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Science Edition 2018

canola DIGEST

The Source for Canada's Canola Growers

SCIENCE OF SUSTAINABILITY

How lower nutrient losses, increased biodiversity and higher productivity can improve economic and environmental sustainability.

INSIDE:

Practical agronomy tips to improve sustainability and profitability

FARMER PERSPECTIVES

SUSTAINABILITY METRICS: We keep getting better

canola council OF CANADA

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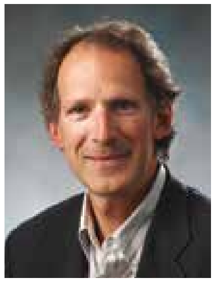

CURTIS REMPEL
Vice President,
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Alignment

Citizens globally and governments expect agricultural producers to grow more food per acre of arable land and do so while preserving soil and water health, air quality, and biodiversity. This is what 'sustainability' has come to mean.

The Canola Council of Canada (CCC) is guided by Keep It Coming 2025 (**keepitcoming.ca**), the strategic plan for the industry that pledges sustainable, reliable canola supply. The canola industry's sustainability goals (see page 4) are intended to align with the United Nations' sustainable development goals (**un.org/sustainabledevelopment**), which have become part of the language of sustainable food production for countries and companies around the world. These goals also align with Canadian Field Print (**fieldprint.ca**) and Canadian Round Table for Sustainable Crops (**sustainablecrops.ca**) sustainability platforms. The canola industry will continue to work with various partners including environmental conservation organizations and levels of government in order to achieve its goals.

By first aligning and then implementing our sustainability goals and metrics, the Canadian canola industry demonstrates to customers a commitment to sustainable, reliable supply through continuous improvement of production practices.

A key sustainability objective is to increase the national average canola yield to 52 bu./ac. per acre. Why 52? Because the predicted global demand for Canadian canola is 26 million tonnes by 2025 and in order to meet that demand on the same number of acres, we need yields of 52 bu./ac. In achieving this goal, Canada will reduce energy use per tonne of canola produced, increase carbon sequestration and increase land efficiency.

EFFECTIVE ACTIONS WITHIN EACH PILLAR

The sustainability objectives are built around the five pillars of Keep It Coming 2025, listed below. Steady advancement within these five pillars will support our sustainability goals while increasing yields and profitability at reduced production risk.

- **Pillar 1: Plant Establishment –** A healthy, uniform stand established early and with minimum tillage will increase land efficiency and carbon sequestration and reduce energy use.
- **Pillar 2: Fertility Management –** Adoption of 4R Nutrient Management guidelines along with precision agriculture and data management will target crop nutrition applications to the plant at rates and timing required and use forms that will reduce loss to the air and water.
- **Pillar 3: Integrated Pest Management –** Better scouting methods, updated insect thresholds that incorporate the contribution of natural enemies, and valuation of the economic benefit of natural habitat will increase profitability, biodiversity, carbon sequestration and land efficiency.
- **Pillar 4: Harvest Management –** Genetics and management practices to promote later swathing or straight cutting, reduce harvest losses and lower storage risks will increase the amount of canola that gets to market, thereby reducing fuel and land use per tonne of crop.
- **Pillar 5: Genetic Improvement –** Public and private canola breeders will develop traits for improved water and nutrient use efficiency, higher yields, greater stress tolerance and protection against current and emerging pest threats.

The industry's investment in research is at the core of these tools and techniques to enhance economic and environmental sustainability of canola production in Canada. The *2018 Canola Digest Science Edition* is just one way to demonstrate the strong collaborative network involved and to improve knowledge transfer throughout the entire value chain.

canola DIGEST
Science Edition 2018

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CANOLA'S SUSTAINABLE FUTURE

The canola industry is focused on the future. We know that we must not only increase yield, we must also be a partner in achieving society's environmental goals. That's why we have set bold environmental sustainability goals to accompany our 2025 production goals:

USE LESS ENERGY

18% REDUCTION in fuel use per bushel

INCREASE LAND EFFICIENCY

40% DECREASE in the amount of land required to produce one tonne of canola

SEQUESTER MORE CARBON

sequestering additional **5 MILLION tonnes** of greenhouse gas emissions in Canadian soils, every year

IMPROVE SOIL & WATER HEALTH

Utilize 4R nutrient stewardship practices on **50% OF CANOLA ACRES**

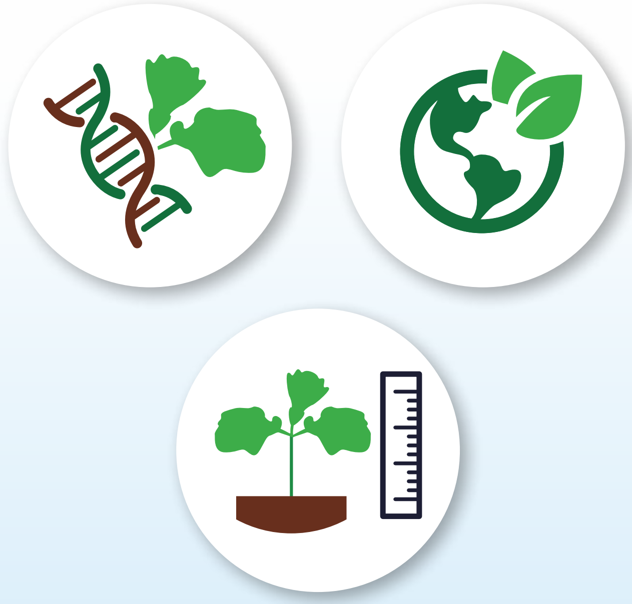
PROTECT BIODIVERSITY

Safeguard over **2,000 BENEFICIAL INSECTS** that call canola fields and surrounding habitat home

INNOVATION IS KEY TO CONSERVATION

Utilizing science and innovation to identify the best sustainability practices is how farmers have and will continue to significantly reduce canola's environmental footprint.

By adopting leading-edge innovations, farmers are able to produce more canola per acre while maintaining the existing farmland footprint. New plant varieties with traits such as herbicide tolerance and innovations in crop protection and nutrient management have improved yields and helped farmers to grow crops more efficiently and profitably.



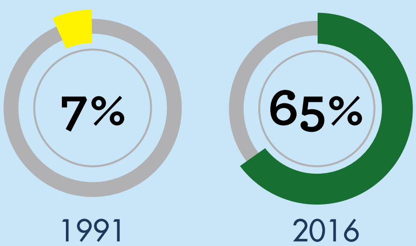
SEQUESTERING CARBON AND BUILDING HEALTHY SOILS

Canola farmers take pride in how they care for their most valued resource, their land. In 1991, 7% of Western Canadian farmland was seeded with no-till practices. By 2016, this number had grown to 65%.[1]

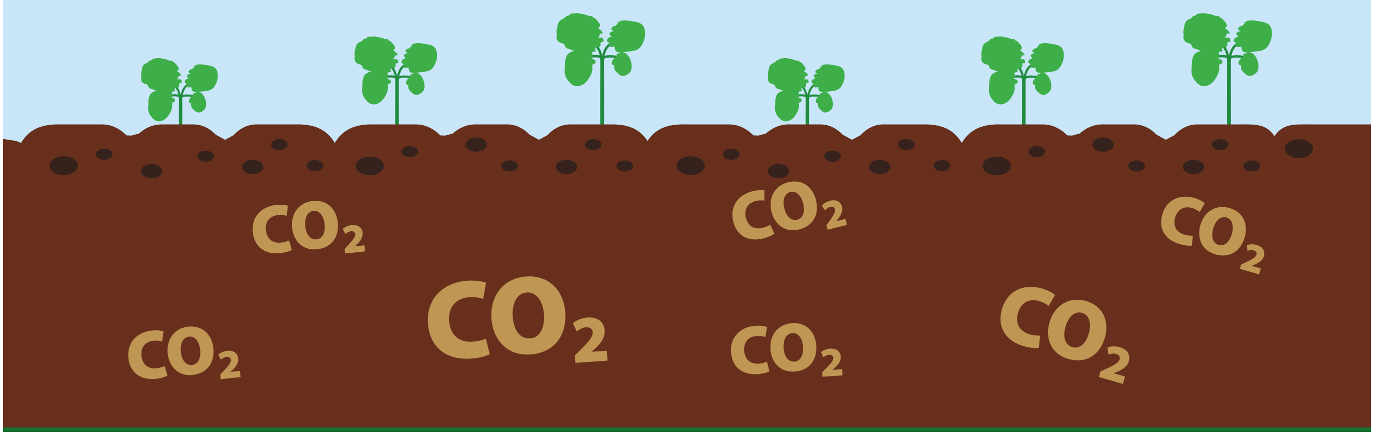
When soils are left untilled, they sequester greenhouse gases. Low-till and no-till farming help Canadian farmers sequester 11 million tonnes of greenhouse gases in their fields every year.[2] 70% of this sequestration has been due to canola. Conservation tillage[3] practices not only sequester carbon, they preserve organic matter in the soil, conserve moisture, and reduce erosion.

The combination of conservation tillage and growing herbicide-tolerant crops means Canadian farmers are making fewer passes over their fields and using less fuel. Conservation tillage practices have resulted in 126-194 million fewer litres of diesel fuel used on Canadian farms each year, reducing GHG emissions by about 450,000 to 750,000 tonnes per year.[4]

Western Canadian farmland seeded with no-till practices



With low- & no-till practices, Canadian farmers sequester 11 million tonnes of greenhouse gasses annually.



[1]CANSIM Tables 004-0010 and 004-0205, Statistics Canada
[2]Environment and Climate Change Canada, *National Inventory Report: 1990-2015, Greenhouse Gas Sources and Sinks in Canada*, (Ottawa: Environment and Climate Change Canada, 2017) at 213
[3]Conservation tillage describes practices that leave agricultural soil relatively undisturbed, such as low-till and reduced-till, as well as practices that seed directly into soil, such as zero-till and no-till.
[4]RIAS Inc, *The Value of Plant Science Innovations to Canadians*, Prepared for CropLife Canada (Ottawa, 2015) at 4

RESPONSIBLE USE OF CROP INPUTS

The canola industry employs a unique network of agronomists dedicated to working with farmers in helping them adopt innovative and sustainable practices like the 4R Nutrient Stewardship Program, which outlines best management practices for the responsible use of important plant nutrients like nitrogen fertilizers. Implementing this program across Western Canada would realize a 1-2 million tonne reduction in greenhouse gases.

4R nutrient stewardship

One of the greatest challenges in growing canola is competition from weeds. Today's herbicide-tolerant varieties have allowed farmers in Canada to reduce the amount of herbicide they use by 20% since 1996.[5]

CANADIAN CANOLA'S CARBON FOOTPRINT VERSUS OUR CANOLA GROWING COMPETITORS.

CANOLA'S SMALLER, SOFTER FOOTPRINT

Between 1981 and 2011[6]:

43%
ENERGY USE
REDUCED BY 43%

31%
LAND USE EFFICIENCY
IMPROVED BY 31%
(per tonne of production)
Land use efficiency updated with StatCan data.

71%
GREENHOUSE GAS
EMISSIONS WERE REDUCED BY 71%
CO_2

SUPPORTING **BIODIVERSITY**

Did you know canola fields provide habitat for over 2,000 beneficial insects, including native pollinators and honeybees? New technologies, such as seed treatments, allow farmers to target pests that damage canola seedlings, while allowing other beneficial insects to flourish.

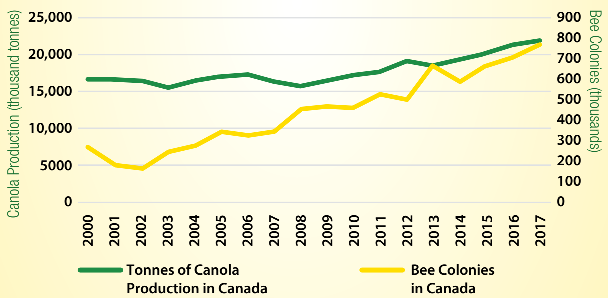
[5]Graham Brookes and Peter Barfoot, "Environmental impacts of genetically modified (GM) crop use 1996 – 2015: Impacts on pesticide use and carbon emissions" (2017) 8 GM Crops & Food 117 – 147 at 121

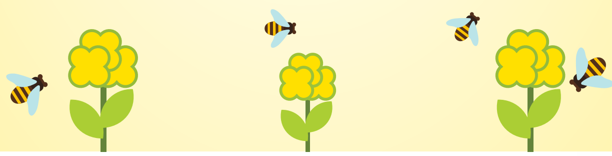
[6]Serecon Inc., *Final Report: Application of Sustainable Agriculture Metrics to Canadian Field Crops 2015*, (Edmonton: Prepared for the Canadian Field Print Initiative, March 2016), at 53-56

CANOLA AND BEES:
A SWEET RELATIONSHIP

Canola is an ideal food source for honeybees, while honeybees can have a positive impact on canola production. Canola farmers work closely with beekeepers to protect bees and this mutually beneficial relationship. Over several decades, canola seeded acres and honeybee colonies have shared a linear increase in numbers.

HONEYBEE COLONIES GROW





CERTIFICATION

Canola is the only Canadian crop to have growers certified sustainable by the International Sustainability and Carbon Certification (ISCC) body[7]. ISCC certification targets the reduction of greenhouse gas emissions, sustainable use of land, and the protection of natural habitats.

ISCC
International Sustainability & Carbon Certification

The canola flower is more than just a pretty sight – it's reflective! A flowering canola crop creates a bright yellow canopy covering approximately 20 million acres in Western Canada. This canopy provides an important cooling effect by reflecting the sun's light away from the earth.

[7] International Sustainability and Carbon Certification Website, www.iscc-system.org

The sustainability of higher yields

Increased production per acre can have trickle-down benefits for the farm economy and for the environment, as long as those higher yields are achieved through greater efficiency of inputs and care for the land.

Higher yields can improve economic and environmental sustainability of Canadian farms if these yields are achieved based on the practices described throughout this magazine: Improved nutrient efficiency based on lower nutrient losses per acre. Lower pest management costs due to better stand establishment, increased biodiversity and decisions based on insect thresholds. Bigger harvests due to later cutting and reduced losses at the combine.

Higher yields also mean that Canada's canola industry can meet its goal within the same land base, which maintains the diversity of crops and conserves natural habitats in Western Canada.

The canola industry goal to increase canola production to 26 million tonnes by producing 52 bu./ac. by 2025 will also:

Reduce fuel use per bushel by 18 per cent. This is based on Manitoba Agriculture's *Guidelines for Estimating Crop Production Costs*. It pegs fuel use for canola at 22 litres per acre. The 18 per cent gain is based on fuel use holding steady while yields increase from 43 bu./ac. average in 2016 to 52 bu./ac. in 2025.

Decrease by 40 per cent the land required to produce one tonne of canola. The canola industry's strategic plan is to produce 26 million tonnes on 22 million acres. Based on census data from 2011, the last census before launch of the strategic plan, Canada produced 14.6 million tonnes on 18.8 million acres. The gain in productivity is about 40 per cent.

Sequester an additional five million tonnes of greenhouse gas emissions. This is based on new carbon calculations, which make it easier to attribute carbon change to individual crops, says Agriculture and Agri-Food Canada (AAFC) research scientist Brian McConkey. Based on those calculations, the 52 bu./ac. target yield would increase Canada's soil carbon sequestration by five million tonnes of CO_2 per year, relative to 2005.

CANOLA'S SMALLER, SOFTER FOOTPRINT

The Canadian Roundtable for Sustainable Crops (CRSC) initiated the Canadian Field Print Initiative to track sustainability changes in Canadian crop production. In 2014, funding was secured from AAFC under Growing Forward 2. The result was a benchmark report from Serecon, "Final Report: Application of Sustainable Agriculture Metrics to Canadian Field Crops 2015." Canadian Canola Growers Association, which is part of CRSC, posted the report at its website, **ccga.ca**.

The Serecon report demonstrated big improvements in sustainability metrics for canola in the 30 years from 1981 to 2011:

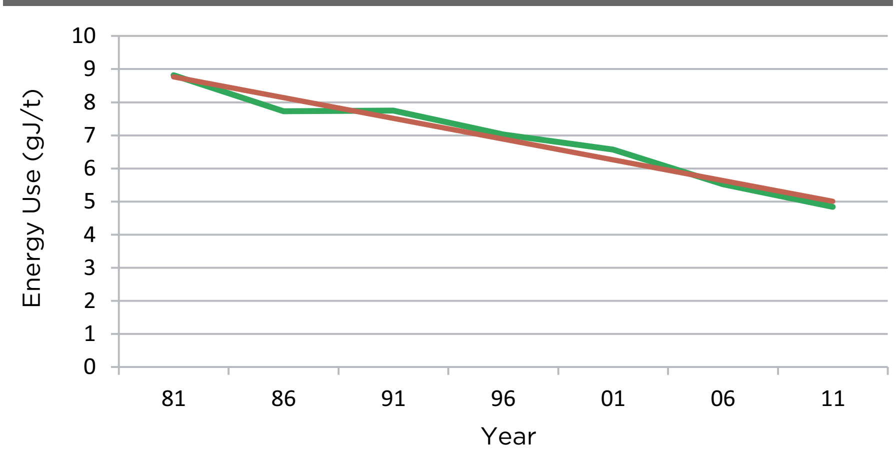
Energy use reduced by 43 per cent per tonne. Energy use per harvested hectare dropped by eight per cent from 1981 to 2011, due in large part to reduced tillage. With the increase in canola yields factored in, energy use per tonne of canola produced dropped by 43 per cent through those 30 years (see graph below).

Land use efficiency is all about productivity per acre: generating more food from the same land base. The amount of land required to produce one tonne of canola went from 0.9 hectares (2.2 acres) in 1981 to around 0.55 hectares (1.4 acres) in 2011.

Greenhouse gas emissions reduced by 71 per cent. Reduced fuel use as a result of conservation tillage is one factor. Another is nitrous oxide emissions from various nutrient-related functions, converted to 'CO_2 equivalent'. Tonnes of CO_2 equivalent produced per hectare dropped from around 1.2 in 1981 to just over 0.6 tonnes per hectare in 2011, which is around 50 per cent. With the yield factor, this works out to a 71 per cent drop per tonne of canola produced.

Serecon also reported soil loss per hectare on an overall (non crop specific) basis. In 2001, AAFC reported soil loss per hectare at 5.66 tonnes for Western Canada. In 2011, this was 3.42, which is a big improvement but something for growers to keep in mind. Soil losses continue.

Graph 1. Canola, Prairies – Energy Use per Tonne



Source: Final Report: Application of Sustainable Agriculture Metrics to Canadian Field Crops 2015, Serecon, Graph 57. Energy use is given as gigaJoules per tonne.

SUSTAINABILITY METRICS

Canola accounts for 70% of the increase in soil organic carbon

Canada's much-increased soil carbon sequestration since 2005 has been driven largely by the increase in area and yield of canola.

BY DONNA FLEURY

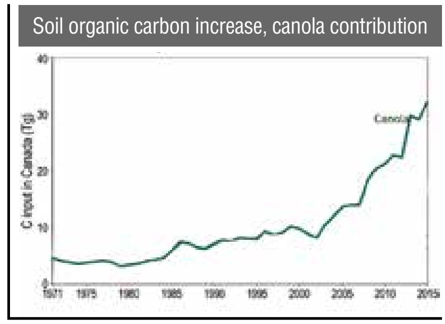
As growers have been increasing yields and diversifying rotations to crops such as canola, carbon sequestration and soil organic carbon levels (SOC) have been increasing significantly over the past few years. A recent study conducted by researchers with Agriculture and Agri-Food Canada (AAFC) focused on quantifying carbon (C) inputs and SOC sequestration for agriculture cropping systems.

"Based on a modelling approach, our results show that increasing crop yields and adopting crop mixes that input proportionately more below-ground C, such as canola and oat, showed additional opportunity to sequester SOC," explains Brian McConkey, research scientist with AAFC in Swift Current, Saskatchewan. This is because canola has more roots and residue than other crops.

Canada has had a much-increased carbon sink since 2005, and it has been driven largely by the increase in area and yield of canola, McConkey says. "Of the recent SOC increases, canola contributed 70 per cent of the total increase in carbon inputs, with the total C input by canola 1.5 times that of wheat."

The majority of carbon input from canola to the soil is mostly above-ground residue and roots that grow near the surface. Canola also has a larger below-ground root mass than most other annual crops, which could add a third more to the total carbon sequestration. "For growers, implementing good agronomic practices that improve productivity and yield translates to better SOC. What is happening below ground in terms of SOC is determined by what you see above ground with vigour and the amount of crop biomass and yield. Although our study didn't focus directly on tillage systems, combining no-till with high yielding and herbicide-tolerant canola varieties, can help maintain the highest level of productivity, which is key to increasing SOC. Reduced and no-till systems not only contribute to increased SOC inputs, they also help conserve moisture and reduce erosion."

Until this study, researchers knew there was a large effect but hadn't really been able to quantify the SOC from increasing crop yield. To do this, they had to include all changes to C inputs including manure additions and removal of crop residues for bedding and fodder. These results add confidence to the project estimates, which were often missing from previous calculations.



"Overall, this increase in SOC contribution from crops like canola has helped move agriculture to approaching carbon neutrality by removing or compensating for as much greenhouse gas (GHG) as is being emitted," says McConkey. "SOC sequestration from increasing crop yield and switching to crops like canola with higher below-ground C input shows a potential to offset most of Canadian agricultural GHG emission since 2015. The C input by crops such as canola continues to increase by about 1.5 per cent per year, providing growing benefits to climate mitigation strategies."

—Donna Fleury is a professional agrologist and freelance agriculture/science writer from Alberta.

FARMER PERSPECTIVE

RON KRAHN
Manitoba Canola Growers director, Rivers, Man.

No-till a 'win'

My dad experimented with zero tillage in the early 1980s, before glyphosate was cheap. He was determined to find a way to be successful and 1997 was our last year for tillage.

I will apply anhydrous ammonia in the fall with 3/4" openers on 12" spacing, but we're never tilling for the sake of tillage.

Zero tillage has been a win for us. It has many benefits, starting with less work and less fuel used. It means our soils have more moisture, which makes a big difference in a dry spring like we had in 2018. Somewhere along the way my dad heard that every tillage pass loses the equivalent of about 1" of moisture. Zero tillage means less wind erosion. We had so much soil blowing around in the 1980s, we had fields where we could drive straight off the road and into the field because the ditches were full of our topsoil. You want to talk sustainability? It's hard to be sustainable when your topsoil is gone. Finally, and this will seem counter to the culture of tillage, I believe zero tillage can also have benefits in a really wet year. With good soil structure that you get with zero tillage, these fields hold up machinery better than a tilled field in wet conditions.

I don't ever want to go back to tillage, but tools like glyphosate to control weeds help make zero tillage possible for us. I hope people recognize the possible bigger damage that could be done to the environment if tools like glyphosate are banned.

A good stand is the foundation for success

A uniform early-established canola stand of six to eight plants per square foot can reduce pest management costs, allow for earlier harvest and improve yield compared to thinner, later and uneven stands.

The tools at **canolacalculator.ca** will help growers understand how their individual scenarios influence plant density targets and seeding rates. The video "Canola Stand Establishment: A Grower Q&A", available at **youtube.com/canolacouncil**, provides a good overview of factors affecting canola emergence.

Plant establishment is one of the five pillars in the Canadian canola industry's goal to increase average yields to 52 bu./ac. by 2025. This yield will allow Canada's canola industry to keep pace with global increases in oil and meal demand while keeping a cap on acres.

A uniform early-established canola stand of six to eight plants per square foot usually yields better than thinner, later or uneven stands. It also improves nitrogen use efficiency and maintains soil organic carbon levels. It makes crop more competitive with weeds and makes it easier to time disease management applications. It makes harvest timing decisions easier. A good stand is the foundation for economic and environmental sustainability.

The target of six to eight plants per square foot is based on meta-analyses by Steve Shirtliffe, professor and researcher at the University of Saskatchewan, and Murray Hartman, oilseeds specialist with Alberta Agriculture. They looked at results for numerous Western Canadian canola studies and found that, overall, hybrid canola achieved 90 per cent of its yield potential with as few as four to five plants per square foot. But a canola crop that misses this minimum threshold can see a dramatic drop in yield and profitability. The target of six to eight plants per square foot allows for the loss of a couple of plants to frost, insects or other establishment threats.

Here are a few practices to improve stand establishment:

Calibrate seeding rate based on seed size and population target. The Target Plant Density and Seeding Rate Calculators at **canolacalculator.ca** will help farmers set a plant population target that suits their risk factors and a seeding rate that accounts for seed size, which can vary significantly from lot to lot. The 2012 *Survey of Management Practices Used by Canola Producers in Western Canada* by Blacksheep Strategy Inc., found that 36.8 per cent of producers calibrate their seeding rate to a specific plant population. It could be much higher than that now.

Slow down. The appropriate seeding speed for good seed and fertilizer placement will depend on the opener and how it performs in given soil types and soil moisture conditions. It takes some digging to compare seed placement and fertilizer separation across the width of the drill, and to see how speed influences this placement. If a drill is not performing as needed, slow down in one-mph increments until placement improves.

Use precision tools for accurate placement in high-residue situations. Direct seeding into residue while also providing consistent seed depth and separation between seed and fertilizer bands can help canola reach many sustainability goals, including higher yield, increased carbon sequestrations and lower greenhouse gas emissions (GHG). In the 2012 Blacksheep survey, 87.4 per cent of canola producers used a conservation tillage system. Soil carbon sequestration from conservation tillage reduces GHG emissions by 0.18 kg of carbon dioxide equivalent (CO_2e) per kg of canola.

Early establishment improves yield, reduces GHG intensity. In a GF2-funded study, Agriculture and Agri-Food Canada (AAFC) research scientist Vern Baron found that early-planted canola will provide a more sustainable on-farm footprint than late-planted canola. From an economic perspective, Baron showed that the land base required to net $100,000 was 442 acres for early-planted canola and 946 acres for late-planted canola. As is often the case, the yield benefit also provided an environmental benefit: GHG intensity per bushel for late-planted canola was about 2.5 times larger than early-planted canola (See Table 1.) Even though overall emissions for late-planted canola were lower than for early-planted canola, the lower yield made the emissions-per-bushel worse. Also, total inputs that contribute to nitrous oxide emissions were greater for late-planted canola than early-planted canola, even though fertilizer-N inputs were the same.

Second in-crop herbicides may not be needed. With six to eight plants emerging from a seeding depth of around one inch, canola can achieve fairly early ground cover. This can have early season economic and environmental benefits by eliminating the need for a second in-crop application of herbicide.

Table 1. Yield and GHG benefits of early-seeded canola

	Intensity
	kg CO_2e kg grain
Early canola	0.73
Late canola	1.76

Early planted canola requires more energy and releases more nitrous oxide than late planted canola but that's because it grows longer and yield way more. In Baron's study, early-seeded canola yielded about 1,400 kg/ha more than late-seeded canola. Soil carbon loss is also less for early seeded. This makes its greenhouse gas (GHG) intensity much lower.

Source: Vern Baron, AAFC. GHG intensity is based on crop lifecycle GHG emissions (given as kilograms of carbon dioxide equivalent) per hectare divided by yield (kg/ha).

The 'cool' crop

Crops can reflect the sun's shortwave radiation back into space, helping to cool the Earth. With its yellow flowers, canola's reflectance is more than most other crops, providing a cooling effect of about 0.5°C during the growing season as compared to a crop like wheat.

BY DONNA FLEURY

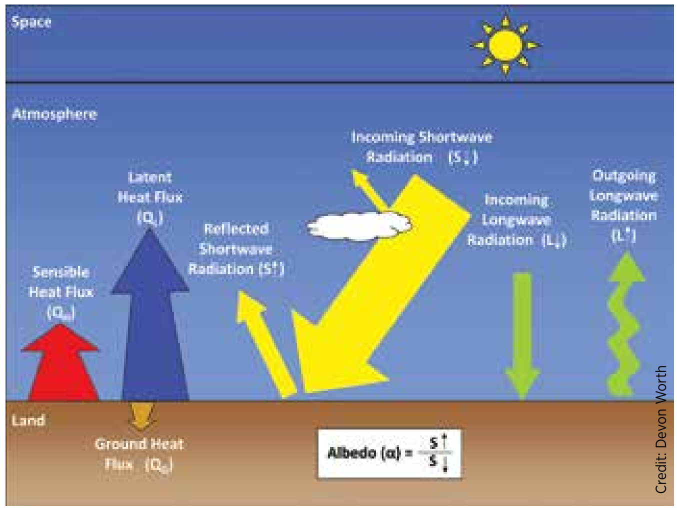
The canola flower is more than just a pretty sight – it's highly reflective! A flowering canola crop creates a bright yellow canopy covering approximately 20 million acres in Western Canada. This canopy, which reflects solar radiation away from the Earth, has the potential to provide a significant cooling effect.

"A few years ago, as part of a World Meteorological Organization sponsored workshop on the contribution of agriculture to the state of climate, we examined the reflectance of different types of vegetation and reported a large positive impact from agricultural crops as compared to native vegetation in cooling the atmosphere," explains Ray Desjardins, atmospheric scientist with Agriculture and Agri-Food Canada (AAFC) in Ottawa. "More recently we have been measuring the fraction of solar radiation reflected by various crops in Canada to try to better understand their potential contribution to mitigate climate change."

A small change in reflected solar radiation can change the temperature on a global scale. Desjardins explains, as a general rule, an increase in the reflected radiation by one Watt/m2 on a global scale can decrease the temperature at the earth surface by 0.5°C.

To measure the amount of reflected shortwave radiation at the field scale, researchers use upward and downward looking pyranometers mounted on either a tower or airplane. Satellite-based sensors, such as Moderate Resolution Imaging Spectrometer (MODIS), show vegetative growth and can also be used to estimate the fraction of solar radiation reflected by crops growing anywhere in Canada. Sensors used to measure all the shortwave radiation between 0.3 and 2.8 microns, compared to the eye that sees only 0.4 to 0.7 microns.

"The fraction of shortwave radiation reflected by a crop is also called the albedo, which is a non-dimensional quantity that indicates how well a surface reflects the sun's shortwave radiation," says Desjardins. "Albedo varies between zero for black and one for white, with fresh snow having an albedo of approximately 0.9, while grasslands are 0.3 or lower. For field crops, reflectance measurements for the whole growing season showed that after the ground is covered by vegetation, the albedo values average 0.217 for soybean, 0.221 for corn, 0.202 for spring wheat and 0.247 for canola (or around 25 per cent reflectivity)."



Albedo is the fraction of solar radiation reflected back into space. Albedo ranges from 0 to 1. Snow has an albedo of 0.9. Albedo values for crops average 0.217 for soybean, 0.221 for corn, 0.202 for spring wheat and 0.247 for canola.

Credit: Science and Technology Branch, Agriculture and Agri-Food Canada.

Land use change, management practices such as no-till and crops can create cooling, not just through reflectivity and carbon sequestration, but also through transpiration which results in more cloud formation and more shortwave radiation reflected," adds Desjardins. "Although we have not yet completed our analysis, overall canola has a higher albedo than most other crops, which adds up to a cooling of about 0.5°C during the growing season as compared to a crop like wheat." Published results are expected to be available in summer 2019.

—Donna Fleury is a professional agrologist and freelance agriculture/science writer from Alberta.

Aim for improved nutrient use efficiency

Applying enough fertilizer to maximize profit potential and taking steps to reducing nutrient losses will improve canola yield per tonne of fertilizer applied. This will have a positive effect for both economic and environmental sustainability.

Fertility management is one of the five pillars in the Canadian canola industry's goal to increase average yields to 52 bu./ac. by 2025. This yield will allow Canada's canola industry to keep pace with global increases in oil and meal demand while keeping a cap on canola acres.

Canola Council of Canada agronomy goals for the fertility management pillar are to target fertilizer applications to be available when the plant requires it and in a form that reduces loss to the air and water. Use of precision agriculture and data management, and increased use of fertilizer stability products will help. Increased adoption of 4R Nutrient Management guidelines will also result in improved soil and water health.

There is no 'one size fits all' approach to achieve sustainable production, but here are a few practices to consider:

If applying fall fertilizer, use banding to minimize run-off. Fall applications of nitrogen can be a logistical benefit, reducing the amount of fertilizer handled at the time of seeding. Research on the Prairies has shown that fall-banded fertilizer is just as efficient as spring broadcast, but fall broadcast is only 80 per cent as efficient as those two other choices. The best choice for fertilizer efficiency is spring banding. Fall banding using a disc opener to reduce soil disturbance and a fertilizer efficiency aid (such as urease inhibitors, nitrogen inhibitors or controlled-release nitrogen) can further improve the efficiency. When applying, band urea at least two inches deep and NH_3 deep enough that you can't smell it releasing from the soil. (For more on the science, read "Improve nitrogen use efficiency" on page 14 of *Canola Digest Science Edition* 2014, posted online at **canoladigest.ca**.)

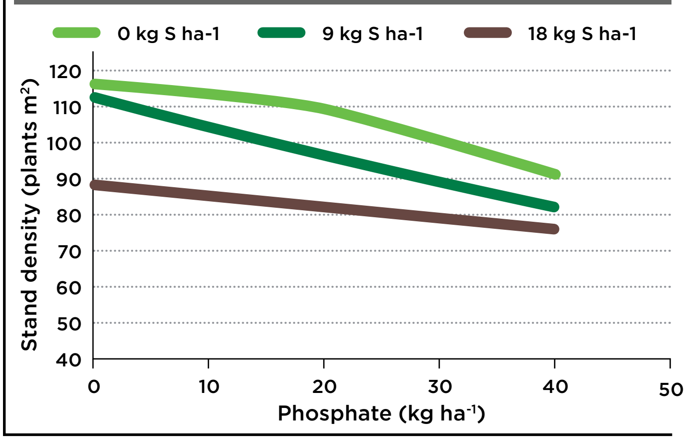


Figure 1. Seed-placed sulphate and phosphate fertilizers can reduce canola stand density

Keep seed-applied fertilizer to a minimum. Because a strong, uniform canola stand is so important to yield potential and pest management, growers will want to limit seed-placed fertilizer. Canola seed and seedlings are especially sensitive to nitrogen fertilizer. Safety of seed-placed nitrogen can be improved with higher seed-bed utilization (narrower rows and wider openers), certain soil characteristics (more clay and lower pH improves safety), polymer coatings and moisture, but the general recommendation is to apply up to 20 lb./ac. of phosphate with the seed and place everything else outside the seed row. A study led by Cindy Grant, now-retired research scientist with Agriculture and Agri-Food Canada (AAFC) in Brandon, compared canola stand density with various rates of seed-placed phosphate and sulphate fertilizer. The study found that adding any amount of sulphate with the phosphate reduced stand density. While canola does often benefit from sulphur fertilizer, it is better applied outside the seed row. (See Figure 1. A summary of the study is on page 12 of *Canola Digest Science Edition* 2013.)

Apply rates that align with increased yield potential. Two canola studies from the past decade showed that canola yield will keep going up with higher rates of nitrogen. The message is that farmers could use higher nitrogen rates to coax more yield out of the crop, but the right economic rate will be lower than the 'top yield' rate. Sustainable nutrient investment finds the balance between potential yield and economic risk tolerance. (This discussion, including background on the two studies, is covered the article "Apply enough nitrogen" on page 12 of the *Canada Digest Science Edition* 2014.)

Use soil tests to determine what each field needs. Soil tests are helpful to show soil nutrient reserves and to see how fertilizer rates could be adjusted field to field and over time. Farmers looking for more precision may set fertilizer rates based on field management zones. This will require more refined analysis but could reduce losses, put a stop to unproductive applications and increase profit. (For more on these concepts, read "Annual soil tests improve nitrogen returns" on page 10 of *Canola Digest Science Edition* 2015 and "Soil sampling in the big data era" in the January 2018 *Canola Digest*.) Another precision approach is overlap-limiting technology, available on newer drills, to shut off fertilizer application on areas the drill has already passed over. This will have an economic benefit because the double-applied nutrient is not used and can actually hurt yield by increasing lodging. Overlap prevention also has an environmental benefit because these doubled rates could result in increased nutrient losses.

SUSTAINABILITY METRICS

Goal: 50% of acres under 4R

The Canola Council of Canada's sustainability targets include a goal to have 50 per cent of canola production acres under 4R Nutrient Stewardship by 2025.

4R Nutrient Stewardship is a framework encouraging growers to use the four 'Rights': Right Source at the Right Rate, Right Time, Right Place. The principle is to use nutrient sources that the crop needs and can take up, apply them at a rate to match crop use, apply them at the right time of the season to minimize losses and be available when the crop needs it, and put them in the right place to minimize loss and maximize crop access to the nutrient.

The Canola Council of Canada's sustainability targets include a goal to have 50 per cent of canola production acres under 4R Nutrient Stewardship by 2025. Canadian farms following the 4Rs can submit their acres under the 4R Designation program described at **fertilizercanada.ca**.

Following the 4Rs will lead to improved nutrient use efficiency, which is good for business and for soil health and air and water quality. Implementing 4R Nutrient Stewardship across all acres in Western Canada will lead to a one- to two-million-tonne reduction in greenhouse gases, which is equivalent to removing 215,000-430,000 cars from the road annually.

Over three years, nine leading researchers of the Canadian 4R Research Network (including Jeff Schoenau from the University of Saskatchewan, Miles Dyck from the University of Alberta and Mario Tenuta from the University of Manitoba) tested various 4R practices for common Canadian crops. They noted two practices of particular value for canola growers:

1. Regardless of fertilizer source, growers can reduce greenhouse gas emissions and increase crop yields by applying nitrogen fertilizer bands as close to the seed row as safely possible and deeper than the seed row to ensure that the crop accesses applied nitrogen early in the growing season.
2. Applying phosphorus fertilizer as an in-soil placement at the recommended rate reduces runoff (as much as 75 per cent) while increasing economic efficiency and profitability. Broadcasting in the fall without incorporation can greatly increase the risk of phosphorus in snowmelt run-off. This is an especially important observation for large-acre Prairie producers who may be trending towards broadcast methods.

Find out more about Fertilizer Canada's 4R designation at **fertilizercanada.ca/nutrient-stewardship/4r-designation/**.

Steve Barron with Double Diamond Farm Supply in Manitoba is an agronomist and an active part of the province's 4R Nutrient Stewardship program, led by Fertilizer Canada, the Manitoba government and Keystone Agricultural Producers. He answered this question:

What key 4R principle is not being done enough in Western Canada?

A key 4R Nutrient Stewardship principle that needs more attention is enhanced efficiency fertilizer (EEF) nutrition placed in the right places at the right rates. The sticker shock of new EEF products might turn off some farmers, but these products need to be discussed with a return on investment (ROI) mindset. EEF products and the placement of these products are more important today than ever before. Our traditional canola nutrition practices were researched and developed for older generation canola genetics. Canola genetics have evolved, and the nutrition consumption habits of these new generation varieties need to evolve as well.

FARMER PERSPECTIVE

GERRY HERTZ
SaskCanola director, Edenwold, Sask.

Economic incentive to practice 4Rs

I apply NH_3 in the fall but wait until the right time, which is after October 15 when the soils are cold. NH_3 is a right source because it binds with soil particles and is less likely to be lost. The right place is banded into the soil.

I direct seed in the spring with a paired-row opener, which keeps good separation between seed and fertilizer (right place).

One thing I'd like to do is remind growers on why they have new technology. Today's drills can apply precision rates, eliminate overlap and provide precise placement for good seed and fertilizer separation. Broadcasting nitrogen is an old fertilizer practice and contradictory to the reason we have this new technology.

As for the many certification programs in front of us, farmers will sign up when the return covers the additional costs to administer. Whether in a program or not, farmers will seek out and use proper crop nutrition principles that will improve profits. The high input cost of fertilizer will motivate people to do the right thing. For me, at $0.50 per pound for nitrogen, I don't want to lose one pound. I also want to choose rates that provide a strong return on investment. I will not apply fertilizer that returns only $1 for each $1 spent. I want to spend $1 and make $3.

Use biodiversity to your advantage

Biodiversity of habitat across the farm can increase populations of bees and beneficials, which can increase yields and provide a natural check on insect populations. Biodiversity through crop rotations can reduce disease severity and expand management options for weeds.

The Canadian canola industry wants to increase production to keep pace with global demand, but the goal also stipulates that canola acres not exceed 22 million per year. At that acreage total, farms can maintain crop rotations necessary for long-term sustainability. The biodiversity that comes with crop rotation can be a valuable part of integrated management of insects, weeds and plant diseases.

In addition to crop rotations, here are a few other effective pest management tools farmers can use to improve profitability and achieve their sustainability goals.

Scout before spraying. Spraying has a cost and farmers want to make sure the pest they're spraying is actually causing enough crop damage to justify that cost. This 'economic threshold' is a key part of integrated pest management, but it requires close scouting and counting. Return on investment for scouting and counting comes when planned sprays don't have to be applied (lower cost) or when an unexpected threat needs immediate action (protected yield). This is already a well-established practice among Canadian farmers. The Canadian Roundtable for Sustainable Crops' Metrics Platform found that 99 per cent of Canadian producers always or usually use timely and regular field scouting to assess their crop and, determine economic threshold levels so they can apply pesticides only when and where they are needed. Find out more at **sustainablecrops.ca/metrics-platform**.

Follow insect thresholds. Established science-based thresholds for many canola insect pests help farmers make better economic and environmental decisions, decreasing the use of prophylactic insecticide applications. The Canola Council of Canada's Canola Insect Scouting Guide, available for download at **canolacouncil.org**, provides a quick reference for insect thresholds. Hector Carcamo, research scientist with Agriculture and Agri-Food Canada (AAFC), is upgrading the lygus thresholds first established based on Wise and Lamb's research paper published in *The Canadian Entomologist* in 1998. Threshold tables for lygus indicate that if canola is \$12 per bushel and spray costs \$8 per acre, the threshold at the early pod stage is five lygus adults or late instar nymphs per 10 sweeps. Carcamo's more recent work found that in moist and high-yield conditions, it could take many more – up to 50 lygus per 10 sweeps at the early pod stage – to cause an economic 2 bu./ac. reduction in yield. Carcamo is also working with University of Manitoba researcher Ale Costamagna to refine the flea beetle threshold.

Diversity through crop rotation can keep blackleg low.

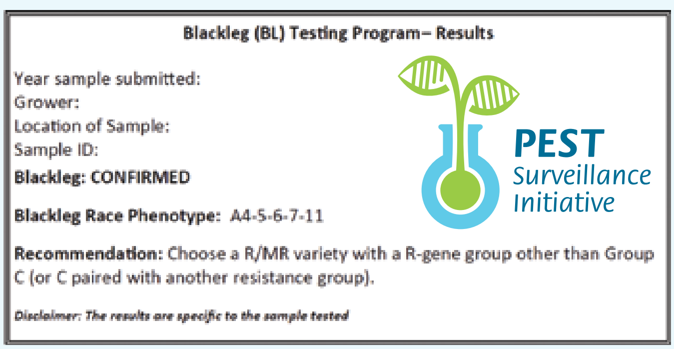
Know your beneficials. Canola fields are habitat for an incredible diversity of beneficial insects (or 'field heroes') such as bees, butterflies, spiders, wasps and beetles. In

Blackleg race ID

Pest Surveillance Initiative (PSI), a project of the Manitoba Canola Growers, identifies, quantifies and tracks risks to successful crop production. PSI has leveraged its suite of advanced DNA technology to include identification of blackleg (*Leptosphaeria maculans*) races.

PSI's blackleg test has two parts. Part 1 confirms that the sample submitted is in fact blackleg. If BL is confirmed, Part 2 will identify the blackleg races present in the field where the sample was taken. PSI also provides growers the phenotype – how the races in a field may affect the variety resistance in that field – to help guide variety selection. For more on the test and results, go to **mbpestlab.ca**.

Other labs offer blackleg identification tests. For a list, read the article "Test blackleg races in a field; make better seed decisions" at **canolawatch.org**.



Blackleg (BL) Testing Program– Results

Year sample submitted:
Grower:
Location of Sample:
Sample ID:
Blackleg: CONFIRMED

Blackleg Race Phenotype: A4-5-6-7-11

Recommendation: Choose a R/MR variety with a R-gene group other than Group C (or C paired with another resistance group).

Disclaimer: The results are specific to the sample tested

Kochia. PSI Labs also has a test for glyphosate-resistant (GR) kochia. PSI uses DNA methodology developed by Colorado State University to determine both the presence of resistance and the levels of glyphosate tolerance within suspected GR kochia populations. For more on the test and a Manitoba GR kochia map, go to **mbpestlab.ca**.

One in four acres

The Census of Agriculture includes a land use report. For the 2011 census, total 'land in crops' for the three Prairie provinces was 71.2 million acres. Of that, 18.8 million were canola (CANSIM table 001-0017). Percentage of land seeded to canola: 26.4 per cent. For the 2016 census, total 'land in crops' for the Prairies was 77.3 million acres. Of that, 20.6 million – or 26.6 per cent – was canola. Land in crops does not include summerfallow, tame or seeded pasture, natural land for pasture, woodlands and wetlands. For more, go to **statcan.gc.ca/eng/ca2016**.

many cases, these diverse insect groups prey on – or parasitize – insect pests, providing a level of control often exceeding that of chemical means. This was shown in a report by Giberson and Cárcamo, published in *Arthropods of Canadian Grasslands* in 2014. Even if farmers don't identify the beneficial species in their fields, waiting to spray until pest numbers reach thresholds can go a long way to limiting pesticide use and protecting these valuable allies. Find out more at **fieldheroes.ca**.

Reduce weed competition early. Early weed control, either through a pre-seed burnoff or in-crop applications around the two-leaf stage of the crop, is a good way to get more out of the herbicide investment. Farmers can also use narrower rows and higher plant stands to increase crop competition, tank mix herbicides to hit weeds with more than one active ingredient, and collect chaff (then feed or burn it) to reduce the weed seedbank. (For more on the science behind early weed control, read "Control weeds early" on page 24 of the *Canola Digest Science Edition* 2014, available online at **canoladigest.ca**.)

Manage diseases with genetic resistance and crop rotation. Growers can use pre-harvest scouting to identify diseases present and then use this information to choose seed with resistance to those diseases. Refined testing will also identify the specific blackleg races present in a field, which can be used to make better blackleg-resistance selections. Read more about R-gene rotation under the Genetic Resistance heading at **blackleg.ca.** Crop rotation is another valuable integrated approach to disease management, keeping levels low and genetic resistance effective for more years to come.

Keep equipment clean. Moving soil means moving clubroot, verticillium, aphanomyces (pea and lentil disease), phytophthera (soybean disease), weed seeds and nematodes. The clean equipment message can also apply to sprayer plumbing. Herbicide residue in sprayers can have a devastating effect on canola, reducing yield and striking a blow to economic and environmental sustainability.

Maintain habitats. Natural habitat has a benefit to farm profitability, including increased crop production efficiency and yields. Setting aside non-profitable areas (where yields don't justify inputs) will also improve biodiversity, carbon sequestration and land efficiency. A Western Canadian canola study by Lora Morandin and Mark Winston concluded that yield and profit could be maximized when 30 per cent of land within 750m of field edges was uncultivated. One of the Canola Council of Canada's sustainability goals is to increase the percentage of farmland that is seeing an increase in its natural habitat.

Canola and bees: A sweet relationship

Credit: iStock.com/Antagain

Canola is good for bees, and bees are good for canola. Together, they are good for the health of our ecosystem and our economy. The Canola Council of Canada (CCC) and the Canadian Honey Council are working together to maintain this mutually beneficial relationship. The CCC is also a partner in Bees Matter (**beesmatter.ca**), an initiative to restate agriculture's commitment to honey bees and bring knowledge to the Canadian public.

WHY BEES LOVE CANOLA

Canola is an ideal habitat and food source for honeybees. Canola flowers produce high amounts of nectar and this nectar has a good sugar profile for honey production. The large amounts of pollen offer a good nutritional balance of amino acids, protein and fats. Plentiful canola blooms allow bees to feed efficiently, without covering large distances. Canola fields bloom for relatively long periods, so one field can provide bees with a good source of nectar for up to a month.

WHY CANOLA LOVES BEES

Bees can have a positive impact on canola production. Pollinators are needed for production of quality hybrid seed – a vital component of the industry. Research suggests pollination by bees may also encourage higher yields, promote more uniform flowering and earlier pod setting, and increase pods per plant, seeds per pod and seed weight.

In the past decade, the number of honeybees in Canada has reached near-record levels and more than 70 per cent of colonies are in Western Canada, where canola has become one of the most important crops.

PROTECTING BEES

Canola growers can protect bees by sharing pest management plans with honey producers in the area. With this information, beekeepers can then reduce exposure by moving or covering their hives during spray applications. The next step is to avoid spraying when canola is in flower. If canola growers must spray while canola is in flower, pay extra attention to the following precautions: Spray after 8 p.m., by which time most bees have returned to the hive. Certainly avoid spraying between 10 a.m. and 4 p.m. Use economic thresholds and integrated pest management. For more details, read "Protecting bees when growing canola" at **canolacouncil.org**. For videos, search "canola and bees" at **vimeo.com**.

Cut later to increase yield with no extra cost

Harvest management steps, including cutting later to realize a canola crop's full yield potential and taking steps to reduce in-field and storage losses, mean more canola per acre goes to market. It has a big impact on real production per acre.

Harvest management is one of the five pillars in the Canadian canola industry's goal to increase average yields to 52 bu./ac. by 2025. Cutting later and taking steps to reduce combine losses can have a big impact on harvest yield with no extra cash costs.

Here are some things farmers can do:

Cut later. A trend to delayed cutting – either through later swathing or straight combining – will increase yield over earlier cut timings. Canola Council of Canada research from the early 2000s showed that canola fields swathed at 60 per cent seed colour change (SCC) on the main stem can yield eight per cent more than fields swathed at 30 per cent SCC. The yield difference could be even higher with lower plant populations because with fewer larger plants more of the yield will be in the side branches. Overall losses do not differ between late-swathed and straight-cut canola, according to research by Teketel Haile in 2014 and Rob Gulden in 2016.

Hit plant establishment targets. Achieving the target of six to eight plants per square foot (read the plant establishment article on page 10) will mean fewer side branches, which has benefits for harvest timing and possibly quality and yield. Seeds in side-branch pods mature later, and the more branches, the longer a canola crop takes to mature. With dry fully mature seeds and green immature seeds in the same plant, it can be difficult to choose an appropriate time to swath or to apply pre-harvest aids. This can have implications for yield if earliest pods are shelling out while the latest pods are too green to mature properly. For more on plant populations and side branching, read "Swath timing: Plant population and SCC" at **canolawatch.org**.

Check for losses. Canola growers can lose up to 5 bu./ac., or more, while combining. Checking for combine losses under various conditions will give operators a feel for best settings under various conditions. It will also help to interpret what combine loss monitors are really saying. For tips, read "How to reduce costly harvest losses" at **canolawatch.org**. The new Combine Optimization Tool at **canolacalculator.ca** will help farmers assess the risk situation and walk through an appropriate series of adjustments to combine settings.

With a drop pan and a set of sieves, farmers can accurately measure losses out the back of the combine.

Use the new Combine Optimization Tool at **canolacalculator.ca** to work through a series of adjustments to reduce harvest losses.

Use genetics to expand harvest options and reduce losses. Pod shatter reduction, a feature available with some canola varieties from various seed companies, can reduce the risk for canola left standing for later swathing or straight combining.

Protect the crop in storage. World-grain.com says some countries often experience post-harvest losses of 30 to 40 per cent. Cold winters on the Canadian Prairies offer some protection against deterioration, but losses can still be substantial if canola is not dry and cool and monitored regularly. Safe storage recommendations for canola – eight per cent moisture and less than 15°C – are based on research from the 1980s and have become standard practice for canola producers. For canola stored winter to summer, recent Prairie Agricultural Machinery Institute (PAMI) studies suggest that farmers monitor closely, but otherwise leave the bins alone rather than put them on aeration again or turn them over. With the rise in bag storage, two studies, including a recent one by Chelladurai Vellaichamy at the University of Manitoba, concluded that if tough canola is stored in bags, it should be very short term (less than three weeks) to avoid deterioration. And finally, a new PAMI study of canola in 25,000-bushel bins found that a standard, single phase 10-hp centrifugal fan could not push air through canola when the bin was full. The bin had to be filled only part way (about two-thirds) to achieve airflow required for aeration and probably even less to achieve the higher airflow required for heated-air drying.

Selling into sustainability supply chains

Customers are asking for sustainably-produced food, so some food companies are sourcing some ingredients from producers who follow sustainable production practices.

Food companies and retailers around the world are using sustainability certification programs within their supply chains to send a message of sustainability to their customers.

INTERNATIONAL SUSTAINABILITY AND CARBON CERTIFICATION

International Sustainability and Carbon Certification (ISCC) targets the reduction of greenhouse gas emissions, sustainable use of land and the protection of natural habitats. (**iscc-system.org**)

ADM and Viterra are working with ISCC to register canola farmers in Canada. Growers interested in learning more about the program and how to qualify can talk with local representatives from these companies.

VITERRA ANSWERS 3 QUESTIONS ON ISCC

What sustainability standards do you (and ISCC) want from your farmers? We require the producers to follow a certain standard in order to be qualified for the program and remain within the program. The requirements ask for land conversion amounts after 2008 and ensure good social practice and human rights for all employees. Farmers also have to provide complete fertilizer and plant protection records, invoices of plant protection products, production records along with land description records.

Why do this? The sustainability program opens up market access channels for various commodities handled through the Viterra network.

What is the benefit to farmers who participate? With more export demand for their products, this helps create movement opportunities and adds value to the bottom line of their operations.

CARGILL ANSWERS 3 QUESTIONS ON 2BSVS

Cargill offers its own 'biomass, biofuel, sustainability voluntary scheme' (2BSVS), which allows Canadian canola farmers to access new markets in the European Union. Cargill answered the same three questions:

What sustainability standards do you want from your farmers? Our 2BSVS audit is an annual program that includes an audit at the farm level, which assesses field boundaries to ensure there's been no planting on high conservation and high carbon-stock areas.

Why do this? This sustainability program, along with others, helps communicate the collective good work Canadian farmers are doing today, without expanding their environmental footprint. Determined by the European Union, participating farmers meet sustainability standards focused on conservation efforts and greenhouse gas emission savings. For example, farmers ensure the protection of high biodiversity value or high carbon stock areas on their land.

What is the benefit to farmers who participate? The program highlights farmers' good stewardship of the land, while participating in competitive global trade flows. This globally-recognized sustainability scheme allows farmers to access new markets in the European Union.

OTHERS

The Serecon report – "Final Report: Application of Sustainable Agriculture Metrics to Canadian Field Crops 2015," available at **ccga.ca** – gave a few examples of food companies with sustainability goals:

- General Mills has committed to "sustainably source 100 per cent of its 10 priority ingredients by 2020."
- Unilever intends to source 100 per cent of its agricultural raw materials sustainably by 2020 (Unilever is working with Bunge to source sustainable canola from Canada. Find the company's *Sustainable Agriculture Code* at **unilever.com**).
- Walmart is sending out questionnaires to suppliers, asking for more information on sustainability performance and sourcing of commodities.

FARMER PERSPECTIVE

DOYLE WIEBE
SaskCanola director, chair
Langham, Sask.

Many farmers already meet sustainability standards

When I signed up for the International Sustainability and Carbon Certification (ISCC) program through Viterra, I was surprised how they had distilled their qualifications down to just five or six questions. For example, "Have you taken out any trees over the past five years?" The form took about two minutes to fill in. But as easy at it was to get approved, there hasn't been an opportunity to take advantage of that status yet.

So why participate? I feel that I'm keeping all doors open for marketing opportunities. Over time, I'm not sure what the advantage is going to be, but it could mean the difference between being able to sell and not being able to sell.

In the bigger picture, by participating it helps us tell our story to consumers. Farmers on the Canadian Prairies have one of the best sustainability stories to tell. We have one of the most sustainable crop rotations in the world, with a variety of oilseeds, pulses and cereals available to us. Widespread adoption of conservation tillage makes us good soil and energy stewards. And we abide by the laws of the land, which set high standards for employees and for air, soil and water quality.

Strong genetics key to sustainability

Genetics will drive a large share of the yield gains needed to get to 52 bu./ac. Genetic traits also reduce pesticide use, increase crop tolerance to disease and improve harvest management – all enhancing the sustainability of canola.

In the Canola Council of Canada's Keep It Coming 2025 strategic plan, improved canola genetics are expected to provide 8 bu./ac. of the yield gain required to meet the 52 bu./ac. average yield target. This is the largest share, by far. (See the graphic on this page.) Canola growers in Canada have come to expect small yield gains with each new generation of commercial hybrids. They like enhanced disease resistance and harvest management traits. And pretty much every canola acre in Canada is seeded to hybrids with a herbicide-tolerant trait. For all of the demands on them to improve existing traits and add others, canola seed companies, with help from public and private plant breeders, keep delivering.

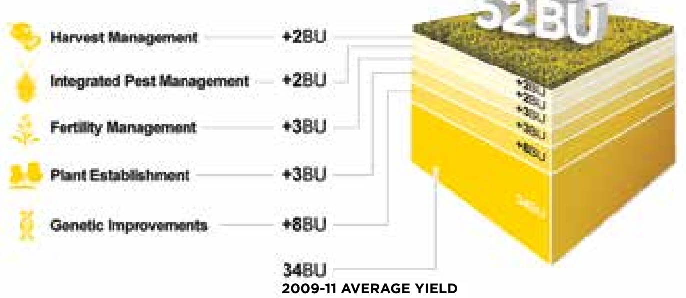
Here are some of the genetic solutions immediately available to farmers, including tips on how to use and protect those traits:

Genetics to improve yield. Many things go into higher yields. In the *Canola Digest* January 2017 article "Unlocking canola's genetic potential for yield (online at **canoladigest.ca**)," Agriculture and Agri-Food Canada (AAFC) research scientists Bob Blackshaw and Neil Harker and Alberta Agriculture and Forestry oilseed specialist Murray Hartman provided these seven keys to higher yields: adequate and timely rainfall; adequate fertilizer at the right time and place to reduce losses and limit adverse effects on seed germination; early weed removal; cool temperatures during flowering and pod development; adequate control of diseases and insect pests; crop rotation; and a hybrid variety with high potential for the area and appropriate disease resistance. Canola Performance Trials provide an excellent resource to compare regional and Prairie-wide yield potential for new varieties. See results from 2011 to 2018 at **canolaperformancetrials.ca**.

Genetics to reduce herbicide use. Herbicide-tolerance traits that allow for the application of broad-spectrum herbicides to canola crops have reduced the range of products applied to canola and, because these traits greatly improved weed management in canola, reduced pesticide applications across the farm's whole rotation. Though these traits do meet with increased regulatory scrutiny in Canada and around the world, the potential for advancement in herbicide tolerance and other novel traits to greatly reduce pesticide use could be a real sustainability win for agriculture. A 2015 study by Graham Brookes and Peter Barfoot (see more about their reports on page 19) concluded that biotech canola varieties increased farmers' yields by up to 12 per cent per hectare from 1996 to 2013. They also concluded that in just one year of growing biotech canola, producers saved one billion kilograms of carbon dioxide from not having to till their fields to manage weeds.

Genetics to reduce disease. Genetic resistance to blackleg and clubroot has been a huge boost to the sustainability of canola in Western Canada. Genetic resistance has proven much better than applied crop protection products at managing these diseases. In 2009, the first clubroot resistance variety was available for producers. In fewer than 10 years, every major canola seed company now offer a clubroot resistant variety, thanks in part to public research – including the recently completed projects described in this magazine. Most canola varieties have full or moderate resistance to blackleg, and our strategies to deploy this trait is improving. With enhanced genetic tools to identify how blackleg-resistance genes stack up to local pathogen populations, farmers can now deploy specific R-genes to match the races in a field (Read more at **blackleg.ca**.) This is already available for blackleg in Canada and could come soon for clubroot.

Our tools for increasing yields



Genetics to improve harvest management. Pod-shatter tolerance has lowered the risk for delayed swathing and straight combining of canola. These practices have potential to increase yield by letting more seeds in side branches reach maturity. Straight combining can also reduce time, labour and machinery costs to harvest canola because it eliminates the swathing step. Increased yield and lower costs that these harvest traits provide are both major benefits to canola sustainability.

GENETICS TO IMPROVE WEATHER STRESS TOLERANCE

Baoluo Ma with AAFC Ottawa was the principal investigator in a Canola AgriScience Cluster (GF2) funded study to investigate various canola genotypes for tolerance to heat and drought stress. Ma's study improved the feasibility of using an electrical measurement method to screen canola lines for root traits that improve response to heat and drought stresses. Ma says the method has the potential to assist plant breeders in selecting genotypes with strong root architecture. The same study also looked at lodging. Ma developed a simulation model to assess lodging, which could be used to develop the appropriate crop management practices for mitigating the risk of lodging and can be applied in breeding programs for selecting genotypes with high yield potential. While these are still in proof-of-concept stages, the results show how new research tools can make it easier for breeders to select for traits that increase canola's tolerance to environmental stress.

Herbicide-tolerant canola lowers herbicide use, tillage

One of the greatest challenges in growing canola is competition from weeds. As Brookes and Barfoot reported in 2017, herbicide-tolerant canola varieties have allowed farmers in Canada to reduce the amount of herbicide they use by 20 per cent since 1996.

Graham Brookes and Peter Barfoot with PG Economics in Dorchester, U.K. estimate that genetic technology has reduced global pesticide use by 618.7 million kg, or 8.1 per cent, over the past 20 years. This drop is due to the change in herbicides typically used, going from a fairly broad range of mostly selective herbicides to one or two broad-spectrum herbicides.

They published these numbers in a report titled "Environmental impacts of genetically modified (GM) crop use 1996–2015: Impacts on pesticide use and carbon emissions," in the journal GM Crops & Food in 2017.

The report includes specific reference to herbicide-tolerant (HT) canola in Canada: Use of HT canola in Canada from 1996-2015 resulted in a 21.1 million kg, or 20 per cent, reduction in active ingredient use "relative to the amount reasonably expected if this crop area had been planted to conventional canola."

Brookes and Barfoot note the downsides to an over-reliance on single active ingredients in these systems, referencing an increase in tank mixing over the past decade. But the paper notes that herbicide use on conventional crops also went up, and that herbicides used in conventional systems also had resistance issues.

Brookes and Barfoot add that HT technology also reduced fuel use and tillage, resulting in a significant reduction in greenhouse gas emissions. Their numbers indicate that in 2015 alone, this was equivalent to removing 11.9 million cars from the roads. Reduced tillage also increases carbon sequestration in the soil and reduces soil erosion.

"It is widely accepted that increases in atmospheric levels of greenhouse gases such as carbon dioxide, methane and nitrous oxide are detrimental to the global environment," they write. "Therefore, if the adoption of crop biotechnology contributes to a reduction in the level of greenhouse gas emissions from agriculture, this represents a positive development for the world."

WHAT IS THE ENVIRONMENTAL IMPACT QUOTIENT?

Brookes and Barfoot use a measurement called the Environmental Impact Quotient (EIQ). It goes beyond a comparison of the volume of active ingredient applied to draws on toxicity and environmental exposure data related to individual products. It also includes benefits from reduced tillage production systems, which are made easier with HT crops. These benefits included reduced fuel use, increased soil carbon and reduced erosion.

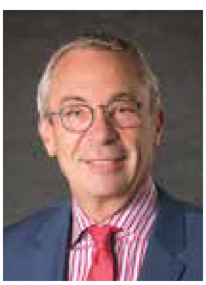
The kilogram-based drop in global pesticide use since the commercial launch of biotech HT traits, which was noted at the top of the article, also decreased the EIQ for herbicide and insecticide use on GM crops by 18.6 per cent.

Table. GM HT canola: Summary of active ingredient usage and associated EIQ changes 1996-2015.

Country	Change in active ingredient use (million kg)	% change in amount of active ingredient used	% change in EIQ indicator
U.S.	-3.1	-33.5	-46.5
Canada	-21.1	-19.8	-32.4
Australia	-0.8	-3.5	-3.0

Source: Brookes & Barfoot, "Environmental impacts of genetically modified (GM) crop use 1996–2015: Impacts on pesticide use and carbon emissions," GM Crops & Food, 8:117–147, 2017

FARMER PERSPECTIVE



ANDRE HARPE
Alberta Canola director, Valhalla Centre, Alta.

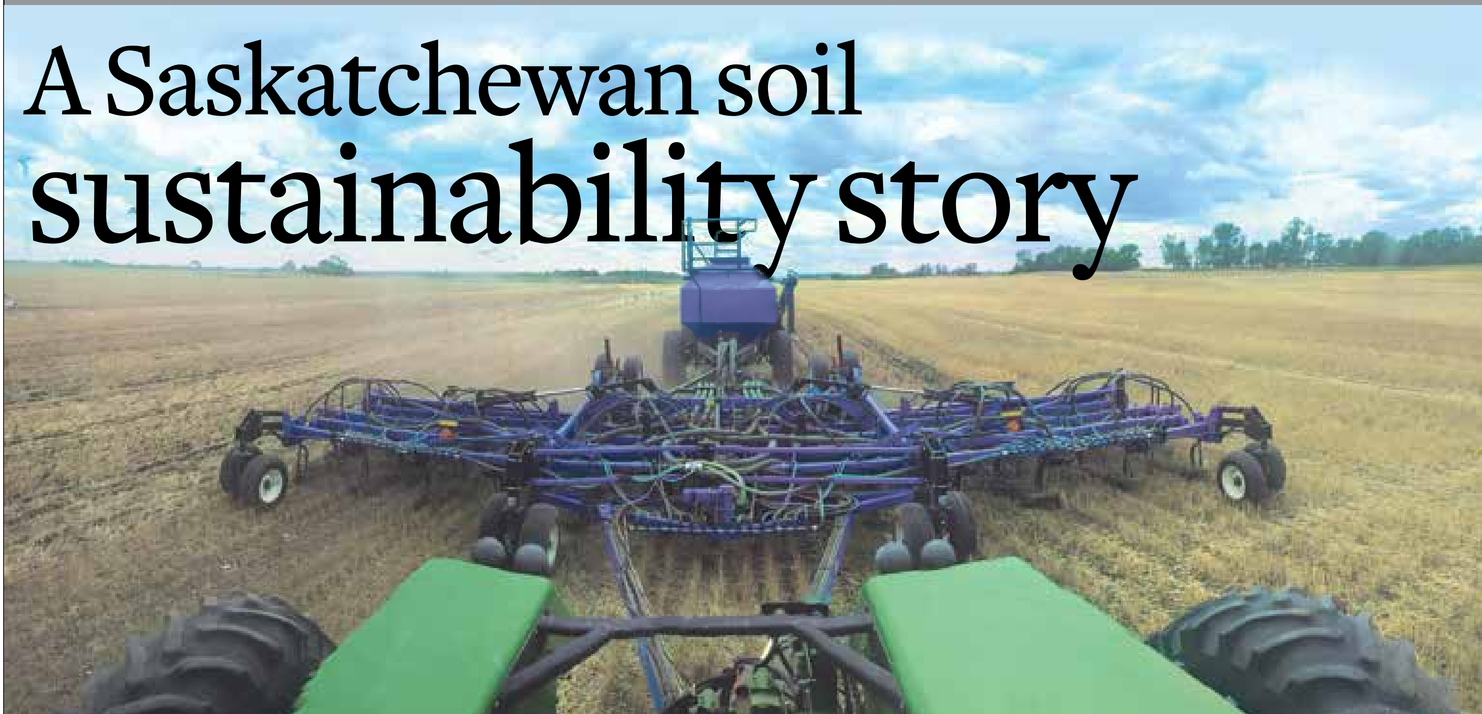
Genetic traits improve the way we farm

Before we had the herbicide-tolerant (HT) canola trait, we would have to do a lot more cultivating to control weeds. We were going over the field five to six times per year to get all the jobs done. Now that we don't have to use tillage anymore, we're down to three or four passes. The HT trait has totally changed how we farm.

The improved weed control in canola also provides a benefit throughout the whole rotation. With a broad spectrum of weeds managed in canola, it leaves us with a better selection of options for our cereals. Overall it has reduced the amount of herbicide in our cereals and canola.

Genetic traits to reduce pod shatter losses at harvest also improve our yield and reduce our harvest risk. As of mid October this year, I still had 65 per cent of my canola standing, waiting for an opportunity to straight combine. I have one field that was one-third swathed, with the rest left standing. I'm really curious to compare yields for the two treatments. We should see a higher yield for the standing crop and I'm hoping to also see a better grade. I have a lot of experience straight combining canola, starting with Polish varieties and now with the pod-shatter-tolerant Argentine varieties. I know straight combining improves yield and with improved genetics I'm more comfortable leaving more acres to harvest this way.

A Saskatchewan soil sustainability story



The Canadian Prairies in the 1980s was a dry and windy place to be. Farmers, government and researchers all recognized the critical importance of protecting the most valuable resource required for growing crops. In 1987, the Saskatchewan Soil Conservation Association (SSCA) was established to encourage soil conservation. The Save Our Soils program was initiated to accomplish soil conservation through a variety of mechanisms. It was funded largely by a federal-provincial partnership to send regional soil conservationists into the community.

"Weed control, crop establishment, fertilizer placement, rotation and straw/chaff management were the five pillars," stated Pat Flaten, one of the former soil conservationists. She can still list the key components of their program off the top of her head. When asked about how they reached farmers with their message, she explained innovation in action. "We had these binders with all the information, but really we did everything we could, accessing growers through town meetings, field days, trade shows. Wherever farmers were, we were too, and because of the field conditions over the previous decade, everyone was committed to protecting the soil."

SSCA and government extension specialists talked about the research and practices that could be implemented on farm, but seeding equipment developers were also coming out with new technology that made direct seeding possible. The introduction of herbicide-tolerant canola was a timely catalyst for a shift across the province toward conservation tillage practices on a large scale.

After some recognition that the needle had moved on soil conservation, SSCA narrowed their focus. There was a conscious decision on the part of the extension specialists to concentrate solely on reduced tillage. The SSCA board also took the opportunity to understand everything they could about this concept of carbon credits, and what it meant for Saskatchewan farmers.

John Bennett, a former member of the SSCA board, talks about the role that they played as farmer directors. "We spent a lot time researching this idea, it was very new. We quickly realized that it was an opportunity for farmers to be recognized and rewarded for their stewardship efforts." As a member-driven organization, they had to be nimble and respond to the changing landscape of the industry. There had been a lot of success on the soil conservation initiative, and they wanted to keep that momentum going.

"The Prairie Soil Carbon Balance project provided a benchmark and a dataset. We knew that an increase in soil health and quality

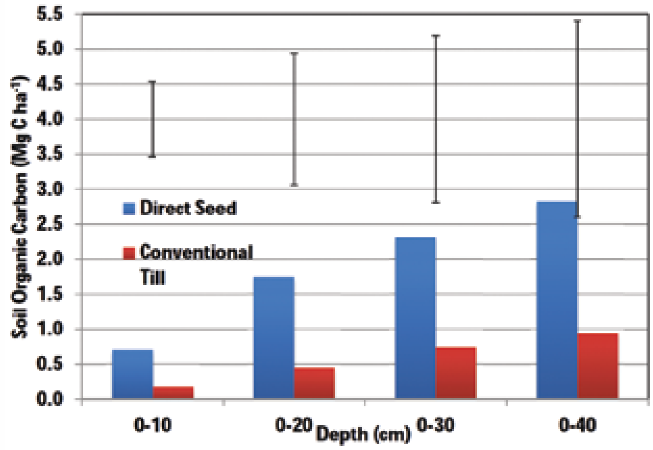
was having positive results, and we quickly learned that soil organic matter was the easiest measure of carbon sequestration," Bennett explains. "In order for farmers to participate in a functioning market, we needed to prove that we were doing something that could be measured." As a board, they also realized there was an opportunity to once again raise awareness among the farming public. At the time, not a lot of farmers had a solid understanding of the positive impacts they were having on the environment by storing carbon in the soil with reduced tillage. Not to mention the future market opportunity in a world where a price is placed on carbon.

Over a 22-year period, the Prairie Soil Carbon Balance has measured almost 140 sites across Saskatchewan. The results are a good news story. Models have guided the discussions on carbon sequestration because of limited datasets. The data in Saskatchewan has exceeded the expectations of these models and demonstrated that farmers are contributing even more than originally expected by practicing conservation tillage. An average of 0.38 tons of CO_2/acre/year of carbon is stored in the soil using conservation tillage programs. This is equivalent to a 1,321 kilometre trip of an average passenger vehicle. Across the 23 million acres in Saskatchewan that are currently direct seeded, this represents enough carbon-storage capacity to offset 30 million kilometres of driving annually. That is the equivalent to taking two million cars off the road.

The announcement of a national climate change strategy which includes a provision for carbon pricing has negative implications for carbon intensive industries like agriculture, particularly for grain farmers. Both the national and international policies mention the importance of natural sinks, which can be great opportunity for farmers to be a part of the solution and offset industrial emissions for our trade sensitive resource economy. A coalition of crop commissions and associations in Saskatchewan are working with the SSCA to communicate the value that farmers provide through conservation tillage practices.

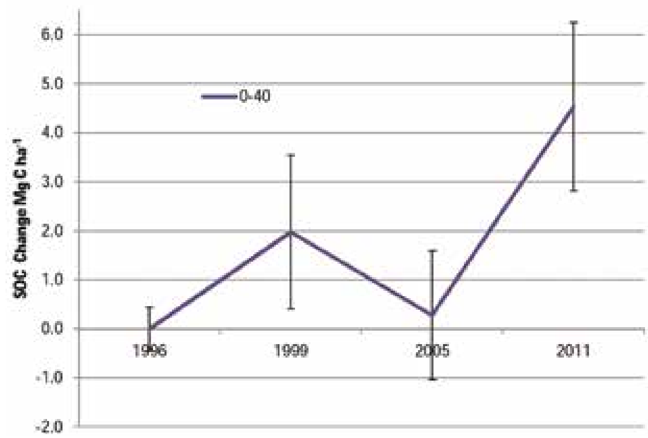
The most important piece of the soil sequestration story is that farmers are doing this for the best interest of the environment. They are capturing carbon in their soils to increase soil organic matter, which offsets industrial carbon emissions. According to the research that has been going on for more than two decades, there is an accumulation of carbon that far exceeds the single shift from traditional tillage to direct seeding. Farmers are not looking for any kind of retroactive payment for this value, but an opportunity to participate in the market into the future for their annual contribution.

Soil Organic Carbon under direct seeding versus conventional tillage from 1996 to 1999 at four depth increments (n=22; LSD p=0.05).



This shows the immediate impact of direct seeding on SOC.

Changes in soil organic carbon (SOC) under direct seeding, given as Megagrams (tonnes) of carbon (C) per hectare.



This is based on samples from 80 direct-seeded fields in Saskatchewan. Sample depth 0-40cm. Researchers attribute the drop in SOC from 1999 to 2005 on the droughts of 2001-2003. These years had dramatically lower yields of crops compared to previous or following years.

2017-18 Alberta Canola Research Numbers

Over the past decades, Agriculture and Agri-Food Canada (AAFC), the largest government funder of crop research, has provided funding in five-year blocks. This has driven much of the research funding in canola to revolve around this timeframe and it was one of the main reasons the research allocation made by Alberta Canola was larger this year than in the past.

With the previous AAFC five-year agreement to end in 2017, the canola industry in Canada began planning the next program in 2016. This effort, coordinated by the Canola Council of Canada, brought the canola growers groups, researchers and industry together to identify those research goals that when achieved would have the greatest ability to help canola growers succeed. This effort culminated in the September 2018 announcement by Minister of Agriculture and Agri-Food Canada, the Honourable Lawrence McAuley, of the Canola AgriScience Cluster. With this announcement, 25 research projects worth $20.1 million will be done over the next five years.

As large an endeavour that the Canola AgriScience Cluster is, not all the research areas identified were included. As they have done in past years, SaskCanola has made application for increased disease research, mainly around blackleg management, and Alberta Canola has committed $500,000 over five years toward this effort in mitigating this serious disease.

Since the untimely passing of Lloyd Dosdall, the Faculty of Agriculture, Life and Environmental Sciences at the University of Alberta has not had an entomologist on staff for research and, more importantly, for teaching. Alberta Canola, together with Alberta Wheat and Barley and Alberta Pulse Growers, has made a five-year commitment towards funding a NSERC Chair in Agri-Entomology. This commitment will allow the university to attract a leading researcher and teacher.

Along with crop production related research, Alberta Canola also made funding commitments in the area of improving the marketability of canola meal in the dairy and swine feeding areas. Three projects that did not receive funding in the Canola AgriScience Cluster were approved for partial funding in collaboration with SaskCanola.

2018 Alberta Canola Research Funding

	Alberta Canola	Total Project	Leverage
Agronomy	$429,570	$874,045	2.03
Disease	$578,843	$2,128,938	3.68
Insects	$329,722	$758,000	2.30
Multi-project Programming	$1,850,140	$27,600,000	14.92
Product Improvement	$647,832	$1,300,749	2.01
Total	**$3,836,107**	**$32,661,732**	**8.51**

Credit: iStock.com/laughingmango

FarmSustainability.com – an online tool to advance farm sustainability

In April 2018, Team Alberta[*] launched **farmsustainability.com**, a web-based farm sustainability readiness tool. The tool is a voluntary self-assessment and action-planning resource that aims to advance on-farm sustainability in Canada.

The readiness tool removes the guesswork by asking questions compiled from three of the most comprehensive, internationally-recognized, sustainability certification programs in a user-friendly format.

The tool addresses the drivers behind sustainable sourcing and certification and will increase producers' understanding of sustainability in Canada. Farmers can complete an assessment of their farm when they visit **farmsustainability.com**, which will generate an action plan tailored to their operation.

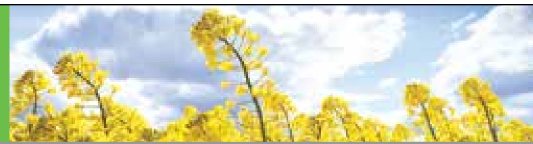
"The tool gives me the first indication of how my farm is matching up with some of those standards and protocols that companies may be looking for in the future," says D'Arcy Hilgartner, current chair of the Alberta Pulse Growers.

Aggregated data gleaned from this tool will give the four Alberta producer commissions insight for directing future resources for research and extension of beneficial management practices.

"I've implemented some of the things that have come up in the sustainability platform that would help my sustainability index," says John Guelly, Alberta Canola director and farmer from Westlock. "Some things are really easy to change and improve your index, and other things take a bit more work, but it certainly gives an idea of what to plan for over the next few years. And when you are doing changes on your farm, you can make sure you do them in a way that matches the sustainability platform."

As the world becomes more environmentally conscious, traditional waste disposal methods are being replaced with better techniques that do not pollute the soil, water, and air. "The readiness tool will help tell our industry's sustainability story which is important for earning public trust," says Kevin Bender, chair of Alberta Wheat Commission.

**Team Alberta is made up of Alberta Barley, Alberta Canola, Alberta Pulse Growers and Alberta Wheat Commission. Together the organizations represent over 20,000 farms across Alberta.*



Farmer-Funded Research: Investing in research that will maximize for canola farmers through sustainable

Quality, relevant and up-to-date information is key in making decisions that benefit our farms – economically, ecologically and environmentally. Farmer-led and funded research is crucial to making this happen.

As public-funded research has declined over the years, it's more important than ever for grower-funded organizations to step up and fill the void.

"It's unbiased research without the goal of selling the farmer a product," states Ron Krahn, chair of Research Committee for the Manitoba Canola Growers Association (MCGA). "It gives farmers control of what the priorities should be and we work with researchers on what is most relevant on our farms today. It allows us to be proactive with the research that is being done rather than just reacting to current problems and demanding an answer 'yesterday'."

Plus seed and chemical companies are not doing a significant amount of practical research on agronomic practices that benefit growers and offer solutions that can improve the bottom line at very little cost. Knowing how clubroot is transmitted and what strains are in an area prevents spread and offers guidance in variety selection. Understanding how swede midge works and what the economic thresholds are before you need to spray helps avoid unnecessary expenses.

MCGA reviews their priorities annually and carefully considers proposals, with farmers' best interests always in mind. Only a fraction of researchers' Letters of Intent received are considered for funding, based on growers' priorities and the amount of funds available.

Krahn believes both short and long-term goals should be considered. Basic research that can be implemented immediately on the farm – optimal seed placement, ideal crop rotation, preventing spread of disease, knowing economic thresholds for insect and disease controls, etc – as well as genetic-based research may take years to yield results and offer improvements.

The MCGA research committee of Ron Krahn, Chuck Fossay, Clayton Harder and John Sandborn works closely with Dane Froese, industry development specialist for oilseeds at Manitoba Agriculture, as well as Canola Council of Canada agronomists Angela Brackenreed and Justine Cornelsen.

Nearly all of the research done is in collaboration with other groups to create the greatest possible return on investment and avoid unnecessary duplication of trials. In 2017-18 MCGA spent an estimated $611,575 on research, which was about 22 per cent of our total checkoff revenue.

For every dollar invested, an additional $8 in research investment is realized through partnership with other industry members and government funding for a total of $5.6 million Partners include the Canola Council of Canada, Alberta Canola Producers Commission, Saskatchewan

4 Research Priorities

Current MCGA priorities are as follows:

1. Agronomy Research

a) Diseases (priorities include clubroot, sclerotinia, blackleg, and verticillium)

b) Insects (priorities include flea beetles, swede midge, bertha armyworm, cutworms and diamondback moth)

c) Weeds

d) Agronomic Practices (priorities include practices that cut costs or increase productivity)

2. Market Development

a) Canola oil

b) Canola meal

c) Canola-based biodiesel

d) Other canola products

3. Variety Assessment

a) Canola varieties that do well in water saturated soil

b) Post commercial variety evaluation

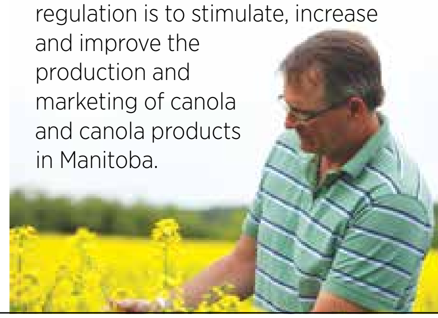
4. Other Research

a) Human health benefits of canola products

b) Animal health benefits of canola products

Our purpose

Manitoba Canola Growers Association is governed by a specific regulation under the Manitoba Government's Agricultural Producers' Organization Funding Act. The purpose of this regulation is to stimulate, increase and improve the production and marketing of canola and canola products in Manitoba.



net income production

Canola Development Commission (SaskCanola), the Western Grains Research Foundation, other Manitoba commodity groups as well as provincial and federal governments.

Agronomic research partnerships include the Pest Surveillance Initiative (PSI) Lab, Canola Agronomic Research Program (CARP) and Canola Performance Trials (CPT).

PSI is a molecular detection laboratory funded by MCGA and Manitoba Agriculture and provides testing to detect low concentrations of clubroot, identify glyphosate resistant kochia and determine specific gene identification in blackleg. MCGA is currently offering one free blackleg gene test per member ($200 value).

Both CARP and CPT are jointly funded by MCGA, SaskCanola and Alberta Canola with the programs administered by the Canola Council of Canada.

Since 1985, CARP has supported canola agronomic research focused on increasing yield and profitability for growers and reducing production risk while enhancing sustainability.

CPT began in 2011 and provides relevant and unbiased performance data that reflects actual production practices, and comparative data on leading varieties and newly introduced varieties. Trials vary widely in size, location and type addressing a wide range of issues for canola production. See results at **canolaperformancetrials.ca.**

In MCGA's strategic plan, maximizing your next income and sustainable research are a priority. Independent, unbiased research is a key to achieving both.

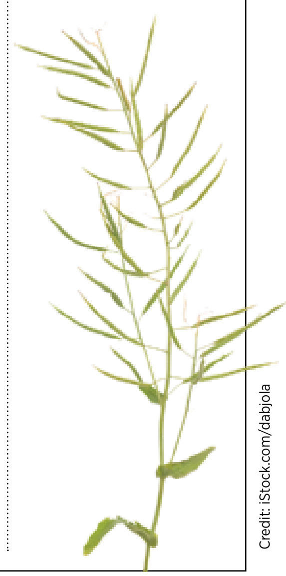
When farmers sit at the table as your representatives, they direct funds accordingly to ensure those goals are being met. They want the research to yield quality, applicable information for all growers as well as creating opportunities for market expansion. When we know better, we do better, not only our individual farms but as an industry.

Total Collaborative Research Investment

$5.6 million

Every $1 invested by MCGA was matched by $8 of partnered funding

Visit **CanolaGrowers.com** to review the latest research on a NEW Manitoba Canola Grower Research Database.



Credit: iStock.com/dabjola

Connect with the Research Committee

If you have thoughts or questions regarding MCGA research, please contact the MCGA Research Committee. You are also invited to join us at this year's annual general meeting Feb. 14, 2019 at Crop Connect in Winnipeg and please stop by to see us at Ag Days in Brandon.

Chair: **Ron Krahn,** Rivers
ron@canolagrowers.com

Executive Director:
Delaney Ross Burtnack
delaney@canolagrowers.com

Charles Fossay, Starbuck
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Clayton Harder, Winnipeg
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John Sandborn, Benito
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COMPLETED PROJECTS

Canola rotations and sustainability

Key result: A nine-year AAFC study compares canola in continuous, two-year and three-year rotations and finds that continuous canola costs more and yields less than canola in rotation with other crops. Whole-rotation revenue is similar, but continuous canola is the less sustainable option.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Canola Sustainability - Risk Mitigation," Neil Harker (retired) and Breanne Tidemann, AAFC Lacombe

FUNDING:
Growing Forward 2

Continuous canola yields less than canola in a two-year or three-year rotation. That yield gap can be narrowed with added inputs, but the questions then are whether the economic cost to manage a continuous canola rotation is worth the risk to the farm and whether continuous canola presents other longer-term risks to sustainability.

This nine-year rotation study compared continuous Liberty Link canola, continuous Roundup Ready canola, canola in a two-year rotation with wheat and canola in a three-year rotation with peas and barley. Trials were repeated at five locations across the Prairies and "all phases" were repeated each year. For example, for the canola-barley-peas rotation, every phase of the rotation – canola, peas and barley – were grown each year to eliminate the confounding effect of different environmental conditions each year.

When all sites and years are averaged, canola yield improved 5 bu./ac. with a one-year break and another 5 bu./ac. with a two-year break. While this is an average, Tidemann notes that results were quite different year to year and site to site. In Melfort, Sask., for example, there was no yield difference between rotations in 2012, but in 2016, canola yields were 17 bu./ac. higher with a one-year break and 34 bu./ac. higher with a two-year break.

When looking only at high-input results for continuous canola, the yield gap between continuous and rotation canola narrowed, suggesting that farmers can rescue most of the lost yield with continuous canola by investing more in crop inputs.

Canola's selling price per tonne is higher than peas, wheat and barley, and even with lower yields, continuous canola can still pencil out better on some farms. This does come to light in economic analysis for this study. Even with higher input costs and lower yields for continuous canola, net returns, when averaged across all years and all locations, were similar for all rotations. From the farmers perspective, the question is whether spending more on inputs to make the same money is worthwhile.

In a related recently-published study, ("Attempts to rescue yield loss in continuous canola with agronomic inputs," Harker et al, *Canadian Journal of Plant Science*, 2018) the researchers investigated whether it was possible to compensate for yield losses in continuous canola by increasing inputs. Blackleg resistance was a priority. "Other possible strategies to rescue yield that declines under continuous canola would be to apply inputs at levels higher than "standard practice" (SP), to increase tillage, or to remove chaff. Our objective was to determine if higher fertility levels alone or in combination with a higher seeding rate, tillage, chaff removal, or additional fungicide could increase continuous canola yield compared with SP. We hypothesized that additional inputs and some nonstandard practices in continuous canola would increase yields compared with SP and would recover yields to levels similar to canola yields in rotation with other crops. Furthermore, we hypothesized that yield recovery would be greater after two or three years of consecutive treatments."

These hypotheses were confirmed with the results. Continuous canola, when given fungicide to manage blackleg and 50 per cent higher fertilizer rates, could achieve yields comparable to canola in rotation. But the paper concluded that "higher fertility regimes in continuous canola may not be as economically viable as simply rotating to other crop species." And added: "Aside from blackleg monitoring, we did not address additional continuous canola production risks from other pests; these might well impact canola's long-term sustainability."


Credit: iStock.com/ooyoo


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COMPLETED PROJECTS

Canola works well in canola-wheat-corn-soybean rotation

Key result: This Eastern Canada study tested canola in typical Eastern Canada crop rotation systems and found that canola performed well after soybeans and wheat produced its best yields following canola.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Canola Rotation Studies," Claude Caldwell, Dalhousie University

FUNDING:
Growing Forward 2

Crop rotation is recognized as one of the best management practices in field crop production, whether canola or any other crop. The purpose of this study was to gain a better understanding of how canola can fit into existing cropping systems in Eastern Canada. Researchers wanted to calculate the economic benefit of growing canola as well as nutrient utilization efficiency and carbon footprints in different cropping systems through the collection of soil, crop growth, yield and tissue N concentration data, to investigate major diseases and insects of canola production in different cropping systems, and to identify and establish a sustainable cropping system for canola production in Eastern Canada.

A four-year phase rotation (canola-wheat-corn-soybean) experiment with 13 crop sequence combinations and four replications per site was established in Ottawa, Ont., Ste. Anne de Bellevue, Que. and Canning, N. S.

The following conclusions are drawn from data analysis:

1. In most cases, the canola following soybean rotation produced the best yields of all the canola rotations.
2. In most cases continuous canola plots (CC) produced the worst yields of all the canola rotations. Clubroot became an issue at one site but only in the continuous canola rotation.
3. There appears to be a slight yield advantage of planting wheat after canola. In four out of the five years, the rotational wheat after canola produced the best yields of all three rotations.
4. The different crop rotations had no significant effect on canola seed oil concentration.
5. Root:shoot ratio can be a good assessment of the health of a crop. Continuous canola plots that had the poorest yields also had the lowest root:shoot ratios, compared to the other canola rotations. However, even though the canola following soybean plots had the highest yields, they did not necessarily have the highest root:shoot ratios. There does not seem to be a correlation between root:shoot ratios and the final yields of the wheat rotations. Wheat plots following canola had the highest yields, but not the highest root:shoot ratios.
6. This rotational effect may likely be associated with the change in soil microbial communities, which indirectly affected the availability of soil nutrient supply, and thereby the uptake of plant nutrients and nutrient balance. This requires further investigation.
7. More research is also required to understand soil and root dynamics.

Baoluo Ma, Agriculture and Agri-Food Canada (AAFC) research scientist and co-investigator for this project, was invited to contribute a review paper titled "Crop rotation: A sustainable system for maize production" in a publication called "Achieving Sustainable Maize Cultivation", published by Burleigh Dodds Science Publishing Ltd., Swanston, Cambridge, U.K. The paper included this observation: "The yield ratio (rotational canola yield as a fraction of the average monoculture canola yield) was also affected by the previous two-year sequence of crops, with canola yield increase by two to 65 per cent when following the maize-soybean sequence, compared to monoculture canola."

Further analysis of the multi-year data is ongoing, and the large dataset generated will provide additional insights into the rotation effect.

FARMER PERSPECTIVE

CLAYTON HARDER
Manitoba Canola Growers director, Winnipeg, Man.

Economic sustainability big factor in rotation

Most of my canola is in a three-year rotation of wheat-soybeans-canola. Sometimes I'll under-seed wheat with perennial ryegrass and harvest it for seed the following year, which extends the rotation to four crops on those fields. This is a dependable rotation for me, economically, and I think it's also acceptable from an overall sustainability perspective. There are certainly lots of farmers growing five crops in my area, with quite a few corn and oats acres, but we're in an area of the Prairies where farmers have quite a few profitable rotation options.

When it comes to sustainability decisions and rotations, it can depend on where you are in the economic lifecycle of the farm. I'm in the early half of my farming career and my focus is on economic sustainability, but I do want to make sure the land is taken care of for later.

One benefit of soybeans in the rotation is that I can leave the stubble standing and direct seed canola into it. This is one way we can reduce tillage in the eastern part of Manitoba. While soybeans, like canola, are also susceptible to sclerotinia (white mould), I've been following this rotation for eight years and the disease has never been that serious in soybeans. I will spray canola to prevent sclerotinia, but I think I'd be doing that anyway.

COMPLETED PROJECTS

Success of VR nitrogen requires field-by-field analysis

Key result: Differences in management, including agronomic practices, variety selection and types of fertilizer, as well as soil properties, elevation and terrain attributes all impact fertility and should be considered, along with historical yields, when planning out a variable-rate (VR) fertility program.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Variable nitrogen fertility management of canola at the field scale," Alan Moulin, Agriculture and Agri-Food Canada, Brandon

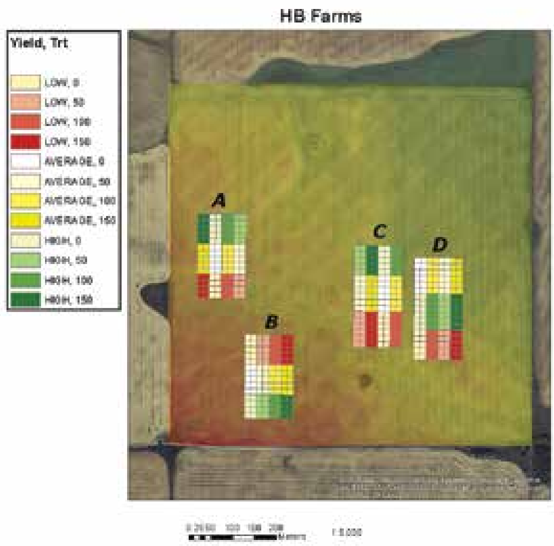
FUNDING:
Growing Forward 2

This project examined several impacts of variable rate nitrogen fertility programs (nitrogen fertilizer rates of 0, 50, 100 and 150 per cent of soil test recommendations) on canola yield in areas with consistently low, average and high production. Data are from 25 sites over four growing seasons in Manitoba, Saskatchewan and Alberta. Investigating variable rate programs proved to be very complex in many ways and a challenge to analyze, but resulting in many types of findings and suggestions for farmers and future research.

Significant improvements in yield were found when comparing plots given nitrogen fertilizer applications versus plots given no nitrogen applications, but not between different fertilizer rates. This is partially due to the variability correlated to terrain and correlations ranging from farm to farm. This emphasized the need for soil tests to account for mineralizable nitrogen, which they currently don't. Moulin hypothesized that mineralizable nitrogen builds up in the soil following rotations (ex. cereal-canola) and annual nitrogen fertilizer applications, and is available to the crop during the growing season, but is not accounted for in soil test analyses. In contrast to 2014, 2015 and 2016, dry conditions during summer 2017, preceded by ample spring soil moisture, forced crops to root deeper than normal. As a result canola accessed Nitrogen which accumulated normally below the root zone in previous years, and yield was similar for all fertilizer treatments in several fields. Furthermore, yield response may also be attributed to a buildup of mineralizable Nitrogen in or below the root zone. It is possible that mineralizable Nitrogen and the distribution of Nitrogen below the root zone resulted in high production in the control treatments, but updated statistical analysis will provide more insight into this.

Phosphorus was applied with seed at the maximum possible rate, while potassium and sulphur were judged sufficient based on soil test and fertilizer rates used by producers. Soil test phosphorous varied with terrain attributes, which accounted for a significant proportion of the variability of canola yield, but (again) varied from farm to farm. The phosphorus tended to accumulate in lower slope positions, in areas with low production. Soil properties and the interaction with canola variety, growing season precipitation and temperature also varied considerably with respect to yield.

The economic return and efficiency of fertilizer use from variable rate management varied between fields and between farms, as did canola yield. While canola production and net revenue functions generally followed conventional response curves, the effects of zones and nitrogen



This field map shows the treatments (0, 50, 100 and 150 per cent of recommended Nitrogen) in low-, medium- and high-yielding parts of a field.

rates at each individual site were mixed. Overall, nitrogen and production zones were significant with the high production zones generating a net $67 more per hectare, on average, and low production zones generating a net $61 less per hectare compared to average zones. Farm location had significant effects on canola yield, with profitability ranging from negative $490 to positive $530 per hectare.

Overall, the integration of an effective variable rate fertility program is very complicated so carrying out field by field analysis is paramount to potential success. Differences in management, including agronomic practices, variety selection and types of fertilizer, as well as soil properties, elevation and terrain attributes all impact fertility and should be considered, along with historical yields, when planning out a variable rate fertility program or studying fields that do utilize this technology.

Future studies on this topic may benefit from including UAV data (to show fertilizer variability response through in-season images), machine learning methods to create prescription maps (as the analyses relate a large number of variables to potential canola yield) and significant expertise with prescription mapping software (as well as testing the prescription map for the seeder 1-2 days prior to seeding). Thorough preparations well in advance of seeding, combined with post-harvest or pre-seeding soil sampling are recommended to ensure accuracy when carried out at busy times (especially in regions with short growing seasons).

COMPLETED PROJECTS

Online tool improves access to Saskatchewan soil data

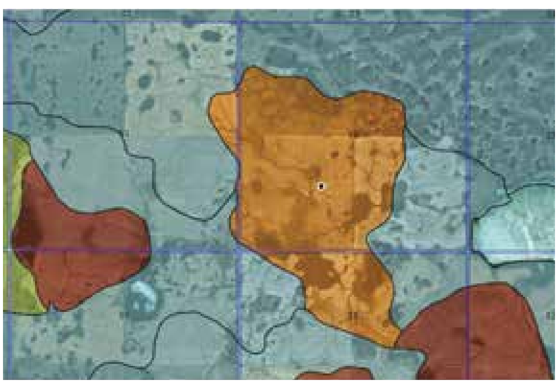
KEY RESULT: Saskatchewan Soil Information System (SKSIS) provides an online and interactive soils resource sksis.usask.ca, helping Saskatchewan farmers make better land-use decisions.

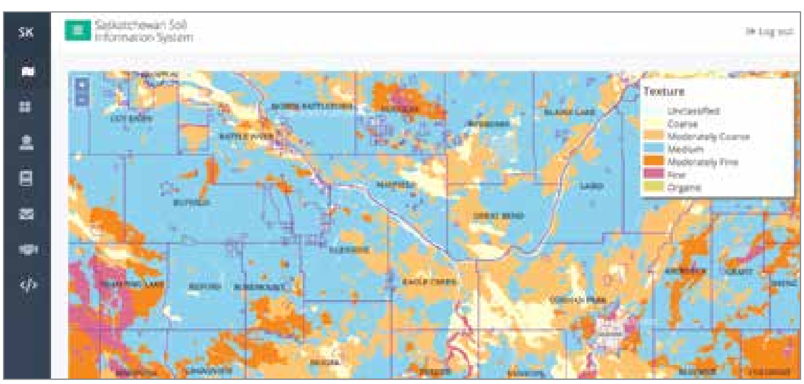
PROJECT TITLE, PRINCIPAL INVESTIGATOR: "Enhanced Saskatchewan Soil Data for Sustainable Land Management," Angela Bedard-Haughn, University of Saskatchewan

FUNDING: SaskCanola, Sask Pulse Growers and Saskatchewan's Agriculture Development Fund (ADF)

In order to make well-informed land management decisions, including those related to precision agriculture practices, accurate, reliable information about soils and land capability is needed. In the 20th century, Agriculture and Agri-Food Canada (AAFC) together with its provincial partners heavily invested in soil survey, and the results were compiled into AAFC's Canadian Soil Information System (CanSIS). However, with reduced staffing in CanSIS and an uncertain future for any ongoing soil survey updates, there was a clear need for improved access to high-quality soil data framework.

To fill this need, researchers at the University of Saskatchewan, in collaboration with AAFC and industry, initiated a two-year project to develop a new enhanced data framework to store and access Saskatchewan soil information. The new program, called the Saskatchewan Soil Information System (SKSIS), has made existing Saskatchewan soils information (from CanSIS at a scale of 1:100,000) available to everyone as an online resource, available at **sksis.usask.ca**. Clicking on a particular location brings up the available information for that area as well as expanded descriptions of the local soil associations. Information about soil type, capability, irrigation potential, texture, salinity, and pH can all be displayed and queried, including compound queries to find soils with a particular combination of properties.



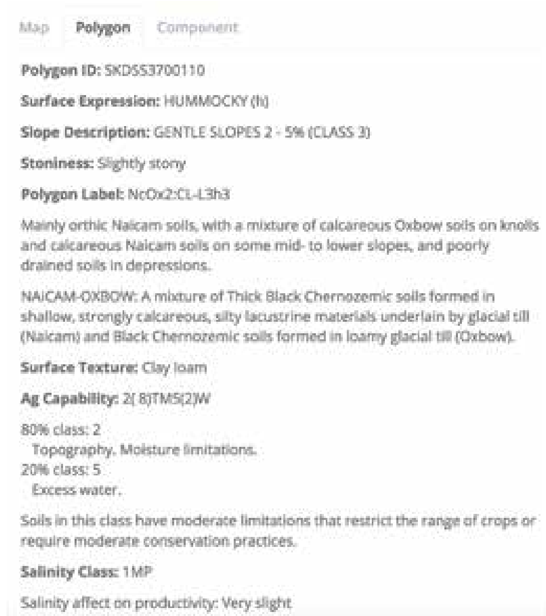


*Anyone can explore Saskatchewan soils at **sksis.usask.ca**. The top map is a zoomed in section from the below map, showing soil results for a specific field. The right image shows details for the orange polygon in the middle.*

Three sites in Western Saskatchewan (Central Butte, Rosetown and Waseca) were used for testing digital soil mapping (DSM) methods that allow soil information to be displayed at a scale that could be used for precision agriculture applications (1:5,000). Mapping was based upon a five-metre grid digital elevation model obtained from data collected with a fixed wing drone and sophisticated software package. The DSM algorithms then used soil information from in-field samples to produce five-metre grid rasters of soil properties for the fields. All soil properties were successfully mapped with high prediction accuracy and verified by the individual land owners and operators, showing the ability of the DSM to produce layers of spatially enhanced soil information at the field scale.

SKSIS is available for both desktop and mobile users to identify soil properties at a specific location, with mobile access using smartphone GPS technology to establish user location. SKSIS supports the uploading of photos, documents and observations (including detailed soil descriptions), and offers other features such as the ability to change base maps to allow users to associate soil information with landmarks they are familiar with, like highways or farm yards. The information can be used alone to better understand variability in the field and assist with nutrient planning, or used with variable rate equipment or other precision agriculture technologies for additional value.

Funding for Phase 2 research has been approved to continue to build on SKSIS, enhancing its usability and accessibility for a wider audience and providing greater refinement of the soils information via broader application of digital soil mapping technologies and development of new decision support systems.


Map Polygon Component

Polygon ID: SKDSS3700110

Surface Expression: HUMMOCKY (h)

Slope Description: GENTLE SLOPES 2 - 5% (CLASS 3)

Stoniness: Slightly stony

Polygon Label: NcOx2:CL-L3h3

Mainly orthic Naicam soils, with a mixture of calcareous Oxbow soils on knolls and calcareous Naicam soils on some mid- to lower slopes, and poorly drained soils in depressions.

NAICAM-OXBOW: A mixture of Thick Black Chernozemic soils formed in shallow, strongly calcareous, silty lacustrine materials underlain by glacial till (Naicam) and Black Chernozemic soils formed in loamy glacial till (Oxbow).

Surface Texture: Clay loam

Ag Capability: 2(8)TM5(2)W

80% class: 2
Topography. Moisture limitations.
20% class: 5
Excess water.

Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices.

Salinity Class: 1MP

Salinity affect on productivity: Very slight

Study finds new clubroot-resistance genes

Key result: This study found seven clubroot-resistance genes in *B. rapa*, *B. nigra* and *B. oleracea* and entered three new CR lines into canola co-op trials, big steps to improve the sustainability of canola production with increasing scope and intensity of clubroot across the Prairies.

PROJECT TITLE, PRINCIPAL INVESTIGATOR: "Characterization and development of new resistant sources for management of clubroot in canola," Gary Peng, AAFC Saskatoon

FUNDING: Growing Forward 2

Clubroot was found in canola in new counties in western Canada in 2018, causing increased concern and likely increased interest in growing clubroot-resistant (CR) varieties. Annual disease surveys, research findings and lab samples continue to gather information on the distribution and prevalence of different pathotypes across the Prairies. However, a strong need to explore new resistant sources to stay ahead of the resilient and complex disease still remains.

This project aimed to discover new CR genes with novel traits from new *B. rapa*, *B. oleracea* and *B. nigra* sources, to develop markers for use in marker-assisted breeding and to investigate resistance mechanisms by different CR genes. It also involved the pyramiding of different resistance genes for the development or re-synthesizing of elite *B. napus* canola lines and of *B. carinata* canola germplasm (all of which involved many steps and required an enormous amount of careful, detailed work).

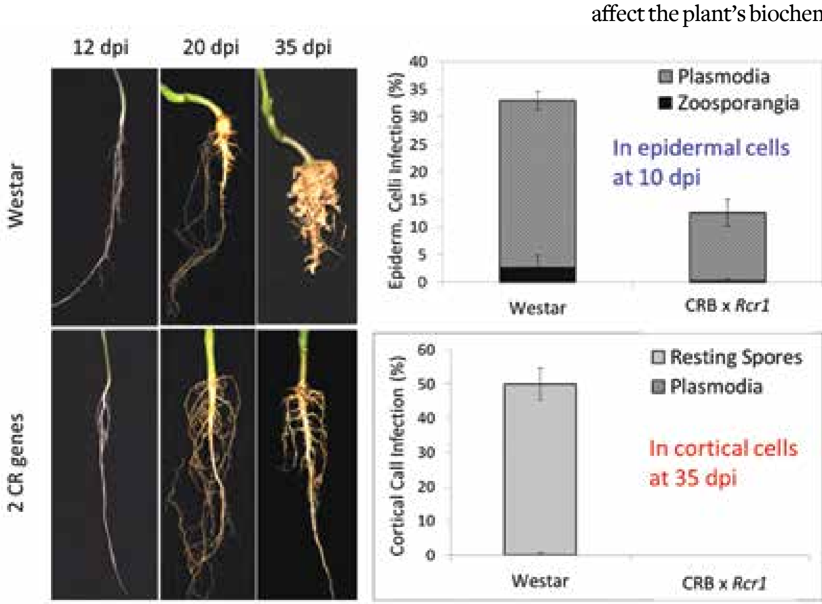
The highlights of the genetic material created, developed or discovered throughout this project include:

- Genetic mapping of several *B. rapa*, *B. nigra* and *B. oleracea* lines have led to the discovery of seven CR genes. Gene-specific markers have also been developed for several of these CR genes.
- A CR *B. carinata* line (which came from a line with complete resistance to a broad spectrum of clubroot races) was created and is currently at the pre-commercialization stage.
- Testing hundreds of lines in preliminary trials for yield and nursery plots for yield, agronomic and seed quality traits as well as in greenhouses or field plots for clubroot resistance resulted in 12 elite CR lines (that have been converted to cytoplasmic male-sterile lines for use as female parents in continued development of CR hybrids).
- Three canola cultivars carrying more than one CR genes have been entered in private co-op trials (and could be registration as early as 2019 if selected by seed companies) and two CR canola cultivars have been developed in collaboration with industry.

The key methods and analytical techniques developed throughout this project include:

- Leading-edge technologies (transcriptome, proteome, metabolome and synchrotron-based spectroscopy) have been developed to better study plant-pathogen interactions and resistance mechanisms, which helps optimize CR genes deployment for maximum efficacy and durability.
- Through an extensive process, it was determined that a new mapping method used in this study (mapping by sequencing) can successfully be used for genetic mapping.
- After multiple steps of analysis and sequencing, CR gene sequences and their expression could be used to distinguish the commonly used CR genes from novel CR genes.

To better understand the mechanisms of the CR gene which affect the plant's biochemistry and make it resistant, a synchrotron-based study was conducted to look at changes in cell-wall components associated with clubroot resistance. The results showed an increased production of lignin and phenolics. Additional fluorescence microscopy on a moderately resistant canola hybrid carrying two CR genes confirmed the increased cell-wall lignification coinciding with reduced infection in root cortical tissues 20 to 35 days after inoculation with pathotype 5X of clubroot pathogen (see Figure 1). This is a very useful disease mechanism discovery.



Measurements of pathogen life-cycle structures (Plasmodia and Zoosporangia of P. brassicae*) in root roots (epidermal and cortical cells) of a double CR-gene* B. napus *hybrid and Westar inoculated with pathotype 5X of* P. brassicae *at 12, 20 and 35 days post-inoculation (dpi).*

Resistant varieties plus crop rotation keys to clubroot management

Key result: This study looked at various clubroot management techniques and found that using clubroot-resistant varieties plus crop rotations with at least two years between host crops were effective in reducing disease severity and yield loss.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Management of clubroot in a dynamic environment"
Sheau-Fang Hwang, Alberta Agriculture and Food

FUNDING:
Growing Forward 2

Clubroot is a very challenging disease to manage. The protist that causes clubroot is complex, with several different life stages that feature characteristics of amoebas, slime molds and fungi. It also has a remarkable ability to spread, with each infected canola plant able produce up to 16 billion resting spores.

This project investigated clubroot management options, including developing economical and effective techniques to eradicate localized infestations using soil fumigants, assessing the impact of cropping rotations which include clubroot-resistant (CR) canola cultivars and optimizing ways to disinfest agricultural and industrial equipment.

These are the key findings from this project:

- Disease severity tended to decline when CR cultivars were rotated, but alternating non-hosts, resistant cultivars or fallow periods with susceptible cultivars did not reduce disease, nor did growing the same resistant cultivar over repeated cycles. All of the commercially available clubroot-resistant cultivars were actually susceptible when grown in soil from fields where resistance loss had been reported, although there was some degree of difference among the cultivars with respect to the extent of susceptibility when inoculum density was ≥ than 100,000 spores per ml of soil and ≤ 1,000,000 spores per ml of soil.
- The use of Vapam, a soil fumigant, was supported as a potential approach in eradicating or containing localized clubroot infestations. Increased efficacy was seen at higher rates, when it was incorporated into the soil and when it was covered with plastic for varying periods of time (although the practicality of this may be more useful to the oil and gas pipeliners than farmers). Although Vapam was effective, it is a non-selective toxin which is both volatile and highly soluble in water.
- Cropping interval has a big impact on resting spore populations in the soil, with large numbers of resting spores dying or disappearing in the first one to two years after a susceptible crop. (Others may survive for many years.) Therefore, even a two-year break between canola crops could reduce yield losses in CR cultivars and prevent selection pressure for new pathotypes.
- It was confirmed that quantitative polymerase chain reaction (qPCR) analysis is an effective tool for evaluating *P. brassicae* resting spore concentrations in naturally infested soil. Peaks in *P. brassicae* inoculum were found in the spring following years when susceptible canola was cultivated and inoculum loads declined rapidly after two years without canola cultivation. It was also reported that exposing clubroot spores to 100°C for at least 30 minutes is sufficient to inactivate clubroot spores.
- A special qPCR technique (using propidium monoazide), developed to differentiate between living and dead spores of *P. brassicae* in field soil, found that resting spore populations declined quickly over the first two years after a susceptible crop, and much more slowly thereafter. Many of the spores in soil in the spring following a susceptible crop were immature, but were likely still infectious (although without a host, these spores rapidly disappeared from the spore bank).

This project also produced some important methodology developments in quantifying resistance to *P. brassicae* in Brassica hosts, in examining root cell (cortical) colonization by *P. brassicae* and in the production of primary and secondary zoospores of *P. brassicae*. A disease nursery was also developed to help breeders and seed companies screen materials for resistance to clubroot.

FARMER PERSPECTIVE

IAN CHITWOOD
Alberta Canola director, Airdrie, Alta.

Taking action to prevent clubroot

Clubroot was confirmed in three fields in the south end of our county this year, which should officially end any sense of complacency around clubroot in southern Alberta.

I farm with my brother and my dad. While clubroot's arrival is inevitable, we have not seen clubroot on our farm yet and we want to keep it that way for as long as possible.

We already have a robust crop rotation, growing canola, barley, wheat and forages in a four-year rotation. We keep our equipment clean and try to combine canola last to prevent spread of clubroot-infested soil just in case it's there and we don't know it. This year, we also designated separate field entrances and exits. Clubroot usually arrives in a field at the entrance, where equipment first starts working and drops clubroot-infested soil. If we leave through a different exit, we're less likely to pick up infested soil on the way out. We also want to minimize all traffic in the fields. We've been asking hunters where else they've been this fall and we actually turned away a few. We have not used clubroot-resistant varieties yet, but we do expect retailers in the area to start bringing in those varieties for seeding this spring.

We want to be proactive in preventing clubroot because once we do have it, management becomes harder. Our goal is to make sure we keep canola as a viable crop on our farm.

COMPLETED PROJECTS

Diversity in clubroot pathotypes, diversity in clubroot resistance

Key result: With tools to identify various clubroot pathotypes, researchers tested existing clubroot-resistant (CR) cultivars against the new 5X pathotype found in Alberta soils. They found that several were resistant to 5X.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Developing canola germplasms with diverse mechanisms to enhance the durability of clubroot resistance," Gary Peng, AAFC Saskatoon

FUNDING:
SaskCanola and Western Grain Research Foundation

The first clubroot-resistant (CR) canola cultivar was released in 2009 as a new management tool to counter the disease that had been found in canola fields in Alberta. Then in 2013 some canola fields seeded with CR varieties showed substantial levels of clubroot damage. When further examination determined that the pathogen strains from these fields were virulent (the ability to infect or damage the host) to all the resistant cultivars in the marketplace, the new pathogen strain was tentatively called pathotype 5X. This incited a renewed need for new clubroot resistant varieties which would be resistant to additional pathotypes instead of just pathotype 3, which had been the most common strain on the Prairies.

Consequently, the goal of this study was to assess previously identified CR genes to see if any would have efficacy against pathotype 5X of *P. brassicae*. As well, it aimed to explore molecular and biochemical tools that can be used for studying CR mechanisms, and develop canola germplasm carrying more diverse CR genes for sustainable clubroot resistance.

First, 24 CR lines from Agriculture and Agri-Food Canada (AAFC) were screened against a mixture of three populations of the pathotype 5X from Alberta fields where resistant cultivars failed in 2013. These populations showed variable virulence against resistant canola cultivars, with some populations being slightly more virulent on resistant varieties. Luckily, several CR genes and lines were resistant to the mixed 5X populations.

Then, new AAFC CR brassica candidate lines were screened against the mixed 5X populations, including those lines carrying the CR genes identified previously from *B. rapa* and *B. nigra*. Many of these CR candidates showed resistance to all other *P. brassicae* pathotypes (2, 3, 5, 6 and 8) found in Canada earlier. Many of these CR genes have now been mapped, with robust markers developed.

Advanced technologies were then explored to better understand the resistance mechanisms associated with specific CR genes, including transcriptome (RNA-seq),

Figure 1. Clubroot severity caused by pathotype 5X-LG3 of Plasmodiophora brassicae *on different canola varieties carrying a single resistance gene, 5 weeks after the inoculation in greenhouse. Galls suggest that these varieties may carry similar resistance genes susceptible to this population of pathotype 5X.*

proteome, metabolome, fluorescent microscopy and synchrotron-based chemometrics.

Finally, germplasms carrying different CR genes were developed. Clubroot resistant *B. napus* germplasm carrying different CR genes were transferred to seven breeding companies for clubroot resistance breeding. *B. napus* germplasm carrying double CR genes (on chromosome A03 and A08) was also produced, which showed moderate but consistent resistance to pathotype 5X populations through collaboration with Nutrien Ag Solutions (formerly Crop Production Services). An elite line of B. *carinata* carrying a CR gene was also stabilized and can be used for commercial variety development. Elite AAFC *B. napus* lines (black- and yellow-seeded) carrying a CR gene have also been produced and the black-seeded lines have been tested in the field. These CR genes can be pyramided in commercial breeding lines for canola hybrids with resistance against a broader range of pathotypes.

Compare varieties, including CR varieties, with the CPT online tool

Canola Performance Trials provide independent third-party canola variety comparison data from locations all across the Prairies. Data is coming in for 2018 and data from 2011 to 2017 is available any time at **canolaperformancetrials.ca**.

The online search tool, situated at the bottom of the CPT home page, allows users to filter by herbicide-tolerance system, location, yield, maturity and more. With each search result, scroll down to get a graph of the results, then a 'Trial results data' table and then a map showing trial locations. To see how two varieties performed when together in the same location, click 'Compare varieties' at the top then choose 'Head to head comparison'. Choose two varieties then 'Search trials'. Note, this only includes data if the two varieties were grown at the same place and time (same site in the same year). That means fewer data points but a high quality comparison. Take time to explore. You'll find many ways to use the tool.

Looking for clubroot resistance in non-host plants

Key result: A grass plant called *B. distachyon* can get infected with clubroot, but secondary gall-forming infection will not occur. While this might show promise, the study concluded that looking for resistance in host brassica species is the better path for now.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Using Non-host Species to Identify Novel Genes For Durable Clubroot Resistance in Canola," Peta Bonham-Smith, University of Saskatchewan

FUNDING:
Growing Foward 2, SaskCanola and Saskatchewan's Agriculture Development Fund (ADF)

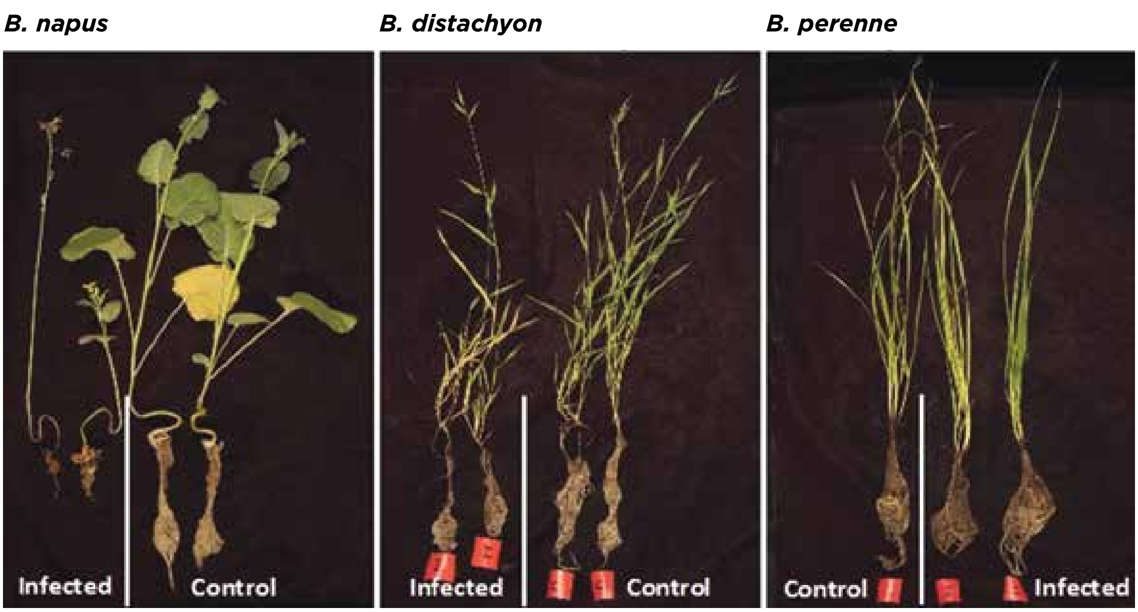
Plasmodiophora brassicae, the pathogen that causes clubroot in species of the Brassicaceae family, including canola, has a complex life cycle comprised of several major stages. This includes survival of resting spores in the soil, primary infection of root hairs, and secondary infection which leads to the eventual release of resting spores back into the soil. Current clubroot-resistant (CR) varieties allow for the primary infection to occur, but prevent the secondary zoospores from infecting the plant. These varieties were developed as a result of identifying clubroot resistance genes in susceptible species of Brassicaceae. While they have been a very useful part of clubroot management, they only protect against specific *P. brassicae* pathotypes and no resistance genes protect against all pathotypes.

This study investigates the use of a non-host species as a potential source of more durable, broad-spectrum resistance genes that could protect against multiple pathotypes. The non-host species that was utilized was *Brachypodium distachyon*, a wild grass species used as a model plant for temperate grasses. The intention in this project was to verify if *B. distachyon* could act as a non-host species for *P. brassicae* infection and subsequent clubroot development and to profile the transcriptome (all the messenger RNA molecules expressed from the genes) of the pathogen and of the non-host plant during infection to identify non-host plant genes likely involved in the mechanism of disease prevention.

By using both light and electron microscopy, Bonham-Smith's research team found that *B. distachyon* allowed for the primary infection to occur but it prevented the secondary infection from ensuing (and therefore did not produce root galls), thereby preventing the establishment and progression of clubroot disease. The resistance, seen as a significant regression of the number of infected cells in the root inner tissues, develops in the non-host plant within a few days after the infection. This suggests that *B. distachyon* was able to recognize and either eliminate the pathogen from the plant or to prevent the completion of the pathogen life cycle, confirming that *B. distachyon* is a non-host and does not develop clubroot.

Utilizing the *B. distachyon* complete genome sequence, they carried out transcriptome sequencing to recognize the genomic differences between the susceptible and the non-host resistant plants (in order to identify the molecular basis of resistance to secondary infection by *P. brassicae*). Comparative heat map analyses of the transcriptomes showed that both *B. distachyon* and *P. brassicae* transcript levels demonstrated very little difference between infected and mock-infected (*B. distachyon*) plants.

Without fully understanding the interactions between *P. brassicae* and host plants, it is very difficult to understand this non-host interaction, particularly in light of very little genome activity from both the non-host and the pathogen. Therefore, it is recommended that research on the compatible host-pathogen system is a higher priority for the identification of plant resistance than understanding non-host systems.



Root galls in the host plant B. napus *but not in the non-host plants* B. distachyon *and* L. perenne*. All seedlings infected with* P. brassicae *resting spores were grown to maturity under controlled, optimal growing conditions in a Conviron growth chamber in the EEPPI centre, Department of Biology, University of Saskatchewan.*

Sclerotinia fungicide improves yield, but check ROI

Key result: Carefully consider the risk scenario and potential return on investment before spraying fungicide for sclerotinia stem rot or selecting current varieties with the sclerotinia-tolerant trait.

PROJECT TITLE, PRINCIPAL INVESTIGATOR:
"Effects of genetic sclerotinia tolerance and foliar fungicide applications on the incidence and severity of sclerotinia stem rot infection in argentine canola," Chris Holzapfel, Indian Head Agricultural Research Farm

FUNDING:
SaskCanola

Sclerotinia stem rot is a major canola disease that causes significant yield loss in Western Canada each year. However, the impact of the disease is still hard to predict, as incidence and severity in individual fields varies dramatically depending on environmental conditions. This can make the grower's decision to spray sclerotinia fungicide difficult. Although hybrids with increased sclerotinia tolerance are now available, sclerotinia infection is not eliminated in them and conditions where foliar fungicide applications are still needed can occur.

This study evaluates the relative effectiveness of genetic tolerance and foliar fungicides to reduce sclerotinia stem rot infection in canola. It also investigates if, and under what conditions, foliar fungicide applications may still be required when growing a hybrid with genetic tolerance to sclerotinia. The three-year field study (2013-15) was carried out at three locations in Saskatchewan (Indian Head, Melfort and Outlook) and two in Manitoba (Melita and Brandon). Two of the locations had access to irrigation and all of the locations were considered to have at least a moderate risk for sclerotinia in canola. Each location compared susceptible hybrid 45H29 RR and tolerant hybrid 45S54 RR, and utilized four foliar fungicide treatments: untreated check, fungicide applied at 20 per cent bloom, fungicide applied at 50 per cent bloom, and fungicide applied twice (at both 20 and 50 per cent bloom).

This study was carried out in small plot trials (which can be criticized for having an edge effect, increased air flow and being on well-drained, uniform ground) rather than field scale sites (which can have low-lying wet areas with higher incidence and severity), but the plot sizes were as large as possible and at least one location had disease incidence and severity consistent with nearby field scale trials.

Despite selecting locations considered to have at least a moderate risk for sclerotinia, the actual disease incidence in 2013-15 was generally low, which may have impacted the range in treatment effects. Under the conditions encountered, disease levels in tolerant 45S54 were frequently lower than those in susceptible 45H29. Under this low disease pressure, however, there were no measurable benefits to applying fungicides with a tolerant hybrid.

A significant yield increase was seen with fungicide use when averaged across locations and hybrids. However, the economic returns (under the conditions encountered) were marginal at best, depending on grain prices and fungicide costs.

Although not statistically significant, there was some evidence that the yield response was slightly larger and more consistent with susceptible hybrids than tolerant ones. Tolerant hybrids were shown to be effective for reducing disease and less likely to benefit from fungicide (see Table 1). However, susceptible hybrids may frequently yield higher, at least under low disease pressure as encountered in these trials.

Dual applications provided no benefit over single applications (neither visual symptoms nor actual seed yields), regardless of location or application timing. Applying fungicide between 20 and 50 per cent bloom, before too many petals drop, was important (for fungicide efficacy).

Improvements in management decisions for sclerotinia stem rot will contribute to long-term economic sustainability of canola in Western Canada. The greatest challenge for managing sclerotinia in canola continues to be accurately predicting whether yield responses to costly fungicide applications are likely. Genetic tolerance is an exciting advancement that has potential to reduce dependence on fungicides and provide adequate protection under low to moderate disease pressure. However, to be widely adopted and utilized to its full potential, sclerotinia tolerance should be incorporated into broader range of hybrids and, given the sporadic and unpredictable nature of this disease, yields must remain competitive with susceptible hybrids.

Table 1. Sclerotinia stem rot treatments and yield

Fungicide Treatment	Hybrid	
	Susceptible (45H29)	Tolerant (45S54)
	Yield (kg/ha)	
Control	3,024 abc (57.4)	2,825 d (57.6)
At 20% bloom	3,081 ab (57.6)	2,904 cd (59.4)
At 50% bloom	3,153 a (57.4)	2,974 cd (58.9)
Dual App.	3,160 a (57.1)	2,810 e (58.9)

Results from a 2013-15 IHARF study. Treatment means and contrast results for hybrid x fungicide (P = 0.248) effects on canola seed yield at 14 location-years in Saskatchewan and Manitoba. Standard errors of the treatment means are enclosed in parentheses. Numbers that share a letter (a, b, c, etc.) are not statistically different.

An economic study of open-pollinated canola varieties

Key result: MCGA tested open-pollinated (OP) canola varieties against two hybrid canola checks. The OP average yield was 18-30 per cent less than the hybrid checks. Farmers will need to do their own economic analysis to see which is the better sustainability choice.

PROJECT TITLE, PRINCIPAL INVESTIGATOR: "Evaluation of OP lines and varieties for suitability for commercial production in Manitoba," Haplotech Inc.

FUNDING: Manitoba Canola Growers

Manitoba Canola Growers ran trials in 2016 and 2017 to evaluate open-pollinated (OP) canola varieties for commercial production. Trials included 10 varieties, including eight open-pollinated (OP) varieties sourced from different breeders and two hybrid check varieties that were used by the Western Canadian Canola/Rapeseed Recommending Committee (WCC/RRC). The WCC/RRC checks provide a relative comparison to commercial hybrids currently sold in Western Canada.

Three of the varieties from the 2016 trials were excluded due to poor performance or inadequate quality and were replaced by three other varieties supplied by the same breeders. Although it was intended to evaluate varieties for resistance to blackleg at two locations (Carman and Minto) in 2017, the disease pressure ended up being lower than allowable by the WCC/RRC (Westar rating of 2.6), so blackleg resistance ratings couldn't be assigned.

Trials were conducted at seven locations, with four replications at each. One of the sites in 2017 (near Beausejour) was dropped and then replaced with another site location (near La Salle) in an attempt to maintain seven locations. But unfortunately one other site (in Winnipeg) had to be dropped due to a seeding error, leaving six trial locations for the 2017 growing season.

Yield results for the OP varieties ranged between 75 and 85 per cent of the check in 2016 and 65 to 79 per cent of the check in 2017, with the best yielding OP varieties yielding 82 per cent of the check (see Table 1). Performance of the OP varieties in 2017 was slightly poorer than in 2016, which could be due to the elevated environmental stress (drought/heat) in 2017.

Unfortunately only two of the OP varieties tested met the oil content requirements for registration in Canada. They all met the protein content requirements. Two varieties were just above the glucosinolates content requirements, while three of the varieties were above the saturated fatty acid content requirement for variety registration.

Relative to the checks, OP varieties ranged from -0.1 days earlier maturing to 5.6 days later. The highest-yielding OP was also the tallest and latest maturing. None of the varieties showed excessive lodging as compared to the WCC/RRC checks (5440 is outstanding, 45H29 moderate to strong). As mentioned above, the disease pressure was too low to make a definite conclusion about rating the varieties, but most entries scored similarly to the resistant checks. None of the varieties had a claim on any value-added trait (e.g. clubroot or blackleg resistance, pod-shatter tolerance etc.).

A full economic analysis was not been carried out, but the two-year yield averages of the OP varieties in the study were about 70-82 per cent of the hybrid check varieties (approximately 18-30 per cent less than the yields of the check varieties). Based on this, if the Manitoba average canola yield is 40 bu./ac., for example, the OP variety average might be 28-33 bu./ac., which would be $84 to $144 less revenue per acre based on $12 per bushel canola.

Table 1. Yield averages for each of the 10 varieties over individual and combined years of the trials

Entry	2016 Yield (bu/ac, %chk)			2017 Yield (bu/ac, %chk)			Avg (bu/ac, %chk)	
Check	5440	50.7	99.2	5440	56.0	100.7	53.9	100.1
Check	45H29	49.8	100.8	45H29	54.1	99.3	52.4	99.9
OP	AC Excel	35.9	72.9	AC Excel	37.4	68.6	36.8	70.3
OP	A05-6NI	37.8	78.0	A05-6NI	36.3	65.2	36.9	70.3
OP	72P01 CL	36.5	74.5	Bounty Gold	42.4	76.6		
OP	Alfa Gold	41.6	83.1	Alfa Gold	42.0	74.9	41.8	78.2
OP	PSL 11	40.9	81.4	PSL 11	40.4	73.0	40.6	76.4
OP	PSL 385	42.5	86.1	PSL 385	44.1	79.4	43.5	82.1
OP	PSL 427	37.5	76.1	PSL 215	39.2	68.7		
OP	PSL 120	38.4	76.9	PSL 488	43.4	78.1		

Intercropping peas and OPs

Lana Shaw, research manager at South East Research Farm in Redvers, Sask., has been testing a few intercrops – growing two crops at the same time in the same field. The idea is that a pulse and an oilseed together provide a symbiotic relationship that boosts overall profitability per acre. With peas and OP canola, the idea is that seed and nitrogen rates will be lower, with a strong pea crop supplying nitrogen to the system. Economic damage from flea beetles could be mitigated by having a non-host companion crop, which would lower the threshold for spraying insecticides, Shaw adds. But she hasn't hit the right formula, yet. "So far I haven't found a canola variety to go with peas that I'm really happy with," she says. The SERF location also had bad aphanomyces in the peas in 2018. "The pea monocrops were a failure," she says. "Pea-canola intercrops at least had some production, but not as much as mono canola with full nitrogen package. If we had top-dressed the pea-canola intercrop with nitrogen when it became apparent the peas were badly hit, I think it would have been a more productive intercrop."

Protein opportunities could improve canola sustainability

Key result: Expanding market opportunities for the protein within canola meal could improve the overall value of canola. Based on the findings in this study, canola protein isolate shows promise as a potential material for the development of edible films for food packaging.

PROJECT TITLE, PRINCIPAL INVESTIGATOR: "Development of Formulated Canola Protein-based Ingredients for the Food Industry," Michael Nickerson, University of Saskatchewan

FUNDING: SaskCanola

Protein ingredients are a huge industry. Animal proteins such as gelatin, ovalbumin, casein and whey currently dominate the market, but market trends are moving more toward lower cost and abundant plant-based protein sources. Canola protein is one option. Currently seeking 'generally regarded as safe' (GRAS) status, canola protein has high nutritional value and the functional attributes required for many food applications, but the widespread use of plant proteins is often hindered by their reduced solubility (and functionality) relative to animal-based alternatives. Successful processing innovations and product characterization could lead to the development of new plant-sourced protein food ingredients.

This project aimed to develop formulated canola protein-based ingredients that could be tailored to many specific food applications (e.g. baking, meats, beverages and dairy alternatives- such as coffee whiteners) and in-house standardized methods for assessment and investigating the potential use of canola proteins as film-forming agents in the development of edible and biodegradable packaging.

Overall, the functionality of protein-polysaccharide complexes involving canola protein isolates (curciferin-rich or napin-rich protein isolates) were found to have a neutral or negative effect on protein functionality. The properties that were most negatively affected were solubility and foaming capacity. Despite this, the protein produced performed much better than expected, and had very comparable functionality relative to commercial protein ingredients derived from egg and milk. This will help the food industry in understanding these complex ingredient interactions and in developing formulations that include canola proteins.

Despite the two canola protein isolates (cruciferin-rich and napin-rich protein isolates) having quite different surface characteristics (charge and hydrophobicity) and solubility, the emulsifying, forming and stabilizing effects were similar. This suggests that separation of the two proteins from the isolate ingredient may not be necessary if emulsification is the only functional role that the proteins are being used for.

Overall, canola protein isolate formed stronger gels than soy protein isolate, with less dependence on disulfide and hydrogen bonds relative to the soy protein isolate. For both proteins, there was no significant difference in gelling temperature as the protein concentration increased.

Canola protein isolate films were found to be less flexible, have better water vapour barrier properties, and have comparable film strength relative to other plant protein-based films.

Based on the findings in this study, canola protein isolate shows promise as a potential material for the development of edible films/packaging in the future. These findings will help the food industry in understanding these complex ingredient interactions and in formulation throughout the product development process when canola proteins are present.

Bill Greuel is CEO of PIC.

Canola meal big part of Protein Industries Canada

Plant protein could account for one third of the world's protein market by 2050. Protein Industries Canada (PIC), the industry-led, not-for-profit supercluster, has been created to capture this growing opportunity for Canadian crops. Research focused on canola meal could boost returns for this plant-based protein source and improve the sustainability equation for canola. The Canola Council of Canada and the three provincial canola grower organizations are PIC supporters.

PIC is one of five superclusters receiving federal support as a part of the Innovation Superclusters Initiative. This federal support will be up to $153 million that will be matched with private sector investment.

PIC hosted its first Thought Leaders' Summit in Winnipeg in October. Over 280 attendees from across the Prairies, Canada, and the U.S. gathered to explore the opportunities and innovations emerging in the plant protein sector. Find out more at **proteinindustriescanada.ca**.

COMPLETED PROJECTS

Ten studies funded through the *Growing Forward 2* Agri-Science Project are wrapped up, providing new tools to manage blackleg and sclerotinia stem rot.

NEW TOOLS TO MANAGE BLACKLEG AND SCLEROTINIA STEM ROT

Growing Forward 2
A federal-provincial-territorial initiative

An Agri-Science Project (ASP) on 'New tools to help producers manage two serious diseases in canola – blackleg and sclerotinia stem rot' led by SaskCanola and in partnership with the Alberta Canola and the Federal Government under the Growing Forward 2 Program included 10 research projects and one knowledge and technology transfer (KTT) project to disseminate the findings. Here are result highlights from each project.

BLACKLEG

Current projects focused on new sources of resistance are making progress towards providing new resources and information for canola breeding programs to help improve blackleg resistance options for growers.

IMPROVING CANOLA RESISTANCE AGAINST BLACKLEG DISEASE THROUGH INCORPORATION OF NOVEL RESISTANCE GENES SOURCED FROM *B. NAPUS*, *B. RAPA* AND *B. OLERACEA*

PRINCIPAL INVESTIGATOR: M. Hossein Borhan, Agriculture and Agri-Food Canada (AAFC) Saskatoon

FINDINGS: An intensive screening of over 1,100 accessions (plant materials collected from a particular area) of *B. napus* and *B. rapa* was conducted to search for novel resistance (R) genes against blackleg. Throughout this, a methodology for accurate and rigorous screening of Brassica species for blackleg resistance was created. As well, two *B. napus* lines with novel R genes were identified and the preliminary mapping conducted on one of these lines supports the presence of a novel broad spectrum R gene.

IDENTIFYING NOVEL RESISTANCE GENES FROM CANOLA RELATIVES AND DEVELOPING CANOLA GERMPLASM WITH MULTIPLE RESISTANCE GENES SOURCED FROM *B. NIGRA*, *B. JUNCEA*, AND *B. CARINATA*

PRINCIPAL INVESTIGATORS: Genyi Li and Dilantha Fernando, University of Manitoba

FINDINGS: The R gene sequences on chromosome N7 were sequenced and functionally confirmed. (They had been studied for three decades but not previously sequenced due to the structural complexity of this chromosome.) Over 10 advanced backcrossing lines (BC5 and BC6) were produced in a susceptible cultivar, Westar, background. All of these lines showed excellent resistance to aggressive isolates of the blackleg pathogen.

COMPLETED PROJECTS

GENOME-WIDE ASSOCIATION MAPPING OF QUANTITATIVE RESISTANCE AGAINST BLACKLEG DISEASE

PRINCIPAL INVESTIGATOR: M. Hossein Borhan, AAFC Saskatoon

FINDINGS: A collection of 58 spring-type *B. napus* with adult plant resistance (also referred to as quantitative resistance, a durable form of resistance) against blackleg disease was identified. These lines offer a source of resistance against blackleg for potential incorporation into commercial canola cultivars.

TRANSCRIPTOMIC ANALYSIS OF THE *LEPTOSPHAERIA MACULANS* (BLACKLEG) AND CANOLA INTERACTION TO IDENTIFY RESISTANCE GENES IN CANOLA AND AVIRULENCE FACTORS IN *L. MACULANS*

PRINCIPAL INVESTIGATOR: Richard Bélanger, Laval University

FINDINGS: Three studies in the project produced three key findings:

1. A unique pipeline with an exhaustive list of classically secreted proteins (that may stimulate plant infection) along with their key conserved motifs found in 12 common plant pathogens including *L. maculans* (the pathogen which causes blackleg in western Canada) were provided and will help with future analyses of pathogenesis processes in canola-*L. maculans* interaction.

2. Comparison of the transcriptome of *L. maculans* during compatible and incompatible interactions has led to the identification of key pathogenicity genes that regulate the fate of the interaction and lifestyle transitions of the fungus.

3. A successful in-depth characterization of *Brassicaceae aquaporins* highlighted transport mechanisms and related physiological processes that could be exploited in breeding of stress-tolerant cultivars.

DURABLE BLACKLEG RESISTANCE STEWARDSHIP THROUGH KNOWLEDGE OF BLACKLEG PATHOGEN POPULATION, RESISTANCE GENES AND CROP SEQUENCE TOWARDS THE DEVELOPMENT OF A CULTIVAR ROTATION PROGRAM IN THE PRAIRIE PROVINCES

PRINCIPAL INVESTIGATORS: Dilantha Fernando, University of Manitoba; Gary Peng, AAFC Saskatoon; Ralph Lange, Innotech

FINDINGS: Understanding the R-gene and the pathogen profiles in the Prairies (by testing *L. maculans* isolates for the presence of 11 Avr alleles using a set of differentials combined with PCR amplification) has helped the industry to launch the R-gene labeling system and rotation strategy.

New tests to identify blackleg races on stubble pieces is a key part of the cultivar rotation program.

INVESTIGATING THE RESISTANCE (R-GENE) DURABILITY OF CANOLA CULTIVARS AND THE EMERGENCE OF VIRULENT BLACKLEG ISOLATES IN FARMERS' FIELDS

PRINCIPAL INVESTIGATOR: Dilantha Fernando, University of Manitoba

FINDINGS: Field trials reported if and when virulent isolates emerged, the number of generations required to produce virulent offspring, and the comparison results between R gene lines, which increased the understanding of the durability (to disease pressure) of some R genes used within commercial cultivars. This helped form the foundation for current major gene resistance labels.

RAPID FIELD DIAGNOSTICS OF THE BLACKLEG PATHOGEN RACES THROUGH THE IDENTIFICATION OF PATHOGEN AVIRULENCE (AVR) GENES AND THE DEVELOPMENT OF AVR-SPECIFIC MARKERS

PRINCIPAL INVESTIGATOR: M. Hossein Borhan, AAFC Saskatoon

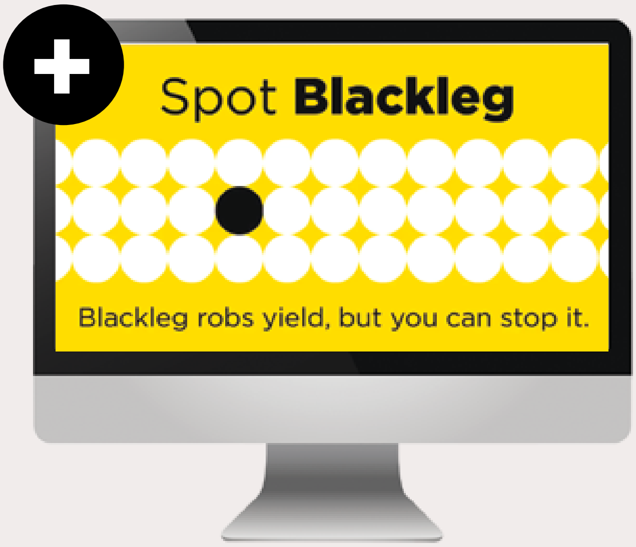
FINDINGS: Through many steps, including cloning genes, generating crosses between isolates and specific gene identifications, polymerase chain reaction (PCR) biomarkers were developed and shared with public and private pathology labs to allow for a rapid 'in-field' test to identify blackleg races present on the canola stubble. This helps growers make informed variety selection decisions based on the blackleg strain found in their fields. It also addresses a concern of a major trading partner.

DEVELOPMENT OF A BLACKLEG YIELD-LOSS MODEL AND ASSESSMENT OF FUNGICIDE RESISTANCE IN WESTERN CANADIAN POPULATIONS OF *LEPTOSPHAERIA MACULANS*

PRINCIPAL INVESTIGATOR: Stephen Strelkov, University of Alberta

FINDINGS: By studying relationships between blackleg disease severity and yield loss and the fungicide sensitivity of *Leptosphaeria maculans* populations from Western Canada, this project was able to develop the first yield loss model for blackleg of canola for Western Canada. This model can provide a foundation for understanding the yield impact associated with certain levels of blackleg, not only on a field scale, but also on local or even regional scales.

For more on genetic resistance for blackleg and the new R-gene labels for canola seed varieties, read the 'Genetic resistance' section at **blackleg.ca**.



INTEGRATION OF CANOLA DISEASE RESEARCH RESULTS WITHIN THE CANOLA INDUSTRY.

PRINCIPAL INVESTIGATOR: Errin Willenborg, Saskatchewan Canola Development Commission (SaskCanola)
FINDINGS: SaskCanola worked alongside AAFC researchers, AAFC commercialization officers and Canola Council of Canada to make the rapid field diagnostics test for blackleg available at commercial labs. This collaboration also led to the development of one 10-minute and three shorter videos, available at **spotblackleg.ca**, that highlight results from these blackleg projects and a guide on blackleg best management practices, including the new blackleg R-gene labeling strategy. Social media was used to draw attention to the video through a 'Spot Blackleg' campaign. A workshop shared the results of this ASP, encouraged information exchanges with industry and allowed for the investigation of potential collaboration opportunities around improving the understanding of blackleg in Canada and Australia (where they have an advanced blackleg management system).

SCLEROTINIA STEM ROT

CHARACTERIZATION OF DEFENSE GENES UNDERLYING QUANTITATIVE RESISTANCE LOCI (QRL) TO SCLEROTINIA STEM ROT IN ASIAN *BRASSICA NAPUS* AND TRANSFER OF RESISTANCE TO CANADIAN SPRING-TYPE CANOLA

PRINCIPAL INVESTIGATOR: Lone Buchwaldt, AAFC Saskatoon
FINDINGS: This study generated new knowledge on individual defense genes against *S. sclerotiorum* and on SNP and SSR markers that can be used in marker-assisted selection. A 'stem test' to screen *B. napus* plants for sclerotinia resistance was also developed and accepted by the canola industry, including adoption by the Western Canadian Canola/ Rapeseed Recommending Committee (WCC/ RRC). Work was started on transferring sclerotinia resistance into an elite AAFC line, and new funding will be sought to continue the project in collaboration with breeding companies.

RESISTANCE TO *SCLEROTINIA SCLEROTIORUM* NECROSIS INDUCING PROTEINS IN CANOLA

PRINCIPAL INVESTIGATOR: Dwayne Hegedus, AAFC Saskatoon
FINDINGS: This research contributed to an international consortium that sequenced the *S. sclerotiorum* genome, which is now serving as a reference for a new international initiative to sequence the genomes a global collection of *S. sclerotiorum* isolates from a multitude of crops. The researchers catalogued the entire suite of genes expressed during each stage of the infection of canola that has led to a much better understanding of how *S. sclerotiorum* causes disease. They also identified several new proteins that are secreted by *S. sclerotiorum* that cause necrosis and began developing tools that will use necrosis proteins to screen *B. napus* collections for lines that are more tolerant of or resistant to their effects.

For project summaries, look for an update on SaskCanola's research page (**saskcanola.com/research/projectreports.php**) and for final project reports, see the Canola Research Hub(**canolaresearch.ca**). Find more information on blackleg at **blackleg.ca** and learn more about sclerotinia in the CCC's Canola Encyclopedia.

PROJECTS FUNDED UNDER THE NEW **CANOLA AGRISCIENCE CLUSTER**

CANADIAN AGRICULTURAL PARTNERSHIP

The Canola AgriScience Cluster is a partnership between Agriculture and Agri-Food Canada and the canola industry under the Canadian Agricultural Partnership. Over a five-year period, this initiative will channel $20 million in public/private funding into six areas of research aimed at sustainably growing the canola industry. By helping to reduce production risk, improve yields, enhance sustainability and increase market demand, the findings are expected to greatly expand the economic value of Canadian canola and its $26.7 billion industry and propel it towards the 2025 strategic goals.

THEME 1 AND THEME 2: ADVANCING END USES

Theme 1 projects will advance canola processing techniques and build on previous ground-breaking research demonstrating canola oil's positive impact on heart health, diabetes and obesity. Theme 2 projects will further demonstrate the value of canola meal as a livestock feed ingredient. This research will build on previous studies, which have demonstrated that using canola meal as protein source can significantly increase the profitability of milk and meat production while also looking at its sustainability in livestock production.

THEME 3: YIELD AND QUALITY OPTIMIZATION FOR SUSTAINABLE SUPPLY

Theme 3 projects will address opportunities to dramatically increase the yield and positive environmental impact of canola production. These studies will increase the economic returns from every acre while improving the efficiency of nutrient use and the crop's value for carbon capture and pollinator health.

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

PRINCIPAL INVESTIGATORS: Brian Beres, Agriculture and Agri-Food Canada (AAFC) Lethbridge; Charles Geddes, AAFC Lethbridge; Breanne Tidemann, AAFC Lacombe; William May, AAFC Indian Head; Ramona Mohr, AAFC Brandon

ENHANCING YIELD AND BIOMASS IN CANOLA BY MODIFYING CARBOHYDRATE METABOLISM

PRINCIPAL INVESTIGATORS: Michael Emes, University of Guelph; Ian Tetlow, University of Guelph

WEEDING OUT SECONDARY DORMANCY POTENTIAL FROM VOLUNTEER CANOLA

PRINCIPAL INVESTIGATORS: Sally Vail, Agriculture and Agri-Food Canada (AAFC) Saskatoon; Rob Gulden, University of Manitoba; Isobel Parkin, AAFC Saskatoon; Steve Robinson, AAFC Saskatoon; Steve Shirtliffe, University of Saskatchewan

ADVANCING THE FUNCTIONAL, NUTRITIONAL AND ECONOMIC VALUE OF CANOLA PROTEIN IN CANADA

PRINCIPAL INVESTIGATORS: Rob Duncan, University of Manitoba; Jim House, University of Manitoba; Janitha Wanusundara, AAFC Saskatoon; Isobel Parkin, AAFC Saskatoon; Rotimi Aluko, University of Manitoba; Lee Anne Murphy, Manitoba Agri-Health Research Network

THEME 4: IMPROVING NUTRIENT AND WATER USE EFFICIENCY

Nitrogen is by far the biggest operating cost of Canadian canola growers and one of the key factors determining oil and protein content. One of the top priorities of the industry is to ensure that a high percentage of applied nitrogen is used by the plant, instead of being lost through leaching and volatilization.

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

PRINCIPAL INVESTIGATORS: Bao-Luo Ma, AAFC Ottawa; Mervin St. Luce, AAFC Swift Current; Yantai Gan, AAFC Swift Current; Paul Tiege, Olds College; Rob Gulden, University of Manitoba; Luke Bainard, AAFC Swift Current; Gary Peng, AAFC Saskatoon; Ramona Mohr, AAFC Brandon; Cindy Gampe, AAFC Scott; Greg Semach, AAFC Beaverlodge

MAKING OF A MORE SUSTAINABLE CANOLA: USING GENETIC DIVERSITY TO IMPROVE NUE

PRINCIPAL INVESTIGATORS: Sally Vail, AAFC Saskatoon; Isobel Parkin, AAFC Saskatoon; Rosalind Bueckert, University of Saskatchewan; Raju Soolanayakanahally, AAFC Saskatoon; Melissa Arcand, University of Saskatchewan; Steve Robinson, AAFC Saskatoon; Andrew Sharpe, Global Institute for Food Security (GIFS); Leon Kochian, GIFS; Robert Guy, University of British Columbia (UBC); Reynald Lemke, AAFC Saskatoon; Bobbi Helgason, AAFC Saskatoon

THEME 5: INTEGRATED PEST MANAGEMENT

As climate, insect populations and pathogens change, so do the pest management challenges faced by Canadian canola growers. Theme 5 research will study the best methods of controlling major pests and pathogens in this changing environment, while protecting pollinators, beneficial insects and biodiversity within the canola canopy.

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

PRINCIPAL INVESTIGATORS: Héctor Cárcamo, AAFC Lethbridge; éric Lucas, Universite du Quebec a Montreal; Luc Belzile, Institut de recherche et développement en agroenvironnement; Dan Johnson, University of Lethbridge; Scott Meers, Alberta Agriculture and Forestry; Boyd Mori, AAFC Saskatoon; Kevin Floate, AAFC Lethbridge; Tara Gariepy, AAFC London; Patrice Bouchard, AAFC Ottawa; Peter Mason, AAFC Ottawa; Meghan Vankosky, AAFC Saskatoon; Tyler Wist, AAFC Saskatoon

Two new studies will look at ways to improve flea beetle management.

INTEGRATED APPROACHES FOR FLEA BEETLE CONTROL II: INCORPORATING THE IMPACTS OF PLANT DENSITY, GROUND PREDATORS, AND LANDSCAPE-SCALE PREDICTIVE MODELS IN THE MANAGEMENT OF FLEA BEETLES IN THE CANADIAN PRAIRIES

PRINCIPAL INVESTIGATORS: Alejandro Costamagna, University of Manitoba; Héctor Cárcamo, AAFC Lethbridge; Jennifer Otani, AAFC Beaverlodge; Tharshinidevy Nagalingam, University of Manitoba; John Gavlovski, Manitoba Agriculture; Rob Duncan, University of Manitoba

GENETIC RESOURCES FOR FLEA BEETLE RESISTANCE IN CANOLA

PRINCIPAL INVESTIGATORS: Dwayne Hegedus AAFC Saskatoon, Sally Vail AAFC Saskatoon, Isobel Parkin AAFC Saskatoon, Chrystel Olivier AAFC Saskatoon

Find summaries of completed projects at the Canola Research Hub

The Canola Research Hub at canolaresearch.ca has funding for another five years through the Canola AgriScience Cluster, a funding agreement between the canola industry and Agriculture and Agri-Food Canada through the Canadian Agricultural Partnership. This project will again be carried out by the Canola Council of Canada (CCC) and will continue to be strongly supported by Manitoba Canola Growers, SaskCanola and Alberta Canola.

Here are some new things to look for on the Hub:

- Canolapalooza videos which feature Agronomy Specialists and industry experts discussing important canola production tips on stand establishment, fertility top dressing, soil compaction, group 2 weed resistance, blackleg management, insect pest management and storage management.
- A link to the new Combine Optimization Tool webinar.
- Added content in the Hub's Research Summaries library.
- Improved on the search function for the Hub library.
- The 2018 Canola Digest Science Edition.

Clubroot continues to be a research priority.

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

PRINCIPAL INVESTIGATORS: Kelly Turkington, AAFC Lacombe; Steve Strelkov, University of Alberta; Mike Harding, Alberta Agriculture and Forestry; Henry Klein-Gebbinck, AAFC Beaverlodge; Breanne Tidemann, AAFC Lacombe; Greg Semach, AAFC Beaverlodge; Charles Geddes, AAFC Lethbridge; Henry de Gooijer, AAFC Indian Head; Gary Peng, AAFC Saskatoon; William May, AAFC Indian Head; Dale Tomasiewicz, AAFC Outlook; Ramona Mohr, AAFC Brandon; Debbie McLaren, AAFC Brandon; Denis Pageau, AAFC Normandin; Barb Ziesman, Saskatchewan Ministry of Agriculture; Syama Chatterton, AAFC Lethbridge

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

PRINCIPAL INVESTIGATORS: Susie Li, Innotech Alberta; Kelly Turkington, AAFC Lacombe; Jian Yang, Innotech Alberta; Jie Chen, University of Alberta

PROTECTION OF CANOLA FROM PATHOGENIC FUNGI USING RNA INTERFERENCE TECHNOLOGIES

PRINCIPAL INVESTIGATORS: Steve Whyard, University of Manitoba; Mark Belmonte, University of Manitoba; Mazdak Khajehpour, University of Manitoba; Dwayne Hegedus, AAFC Saskatoon

RESISTANCE TO *SCLEROTINIA SCLEROTIORUM* EFFECTORS IN CANOLA

PRINCIPAL INVESTIGATORS: Dwayne Hegedus, AAFC Saskatoon; Hossein Borhan, AAFC Saskatoon; Yangdou Wei, University of Saskatchewan

CANADIAN CANOLA CLUBROOT CLUSTER (C1) PILLAR 1: INTEGRATED DISEASE MANAGEMENT

Principal investigators: Sheau-Fang Hwang, Alberta Agriculture and Forestry; Steve Strelkov, University of Alberta; Rudolph Fredua-Agyeman, Alberta Agriculture and Forestry; Bruce Gossen, AAFC Saskatoon; Mary-Ruth McDonald, University of Guelph

DEVELOPING NOVEL RESISTANCE RESOURCES AND STRATEGIES TO ADDRESS THE NEW THREAT OF CLUBROOT CANOLA PRODUCTION ON THE PRAIRIES

PRINCIPAL INVESTIGATORS: Gary Peng, AAFC Saskatoon; Habibur Rahman, University of Alberta; Rudolph Fredua-Agyeman, Alberta Agriculture and Forestry

CANADIAN CANOLA CLUBROOT CLUSTER PILLAR 3: HOST-PATHOGEN BIOLOGY AND INTERACTION

PRINCIPAL INVESTIGATORS: Bruce Gossen, AAFC Saskatoon; Mary-Ruth McDonald, University of Guelph; Gary Peng, AAFC Saskatoon; Fengqun Yu, AAFC Saskatoon; Sheau-Fang Hwang, Alberta Agriculture and Forestry; Steve Strelkov, University of Alberta

THEME 6: PUTTING INNOVATION INTO ACTION

Theme 6 activities are about knowledge and technology transfer to increase the value of all Science Cluster research by assisting scientists and sharing their findings with growers and other industry stakeholders. The Canola Council's agronomy specialists will translate research results into tangible practices that can be applied on farms. The information will also be widely available through the Canola Research Hub, a state-of-the-art online information resource maintained by the Council.

NEW PROJECTS

Canola growers across the Prairies fund dozens of research projects with their levy payments to Saskatchewan Canola Development Commission, Alberta Canola Producers Commission and Manitoba Canola Growers Association. Many of those projects are funded through their joint Canola Agronomic Research Program (CARP). Other projects are funded through arrangements with other organizations listed in these summaries. The following is a list of all new projects announced or initiated in the past year.

NEW GROWER-FUNDED RESEARCH PROJECTS

PLANT ESTABLISHMENT

Right: What is the ideal plant spacing within the row? Steven Shirtliffe will study this question.

RYE COVER CROP TERMINATION DATE EFFECT FOR NO-TILL CANOLA EMERGENCE

PRINCIPAL INVESTIGATOR: FarmWise Inc (Rob Dunn) and Palliser Agriculture Management Society (PAMS)
FUNDING: Alberta Canola

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

PRINCIPAL INVESTIGATOR: Steven Shirtliffe, University of Saskatchewan
FUNDING: SaskCanola

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

PRINCIPAL INVESTIGATOR: Nathan Gregg, Prairie Agricultural Machinery Institute (PAMI)
FUNDING: SaskCanola and Sask Wheat

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

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

FERTILITY MANAGEMENT

REDUCING TOXICITY OF SEED-PLACED PHOSPHORUS FERTILIZER IN OILSEED CROPS

PRINCIPAL INVESTIGATOR: Patrick Mooleki, AAFC Saskatoon
FUNDING: CARP (Alberta Canola and SaskCanola)

CANOLA FREQUENCY EFFECTS ON NUTRIENT TURNOVER AND ROOT-MICROBE INTERACTIONS

PRINCIPAL INVESTIGATOR: Bobbi Helgason, AAFC Saskatoon
FUNDING: CARP (Alberta Canola and SaskCanola)

OPTIMAL SOURCE, PLACEMENT AND APPLICATION TIMING FOR YIELD AND REDUCTION OF GREENHOUSE GAS FOOTPRINT FOR CANOLA PRODUCTION ON LIGHT TEXTURE SOILS

PRINCIPAL INVESTIGATOR: Mario Tenuta, University of Manitoba
FUNDING: CARP (SaskCanola and Manitoba Canola Growers)

REVISITING NITROGEN FERTILIZER RECOMMENDATIONS FOR SASKATCHEWAN: ARE WE MEASURING THE RIGHT SOIL NITROGEN POOL?

PRINCIPAL INVESTIGATOR: Richard Farrell, University of Saskatchewan
FUNDING: SaskCanola, Sask Wheat, Alberta Wheat, Western Grains Research Foundation (WGRF)

DEEP BANDING IMMOBILE NUTRIENTS UNDER DIRECT SEEDING SYSTEMS TO IMPROVE CROP PRODUCTION AND TACKLE NUTRIENT STRATIFICATION

PRINCIPAL INVESTIGATOR: SARDA Ag Research
FUNDING: Alberta Canola

Ultimate Canola Challenge: Seeding speed trial

The Ultimate Canola Challenge (UCC) test for 2018 was to see how seeding speed influenced seed placement. Growers who participated in the study would learn more about the right seeding speed for their drill and soil conditions, with the 'ultimate' goal of improving seed survival and overall profitability and risk management.

Trials included the grower's base seeding speed and strips at one mph slower and one mph faster than the base. Each strip had plant counts done 10 and 21 days after seeding. Those counts were related back to seeding rate (seeds per square foot) to see how seeding speed influenced seed survival, days to emergence and uniformity of emergence. Differences in plant stand and uniformity were monitored all season to see how seeding speed influenced crop performance, management decisions and harvest timing.

Results were not available when this magazine went to print, but look for them on the UCC website at **ultimatecanolachallenge.ca**. The website also has protocols for on-farm trials and results from previous UCC research.

MONITORING SOIL ORGANIC CARBON ON COMMERCIAL DIRECT-SEED FIELDS ACROSS SASKATCHEWAN, PHASE 4

PRINCIPAL INVESTIGATOR: Brian McConkey, AAFC Swift Current
FUNDING: SaskCanola, Sask Wheat, Sask Pulse, SaskOat, SaskBarley, SaskFlax and Saskatchewan's Agriculture Development Fund (ADF)

DEVELOPING A SOIL HEALTH ASSESSMENT PROTOCOL FOR SASKATCHEWAN PRODUCERS

PRINCIPAL INVESTIGATOR: Kate Congreves, University of Saskatchewan
FUNDING: SaskCanola, Sask Wheat and WGRF

SOIL HEALTH AND NUTRIENT UPTAKE AMONG DIVERSE CANOLA LINES – ADDED VALUE TO CROP PHENOTYPING

PRINCIPAL INVESTIGATOR: Melissa Arcand, University of Saskatchewan
FUNDING: SaskCanola

STRATEGIES TO REDUCE FERTILITY INPUTS AND IMPROVE SOIL HEALTH AND C-SEQUESTRATION IN MIXED CROP-LIVESTOCK SYSTEMS

PRINCIPAL INVESTIGATOR: Akim Omokanye, Peace Country Beef and Forage Association
FUNDING: Alberta Canola

INTEGRATED PEST MANAGEMENT

UNIVERSITY OF ALBERTA NSERC INDUSTRIAL CHAIR IN AGRO-ENTEMOLOGY

PRINCIPAL INVESTIGATOR: To be named
FUNDING: Alberta Canola along with University of Alberta, Alberta Wheat Commission, Alberta Barley and Alberta Pulse Growers

BIOPESTICIDES AS A NOVEL MANAGEMENT STRATEGY FOR SCLEROTINIA IN CANOLA

PRINCIPAL INVESTIGATOR: Susan Boyetchko, AAFC Saskatoon
FUNDING: CARP (SaskCanola and Manitoba Canola Growers)

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

PRINCIPAL INVESTIGATOR: Chrystel Olivier, AAFC Saskatoon
FUNDING: CARP (SaskCanola and Alberta Canola)

ASSESSING SURFACE WAX CHEMICAL DIVERSITY AS A TOOL TO DEFEND AGAINST ABIOTIC AND BIOTIC STRESS IN CANOLA

PRINCIPAL INVESTIGATOR: Mark Smith, AAFC Saskatoon
FUNDING: CARP (SaskCanola)

DEVELOPMENT OF A HARMONIZED CLUBROOT MAP

PRINCIPAL INVESTIGATOR: Stephen Strelkov, University of Alberta
FUNDING: CARP (Alberta Canola, Manitoba Canola Growers and SaskCanola)

GENERATE KNOWLEDGE AND CONTROL STRATEGIES FOR THE POLLEN BEETLE *BRASSICOGETHES VIRIDESCENS* (COLEOPTERA: NITIDULIDAE), A NEW INVASIVE INSECT PEST OF CANOLA

PRINCIPAL INVESTIGATOR: Christine Noronha, AAFC Charlottetown

FUNDING: CARP (Alberta Canola, Manitoba Canola Growers and SaskCanola)

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

PRINCIPAL INVESTIGATOR: Sharavari Kulkarni and Maya Evenden, University of Alberta

FUNDING: CARP (Alberta Canola and SaskCanola)

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

HARVEST MANAGEMENT

INVESTIGATION INTO CONVERTING A COMBINE GRAIN LOSS SIGNAL INTO A GRAIN LOSS RATE

PRINCIPAL INVESTIGATOR: Nathan Gregg, PAMI

FUNDING: SaskCanola, Sask Wheat, Sask Pulse and WGRF

DEFINING BEST MANAGEMENT PRACTICES FOR USING SUPPLEMENTAL HEATING WITH NATURAL AIR DRYING

PRINCIPAL INVESTIGATOR: Joy Agnew, PAMI

FUNDING: SaskCanola and Sask Wheat

Right: Joy Agnew will define the best practices for using heaters (in blue) within a bin aeration system.

GENETICS

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

PRINCIPAL INVESTIGATOR: Dilantha Fernando, University of Manitoba

FUNDING: SaskCanola

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

PRINCIPAL INVESTIGATOR: Fengqun Yu, AAFC Saskatoon

FUNDING: Alberta Canola

EXPLORING *BRASSICA OLERACEA* FOR RESISTANCE TO THE NEWLY EMERGED *PLASMODIOPHORA* BRASSICAE PATHOTYPES: RESISTANCE MAPPING AND INTROGRESSION INTO CANOLA

PRINCIPAL INVESTIGATOR: Habibur Rahman, University of Alberta

FUNDING: Alberta Canola

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

PRINCIPAL INVESTIGATOR: Habibur Rahman, University of Alberta

FUNDING: Alberta Canola

DEFINING POPULATIONS OF *PLASMODIOPHORA BRASSICAE* WITH NEAR ISOGENIC BRASSICA NAPUS LINES

PRINCIPAL INVESTIGATOR: Fengqun Yu, AAFC

FUNDING: SaskCanola's Canola and ADF

OVERCOMING BLACKLEG DISEASE IN CANOLA THROUGH ESTABLISHMENT OF QUANTITATIVE RESISTANCE

PRINCIPAL INVESTIGATOR: Hossein Borhan, AAFC

FUNDING: SaskCanola

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

PRINCIPAL INVESTIGATOR: Isobel Parkin, AAFC Saskatoon

FUNDING: SaskCanola and ADF