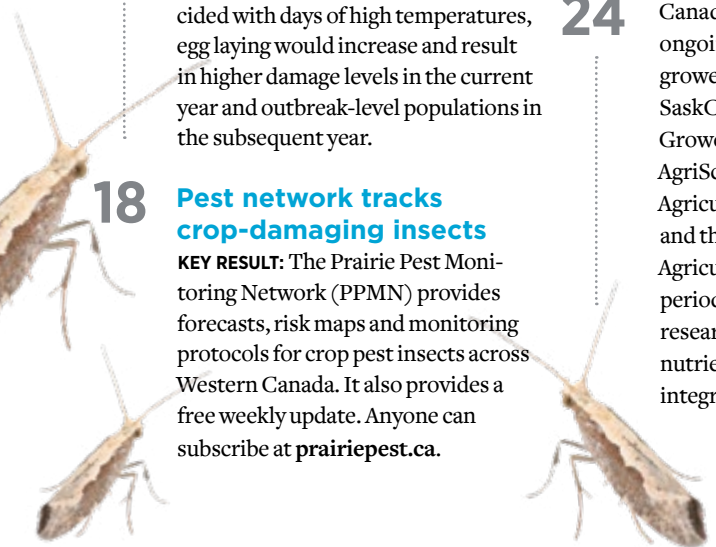
KEY RESULT: Researchers identified a sex pheromone used by female canola flower midge. The sex pheromone can be produced synthetically and is highly attractive to males in the field. This identification will facilitate development of a pheromone-based monitoring system for *C. brassicola*.

17 Hot weather can increase swede midge damage

KEY RESULT: Swede midge, an invasive species, causes costly damage to canola in Ontario – but not on the Prairies at this time. Modeling found that when a high number of adults coincided with days of high temperatures, egg laying would increase and result in higher damage levels in the current year and outbreak-level populations in the subsequent year.

18 Pest network tracks crop-damaging insects

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. Anyone can subscribe at **prairiepest.ca**.



HARVEST MANAGEMENT

19 Study compares plant and seed dry down for pre-harvest options

KEY RESULT: This three-year study frequently showed benefits to using pre-harvest herbicide and desiccant options as tools to improve straight combining results. However, results show that going without a pre-harvest herbicide or desiccant is a potentially viable option, especially for early seeded, reasonably uniform and weed-free fields where a hybrid with good pod shatter tolerance is being grown.

20 Weather is a big factor in combine losses

KEY RESULT: A combine yield loss survey of 50 combines across the Prairies in 2019 found that weather factors had significant influence on losses. This emphasizes the need to regularly adjust and test throughout the day and harvest season. Temperatures greater than 23°C, relative humidity less than 45 per cent, and low cloud cover all contributed to lower losses during this survey.

21 Airflow key to in-bin drying

KEY RESULT: Supplemental heat added to natural air drying systems can improve drying capacity for canola as long as airflow is a minimum of one cubic foot per minute per bushel (cfm/bu.). Air must be heated to at least 5°C but not more than 30°C for in-bin drying.

GENETICS

22 Toward a boost in canola's waxy defensive layer

KEY RESULT: This study identified the chemical composition of surface wax in *B. napus* and various other Brassica species. It also identified genes responsible for wax production. It advances the possibility of eventually selecting for canola lines better able to produce more or different wax in response to drought and pest threats.

23 Tool helps breeders select for complex multi-gene traits

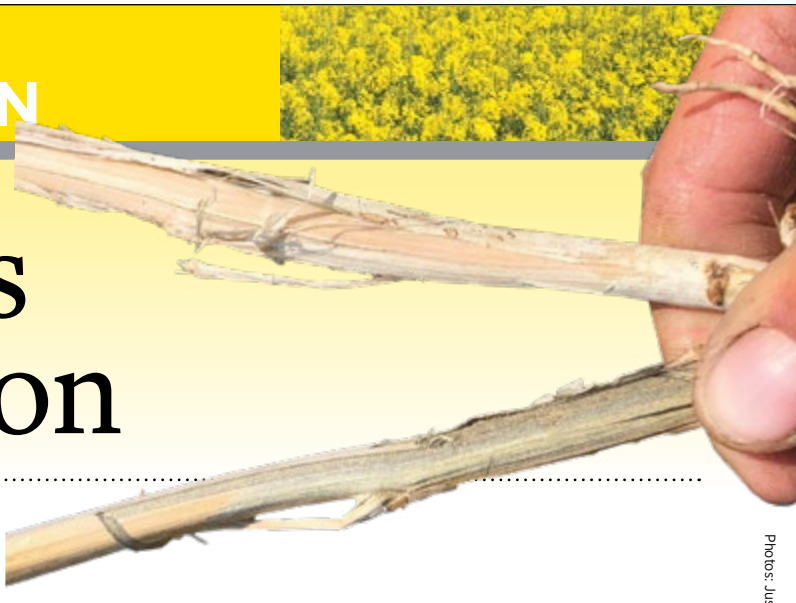
KEY RESULT: Researchers have put together a nested association mapping (NAM) population for spring *Brassica napus* canola. With this tool, breeders can select for complex traits and identify cultivars that perform better under specific growing conditions – such as long day-lengths in northern growing regions, for example.

SHORT UPDATES FOR ONGOING RESEARCH

24

Canadian canola researchers have dozens of ongoing projects. Some are funded by canola growers through their levy payments to SaskCanola, Alberta Canola and Manitoba Canola Growers. Some are funded through the Canola AgriScience Cluster, a partnership between Agriculture and Agri-Food Canada (AAFC) and the canola industry under the Canadian Agricultural Partnership (CAP). Over a five-year period, this initiative will invest $25.5 million in research to optimize yield and quality, improve nutrient and water use efficiency, and enhance integrated pest management practices.

SaskCanola's research vision



Photos: Justine Cornelsen

Why is research critical to Canadian growers? Think of how far canola has come since 1991 when SaskCanola was formed and all the innovations that you have adopted on your farm. This includes major resistance genes to diseases that had the potential to wipe out canola production, herbicide tolerance traits, fertilizer recommendations, crop rotations, agronomic best management practices, and a near doubling of average yields – to name just a few. Where would we be without all the research investments over the last 30 years and the decades of oilseed innovation before that?

Research was essential to create the first double low varieties with low glucosinolates and low erucic acid – the very definition of "canola".

Every organization in the canola value chain has a role to play in funding the various canola development stages, and each stage from basic and applied research, to incorporation of new traits into commercial variety development, to expansion into new use markets, all have costs and associated risks. Where the major benefits and risks lie for each stage is where the primary research funds should be coming from. For example, where research is attempting to solve issues that benefit growers directly, such as yield improvement, sustainable farming practices, or greater farm profitability, growers should primarily fund these types of projects. Whereas, when research is required for the benefit of companies that will develop and market new products made from canola, the benefits will mostly be seen by those companies, with a smaller direct benefit for growers due to expanded markets for their commodities. In those cases, a greater investment from private industry should be expected. Additionally, society in general benefits from increased economic activity and food security, so it is reasonable that governments also invest in research for our future prosperity.

SaskCanola works hard to ensure that levy dollars are invested in only the best potential research. It also leverages funds by partnering with other commodity groups, research institutions, and funding agencies at local, provincial, federal and international levels. This ensures that research projects have the greatest expertise and cooperation while reducing investment risk to each organization.

For more information about SaskCanola's research investments, visit **saskcanola.com**

VALUABLE OUTCOMES

Valuable research outcomes for growers include topics such as: independent evaluation of varieties in canola performance trials, independent evaluation of fertilizer products to support optimal rate recommendations, identification of disease resistance traits and cooperation with canola breeders to bring these traits to new varieties, best practices for seeding depth and seeding density for better and uniform emergence leading to higher yields, continual improvement of disease resistance genetics for major diseases of canola as well as stewardship recommendations to make these genetics more durable, proper storage and monitoring of canola in the bin and grain bags, and integrated pest management with threshold recommendations.

Verticillium stripe can have stem shredding that looks a bit like sclerotinia stem rot and stem cross-section discolouration that might make a person think blackleg. Research projects are looking into yield effects and management options for verticillium stripe.

Research is critical to combat challenges from newly emerging and rapidly evolving diseases in Canada such as clubroot and verticillium stripe, as well as staying ahead of perpetual problems like blackleg and sclerotinia.

SaskCanola's research funding process

In order to be funded by SaskCanola, research proposals must show short- and/or long-term value to canola growers either through research outcomes with direct relevance to improve their production profitability or sustainability, or creation of research tools and resources that will enable these goals.

SASKCANOLA HAS THREE MAIN STREAMS TO INTAKE ANNUAL RESEARCH PROPOSALS:

- Saskatchewan Ministry of Agriculture - Agriculture Development Fund (ADF)
- Canola Council of Canada – Canola Agronomy Research Program (CARP)
- SaskCanola – internal funding calls, including:
  - Morris Sebulsky Endowment Fund
  - Other high priority opportunities

SaskCanola is always looking for ways to extend research spending by leveraging the funding of projects with other co-funders. In addition to the above, these include:

NATIONAL

- Canadian Agricultural Partnership (Canola AgriScience Cluster)
  - This funding opportunity has run in five-year cycles (previously Growing Forward and Growing Forward 2), and we are now in the middle of the third cycle.
  - Significant funding contributions are made annually to important canola research in this program, which is funded by Agriculture and Agri-Food Canada, the canola industry and the provincial canola organizations and administered by the Canola Council of Canada.
- National Sciences and Engineering Research Council of Canada (NSERC)
- Mitacs
- Genome Canada/Genome Prairie

PROVINCIAL

- SaskCanola often co-funds research with provincial commodity organizations, including Western Grains Research Foundation, Alberta Canola, Manitoba Canola Growers, Sask Wheat, Sask Pulse Growers, SaskFlax and others.

Funding competitions generally make a call for Letters of Intent (LOI) from researchers. In these letters, researchers give an overview of the research they are requesting funds for. At this point, the SaskCanola research manager reviews the set of LOIs from each competition with an eye for relevance to growers. Some research may be very interesting to do but will have no benefit to growers in the near to mid-term, so they would be better funded by other sources. The best LOIs, including those with potential for other co-funders to contribute to, are selected to go to the full proposal stage. This is the chance for the researcher to provide more in-depth context of the problem that they are going to solve, the budget that is required, and develop key measurable milestones so that SaskCanola can ensure that good progress is being made each year from the investment into the research.

Once the set of full proposals comes in from a research competition, SaskCanola also requests external experts to critically evaluate each one based on their area of expertise. This provides a thorough review to help ensure that we are not funding duplicative research projects that are on-going or completed elsewhere in Canada.

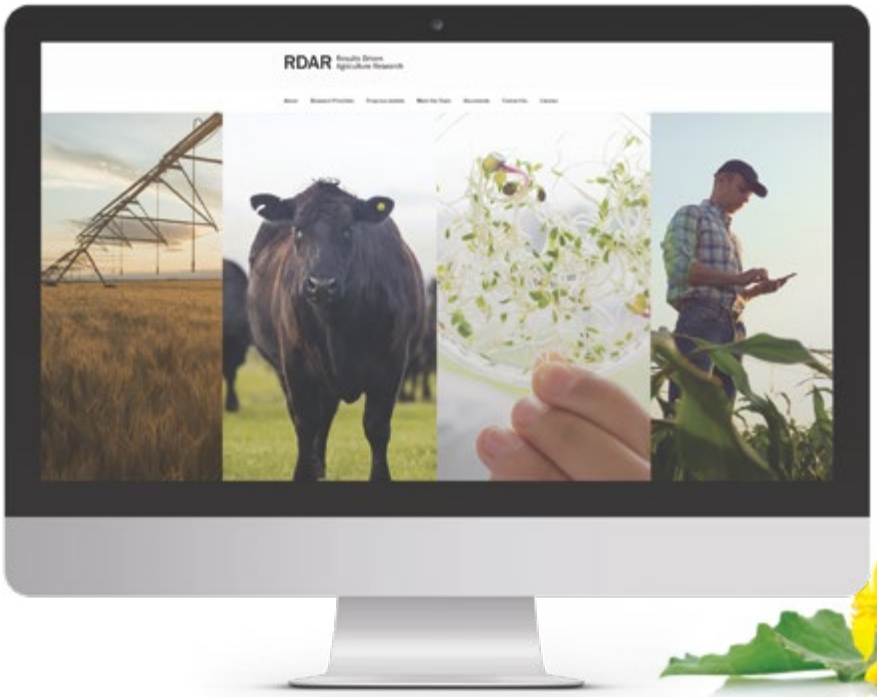
The SaskCanola Research Committee, made up of four directors and the research staff, then meets with the external advisors to engage in thorough discussion of the merits and any potential issues of each full proposal.

Discussions include the expertise of the research team that will perform the work, the amount of requested budget, past experience with previous projects funded for the same research group and relevance of the research to growers.

The majority of projects funded fall under one of three main categories: agronomy, trait development and utilization. This is mirrored by the SaskCanola research priorities listed on our website at **saskcanola.com**.

Have a Research Project Idea?

If you are facing a challenge on your farm that a research project could investigate and help resolve, SaskCanola wants to hear from you! Contact our research manager, Doug Heath, by calling **306-975-0730** or email **dheath@saskcanola.com**



For up to date information on Results Driven Agriculture Research, please visit RDAR's website at **rdar.ca**.

Update on agriculture research in Alberta

On March 30, Alberta's Minister of Agriculture and Forestry, Honourable Devin Dreeshen, announced a new vision for provincial agriculture that will see Alberta farmers and ranchers determine the priorities that will guide research funding and program decisions. The Minister announced that an arm's length organization, Results Driven Agriculture Research (RDAR), will be established to bring together the diverse groups involved in ag research.

RDAR identified 33 farmer-governed organizations that will make up its Class A voting membership. It also identified Class B non-voting members representing research institutions, universities and colleges.

The RDAR board of directors will consist of a minimum of nine and a maximum of 11 members, with up to seven directors elected from candidates nominated by the Class A members and up to four directors elected from candidates nominated by the board. This will ensure a broad cross-section of skills, regional representation and competencies to effectively govern RDAR. There will be four standing committees: governance, research, communications and engagement, and finance and audit.

With a small board representing the vast livestock and cropping industries that make up Alberta agriculture, RDAR has established an advisory committee that will be an important part of RDAR's governance framework. The advisory committee will keep the RDAR board aware of industry trends and developments and will connect the RDAR board and staff with the farmer and rancher community to ensure alignment of research priorities.

The advisory committee will recommend research priorities to the board, advise the board on key emerging industry issues, provide advice to RDAR on policy, procedures and performance and review RDAR performance metrics annually and the value of its research investments.

To ensure that the advisory committee represents all aspects of agriculture in Alberta, members will be drawn from over 40 organizations and can be comprised of up to 50 representatives.

Alberta Canola has been actively involved in the RDAR establishment process and Alberta Canola research committee chair John Mayko is on the RDAR advisory committee.

Alberta Canola research committee chair John Mayko is on the RDAR advisory committee

ALBERTA CANOLA'S NEW RESEARCH PROJECTS FOR 2019-20

	ALBERTA CANOLA FUNDING	TOTAL PROJECT
Establishing the importance of canola-derived long chain n-3 polyunsaturated fatty acids on immune development. **Dr. Catherine Field, University of Alberta**	$401,000	$695,250
Identifying key predators and their role in canola insect pest suppression. **Dr. Boyd Mori, University of Alberta**	$104,098	$312,296
Suitability and efficacy of chaff lining for weed control in Western Canada. **Dr. Breanne Tidemann, Agriculture and Agri Food Canada**	$268,000	$268,000
Biological control of lygus plant bugs in established and emerging crops. **Dr. Hector Carcamo, Agriculture and Agri Food Canada**	$22,000	$141,025
Monitoring the canola flower midge with pheromone-baited traps. **Dr. Boyd Mori, University of Alberta**	$21,446	$128,678
Pre-breeding lines combining canola quality with sclerotinia resistance, good agronomy and genomic diversity from PAK93. **Dr. Sally Vail, Agriculture and Agri Food Canada**	$46,666	$280,000
Evaluating the effect of canola seeding rate and seed size seeded into wheat stubble in flea beetle damage and population. **Dr. Maria Angelica Ouellette, North Peace Applied Research Association**	$208,050	$208,050
Improving heat and drought resistance in canola (*Brassica napus*) through regulating diacylglycerol acyltransferase activity. **Dr. Gavin Chen, University of Alberta**	$120,000	$416,750
Clubroot pathotype surveillance and research. **Dr. Stephen Strelkov, University of Alberta**	$20,000	$615,904

FUNDING IN CORE AREAS SINCE 2012	ALBERTA CANOLA FUNDING	TOTAL PROJECT COST	MATCHING FUNDS
Agronomy	**$1,599,589**	**$4,999,859**	**$3.13**
Genetics	**$582,933**	**$2,059,863**	**$3.53**
Insects	**$1,221,390**	**$4,249,689**	**$3.48**
New Product/New Uses	**$1,287,081**	**$2,085,157**	**$1.62**
Disease	**$2,005,563**	**$9,184,404**	**$4.58**
Canadian AgriScience Canola Cluster 25 projects over 5 years	**$1,030,142**	**$25,513,838**	**$24.77**
Total	**$7,726,698**	**$48,092,810**	**$6.22**

How Manitoba canola farmers get value from farmer-funded research

With research being a key priority for Manitoba Canola Growers Association (MCGA), have you ever wondered how your commodity organization sets and funds research priorities? Or who is involved in those decisions? The MCGA research committee is a farmer-directed committee responsible for selecting projects and directing research funds to find better ways to grow canola, control pests and protect the ongoing productivity of Manitoba's number one crop.

Recent research has helped farmers recognize situations that lead to higher losses, and to see the value in checking for combine losses.

The research committee takes an active and holistic approach to setting its research priorities, reviewing the research priorities of other Canadian canola organizations annually and considering them alongside the needs of Manitoba canola farmers. Research priorities include:

- practical projects on all aspects of agronomy and crop production;
- market development projects to improve and expand the market uses for canola;
- variety assessment work to help farmers make the best variety decisions and;
- additional research to support all aspects of canola and canola production.

The research committee reviews and approves all research projects, often working in collaboration with multiple partners to select and jointly fund projects that benefit canola farmers in Manitoba and across Canada. The committee consults topic experts to confirm that project methodology is sound, that they are relevant, a valuable investment, and that they meet the greatest priorities of Manitoba canola farmers.

HOW DOES MCGA DECIDE HOW TO DISTRIBUTE RESEARCH INVESTMENTS?

MCGA works through several funding streams to fund research projects. These include:

1. Canola AgriScience Cluster funding is negotiated among the Canola Council of Canada, SaskCanola, Alberta Canola and MCGA. The research committee submits a 'wish list' of projects, which gets adjusted based on the initiatives Agriculture and Agri-Food Canada agrees to support. Funding is often based proportionately on the volume of canola sold in each province, so smaller organizations like MCGA pay a smaller share.

2. Canola Agronomic Research Program funding is also negotiated among the provincial canola groups. Funding shares may vary based on the interest level and budget for each organization. Some projects are split evenly among all three groups while others might be a partnership. MCGA funds as many projects as possible within its limited budget and rarely funds projects on their own.

There are additional funding options and partners MCGA collaborates with to ensure significant projects are selected. "MCGA seeks to stretch member dollars as far as possible with funding partners," says Delaney Ross Burtnack, executive director of MCGA. "In recent years, MCGA has typically leveraged its research funding dollars 8:1, so for every dollar invested, it is matched by an average of $8 of partner funding. This maximizes the number of research projects supporting canola farmers in the province."

As one of the smaller canola organizations in the Prairies, MCGA focuses each aspect of its programming on stretching every dollar. In research this means seeking funding partners wherever possible and ensuring research projects achieve multiple objectives within the same budget.

L to R: Nicolea Dow, Chuck Fossay and Clayton Harder are the directors on MCGA's research committee. The committee is welcome to input that will help them understand the challenges that may benefit from further research. If you have research ideas for them, please email ***info@canolagrowers.com****.*

"In recent years, research funding has been leveraged 8:1 and has been leveraged as much as 12:1, making sure every dollar invested by MCGA farmers is matched by as many partner dollars as possible."

–Delaney Ross Burtnack.

WHY SHOULD FARMERS FUND RESEARCH?

Farmer-funded research fills an important gap in the research field ensuring the interests of farmers are not only voiced, but met by investing in the most relevant projects. This research often fills gaps not met through private research and ensures the outcomes are brought back to farmers as they are a key stakeholder. The research results in solutions that can be applied on farms such as:

- Comparing canola seeded using a planter and an air seeder to help farmers understand whether other seeding methods can save costs while getting the same yield, without having to invest in a planter and testing for themselves.

- Without proper calibration for harvest conditions harvest loss research has shown losses up to four bu./ac. out of the back of the combine. Proper calibration and confirming the settings using harvest loss measurement tools like drop pans and the combine optimization tool could save up to 10 per cent of yield, leaving more dollars in farmers' pockets.

The dollars MCGA invests are done on behalf of members. The decisions are farmer directed with very careful consideration of members' needs, priorities and dollars. The research committee is always open to gaining a better understanding of the challenges facing canola farmers across Manitoba that may benefit from further research.

Canola farmers in Manitoba are encouraged to share their areas of concern and interest with any of the MCGA directors. "This communication is important so MCGA can investigate funding research proposals that are of greatest value to members, and it helps direct researchers on the priorities of greatest interest to farmers," adds Ross Burtnack.

One of the many ways our farmer directors bring value to the canola industry and the province is by sitting on the research committee and supporting investment decisions on behalf of MCGA's membership. If you are a farmer interested in becoming more involved in canola research decisions in Manitoba, contact MCGA and help build a stronger future for your farm and for future generations of canola farmers. Find our contact information at **canolagrowers.com**.

Top practices and the research behind them

The Canola Encyclopedia at **canolaencyclopedia.ca** has a fresh new look, but the canola best management practices (BMPs) described throughout are – as always – based on research. This article provides a quick glance at the science behind some of the fundamental canola agronomy practices.

BY NATE ORT AND THE CCC AGRONOMY SPECIALISTS

A successful canola crop starts with choosing a cultivar suited to the conditions specific to each field. With that basis, the following agronomy practices can improve the chance of delivering a profitable high-quality crop to the end user. The article references influential studies and provides links to the Canola Encyclopedia sections for more agronomy details and full research citations.

TARGET 5 TO 8 PLANTS PER SQUARE FOOT TO BALANCE SEED YIELD POTENTIAL AND COST

Steve Shirtliffe (2009) reported that a canola plant stand of three to four plants per square foot is required to maintain full seed yield potential. Other studies have reported that reducing targeted plant populations is possible without compromising seed yield, however, uniform spatial arrangement or seed distribution per unit area must be maintained (Angadi et al. 2003). Currently, Shirtliffe (University of Saskatchewan) leads a project on spatial arrangement and its effect on canola yield. For more on target stands, read the plant populations chapter at **canolaencyclopedia.ca/plant-establishment**.

TAILOR 4R NUTRIENT PLANS SPECIFICALLY TO EACH FIELD

Nutrient concentrations are inconsistent from field to field and from one year to the next. Regular soil testing of each field is crucial to developing appropriate fertilizer plans based on yield targets for each field. 4R principles are based on applying the Right Source at the Right Rate, Right Time, Right Place. Not only is it economically wasteful to over-fertilize a crop, as environmental stewards of the land it is our responsibility to minimize harmful effects excess nutrient applications pose, including nutrient runoff into water systems (Sims et al. 2000). Bao-Luo Ma (Agriculture and Agri-Food Canada, Ottawa) is currently leading a study looking at improving nitrogen use efficiency in canola, which will improve the decision making process when it comes to the right rate in canola. For more on fertilizer management, explore **canolaencyclopedia.ca/fertility**.

TIME HERBICIDE APPLICATIONS TO CONTROL EARLY, MOST COSTLY WEEDS

Weed species are, in general, easier to control when they are younger. While application timing for best weed control can be a challenge logistically, Clayton et al., (2002), Harker et al., (2004), and Grey et al., (2006) have all reported more effective weed control when herbicides were applied earlier than later. In addition to superior weed control, Harker et al., (2008) found that canola yield declined linearly as herbicide application was delayed beyond the one- to two-leaf stage, therefore early herbicide applications will protect crop yield. For more on weed management, read **canolaencyclopedia.ca/weeds**.

FOLLOW INSECTICIDE ECONOMIC THRESHOLDS FOR ROI AND BIODIVERSITY

To achieve a return on investment (ROI) for insecticide applications, only apply once pests present in the crop have exceeded their respective economic thresholds. Thresholds-based decisions protect the crop while decreasing input expenses and reducing the risk of killing beneficial insects and the vast number of insects that are of no concern. For an example of new research, Hector Carcamo (2019) found a reliable estimate of cabbage seedpod weevil could be determined with four sets of 10 sweeps taken at paired locations. If weevil counts exceed the current economic threshold of 25-40 per 10 sweeps, then growers might consider a spray. For scouting tips and thresholds for all insects, including bertha armyworm and flea beetles, read their respective chapters at **canolaencyclopedia.ca/insects**.

SEED CANOLA ONCE EVERY THREE (OR MORE) YEARS TO REDUCE CLUBROOT RISK

Clubroot is a major disease and yield robber of canola. A minimum two-year break between canola crops (and other hosts) will help reduce clubroot spore levels in soil, with over 90 per cent of the spores not being viable after a two-year break (Peng et al., 2014). Furthermore, Ernst et al. (2019) recommended that growing clubroot-resistant cultivars should not be solely relied upon to

The Canola Encyclopedia began as the Canola Grower's Manual – a paper document created by Phil Thomas. It went online eight years ago, and has just gone through another major update and refresh. The Canola Encyclopedia recognizes the legacy of Phil Thomas and the combination of scientists, agronomic and extension specialists and organizations that conducted all the valuable research over many years in many locations and under a range of conditions.

Photo: Clint Jurke

reduce clubroot soil spore loads and that expanding crop rotations beyond susceptible hosts is the most effective approach. Current research is investigating management strategy interactions and effectiveness. This includes resistant cultivars, lime application and control of clubroot susceptible weeds by Brittany Hennig (University of Alberta). For more on clubroot identification, prevention and management, go to **canolaencyclopedia.ca/clubroot**.

ROTATE MAJOR RESISTANCE GENES TO STOP BLACKLEG

Using the same blackleg resistance genetics every year in the same field will lead to a breakdown in the cultivar's resistance to the disease. In some cases, this breakdown has been reported in as little as two years (Kutcher et al. 2010). Marcroft et al., (2012) found reduced blackleg incidence when cultivars with different blackleg resistance genes were grown consecutively. For this reason, it is important to know the races of blackleg in your fields, and to rotate between effective major resistance genes. Gary Peng (Agriculture and Agri-Food Canada, Saskatoon) leads a research project on monitoring blackleg race dynamics across Western Canada, while Dilantha Fernando (University of Manitoba) is identifying ways to steward blackleg major resistance gene cultivars. For the latest of blackleg testing and management, read **canolaencyclopedia.ca/blackleg**.

APPLY SCLEROTINIA FUNGICIDES AT EARLY FLOWERING

Timing is the most important component of a fungicide application. While the window for control of sclerotinia is between 20 and 50 per cent flowering, spraying at the earlier flowering stage can increase your ROI. Canola petals begin to drop at around 30 per cent flowering, land on lower parts of the plant and serve as a nutrient source for fungal spores to germinate and infect surrounding plant tissue (Bardin and Huang 2001). A fungicide applied just before this time is most effective because the initial dropped petals will be protected, providing sclerotinia control from the beginning of the infection period. Kelly Turkington (Agriculture and Agri-Food Canada, Lacombe) is looking to improve the management of sclerotinia by using fungicides and effective risk assessment tools. For more, read **canolaencyclopedia.ca/sclerotinia**.

SWATH CANOLA AT 60 PER CENT SEED COLOUR CHANGE

Vera et al., (2007) reported increased seed yield with later swath timing. In field scale trials, Brown et al., (2013) reported the highest yield loss when canola was swathed at 10-20 per cent seed colour change, and the lowest yield loss when swathing at 60-80 per cent seed colour change. As always, pod colour change is an inaccurate method in determining swath timing and pods should be split open to examine seed colour change. Straight cutting canola, which achieves the yield advantage of later swathing, is becoming more popular. Chris Holzapfel (Indian Head Agricultural Research Foundation) is exploring preharvest herbicide and desiccation options for this practice. See a summary of the Holzapfel project on page 19. For more on harvest timing, read **canolaencyclopedia.ca/harvest**.

KEEP CANOLA DRY AND COOL FOR SAFE STORAGE

Protect your investment. Canola should be eight to nine per cent moisture concentration for safe storage for up to a year in temperate climates (Jayas 2012). Furthermore, it is critical that canola is cooled to less than 15° for safe storage, especially if moisture concentrations exceed eight to nine per cent. The combination of eight to nine per cent moisture and grain temperature of less than 15° is ideal for safe long-term storage...but check regularly just to make sure. For more on storage risks and conditioning tips, see **canolaencyclopedia.ca/storage**.

While these practices are based on the best research we have at this time, further research is in progress on many of these topics. After having a look around the new Canola Encyclopedia, check the research tab at **canolacouncil.org** to see what new projects are underway through the Canola Agronomic Research Program (CARP) and Canadian AgriScience Cluster.

*—Nate Ort, Canola Council of Canada agronomy specialist, took the lead on this report. To contact Nate and the other CCC agronomy specialists, look for the staff list at **canolacouncil.org**.*

Good canola establishment with narrow-row planter

KEY RESULT:

For this study conducted in southern Alberta on irrigated and dryland plots, the precision planter with 12″ spacing increased seedling emergence and plant stand density compared to the conventional air drill and precision planter with 20″ spacing — as long as seeding rates were higher than 20 seeds/m².

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Developing Canola Agronomy with Precision Planters," Lewis Baarda and Ken Coles, Farming Smarter

FUNDING:
Alberta Canola and Manitoba Canola Growers

Precision planters are being used to seed canola in order to improve seedling emergence, stand establishment and yield. To determine the efficiency of precision planters for canola seeding, Farming Smarter conducted field experiments at three locations across southern Alberta from 2016 to 2019. The study compared the performance of precision planters (12″ and 20″ seeding row width) and conventional air drill seeder at five different seeding rates (20, 40, 60, 80 and 160 seed/m²) for their effect on the emergence, growth and yield of canola.

Aerial photograph showing canola emergence and plant density for the air drill, and precision planters (12″ and 20″) for different seeding rates

Canola growth, yield and seed quality were estimated using various parameters including crop emergence, plant density, canopy closure (determined using normalized difference vegetation index and fractional green canopy cover measurements), plant vigour ratings, seed yield, kernel weight, oil concentration and dockage.

When seeding rates were higher than 20 seeds per square metre, the precision planter with 12″ spacing increased seedling emergence and plant stand density compared to the conventional air drill and precision planter with 20″ spacing. Seedling emergence was also observed to be more uniform for the precision planters compared to the air drill across both irrigated and rainfed locations.

Additionally, the green canopy covering and plant vigour improved with the precision planter (12″) compared to the air drill – especially at higher seeding rates (i.e. 80 and 160 seeds/m²). At seeding rates less than 60 seeds/m², crop vigour and canopy covering for air drill were comparable to or higher than the precision planter (12″).

The precision planter with 20″ spacing led to poor crop emergence and canopy covering for all seeding rates compared to both the seeders. The wider 20" rows on the precision planter delay canopy closure. Additionally, more seeds need to be placed in each row, thus leading to higher competition between the plants for resources such as water, sunlight, and nutrients. Consequently, 20″ planters led to a significant decrease in yield across all seeding rates. On average, canola yield with 20″ planter decreased by 20 to 28 per cent compared to the conventional air drill. Thus, the adoption of wide row (20″) precision planters for the seeding of canola is not recommended.

Narrow (12″) planters, on the other hand, led to two to 10 per cent increase in canola yield compared to air drill. At the irrigated plot, the increase in canola yield with precision planter (12″) was even higher. Similarly, the 12″ precision planter led to higher canola yield in years with higher annual precipitation (2016 and 2017), while the air drill led to a relatively higher or comparable yield to the precision planter (12″) in years 2018 and 2019, which had low annual precipitation.

The investigators conclude that under favourable conditions for crop growth, spatially uniform crop stands established by precise placement of seeds allow for more efficient utilization of resources by individual plants, and less inter-plant competition, thus leading to better crop growth and yield.

PHOSPHORUS TRIAL

This study also tested the application of liquid phosphorus (P) within seed rows at different rates. Liquid P application at 60 kg/ha showed some degree of seedling mortality in case of the precision planters (12″ and 20″), thus leading to lower plant emergence and canopy covering. However, no such observation of seedling mortality or decrease in plant emergence was made for the lower P application rates between 0 to 40 kg/ha for any of the seeders. For the narrow (12″) precision planter, crops were able to recover from the initial losses leading to no substantial difference in yield for different P application rates. However, crop recovery was less effective for the 20″ planter, thus leading to a lower yield at 60 kg/ha application rate of liquid P.

Flexibility but no added yield for fertigation

KEY RESULT:

This study compared nitrogen application through side-banding at seeding and through a split application of side-banding at seeding plus in-season through an irrigation system. It found no yield advantage to the split, but the flexibility of fertigation (for those with irrigation systems) allows farmers to adjust rates based on conditions through the season.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:

"Evaluation of sap nitrate for in-season assessment of crop nitrogen status," Dale Tomasiewicz, AAFC Outlook, Saskatchewan

FUNDING:
Canadian Agricultural Partnership

Delaying application of a portion of the crop's fertilizer nitrogen provides an opportunity to assess the crop's nitrogen status in-season to better match fertilization to crop needs. This study (1) compared various in-season plant analysis tests for N, including a sap test, and (2) compared in-season nitrogen top up with fertigation compared to applying all nitrogen in a side-band at the time of seeding.

SAP TEST

Researchers evaluated effectiveness of various plant tissue testing technologies and plant reflectance (NDVI) as in-season indicators for the need to supply additional nitrogen to crops that are becoming deficient. Most tests require submission of samples to a laboratory – which is not ideal in-season due to the additional work required and the delay before results are received.

Sap nitrate tests can be conducted quickly on-site using canola petioles (leaf stems). These are easily sampled and high in moisture, so the sap can be easily expressed. Two methods of measurement of nitrate in the sap were assessed. Both are quick to use and relatively inexpensive (on a per-sample basis). The plant nitrate tests (including sap tests) were found to provide a better basis for indicating the need to apply additional nitrogen for optimum yield, as compared to tests for tissue total nitrogen or canopy NDVI. Tests taken at the bolting stage generally provided a much better indicator of the need for additional nitrogen than those taken at the earlier (five- to six-leaf) stage. With fertigation (or timely rainfall), nitrogen application at the bolting stage is early enough to provide for a substantial portion of canola nitrogen requirement.

FERTIGATION

The capability to apply fertilizer through an irrigation system (or "fertigate") can offer producers the means to maximize their nitrogen use efficiency by more closely matching the timing of nutrient application to crop needs. It also avoids the added cost of enhanced efficiency fertilizer products, which are often suggested to reduce losses of spring-applied nitrogen, and the extra field operation and crop damage associated with in-season fertilizer application.

For fertigation, urea-ammonium nitrate 28-0-0 was injected into the irrigation line. Fertigation nitrogen applications were made in irrigation events with 0.5 inch of irrigation water. Plots not receiving fertigation were also irrigated.

Dale Tomasiewicz, Agriculture and Agri-Food Canada research scientist, studied the fertigation option for canola at the irrigation research centre at Outlook, Saskatchewan.

Results show that canola yields were strongly related to total nitrogen applied – no matter the method used.

In contrast, the nitrogen application method and timing had little impact on canola yield. The option to delay a portion of the nitrogen application through fertigation can increase flexibility of nitrogen fertilizer application timing, but this practice did not provide any incremental benefit to canola yield or quality under the study conditions. Soil and weather conditions were not conducive to in-season loss of applied nitrogen through leaching in the study.

Emissions of the greenhouse gas nitrous oxide (N_2O) were affected more by the total amount of fertilizer nitrogen applied than by which method was used to apply it. Total seasonal emissions of N_2O were generally low, well under one kilogram of N_2O-N per hectare, in all monitored treatments in all years.

Quest continues for Prairie-wide clubroot map

KEY RESULT:

A harmonized clubroot map for the Prairies could reduce confusion and allow for meaningful comparisons between regions. This project resulted in a map for Alberta and Saskatchewan, but the goal remains to include Manitoba.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Development of a Harmonized Clubroot Map," Stephen Strelkov, University of Alberta

FUNDING:
Alberta Canola, Manitoba Canola Growers, SaskCanola

A clubroot distribution map that is harmonized across Alberta, Saskatchewan and Manitoba can help to improve grower and industry education, better understand disease risk by region, better understand the nature of spread, and identify areas in need of resources.

Current maps produced across the three provinces vary widely in what they show and how they show it. This project had three main objectives: (1) to examine the feasibility of a harmonized clubroot map for the Prairies, (2) to determine what such a map will look like, and (3) to communicate findings and recommendations to stakeholders including the Clubroot Steering Committee.

As a first step, Strelkov and colleagues had to select the type of data used to generate the map. These data had to be representative of clubroot distribution, yet not be prohibitively expensive, labour-intensive or time-consuming to collect. The number of confirmed clubroot infestations (fields) was selected as a good basic datatype, noting that additional information (such as pathotype distribution or presence of pathogen DNA) could be added to specific variants of the map as needed.

Different ways of depicting clubroot infestations were compared. One way is to show the total number of infested fields per county/municipality. Another is to show infestations as individual points on a map. Both types of maps are valuable, but in regions where clubroot is not prevalent, there may be privacy concerns associated with the latter.

Various colour schemes were evaluated for depicting the total number of infestations within districts. Since distinct colour categories representing different numbers of confirmed infestations exacerbated the artificial effects of political (county/municipality) borders, Strelkov and his colleagues developed a map that shows infestation level as a continuum, from very light yellow to red, so that a difference of one or two infested fields does not result in the movement of a county into a different colour category.

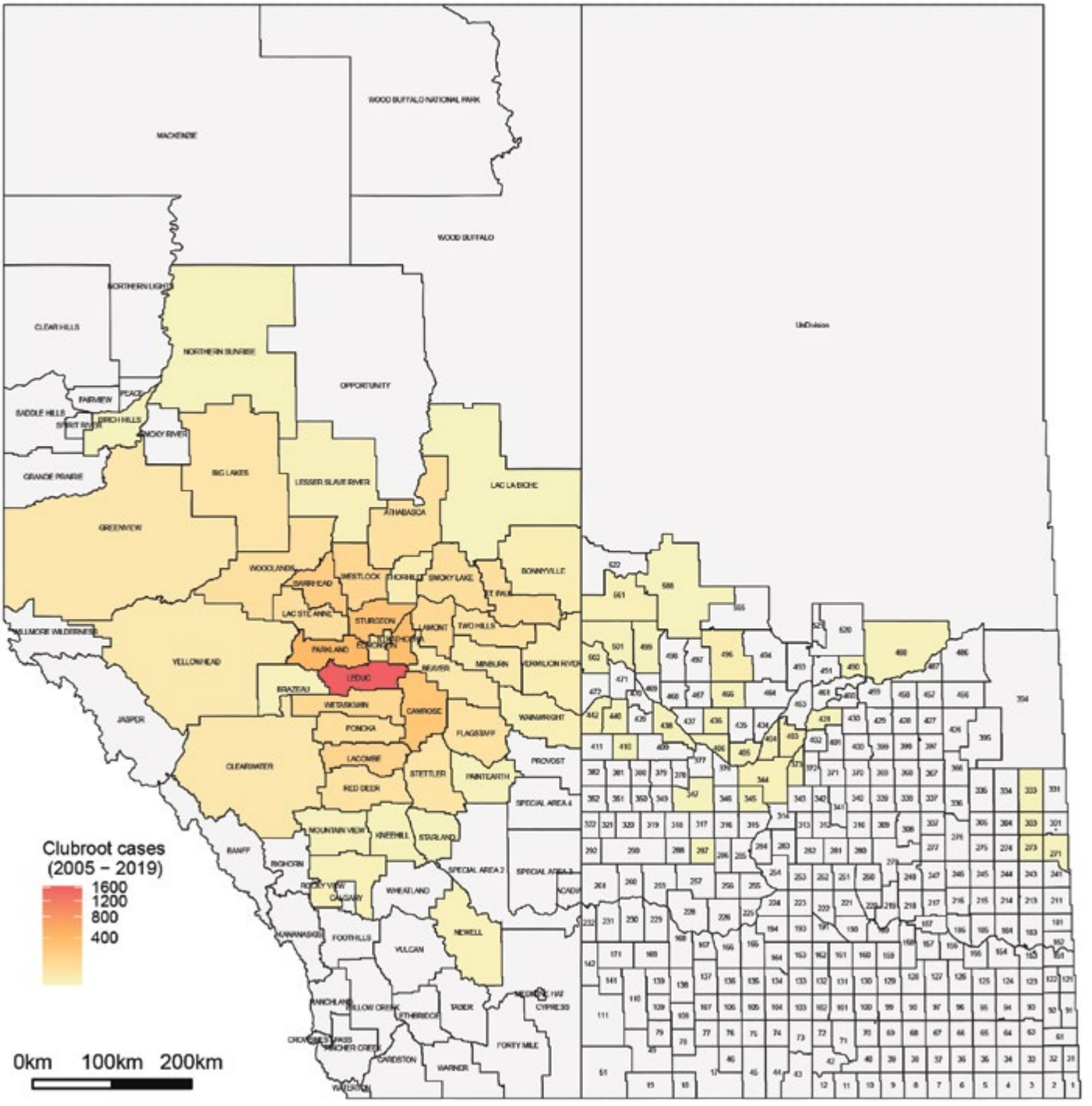
In addition, they explored two ways to present the clubroot map, specific to the communication format used. The first is a static format best suited to communication via factsheets, handouts, journals, and industry newspapers and magazines. The second type of format is a dynamic or animated version of the static maps, which is better suited for slide presentations and similar types of interactions. Animated maps are very useful in showing a sequence of changes over time (such as the spread of the outbreak), and can serve as important teaching and education tools. Finally, an interactive map was developed for communication via a website. While extremely informative, an interactive map may contain sensitive information that cannot be made public. It is nonetheless valuable for restricted use as a research or management tool.

Photo: Dan Orchard

In the end, Strelkov and his project collaborators met their objectives of examining the feasibility of the map, suggesting the best mapping method, and presenting those findings to the clubroot steering committee. However, there is still no three-province harmonized map.

In his analysis, Strelkov wrote: "Despite the potential benefits of harmonized clubroot maps, the sensitivity related to this disease and its distribution may make their adoption difficult in the near future. This was highlighted in the current study by the difficulty in obtaining data from some provinces. Nonetheless, the recommendations from this work should continue to be utilized until such time that map production is feasible. All provinces should be encouraged to continue record keeping and gathering data for the eventual execution of this map." It is likely that, as clubroot becomes more widespread in regions where it is presently rare, the sensitivity to sharing clubroot distribution information will decline, allowing publication of harmonized maps.

Clubroot cases by county (2019)



This version of the harmonized map shows the total number of infested fields per county or municipality. It provides a clear comparison of clubroot infestations across Alberta and Saskatchewan.

Canola flower midge found across the Prairies

KEY RESULT:

The newly discovered canola flower midge, *C. brassicola*, may be a species native to the Prairies. It is found across the canola-growing region, but population density, for the most part, is low and the midge has not had a significant impact on yield. This midge causes flower galls that result in aborted pods.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:

"Assessing the impact of *Contarinia* sp. on canola production across the Prairies," Meghan Vankosky, AAFC Saskatoon

FUNDING:
Alberta Canola and SaskCanola

Right: Galled flowers are a known symptom of C. brassicola infestation. For this study, galled flowers were collected from fields and returned to the laboratory. A portion of the flowers were used to collect larvae for population genetics analyses and larvae in the remaining flowers were reared to determine if they were parasitized.

In 2016, Boyd Mori and colleagues discovered a new species of canola midge, *Contarinia brassicola* Sinclair (Diptera: Cecidomyiidae), in Saskatchewan and Alberta. At the time, nothing was known about its biology or potential impact on canola production. The discovery of *C. brassicola* also raised questions about the presence of swede midge (*Contarinia nasturtii* (Kieffer), Diptera: Cecidomyiidae) on the Prairies. This project was initiated to (1) to determine the distribution of *C. brassicola* and swede midge, (2) to describe the life history of *C. brassicola* and estimate its potential impact on canola yield, (3) to use population genetics to determine the source of *Contarinia* sp. midges on the Prairies, and (4) to identify parasitoids of *Contarinia* sp. for biocontrol.

A survey of randomly selected canola fields was conducted in late July of 2017, 2018 and 2019. To establish the range of *C. brassicola* across the Prairies, 10 canola racemes at 10 locations in each field were examined for galled flowers, a known symptom of *C. brassicola* infestation.

All galled flowers were collected and returned to the laboratory. A portion of the flowers were used to collect larvae for population genetics analyses and larvae in the remaining flowers were reared to determine if they were parasitized.

As part of the field survey, canola plants were also examined for symptoms of swede midge damage and a network of swede midge pheromone traps was deployed in all three years of the project. Plant samples were collected during the growing season and examined for *C. brassicola* eggs and larvae and emergence cages were used to determine the timing of adult midge emergence.

The study determined that *Contarinia brassicola* is widely distributed across the Prairies (Figure 1), including the Peace River Region of Alberta. Its distribution appears to be correlated to the dark grey, black, and dark brown soil zones. In all three years of the project, the population density of *C. brassicola* was relatively low, and unlikely to have a significant impact on canola yield. However, at least two fields in 2019 had damage that likely resulted in economic loss of yield. Eggs are laid on or very close to canola flower buds. Larvae were only detected inside canola flowers.

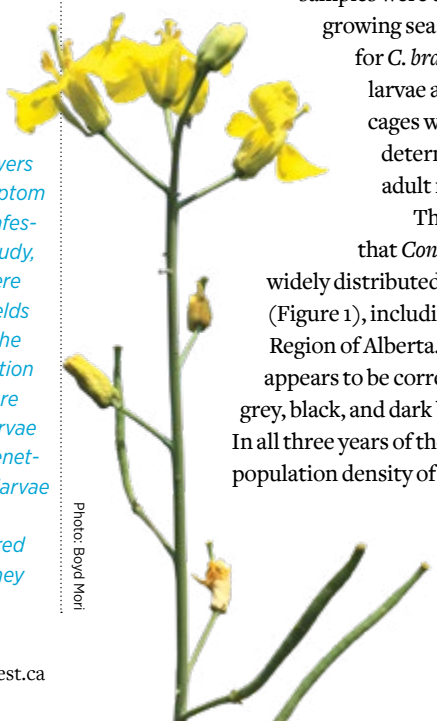
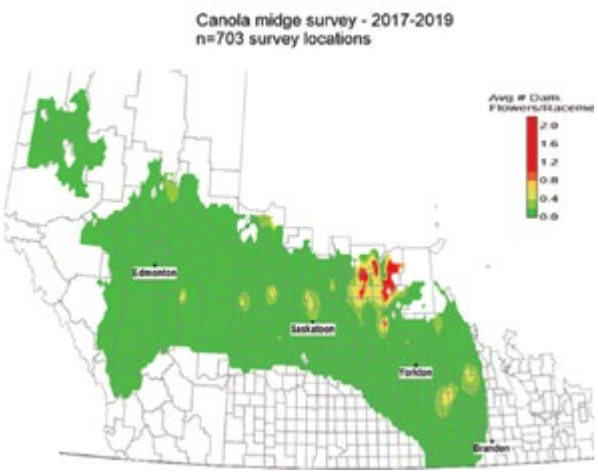


Photo: Boyd Mori

Figure 1. The distribution of *Contarinia brassicola* (canola flower midge) across western Canada, based on surveys conducted in 2017, 2018, and 2019. Inset: canola flowers infested by midge larvae. Map produced by R.M. Weiss (AAFC); image by J. Williams.



Mori, B.A., L. Andreassen, J.D. Heal, J.R. Dupuis, J.J. Soroka, B.J. Sinclair. 2019. A new species of Contarinia Rondani (Diptera: Cecidomyiidae) that induces flower galls on canola (Brassicaceae) in the Canadian prairies. The Canadian Entomologist 151: 131-148.

Based on emergence patterns observed in cages in all three years of the study, the researchers believe that there are at least two generations of *C. brassicola* per year. This species may be able to prolong its diapause and pupal development in the soil, similar to swede midge (Hallett et al. 2009). Additional research is required to address this hypothesis.

There are at least two species of parasitoid that attack *C. brassicola* on the Prairies, however, parasitism rates were low and variable across the host's range. Population genetics analyses revealed high genetic diversity across the known range of *C. brassicola*, suggesting that this may be a species native to the Prairies.

Overall, this project contributed to our knowledge of a new and potentially important pest of canola in western Canada. It also confirmed that there are presently no established populations of swede midge on the Prairies.

Pheromone found for trapping canola flower midge

Photo: Boyd Mori

KEY RESULT: Researchers identified a sex pheromone used by female canola flower midge. The sex pheromone can be produced synthetically and is highly attractive to males in the field. This identification will facilitate development of a pheromone-based monitoring system for *C. brassicola*.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Development of a pheromone-based monitoring system for a newly identified Contarinia midge on the Canadian Prairies," Meghan Vankosky, AAFC Saskatoon

FUNDING: Alberta Canola, SaskCanola

Right: Contarinia midge.

The canola flower midge, *Contarinia brassicola Sinclair* (Diptera: Cecidomyiidae) is a newly-described species that induces galls on canola. The galls prevent flowers from opening and pods from forming. The small size of *C. brassicola* and its similarity to other species of midge make detection and identification difficult, such that damage to crops by *C. brassicola* is often overlooked. A pheromone-based trap could help.

Many midges of agricultural importance use sex pheromones, which are species-specific volatile chemical signals, to coordinate mate finding. Once these species-specific pheromones are properly identified, synthetic versions of these chemicals can be used as the basis of sensitive pheromone-based monitoring and management tools.

This study aimed to identify and synthesize the female-produced sex pheromone of *C. brassicola* and demonstrate its effectiveness in attracting males to traps in the field.

Using gas chromatography-electroantennography (GC-EAG) analysis of female-produced volatiles, two chemicals were identified that elicited responses in male antennae. Four versions of the major chemical, 2,7-diacetoxynonane, were synthesized and used in field trapping trials. The versions used separately were unattractive to *C. brassicola* males. However, by testing various blends, the research team did identify a blend of synthetic pheremones that was highly attractive to males in the field. This identification will facilitate development of a pheromone-monitoring system for *C. brassicola*.

Hot weather can increase swede midge damage

KEY RESULT: Swede midge, an invasive species, causes costly damage to canola in Ontario – but not on the Prairies at this time. Modeling found that when a high number of adults coincided with days of high temperatures, egg laying would increase and result in higher damage levels in the current year and outbreak-level populations in the subsequent year.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Enhanced modelling of swede midge population dynamics in North America," Rebecca Hallett, University of Guelph

FUNDING: SaskCanola, Alberta Canola

Effective pest management of the invasive swede midge, *Contarinia nasturtii* Kieffer, is hindered by the lack of development and mortality information in its invasive range. This project had three main objectives: (1) generate temperature-dependent development and mortality data for Ontario populations of *C. nasturtii*; (2) revise an existing *C. nasturtii* life cycle model (MidgEmerge) with this information; and, (3) utilize the new model (MidgEmergeII) to determine climatic contributors to *C. nasturtii* outbreak in its invaded range.

Temperature-dependent development and mortality rates were determined for all *C. nasturtii* life stages. This information, and robust adult count field data, were used to re-parameterize MidgEmerge and develop MidgEmergeII. Egg and larval development times were found to differ between Ontario and U.K. populations. The re-developed MidgEmergeII model accurately predicted *C. nasturtii* population dynamics in various southern Ontario locations.

Results indicate that there are three *C. nasturtii* emergence phenotypes and two to three generations in Ontario, in contrast to the previous model.

MidgEmergeII was then run with weather data from Ontario sites that experienced *C. nasturtii* outbreaks, and compared with those that did not. It was found that when a high number of adults coincided with days of high temperatures, egg laying would increase and result in higher damage levels in the current year and outbreak-level populations of adults in the subsequent year. These findings have implications for *C. nasturtii* management in its invasive range.

PRAIRIE PEST MONITORING NETWORK

Pest network tracks crop-damaging insects

Photo: Jonathon Williams, AAFC.

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. Anyone can subscribe at prairiepest.ca.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:

"Coordinated surveillance, forecasting and risk warning systems for field crop insect pests of the Prairie ecosystem," Jennifer Otani, AAFC Beaverlodge, and Meghan Vankosky, AAFC Saskatoon

FUNDING:

Canadian Agricultural Partnership (CAP) Integrated Crop Agronomy Cluster, which includes SaskCanola, Manitoba Canola Growers, WGRF and other commodity organizations

This project provides ongoing funding for the Prairie Pest Monitoring Network (PPMN). The concept of 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. Farmers, agronomists and extension staff can use PPMN reports to better understand where and when crops may be affected.

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 and Resource Development, Saskatchewan Ministry of Agriculture, Alberta Agriculture and Forestry, and university researchers. Industry stakeholders provide regular input and valuable insight at annual PPMN working group meetings.

DIAMONDBACK MOTH

One service the PPMN provides is to use wind trajectory models to predict the arrival of diamondback moths (as well as aster leafhoppers) from their overwintering areas in the United States.

They use estimate arrival dates– a "biofix" date – to predict how many generations of diamondback moth there could be in a year. The 2020 model had a biofix date of May 15. Diamondback moth densities generally increase with increasing numbers of generations. The PPMN estimated that western Alberta had two generations of DBM and southeastern Saskatchewan and most of Manitoba had four generations as of August 17, 2020. When compared to historic averages, these results indicate that there was an elevated diamondback moth risk in 2020.

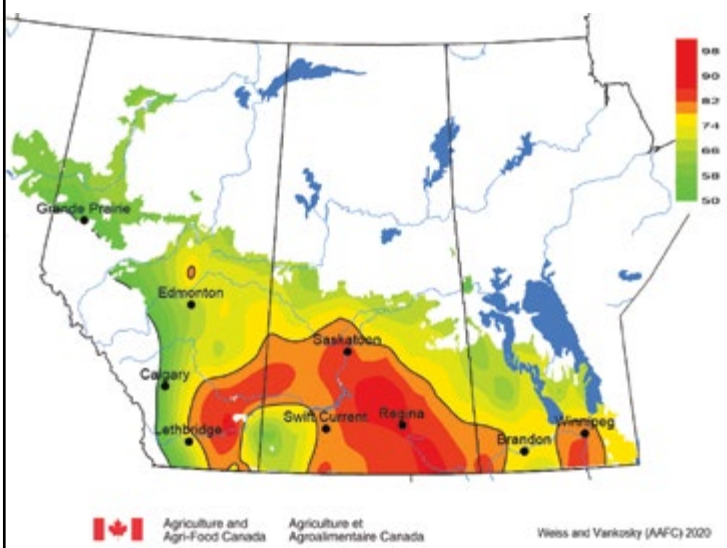
Photo: iStock.com/Jess311

BERTHA ARMYWORM

In its weekly updates, PPMN provides information about the development of bertha armyworm pupae to estimate the timing of adult emergence. Collaborators use this information for setting up pheromone traps to monitor bertha armyworm moths. After the traps are up, the PPMN weekly update provides links to the provincial websites, as they provide (nearly) real-time maps of cumulative trap catch and thus provide an estimate of regional risk.

See the forecast maps and sign up for the weekly updates at **prairiepest.ca**.

BAW pupal development (%) projected to June 8, 2020 (Model run: June 1, 2020)



This map shows the development of bertha armyworm as predicted by PPMN modelling in early June 2020.

Wind trajectories are used to predict the arrival of diamondback moths, which blow into Western Canada each year on winds from the south and southwest. The earlier they arrive, the more generations they can have per year.

Study compares plant and seed dry down for pre-harvest options

KEY RESULT:

This three-year study frequently showed benefits to using pre-harvest herbicide and desiccant options as tools to improve straight combining results. However, results show that going without a pre-harvest herbicide or desiccant is a potentially viable option, especially for early seeded, reasonably uniform and weed-free fields where a hybrid with good pod shatter tolerance is being grown.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:

"Pre-harvest herbicide and desiccation options for straight-combining canola: Effects on crop dry-down and seed quality," Chris Holzapfel, Indian Head Agricultural Research Foundation

FUNDING:

Manitoba Canola Growers and SaskCanola

With improved genetic pod-shatter resistance and increasing producer confidence in the practice, straight-combining canola has become increasingly common in western Canada. Several agronomic questions have arisen with this dramatic increase in uptake, including whether pre-harvest herbicide or desiccant applications are necessary and which options are most effective.

Pre-harvest options were evaluated for both LibertyLink (glufosinate-tolerant) and Roundup Ready (glyphosate-tolerant) canola. Field trials were completed in 2017, 2018 and 2019 at four locations – Indian Head, Melfort and Scott in Saskatchewan and Melita in Manitoba. For LibertyLink canola, the pre-harvest options were glyphosate (890 grams of active ingredient per hectare), saflufenacil (50 g AI/ha), glyphosate plus saflufenacil (890 plus 50 g AI/ha), and diquat (40 g AI/ha). For Roundup Ready, the pre-harvest options were similar except glyphosate (applied alone) was replaced with glufosinate ammonium (408 g AI/ha) which, it should be noted, is not a currently registered pre-harvest option for canola.

Various data were collected but the most important were whole plant and seed moisture content at harvest time, seed size and per cent green seed.

Factors to consider when choosing an ideal pre-harvest option include:

- specific herbicide tolerance system
- relative crop dry-down benefits of the various options
- specific crop stage
- anticipated time until harvest
- weed control requirements
- cost

With high variability resulting from differences in environment (i.e. weather), timing of operations, and methods, the response data were not combined across site-years for analyses.

RESULTS

Whole plant dry down is an important measurement, and in this study the effects of the treatments were not always consistent. Glyphosate applied alone reduced moisture content in LibertyLink (LL) canola 67 per cent of the time (from 29 to 24 per cent across all site-years) while glufosinate ammonium reduced plant moisture content in Roundup Ready (RR) canola 45 per cent of the time (from 28 to 24 per cent on average).

When saflufenacil is applied alone, it significantly reduced whole plant moisture content relative to the control at 33 per cent of the site-years, from approximately 29 to 27 per cent when averaged across all 12 site-years and both canola herbicide systems. (Results are given for saflufenacil alone in order to keep the effects of glyphosate and saflufenacil separate – for LL canola in particular – and the results are averaged across both RR and LL canola.)

Photo: iStock.com/simazoran

When tank-mixed with glyphosate, the effects of saflufenacil on crop dry-down were similar to when this product was applied alone for RR canola and usually similar to glyphosate applied alone for LL canola. While it was relatively rare that saflufenacil plus glyphosate provided a measurable benefit over glyphosate applied alone in LL canola, this occasionally did occur (i.e. Indian Head 2019).

Diquat provided the most consistent dry-down benefits. It reduced plant moisture content at 83 per cent of the site-years, from 29 to 22 per cent when averaged across herbicide systems and site-years.

With regard to seed quality, impacts on seed size were infrequent and inconsistent. In cases where they did occur, it was presumably due to applying the treatments too early. Green seed was most commonly impacted by diquat – applying this product too early could result in dramatic increases in green seed.

Researchers note that individual results are likely to vary based on cultivar, crop stage and environmental factors such as soil moisture and weather leading up to and after applications.

Finally, while the researchers frequently observed benefits to spraying, they note that not applying a pre-harvest herbicide or desiccant should be considered a potentially viable option, especially for early seeded, reasonably uniform and weed-free fields where a hybrid with good pod shatter tolerance is being grown.

Weather is a big factor in combine losses

KEY RESULT:

A combine yield loss survey of 50 combines across the Prairies in 2019 found that weather factors had significant influence on losses. This emphasizes the need to regularly adjust and test throughout the day and harvest season. Temperatures greater than 23°C, relative humidity less than 45 per cent, and low cloud cover all contributed to lower losses during this survey.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:

"On-Farm Survey of Combine Grain Loss in Canola Across Western Canada," Amie Harrison, Prairie Agricultural Machinery Institute (PAMI)

FUNDING:

SaskCanola, Manitoba Canola Growers

The objective of this project was to obtain a snapshot of the canola combine losses that producers are experiencing across Western Canada and to gain a better understanding of these losses by determining which variables are most likely to have an effect. A secondary goal was to continue to provide awareness to the seriousness of combine losses and to educate producers on methods for measuring their losses.

In-field testing occurred between August 22 and October 18, 2019. PAMI visited 31 producers across Alberta, Saskatchewan and Manitoba, and measured canola combine losses from 50 combines. Six combine manufacturers were represented during testing with a total of 40 different combine models.

Surveyors used drop pans provided by Bushel Plus and Schergain to measure the canola losses. The drop pans were attached underneath the combine and were dropped once the combine reached a steady state. The canola seed collected in the pans was separated from the chaff/straw and weighed. To ensure an accurate representation of producer's losses, each combine loss test was repeated three times per combine, and producers were asked to run at their normal operating conditions during testing.

PAMI followed strict biosecurity procedures to prevent the transfer of crop contaminants, such as weed seeds, insects, and pathogens.

Of the 50 combines tested, 44 dropped their straw into windrows during the loss testing, while the remaining six spread their straw. Due to the reduced accuracy experienced when spreading straw (unpredictability of the distribution of grain throughout the discharged material), the results from those six tests were not included in the data analysis.

Here are the variables investigated to determine their potential impact on combine losses: harvest timing, ambient temperature, relative humidity (RH), weather conditions, wind conditions, harvest practices (straight-cut, swathed), grain moisture content, canola variety (shatter resistant, non-shatter resistant), ground speed, grain feed rate, combine settings, combine age, and separator hours.

Statistical analysis identified whether differences observed in the combine loss data were due to the

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Table 1. Variables that were found to have a significant impact on canola combine losses during the 2019 combine loss testing.

COMBINE LOSS VARIABLES	VARIABLE BOUNDARIES	AVERAGE LOSSES (BU/AC)	NUMBER OF COMBINE TEST REPETITIONS	CONCLUSIONS
Ambient Temperature	< 23.0°C	1.4	96	Significantly lower losses experienced with higher ambient temperature.
	≥ 23.0°C	0.8	36	
Relative Humidity	< 45% RH	1.2	108	Significantly lower losses experienced with lower relative humidity.
	≥ 45% RH	1.6	24	
Weather Conditions	Sunny	1.0	33	Significantly lower losses experienced with sunny conditions compared to cloudy and partially cloudy compared to cloudy.
	Partially Cloudy	1.1	60	
	Cloudy	1.7	39	
Harvest Practice	Straight-Cut	1.5	30	More testing required to better understand results.
	Swathed	1.2	102	
Canola Variety	Shatter Resistant	1.3	87	More testing required to better understand results.
	Non-Shatter Resistant	1.1	45	
Ground Speed	< 4.3 mph	1.2	123	Significantly lower losses experienced with slower ground speed. Take note of small sample size for higher ground speed results.
	≥ 4.3 mph	2.2	9	
Grain Feed Rate	< 350.0 bu/hr	0.5	6	Significantly lower losses experienced with lower grain feed rate. Take note of small sample size for lower grain feed rate.
	≥ 350.0 bu/hr	1.3	123	
Combine Age	1993 to 2005	0.8	33	Regarding losses, a well-set older combine can outperform a poorly set newer combine.
	2006 to 2014	1.5	57	
	2015 to 2019	1.3	42	

Airflow key to in-bin drying

KEY RESULT:

Supplemental heat added to natural air drying systems can improve drying capacity for canola as long as airflow is a minimum of one cubic foot per minute per bushel (cfm/bu.). Air must be heated to at least 5°C but not more than 30°C for in-bin drying.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Best Management Practices for Using Supplemental Heating with Natural Air Drying,"
Joy Agnew and Charley Sprenger, Prairie Agricultural Machinery Institute

FUNDING:
Alberta Canola, Manitoba Canola Growers, SaskCanola

This two-year project on canola and wheat found that adding supplemental heat to natural air drying (NAD) systems can be a lower-capital alternative to dedicated heated-air dryers, but careful management is required to keep operating costs comparable to that of a dedicated dryer system.

First year trials, using bench-scale test bins, compared the effect of air flow rate on supplemental heating with NAD compared to NAD without added heat.

Second year trials assessed the rate of drying with supplemental heat at three different temperature increases.

All trials were planned to occur in mid-late fall to ensure the ambient conditions were representative of conditions where supplemental heating is typically used. Moisture content, grain weights, and grain temperature data from each bin were recorded for the six treatments (three airflow rates and two temperatures). Ambient temperature and humidity data were averaged for the three standard bins at the fan intake as well as for the three bins with supplemental heat.

First year results indicated that adding 10°C of heat when ambient conditions are cool and damp will increase the drying rate, as long as the airflow rate is at a minimum of one cubic foot per minute per bushel (cfm/bu.) and sufficient to move the moisture all the way through the grain bulk. Airflow rate has an impact on drying rate, particularly for wetter grain. Airflow rate will depend on the type of fan used, the density of the grain and grain depth within the bin. (If airflow is too low, consider removing some grain from the bin.)

The trials also showed that over-drying at the bottom of the bin may not be avoidable, therefore an average dry moisture should be targeted, followed by mixing the grain.

Second year trials showed that a 10°C increase in temperature is adequate as long as the result is a plenum temperature of greater than 5°C. However, if sub-zero ambient conditions are being experienced for prolonged periods of time, then higher temperature increases would be required. Based on the observed rates of drying for both canola and wheat in the trials, supplemental heating with a NAD system may not be suitable for starting grain moisture contents more than three percentage points above "dry" because an increased risk of spoilage is possible. Careful monitoring or reduced grain bed depths can help mitigate this risk if a heated-air dryer is not available.

Fuel comparison. The study included an economic assessment of supplemental heating with various fuel types. It found that fuel type has the greatest impact on operating costs. Natural gas has lower cost than diesel and propane, however, access to natural gas can be capitally hindering in certain regions. Estimated efficiencies for NAD systems with supplemental heat range from 50 to 75 per cent compared to efficiencies of 40 to 55 per cent for dedicated heated-air drying systems.

	DESCRIPTION	PROS	CONS
Heated air drying	• Usually a small batch process • Uses hot air (45-80° C) to dry grain • Uses very high air flow rates (approx. 20 cfm/bu)	• Success does not depend on ambient conditions • Dries grain quickly (hrs) • Suitable for any ambient condition	• Can result in seed damage • Requires cooling cycle • High capital and energy costs
Natural air drying (NAD)	• Turns the grain bin into a "dryer" • Blows ambient air (5-25° C) through grain • Uses moderate air flow rates (approx. 1 cfm/bu)	• Energy savings • Smaller investment • Reduced risk of heat damage • Most suitable when ambient > 15°C	• Slow (can take weeks) • Requires management • Success dependent on ambient conditions
NAD with heat	• Adding a heater to a NAD fan to increase the temperature of the air going into the bin	• Turns a "poor" drying day into a "good" drying day • Minimal capital investment • Most suitable when ambient > 0°C • Reduces drying time to days	• Requires management (and grain turning) • Few options for temperature control • Energy cost

PAMI tips to manage NAD with supplemental heat

PAMI has a document "Using supplemental heat to manage grain in the bin – FAQ", which is posted at **pami.ca**. The following tips are from that report.

1. Only use a CSA certified heater that is designed for use with grain storage fans for safety and grain quality reasons.
2. Ensure adequate air flow rate (minimum 0.75 cfm/bu) or there is a risk of overheating the grain.
3. Limit air temperature increase to 15°C or less. Higher temperature increases result in high fuel costs, reduced heat transfer efficiency, increased chance of over drying, and increased chance of freezing/sticking at edge of bin.
4. Do not exceed an inlet (after heater) temperature of 30°C. Air flow rates of 0.75 to 1 cfm/bu can "keep up" with moderate drying rates, but not with high drying rates associated with high temperatures (>30°C).
5. As much as possible, maintain a CONSISTENT air temperature going into the bin.
6. A minimum of one square foot of vent space for every 1,000 cfm of air flow is required. Consider the use of "active" ventilation in the headspace which helps to expel moist air more effectively.
7. Grain MUST BE turned and cooled to less than 15°C after drying. Cooling will also remove some moisture, so drying may be complete when moisture is within one per cent of target.
8. Monitor grain conditions with in-bin cables and/or samples during drying

Toward a boost in canola's waxy defensive layer

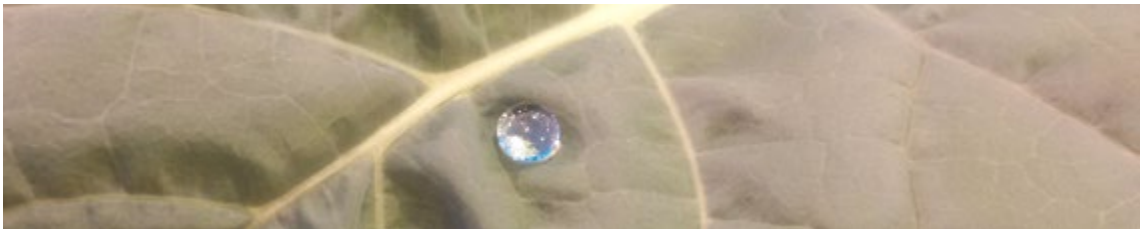
KEY RESULT:

This study identified the chemical composition of surface wax in *B. napus* and various other Brassica species. It also identified genes responsible for wax production. It advances the possibility of eventually selecting for canola lines better able to produce more or different wax in response to drought and pest threats.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:

"Assessing surface wax chemical diversity as a tool to defend against abiotic and biotic stress in canola," Mark Smith, AAFC Saskatoon.

FUNDING:
SaskCanola



The outer surface of a canola plant (*Brassica napus*) is covered by a complex mixture of water-repelling material referred to as cuticular wax. This layer plays a role in in prevention of water loss from the plant and in defence against attack by insect pests and fungal pathogens. For canola, little is known about the chemical composition of cuticular wax, its synthesis, biological function, and if there is chemical diversity within Canadian varieties.

A two-year study was conducted by Agriculture and Agri-Food Canada researchers to determine the chemical composition of wax in *B. napus* and to investigate the distribution of these chemicals on different plant parts and between different canola varieties. To aid in potential breeding efforts for new wax traits, researchers also identified genes encoding enzymes involved in wax biosynthesis and genes that regulate wax production.

Results showed that *B. napus* wax is a complex mixture of aliphatic (chain like) hydrocarbons, with five main components and many minor ones. The chemical composition of wax in *B. napus* appears relatively uniform over the plant, with significant differences in composition only seen in petals.

Low chemical diversity of wax was observed between *B. napus* varieties. The study surveyed canola varieties ranging in registration date from 1966 to 2019. Wax composition was similar for all varieties, but with some variation in total wax load and relative percentage of individual components. The results indicate that the development of Canadian spring canola varieties likely did not result in major changes to the wax profile.

Expanding the study to include founder lines from a *B. napus* nested association mapping population (NAM) indicated that chemical diversity of epicuticular wax in *B. napus* is limited. Wax composition of other Brassica species *B. rapa, B. oleracea, B. juncea* and *B. carinata* was determined from multiple tissues of greenhouse grown plants.

Preliminary studies conducted on the effect of the environment on wax production indicates that the amount of wax on the plant increases under drought stress, but with little change in overall composition. Small but significant differences were seen when greenhouse grown plants were compared with the same varieties grown in the field, providing further evidence for the role of the environment in wax biosynthesis. No significant response in wax load or composition was seen under high or low nitrogen in field grown plants.

An epidermal transcriptome was developed and used as a resource to identify genes encoding proteins involved in wax biosynthesis and its regulation. The most highly expressed genes encode small proteins that are thought to play an important, but at this time unknown, function in wax export into the cell wall and may also be involved in host recognition or plant defence against fungal pathogens.

This work has considerably enhanced our understanding of wax chemistry and biosynthesis in *B. napus* and identified gaps where further knowledge is required. For example, knowing the chemistry of wax will help in determining how different components function in plant defence.

Weather is a big factor in combine losses report continued from page 20

measured variables listed above or due to random variability. Table 1 shows the variables that were found to have a significant impact on canola combine losses, along with the observed losses. For all other variables investigated (not included in table), no significant differences were observed in the data collected from the 2019 harvest season.

Of the analyzed results, the minimum loss measured was 0.2 bushels per acre (bu./ac.), which was 0.4 per cent of the producer's yield. The maximum combine loss measured was 4.1 bu./ac., or 10.7 per cent of the producer's yield. Average loss was 1.3 bu./ac., or 2.8 per cent of yield.

This project highlights how important it is for producers to set their combines for current weather conditions and to use loss measurement as a way of verifying these settings. Producers also need to reassess combine losses as conditions change throughout the harvest day and season. For more on how to measure harvest losses and a link to the CCC and PAMI Combine Seed Loss Guide, please visit the Harvest Management section at **canolaencyclopedia.ca**.

Tool helps breeders select for complex multi-gene traits

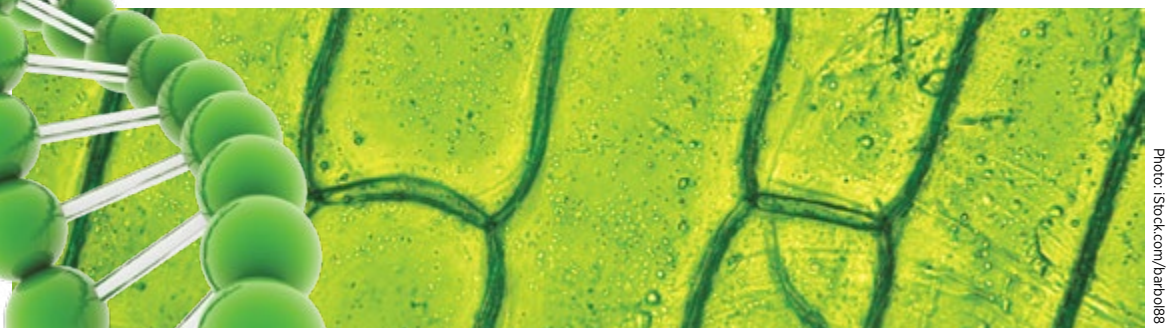


Photo: iStock.com/barbol88

KEY RESULT:

AAFC research scientists have put together a nested association mapping (NAM) population for spring *Brassica napus* canola, a tool which has helped them identify the multitude of genes associated with complex traits – such as seed glucosinolate content. Breeders can use the tool to select for complex traits and identify cultivars that perform better under specific growing conditions – such as long day-lengths in northern growing regions, for example.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:

"Field evaluation of a valuable germplasm resource designed to dissect complex traits in *Brassica napus* (the Nested Association Mapping population)," Sally Vail, Steve Robinson and Isobel Parkin, AAFC Saskatoon

FUNDING:

SaskCanola, Manitoba Canola Growers, Alberta Canola

Nested association mapping (NAM) populations have proven quite useful in other crop species, such as corn and barley, as a platform to bridge the divide in knowledge between the plants genetic code (or 'genome') and the physical characteristics (or 'phenotype') of complex 'traits'. These associations not only provide insight into basic science questions, but also yield practical tools and germplasm for plant breeders. We now have a NAM population for canola.

The spring *B. napus* NAM population has over 2,500 lines (RILs), which were derived from crossing or recombining the genes from 50 diverse parental lines with those of a reference line.

The existing *B. napus* NAM project encompassed one field season of evaluation of the large RIL population in 2016 at a single location/environment; however, extensive evaluation over several years under multi-environments is necessary to fully realize the complex trait combinations of this unique germplasm resource.

Throughout the current project, analysis continued on associations between the genome and key phenotypes based on the 2016 field data. The regions of the genome housing genes associated with flowering and maturity time, seed size and seed glucosinolates (GLS) were identified and will be validated using data in subsequent field trials containing sub-sets of the RILs (2017-19). Identified molecular markers will also immediately be used for selection within the Agriculture and Agri-Food Canada canola breeding program. For example, previously known genes controlling seed GLS plus new minor genomic locations that were identified will be used to quickly recapture this trait in populations with non-canola quality genes.

In this project, we also conducted two field trials in 2017 to further asses a sub-set of the RILs and the parental lines in unique environments. From the 2016 RIL trial, about 450 lines were identified as having ideal agronomic characteristics, thus were retested in 2017. From this trial, 93 (or only about four per cent of the entire NAM RIL population) showed an ideal combination of agronomics (days to flowering and maturity), seed quality profile (acceptable oil percentage, low GLS and low erucic) and yield greater than the reference line. This demonstrates the essential need for subsequent crossing between RILs to capture new traits in germplasm that can be used in commercial canola cultivar development.

Field testing of the NAM parental lines in 2015 across several field sites in Saskatchewan and at Beaverlodge in Alberta demonstrated the uniqueness of the extreme environment at northern latitude in the Peace River Region. Thus, we retested the parents in 2017 and compared flowering patterns confirming the utility of field trials in this region for further investigating response to different day-lengths in *B. napus*. This characteristic is not well understood yet is underlying the optimization of canola varieties for emerging canola growing regions at high latitudes.

To date, NAM parental lines, RILs and tester NAM-hybrids have being grown and assessed for agronomic traits and yield in more than 50 trials across Canada since 2013. This data, harvested seed and an associated database of phenotypic images will be a tremendous resource for the canola industry going forward for the study of physiological traits and yield stability as well as the study of new traits.

Furthermore, funding of this work has enabled collaborations studying new seed quality traits (protein fraction profiles), abiotic stress tolerance, existence of microbiome differences between lines and digital plant phenotypes.

Next steps in continuing to utilize this resource is increasing seed for repeated field trials of the NAM RILs in future growing seasons and development of a NAM centralized database that will enable the canola research community to address producer-determined research objectives including further development of agronomics, pre-breeding tools, and new uses of canola constituents.

Canadian canola researchers have dozens of ongoing projects. Some are funded by canola growers through their levy payments to SaskCanola, Alberta Canola and Manitoba Canola Growers. Some are funded through the Canola AgriScience Cluster, a partnership between Agriculture and Agri-Food Canada (AAFC) and the canola industry under the Canadian Agricultural Partnership (CAP). Over a five-year period, this initiative will invest $25.5 million in research to optimize yield and quality, improve nutrient and water use efficiency, and enhance integrated pest management practices. Here are short descriptions and updates for these projects.

SHORT UPDATES FOR ONGOING RESEARCH

PLANT ESTABLISHMENT

AN ON-FARM APPROACH TO MONITOR AND EVALUATE THE INTERACTION OF MANAGEMENT AND ENVIRONMENT ON CANOLA STAND ESTABLISHMENT AND DISEASE DEVELOPMENT

PRINCIPAL INVESTIGATOR: Christiane Catellier, Indian Head Agricultural Research Foundation (IHARF)

FUNDING: SaskCanola

PURPOSE/OBJECTIVES: This observational study, using data collected directly from producers' fields, is examining how management decisions and environmental conditions interact to affect (1) canola emergence and seedling development and (2) disease (sclerotinia and blackleg) development. This approach will allow researchers to examine several intercorrelated factors simultaneously. This will better show how field conditions can affect the outcome of management decisions.

PROGRESS: Field data collection has been completed for three growing seasons. Preliminary data exploration has shown interesting trends, and full statistical analysis will only be completed once the full data set has been assembled.

IHARF summer student Logan Fahlman measures soil temperature and soil moisture content as part of the canola emergence study.

EFFECT OF CEREAL CROP RESIDUE DISTRIBUTION ON THE FOLLOWING YEAR'S CANOLA EMERGENCE AND YIELD

PRINCIPAL INVESTIGATOR: Katelyn Gaetz, Prairie Agricultural Machinery Institute (PAMI)

FUNDING: SaskCanola and others

PURPOSE: This three-year project analyzes the effect of poor versus good cereal crop residue distribution and the effects on the following year's canola emergence and yield. The study also observes two post-harvest treatments: harrowing and high-speed discing. Field-scale equipment was used to represent meaningful results that can be related directly to producers.

PROGRESS: Field work finished this fall but the final data set is yet to be analyzed. Some key difficulties to note during the data acquisition was the growing conditions by year. Each growing season observed (2018, 2019, 2020) displayed unique conditions that at times were not ideal for accurate data acquisition. This included extreme differences in weather (very dry to very wet).

FERTILITY MANAGEMENT

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

PRINCIPAL INVESTIGATOR: Bao-Luo Ma, AAFC Ottawa

FUNDING: Canadian Agricultural Partnership (CAP)

PURPOSE: The study includes two field experiments at eight locations across Canada and laboratory analysis. Objectives are to (1) assess agronomic and economic responses of canola to nitrogen (N) fertilizer management in terms of nitrogen use efficiency (NUE), yield and crop standabilty, (2) improve NUE, crop productivity and lodging resistance through management practices under different soil and cropping system conditions, (3) identify root architecture traits for efficient N acquisition and strong anchorage strength, and (4) investigate the taxonomic and functional response of the soil microbiome to N management.

PROGRESS: The project goes until 2023, but early results showed, at most sites, a positive response of canola yields to N application rates, and at some site-years, a better response to the split (base fertilizer plus top dress at the four- to six-leaf stage) compared to the same amount of N applied only at preplant. The estimated most economic rate of nitrogen (MERN) appears to indicate the need for region-specific recommendations.

ENHANCING THE SASKATCHEWAN SOIL INFORMATION SYSTEM

PRINCIPAL INVESTIGATOR: Angela Bedard-Haughn, University of Saskatchewan

FUNDING: SaskCanola, Western Grains Research Foundation, Canadian Agricultural Partnership (CAP) and others
PURPOSE: This project aims to enhance Saskatchewan Soil Information System (SKSIS) by developing and integrating predictive soil mapping (PSM) tools into SKSIS, and by creating a standalone SKSIS feature for efficient use of SKSIS in internet-deficient areas.
PROGRESS: The beta version of the SKSIS standalone app has been developed and has undergone internal testing. The app will enable producers to access soil data digitally even when they are in an internet-deficient area. Development and testing of PSM tools has led to refining of the PSM approach to adapt it to Saskatchewan landscapes and conditions. Further testing is ongoing at nine sites across Saskatchewan and is expected to be completed in the first half of 2021. Data-sharing models are currently in development, specifically focused on the use of blockchain tools to ensure data ownership and control will be completely maintained and tracked when data is uploaded into the SKSIS PSM system. Beta testing of the data sharing management system and producer partnered PSM tools is expected to be undertaken in the second half of 2021.

DEVELOPING A SOIL HEALTH ASSESSMENT PROTOCOL FOR SASKATCHEWAN PRODUCERS

PRINCIPAL INVESTIGATOR: Kate Congreves, University of Saskatchewan
FUNDING: SaskCanola, Western Grains Research Foundation and others
PURPOSE: Soil health can be defined as the capacity of a soil to function, which reflects sustained biological productivity, environmental quality and plant health. This project will assess soil health across Saskatchewan, which will contribute to developing a standard Saskatchewan soil health assessment protocol.
PROGRESS: Soil samples from 0-15, 15-30 and 30-60cm depths were collected from 55 fields across 26 sites in fall 2018. The sites are representative of Saskatchewan agriculture. Some native prairie samples were also collected. Lab-work was conducted to characterize soil health attributes, such as organic carbon, total nitrogen, active carbon, soil protein, mineralizable nitrogen, nutrient composition, wet aggregate stability, texture, pH, electrical conductivity and more. Descriptive statistics for each soil health attribute have been computed, and we have developed preliminary scoring functions.

CANOLA FREQUENCY EFFECTS ON NUTRIENT TURNOVER AND ROOT-MICROBE INTERACTIONS

PRINCIPAL INVESTIGATORS: Bobbi Helgason, University of Saskatchewan; Tim Dumonceaux, AAFC Saskatoon
PURPOSE: Crop rotation is a well known management practice that aids in sustainable and healthy agroecosystems and can mitigate risks associated with crop disease and soil nutrient depletion. To better understand the effects of short canola rotations on soil nutrients and microbiology, this project examines root nutrient fluxes and plant, soil, and root-associated microbes using herbicide-resistant commercial varieties of canola.
PROGRESS: Nutrient fluxes during plant growth were examined using plant root simulator (PRS) probes. Analysis of the bacterial and fungal microbial communities revealed that crop rotation had a significant effect on the composition of the soil microbiome. The data from both 2018 and 2019 revealed an extreme abundance of a fungus, *Olpidium brassicae*, in root samples at all sampling locations, with one strain unique to samples from Lacombe. While *O. brassicae* is not known to cause disease in canola, related organisms can vector viruses that affect canola productivity. The microbiome data is currently being analyzed in the context of cultivar, locality, nutrient fluxes, and agronomic traits to better resolve microbiome-mediated effects of rotation on crop performance.

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

PRINCIPAL INVESTIGATOR: Bobbi Helgason, University of Saskatchewan
FUNDING: SaskCanola
PURPOSE: The objective is to determine how canola root architecture and the root-associated microbiome impact the plant's ability to forage for phosphorus. This research combines field and laboratory experiments to see how soil phosphorus fertility affects canola roots and their microbiome in order to develop strategies for overcoming phosphorus deficiency in canola production.
PROGRESS: Canola plants including roots, rhizosphere and bulk soil were collected from the field where the effects of phosphorus rate and opener width were tested. Researchers measured plant growth and nutrient uptake, and are using DNA sequencing to examine the response of bacteria and fungi to different phosphorus applications. COVID-19 has delayed the more mechanistic aspects of this work in the greenhouse and laboratory, but results from two years in the field will guide ongoing project objectives imaging root growth and profiling microbiome development in rhizoboxes.

REDUCING TOXICITY OF SEED-PLACED PHOSPHORUS FERTILIZER IN OILSEED CROPS

PRINCIPAL INVESTIGATOR: Patrick Mooleki, AAFC Saskatoon
FUNDING: SaskCanola, Alberta Canola
PURPOSE: Objectives are to determine the maximum safe rate of seed-placed phosphorus fertilizer with different row spacing and opener widths, and to develop guidelines.
PROGRESS: This two-year field study was conducted in 2018 and 2019 at five locations across Saskatchewan and Alberta. Results from year one showed more plants per square metre at 9" row spacing than at 12". As well, plant density increased with opener width. However, plant density decreased with increasing P rate. No significant effect on grain yield and grain quality characteristics were observed for all the three factors. Results from year two show that increasing seed-placed phosphorus rate can cause significant reduction in plant population. Combined statistical analysis and summaries are underway.

ENHANCING THE BENEFICIAL ROOT MICROBIOME IN CANOLA

PRINCIPAL INVESTIGATOR: Mohamed Hijri, Université de Montréal
FUNDING: Canadian Agricultural Partnership (CAP), Alberta Canola, SaskCanola, Manitoba Canola Growers, WGRF, NSERC
PURPOSE: This project will identify the prokaryotic community within the canola-specific root rhizosphere, and follow up to see how beneficial associative microorganisms could help to improve crop yield.
PROGRESS: This long-term field experiment conducted at three locations on the Prairies found that the prokaryotic community of

the canola rhizosphere has a stable core of organisms. This could be important for future enhancement of canola production through microbiota manipulation or development of new cohorts for bio-inoculants-associative microorganisms.

INTEGRATED PEST MANAGEMENT

IDENTIFICATION AND ASSESSMENT OF THE ROLE OF NATURAL ENEMIES IN PEST SUPPRESSION IN CANOLA, WITH SPECIFIC REFERENCE TO DIAMONDBACK MOTH MANAGEMENT

PRINCIPAL INVESTIGATOR: Maya Evenden, University of Alberta

FUNDING: Alberta Canola, SaskCanola

PURPOSE: Objectives are (1) to monitor natural enemies associated with diamondback moth (DBM) in canola, with a focus on larval parasitoid, (2) understand relationships between DBM and its natural enemies and to develop dynamic action thresholds and (3) understand factors to enhance foraging and parasitism of parasitoids associated with DBM.

PROGRESS: Commercial fields of canola in southern Alberta were surveyed in 2020, but high rainfall resulted in low DBM populations and overall low infestation levels. A similar survey will be conducted in the summer of 2021. Laboratory studies were conducted to determine functional response of predator insects. Field cage and laboratory studies were continued in 2020 to calculate economic thresholds of DBM in canola fields.

SURVEILLANCE NETWORKS FOR BENEFICIAL INSECTS: CAN NATURAL HABITATS SERVE AS INSECT RESERVOIRS, AND DO THEY CONTRIBUTE TO CANOLA YIELD?

PRINCIPAL INVESTIGATOR: Paul Galpern, University of Calgary

FUNDING: Alberta Canola, Manitoba Canola Growers, SaskCanola

PURPOSE: This project examined the relationship between the diversity and abundance of beneficial insects and canola production in Western Canada. Specifically, it addressed the role of natural habitats near canola fields provide as reservoirs for pollinators and natural enemies of canola pests, and the effect on canola yield.

PROGRESS: For this final year of the project, researchers focused on ground-dwelling beneficial arthropods, which may be important predators of crop pests. Species examined included two wolf spiders, a carabid beetle, and a harvestman. Natural habitats within and near fields appear to function as reservoirs, and therefore may help maintain populations of natural enemies. A second phase of the network has begun. It advances the yield-related objectives piloted in this project and aims to measure the contribution of natural habitats that support beneficial arthropods to canola yields in the surrounding fields.

VERTICILLIUM STRIPE MANAGEMENT

PRINCIPAL INVESTIGATORS: Sheau-Fang Hwang and Stephen Strelkov, University of Alberta

FUNDING: Alberta Canola, SaskCanola, Manitoba Canola Growers

PURPOSE: 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.

PROGRESS: Greenhouse experiments on the effect of different inoculum densities on plants at different growth stages are being evaluated. Despite COVID-19, field experiments on the effect of different inoculum densities on disease severity and yield were seeded and are being collected.

IMPACT OF DROUGHT AND HEAT DURING FLOWERING ON CANOLA YIELD

PRINCIPAL INVESTIGATOR: Raju Soolanayakanahally, AAFC Saskatoon

FUNDING: SaskCanola, Saskatchewan's Agriculture Development Fund (ADF)

PURPOSE: The main objective is to see how drought, heat and a combination of the two can affect canola seed yield, oil composition and carbon assimilation.

PROGRESS: Researchers used a drought-tolerant (DT) and a drought-susceptible (DS) canola cultivar to compare day- and night-transpirational water loss under optimal watering and water deficit conditions. Results showed that the DS canola cultivar had higher rates of day- and night-transpirational water losses. Stomatal conductance in particular was always higher in the DS canola cultivar under control and drought conditions. Further investigation is needed to disentangle the role of leaf waxes and their chemical composition in reducing non-stomatal transpirational water loss and increasing crop water-use efficiency.

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

PRINCIPAL INVESTIGATOR: Maria Angelica Ouellette, North Peace Applied Research Association

FUNDING: Alberta Canola

PURPOSE: Cultural methods for flea beetle include high seeding densities, larger seed size (up to 2.2mm), as well as higher soil temperatures at seeding, but there is limited research showing how these three recommendations, acting in conjunction, affect flea beetle damage. This study will evaluate these recommendations.

PROGRESS: The summer and fall of 2019 was unseasonable wet, which made for difficult spring seeding condition in 2020. Early and late seeding dates ended up being close to each other. Precipitation in early June also had a negative impact on seedling vigour and emergence. Despite cold wet conditions this spring, all the data was collected on flea beetle seedling damage. Data will be processed in the upcoming months.

BIOPESTICIDES AS A NOVEL MANAGEMENT STRATEGY FOR SCLEROTINIA IN CANOLA

PRINCIPAL INVESTIGATOR: Susan Boyetchko, AAFC Saskatoon

FUNDING: SaskCanola, Manitoba Canola Growers

PURPOSE: The main objective is 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.

PROGRESS: Five bacterial strains were found to inhibit ascospore germination, mycelial growth and sclerotial formation of *S. sclerotiorum*. All plants sprayed with bacterial strain PENSV20 in the presence of the pathogen had no symptoms of the disease and plant defense genes were triggered when sprayed 24 hours before and 24 hours after the pathogen. A canola petal bioassay was conducted that revealed spraying the

ascospores onto petals along with the bacterial biopesticide reduced ascospore germination. The canola petal bioassay and the results from the plant defense genes corroborate the results that one of the mechanisms is the induction of host plant defense genes. The second mechanism appears to be the production of bacterial secondary metabolites that possess antifungal activity against the pathogen. The full genome of the leading bacterial biopesticide strain was sequenced. The use of genomic databases will be used to conduct comparative genomics in order to identify genes that help determine biopesticidal properties responsible for antagonism against *S. sclerotiorum*.

EFFECT OF HAIRINESS IN BRASSICA LINES ON THE ABUNDANCE, FEEDING AND OVIPOSITION BEHAVIOUR OF FLEA BEETLES, DIAMONDBACK MOTHS AND ASTER LEAFHOPPER

PRINCIPAL INVESTIGATOR: Chrystel Olivier, AAFC Saskatoon

FUNDING: SaskCanola, Alberta Canola

PURPOSE: The project aims to determine the effects of trichomes (hairs) on the feeding and/or egg-laying behaviour of three canola pests: striped flea beetles, diamondback moths (DBM) and aster leafhoppers.

PROGRESS: Lab bioassays and field trials were conducted with a hairy *Brassica napus* line and a very hairy Brassica species, *B. villosa*. Lab bioassays with aster leafhoppers were started in 2020 but remain unfinished because of COVID-19. Lab bioassays and a reduced field trial demonstrated that striped flea beetles tend to avoid hairy leaves and move to feed on the less hairy stems or petioles. The low level of aster yellows and absence of DBM in the field trails did not allow confirmation of the lab bioassay results.

MONITORING THE RACE DYNAMICS OF *LEPTOSPHAERIA MACULANS* FOR EFFECTIVE USE OF *R* GENES TO CONTROL BLACKLEG IN WESTERN CANADA

PRINCIPAL INVESTIGATOR: Gary Peng, AAFC Saskatoon

FUNDING: SaskCanola, Alberta Canola, Manitoba Canola Growers

PURPOSE: This study is part of the continued efforts to provide industry and producers with up-to-date pictures of *L. maculans* race profile, which can be used to guide the deployment or rotation of canola cultivars carrying different *R* genes. It can also gain important insights into pathogen race changes in response to resistant cultivars used over the years, allowing industry to be proactive before the erosion of specific resistance *R* genes.

PROGRESS: Monitoring has continued since 2010. Isolates from 2018 have been analyzed, and samples from 2019 and 2020 are being tested and collected. COVID-19 affected progress, but researchers hope to complete 2019 samples by end of this fiscal year. Annual information on the avirulence-gene profile in *L. maculans* population allows breeders to pick effective *R* genes for blackleg resistance breeding, and helps agronomists and growers to select cultivars that carry effective *R* genes on a regional basis.

VALIDATION OF LYGUS AND OTHER INSECT PEST THRESHOLDS IN COMMERCIAL FARMS THROUGHOUT ALBERTA

PRINCIPAL INVESTIGATOR: Hector Carcamo, AAFC Lethbridge

FUNDING: Alberta Canola, SaskCanola

PURPOSE: Economic thresholds for lygus were developed for open pollinated cultivars. Recent cage and plot data suggest that the threshold should be raised to two or three lygus per sweep for new hybrids. This study will try to validate economic thresholds for lygus using commercial canola fields.

PROGRESS: From 2016 to 2019, 28 farm site-year combinations have been studied. Results have been variable but data support increasing the threshold. Landscape analysis of current and previous surrounding land cover has been added as extra value to get the most of the data. Data analysis and synthesis for all years to validate thresholds remains on target to produce a final report by the end of 2020.

INVESTIGATING THE ROLE OF PLANT HOSTS IN THE OUTBREAKS OF THE ASTER LEAFHOPPER VECTORED ASTER YELLOWS

PRINCIPAL INVESTIGATOR: Sean Prager, University of Saskatchewan

FUNDING: SaskCanola, WGRF

PURPOSE: The objective is evaluate several crop and non-crop species commonly found in the Canadian Prairies as possible hosts for aster leafhopper development and/or phytoplasma infection.

PROGRESS: Oviposition behaviour and nymph development of aster leafhoppers was examined on wheat, oat, barley, canola, spiny annual sowthistle, dandelion, fleabane, marigold and *Arabidopsis thaliana*. To examine possible differences due to phytoplasma infection, experiments were repeated with infected aster leafhoppers. Additionally, two-choice bioassays with these plant species were carried out, in order to examine host choice selection in uninfected and infected aster leafhoppers. These bioassays have been complemented with egg and probing event counts to examine whether host choice selection is associated with feeding activity and/or oviposition.


Photo: Kelly Turkington

Donald David, AAFC Outlook, and Noryne Rauhala, AAFC Lacombe, check plots for an AAFC fungicide trial.

INTEGRATED PEST MANAGEMENT

FEASIBILITY OF USING *TRICHOMALUS PERFECTUS* FOR BIOLOGICAL CONTROL OF CABBAGE SEEDPOD WEEVIL IN THE PRAIRIES

PRINCIPAL INVESTIGATOR: Hector Carcamo, AAFC Lethbridge

FUNDING: Canadian Agricultural Partnership (CAP)

PURPOSE: 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.

PROGRESS: In 2020, staff from the University of Lethbridge, Canola Council, Alberta Agriculture and Saskatchewan Agriculture sampled around 28 canola fields to determine effect of landscape structure on cabbage seedpod weevil, and to search for potential non-target weevils in canola. Potential predators of cabbage seedpod weevils were investigated using simple container tests at home or field observations. Effects of previous year distance to canola fields was investigated using an AAFC digital repository for about 76 canola sites dating from 2015 to 2020, with more to come from past studies.

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

PRINCIPLE INVESTIGATOR: Kelly Turkington, AAFC Lacombe

FUNDING: Canadian Agricultural Partnership (CAP)

PURPOSE: The main objective is to improve management practices for *Sclerotinia sclerotiorum* by developing a better understanding of the relationship between inoculum availability and environmental conditions before and during flowering, and how this impacts stem rot risk and fungicide response. Researchers are looking at factors (seeding rate) that influence crop development, as well as variability in flowering and the resulting fungicide efficacy at different canola growth stages. They will also evaluate fungicide efficacy when applied as a single early application or as dual applications at different flowering stages, and will refine the use of qPCR analysis and investigate the use of spore traps to assess inoculum load before and during flowering.

PROGRESS: Conditions in 2019 were favourable for stem rot. In general, final stem rot levels generally reflected spore loads as well as relative humidity and temperature conditions. Where fungicide responses occurred, better efficacy generally reflected peak spore loads and the occurrence of favourable weather conditions. Unfortunately, in 2020 the fungicide trial experiments were postponed due to COVID-19 and will be conducted during the summer of 2022, while the 2021 field season should progress as normal. However, Eleanor McBain was able to continue her M.Sc. project work in the Fort Saskatchewan and Legal region of Alberta in 2020. Preliminary results indicated lower spore loads and lower disease levels, which contrasted with higher spore loads and disease in 2019.

EXPLORE SEED TREATMENT OPTIONS TO MITIGATE THE IMPACT OF BLACKLEG ON CANOLA

PRINCIPAL INVESTIGATOR: Gary Peng, AAFC Saskatoon

FUNDING: Alberta Canola, Manitoba Canola Growers

PURPOSE: This study assesses the importance of infection from soil. It also investigates the conditions that affect the success of infection, especially under the influence of quantitative resistance (QR) and fungicide seed treatment. The information will help understand how relevant this infection route is to blackleg incidence and whether a fungicide seed treatment can mitigate this.

PROGRESS: Experiments conducted under controlled conditions showed that blackleg can be caused by soil inoculum at levels higher than 1,000 spores per gram of soil. Wounding roots exacerbated the infection, and this indicates that root injuries by other factors (diseases or insects) may increase the infection from soil inoculum. Current seed treatments did not control the infection from soil but a newly registered seed-treatment product appeared effective. Our next step is to develop a PCR-based protocol to quantify the inoculum level in commercial fields to better understand the risk for infection from soil on the prairies.

UNDERSTAND THE CRITICAL WINDOW FOR BLACKLEG INFECTION ON CANOLA

PRINCIPAL INVESTIGATOR: Gary Peng, AAFC Saskatoon

FUNDING: Canadian Agricultural Partnership (CAP)

PURPOSE: The study investigates the relative importance of cotyledons vs. lower true leaves for blackleg infection. It is also be of interest 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 as a new option.

PROGRESS: Early results showed that on a susceptible cultivar, infection via cotyledon resulted in >80 per cent blackleg, whereas true-leaf (tested at one- to six-leaf stages) infection caused only five to 15 per cent disease. On resistant cultivars based on the QR trait only, the disease incidence was much lower, especially via the true-leaf infection. The results are being validated in field trials, in combination also with fungicide seed treatment.

FINE-TUNING OF THE BLACKLEG YIELD LOSS MODEL IN CANOLA

PRINCIPAL INVESTIGATORS: Sheau-Fang Hwang and Stephen Strelkov, University of Alberta

FUNDING: Canadian Agricultural Partnership (CAP)

PURPOSE: To refine and improve on an earlier yield loss model by using modern hybrid cultivars

PROGRESS: Despite COVID-19, field experiments were conducted at two sites. Two canola hybrids, rated as moderately resistant to blackleg, were seeded in the field. The stem cross-sections are currently being rated for blackleg disease severity and the plants will be harvested to collect the yield data.

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 (CAP)

Right: Verticillium symptoms outside and inside stem.


Photo: Justine Cornelsen

PURPOSE: The study assesses potential connection between flea beetle feeding and blackleg infection. The study also investigates whether controlling flea beetles with foliar insecticide, using a resistant cultivar and protecting seedlings with a fungicide seed treatment can alleviate the blackleg infection under different flea beetle feeding pressure.
PROGRESS: Under controlled conditions without added moisture, cotyledons were given mechanical wounds and then exposed to the pathogen at various times – zero, two, four, eight, 12 and 24 hours – post wounding. Wounds older than eight hours showed much lower disease incidence than younger wounds, and the pattern was similar on both susceptible and resistant cultivars. This shows that *L. maculans* infects through fresh wounds more readily than through older wounds or intact cotyledons when there is a lack of leaf-surface wetness. Field trial data are still being analyzed.

MANAGING SMALL PATCHES OF CLUBROOT INFESTATION IN CANOLA FIELDS

PRINCIPAL INVESTIGATOR: Bruce Gossen, AAFC Saskatoon
FUNDING: Alberta Canola, SaskCanola, Manitoba Canola Growers
PURPOSE: The main objective is to develop practical recommendations for managing small patches of clubroot in commercial canola fields. The project includes lab studies of rotation crops and grass cover crops, field studies of the efficacy of liming and grasses, and identification of improved techniques for estimating resting spore numbers in soil.
PROGRESS: In the second year of the project, several studies to examine the effect of grass crops and rotation crops on resting spore concentration under controlled conditions have been completed but analysis has been delayed because of the COVID-19 shutdown. Soil samples have been collected from four field sites to assess efficacy of grass crops and liming on reducing spore numbers in fields. An improved (more reliable) molecular test for spore concentration in soil was validated and described in a scientific paper that was published in 2020.

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

PRINCIPAL INVESTIGATOR: Stephen Strelkov, University of Alberta
FUNDING: Alberta Canola, SaskCanola and the Manitoba Canola Growers
PURPOSE: To determine whether strains of the clubroot pathogen respond differentially to soil pH and whether pathogen strains can become adapted to high pH conditions.
PROGRESS: At present, isolates of the pathogen representing different pathotypes are being evaluated for pH sensitivity, including isolates recovered from fields with a higher pH. Work was temporarily suspended due to the COVID-19 pandemic, but has now resumed.

HARVEST MANAGEMENT

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

PRINCIPAL INVESTIGATOR: Brian Beres, AAFC Lethbridge
FUNDING: Canadian Agricultural Partnership (CAP)
PURPOSE: The project is looking at the canola yield effect of seeding rates, hybrid maturity and harvest method.
PROGRESS: The trial was suspended for the 2020 growing season, but results from 2018 and 2019 indicate a connection between a cultivar's maturity and its ideal harvest method. Based on these results, early- or medium-maturing hybrids could produce higher yields when straight combined while later-maturing hybrids could produce greater yield stability if swathed. The study used hybrids with the pod-shatter reduction trait and observed no seed losses, irrespective of harvest method.

GENETICS

UNDERSTANDING THE NEW PATHOGEN *VERTICILLIUM LONGISPORUM* AND ITS INTERACTIONS WITH CANOLA

PRINCIPAL INVESTIGATORS: Dilantha Fernando and Mario Tenuta, University of Manitoba
FUNDING: Canadian Agricultural Partnership (CAP)
PURPOSE: The main objective is to identify and characterize *Verticillium longisporum* isolates from across the Prairies. The researchers will also investigate the longevity of microsclerotia produced by this fungus in canola stems, monitor the pathogen movement in soil or through space, and test canola and rapeseed lines for their resistance to the pathogen and to identify new R-genes.
PROGRESS: Researchers studied two field locations in Manitoba in 2020 and are analysing all field experimental data now. To test the survival rate of Verticillium microsclerotia in soil, stubble with microsclerotia were placed in a miracloth bag and placed at various depths. After intervals of one to 36 months, stubble from the bags will be analyzed for survival of *V. longisporum*. All the bags were buried at the beginning of June 2020. The dispersal study was performed in two locations in Manitoba. Stubble residues were placed in a one by one metre square centre of a 10×10m square region. Plants in the outside edges (up to four metres away) had infection rates of 32.5 per cent for one site and 52.5 per cent for the other site. For the resistance assay of canola varieties, 78 lines were planted for determining resistance to *V. longisporum* at two farms with three replicates. Researchers identified some lines showing high resistance to *V. longisporum* and some displaying high susceptibility to this pathogen.

GENETICS

GENETICS AND GENOMICS OF *BRASSICA-VERTICILLIUM* INTERACTION

PRINCIPAL INVESTIGATOR: Hossein Borhan, AAFC Saskatoon

FUNDING: Canadian Agricultural Partnership (CAP)

PURPOSE: Verticillium stripe cause by the fungus *Verticillim longisporum* (*Vl*) is a challenging disease to control due to the long-term persistence (up to 14 years) of the pathogen spores (microsclerotia) in soil. Being a soil-borne disease, the best control measures are deployment of verticillium resistant cultivars and monitoring the pathogen spread using *V. longisporum* specific molecular markers. Objectives of this research is to identify verticillium-resistant *B. napus* (canola) lines and to develop pathogen diagnostic tools.

PROGRESS: A *B. napus* line with the highest quantitative resistance against *Vl* was crossed with a *B. napus* susceptible line. A doubled-haploid (DH) mapping population was developed to identify the quantitative resistance genetic location. Phenotyping and genotyping of the progenies of this population had to be postponed due to COVID-19. Work on this project is expected to resume upon gradual re-opening of the research labs at AAFC.

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 (CAP)

PURPOSE: The objective of this research project is 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.

PROGRESS: Researchers have cloned the *Rlm9* gene. *Rlm9* encodes a wall associated kinase like (WAKL) protein. WAKLs are a new emerging class of *R* genes and *Rlm9* is the first WAKL to be reported from Brassica. *Rlm9* was intorgressed into the *B. napus* cultivar Topas and provided to the industry as a donor line to be used in canola breeding against blackleg disease.

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 (CAP)

PURPOSE: Adult plant resistance (APR), also called quantitative resistance, is the most favourable form of genetic resistance against blackleg disease, since it is controlled by several genes, hence being more durable. Despite its importance, it is very challenging to identify and introduce APR into canola cultivars. The goal is to optimize a protocol for identifying APR to blackleg disease under controlled conditions (growth chamber) and validate results in the field. Molecular markers associated with the APR genes will be developed and offered as a diagnostic and breeding tool.

PROGRESS: A growth chamber assay identified 47 lines with APR. A population that consisted of 36 of these lines were tested for their response to blackleg disease in a field trial conducted in Morden, MB. Presence of APR was confirmed under the field conditions, which indicates the validity of the growth-chamber-based assay. Further confirmation tests will be conducted.

TOWARDS BETTER UNDERSTANDING OF GENETICS IN *LEPTOSPHAERIA-BRASSICA* INTERACTIONS

PRINCIPAL INVESTIGATOR: Hossein Borhan, AAFC Saskatoon

FUNDING: Alberta Canola, SaskCanola

PURPOSE: 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. Borhan will coordinate efforts with the international blackleg research community to expand the current set of host differentials for new *R* genes and define a common set of *Leptosphaeria maculans* differential isolates.

PROGRESS: Collaboration between AAFC and INRA (France) has led to the cloning of AvrLep2/AvrLmS. Coordination of research activities and exchange of materials had little progress due to COVID-19.

FROM FIELD TO THE GENOME, APPLICATION OF THIRD GENERATION SEQUENCING TO DIRECT GENOTYPING OF CANOLA PATHOGENS

PRINCIPAL INVESTIGATOR: Hossein Borhan, AAFC Saskatoon

FUNDING: Alberta Canola, SaskCanola

PURPOSE: 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.

PROGRESS: Target capture enrichment and re-sequencing of soil spiked with various concentration of clubroot spores was successful in recovering close to 580 predicted effector genes. Collection of soil samples and application of this approach to naturally infected samples from canola fields awaits lifting restriction for travel and lab activities imposed by COVID-19.

Above: Gavin Chen, researcher at the University of Alberta, is studying how one specific enzyme might increase tolerance to drought, heat or freezing stress in canola.

IMPROVING HEAT AND DROUGHT RESISTANCE IN CANOLA (*BRASSICA NAPUS*) THROUGH REGULATING DIACYLGLYCEROL ACYLTRANSFERASE ACTIVITY

PRINCIPAL INVESTIGATOR: Gavin Chen, University of Alberta

FUNDING: AlbertaCanola

PURPOSE: Heat and drought stress can cause a severe negative impact on canola seed yield and quality. The over expression of diacylglycerol acyltransferase 1(DGAT1), an enzyme catalyzing the last commitment step of seed oil biosynthesis, can increase tolerance to drought, heat or freezing stress in the model plant Arabidopsis. This study will generate and evaluate canola lines with distinct modifications of DGAT1 under heat and drought stress and to identify additional candidate genes related to heat and drought stress via transcriptomic analysis of the canola lines.

PROGRESS: Researchers are in the process of generating DGAT1 constitutive over-expression canola lines. In addition to the native *B. napus* DGAT1, two high-performance DGAT1s are being identified via directed evolution are also used in the experiments. Researchers are making constructors with the DGAT1 genes, which will be used to transform a wild-type canola line.

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

PURPOSE: The study will 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 resistance is not strongly associated with the two well-known sources, so could be a new source of resistance.

PROGRESS: Introgression of resistance from *B. rapa var. rapifera* (radish) and *B. rapa var. chinensis* (Chinese cabbage) into *B. napus* is completed. A few hundred reconstituted *B. napus* lines carrying resistance to pathotype 3/3A were tested in a clubroot diseases infested field which carry pathotype 5X. Several lines showed resistance to the pathotypes present in this field. Marker development for these resistances is in progress. Some research has been delayed due to COVID-19.

DEFINING POPULATIONS OF *P. BRASSICAE* WITH NEAR ISOGENIC *B. NAPUS* LINES

PRINCIPAL INVESTIGATOR: Fengqun Yu, AAFC Saskatoon

FUNDING: SaskCanola, Saskatchewan Agriculture Development Fund

PURPOSE: This study aims 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.

PROGRESS: Six near isogenic lines have been obtained, and further selection from other double-haploid lines will be resumed. Major pathotypes of *P. brassicae* have been classified into five clades.

GENOME WIDE FUNCTIONAL ANALYSIS OF *PLASMODIOPHORA BRASSICAE* EFFECTORS AND THE MANAGEMENT OF CLUBROOT DISEASE.

PRINCIPAL INVESTIGATOR: Peta Bonham-Smith, University of Saskatchewan

FUNDING: SaskCanola, Saskatchewan Ministry of Agriculture

PURPOSE: The main objective is to profile *Plasmodiophora brassicae* candidate effector proteins. Using the RNA-Seq data from clubroot-infected Arabidopsis, previously generated by the same research group, the researchers have identified candidate effector proteins secreted by the clubroot pathogen during secondary infection. A number of these effectors have been characterized and researchers are currently identifying their target plant proteins. Levels of clubroot resistance of the plant target protein mutants is also being explored as potential sources of resistance to clubroot disease.

PROGRESS: A number of candidate effector proteins have been characterized and their role in plant effector-triggered immunity is being established. Characterization of more effector proteins continues.

ENHANCING YIELD AND BIOMASS IN CANOLA BY MODIFYING CARBOHYDRATE METABOLISM

PRINCIPAL INVESTIGATOR: Michael Emes, University of Guelph

FUNDING: Canadian Agricultural Partnership (CAP)

PURPOSE: These researchers found that when the endogenous leaf starch branching enzymes (SBEs) in Arabidopsis are replaced with maize endosperm homologues, the result was a 250 per cent increase in total seed oil produced per plant. Because canola (*Brassica napus*) is genetically close to Arabidopsis, this study will look into a transfer of the above technology to canola.

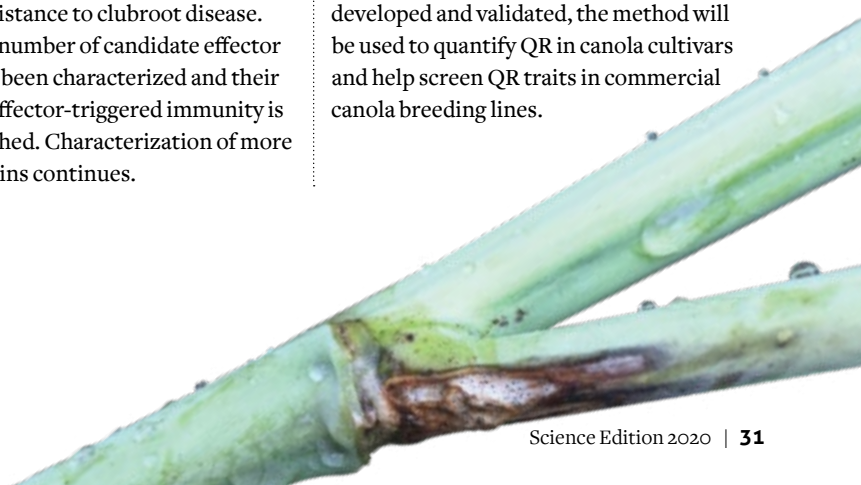
PROGRESS: Six SBEs were identified in the canola cultivar DH12075 and a range of mutants in up to six canola starch branching enzyme genes have been obtained using the CRISPR-Cas9 system. The polyploidy genetic background added a complexity and prolonged the timeline for characterizing a completely null mutant. Overexpression of maize endosperm homolog of SBE I in a quadruple-mutant canola background has generated some lines showing promising traits. A small-scale field trial is under way. Further evaluation of the impact on yield is in progress.

DEVELOPING A ROBUST SYSTEM FOR EFFICIENT ASSESSMENT OF QUANTITATIVE RESISTANCE IN COMMERCIAL CANOLA LINES AND VARIETIES FOR BLACKLEG MANAGEMENT

PRINCIPAL INVESTIGATOR: Gary Peng, AAFC Saskatoon

FUNDING: Canadian Agricultural Partnership (CAP)

PURPOSE: This study explores a ddPCR-based protocol to measure quantitative resistance (QR) to blackleg in canola. Once developed and validated, the method will be used to quantify QR in canola cultivars and help screen QR traits in commercial canola breeding lines.



PROGRESS: More than 50 canola hybrids/inbred lines with varied blackleg resistance in multi-year field trials were gathered from seed companies. Initial experiments identified a relationship between the level of QR and the amount of pathogen DNA detected in infected canola tissues. This relationship is being validated using petiole and cotyledon inoculations under greenhouse and field conditions. The results showed a high correlation between disease levels observed in both conditions and QR based on ddPCR measurement. The next step is to test more commercial breeding lines/cultivars for QR screening/identification/quantification.

IDENTIFICATION AND GENETIC MAPPING OF NOVEL GENES FOR RESISTANCE TO BLACKLEG IN CHINESE AND CANADIAN *BRASSICA NAPUS* VARIETIES/LINES/GERMPLASM

PRINCIPAL INVESTIGATOR: Dilantha Fernando, University of Manitoba
FUNDING: SaskCanola, Alberta Canola
PURPOSE: This study will identify and maps new sources of blackleg resistance.
PROGRESS: Through screening Chinese *B. napus* lines, researchers discovered one line containing unknown *R* genes. The inheritance model analysis indicated that the resistance was controlled by a single gene. Research is identifying markers, which will be useful for marker-assisted selection as well as fine-mapping of this locus.

IMPROVING BLACKLEG RESISTANCE DURABILITY THROUGH *R*-GENE ROTATION IN COMMERCIAL FIELDS ON THE CANADIAN PRAIRIES

PRINCIPAL INVESTIGATOR: Dilantha Fernando, University of Manitoba
FUNDING: Canadian Agricultural Partnership (CAP)
PURPOSE: This study will 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.
PROGRESS: Westar (No *R* gene), var (E1 (*Rlm4*)), 6090RR (AC (*LepR3*/*Rlm3*), and CS2400 (*CX* (*Rlm3*/*RlmX*) were set as non-rotation control in year 2020. A new variety with *Rlm2* was introduced to the rotation with the canola varieties CS2400 and 74-44BL from year 2019. Susceptible canola variety Westar showed the highest disease incidence (99.3 per cent) and severity (4.13) in Manitoba. The new introduced *Rlm2* showed the lowest disease incidence (36.5 per cent) when rotated with the canola variety 74-44BL (2019). Also, it showed lower disease incidence (64.5 per cent) when rotated with the canola variety CS2400 (2019). Similarly, the *Rlm2* plots displayed lower disease severity values (1.44-1.78). Plots seeded to the same canola variety without *R* gene rotations showed both higher disease incidence and severity.

GENETIC RESOURCES FOR FLEA BEETLE RESISTANCE IN CANOLA

PRINCIPAL INVESTIGATOR: Dwayne Hegedus, AAFC Saskatoon
FUNDING: Canadian Agricultural Partnership (CAP)
PURPOSE: Researchers at AAFC and the University of Saskatchewan previously identified Brassica species that produced hairs (trichomes) that deter flee beetle feeding. This project is investigating 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.
PROGRESS: Two *B. napus* lines with bristly/coarse hairs and a single *Brassica villosa* line that is densely covered with short/soft hairs are being investigated. Genetic analysis of crosses between hairy and non-hairy *B. napus* lines revealed that the presence/absence of hairs is controlled by a single gene and that trichome abundance is controlled by additional genes. Crosses between *Brassica villosa* and *Brassica oleraceae* were successful in bringing the short/soft hair trait into a background that is more amenable to crossing with *B. napus*.

WEEDING OUT SECONDARY DORMANCY POTENTIAL FROM VOLUNTEER CANOLA

PRINCIPAL INVESTIGATORS: Sally Vail, AAFC Saskatoon; Rob Gulden, University of Manitoba
FUNDING: Canadian Agricultural Program (CAP)
PURPOSE: Underlying the persistence of volunteer canola in weed seed banks is the secondary dormancy potential of the species. The objective of this project is to develop molecular breeding tools to eventually be used in commercial breeding programs to reduce the secondary dormancy potential of canola.
PROGRESS: The spring *Brassica napus* Nested Association Mapping population is the germplasm and genomic resource that is being used to used to study the genetics of secondary dormancy potential in this project. Seed of select recombinant lines was produced in contrasting environments for assessing the likelihood of induction into secondary dormancy. For this, an established screening method under controlled conditions is being used. Screening was interrupted due to COVID-19 and will resume in the fall of 2020.

MAKING OF A MORE SUSTAINABLE CANOLA: USING GENETIC DIVERSITY TO IMPROVE NITROGEN USE EFFICIENCY.

PRINCIPAL INVESTIGATORS: Sally Vail, AAFC Saskatoon
FUNDING: Canadian Agricultural Program (CAP)
PURPOSE: This project will determine what makes a spring canola plant nitrogen-use efficient by characterizing the above-ground and root components of the plant, the correlation of shoot vs root components, the overall growth parameters and flowering patterns in response to nitrogen (N). In addition, this project will examine how to improve N-capture (NUpE) and repartitioning within the plant (NUtE). Through characterization of these phenotypes and by correlating these phenotypes with the genetic make-up of the lines, we will eventually provide the industry with methods to predict the N-response for new lines, without having to test individual lines and hybrids.
PROGRESS: Successful field trials evaluating a historical series of rapeseed and canola cultivars under high and low nitrogen fertilization levels were conducted at Saskatoon and Melfort in 2019 and 2020. Thousands of data points and samples were collected from the trials. Due to COVID-19, greenhouse and laboratory components of this project have been delayed.

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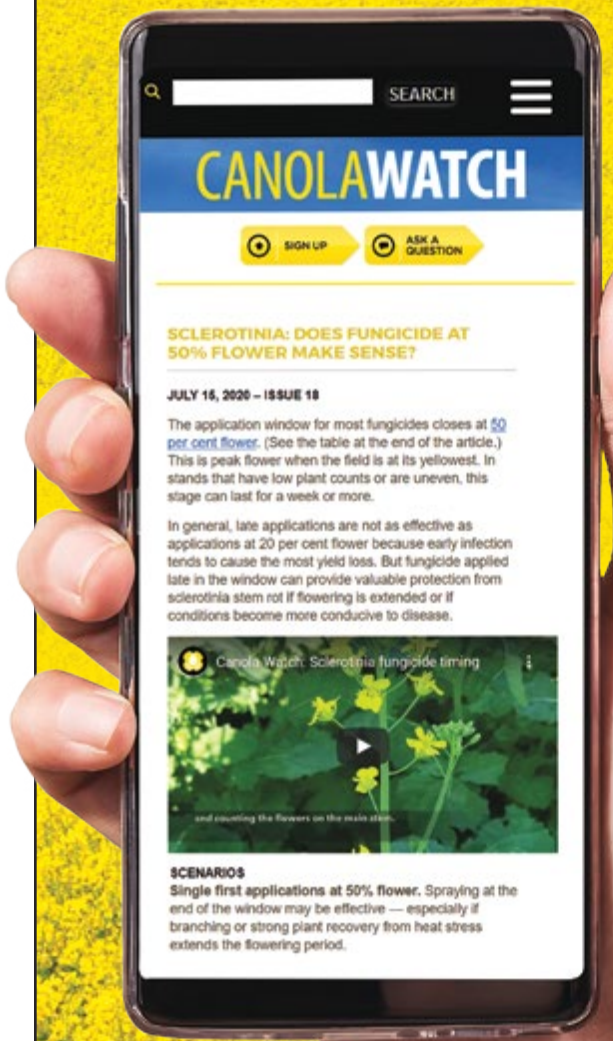

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