Agriculture and Agri-Food Canada
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Introduction

Since 1886, Agriculture and Agri-Food Canada (AAFC) has provided leadership in the growth and development of a competitive and sustainable agriculture and agri-food sector. Our vision is to drive innovation and ingenuity to build a world-leading agricultural and food economy for the benefit of all Canadians. Now with climate change, biodiversity threats, opportunities with new technology, and changing consumer and market demands, this objective is more important than ever.

In this volume of *Agricultural Innovations*, you will find several stories highlighting our recent scientific accomplishments. These achievements would not be possible without the collective efforts of our researchers, technicians, support staff, and academic and industry stakeholders across the country and around the world. Each of these research stories is marked with one or more of the following icons, showing how this research fits into AAFC's Strategic Plan for Science and our four Missions:

Mitigating and adapting to **climate change**

Advancing the circular economy by developing value-added opportunities

Increasing the **resiliency of agro-ecosystems**

Accelerating the digital transformation of the agriculture and agri-food sector

The research outcomes of each Mission provide clear and measurable results that will have positive impacts on the agriculture and agri-food sector, and the lives of Canadians.

At AAFC, we strive to conduct world-class research and achieve innovative results while guided by the values and ethics outlined in our Science Integrity Policy. This policy sets the foundation for our work, helping ensure we maintain and increase public trust in government science, uphold scientific integrity, and enhance the understanding of science to aid evidence-informed decision making. Our participation in the Federal Open Science Repository of Canada, launched in 2023, also helps foster public trust and enable scientific collaboration by providing web-based access to our researchers' articles and publications.

We hope you enjoy learning more about some of AAFC's recent scientific achievements in this issue. The special "Spotlight" sections feature the important work of our Pest Management Centre and Office of Intellectual Property and Commercialization, both having recently celebrated their 20th anniversary.

We take great pride in our past achievements and are excited to continue pushing the boundaries of possibilities in our future research plans.

AAFC Research Successes

Potatoes are Canada's largest vegetable crop ($1.29 billion in receipts, 2019) & the world's 4th most widely grown and economically important crop.

Antioxidant surprises by boosting immunity of potatoes

The challenge

Late blight disease can destroy entire potato and tomato crops, causing more than $6 billion annually in losses worldwide. The pesticides farmers use to fight it are not allowed in certain countries under organic standards.

AAFC research findings

Looking for alternative treatments, scientists found that spraying a solution of selenium (an antioxidant) on healthy potato plants helped them defend themselves against late blight. When sprayed on infected plants, selenium prevented disease development. In addition, scientists identified the potato genes that are activated by selenium, further highlighting that selenium could be used to induce resistance or immunity to late blight in potato varieties.

The impacts

Selenium is an environmentally friendly and cost-effective way to save potato crops from late blight and prevent growers from losing revenue. Further studies on selenium could help prevent other potato diseases, protect other crops vulnerable to late blight disease, and reduce cereal crop diseases.

Developing new barley varieties that tolerate excess water

The challenge

Of all the cereal crops in Canada, barley is the most vulnerable to waterlogging stress—high precipitation and poor drainage leave too much water in the soil, which reduces the oxygen available to the plant's roots. With the rapidly changing climate, developing new barley varieties that tolerate waterlogging is critical in reducing yield losses.

AAFC research findings

Scientists assessed 247 spring barley varieties for yield characteristics under waterlogging field conditions. They also investigated the genes in roots of waterlogging-tolerant varieties and identified:

- significant genes that activated the plant's waterlogging tolerance;
- how the roots of moderately tolerant and tolerant barley respond to waterlogging stress; and
- new genomic regions never before reported in waterlogging-related studies.

This is possibly the first ever genome-wide study to identify genetic variations associated with waterlogging tolerance in a worldwide barley collection under field conditions.

The impacts

The discovery of this critical new information will help identify barley varieties that can tolerate waterlogging, possibly leading to the development of barley varieties that are more resilient in the face of climate change.

Our research collaborators: Yangzhou University (China) and University of Tasmania (Australia)

Canada exports more than $1 billion a year worth of barley.

New solutions to reduce mastitis and antibiotic use in dairy production

The challenge

Mastitis, an infection of cows' udders caused mainly by bacteria such as *Staphylococcus aureus (S. aureus)*, is the most common health problem of lactating cows, costing approximately $662 per cow annually. Antibiotics used in treatment are becoming less effective; commercial disinfectants can irritate cows' skin; and existing vaccines vary in efficacy. New ways to prevent or treat infections (like mastitis) in farm animals are essential in reducing antibiotic use and the development of resistance.

AAFC research findings: Antibacterials

For the first time, researchers found that bacteriocins—antibacterials produced by certain bacteria to defend themselves against other bacteria—are effective in eliminating mastitis-causing bacteria, including bacteria resistant to several antibiotics. When applied to teats, the disinfecting solution containing the three most promising bacteriocins showed that it:

- was a lot more effective than solutions containing single bacteriocins;
- was as effective as a commercial iodine-based solution, but without irritation to the skin;
- can eliminate more bacterial strains than a single bacteriocin; and
- can reduce the risk of bacteria developing resistance to the bacteriocins.

Canada has 9,700 dairy farms (2022).

AAFC research findings: New vaccine

In another first, scientists identified six antigens (fragments of proteins in *S. aureus*) that were produced by this bacterium during a mammary infection. This helped them create a new vaccine containing these six antigens and a triple adjuvant (instead of a single used by conventional vaccines) in order to increase the vaccine's efficiency in triggering an immune response. The six antigens all produced specific antibodies in the cows' blood and reduced udder inflammation during a *S. aureus* infection.

Recent trials proved the AAFC vaccine was more effective than the currently used one by:

- reducing the number of *S. aureus* bacteria present in the cow by 18%; and
- enabling the affected udders to produce 18% more milk in the three weeks following the infection.

The impacts

These discoveries offer an effective, low-cost option for preventing and treating mastitis while limiting antibiotic use. This can help reduce the risk of antibiotic resistance, improve animal health, and increase profitability of dairy farms in Canada. Further studies are needed before the new vaccine can be commercially available.

Our research collaborators: Université Laval and Université de Sherbrooke, Quebec

Using AI, the smart way to manage nitrogen

The challenge

Applying the right amount of nitrogen fertilizer at the right time is essential for boosting crop productivity, but minimizing fertilizer costs, preventing nitrogen (N) runoff into waterways, and reducing greenhouse gas (GHG) emissions are also important.

AAFC research findings

To calculate optimum nitrogen application rates for canola, researchers used artificial intelligence (AI) to incorporate historical weather data and early-stage plant and soil data from 22 site-year combinations in eastern Canada. They hoped to identify opportunities to reduce GHG emissions from fertilizer applications. The study included split-N application where nitrogen fertilizer is added before planting (preplant) and when plants begin rapidly absorbing nitrogen (6-leaf stage).

Results showed that under favourable conditions (including weather, plant traits, soil properties and field management) conducive to high yields (more than 3 tonnes/ha), the split-N application increased yield by 20% compared with preplant-only application. However, under low-yielding conditions (less than 2 tonnes/ha), split-N treatments were not always beneficial but provided producers the opportunity to reduce total nitrogen added.

The impacts

Using these new AI models (such as the “Random Forest” algorithm) to accurately predict the optimum amount of nitrogen needed helps canola producers increase yields while reducing their costs and environmental footprint.

Our research collaborators: Environment and Climate Change Canada, McGill University, Université Laval, Dalhousie University, University of Manitoba, Olds College (now College of the Rockies)

SPOTLIGHT

Pest Management Centre

Two decades of delivering solutions to the agricultural sector

For more than 20 years, AAFC's Pest Management Centre (PMC) has helped Canadian growers protect their crops from harmful pests. Operating from the Ottawa headquarters and 11 research centres and farms across Canada, the PMC helps growers gain access to new minor uses of pesticides and alternative pest control strategies to reduce the risk from pesticides.

The term "minor use" refers to the use of pesticides (i.e. fungicides, insecticides, and herbicides) on high-value crops grown on a smaller acreage, such as horticulture and specialty crops.

PMC teams conduct research on insect pests, plant diseases, and weed management, focusing on conventional and non-conventional solutions and Integrated Pest Management (IPM) approaches. This ultimately provides Canadian producers with diverse tools to protect the yield, value, and quality of their crops.

Collaboration

The minor use activities of the PMC are a joint initiative between AAFC and Health Canada's Pest Management Regulatory Agency (PMRA). The PMC teams also collaborate with pesticide registrants, researchers and academia, growers and grower organizations, and provincial, federal, and international partners.

The PMC works with the United States Inter-regional Project 4 (IR-4) to provide equal access to new pest management tools for horticulture and specialty crop producers in both countries, including harmonized Maximum Residue Limits (tolerances) which help prevent trade barriers. The data are submitted jointly to the PMRA and the United States Environmental Protection Agency, who collaborate on the regulatory evaluation.

The PMC delivers the following programs:

Minor Use Pesticide Program (MUPP)

Purpose: to increase grower competitiveness by improving access to newer and more effective pesticides

Every year, growers work with provincial representatives to identify crop/pest problems and potential solutions which are then prioritized at the Canadian Pest Management Priority Setting Workshop. Once priorities are established, the PMC undertakes field and greenhouse research trials to determine efficacy and crop tolerance, and laboratory analysis to determine pesticide residues in crops. Data from this research is used in regulatory submissions to the PMRA to support the registration of new minor uses of pesticides.

Many of these new crop protection products replace older formulations which have been taken off the market. These efforts help new products obtain regulatory approval faster, which helps Canada's producers compete in global markets.

Pesticide Risk Reduction Program (PRRP)

Purpose: to reduce risks to human health and the environment from pesticides used in the agriculture and agri-food industry

The PRRP team consults and works with many collaborators to address priority pest issues. They help develop, demonstrate results of, and transfer alternative pest management technologies that reduce pesticide risk.

Ultimately, the PRRP helps growers access and adopt IPM practices, a broad-based approach to managing pests in an effective, economical, and environmentally sound way.

Biopesticides

In addition to conducting research to support the registration of newer, more effective, and safer pesticide uses, the PMC helps growers access low-risk, environmentally and economically sustainable pest control products. These include biopesticides, which are non-chemical control options like: living microorganisms (e.g. bacteria, fungi, viruses); compounds that change an organism's behaviour (e.g. insect sex pheromones); and common household substances (e.g. garlic powder, table salt, vinegar).

Read more about biopesticide projects and submissions.

Integrated Pest Management (IPM) Solutions

The PRRP develops and evaluates IPM tools and practices to help growers produce crops in environmentally sustainable ways. The emphasis is on reducing growers' reliance on traditional pesticides. Beneficial farm and crop management practices like crop rotation, good drainage, clean seeds, cultivar resistance, and proper sanitation also play a role in managing pests.

View IPM projects in the PMC's online database.

Knowledge and Technology Transfer

To communicate the innovations resulting from PMC-supported projects and activities, the PRRP team develops and publishes crop protection information such as: crop profiles, factsheets, grower guides, and articles. The team also organizes technology demonstration events to promote grower awareness and uptake of alternative pest management tools and IPM approaches.

View PMC publications on AAFC's Agricultural Pest Management Resources web page.




Key PMC Accomplishments

Through expansive collaborations with national and international partners, and by sharing expertise to lead and support pest management initiatives, the PMC's work has helped create strong sector resiliency in Canada.

Here are a few of the PMC's major accomplishments since 2003:

- **Crop profiles:** providing an up-to-date online resource for growers on pest issues, available control practices, and IPM approaches for 36 crops
- **Crop protection products:** addressing growers' pest priorities for horticulture and specialty crops with research, leading to the registration of more than 5000 new minor uses of pesticides
- **Biopesticide solutions:** facilitating more than 25 new product registrations, amounting to over 900 uses for growers to adopt; supporting biopesticide research to effectively incorporate these tools into crop protection programs
- **Organic solutions:** supporting research for new products targeting the organic sector
- **Innovative technologies:** supporting more than 230 projects to develop new pest control tools/practices that reduce pesticide use (e.g. diagnostic and decision-making tools, biocontrol and cultural methods, bee and drone-enabled applications)

To our knowledge, this research is a “first” for studying the impact of replacing milk fat with vegetable oil in high-protein yogurt.

A new yogurt—a partner in the circular economy?

The challenge

In Canada, production of high-fat cheeses, ice cream, and butter creates 340,000 tonnes/year of dairy by-products known as “solid non-fat” (SNF). Although SNF is very nutritious (with protein, lactose, and minerals), the dairy industry struggles to use and market it.

AAFC research findings

Scientists found a way to reduce SNF surpluses by using them in a new type of yogurt that is rich in protein (9%) and creamy in texture, much like the popular Greek-style yogurt, but without milk fats. Instead, they used canola oil that has a neutral taste, high levels of polyunsaturated fatty acids, and vitamin E.

Researchers added skim milk powder (SNF) to water and combined it with 25%–100% canola oil to replace milk fats. They then homogenized it at a high pressure, creating smaller canola oil droplets throughout the yogurt to make it firm and creamy.

The impacts

With further research, this innovative canola oil yogurt could help dairy processors offer consumers a new quality product, reduce food waste, and move into the circular economy where they create income from previously unused by-products.

Read how farmers, stakeholders, and researchers continue to collaborate in AAFC's new Living Lab – PEI.

Soil revival brings surge in spuds

The challenge

Potato farming can sometimes result in increased nitrogen leaching and soil degradation, especially after harvest and during periods of increased precipitation. As part of the Living Lab – Atlantic project (2019-2023), AAFC researchers worked with potato growers and industry partners to develop better ways of plowing and adding manure or compost to potato fields to help soil health and reduce nitrogen leaching.

AAFC research findings

The living lab compared conventional plowing that inverts soil, burying crop residues deeper, with a less invasive plowing method that cuts residues into small pieces, distributing them through the soil (primary non-inversion shallow tillage [PNIST]). Although potato yields were comparable between the two methods, using PNIST improved:

- soil stability, making it less prone to erosion;
- levels of active carbon (food and energy for soil microbes); and
- levels of available nitrogen.

Adding cow manure also improved soil health, with just one application increasing potato yield by 28% and soil nitrogen by an average of 44%. In the absence of manure or compost, applying willow chips to the soil after harvest helped increase soil carbon, diminish erosion, add potassium, and retain nitrogen, preventing nitrogen leaching.

The impacts

These results provide growers with practical options to regenerate soil health, reduce nitrogen leaching, and improve potato yields, increasing the environmental sustainability of potato production.

Our research collaborators: Prince Edward Island (PEI) Department of Agriculture and Land, PEI Potato Board, Université Laval, University of Prince Edward Island, 12 growers, East Prince Agri-Environment Association, Kensington North Watersheds Associations, and Souris and Area Branch of the PEI Wildlife Federation

Herbicide resistance costs Canada more than half a billion dollars annually in alternative herbicides and reduced crop yields.

Tackling herbicide resistance with teamwork

The challenge

Weeds compete with crops for space and nutrients in fields and, without control measures, can drastically affect yields. Because of genetic mutations, some weeds are developing resistance to the herbicides used to eliminate them.

AAFC research findings

Researchers have developed 38 rapid genetic herbicide resistance tests for many weed species. These tests are ten times less expensive and much faster than conventional screening methods. The tests use small samples of weed leaves to confirm herbicide resistance within two weeks. Available through provincial laboratories, the tests can help growers make informed decisions about weed control, avoid the costs of using ineffective herbicides, and reduce the amount of herbicides in the environment.

In addition, AAFC has collaborated with cross-provincial weed scientists to increase the availability and delivery of such tests and prevent herbicide resistance from spreading. External collaborators have created 27 additional genetic tests, for a total of 65!

The impacts

As climate change undermines global food production, Canada's produce and grains are essential food sources for Canadians and other global citizens. These tests, coupled with cross-country collaboration, are essential in reducing the threat of herbicide resistance and protecting crops.

Our research collaborators: Ministry of Agriculture, Food and Agribusiness and Ministry of Rural Affairs (Ontario); ministère de l'Agriculture, des Pêcheries, et de l'Alimentation du Québec; Harvest Genomics (now Turnkey Genomics); Results Driven Agriculture Research (RDAR)

Move over antibiotics—Black Soldier Fly larvae to the rescue!

The challenge

Poultry producers worldwide have been using soybean meal (SBM) for protein and energy with bacitracin, a commonly used antibiotic, to promote good health and growth of birds. With growing concerns of antimicrobial resistance (AMR), producers urgently need non-antibiotic alternatives that are easy to adopt.

AAFC research findings

Scientists are studying black soldier fly larvae meal, a rich source of protein and natural antibacterial compounds, as a partial substitute for SBM and bacitracin in poultry feed. The larvae can be used to make black soldier fly larvae meal (BSFLM), a nutrient-rich feed for poultry, salmon, and tilapia.

Researchers substituted SBM in broiler chickens with either low level (12.5% and 25%) or high level (50% and 100%) BSFLM concentrations and compared them to broiler chickens fed a conventional diet of SBM and bacitracin. They found that substituting SBM with low levels of BSFLM enhanced chicken growth during the first three weeks, whereas high levels of BSFLM decreased their growth.

The impacts

If BSFLM is used at the right concentration, it could be an effective alternative to the commonly used antibiotic growth promoter bacitracin. Because black soldier fly larvae eat agricultural waste (spoiled produce or stale grains), this would also support a circular economy in Canadian poultry production.

Our research collaborator: University of Guelph

Taking the high road … better transport for livestock

The challenge

Beef cattle and pigs sometimes travel long distances by truck from farms to slaughter. The stress of the transport can reduce immunity, cause illness, and compromise the quality of meat, costing the industries millions of dollars annually.

AAFC research findings: Transporting beef cattle

To determine the importance of stopping for a rest during long distance transport on calf welfare, scientists conducted three studies using 960 calves. Each study looked at varying transport durations before and after a rest, with varying lengths of rest. Under Canadian regulations, weaned cattle receive a minimum 8 hour rest after 36 consecutive hours of transport with feed, water, and rest space provided. The two most important factors impacting calf welfare were:

- Pre-shipping calf management ("conditioning"): This practice ensures calves are weaned, vaccinated, dewormed, castrated, dehorned (if needed), and have been eating solid feed and drinking from a trough for at least 18 days before transport. Overall, conditioned calves weighed more after transport, showed less stress, and had greater immunity compared to unconditioned calves regardless of the length of rest they received.
- Length of transport: Calves transported for longer periods experienced more stress (weighed less and laid down more after transport) than calves shipped for shorter time periods.

More than 72,000 Canadian farms raise approximately 12 million beef cattle and calves (2022).

More than 20 million pigs are transported to slaughterhouses in Canada annually (2022).

AAFC research findings: Transporting pigs

For the first time, scientists observed pigs' behaviour in the slaughterhouse rest area following an eight-hour trip in a truck with compartments providing pigs different amounts of floor space to lie down and rest. They discovered that by not exceeding two pigs per square metre of space, animals could lie down easily during transport. They arrived rested, laid down less in the slaughterhouse rest area, and were less fatigued. However, increasing the number of animals per square metre forced them to stand or sit during transport, risking injury when looking for space to lie down, or being knocked over by the truck's movements. At the end of the trip, most of these pigs were tired and laid down. Their fatigue lasted until slaughter, resulting in darker and drier meat.

The impacts

This cattle research is the first in Canada to provide science-based information that regulatory agencies can use to develop appropriate guidelines. The findings can help the beef industry improve the health and welfare of calves during transport, which is more cost efficient for producers.

This pig research proved that transporting fewer pigs in a truck (as already recommended) can benefit animal welfare and meat processors, and please consumers.

Our cattle research collaborators: University of Guelph, Institute of Agri-Food Research and Technology (Spain)
Our pig research collaborators: University of Calgary, Universidade Estadual Paulista and Universidade Estadual de Londrina (Brazil)

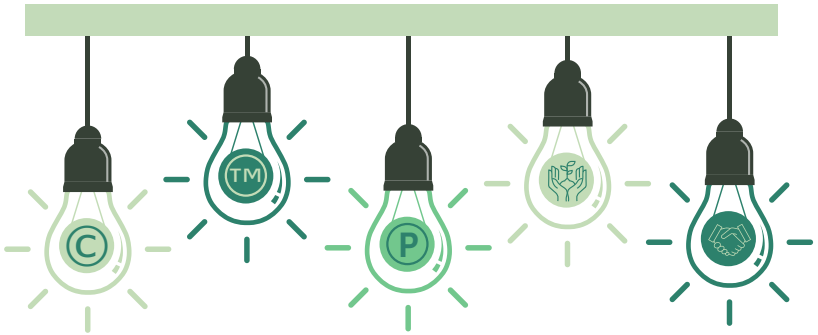
SPOTLIGHT

Office of Intellectual Property and Commercialization

Protecting and promoting AAFC's inventions for 20 years

Intellectual property: creations of the mind, including scientific inventions and artistic work, that can be protected by law

Intellectual property (IP) allows researchers to protect innovations, foster collaboration, and create commercialization opportunities through licensing. AAFC's IP portfolio includes copyrights, trademarks, patents, trade secrets, and Plant Breeders' Rights.



For more than 20 years, AAFC's Office of Intellectual Property and Commercialization (OIPC) has provided leadership, expertise, and guidance on IP matters to AAFC researchers, their team members, and external partners.

OIPC Commercialization Officers guide innovations from the first proposal of an idea or a project, through facilitating research collaborations and managing IP, to overseeing the transfer of research results to the sector for the benefit of all Canadians. They also ensure AAFC's Freedom to Operate with its IP—to develop, make, and market products, tools, or processes while mitigating legal liabilities to third parties. Their work supports sustainability goals like zero hunger, good health, responsible agriculture, and climate action.

There are three service teams within the OIPC:

Business Development Office (BDO)

The BDO manages AAFC's technology portfolio and analyzes all AAFC inventions (new tools, processes, or products) to determine how to maximize adoption and benefits for all Canadians and Canadian agricultural stakeholders. In addition to currently managing active patents, the BDO also conducts market studies to optimize the value of AAFC's IP.

Plant Variety Protection Office

AAFC invests significant resources and expertise in developing new plant varieties. The OIPC's Plant Variety Protection Office works with the Canadian Food Inspection Agency (CFIA) to secure and maintain IP protection for new varieties under the Plant Breeders' Rights Act.

To ensure the high standards and reputation of Canadian crop varieties, before new variety seeds can be sold in Canada, they must go through additional years of trials and testing, inspection, and quality control, and be registered under Seeds Regulations through the CFIA's Variety Registration Office.

OIPC Specialized Unit

AAFC's Research Participant Program is led by the OIPC's Specialized Unit in collaboration with the science team. The Program promotes collaborative research and develops highly skilled personnel for the agriculture sector by hosting research participants to work on projects in AAFC facilities.

Research agreements

3,639 active agreements currently exist between external collaborators and AAFC.

Plant varieties

503 AAFC-developed plant varieties are grown in Canada and around the world.

The OIPC currently manages **212** active Plant Breeders' Rights and **771** active registered plant varieties.

Patents

114 active patents exist in **27** countries for **45** AAFC technological inventions.

Commercialization

661 active licences exist for both AAFC technologies and plant varieties.

There are **165** AAFC entries on ExploreIP Marketplace, an online tool hosted by Innovation, Science and Economic Development Canada, promoting business opportunities with AAFC for the agricultural and agri-food industry.

The OIPC in action: Bringing new inventions to agricultural stakeholders and Canadians

Biopesticides for control of potato late blight disease

Late blight disease harms potatoes, causing $7 billion in damages globally.

AAFC scientists developed a biopesticide with antifungals from Canadian prairie soils and plant roots, and a new fermentation technology to cost-effectively produce it. Its use reduces chemical fungicide applications, releases fewer chemicals into the environment, and lowers pesticide residues in the food supply.

OIPC worked with the scientists from the beginning of the research to obtain issued patents in Canada (pending), the US, China, Brazil, and Mexico, and identify a commercial partner. The OIPC is currently negotiating a sole license agreement for the new technology, ensuring it is available to the Canadian agriculture sector.

A solid new wheat variety to defeat prairie pest

The sawfly pest has devasted prairie wheat crops by weakening their stems.

AAFC breeders developed AAC Oakman, a solid-stem Canada Western Red Spring wheat variety that can withstand sawfly damage. Through a competitive process led by the OIPC, SeCan was awarded the license to produce and market the variety.

OIPC worked with scientists to help accelerate the commercialization of AAC Oakman by negotiating a deal to facilitate a seed increase in New Zealand during our winter months. Thanks to more than 40 tonnes of foundation seed grown in New Zealand, SeCan will be able to produce commercial quantities of seed for Canadian farmers two years earlier than expected, by 2026.

Meet the mighty millet

The challenge

Unknown to most Canadians, millet is much more than animal feed or bird seed. This "super grain" is nutritionally rich and high in dietary fibre, tolerates poor soils, weathers the effects of climate change, grows quickly, and thrives without much water or fertilizer. Yet very little is known about its genetic makeup which could provide opportunities for crop improvement and breeding strategies.

AAFC research findings

AAFC scientists and their collaborators created the first genetic atlas of all the different life cycle stages of little millet: from seed germination and plant growth to flower and grain maturity.

They studied its RNA (ribonucleic acid) and identified key genes which acquire minerals (particularly iron and zinc) from the soil, distribute nutrients, and promote growth. Researchers also used this gene atlas to explore the genetic relationship between little millet and other cereal crops.

The impacts

This research breakthrough could:

- help fortify millet and other crops with important micro-nutrients to reduce global hidden hunger (micronutrient deficiencies);
- create new varieties or improve existing ones to be more resilient in the face of climate change;
- encourage millet production across Canada and increase income potential for farmers.

Our research collaborators: National Research Council Canada, Saskatoon; University of Toronto; University of Calgary; Canadian Light Source Inc., Saskatoon; University of Agricultural Sciences, Bangalore (India)

The United Nations General Assembly chose 2023 as the International Year of Millets because of their high nutritional value and ability to help us adapt to climate change.

New sources for bioethanol hit the sweet spot

The challenge

Ethanol comes from pressing plant stalks to extract sugar-rich juice that is then fermented. Sweet pearl millet and sweet sorghum are two new potential sources for producing bioethanol as they require less fertilizer and water than other energy crops, and their post-pressing residue can produce silage (feed) for cattle. However, transporting the stalks to process is expensive because of their weight, and the sugars in the stalks degrade rapidly after cutting.

AAFC research findings

To find solutions, scientists tested different pressing methods right in the field and found this method gave the best results:

- Roughly chop the stems and press them.
- Soak the bagasse (post-pressing residue) in half as much water at ambient temperatures.
- Press a second time to remove residual sweet liquid.

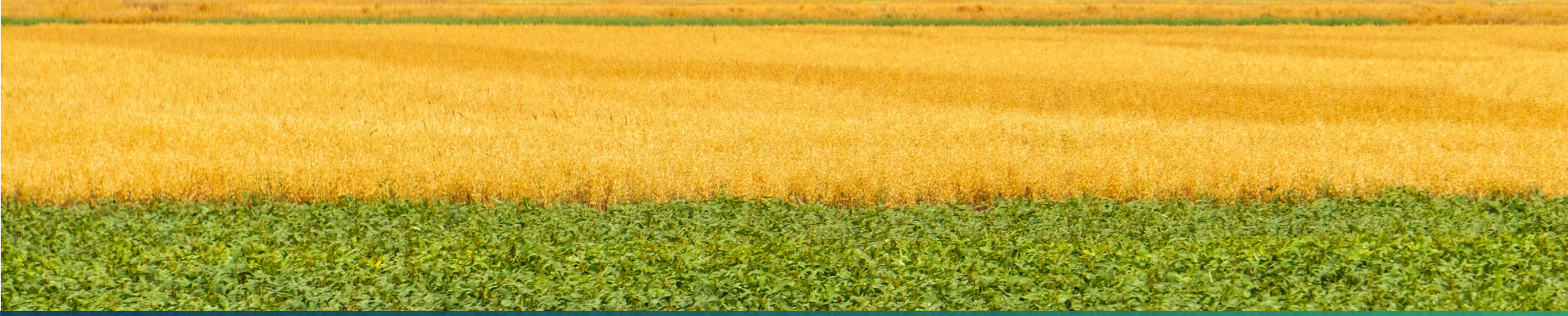
The second pressing gave 20% more sweet liquid, which could mean getting more than 750 litres of ethanol per hectare under Quebec soil and climatic conditions.

The impacts

Further research is needed to study this method's effect on silage digestibility and milk production. However, this new technique promises to increase the profitability of bioethanol production plants and growers of bio-energy crops.

Our research collaborator: Université Laval

Millets include more than a dozen varieties of millet, sorghum, fonio, and teff. Read more about our research on millet.



Diversify crops and reduce nitrogen input—keys to sustainable agriculture

The challenge

Nitrogen fertilizers promote healthy plant growth; however, any excess nitrogen has the potential to escape into the air mainly as nitrous oxide (contributing to greenhouse gas emissions [GHG]) or into ground waters as nitrate. These losses cost farmers money and can cause health and environmental issues.

AAFC research findings

To help optimize nitrogen use, scientists studied crop rotation—a practice of planting different crops sequentially on the same field over time. They examined six different crop rotations at seven sites in the Canadian prairies to determine productivity, GHG emissions, and revenue for each rotation. They found two promising practices for reducing nitrogen use and GHG emissions, without negatively affecting farmers' profits or crop yields:

- Planting more diverse rotations with pulse crops (e.g. peas) produced a similar yield and market value to rotations dominated by wheat and canola, but required 52% less nitrogen fertilizer.
- Using slightly less nitrogen fertilizer than otherwise recommended, by factoring in nitrogen credits from pulse crops, could reduce GHG emissions without negatively affecting yield or profitability.

The impacts

This research offers practical advice that Canadian growers could apply to sustain profitability while cutting nitrogen fertilizer usage, thus lowering nitrous oxide emissions.

Our research collaborators: University of Alberta, University of Saskatchewan, and University of Manitoba

Plant trees and shrubs … and cash in!

The challenge

To help Canada meet its objectives under the Paris Climate Agreement (2015), AAFC scientists joined other Canadian and American researchers to conduct the first study on 24 Natural Climate Solutions (NCS) in forests, grasslands, agricultural landscapes, and wetlands.

AAFC research findings

AAFC scientists focused on agroforestry practices—integrating trees and shrubs into farming practices to sequester carbon and reduce greenhouse gas (GHG) emissions. Aside from shelterbelts, they found three practices with the most potential:

- **Intercropping:** planting trees and shrubs effective at capturing carbon dioxide (CO_2) directly in cultivated fields;
- **Silvopasture:** rearing livestock in treed pastures where they eat undergrowth vegetation; and
- **Riparian buffer strips:** planting perennial vegetation along the rivers and creeks adjacent to farm fields.

Adopting these practices across Canada by 2030 could capture almost 8.5 million tons of CO_2/year—equivalent to removing about 1.8 million passenger vehicles from the streets for one year.

The impacts

These three agroforestry practices could help Canada meet and even exceed its Paris Agreement targets, as well as improve soil health, water and air quality, and biodiversity. With a value of $10 to $50/ton of CO_2 when traded on the carbon exchange market, these practices could also generate significant additional income for farmers.

Our research collaborators: University of Guelph, Nature United, The Nature Conservancy

Allium crops (dry onions, shallots, green onions, garlic, and leeks) have a combined farm gate value of $186M (2021).

Where there's a wasp, there's a way

The challenge

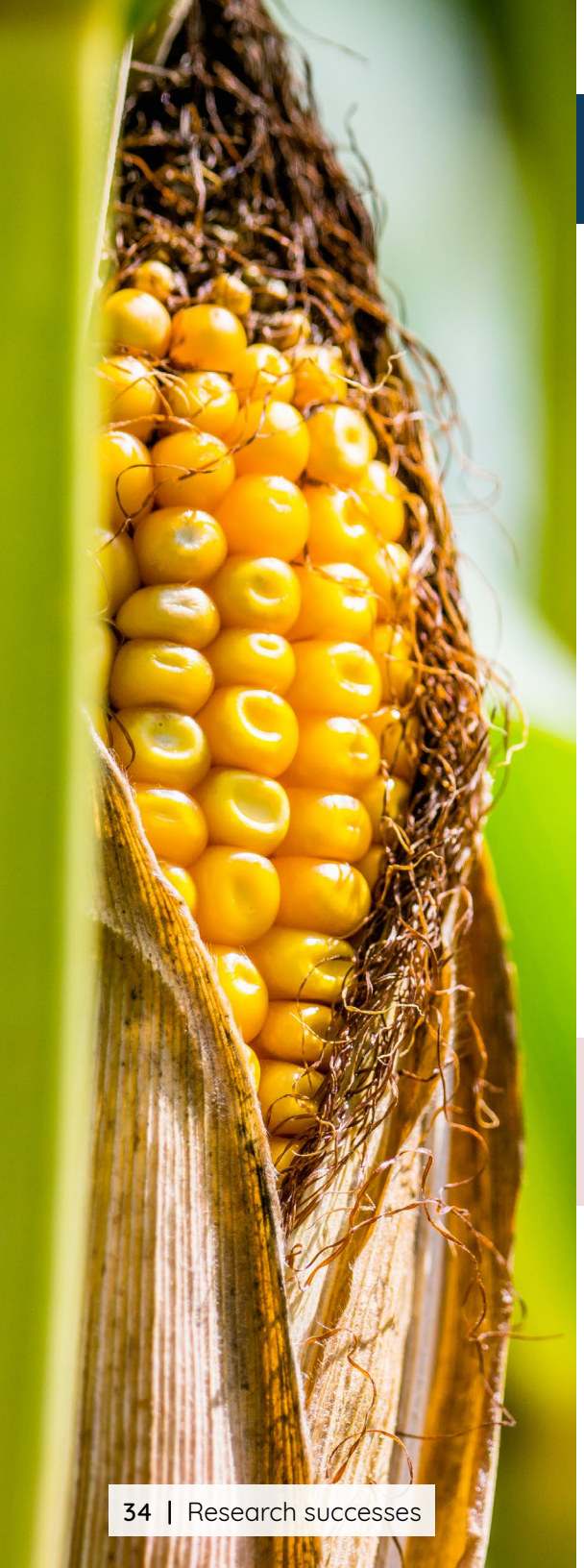
If left unchecked, the leek moth, an invasive pest from Europe, can have three generations within a growing season and destroy up to 100% of allium crops (onions, leeks, and garlic). It has spread from Ontario to Quebec, Prince Edward Island, Nova Scotia, and the USA. Researchers predict that as our climate warms, more generations will attack crops each growing season.

AAFC research findings

Scientists studied various pest control options, including the parasitic wasp *Diadromus pulchellus* which destroys the leek moth by laying its eggs inside its pupae. After obtaining Canadian Food Inspection Agency approval, they scaled-up efforts to mass produce the wasp and collaborated with farmers and the Ontario and Quebec provincial governments to release the wasp before the second and third generations of leek moths develop. On-going tracking confirms this wasp is very effective and can survive cold winters. Researchers are creating an on-farm, user-friendly tool for growers with helpful wasp management strategies to reduce crop damage by leek moths. (As a bonus, this is a non-stinging wasp which does not pose a risk to humans or livestock.)

The impacts

These efforts will help protect allium crops with an effective and environmentally-friendly pest control solution, saving growers' money and crops and providing an alternative to chemical pesticides and calendar-based spray programs.



Shining a light on food safety

The challenge

Bacteria and fungi can infect grains and other crops, causing yield and economic losses. For example, *Fusarium graminearum*, the pathogen that causes Gibberella ear rot in corn—a serious problem for Ontario farmers—can produce mycotoxins like deoxynivalenol (DON), making the crop unfit for human and animal consumption.

AAFC research findings

Scientists studied how ultraviolet (UV) light, operating at different wavelengths and targeting specific pathogens, could disinfect grains. They applied UV light on fungi-infected wheat and corn kernels as well as petri dishes containing fungal spores. This treatment reduced more than 94% of the fungi on grain kernels, up to 99% in the petri dishes, and 75% to 97% of the toxins (e.g. DON) produced by the fungi.

Based on this discovery, researchers developed a UV processor that uses four different light sources (with various wavelengths) to disinfect products. Using this processor, they achieved the highest reduction of DON after exposing whole and ground grain to polychromatic medium pressure mercury and pulsed lamps (emitting UV light at different frequencies and higher power), with higher reduction in ground corn.

The impacts

While more research is needed, this work on novel food processing technologies will ultimately help the food and grain industry improve the safety, quality, and sustainability of food processing.

Our research collaborators: Grain Farmers of Ontario, Deep Light Photonics, Eastern Fabricators Inc. (a division of Ag Growth International), Coop students from the University of Waterloo and McMaster University

Using models, the PPMN predicts when insect pests will be active and shares this information with farmers to help them monitor pests.

Predicting their next move … insect pest forecasts

The challenge

A changing climate creates new environments for insect pests in Canada and around the world. Longer, warmer summers and milder winters could result in greater overwinter survival of pests, a northward expansion, and invasion of new insect pests, which can affect crop yields.

AAFC research findings

To help growers make effective pest management decisions, scientists in western Canada conducted field and laboratory research, annual pest monitoring, and looked at historical data. They also used AAFC Prairie Pest Monitoring Network's (PPMN) vast datasets on pest activity since 1997. Using this information, researchers developed models to better understand how climate affects insect pest populations and how these changes affect crop yields.

For example, the Lygus bug, a pest of canola, alfalfa, quinoa, and flax, prefers hot, dry conditions typical of a drought. As warm and dry growing seasons are expected in the future, this may increase its numbers, resulting in higher yield losses. In contrast, the wheat midge needs rain to complete larval development, so a hotter and drier climate could reduce its numbers.

The impacts

With continued research and modelling, farmers and agronomists will have timely information to monitor insect pest invasions and make plans to reduce new infestations under the changing climate.

Our research collaborators: Alberta Agriculture and Irrigation, Saskatchewan Ministry of Agriculture, Saskatchewan Crop Insurance Corporation, Manitoba Agriculture, and many volunteer farmers and agronomists

Harvesting more scientific achievements

The stories featured in this issue of *Agricultural Innovations* show only a fraction of the great work done by our scientists every year. Here is a quick look at more accomplishments by AAFC and our collaborators:

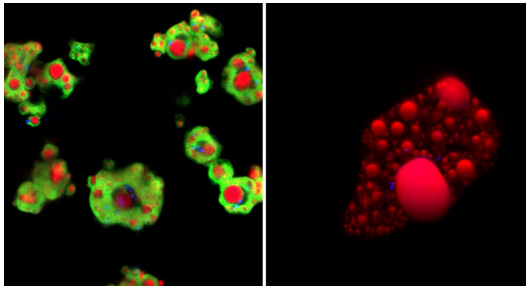
By using nematodes (tiny round worms) to biologically control beetle pests by up to 90%-100%, highbush blueberry and other berry farms could reduce their reliance on pesticides.

A new guide of adaptation strategies could become a key tool for farmers in Eastern Canada and the Northeastern United States, as it helps beef and dairy farms deal with the impact of climate change on forage production.

AAFC developed, patented, and licensed to a Canadian company a micro-encapsulation technology that protects heat-sensitive compounds, such as probiotics, and enables their delivery through animal feed to enhance animal health, providing an alternative to antibiotic use.

Giving first-time pregnant sows 40% more lysine (an essential amino acid) than usual by feeding more soybean meal during the last three weeks of gestation increases their mammary development by 44%, allowing them to produce more milk for their piglets. This discovery will change feeding recommendations around the world.

Launch of the Fermented Foods Safety Guidance website, developed by the Fermented Foods Working Group through broad national collaboration, assists health inspectors and operators of food processing facilities with evaluating the safety of fermented foods and fermentation processes.



Studies show an enriched diet containing complementary vitamins, and prebiotic, antimicrobial, and antioxidant supplements can help piglets better fight salmonella without antibiotics, allowing pig farms to reduce/replace the use of antibiotics against intestinal diseases.

The Nitrogen Nutrition Index, a diagnosis tool for Canadian crops like canola, corn, spring wheat, and potato, can improve nutrient management by measuring crops' nitrogen requirements, and the likelihood of nitrogen accumulation and leaching to the environment.

After more than 20 years of study, AAFC scientists discover that repeated annual applications of paper mill biosolids (waste) to agricultural soil improve soil quality and crop yield, while reducing farmers' costs.

The first nurseries of a weevil native to Serbia, to be used to control yellow toadflax (an invasive weed harmful to agriculture and biodiversity), are an important step in offering an organic method of weed control.

The release of two European moths enables potential long-term biological control of phragmites, Canada's worst invasive weed that threatens biodiversity, destroys wetland habitats, and obstructs infrastructure, such as roadways and agricultural irrigation networks.

For more information, please contact aafc.info.aac@agr.gc.ca.
For media inquiries, please contact aafc.mediarelations-relationsmedias.aac@agr.gc.ca.

AAFC at a glance

Key figures 2023–2024

2,387
Science and Technology staff

829
Science and Technology projects

795
Science articles published in **370** journals

20
Research and Development Centres across Canada

29
Satellite research locations across Canada

Genetic resources and biological collections

AAFC maintains the following biological collections and genetic resources to help researchers, breeders, and industry stakeholders in their efforts to analyze and manage important agricultural and environmental issues.

- Animal Genetic Resources of Canada
- Canadian Clonal Genebank
- Canadian Collection of Arbuscular Mycorrhizal Fungi
- Canadian Collection of Fungal Cultures
- Canadian National Collection of Insects, Arachnids and Nematodes
- Canadian National Mycological Herbarium
- Canadian Potato Gene Resources
- National Collection of Vascular Plants
- Plant Gene Resources of Canada
- Canadian Plant Virus Collection

Find more information on these collections at AAFC's Genetic Resources and Biological Collections.

Additional resources

Sharing the findings of our research with producers, provincial partners, other government departments, commodity groups, and academia so they can benefit from the latest data is a priority for AAFC. We provide practical, science-based information to farmers and agricultural stakeholders so they can plan their activities and be ready for any challenge with confidence. For example, our agroclimate maps and monitoring tools, available on our Weather and Drought web page, can help them prepare for extreme weather conditions and plan their operations accordingly.

To help mitigate the effects of climate change and build sustainable farming practices, our agri-environmental indicators are a helpful resource with web-based interactive maps, reports, and data measuring the environmental sustainability of Canadian agriculture. By consulting these resources, producers can learn more about reducing their greenhouse gas emissions, managing water resources, improving soil quality, and protecting on-farm biodiversity.

Producers and stakeholders can also consult our crop protection information to find out different ways to manage plant disease and invasive pests, and mitigate risks to crops in drought conditions. Our Pest Management Centre is a key resource, helping Canadian growers protect the yield, value, and quality of their crops by providing access to new pest management products, technologies and Integrated Pest Management approaches.

Read more information about these resources on AAFC's website under "Agricultural production tools and data", "Science and innovation", and "Environment and sustainability".

Find out more

Here are a few ways to stay informed of all of AAFC's latest discoveries and initiatives:

The Government of Canada's open access portal for its scientific articles and publications, including those from AAFC

Personal and professional stories about women who have laid the groundwork for young girls and women in the fields of science, technology, engineering, and math

Inspiring stories featuring incredible farmers, scientists, youth, and more

The **First Sixteen**

A **podcast** from Agriculture and Agri-Food Canada

AAFC's podcast series featuring in-depth interviews with dynamic agricultural changemakers

Personal profiles of some of AAFC's scientists and why they are passionate about their research

Profiles of AAFC's scientists and research and development centres

A special blog series from AAFC's research centre in the Okanagan Valley in British Columbia

Information on a 10-year commitment bringing farmers, scientists, and agricultural stakeholders together to co-develop and test beneficial on-farm practices to tackle climate change

Feature articles highlighting recent scientific discoveries, new technologies, and successes accomplished by AAFC researchers

Profiles of Canadian farmers and agricultural businesses that are dedicated to bringing us quality food while protecting the environment