Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

Canada

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Volume V

Agricultural Innovations Volume V

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Introduction

Canada's agriculture and agri-food sector is a major driver of the economy, contributing over $143 billion annually to the country's gross domestic product. It encompasses almost 200,000 farms, thousands of small and medium-sized agri-businesses, and almost 2.3 million jobs right across the country—more than any other manufacturing industry.

For over 130 years, the success of Canadian agriculture and food has been built on the hard work of farmers and food processors, supported on a strong foundation of agricultural science. Scientific collaboration is critical to helping the agricultural sector emerge even stronger from the many challenges and changes it now faces. Farmers and food processors are learning about revolutionary new technology, dealing with a changing climate and accelerating threats to biodiversity, all while responding to shifting consumer and market demands. Modernizing agricultural research, Agriculture and Agri-Food Canada (AAFC) is helping Canada's agricultural sector be more dynamic and innovative, increasing its competitiveness at home and in markets around the world.

A centre of research excellence

Founded in 1886, AAFC is now the largest single provider of agricultural research in Canada, conducting about half of all agriculture-related research in the country. Our more than 2,000 science staff (including over 450 scientists) help farmers and food processors ensure Canadian foods and exports are safe, high quality, and produced in environmentally sustainable ways. Our workplaces go beyond traditional labs, fields, orchards, and ranches to one of the largest research greenhouse facilities in North America; facilities for insect rearing; a winery; shipping containers in the Far North; and living labs at regional farms.

Our research helps establish Canada as a global agricultural leader and improves life for many farmers, processors and Canadians by:

- safely and sustainably protecting crops and animal agriculture
- helping farmers reduce their environmental footprint
- strengthening food security in northern and Indigenous communities
- encouraging new ways to eliminate, reduce or repurpose food waste
- supporting alternative pest management approaches that reduce the need for chemical pesticides
- protecting and restoring our large lakes and river systems

Our staff rose to the challenges presented by the COVID-19 pandemic and found new ways of working in labs, fields, and remotely from their homes when necessary. We continue to embrace the opportunities presented during these unique times and remain dedicated to providing the best science possible for our agricultural clients and all Canadians.

Science on a mission

Over the past decade, AAFC has structured its science approach around four strategic objectives:

- increasing agricultural productivity
- improving environmental performance
- improving attributes for food and non-food uses
- addressing threats to the agriculture and agri-food value chain

While these objectives remain central to the success of agriculture in Canada, new complex and connected challenges require a new integrated and sustainable approach that takes into consideration the environmental, social and economic context of our research. This new strategic approach is anchored around "missions". It will begin in 2022 and be implemented over the next ten years.

This mission-driven research will focus on:

- mitigating and adapting to climate change
- increasing the resiliency of agro-ecosystems
- advancing the circular economy by developing value-added opportunities
- accelerating the digital transformation of Agriculture and Agri-Food Canada

Opening our science

At the same time, providing greater public access to federal science is important to help Canadians understand the importance of our research and fulfill the Government of Canada's commitment to a more open government. AAFC recently released its Open Science Action Plan that will not only increase the accessibility of science, but also help accelerate the pace of new discoveries and innovations within the scientific community.

We hope you enjoy reading about some of our most recent scientific accomplishments in this issue as well as additional key projects featured in the new "Spotlight" sections.

AAFC AT A GLANCE

Key Figures 2021–2022

2303

Science and Technology staff

899

Science and Technology projects

20

Research and Development Centres

30

Satellite Research Locations

1111

Science articles published in:

425

Journals

Intellectual Property and Commercialization 2021–2022

AGREEMENTS

239
Collaborative Research Agreements executed

271
Material Transfer Agreements executed

333
External collaborators executed Research Agreements with AAFC

PLANT VARIETIES

16
New varieties registered

14
Plant Breeders' Rights granted

488
AAFC-developed varieties currently sold

PATENTS

7
Invention disclosures received

5
Patent applications submitted

2
Notices of Allowance received

142
Active patents in **26** countries for **52** technologies

COMMERCIALIZATION

3
Business opportunity documents developed

2
Invention Disclosures assessed for their commercial potential

35
Commercialization License Agreements executed

611
Active licenses
(technologies and varieties)


RESEARCH AND DEVELOPMENT CENTRES
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
ATLANTIC REGION
Agassiz
Summerland
Lacombe
Lethbridge
Saskatoon
Swift Current
Brandon
Morden
St. John's
Quebec
Saint-Hyacinthe
Fredericton
Charlottetown
Kentville
Sherbrooke
Saint-Jean-sur-Richelieu
Ottawa
Guelph
London
Harrow
Coastal Region
Prairie Region
Ontario-Quebec Region

Coastal Region

Clearbrook sub-station
Abbotsford, British Columbia

Harrington Research Farm
Harrington, Prince Edward Island

Benton Ridge sub-station
Woodstock, New Brunswick

Nappan Research Farm
Nappan, Nova Scotia

Dalhousie University's Agricultural Campus
Truro, Nova Scotia

Avondale sub-station
Avondale, Newfoundland

Satellite Research Locations

Prairie Region

Beaverlodge Research Farm
Beaverlodge, Alberta

University of Alberta
Edmonton, Alberta

Vauxhall Research Farm
Vauxhall, Alberta

Calgary office
Science and Technology Branch

Edmonton office
Science and Technology Branch

Melfort Research Farm
Melfort, Saskatchewan

Scott Research Farm
Scott, Saskatchewan

The Canada-Saskatchewan Irrigation Diversification Centre (CSIDC)
Outlook, Saskatchewan

Indian Head Research Farm (IHRF)
Indian Head, Saskatchewan

Prairie Directorate Regina Office
Regina, Saskatchewan

The Canada-Manitoba Crop Diversification Centre
Carberry and Portage la Prairie, Manitoba

The Canadian Centre for Agri-Food Research in Health and Medicine (CCARM)
Winnipeg, Manitoba

The Richardson Centre for Functional Foods and Nutraceuticals (RCFFN)
Winnipeg, Manitoba

The Canadian Centre for Grain Storage Research
Winnipeg, Manitoba

The Cereal Quality Laboratory
Winnipeg, Manitoba

Ontario-Quebec Region

Honourable Eugene F. Whelan Experimental Farm, Woodslee, Ontario

The Ontario Development and Technology Transfer unit, Guelph, Ontario

Research Farm at Vineland Station
Vineland Station, Ontario

Saint-Augustin-de-Desmaures Research Farm
Saint-Augustin-de-Desmaures, Quebec

Normandin Research Farm
Normandin, Quebec

L'Acadie Experimental Farm
Saint-Jean-sur-Richelieu, Quebec

Sainte-Clotilde Experimental Farm
Sainte-Clotilde de Châteauguay, Quebec

Frelighsburg Experimental Site
Frelighsburg, Quebec

Collections & resources

Agriculture and Agri-Food Canada (AAFC) maintains the following biological collections and offers numerous resources to assist producers, industry, and researchers in their efforts to analyze, gauge, and manage important agricultural and environmental issues.

Biological collections:

Animal Genetic Resources of Canada (AGRC)
The AGRC is a genebank for livestock and poultry genetic resources (DNA, semen/sperm or embryos) that stores tissues and cells at very low temperatures (cryobiology) to study, understand, and reintroduce genetic variability.

Canadian Collection of Fungal Cultures (DAOMC)
The DAOMC is a repository and distributor of fungal genetic resources that holds the largest collection of its kind in Canada (more than 20,000 living fungal cultures), with important agricultural and environmental species and strains for use by national and international researchers.

Canadian National Collection of Insects, Arachnids and Nematodes (CNC)
The CNC is a national resource with more than 17 million specimens—one of the five largest collections of its kind in the world. It supports science that protects Canada's biodiversity, reduces the flow of invasive alien species into Canada, and identifies new invasive pests of concern.

Canadian National Mycological Herbarium (DAOM)
The DAOM is the largest collection of non-lichenized fungi in Canada (more than 350,000 fungal and fungal plant disease specimens). It documents the existence of Indigenous and invasive species in all Canadian provinces and territories for use in scientific research. It also acts as a physical and historical archive of species existence and distribution which contributes to Canadian biodiversity initiatives and international databases.

Canadian Collection of Arbuscular Mycorrhizal Fungi (CCAMF)
The CCAMF is a collection of AM (arbuscular mycorrhizal) fungi that live with plants and are beneficial to their growth and protection against stresses. It offers high-quality AM fungi to scientists and the clean-technology industry, helping them develop new bioproducts and biotechnologies capable of sustaining the quality and yields of Canadian agriculture.

National Collection of Vascular Plants (DAO)
The DAO is the largest collection of dried vascular (having conductive tissue which transports water and nutrients) plants in Canada, containing 1.5 million irreplaceable specimens protected in a climate-controlled environment. It allows for the identification of plants from anywhere in Canada, provides information for developing new crops and for ecological studies, and supports research on plant classification worldwide (including borrowing and loaning specimens worldwide).

Plant Gene Resources of Canada (PGRC)
The PGRC is a genebank for cultivated plants of importance to Canadian agriculture and their wild relatives. It protects, preserves, and enhances genetic diversity, thereby contributing to food security and the sustainability of agriculture.

Canadian Plant Virus Collection (CPVC)
The CPVC is an amalgamation of two distinct collections forming one of the largest virus collections in the world, with over 720 isolates representing almost 300 virus species: one collection of mainly herbaceous infecting viruses that can be stored freeze-dried, and the other collection consisting of primarily tree fruit and other woody plant viruses that need to be maintained in living plants. It acquires, distributes, and conserves virus isolates; provides reliable control samples for regulatory testing; supplies reference material when dealing with viral outbreaks; and provides samples to researchers for identification, characterization, and analysis of the viral samples.

AgroClimate, Geomatics and Earth Observations Division:

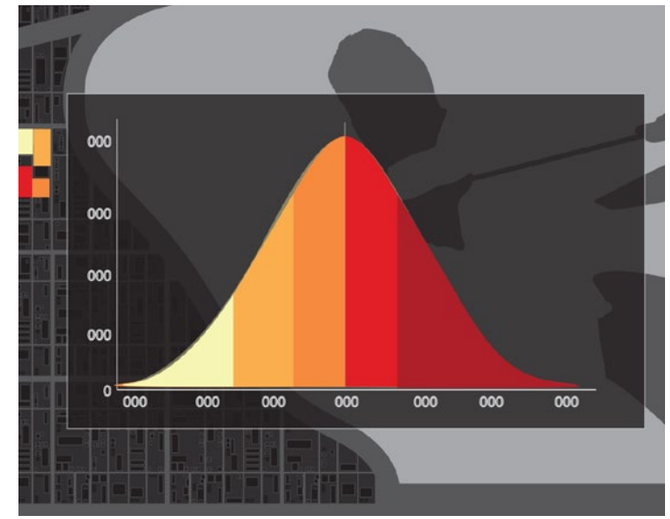
Agriculture and Climate
The agri-environmental indicators, studied since 1993, measure key environmental conditions (including indicators like air quality, greenhouse gases, soil health, water quality, and biodiversity) to gauge the impact of agriculture on the environment and to determine, for example, how to reduce agricultural emissions.

Canadian Soil Information Service (CanSIS)
The CanSIS is a national source for soil data and land resources information for Canada. It includes the National Soil Database (a collection of geospatial datasets containing soil, landscape, and climatic data for all of Canada), soil survey reports, interactive maps and illustrations of Canadian soils, landscapes and climate, etc. to help researchers address a wide variety of agro-environmental issues.

Drought Watch
This is a resource for maps, reports, and data on weather and climate, drought, yield forecasts, and weather impacts across Canada. It provides information on historical and current conditions, and forecasted conditions and impact assessments, enabling researchers and farmers to manage climate conditions.

Geospatial products
This is a resource for interactive agriculture-related maps, geospatial data, and decision-making tools. It provides geographic-based information and knowledge online to help farmers make sound decisions and manage risks on their farms and when dealing with environmental challenges.

Agri-environmental indicators
This is a resource for web-based interactive maps, reports, and data on measurements of the environmental sustainability of Canadian agriculture, including AAFC's suite of Agri-Environmental Indicators (AEIs). It provides analysis of historical data since 1981 (in some cases from 1993 due to data availability) on key environmental conditions, risks, and changes resulting from agriculture management practices.



Additional resources:

Canada-Saskatchewan Irrigation Diversification Centre (CSIDC)
The CSIDC is a partnership between AAFC, the Saskatchewan Ministry of Agriculture, the Irrigation Crop Diversification Corporation, the Saskatchewan Irrigation Projects Association and the University of Saskatchewan. It promotes economically and environmentally sustainable irrigation practices to producers and industry. It also investigates and demonstrates crops, technologies, and best management practices that help producers sustain land and water resources while maintaining their economic viability.

Pest Management Centre (PMC)
The PMC is a national resource helping Canadian growers protect the yield, value, and quality of their produce by providing access to new and effective crop protection products and technologies for minor crops, and alternative pest management solutions for major and minor crops. In partnership with producers, provincial governments, Health Canada's Pest Management Regulatory Agency, scientific experts, and the crop protection industry, the PMC: identifies critical weed, insect and disease pest problems and matches them with potential solutions, including non-chemical control options (e.g. biopesticides) and farm management practices (tillage, crop rotation, cultivar resistance, seed selection, etc.); conducts trials and collects data at AAFC research and development centres to meet regulatory requirements for registering minor uses of pesticides and to develop alternative pest management solutions.

AAFC'S RESEARCH SUCCESSES

According to Statistics Canada, average Canadian oat yields rose 13% between 2014 and 2019, thanks in part to the work of AAFC scientists.

Organic oats … brought to you by AAFC

Almost 100 years after developing Canada's first oat variety, Legacy in 1920, oat breeders at Agriculture and Agri-Food Canada (AAFC) developed another "Canadian first" — the first oat varieties developed specifically for organic production. Both organic varieties, AAC Oravena (registered in 2014) and AAC Kongsore (registered in 2018), have acceptable resistance to major diseases, good yields and good milling quality. In addition, these cultivars have quite large seeds, which may enable them to establish stronger seedlings, to help them out-compete weeds.

Since its inception in 1906, the oat breeding program at AAFC has worked on developing varieties that are suitable for the Canadian climate. It has also provided farmers and oat enthusiasts with new varieties that incorporate resistance to specific diseases and address desirable uses important to industry. New varieties have enhanced beta-glucan levels, improved end-use quality characteristics, higher milling yields, and more. So when you eat or use oats, be sure to tip your hat to these pioneering scientists!

An astonishing 90% of the world's mustard is grown in Canada, for domestic and international markets, and almost 80% of that is grown in Saskatchewan.

AAFC cuts the mustard with a genetics breakthrough

In Indian cuisine, the black mustard plant Brassica nigra is prized like gold; the black or dark brown seeds make a great spice often used in curries. However, the genetics of this valuable plant have remained a mystery — until now. Agriculture and Agri-Food Canada (AAFC) scientists recently made a great breakthrough in understanding the plant's genetic code.

A plant's genome (the entire collection of its DNA) is a blueprint for how it will grow, its appearance, the conditions it can withstand, and the kind of taste and nutrients it will deliver. By understanding the genome, scientists can select desired traits more efficiently and improve varieties, making them better for growers and consumers.

The Brassica nigra genome had been difficult to sequence because it contained many repeating sections of DNA, but with recent improvements and cost reductions in genomic sequencing technologies, the AAFC science team was able to crack most of the genetic code of the black mustard plant. Their work represents the near-complete assembly of two Brassica nigra genomes, shedding light on how they may have evolved from their wild ancestor and giving plant breeders an advantage in improving crop traits — something all mustard lovers can relish!

Forage U-Pick: sharing agriculture advice through technology

Agriculture is a team endeavour with everyone working together, passing knowledge from generation to generation. Now, thanks to Agriculture and Agri-Food Canada (AAFC) and over a dozen organizations across Western Canada, this tradition is meeting the modern age with a new interactive, mobile-friendly tool — Forage U-Pick. It's designed to help Western Canada producers decide what forage species to plant.

AAFC staff contributed scientific knowledge of forages (plants grown for feeding livestock), technical support, and helped test the new tool. Growers simply input information about their field and desired outcomes, and the tool then offers suggestions of suitable species. It can even help users understand seeding rates of each species chosen, suitability, and calculate the cost of a seed mixture. Those preferring more traditional sources of information can access the data through trusted technical bulletins and field guides.

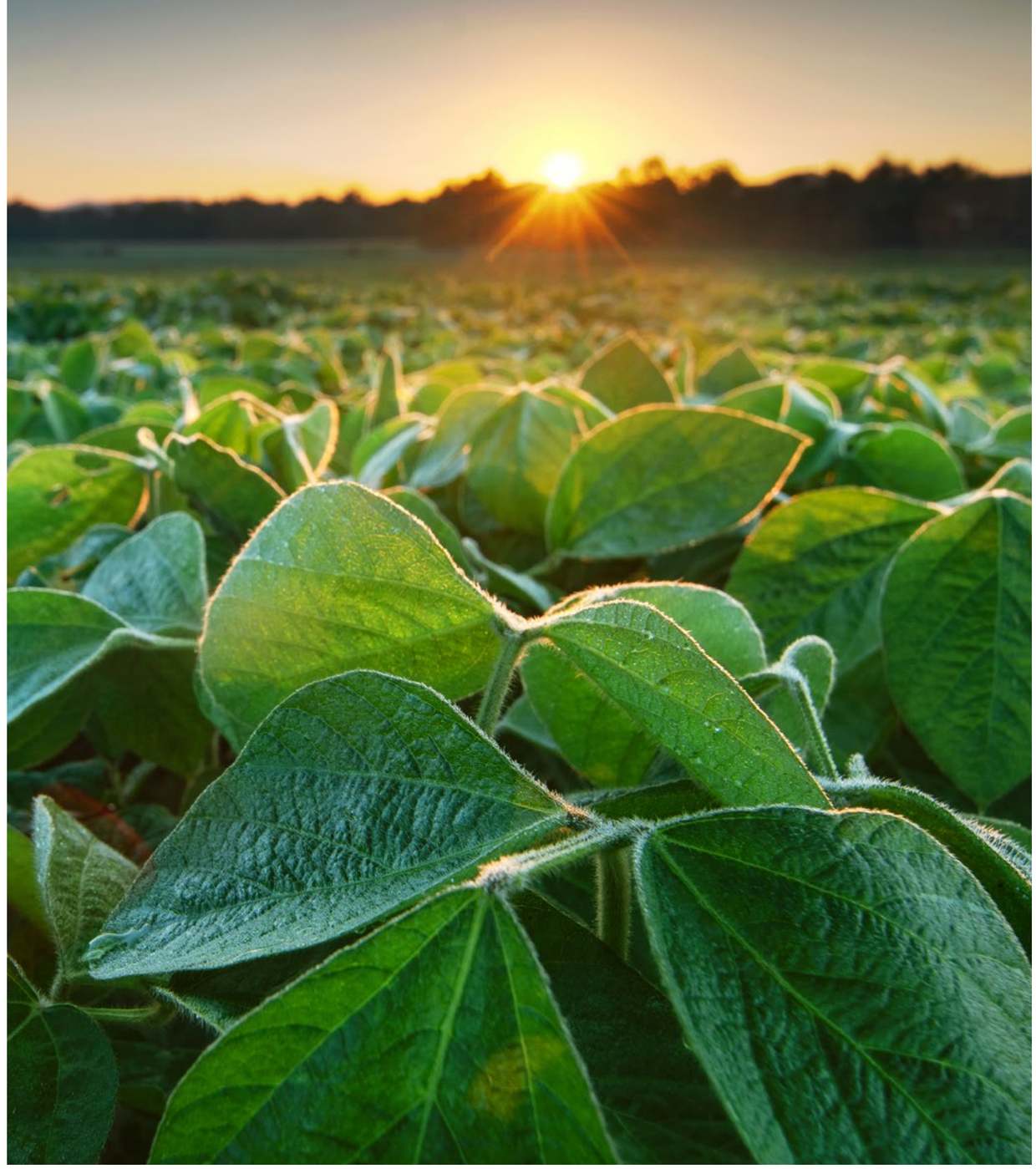
How popular is Forage U-Pick? Within a few months of its launch, it garnered more than 2,000 users! In January 2021 alone, the tool was used 113 times. Forage U-Pick is providing forage growers in Western Canada with the opportunity to share information using interactive technology. The next step will be to expand the tool to provide support for growers in Eastern Canada.

An ideal virtual interactive map for crop yield predictions

Scientists at Agriculture and Agri-Food Canada, developed a new tool that makes it easier for Canadian farmers to determine which factors are influencing production of each crop in their area throughout the year. Launched in 2020, the Canadian Crop Metrics application is a user-friendly interactive map that shows the monthly yield forecast for 11 different crops, including corn, soybeans, canola, and barley.

The app also provides weather forecasts, growing conditions, and various risks within an agricultural region. The map is regularly updated with the most recent weather data, enabling the producers who use it to adapt their farming practices so that they can optimize annual yields and minimize losses. All users can also consult historical data to look at past trends and the average yield for a particular crop in an area, which can help researchers and economists, as well as growers, understand the impacts of weather and climate extremes on agricultural production.

Find this application at Canadian crop metrics.
Other agri-climate information and planning tools are at Drought Watch and agroclimate.



In 2019, Gibberella ear rot in corn reduced yields by nearly 60 million bushels in the northern United States and Ontario.

Fine-tuning control of Gibberella ear rot in corn

Gibberella ear rot, the most common and important fungal disease affecting corn in Ontario, causes significant yield losses and can contaminate grain with mycotoxins harmful to human or animal health. Since fungicides and crop management practices are not fully effective against outbreaks, a team of scientists at Agriculture and Agri-Food Canada turned to genetics to better understand resistance to this disease.

The team examined two very different self-pollinized corn inbred lines (breeding lines developed and maintained by self-pollination) and identified 81 genes that may help increase corn resistance to Gibberella ear rot. Four of those genes appeared to be most active against the disease in resistant plants, making them promising candidates for further research.

Such a discovery will help scientists to better understand this disease, and to develop new more resistant corn lines. The use of association mapping, a genetic tool to map DNA variants associated with specific traits, could accelerate the development of self-fertilized lines resistant to Gibberella ear rot.

Having new self-pollinated corn lines with better resistance to fungal diseases will help improve the quality and quantity of crops in Canada — great news for corn growers and Canadians!

SPOTLIGHT

Agriculture in the North

Canadians living in the northern regions of the country face unique challenges in growing and obtaining their food. Shorter growing seasons, frequency of spring and fall frosts, and poor soil conditions are just a few of their constraints. Food transported to northern regions is generally more expensive, less fresh, and often very different from the traditional local diet. Agriculture and Agri-Food Canada (AAFC) researchers are collaborating with northern communities to support sustainable food production in the North and increase food security. Here are just a few examples of these projects:

Extending the growing season in the North

Who said "tunnel vision" was a bad thing? Researchers from AAFC and the Government of Yukon, the Pye Centre for Northern Boreal Food Systems, and local farmers in Whitehorse and Happy Valley-Goose Bay, Labrador began a three-year project to increase vegetable production, extend the growing season, and improve food security in Northern communities. They are using low tunnels (which act like miniature greenhouses) over rows of potatoes, carrots, rutabaga, and green beans to warm the air temperature around crops and promote growth. They are also putting thin layers of biodegradable plastic mulch over the ground to help trap heat in the soil, promoting earlier growth. The research teams are studying the effects of these strategies on soil health and quality, nutrition in harvested crops, pest management approaches, and any emerging disease threats. After collaborating and co-developing new studies, they hope their work provides a light at the end of the tunnel, putting more locally sourced food into northern communities.

Growing food in the Arctic

Take three recycled shipping containers, add wind and solar energy sources, and toss together with the creative efforts and enthusiasm of AAFC researchers and a small community in Gjoa Haven, Nunavut. The result? A recipe for fresh and delicious food grown 250 km north of the Arctic Circle, where the winters are long and temperatures often dip to -40 degrees Celsius. The Naurvik project ("the growing place" in Inuktitut) is a collaboration with the Gjoa Haven community, the Arctic Research Foundation, the National Research Council of Canada, the Canadian Space Agency and AAFC, and is led by local Inuit technicians trained in controlled environment food production. The goal is to find the best ways to sustainably grow fresh, local produce in the retrofitted container "pods" year-round, despite the harsh climate, and in a way that brings together the western science knowledge of AAFC researchers with the traditional knowledge and expertise of the local Inuit partners. So far, it is proving that good things can grow almost anywhere with a little determination and a desire to work together for the common good.

Calling in SWAT to protect our soil

Recently, researchers from Agriculture and Agri-Food Canada and universities in Manitoba and Alberta significantly improved the efficiency of the Soil and Water Assessment Tool (SWAT)—a modelling tool for predicting how land will react under different environmental conditions. Traditionally, this widely-used U.S.-based tool required manual processing of soil information which was time-consuming and laborious.

Now, thanks to the great work of this collaborative team, the **improved version of the SWAT model** significantly saves users time and resources as it includes soil information in a form that is user-ready, which completely removes the need for manual data processing. Researchers also added information on the susceptibility of soil to erosion which was not previously available. Soil erosion can negatively impact soil health and reduce the nutrients available to promote crop growth, leading to decreased crop yield and quality. In Canada, soil erosion costs farmers approximately $3 billion annually, so predicting which regions are at-risk to erosion is both an economic and scientific priority.

These improvements to the SWAT model will make data on soil more accessible and usable by scientists and agriculturalists across Canada, and help develop sustainable agricultural practices to improve the long-term health of Canada's croplands.

Minimizing nutrient runoff to protect our water

Agriculture and Agri-Food Canada (AAFC) scientists are helping minimize the environmental impact of agricultural production and safeguard Canada's water supply. Specifically, they are examining how landscape features affect nutrient runoff and help minimize losses. They found that maintaining or restoring storage of water (after rain or snowmelt) and natural landscape features (wetlands, unfertilized pastures, or trees) in watersheds could help keep nutrients on the land and out of waterways. Nutrient runoff from agricultural lands can diminish water quality in rivers and lakes, leading to excessive algae growth and a loss of valuable nutrients that could otherwise nourish crops.

Potholes and reservoirs act as barriers to water flow and can minimize nutrient runoff. They store water, and nutrients in that water, on land which reduces runoff into waterbodies downstream. They also help replenish aquifers. During storm events, natural landscape features appear to help reduce nutrient losses in runoff. In contrast, surface drainage ditches can increase nutrient loss by providing the runoff with a direct connection to streams. Recent research showed that areas with extensive networks of drainage ditches and those where natural landscape features have been removed had higher nutrient loss during snowmelt and extreme rainfall events.

AAFC's research is helping improve our agricultural production systems and protect our environment for future generations.

Great potential for “precision manure”

Agriculture and Agri-Food Canada (AAFC) scientists are helping farmers maximize crop yields while increasing the sustainability and profitability of their farms. They found cow manure could fully replace commercial fertilizers if applied in precise ways. After letting manure naturally separate into thin and thick portions, they spread the thin fraction with special applicators and found it saved nutrients (nitrogen) from evaporating and reduced odours. Then they injected the thicker sludge into the soil and planted crop seeds within 10 cm of the manure furrow. This demonstrated the most efficient manure phosphorous absorption by crops and eliminated the need for commercial fertilizer application. Precision injection has since been tested by scientists in Denmark and Netherlands and adopted by German farmers.

Scientists further developed the “dual manure stream” method to target different crops. Rich in available nitrogen, the thin portion applied to soil surface is best suited for crops such as perennial grasses. Rich in phosphorus, the thick portion precisely injected into the soil is suitable for crops like corn.

AAFC’s findings should help farmers become less dependent on commercial fertilizers by using their own manure (a readily available source of nitrogen and phosphorus), thereby lowering costs, achieving higher yields, and reducing their environmental footprint. “Precision manure” could reduce commercial fertilizer use by thousands of tonnes each year!

Making the most of phosphorus benefits potatoes and the environment

Thanks to scientists from Agriculture and Agri-Food Canada (AAFC), provincial agencies, and universities, Canadian potato growers can now maximize their yields by using phosphorus (P) more efficiently.

Simply adding phosphate fertilizer to potato fields may not always promote maximum yields because when soil is acidic, the added P binds to aluminum (Al) and plants cannot absorb it. Adding more fertilizer to compensate leads to the unabsorbed P ending up in surface runoff. As phosphate fertilizer is also a finite, non-renewable resource, researchers looked for ways to help potato plants use P from fertilizer more efficiently.

AAFC scientists discovered when Al was more than 10 times the amount of P, potato plants were unlikely to benefit from additional phosphate fertilizer. By adjusting the P application based on this ratio, farmers could save up to 100 kg of P per hectare when compared with current recommendations based on soil P alone. This is also more environmentally friendly, since unused P is lost in surface runoff.

Researchers also developed a fast, cost-effective way to monitor crops for P deficiency through analyzing foliage and, if needed, applying foliar soluble P fertilizer using irrigation systems.

They also evaluated struvite, a renewable resource recovered from municipal wastewater and sewage, as a replacement for phosphate rock. They found that a fertilizer mix containing 75 percent struvite can be as effective as conventional fertilizer.

With this research, farmers now have several simple, cost-effective tools to help them use P efficiently, detect deficiencies in potato plants, and take advantage of a sustainable P source.

SPOTLIGHT

AAFC's Living Labs

Farmers, scientists, and others working in the agriculture sector innovate every day, but it can take many years for innovations to become widely adopted. Recognizing the importance of working together and the urgent need for new solutions to agri-environmental issues — especially those related to climate change — Agriculture and Agri-Food Canada (AAFC) has been building a nationwide network of living labs since 2018.

AAFC's living labs use a collaborative approach to innovation to co-develop, test, evaluate, and improve new solutions so that they can be adopted faster by farmers. This new approach to agricultural innovation and research is based on:

- involving farmers in every step of the process and focusing on their needs
- working in diverse partnerships with farmers, scientists, industry organizations, not-for-profit organizations, and Indigenous groups
- having farmers test the proposed solutions on their own farms, alongside scientists and partners studying results and making contributions

Having farmers directly involved, from giving input into possible solutions to testing them and helping further improve them, ensures that these solutions will fit farmers' needs and be easier to adopt. Ultimately, these solutions strengthen environmental protection and sustainable farming regionally and nationally. Internationally, our model of building strong networks of collaborative relationships has inspired the European Commission as they build their living lab networks.

AAFC has 13 living labs—the first four under the Living Laboratories Initiative and nine new ones under the new Agricultural Climate Solutions–Living Labs program. While the issues they are working on are as varied as the regions, what these living labs have in common are the critical exchange of knowledge and building of relationships, which have resulted in unprecedented benefits for all partners involved.

Here are the four initial Living Labs:

Living Lab – Atlantic

Prince Edward Island is one of Canada's top producers of potatoes. However its iron-rich red soil is prone to erosion, and leaching of nutrients and contaminants like pesticides. In response, the East Prince Agri-Environment Association is leading more than a dozen local farmers and partners to try to reduce the environmental impacts of growing potatoes. They are co-developing and studying soil and water management strategies, cover and companion crops, rotational practices, and slow-release fertilizers.

Living Lab – Eastern Prairies

Diversity defines the agriculture in Manitoba—from cereals and canola to potatoes and livestock. As such, the Manitoba Association of Watersheds organized more than a dozen regional partners to co-develop solutions that tackle issues like: preventing nutrient, water and habitat losses; improving tile-drainage practices; enhancing habitats for beneficial insects and pollinators; and investigating regenerative grazing to see how well it can capture and store carbon in grassland soil.

Living Lab – Quebec

Increasing spring flooding in the Lac Saint-Pierre region of Mauricie threatens grain crops, animal agriculture and livelihoods. The Union des producteurs agricoles du Québec, plus eight regional partners including the Waban-Aki Nation, are working with scientists to co-develop solutions that: reduce erosion and improve soil health with cover crops; lessen bank erosion and protect diversity through riparian buffers; and reduce the environmental effects of livestock production with improved feed and waste management practices.

Living Lab – Ontario

As the smallest and shallowest of the Great Lakes, Lake Erie is particularly vulnerable to nutrient runoff from activity like farming. The Ontario Soil and Crop Improvement Association is leading this living lab and working with local partners, farmers and scientists to develop solutions to reduce soil and nutrient runoff through practices like continuous cover cropping and reduced tillage, and promote soil conservation and overall watershed health.

Here are the newest Living Labs:

The nine new living labs under the Agricultural Climate Solutions program will focus on carbon sequestration and mitigating greenhouse gas (GHG) emissions through the development and testing of beneficial management practices (BMPs), which could then be widely adopted across the region and country. Many of the activities will include a focus on: crop rotations and cropping systems; land use changes; pasture and forage management; feeding strategies; nutrient and pesticide management; fertilizer use optimization; soil health enhancement; and restoration and enhancement of perennials.

Find out more about AAFC's Living Labs:

See how Living Lab – Atlantic is using precision agriculture to help improve potato production.

Listen to how Living Lab – Quebec is revolutionizing agricultural innovation.

Watch how Living Lab – Ontario farmers are working with scientists to protect Lake Erie water quality.

Find these and other stories at agriculture.canada.ca/living-lab.

Living Lab – British Columbia	Co-led by the B.C. Investment Agriculture Foundation and BC Agriculture Council, this living lab aims to help farmers fight climate change by exploring new, cutting-edge BMPs.
Living Lab – Peace Region	This living lab focuses on carbon sequestration, greenhouse gas mitigation and enhancing agroecosystem services in the Peace Region that straddles British Columbia and Alberta.
Living Lab – Alberta	Led by Alberta Beef Producers, this living lab will explore the use of beef, forage and cropping systems to improve soil carbon sequestration and reduce greenhouse gas emissions.
Living Lab – Alberta Food	A collaborative effort between the Alberta Conservation Association and Food Water Wellness Foundation aims to improve soil health, reduce costs of production, and sequester carbon in the soil using regenerative agriculture. This living lab's projects will also amplify and support traditional ecological knowledge and efforts of First Nations in tackling agricultural climate solutions.
Living Lab – Saskatchewan North	This Indigenous-led (Mistawasis Nêhiyawak), Bridge to Land Water Sky project will see producers and First Nations work towards a common goal of improving the surrounding environment while committing to the protection of Indigenous values, treaties, communities, lands, and resources.
Living Lab – Saskatchewan South	This living lab, led by the South of the Divide Conservation Action Program, will focus on developing agricultural climate solutions for the Prairie ecoregions.
Living Lab – New Brunswick	The Agricultural Alliance of New Brunswick and their partners will look at the feasibility of adopting practices to sequester carbon and reduce greenhouse gas emissions on farms.
Living Lab – Nova Scotia	This living lab, led by the Nova Scotia Federation of Agriculture, will focus on practices important to this region such as cover cropping in annual and perennial systems, establishing riparian zones and shelterbelts, and land swapping.
Living Lab – Newfoundland and Labrador	Led by the Newfoundland and Labrador Federation of Agriculture, this living lab will focus on cropping, fertilization, and soil conditioning strategies for combatting climate change on farms across the province.

The science behind timing wine— let's drink to that!

British Columbia's wine industry contributes $2.8 billion annually to the province's economy.

Thanks to science, British Columbia winemakers now have a new tool to help ensure that all their wines are at peak quality when they reach marketplace. As wines age, chemical reactions occur that affect flavour, taste and quality, making it hard for winemakers to know when a wine reaches its top quality. Fortunately, researchers from Agriculture and Agri-Food Canada and the University of B.C. developed easy-to-use models to predict changes in volatile (aromatic) compounds over time, enabling winemakers to understand how wines evolve as they age.

The researchers analyzed eight different varieties of B.C. wines and established a database consisting of the chemical fingerprint of the volatile compounds in the wines produced from *Vitis vinifera* grapes. They tracked the rate of change of 23 compounds as the wines aged and found most compounds decreased in concentration while a few increased. The production and concentration of these compounds depend on environmental conditions, grape variety, winemaking practices, and temperature.

This research has significantly increased the understanding of age-related changes in wines. So now, B.C. vintners can use these models to predict the concentration of desirable and undesirable compounds in their wines, and time their market release just right! Cheers to that!

Cheers to the first sequencing of the barley genome in Canada!

Canada is the second largest producer of malt barley (used to make beer), but approximately 75% of it does not meet the strict grading standards for brewing beer and is used for livestock feed instead. Recently, Agriculture and Agri-Food Canada (AAFC) made a major breakthrough that could significantly accelerate the breeding of new high-quality barley varieties in Canada. An AAFC-led team of scientists sequenced the entire genome (genetic fingerprinting) of one of Canada's most popular malt barley varieties—AAFC Synergy—which has a number of excellent traits that can be used to develop new and improved varieties. This sequencing process used to take up to a decade but thanks to new genome sequencing technology, the scientists completed it in only one year!

By understanding the barley's genetic code, scientists can better predict its potential growth under various conditions such as drought or extreme temperatures, and the potential quality of the end product. This will enable breeders to select favorable traits and develop new varieties more efficiently.

Since malt barley usually sells at a higher price than feed barley, the new and improved malting varieties developed by applying the knowledge gained from this genome sequence could help grow farmers' profits, increase consumer satisfaction, and strengthen competitiveness of the Canadian barley industry.

Faster drying wheat makes a great bowl of pasta

Canada accounted for 70% of the world's durum exports in 2021.

Canada is the top exporter of durum wheat which is used to make pasta, couscous and bulgur. If grain is damp at harvest time though, farmers may opt for crop desiccation to accelerate drying and avoid fungal growth and deterioration during storage. Using chemical desiccants can increase production costs, plus environmental and consumer concerns. Agriculture and Agri-Food Canada (AAFC) is tackling this problem by developing new varieties with a faster "dry down period"—the time between full kernels with high moisture and optimal harvest time.

This dry down time can vary, but the shorter, the better because it decreases the risk of exposure to rain, speeds up the harvest, and decreases the need for desiccants.

To provide new genetic options for faster dry down, AAFC scientists studied 235 durum lines from around the world and analyzed their drying potential. They used different tactics to measure moisture including adapting a digital meter to measure moisture in a single kernel. Although research is still ongoing, they discovered 110 durum lines with a dry down period from 2.5 to 11 days. The goal is to give more options to wheat breeders and farmers, helping to reduce production costs, improve environmental choices, and please pasta lovers everywhere!

SPOTLIGHT

Indigenous Agriculture

Indigenous knowledge systems in Canada have been developed, refined, and maintained over thousands of years, and Agriculture and Agri-Food Canada (AAFC) is eager to build reciprocal research relationships with Indigenous Peoples that are based on respect, knowledge exchange, and co-development. At the same time, Indigenous communities and organizations have expressed strong interest in advancing agricultural and agri-food initiatives to contribute to food sovereignty, cultural revitalization, environmental sustainability, and commercial opportunities. With our world-class science, technological expertise, and knowledge of markets, AAFC is uniquely positioned to support these objectives.

Bridging, braiding, and weaving between western science and Indigenous knowledge involves actively listening to each other, fostering trust in relationships, and creating mutually beneficial partnerships. These alliances can then help realize the significant innovation potential of Indigenous Peoples and their sciences, expand Canada's agriculture and agri-food sector, and make a substantial contribution to Reconciliation.

Here are a few examples of successful AAFC and Indigenous partnerships:

Normandin Research Farm

Since 1936, the Normandin Research Farm has been improving farming practices in Quebec's Saguenay–Lac-Saint-Jean region by evaluating plant varieties and practices in this northern climate. After recently reviewing the Farm's priorities and hiring new staff, AAFC scientists will continue their work on grains, canola, forage crops and berries, among others, but for the first time, will also launch new research geared specifically to support northern and Indigenous agricultural crops. Collaborations with Indigenous communities in the area will help researchers work with Indigenous knowledge holders to guide future research. For example, research and innovation related to the management and production of culturally important food and medicinal plants may improve food security and economic development in Indigenous communities. With renewed focus, the Normandin Research Farm is a critical member of AAFC's network of research farms that are committed to northern agriculture and focused on including more research activities on Indigenous agriculture. This network also includes farms in St. John's, Newfoundland and Beaverlodge, Alberta.

The Three Sisters — a winning combination!

For hundreds of years, Indigenous groups in North America have intercropped corn, beans, and squash — a combination known as "the Three Sisters". The corn provides a structure for the beans to climb; the beans provide nitrogen to the soil; and the squash acts as ground cover reducing weeds, weed biomass, soil erosion, and water and nutrient loss. Intercropping involves growing two or more types of plants close by so they can assist one another. This traditional practice yields many benefits including: increased overall production, more efficient use of resources, better soil health, and less reliance on synthetic fertilizers and pesticides. It may also help adapt hard-to-farm landscapes into profitable areas and protect soil from erosion.

Researchers from AAFC, Université Laval, and the University of Ottawa worked with collaborators from the Haudenosaunee and Huron-Wendat Nations — First Nations seed keepers — to learn more about this unique system. Building on this knowledge, AAFC scientists found benefits of intercropping other crop combinations, including: canola and peas; oats and peas; mustard and lentils; chickpeas and flax; and hazelnut shrubs and berry-producing shrubs such as sea buckthorn and buffaloberry — further proof that a good neighbour brings many treasures.

A western partnership that is reaping great rewards

What began as a desire to enhance access to Indigenous food plants has grown into an amazing partnership between AAFC and Westbank First Nation in British Columbia. More than 30 AAFC staff at the Summerland Research and Development Centre have partnered with three Indigenous communities for the Indigenous Food Systems project. The partners in this project are learning and exchanging knowledge about traditional food plants (like native berries and edible bulbs), and looking for ways to conserve Indigenous plant species and enhance Indigenous communities' access to them. To emphasize the importance of culturally significant plants to Syilx Okanagan Nation and strengthen relationships with regional Indigenous groups, AAFC also planted an Indigenous demonstration garden and hired Indigenous and non-Indigenous students to help tend it. This cross pollination of traditional and western knowledge is proving to be very fruitful!

Apple and pear farmers with SAD can now smile

Apples are the second-most cultivated fruit crop in Canada with a farm gate value of about $225 million annually.

Agriculture and Agri-Food Canada (AAFC) researchers have given Canadian growers of dwarf apple and pear trees reason to smile—they found what they believe is one of the major causes of Sudden Apple Decline (SAD)! Orchards in Nova Scotia, Ontario, British Columbia, and Prince Edward Island are experiencing this devastating disease (also known as Rapid Apple Decline). First reported in Pennsylvania in 2013, this phenomenon causes the sudden, unexpected death of healthy young trees.

AAFC researchers isolated fungal pathogens from four different types of rootstocks infected with the disease. Their findings convinced them that *Diaporthe eres* is one of the major causes of SAD in infected rootstocks in Atlantic Canada. *Diaporthe* is a fungi that becomes a pathogen when the plant is stressed or injured. In greenhouse studies, apple rootstocks showed symptoms such as canker sores three days after introducing *Diaporthe eres*, and died after four weeks.

While *Diaporthe eres* is one of the potential pathogens, there are likely multiple stressors that cause the apple decline, and each reported incident should be investigated. However, the more AAFC scientists understand SAD, the more they can help apple and pear growers come up with management strategies for this newly reported threat.

Mobile detection of pests creates a field of dreams

Researchers from Agriculture and Agri-Food Canada and the University of Saskatchewan have developed an accelerated testing method for detecting insects that transmit plant diseases which can be done in fields in less than two hours. This is much faster than the traditional method which is time consuming and requires a laboratory for DNA testing.

When monitoring for pests like the migratory Aster leafhopper that can carry Aster yellows disease (a major threat to crops such as canola), time is critical. Producers need to make informed decisions on the best insect control measures quickly. To speed up the process, scientists examined the use of PlantSaver cards, a system used to extract DNA, and combined it with loop-mediated isothermal amplification (LAMP), a technique for analyzing DNA. Coupling these techniques means that the entire screening process can happen in the field.

This new method can accurately determine if leafhoppers are carrying the Aster yellow pathogen, and it gets more positive insect samples than the traditional method with a lower threshold of detection. When coupled with the molecular barcoding technique, it can also identify many other field insects more quickly. This discovery enables same-day management decisions which are essential for preventing the spread of insect-transmitted diseases and protecting Canadian crops.

Rapid test for respiratory disease in cattle lowers the need for antibiotics

Canada's cattle industry contributes approximately $18 billion annually to the economy and generates an estimated 228,000 jobs.

Agriculture and Agri-Food Canada scientists have developed a new rapid and accurate diagnostic test to help control Bovine respiratory disease (BRD), which is responsible for about 70% of illnesses and 40% of deaths in cattle. When cattle experience stress and crowding, such as during transportation to a new feedlot, they are prone to spreading bacteria which can make them sick. The new test provides earlier diagnosis of BRD, which leads to faster treatment and more judicious use of antibiotics, benefiting producers and Canadians.

When cattle arrive at a feedlot, a nasal swab is collected and tested for harmful bacteria. Using portable equipment in the field, the test analyzes the DNA of the bacteria and identifies it in 30 minutes! This quick diagnosis tells ranchers what type of bacteria could be making cattle sick and the genes present that would make the bacteria resistant to certain antibiotics. This information helps the veterinarian and producer make informed decisions about the most effective antibiotic to use.

BRD has been difficult to diagnose because the symptoms are often subtle. Although this tool is not yet ready for commercial feedlot use, initial results are promising.

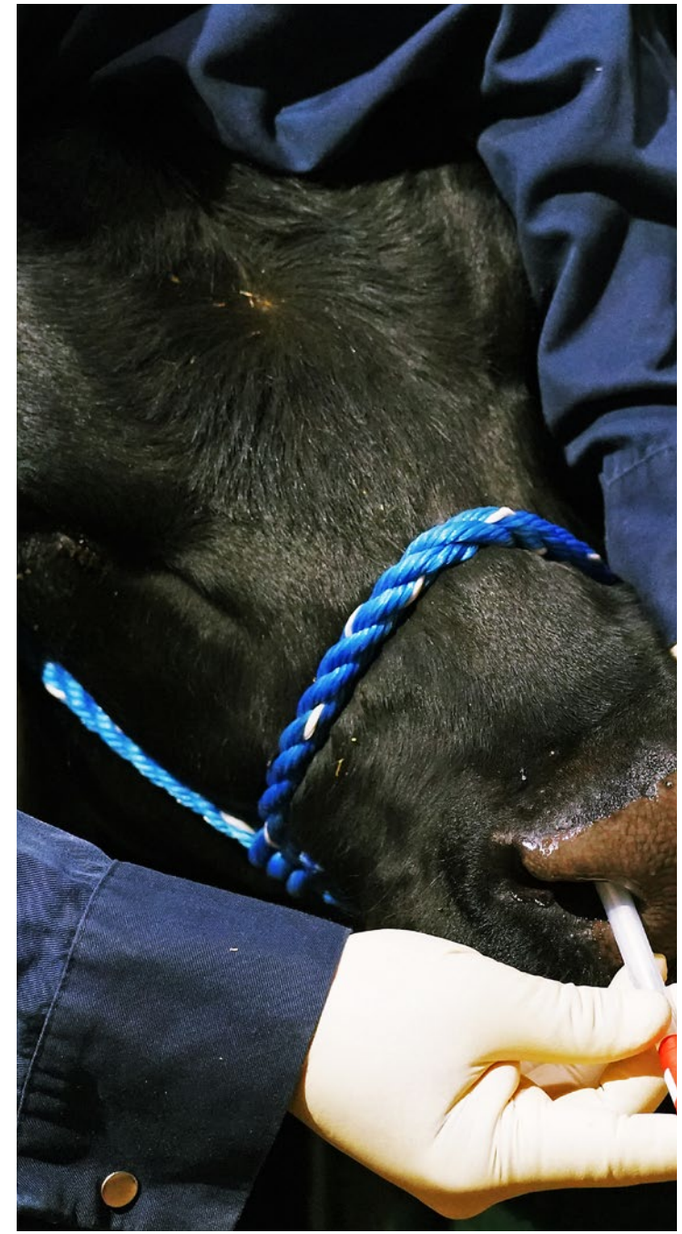


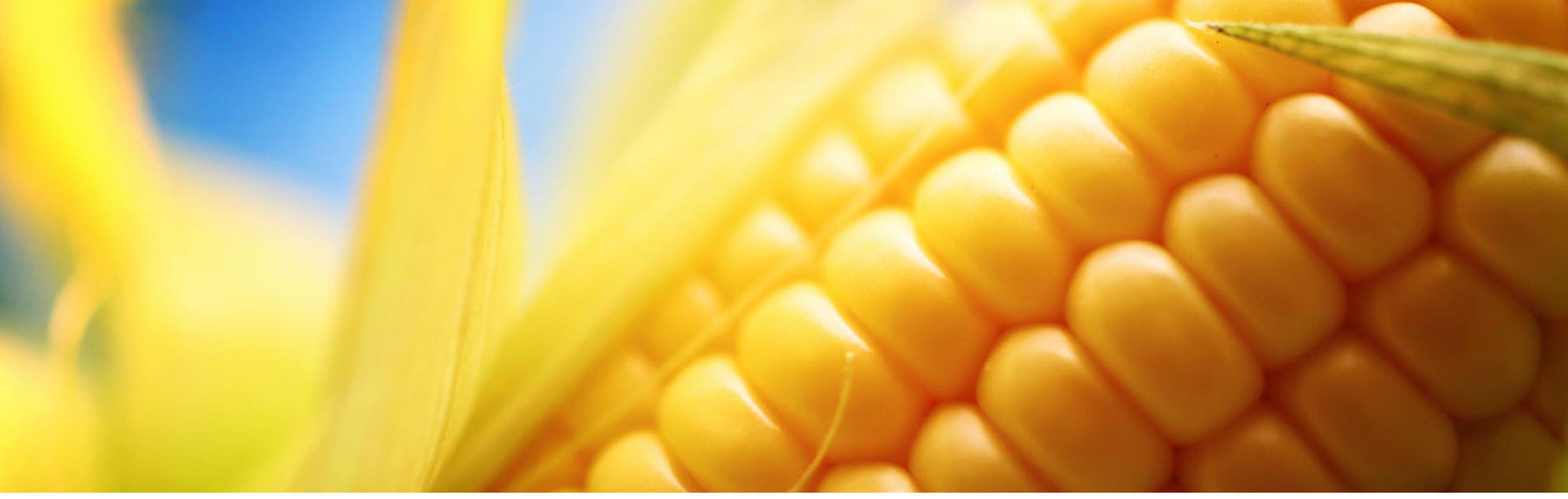
Image courtesy of Elijah Talamas

Idris elba wasp: powerful defender of crops

A newly identified wasp, named *Idris elba* after the British actor in Marvel's Thor films, could become a superhero! This potential new ally in biological pest control can kill a destructive species of stink bug—the bagrada bug—which attacks more than 74 different crops, including cabbage, radish, kale, cauliflower, and broccoli. In 2013, this bug caused damage of US$679 million in California alone. This parasitic wasp grows inside the egg of a bagrada bug, feeds on the nutrients, and then chews an exit hole and flies away to parasitize another bagrada bug egg.

The wasp was first found in Mexico. An Agriculture and Agri-Food Canada scientist identified its DNA (genetic fingerprint) and confirmed it had emerged from bagrada bug eggs. A Florida government taxonomist (a specialist in the classification of insects) confirmed it was indeed an undescribed and un-named species. Since a group of parasitoid wasps called "*Idris*" already existed, scientists named this newly discovered wasp "*Idris elba*".

Although the bug has not been seen yet in Canada, it is spreading rapidly in North America. Just as Idris Elba's movie character defends a bridge to the gods, the *Idris elba* wasp may help protect agriculture by reducing the movement and spread of the bagrada bug in North America through biological pest control.



New ways to detect fungal toxins!

Mycotoxins, a class of toxins produced by certain fungi, can grow on crops in the field or during storage. These toxins reduce trade revenues and have an impact on animal health and crop productivity. In humans, some mycotoxins target the liver, kidneys, or immune system, while others are known to cause cancer. Detecting and measuring levels of the most significant mycotoxins have been key to ensuring food and feed safety. However, methods currently used to detect and measure the most significant mycotoxins are limited in their ability to detect new and emerging mycotoxins.

That is why Agriculture and Agri-Food Canada developed a new method to detect and measure both known and emerging toxins from a wide variety of crops and foods. Researchers linked modern analytical instruments with in-house developed software to analyze large datasets.

This has recently led to important findings including new toxins and the discovery of significant levels of the mycotoxin commonly referred to as DON in some Ontario corn.

As the research team focuses on understanding emerging mycotoxins in crops, these advancements in toxin detection will help ensure food and feed safety across the entire Canadian agri-food chain.

Canadian honey bee colonies account for $1.3 to 1.7 billion annually in increased production of fruits and vegetables through pollination services. (Canadian Honey Council)

Protecting bees while reducing pesticide use

Thanks to the efforts of the Pesticide Risk Reduction team at Agriculture and Agri-Food Canada, Canadian apiculturists now have two new biopesticides that can help control varroa mites—a serious threat to honeybee colonies across Canada. Scientists estimate that a single mite can reduce the lifespan of a honeybee by 50%. In fact, while the number of honeybee colonies has increased by 6.5% since 2015, the amount of honey produced has decreased by 12.7% over the same period, partly due to the destructive effects of the varroa mite.

The team, in collaboration with provincial and industry partners, prepared registration submission packages that successfully met Health Canada's Pest Management Regulatory Agency standards. The two new biopesticides—naturally occurring substances, e.g., bacteria, fungi, growth regulators or biochemicals used to control pests—were registered in 2019 (HopGuard II) and in 2020 (ApiLife VAR). With these biopesticides, Canadian beekeepers are now better equipped to manage varroa mites in their hives while reducing the use of conventional pesticides.

A mega team battling wheat leaf rust

Wheat leaf rust is a serious fungal disease that has periodically caused catastrophic losses to cereal crops worldwide. For over 100 years, Agriculture and Agri-Food Canada (AAFC) researchers have battled this disease. It is currently controlled by resistant cultivars and incessant fungicide applications but remains a threat because the pathogen adapts and mutates. Now, AAFC specialists are joining forces with 11 businesses and Canadian universities under the "Computational Biochemistry Platform for Crop Health" project led by Terramera, a West Coast company.

Researchers will use cutting-edge technologies such as computational biochemistry, automated plant analyses, and plant-pathogen interaction genomics to find optimal disease management strategies.

Over the decades, AAFC scientists have collected numerous Canadian fungal samples and developed a wide variety of wheat cultivars with various levels of resistance. Since 2000, they have studied fungal genomes and gene expression during infections in both the fungus and a variety of wheat cultivars. Results from this work are being incorporated into a digital platform for machine learning — a process that allows software applications to become more accurate at predicting outcomes (by analyzing and finding patterns in data).

The findings of these studies will result in more effective and less expensive crop protection tools to be used in conjunction with more leaf-rust resistant wheat varieties.

FIND OUT MORE

Stay informed on the latest news about Agriculture and Agri-Food Canada's (AAFC) research… from breakthrough scientific discoveries and departmental initiatives to inspiring personal stories and helpful information. Whether you are a farmer, a food processor, an "aggie" or just a foodie, you will find something that transforms the way you think about agriculture and the science behind it.

FIND OUT MORE

AGRI info

Keep up to date on AAFC's programs and services for industry, markets and trade information, and science and innovation news by subscribing to Agri-Info.

Come meet some of our scientists through Fields of Science. Their research helps farmers produce safe, high quality foods in sustainable ways for Canadians and people around the world.

Good News Grows gives you inspiring stories about the people making a difference in Canadian agriculture — farmers, AAFC scientists, youth, and more.

The First Sixteen is AAFC's podcast series that examines innovative ideas in the world of agriculture and food. To find out more about agricultural changemakers and their big ideas, tune in to our new episodes every month.

Still hungry for more science stories? Check out this blog series coming from one of our research centres in the heart of the Okanagan Valley in British Columbia.

Read up on the dynamic stories of Women in Science who are paving the way for more young girls and women to get involved in science, technology, engineering and math (STEM).


At science.gc.ca, you can find our scientists' profiles and our research and development centres.